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MORPHOCHEMICAL EVALUATION OF JAMUN

(*Syzygium cuminii* Skeels) COLLECTIONS

by

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(2013-12-123)

THESIS

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DECLARATION

I hereby declare that the thesis entitled "Morphochemical evaluation of jamun (*Syzygium cuminii* Skeels) collections" is a bonafide record of research work done by me during the course of research and the thesis has not been previously formed the basis for the award to me any degree, diploma, fellowship or other similar title, of any other University or Society.

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Introduction

1. INTRODUCTION

Jamun possesses commercial importance as a minor fruit in tropical and subtropical conditions. It is a versatile fruit tree of best food and medicinal value. It is found throughout India up to an altitude of 1800 m and its habitat starts from Myanmar and extended to Afghanistan. This plant is also found in other countries like Thailand, Philippines, Madagascar *etc.* World production of jamun is estimated as 13.5 million tonnes out of which 15.4 % is contributed by India (Singh *et al.*, 2011). India ranks second in production of jamun in the world. Maharashtra is the largest jamun producer followed by Uttar Pradesh, Tamil Nadu, Gujarat and Assam.

Jamun (*Syzygium cuminii* Skeels or *Eugenia jambolana*) is an important under-exploited indigenous fruit tree of India. It is a very common, large, evergreen beautiful tree of Indian sub-continent belongs to the Myrtaceae family. The tree is 8 m to 15 m tall, with oblong, opposite leaves that are smooth and glossy with a turpentine smell. The bark is scaly grey and the trunk is forks or multiple stem which has fragrant white flowers in branched clusters with hermaphrodite nature at stem tips and purplish-black oval edible berries with single seed.

Jamun has promising theraupeutic value due to its various phyto-constituents and pharmacological properties. It is a good source of iron apart from being the source of other minerals, sugars and phytochemicals (Singh *et al.*, 1967). The fruit is a rich source of anthocyanins, pectin, phenols and protein. Seed contains an alkaloid jambosin and a glycoside, jambolin or antimallin, which reduces or stop diastatic conversion of starch into sugars. The volatile oil from the jamun seeds can be extracted and used as an effective medicine against diabetes, heart and liver troubles. The antioxidant activity of jamun fruit has been attributed to its total phenolic compounds including anthocyanins. Glucose and fructose are the principal sugars in the ripe fruits, with no trace of sucrose. In recent years, jamun fruits are becoming popular due to their rich medicinal properties particularly for the

antidiabetic properties. The medicinal value is due to the presence of malic acid, oxalic acid, gallic acid and tannins.

Jamun is a nutritious fruit tree with a variety of uses. The fully ripe fruits with sub-acid spicy flavour are eaten as fresh and can be processed into a variety of products like jam, jelly, squash, wine, vinegar and pickles. Flowers rich in nectar, yield high quality honey. Jamun seed can be used as concentrate for animals because it is rich in protein, carbohydrates and calcium. The foliage serves as fodder for cattle, twigs form good datoon and as rough painting brush. The timber is used for buildings, agricultural implements and railway sleepers.

The jamun fruit demand is increasing day by day because of its nutritive value and that will require selected plants of superior quality with high yield potential. As majority of jamun trees are of seedling origin, they show tremendous variation in their morphology and physicochemical attributes. Lack of improved high yielding varieties with dwarf stature and good keeping quality are the major bottlenecks for the commercial cultivation of jamun in India. Considering the above facts, the present study entitled "Morphochemical evaluation of jamun (*Syzygium cuminii* Skeels) collections" was undertaken with the objective to evaluate the morphological and chemical characters of jamun collections for identifying the superior types.

Review of literature

2. REVIEW OF LITERATURE

2.1 Variability in jamun

Ashraf (1987) reported that fruit shape in jamun varied from round to oblong and apex of fruits from flat to pointed one. He also observed great variability in physico-chemical characteristics of fruits offering possibility of selecting a variety suitable for fresh market and processing. Small seed size, high pulp content with better chemical properties are considered ideal characteristics.

Singh *et al.* (1999) conducted a survey of bael, jamun, mahua, lasora, wood apple, monkey jack and karonda growing regions in eastern Uttar Pradesh, to examine the variability in existing germplasm for selection of desirable genotypes. They observed much variability on physicochemical charecteristics on fruits and also identified some desirable traits.

Kundu *et al.* (2001) evaluated the four local types of jamun in West Bengal for fruit yield and physicochemical characters. They found the variation among selected four types and recorded JS-1 (with 1 oval-shaped large fruit) and JS-2 (cylindrical-shaped, medium-sized fruit) showed high characteristics for yield, fruit size and weight. Fruits of JS-2 and JS-3 (pear-shaped, medium-sized fruits) showed high amounts of total soluble solids, reducing sugar and total sugar.

Srimathi *et al.* (2001) carried out a comparative study in jamun (*Syzygiumcuminii*) to determine the effect of fruit colour on the fruit, seed and seedling quality. They separated the collected fruits into green fruits with rosy tinge (on fruit coat), rosy fruit, and blackish purple fruit. They observed the highest fruit length (2.1 cm), fruit breadth (1.3 cm), fresh weight (1.944 g), fruit dry weight (0.378 g), seed fresh weight (0.380 g), root length (8.1 cm), shoot length (21.2 cm), dry matter production (524 mg), and vigour index (2825) in blackish purple fruit and the highest fruit volume (1.1 ml) and seed length (1.3 cm) were obtained in

rosy fruit, while the highest seed moisture content (86.9 per cent) was obtained in green fruit with rosy tinge.

Devi *et al.* (2002) studied the variability in physico-chemical characters of 18 jamun accessions from Goa. Their results revealed that there was a wide variation among its accessions. Individual fruit weight ranged from 3.42 to 13.67 g; length from 3.31 to 5.26 cm; girth from 5.21 to 9.82 cm; length/width ratio from 1.44 to 2.30 and pulp percentage from 58.57 to 84.55%. They found a wide variation in chemical characters also. TSS varied from 12.0 to 26.8° Brix, titratable acidity from 0.59 to 1.63%, total sugars from 6.87 to 25.31% and sugar/acid ratio from 15.39 to 27.92. They conclude that OG1 was found to be promising among all accessions studied, based on its desirable physicochemical characteristics.

Prabhuraj *et al.* (2002) investigated the nature and extent of variability present in jamun seedling progenies for morphological characters of trees in the Belghum district of Karnataka. They observed the high variability for the characters, *viz.*, plant girth, leaf area, petiole length and leaf length to petiole length ratio.

Prabhuraj *et al.* (2003) conducted a study to found the existing natural variability among the selected 125 promising jamun selections and to locate genotypes with excellent fruit qualities. They recorded the physico-chemical parameters of the fruits and seeds such as fruit length and breadth, fruit weight, fruit volume, seed length and breadth, seed weight, seed volume, pulp weight, pulp per cent, pulp to seed ratio, total soluble solids, acidity and anthocyanin content. They conclude that the selected 125 plants showed a great deal of variation with respect to the physico-chemical and organoleptic properties. Among 125 plants they determined the nine desirable seedling trees.

Survey was conducted in Uttar Pradesh (Lucknow, Varanasi and adjoining areas) and Jharkhand (Ranchi and adjoining areas) to find out the existing natural variability among the jamun seedling trees and to identify superior genotypes with good fruit qualities. Observations on the physico-chemical parameters of fruits were

recorded on 32 genotypes. All the genotypes showed considerable variability with respect to the physico-chemical characters assessed. The genotypes, RNC-26 and RNC-11 were found promising and had higher fruit and pulp weight with sweet fruits. Highest pulp content (97.71%) was recorded in V-8 followed by V-6 (95.84 %) and V-7 (93.81%) genotypes collected from Varanasi region. Thin seed with almost negligible seed weight (0.12 g) was observed in V-8 followed by V-6 (0.16 g) and V-7 (0.31 g). Hence, these genotypes might be used as seedless jamun (Patel *et al.*, 2005).

Evaluation of 55 genotypes was carried out for physicochemical characters in Arabhavi, Maharashtra, which indicated wide variation among the strains in terms of economic characters. Strain ALG-58 emerged as a potential one for superior characters (Athani *et al.*, 2006).

A survey was conducted in 22 jamun accessions to find out variations in the morphological and physicochemical traits of accessions of jamun (*Syzygium cuminii*) identified in the region. The study revealed that there was wide variation among the identified accessions. The individual fruit weight ranged from 4.80 to 17.60 g, length from 2.22 to 4.51 cm, diameter from 1.66 to 3.04 cm, seed weight from 1.30 to 2.36 g and pulp content from 68.75 to 86.59%. The total soluble solids among different accessions varied from 12.2 to 18.4°B whereas the titrable acidity (%) varied from 0.79 to 1.25%. They concluded that the cultivars CISH J-17, CISH J-14, CISH J-19 and CISH J-20 promising accessions based on their physicochemical characters (Singh *et al.*, 2007).

In Himachal Pradesh Thakur *et al.* (2008) conducted a study in aonla, jamun and soapnut to assess the natural variation in these species, so as to screen out their promising strains for higher and quality production. They observed the wide range of variation in fruit and seed characters of these species which revealed that selection for their improvement could be very effective.

Ghojage *et al.* (2009) reported the variability of quality characters among the best selected 30 genotypes of jamun from seedling trees located in Karnataka & Maharashtra and found that physicochemical characters varied considerably and also observed the genotypes KJS-4, KJS-9, KJS-28 and KJS-1 were found to be promising and could be used for further evaluation.

The study was conducted for the evaluation of jamun collections for productivity on black clay soils and observed that performance of Krishnagiri series is higher in fruit yield and low genetic variations within the families among the different selections (Patil *et al.*, 2009).

Singh *et al.* (2009) identified that the accession CISH J-37 has the superiority due to its bold large sized bunches with attractive deep purple colour, high pulp/seed ratio (90–92) and TSS (16–17^{o}Brix).

The investigations carried out in jamun showed the wide range of variability in the physico-chemical composition and also observed that the 'Selection 1' was most promising for fruit weight, minimum seed weight, higher pulp percent, TSS and total sugar. Therefore, Selection-1 is suitable for further perpetuation for commercial and systematic orcharding of jamun (Prakash *et al.*, 2010).

The variability in physico-chemical characters of different accessions of jamun were studied in Varanasi, Pantnagar, Uttarkand by Srivastava *et al.* (2010). They concluded that there was a significant variation in morphological characters, fruit yield and quality characters of all the 25 selected jamun genotypes and stated that PJ-23 was found best among all the selected genotypes for its physical characters. For chemical parameters, VJ-5 was found best for TSS: acid and sugar: acid content, VJ-14 for total sugar content and TSS, VJ-20 for titrable acidity and PJ-23 for ascorbic acid.

Shanawaz and Sheik (2011) carried out a comparative study between the (V_1) improved and (V_2) indigenous cultivars to present basic principles of physical

properties of jamun fruit in order to facilitate its handling and processing. The morphological parameters includes weight, volume, length, diameter, shape, color, firmness/softness, edible and non-edible contents, specific gravity, juice and seed contents. They analyzed that the improved cultivar was found superior in all parameters than the indigenous cultivar. The weight, length, width and volume of V_1 was determined as 9.55 g, 3.88 cm, 2.98 cm and 7.60 ml whereas V_2 was determined as 6.71 g, 2.73 cm, 2.10 cm, and 5.33 ml respectively. Likewise, edible portion was 69.10% whereas non-edible portion was 30.90% in V_1. In case of V_2, edible portion was determined as 39.19% whereas non-edible portion was 60.81%. They conclude that the few parameters indicate that $V_1$is comparatively better than V_2.

Hareesh *et al.* (2012) studied the variation of fruit, seed and seedling growth attributes among purple (normal) and white (off-type) types in jamun. For the first time they have noticed a tree near Sonda forests of Hulekal forest range of Canara forest circle of Karnataka, which yields whitish coloured fruits. They found that the fruits and seeds of white type were smaller than that of purple type. In contrast, embryo of white type fruit was larger in size than purple type. Seeds of white type showed delayed germination and seedlings of white type recorded poor growth as compared to normal ones (purple type). They conclude that there were significant differences among purple and white types for fruit, seed, germination, growth and biomass of seedlings an also the poor performance of white type might be due to inherent character of off type.

Singh and Singh (2012) conducted a survey for studies on variability in jamun to identify the elite genotypes in Gujarat. They studied the flowering, fruiting and fruit quality attributes of sixteen genotypes. The study revealed that there was a wide variation among the selected genotypes and concluded that performance of GJ-2, GJ-3 and GJ-8 were found to be promising among all genotypes on the basis of overall performance.

2.2 Genetic diversity

The native range of another important species are Rose apple (*Syzygium jambos*) originally encompassed of all parts of the Malay Archipelago and upper Myanmar (Troup, 1921); Brazil cherry (*Syzygium uniflora*) is native to South America; *Syzygium aqueum, Syzygium malaccensis, Syzygium samarangense* originated in South East Asia; Wild jamun (*Syzygium claviflorum*) is uncommon, found in evergreen forest of Baratang, Andamans and navy Bay (Singh and Srivastava, 2000).

Wild jamun (*Syzygium claviflorum*) seeds are used as medicines for stomachic, carminative, diuretic, improve blood haemoglobin content and also it contains ellazic acid (Singh, 2001). The root, bark and seeds of *Syzygium jambos* are employed in several home remedies (Roig and Jan, 1945).

2.3 Medicinal uses

Methanol extract of jamun bark is effectively inhibited the enzymatic activity of HIV-I (Human Immuno Deficiency Virus type – I) protease by more than 70% (Kusumoto *et al.*, 1995). Medicinally, the fruit is astringent, stomachic, carminative, antiscorbutic and diuretic. Jamun fruit contains polyphenols like delphinidin, malvidin (with bioside sugars). These are essentially hydrolysable tannins. Fruit also contains tannic acid derivatives such as gallic acid, corilagin and ellagic acid (Basak, 2003).

Gallic acid in this fruit besides exerting the effects of tannin derivatives is useful in treatment of anti-influenza A and B and polio 1 virus. Citric acid present in the fruit is a known antibacterial compound. This compound kills and cleanses *Escherichia coli* from the urinary tract (Mitra *et al.*, 2008).

Syzygium cuminii seed extract involves preventive and therapeutic activities against chemical induced gastric carcinogenesis (Goyal *et al.*, 2010).

Baliga *et al.* (2011) found that the jamun fruits are effectively having the anticancer, chemopreventive and radioprotective potential due to its antioxidant properties.

Chaudhary and Prasad (2014) reported that the jamun fruits are rich in anthocyanin which have the medicinal properties like anti-diabetics and also suggested for diabetic patients that the consumption of jamun wine (200 ml/day) in regular diet showed good decrease in fasting blood glucose as well as lipid levels in blood.

2.3.1 Antioxidant properties

Venkateswarla (1952) reported that the color of the fruits might be due to the presence of anthocyanins namely delphinidin-3-gentiobioside and malvidin-3-laminaribioside along with petunidin-3-g entiobioside.

Jyothi *et al.* (2007) has studied anthocyanin pigments from *Syzygium cuminii* fruit peels were characterized and evaluated for their antioxidant efficacy.

Vasi and Austin (2009) have studied the antioxidant potential of *Eugenia jambolana* using various in vitro models. Ethanolic (50%) extract showed maximum scavenging activity in all models. The finding justifies the therapeutic application of the plant in the indigenous system of medicine, augmenting its therapeutic value.

The hydroethanolic extract of the seed (Hasan *et al.*, 2009), methanolic extracts of stem (Kshirsagar and Upadhyay, 2009), anthocyanin-rich fruit peel extract (Veigas *et al.*, 2007) and the methanolic extract of the leaves (Kshirsagar and Upadhyay, 2009) are observed to be free radical scavengers in the DPPH scavenging assay. Bajpai *et al.* (2005) have also observed that the hydromethanolic extract of the Jamun seed was effective in scavenging (90.6%) free radicals as evaluated in the auto-oxidation of β -carotene and linoleic acid assay and was due to the presence of high total phenolic content in the extract.

Compared to other popular fruits like sapota, papaya, banana and guava, jamun has higher level of antioxidant activity. The higher antioxidant activity in the fruit is attributed to the presence of antioxidant, vitamins, tannins and anthocyanins (Koley *et al.*, 2011).

Jamun is a widely distributed forest tree in India and other tropical and subtropical regions of the world. The jamun fruit is rich in phytochemicals like glycoside jambolin, anthocyanins, tannins, terpenoids, gallic acid and various minerals. Jamun fruits posses antineoplastic, radioprotective and chemopreventive effects which are useful in the prevention and treatment of cancer (Swami *et al.*, 2012).

Shrikanta *et al.* (2015) found that the jamun seed (34.87 µg g^{-1} dry weight), jamun pulp (13.70 µg g^{-1} dry weight) and skin of jamun (11.19 µg g^{-1} dry weight) have high resveratrol content next to mulberry fruit (50.61 µg g^{-1} dry weight).And also recorded that the jamun seed extract exhibited the highest polyphenol content (55.54 mg gallic acid equivalent g^{-1} dry weight) and highest antioxidant property (IC_{50} value-0.40 mg ml^{-1}). Finally suggest that underutilized fruits high in resveratrol and other polyphenols can be used as functional beverages.

2.4 Physiology of flowering

Misra and Bajpai (1975) reported that the inflorescence of jamun plant carried about 35-45 flowers and they are generally born in axils of one season old branchlet and the floral buds assume a club shaped appearance.

Bajpai and Chaturvedi (1985) observed that the flowering of jamun starts in first week of March and continues up to the end of April.

Tarai *et al.* (2006) reported that the flowering of jamun was started at the last week of March and ends at the last week of April which takes four week duration of flowering.

Tarai and Kundu (2008) studied the flowering behavior of jamun and other minor fruits in the new alluvial zone of West Bengal. They recorded the jamun flowered once in the spring season, the number of days for flower bud development was 50 days and the type of inflorescence in jamun was panicle.

2.5 Pollination and fruit set

Misra and Bajpai (1984) studied that the maximum fruit set in jamun was taken place under open pollination by wind, insects and gravity. They observed maximum fruit drop of 84.63 and 81.81% occurred in two consecutive years. The fruits took about 3.5 months to mature after full bloom, at the fully ripe stage the fruits were dark violet in colour, very sweet and had a pleasant flavour.

Tarai *et al.* (2006) studied the performance of minor fruits in West Bengal, in that they observed that the jamun fruits matured in 63 days after flowering and the fruit retention was 5.72%.

2.6 Fruit development

Shukla and Prasad (1980) studied the respiration rate in developing jamun fruits at frequent intervals from 15 to 61 days after fruit set. They recorded that initially high respiration rate (15-30 days) declined, rose again at 56 days (climacteric peak) and then declined again until harvest maturity at 60 days after fruit set and their findings are discussed in relation to the determination of the state of fruit maturity after harvest.

Geetha *et al.* (1992) made an observation at seven day intervals from fruit set and recorded the changes in fruit length, fruit girth, fruit weight, fruit volume and moisture content. They conclude that the values of all these parameters increased with increasing fruit age and also the pattern of fruit growth followed a sigmoidal curve with the first phase (days 7-14 after fruit set) slow, the second phase (days 14-35) rapid and the last phase (days 35-42) slow.

2.7 Fruit growth and development

Garande *et al.* (1998 a) studied the changes in chemical composition during growth and development of jamun fruit. They observed the total soluble solids, total and reducing sugars and moisture content showed a continuous increase as the fruits developed with a marked increase during ripening. Acidity and pH first decreased and then increased. There was a gradual decrease in tannins whereas pectins rose and then fell during the growth period. Fruit TSS-acid ratio and anthocyanin content followed an increasing trend with advancing maturity and markedly increased during ripening.

Garande *et al.* (1998b) conducted a study on jamun fruits which were sampled at 10-day intervals, from fruit set to until partial ripening. They observed the physical changes (length, diameter, weight and volume) in jamun fruits showed continuous increases during development, the increase in fruit volume was more rapid than the increase in fruit weight, specific gravity showed a continuous decrease from fruit set to ripening but always remained >1 and the fruit took 63 days for complete ripening from fruit set, fruit colour changed from dark green at fruit set to light reddish-purple at the partial ripening stage, ripe jamun fruit was75.67% was edible and the pulp to seed ratio was 3.11:1.

2.8 Yield

Tarai *et al.* (2006) reported that the jamun yields 37.40 kg/tree i.e. 8500 fruits/tree in their fruit performance studies. Variability in yield attributes in jamun was reported by Keskar *et al.* (1989), kundu *et al.* (2001) and Singh and Singh (2005).

Haldankar *et al.* (2014) reported that after fruit set jamun tree takes about 60 days for harvesting and mostly the fruits become ready for harvest at the end of the summer.

Lawande *et al.* (2014) observed that all fruits in a bunch do not mature at one time and they require 4-5 pluckings for harvesting the ripe fruits in a bunch.

2.9 Fruit quality

Correlation and regression analysis was carried out in 31 genotypes of jamun by Jadon *et al.* (1999) in Madhya Pradesh. They found positive and significant correlations between different fruit parameters (weight, length, diameter, volume and pulp weight) and the regression analysis showed that fruit volume and pulp weight were most significantly correlated with fruit weight while pulp weight and seed weight were better correlated with fruit diameter.

Vanangamudi *et al.* (2000) studied the prediction of seed storability in jamun (*Syzygium cuminii*) through accelerated ageing test. Seed samples of jamun drawn at 24h intervals were tested for germination and seedling vigour in terms of root and shoot length, vigour index and dry weight and found reduction in germination below 50% occurred earlier in jamun (fourth day of ageing). Therefore, they concluded that seeds of jamun should be sown in the nursery immediately after collection.

Correlation study between different physico-chemical characters of fruits from the selected 34 jamun genotypes showed highly significant positive correlation with pulp weight (0.998 g), fruit volume (0.993 cc), seed weight (0.952 g), seed volume (0.918 cc), fruit length (0.897 cm), fruit size (0.896 cm), seed length (0.875 cm), pulp thickness (0.842 kg/cm^2) and seed breadth (0.684 cm). Seed percentage had highly significant but negative correlation with fruit weight. They concluded that major emphasis in selection should be given for higher pulp weight, fruit volume, fruit size, pulp thickness and pulp: seed ratio (Inamdar *et al.*, 2002).

Tarai *et al.* (2005) conducted a fruit quality study in a new alluvial zone of West Bengal and recorded the jamun fruit showed moderate contents of TSS, total sugar and reducing sugar.

Ghosh *et al.* (2006) conducted the experiment to study the quality and storage behavior of some local types of jamun fruits. They found the significant variation in physical parameters includes length, transverse diameter and weight of the fruit and the range of variation in chemical constituents are total soluble solids (10.6 – 16.10° Brix), total sugar (4.86 – 11.10 %), reducing sugar (3.92 – 10.12 %), non-reducing sugar (0.94 – 1.61 %), acidity (0.861.90 %) and ascorbic acids (1.28 – 7.63 mg/100 g) and also recorded that the fruits can be stored upto the 4th day with a considerable percentage of fruits retaining in edible condition.

Kumar *et al.* (2006) reported that jamun was a good source of iron (1.0 %), protein (0.7 %), minerals (0.4 %), calcium (0.02%), phosphorus (0.01%), fibre (0.9%), carbohydrate (19.7), carotene (48 IU) and vitamin C (18 mg/ 100 g).

Pathak and chakraborty (2006) studied the physico-chemical characters of tropical underutilized fruits. In jamun, they observed the variation in physical characters includes fruit weight (5.35g), fruit length (2.88 cm), fruit diameter (1.65cm), pulp weight (3.91g), seed weight (1.42g), pulp/seed ratio (2.75),edible portion (73.08) and the chemical characters are total soluble solids (10.8° Brix), acidity(0.38 %), TSS/acid ratio (28.42), total sugar (9.52%), reducing sugar(8.16%), non-reducing sugar (1.29 %), and ascorbic acids (16.78 mg/100 g).

Tarai *et al.* (2006) studied the performance of jamun in west Bengal. The physico-chemical properties of fruit was recorded as fruit weight(4.4g), total soluble solids (10.5° Brix), total sugar(9.09%), acidity(0.38%), TSS/acid ratio (27.63) and ascorbic acid (7.8 mg/100 g of pulp).

Nawaz *et al.* (2010) conducted a study to determine the mineral contents of jamun fruit products namely pulp powder, seed powder jam, squash and ready-to-drink juice between the improved-V_1 and indigenous-V_2 varieties. These findings concluded that there is a significant difference between the products as well between the cultivars however, V_1 is comparatively better than V_2 for containing minerals, sodium and potassium are found to be abundant in quantity particularly in

jamun seed. No large reduction of minerals during storage was found once the product is prepared through processing and also recommended that jamun fruit can be utilized in beverage or even baby foods for the supplementation of essential mineral elements to malnourished. A correlation study conducted for physico-chemical characters in jamun revealed that for superior genotypes, major emphasis in selection should be given for higher pulp weight, fruit volume, fruit size and pulp/seed ratio and high TSS along with less seed size (Srivastava *et al.*, 2012).

Siddig *et al.* (2015) found that the leaves and bark of jamun contains the following elements Potassium (K), Calcium (Ca), Titanium (Ti), and Magnesium (Mn), Iron (Fe), Copper (Cu), Zinc (Zn), Zernike (As), Lead (Pb), Barium (Br) and Strontium (Sr) by using the X-ray fluorescence (XRF) and X-ray diffraction (XRD).

2.10 Postharvest studies

The TSS, total sugars and reducing sugars, in general increased during the period of storage (Banik *et al.*, 1986).

Jamun fruits are highly perishable and cannot be stored more than 3 to 4 days under room temperature. However precooled fruits packed in polythene bags can be stored well upto three weeks at low temperature of 8 to 10°C (Shukla, 1979).

2.11 Product diversification

Powdered seed in combination with mango kernels were administered with curd to overcome the problem of diarrohea and dysentery, enlargement of spleen and as diuretic in scanty (Rastogi and Mehrotra, 1980).

Jamun honey collected from Apisdorsata Fabr. in North India is obtained from jamun flowers. The honey was amber coloured and delicious. Individual bee colonies are reported to collect 2.3 – 4.6 kg honey and the trees on the Western Ghats contributes 30-40 percent of the annual harvests of honey (Naik *et al.*, 1996).

Shahnawaz *et al.* (2009) conducted a study on the nutritive values of stored jamun products, namely jam, squash, ready-to-drink juice, seed powder and pulp powder. Besides of jam, squash and juice products, jamun seed and pulp powder also have good nutritive values and were quite rich in carbohydrates accompanied by enough protein, ash, crude fibers but were not sufficient in fat composition. They concluded that the study could be a beneficial source to the dieticians/nutritionist to consider jamun as best nutraceutical fruit with natural curing and food industries for manufacturing commercially viable food products.

The diversified products in jamun includes blended nectar (Chakraborty *et al.*, 2011), jam, jellies, sauce, chutney, vinegar, pickles, wine (Kumar *et al.*, 2006), jamun shirkhand (Lakshmi *et al.*, 2013) and non-fermented beverages are ready- to-serve (RTS), squash, nectar and syrup (Sharma *et al.*, 2009).

2.12.1 Pest

Chatterjee (1979) reported a Micro lepidopterous larval infestation on jamun leaves.

Rao *et al.* (1979) found a *Balochabi furcata*sp (Homoptera: Cicadellidae) from Delhi was described from adult males collected on jamun.

Field tests were carried out by Singh and Singh (1979) to determine the effectiveness of several insecticidal sprays for the control of Jamun leaf miner, *Acrocercops phaeospora* Meyr. (Gracillaridae: Lepidoptera). They found that spraying with 0.023% parathion had resulted in the highest mortality rate (96.2%), followed by 0.05% Quinalphos, which gave a mortality rate of 85.35% and conclude that both treatments were significantly superior.

An outbreak of *Metanastria recta* (Wlk.) was observed around Ludhiana on jamun by Sandhu and Shohi (1980). They also found that the high volume spraying of 1% Dichlorvos applied at a rate of 2 ml/litre water using 0.5 litre water per tree

resulted in mortality of the larvae within 2 h, while 0.05% Permethrin resulted in mortality after 15 min.

Heavy infestation of jamun trees by the lasiocampid (*Metanastria hyrtaca)* was observed in Hyderabad and found upto 42.4% of early-instar larvae were parasitized by *Apantelessp.* (Joshi, 1985).

Talwar (1993) reported that the three species of Curculionidae, *Curculio album, Apotomorhinus cribratus* and *Sitophilus rugicollis* attack the fruits of jamun. The larvae of all three species complete their development in the kernel and for the *C. album* and *A. cribratus* there is only one species of larva per seed whereas larvae of *S. rugicollis* can coexist with the larvae of other two species.

Bark eating caterpillar (*Inderbela tetraonis* and *Inderbela quadrinota*), leaf eating caterpillars (*Carea subtilis*), jamun caterpillar (*Trabala vishnou*), leaf miner (*Acrocercops* spp.) are reported as important pests of jamun by Lakra (1997).

Dahiya and Lakra (2001) reported the thrips (*Rhipiphorothrips cruentatus)* infestation of jamun in Haryana district.

Sharma and Arora (2009) reported that the mealy bugs *Planococcus citri* (Risso) attacks leaves, twigs and branches of jamun and also *Planococcus lilacinus* (Cockerell) had 5-15 per cent infestation on the jamun.

The survey of insects associated with jamun in India was conducted by Kumar *et al.*(2010). The collected 300 specimens belonging to five orders which comprises of 78 species mainly representing two orders *i.e.,* Lepidoptera (34 species) and Hemiptera (26 species) and also recorded the salient details of their locality, feeding behavior and pest status.

Indarbelatetraonis (Bark borer) in jamun was identified by Dhote *et al.* (2012).

Khan *et al.* (2013) studied the nematode assemblages associated with jamun (*Syzygium cuminii* L.) trees in twelve localities and analysed the species of nematodes were determined and the rhizosphere bacteria. They found the predominant nematodes were: *Filenchus filiformis*, *Helicotylenchus indicus*, *Filenchus vulgaris*, *Basiria graminophila*, *Tylenchus butteus* and *Meloidogyne incognita* and also the dominant rhizosphere bacteria were: *Pseudomonas* sp. >*Bacillus* sp. >*Clostridium* sp. >*Azotobacter*.

Sathe (2014) reported the Cerambycid beetles infestation on jamun in the Western region of Maharashtra.

2.12.2 Disease

Kaiser and Saha (2005) reported the anthracnose (*Colletotrichum gloeosporioides)* affected the jamun fruits in West Bengal.

Leaf spot, fruit rot (*Glomerella cingulata*) causes serious damage to the leaves and fruits of jamun (Sutherland, 1977). Botrytis blight (*Botrytis cinerea*) affects the opening buds, juvenile leaves and green stem (Smith *et al.*, 1973, Khan and Misra, 1995).

Materials and methods

3. MATERIALS AND METHODS

The investigation envisages to evaluate the morphochemical characters of jamun collections maintained in and around the KAU main campus to identify the superior types. The procedures adopted are discussed below.

3.1 Experimental site

The experiment was conducted during August 2014 to December 2015 at the KAU main campus, College of Horticulture, Vellanikkara, Thrissur, Kerala.

3.1.1 Location

The KAU main campus, College of Horticulture, Vellanikkara situated at 10° 54' North latitude and 76° 28' East longitude at an altitude of 22.25 m above mean sea level.

3.1.1 Climate

The climate of the experimental site was humid tropical. The mean temperature, rainfall and relative humidity during the investigation period are presented in Appendix I.

3.1.3 Materials

Bearing trees were selected from the collection of jamun maintained in the departmental orchard of department of Pomology and Floriculture and in and around the KAU main campus, Vellanikkara, Thrissur, Kerala. Each jamun trees from the collection are mentioned as Kerala Jamun (KJ).

3.1.4 Methods

Tree characters were observed. Floral characters were recorded at the time of flowering. Mature fruits were collected for recording fruit characters, quality attributes and sensory evaluation.

3.2 Observations

Observations of individual plants were recorded. The observations on tree characters, floral characters, fruit characters, quality attributes and sensory evaluation were taken.

Plate 1a. Location of jamun collection

Departmental orchard
KJ- 1, 2, 3, 4, 5, 6, 7, 8, 9, 47, 48

Central nursery
KJ- 10 to 32

KAU School

KJ- 33

KJ- 37

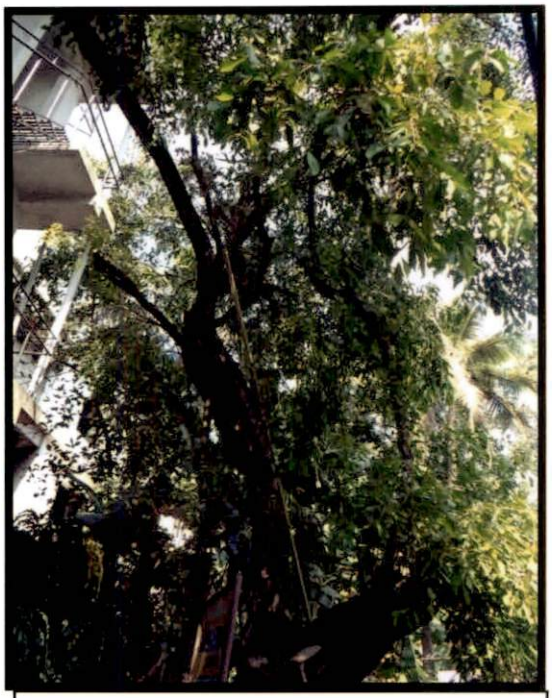
KJ- 51

Plate 1b. Location of jamun collection

Mango orchard
KJ- 39

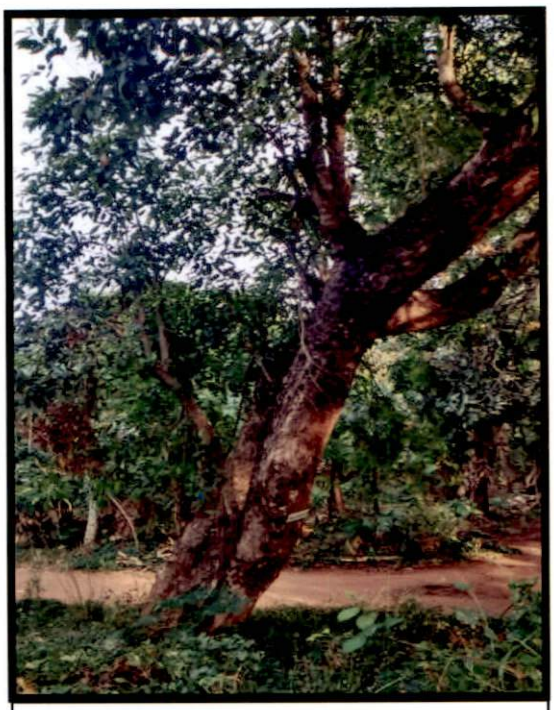
KVASU, Mannuthy
KJ- 40

College of Forestry
KJ- 43



Market road, Mannuthy
KJ- 45

Plate 1c. Location of jamun collection



Coconut Development Farm
KJ- 52

Pineapple Research Centre
KJ- 40, 44, 49, 53, 54, 55, 56, 57, 58

3.2.1 Tree character

Observations of tree characters recorded from the selected plants are listed below.

3.2.1.1 Age of the tree

Age of the tree was recorded based on date of planting of jamun recorded in the register maintained in the Central Nursery and Departmental Orchard, College of Horticulture, Vellanikkara.

3.2.1.2 Tree height

Height of the tree was measured from the ground level to the top of the tree using ultimeter and expressed in meter (m).

3.2.1.3 Trunk girth

Girth of the tree was measured at 25 cm above the ground level and expressed in centimeter (cm).

3.2.1.4 Crown shape

Shape of the crown were observed and classified into three groups namely oval, round and pyramidal.

3.2.1.5 Leaf length

Average length of ten fully expanded leaves of each trees from the base to the tip of the leaf blade were taken and expressed in centimeter (cm).

3.2.1.6 Leaf width

Average width of ten fully expanded leaves of each trees at the widest point were taken and expressed in centimeter (cm).

3.2.1.7 Leaf shape

Leaf shape of the trees were recorded and classified into four groups namely broadly ovate, elliptic oblong, elliptic and lanceolate.

3.2.1.8 Leaf colour

Leaf colour was noted as per the Royal Horticultural Society Colour charts (Edition V).

3.2.1.9 Shoot length

Shoot length was measured from the base of primary leaf to collar region of ten randomly selected current season shoot and expressed in centimeter (cm).

3.2.1.10 Internodal length

Internodal length was measured between two successive nodes of ten randomly selected nodes and the average is expressed in centimeter (cm).

3.2.2 Inflorescence character

Inflorescence character was observed and recorded at the time of flower bud initiation.

3.2.2.1 Position of inflorescence

Position of inflorescence was recorded and classified into axillary and terminal.

3.2.2.2 Flower composition in the inflorescence

The flower composition in the inflorescence were recorded and classified as solitary and clusters.

3.2.2.3. Flower colour

Flower colour was identified by using the Royal Horticultural Society Colour charts (Edition V).

3.2.2.4 Flowering season

Flowering season was observed at the time of 50 per cent and recorded as early (Nov - Dec), mid (Dec - Jan) and late (Jan - Feb) flowering.

3.2.2.5 Duration of flowering

Duration of flower retained after anthesis was observed and expressed in days.

3.2.3 Fruit character

The observations on fruit characters were taken from ten fruits per cluster selected at random and mean value was recorded.

3.2.3.1 Fruiting season

Time of fruiting was recorded in each collection.

3.2.3.2 Days from flowering to fruit maturity

Days taken from flowering to reach harvesting maturity were recorded.

3.2.3.3 Days from fruit set to maturity

Days taken from fruit set to reach harvesting maturity were recorded.

3.2.3.4 Fruit clustering habit

Fruit clustering habit was recorded at the time of harvesting and classified into solitary and clusters.

3.2.3.5 Fruit weight

Fruit weight of ten randomly selected samples of variable sizes were collected to find out the mean weight of fruits and expressed in gram (g).

3.2.3.6 Fruit volume

Volume of fruit was estimated by water displacement method and expressed as cubic centimeter (cc).

3.2.3.7 Number of fruits per cluster

Number of fruits per cluster was recorded as average of ten randomly selected clusters from each tree.

3.2.3.8 Specific gravity

Specific gravity of the fruit was determined by the formula,

$$\text{Specific gravity value} = \frac{\text{Weight of the fruit}}{\text{Weight of water equivalent to volume of the fruit}}$$

3.2.3.9 Overall length of fruits

The distance between the base and the apex of ten randomly selected fruits were measured and the average was expressed as centimetre (cm).

3.2.3.10 Maximum width

Width of ten randomly selected fruits was measured around the midpoint of the fruit and the average was expressed as centimeter (cm).

3.2.3.11 Fruit shape

Shape of the fruit was recorded and classified into four groups namely round, oblong, oval and ellipsoid.

3.2.3.12 Firmness/softness

Firmness of fruit was measured using penetrometer and the average was expressed as kg cm^{-2}.

3.2.3.13 Colour

Fruit colour was confirmed using the Royal Horticultural Society Colour charts (Edition V).

3.2.3.14 Per cent of pulp in fruit

Ten selected sample of fruit was first weighed and cut to separate the seed from pulp. Then the pulp was weighed. Content of pulp was calculated using the formula and expressed as percentage.

$$\text{Pulp per cent} = \frac{\text{Weight of the pulp (g)}}{\text{Weight of the whole fruits (g)}} \times 100$$

3.2.3.15 Per cent of seed in fruit

Ten selected sample of fruit was weighed. Then the seed was weighed separately. Content of seed was calculated using the formula and expressed as percentage.

$$\text{Seed per cent} = \frac{\text{Weight of the seed (g)}}{\text{Weight of the whole fruits (g)}} \times 100$$

3.2.3.16 Pulp/seed ratio

Pulp and seed weight were recorded for each sample and pulp/seed ratio was worked out.

$$\text{Pulp/seed ratio} = \frac{\text{Weight of the pulp (g)}}{\text{Weight of the seed (g)}}$$

3.2.3.17 Juice content

Selected samples were weighed and the pulp was grinded thoroughly in a blender by adding a known volume of distilled water.The ground material was filtered through muslin cloth with many folds to separate the pulp pieces completely. Volume of the filtrate was measured by measuring cylinder and the content of juice was calculated using the formula and expressed as per cent.

$$\text{Juice content} = \frac{\text{Volume of the filtrate (ml) - Volume of distilled water used (ml)}}{\text{Weight of fruit (g)}} \times 100$$

3.2.3.18 Yield/

The yield of fruits from each plant was assessed by weighing the fruits harvested separately and expressed as kg per plant.

3.2.4 Observations on Quality attribute

The following quality attributes were analysed after the harvest of the fruit.

3.2.4.1 Moisture content

The moisture content was determined by drying a known weight of the sample at 50-60 ^{0}C to a constant weight and expressed as per cent (Ranganna, 1997).

$$\text{Moisture (\%)} = \frac{\text{Fresh weight} - \text{dry weight}}{\text{Fresh weight}} \times 100$$

3.2.4.2 Acidity

The titratable acidity was estimated by titrating a known weight/volume of the sample against 0.1N NaOH solution using phenolphthalein as an indicator for all the samples. The acidity was calculated and expressed as per cent citric acid (Ranganna, 1997).

3.2.4.3 Total Soluble Solids

TSS was recorded directly using a digital refractometer (range 0-32°brix) and expressed as degree brix (^{0} Brix).

3.2.4.4 Anthocyanin

Fully ripened fresh fruit pulp was ground to paste using a pestle and mortar. From each sample 10 g of the homogenizer was taken in a small conical flask, added 10 ml of ethanol, closed it and agitated on shaker for one hour. The mixture was centrifuged at 1800 rpm for 10 minutes and transferred 200 µl of extract to an cuvette, add 3.8ml of 1.0 M HCL, cover with parafilm and incubate at room temperature for 3h. Measure the acidified diluted extract at 520 nm by using the spectrophotometer. The total anthocyanin content was estimated as per the above procedure prescribed by Cynkar *et al.* (2009).

$$\text{Anthocyanin (mg/berry)} = \frac{520 \times \text{Dilution factor} \times \text{final extract volume} \times 1000}{500 \times 100 \times \text{homogenate weight}}$$

3.2.4.5 pH

pH of the fruit was recorded with the help of digital pH meter.

3.2.4.6 Reducing sugar

Reducing sugars were determined by adopting the method given by Lane and Eynon (Ranganna, 1997). The fruit sample was crushed in a grinder and filtered through No. 4 Whatman paper. An aliquot of 25 ml filtered juice was transferred to a 250 ml volumetric flask, mixed with distilled water and neutralized with NaOH. Solution was clarified with neutral lead acetate. Excess lead acetate was removed by adding potassium oxalate and volume was made up to 250 ml.The solution was filtered and aliquot of the filtrate was titrated against a mixture of Fehling's solution A and B using methylene blue as indicator and the reducing sugar was expressed as percentage.

$$\text{Reducing sugars (\%)} = \frac{0.05 \times \text{Volume made up} \times 100}{\text{Titre value} \times \text{Weight of the sample}}$$

3.2.4.7 Total sugar

For the estimation of total sugars, 50 ml of the clarified solution (filtrate of reducing sugars) was boiled gently after adding citric acid and water. It was neutralized using NaOH and volume made up to 250 ml. the made up solution was titrated against a

mixture of Fehling's solution A and B and total sugars was expressed as percentage (Ranganna, 1997).

$$\text{Total sugars (\%)} = \frac{\text{Titre value x 0.1 x Volume made up x 0.064 x 100}}{\text{Volume of the sample x Weight of the sample}}$$

3.2.4.8 Sensory evaluation

Appearance, colour, sweetness, taste and texture were recorded as per a 9 point hedonic scale noted below.

3.2.4.8.1. Selection of judges

A series of sensory evaluations were carried out using hedonic scale at laboratory level to select a panel of ten judges between the age group of 18-40 years as suggested by Jellinek (1985).

3.2.4.8.2. Preparation of score card

Score card including the quality attributes appearance, colour, sweetness, taste and texture was prepared for sensory evaluation of jamun. Each of the above mentioned qualities were assessed by a nine point hedonic scale. Total score was calculated separately using the average of above mentioned quality attributes. The score card used for the evaluation of fruits was given in Appendix II.

3.2.4.8.3. Organoleptic evaluation

Organoleptic evaluation of fruits was carried out using the score card by a panel of ten selected judges. Hedonic rating scale method measures the level of liking of any product based on a test which relays on the people's ability to communicate their feelings of like or dislike. Hedonic ratings were converted to rank scores and rank analysis was done by Kendall's coefficient of concordance.

3.2.5 Postharvest study

The postharvest study was observed and recorded after the harvest of the fruits.

3.2.5.1 Shelf life in days

Number of days the fruit remained at marketable good condition under room temperature was recorded.

3.2.6 Pest and disease incidence

Constant caution and monitoring of the experimental area was exercised to check the incidence of pests and diseases were observed and recorded during the study period.

3.2.7 Statistical analysis

The data pertaining to the morphological and biochemical characters were compared with Jaccard's similarity coefficients and was clustered by the Unweighed Pair Group Average Method (UPGAM) devised by Sneath and Sokal (1973) using NTsys pc 2.02 software. Similarity matrix was computed and the dendrogram was constructed accordingly. The data pertaining to organoleptic evaluation were analysed using Kendall's coefficient of concordance.

Results

4. RESULTS

The results of the study pertaining to the "Morphochemical evaluation of jamun (*Syzygium cuminii* Skeels) collections" are presented in this chapter. Fifty nine collections were collected and the results are presented under the heads, morphological characters namely tree characters, inflorescence characters, fruit characters, quality attributes and pest and disease incidence. Morphological characters were recorded based on NBPGR descriptor. Data were subjected to multivariate analysis utilizing cluster analysis using NTsys software.

4.1 Morphological characters

Various observations on morphological characters *viz.*, tree characters, inflorescence characters, fruit characters, fruit quality parameters like sensory evaluation, biochemical characters and pest and disease incidence were recorded and analysed.

4.1.1 Tree characters

The data depicting tree characters are presented in (Tables 1a and 1b). At the similarity coefficient status of 6 per cent, grouping of collections were done which resulted in 12 non-overlapping clusters. Cluster wise listing of collections according to tree characters are given in (Table 2). Cluster VIII had maximum number of collections (11) and Cluster II had the minimum number of collection (1).

4.1.2 Age of the tree

The tree age of the collections varied from 20 to 35 years. KJ- 44, KJ- 49, KJ- 50, KJ- 53, KJ- 54, KJ- 55, KJ- 56, KJ- 57, KJ- 58 and KJ- 59 recorded the highest age group of 35 years and the collections KJ- 34, KJ- 35 and KJ- 36 recorded the lowest age group of 20 years (Tables 1a and 1b). The cluster mean ranged from 20.66 ± 0.81 to 35 years. The Cluster V and VI has the highest age group of 35 years and the Cluster III recorded the lowest (20.66 ± 0.81) age group (Table 3).

4.1.3 Tree height

The tree height of the collections varied from 12 m to 20 m. KJ- 13 recorded the lowest height (12 m) and KJ- 52 and KJ- 56 recorded the highest height (20 m) (Tables 1a and 1b).

The cluster mean of tree height ranged from14.5 ± 0.71 m to 18.14 ± 1.14 m. Cluster VI (18.14 ± 1.14 m) recorded the highest tree height and the Cluster VII (14.5 ± 0.71 m) recorded the lowest tree height (Table 3).

4.1.4 Trunk girth

The trunk girth of the collections varied from 0.95 m to 4.1m. KJ- 1 recorded the highest trunk girth of 4.1m and the KJ- 10 recorded the lowest value of 0.95 m (Tables 1a and 1b).

The cluster mean value ranged from 1.46 ± 0.30 m to 2.70 ± 0.88 m. The Cluster IX has the maximum girth of 2.70 ± 0.88 m and the minimum girth of 1.46 ± 0.30 m was recorded in Cluster XI (Table 3).

4.1.5 Crown shape

Different crown shapes like pyramidal, broadly pyramidal, spherical, semi-circular and irregular shapes were noticed among the collections. Pyramidal shapes were recorded in KJ- 8, KJ- 10, KJ- 11, KJ- 12, KJ- 14, KJ- 17, KJ- 18, KJ- 19, KJ- 20, KJ- 21, KJ- 22, KJ- 23, KJ- 24, KJ- 25, KJ- 26, KJ- 27, KJ- 29, KJ- 31, KJ- 32, KJ- 38, KJ- 44, KJ- 46, KJ- 49,KJ- 50,KJ- 53, KJ- 54, KJ- 55, KJ- 56, KJ- 57, KJ- 58, and KJ- 59. Irregular crown shapes were recorded in KJ- 4, KJ- 13, KJ- 36, KJ- 43, KJ- 52 and KJ- 6 has Semicircular crown shape. Broadly pyramidal crown shapes were recorded in KJ- 1, KJ- 2, KJ- 3, KJ- 5, KJ- 7, KJ- 9, KJ- 15, KJ- 16, KJ- 28, KJ- 30, KJ- 33, KJ- 34, KJ- 35, KJ- 37, KJ- 39, KJ- 40, KJ- 41, KJ- 42, KJ- 45, KJ- 47, KJ- 48, KJ- 51 (Tables 1a and 1b).

The Cluster I and III included the broadly pyramidal and irregular crown shapes. Cluster II had the irregular crown shape. Broadly pyramidal and pyramidal

Table 1a. Tree characters of jamun collection (1 to 30)

Collection	Tree characters of collection									
	Age of the tree	Tree height (m)	Trunk girth (cm)	Crown shape	Leaf length (cm)	Leaf width (cm)	Leaf shape	Leaf colour	Shoot length (cm)	Internodal length (cm)
KJ- 1	24	18	4.1	Broadly pyramidal	14.4	4.8	Lanceolate	Dark green	17	8.2
KJ- 2	24	14	2.25	Broadly pyramidal	10.2	6.1	Broadly ovate	Dark green	16	9.6
KJ- 3	24	15	2.1	Broadly pyramidal	9.1	4.7	Broadly ovate	Dark green	24	8.5
KJ- 4	24	17	1.72	Irregular	12.9	4.9	Lanceolate	Dark green	20	11.0
KJ- 5	24	16	2.65	Broadly pyramidal	11.5	5.4	Broadly ovate	Dark green	15	8.4
KJ- 6	24	19	2.8	Semicircular	16	5.7	Lanceolate	Dark green	16	8.8
KJ- 7	24	18	2.2	Broadly pyramidal	15.5	4.5	Lanceolate	Dark green	26	9.8
KJ- 8	24	14	1.4	Pyramidal	13.4	3.9	Lanceolate	Dark green	18	8.1
KJ- 9	24	15	2.61	Broadly pyramidal	15.5	4.9	Lanceolate	Dark green	11	9.5
KJ- 10	24	16	0.95	Pyramidal	9.1	4	Broadly ovate	Dark green	14	8.0
KJ- 11	24	15	1.36	Pyramidal	11.6	4.6	Lanceolate	Dark green	10	9.3
KJ- 12	24	15	1.46	Pyramidal	14.6	6.5	Broadly ovate	Dark green	18	9.2
KJ- 13	24	12	1.82	Irregular	15.5	4.4	Lanceolate	Dark green	13	8.3
KJ- 14	24	15	1.32	Pyramidal	15.9	6.2	Lanceolate	Dark green	18	9.3
KJ- 15	24	14	1.47	Broadly pyramidal	13.4	5.7	Lanceolate	Dark green	11	9.2
KJ- 16	24	18	1.62	Broadly pyramidal	15.3	4.8	Lanceolate	Dark green	13	9.6
KJ- 17	24	16	1.34	Pyramidal	10.1	4.6	Broadly ovate	Dark green	10	8.6
KJ- 18	24	13	1.23	Pyramidal	11.2	6.2	Broadly ovate	Dark green	8	7.8
KJ- 19	24	14	1.21	Pyramidal	17	6.1	Broadly ovate	Dark green	18	8.9
KJ- 20	24	17	1.8	Pyramidal	14.5	5.5	Lanceolate	Dark green	7	8.7
KJ- 21	24	15	1.95	Pyramidal	16.8	4.6	Lanceolate	Dark green	16	7.7
KJ- 22	24	18	1.81	Pyramidal	11.9	5.2	Broadly ovate	Dark green	15	8.4
KJ- 23	24	17	4.0	Pyramidal	14.4	5.4	Broadly ovate	Dark green	11	8.2
KJ- 24	24	15	1.31	Pyramidal	12.2	5.2	Broadly ovate	Dark green	19	9.0
KJ- 25	24	14	1.9	Pyramidal	12.9	4.9	Lanceolate	Dark green	10	8.4
KJ- 26	24	13	1.8	Pyramidal	12.4	5.3	Broadly ovate	Dark green	20	9.7
KJ- 27	24	16	2.41	Pyramidal	14.9	5.3	Lanccolate	Dark green	11	9.1
KJ- 28	24	15	1.9	Broadly pyramidal	13.2	5.2	Lanceolate	Dark green	13	7.9
KJ- 29	24	14	1.65	Pyramidal	12.7	5.2	Lanceolate	Dark green	20	8.5
KJ- 30	24	17	1.55	Broadly pyramidal	13.6	6.1	Lanceolate	Dark green	18	10

Table 1b.Tree characters of jamun collection (31 to 59)

Collection	Tree characters of collection (31 to 59)									
	Age of the tree	Tree height (m)	Trunk girth (cm)	Crown shape	Leaf length (cm)	Leaf width (cm)	Leaf shape	Leaf colour	Shoot length (cm)	Internodal length (cm)
KJ-31	24	19	1.0	Pyramidal	13	5.1	Lanceolate	Dark green	17	9.3
KJ-32	24	15	1.22	Pyramidal	13.1	4.3	Lanceolate	Dark green	14	8.2
KJ-33	21	16	1.74	Broadly pyramidal	15	5.7	Broadly ovate	Dark green	21	9.6
KJ-34	20	17	1.84	Broadly pyramidal	11.8	5.1	Lanceolate	Dark green	22	10.6
KJ-35	20	18	1.9	Broadly pyramidal	16.1	5.4	Lanceolate	Dark green	20	9.2
KJ-36	20	19	2	Irregular	15.5	5.4	Lanceolate	Dark green	23	10.7
KJ-37	21	14	2.26	Broadly pyramidal	14.9	3.9	Lanceolate	Dark green	22	9.9
KJ-38	23	15	1.84	Pyramidal	12.7	4.5	Lanceolate	Dark green	16	9.4
KJ-39	22	16	2.41	Broadly pyramidal	12.5	4.3	Lanceolate	Dark green	22	10.5
KJ-40	22	19	1.3	Broadly pyramidal	15.1	5.4	Lanceolate	Dark green	11	8.6
KJ-41	22	14	1.18	Broadly pyramidal	17.5	4.9	Lanceolate	Dark green	14	8.8
KJ-42	22	16	1.24	Broadly pyramidal	14.3	4.4	Lanceolate	Dark green	15	9.2
KJ-43	30	15	1.59	Irregular	14.1	6.1	Broadly ovate	Dark green	25	10.8
KJ-44	35	17	1.76	Pyramidal	16.1	5.1	Lanceolate	Dark green	13	9
KJ-45	25	16	1.96	Broadly pyramidal	15.9	4.8	Lanceolate	Dark green	20	9.6
KJ-46	22	18	1.81	Pyramidal	14.5	5.6	Lanceolate	Dark green	12	8.4
KJ-47	24	14	2.01	Broadly pyramidal	15.1	5.4	Lanceolate	Dark green	21	11.2
KJ-48	24	16	2.21	Broadly pyramidal	16.2	5.3	Lanceolate	Dark green	22	10.9
KJ-49	35	15	1.65	Pyramidal	15.7	5.2	Lanceolate	Dark green	13	8.7
KJ-50	35	18	1.47	Pyramidal	16.8	5.1	Lanceolate	Dark green	14	9.1
KJ-51	22	17	2.34	Broadly pyramidal	11.5	4.8	Lanceolate	Dark green	23	12.2
KJ-52	22	20	2.0	Irregular	15.1	6.1	Broadly ovate	Dark green	26	10.4
KJ-53	35	17.5	1.81	Pyramidal	12.1	2.3	Broadly ovate	Dark green	11	9.3
KJ-54	35	16.5	2.1	Pyramidal	12.8	3.6	Lanceolate	Dark green	13	8.5
KJ-55	35	18.5	1.84	Pyramidal	12.9	4.7	Lanceolate	Dark green	10	9.3
KJ-56	35	20	1.75	Pyramidal	10.2	4.8	Broadly ovate	Dark green	14	9.2
KJ-57	35	19	2.0	Pyramidal	16.3	4.1	Lanceolate	Dark green	12	8.4
KJ-58	35	17.5	2.45	Pyramidal	12.2	5.2	Broadly ovate	Dark green	11	8.6
KJ-59	35	18	1.71	Pyramidal	12.4	4.6	Lanceolate	Dark green	12	9.4

Fig 1. Dendrogram of tree character

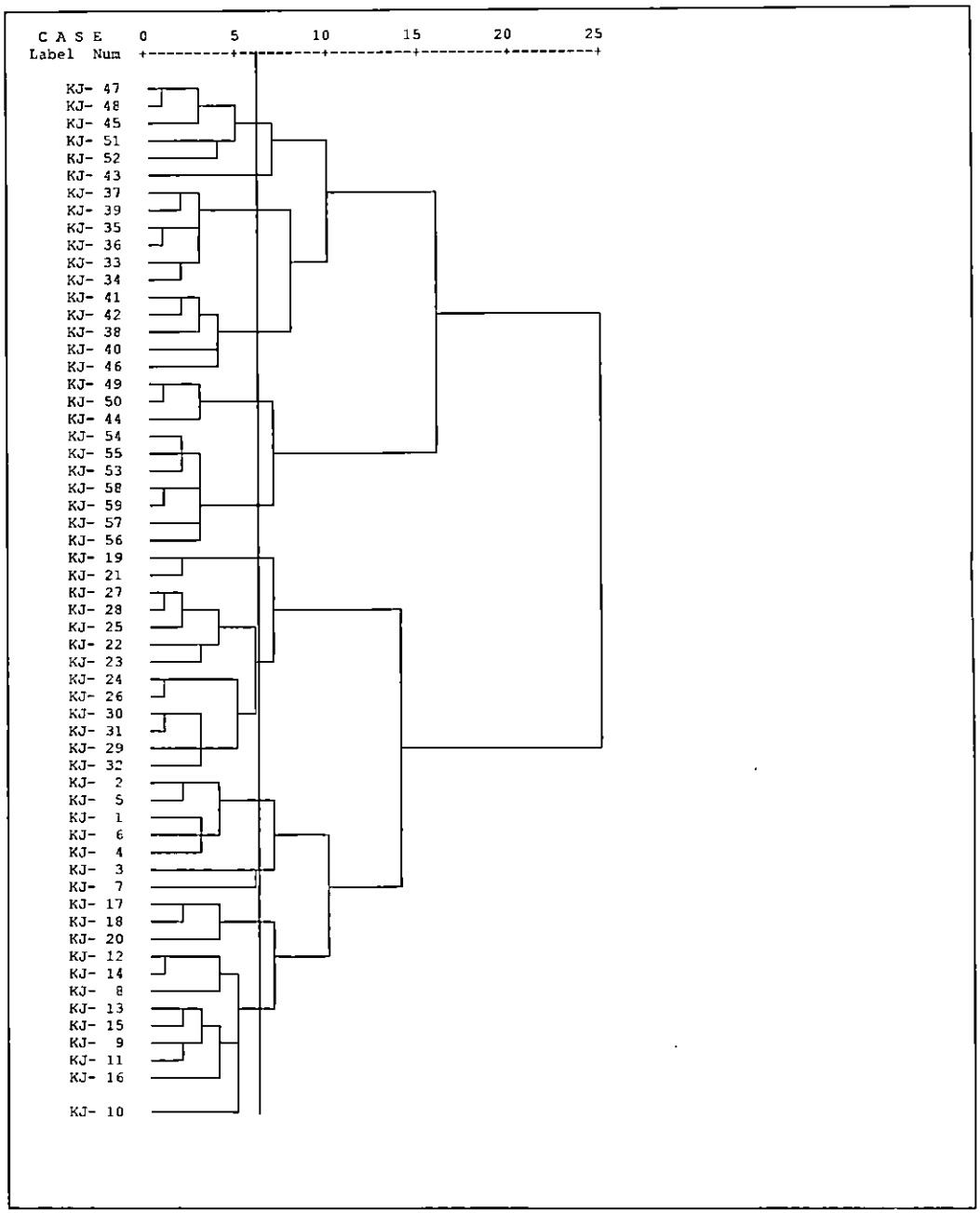


Table 2. Cluster wise listing of collection according to tree characters

Clusters											
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
KJ- 47	KJ- 43	KJ- 37	KJ- 46	KJ- 49	KJ- 57	KJ- 19	KJ- 27	KJ- 2	KJ- 3	KJ- 17	KJ- 13
KJ- 48		KJ- 39	KJ- 41	KJ- 50	KJ- 59	KJ- 21	KJ- 28	KJ- 5	KJ- 7	KJ- 18	KJ- 15
KJ- 45		KJ- 35	KJ- 42	KJ- 44	KJ- 54		KJ- 25	KJ- 4		KJ- 20	KJ- 11
KJ- 52		KJ- 36	KJ- 40		KJ- 55		KJ- 22	KJ- 6			KJ- 16
KJ- 51		KJ- 33	KJ- 38		KJ- 56		KJ- 23	KJ- 1			KJ- 9
		KJ- 34			KJ- 58		KJ- 24				KJ- 10
					KJ- 53		KJ- 26				KJ- 12
							KJ- 30				KJ- 14
							KJ- 31				KJ- 8
							KJ- 29				
							KJ- 32				

Table 3. Cluster wise summary statistics of tree characters

Characters	Clusters											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Age of the tree	23.4 ± 1.34	30	20.66 ± 0.81	22.2 ± 0.44	35	35	24	24	24	24	24	24
Tree height (m)	16.6 ± 2.19	15	16.66 ± 1.75	16.4 ± 2.07	16.66 ± 1.52	18.14 ± 1.14	14.5 ± 0.71	15.72 ± 1.84	16.8 ± 1.92	16.5 ± 2.12	15.33 ± 2.08	14.88 ± 1.61
Trunk girth (cm)	2.10 ± 0.16	1.59	2.02 ± 0.25	1.47 ± 0.32	1.62 ± 0.14	1.95 ± 0.25	1.58 ± 0.52	1.86 ± 0.80	2.70 ± 0.88	2.15 ± 0.07	1.46 ± 0.30	1.55 ± 0.45
Crown shape	Broadly pyramidal, Irregular	Irregular	Broadly pyramidal, Irregular	Broadly pyramidal, Pyramidal	Pyramidal	Pyramidal	Pyramidal	Broadly pyramidal, Pyramidal	Broadly pyramidal, Irregular, Semi circular	Broadly pyramidal	Pyramidal	Irregular, Pyramidal, Broadly pyramidal
Leaf length (cm)	14.76 ± 1.88	14.1	14.3 ± 1.73	14.82 ± 1.74	16.2 ± 0.55	12.7 ± 1.82	16.9 ± 0.14	13.11 ± 0.90	13 ± 2.29	12.3 ± 4.52	11.93 ±2.29	13.81 ± 2.24
Leaf width (cm)	5.28 ± 0.53	6.1	4.96 ± 0.70	4.96 ± 0.53	5.13 ± 0.05	4.18 ± 0.98	5.35 ± 1.06	5.2 ± 0.42	5.38 ± 1.64	4.6 ± 0.14	5.43 ±0.80	5 ± 0.93
Leaf shape	Broadly ovate, Lanceolate	Broadly ovate	Broadly ovate, Lanceolate	Lanceolate	Lanceolate	Broadly ovate, Lanceolate	Broadly ovate, Lanceolate	Broadly ovate, Lanceolate	Broadly ovate, Lanceolate	Broadly ovate, Lanceolate	Broadly ovate, Lanceolate	Broadly ovate, Lanceolate
Leaf colour	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green
Shoot length (cm)	22.4 ± 2.30	25	21.66 ± 1.03	13.6 ± 2.07	13.33 ± 0.57	11.8 ± 1.34	17 ± 1.41	15.27 ± 3.74	16.8 ± 1.92	25 ± 1.41	8.33 ±1.52	14 ± 3.24
Internodal length (cm)	10.86 ± 0.96	10.8	10.08 ± 0.61	8.88 ± 0.41	8.93 ± 0.20	8.96 ± 0.43	8.3 ± 0.85	8.79 ± 0.67	9.2 ± 1.14	9.15 ± 0.91	8.36 ±0.49	8.94 ± 0.62

crown shapes were noticed in the Cluster IV and VIII. Cluster V, VI, VII and XI had the pyramidal crown shape while the Cluster X had the broadly pyramidal crown shape. Broadly pyramidal, irregular and semi circular crown shapes were seen in Cluster IX and the Cluster XII had irregular, pyramidal and broadly pyramidal crown shapes (Table 3).

4.1.6 Leaf length

The leaf length of the collections varied from 9.1 cm to 17.5 cm. KJ- 41 recorded the maximum leaf length of 17.5 cm and the KJ- 3 and KJ- 10 recorded the minimum leaf length of 9.1 cm (Tables 1a and 1b).

The cluster mean ranged from 11.93 ±2.29 cm to 16.9 ± 0.14 cm. The Cluster VII recorded the highest mean value of 16.9 ± 0.14 cm and the Cluster XI recorded the lowest mean value of 11.93 ±2.29 cm (Table 3).

4.1.7 Leaf width

The leaf width of the collections varied from 2.3 cm to 6.5 cm. KJ- 12 recorded the highest mean value of 6.5 cm and the KJ- 53 recorded the lowest value of 2.3 cm (Tables 1a and 1b).

The cluster mean value ranged 4.18 ± 0.98 cm to 6.1 cm. Cluster II recorded the highest mean value of 6.1cm and the Cluster VI recorded the lowest value of 4.18 ± 0.98 cm (Table 3).

4.1.8 Leaf shape

Broadly ovate and lanceolate types of leaf shapes were noticed among the collections. Majority of the collections has lanceolate leaf shape and the KJ- 2, KJ- 3, KJ- 5, KJ- 10, KJ- 12, KJ- 17, KJ- 18, KJ- 19, KJ- 22, KJ- 23, KJ- 24, KJ- 26, KJ- 33, KJ- 43, KJ- 52, KJ- 53, KJ- 56 and KJ- 58 recorded the broadly ovate shape (Tables 1a and 1b).

Plate 2. Transition from bud to flower development

Bud emergence

Bud development

Blooming of flowers

At the time of pollination

After pollination

Fruit set stage

Results showed that the Cluster I, III, VI, VII, VIII, IX, X, XI and XII included both broadly ovate and lanceolate leaf shapes. Cluster IV and V had the lanceolate leaf shape whereas the Cluster II had broadly ovate leaf shape (Table 3).

4.1.9 Leaf colour

All the collections have dark green colour leaves (Tables 1a and 1b).

4.1.10 Shoot length

The shoot length of the collections varied from 7 cm to 26 cm. KJ- 7 and KJ-52 recorded the highest shoot length of 26 cm and the KJ- 20 recorded the lowest value of 7 cm (Tables 1a and 1b).

Wide variability observed in the cluster mean value ranged from 8.33 ±1.52 cm to 25 ± 1.41 cm. Cluster X (25 ± 1.41 cm) recorded the highest shoot length and the Cluster XI (8.33 ±1.52 cm) recorded the lowest mean values (Table 3).

4.1.11 Internodal length

The internodal length of the collections varied from 7.7 cm to 12.2 cm. KJ-51 recorded the highest value of 12.2 cm and the KJ- 21 recorded the lowest value of 7.7 cm (Tables 1a and 1b).

The cluster mean value ranged from 8.3 ± 0.85 cm to 10.86 ± 0.96 cm. The Cluster VII recorded lowest value of 8.3 ± 0.85 cm and the Cluster I recorded the highest value of 10.86 ± 0.96 cm (Table 3).

4.2 Observations on Inflorescence character

The data depicting the inflorescence characters are presented in (Table 4).

4.2.1 Position of inflorescence

Axillary position of inflorescence was observed in all the collections (Table 4).

Table 4. Inflorescence character of jamun collection

Collection	Flower characters of collection				
	Position of inflorescence	Flower composition in the inflorescence	Flower colour	Flowering season	Duration of flowering (days)
KJ- 7	Axillary	Cluster	White	December	35
KJ- 19	Axillary	Solitary	White	January	27
KJ- 24	Axillary	Cluster	White	January	28
KJ- 26	Axillary	Solitary, cluster	White	January	26
KJ- 33	Axillary	Cluster	White	December	34
KJ- 34	Axillary	Cluster	White	December	32
KJ- 35	Axillary	Cluster	White	December	33
KJ- 36	Axillary	Cluster	White	December	33
KJ- 37	Axillary	Cluster	White	December	33
KJ- 39	Axillary	Cluster	White	December	30
KJ- 43	Axillary	Cluster	White	January	37
KJ- 45	Axillary	Cluster	White	December	42
KJ- 46	Axillary	Solitary	White	December	36
KJ- 47	Axillary	Cluster	White	December	36
KJ- 48	Axillary	Cluster	White	December	37
KJ- 51	Axillary	Solitary	White	December	28
KJ- 52	Axillary	Cluster	White	December	34

4.2.2 Flower composition in the inflorescence

Two types of flower composition were observed among the collections namely solitary and cluster. Majority of the collections had cluster composition. KJ- 7, KJ- 24, KJ- 33, KJ- 34, KJ- 35, KJ- 36, KJ- 37, KJ- 39, KJ- 43, KJ- 45, KJ- 47, KJ- 48 and KJ- 52 recorded the cluster composition. KJ- 19, KJ- 46 and KJ- 51 recorded the solitary composition and KJ- 26 recorded both the solitary and cluster composition of inflorescence (Table 4).

4.2.3 Flower colour

In all the collections white colour flowers were observed (Table 4).

4.2.4 Flowering season

Flowering was observed in December and January. KJ- 19, KJ- 24, KJ- 26 and KJ- 43 recorded flowering in the month of January and the KJ- 7, KJ- 33, KJ- 34, KJ- 35, KJ- 36, KJ- 37, KJ- 39, KJ- 45, KJ- 46, KJ- 47, KJ- 48, KJ- 51 and KJ- 52 recorded flowering in the month of December (Table 4).

4.2.5 Duration of flowering

The duration of flowering varied from 26 days to 42 days. KJ- 26 recorded the lowest duration of flowering (26 days) and KJ- 45 recorded the highest duration of flowering (42 days) as given in Table 4.

4.3 Fruit character

Various observations on fruit characters are presented in Tables 5a and 5b. At the similarity coefficient status of 40 per cent, grouping of collections were done which resulted in 5 non-overlapping clusters.

Table 5a. Fruit characters of jamun collection

Collection	Fruit characters of collection								
	KJ- 7	KJ- 19	KJ- 24	KJ- 26	KJ- 33	KJ- 34	KJ- 35	KJ- 36	KJ- 37
Fruiting season	March - April	April - May	April - May	April - May	March - April	March - April	April - May	March - April	March - April
Days from flowering to fruit maturity	64	67	68	67	64	64	66	64	65
Days from fruit set to maturity	60	63	64	62	60	60	61	60	61
Fruit clustering habit	Cluster	Solitary	Solitary	Solitary	Cluster	Cluster	Cluster	Cluster	Solitary
Fruit weight (g)	9.43	6.92	8.56	5.91	9.18	8.12	8.72	8.47	7.3
Fruit volume (cc)	9.1	7.0	9.0	6.0	8.2	7.5	8.0	7.9	7.7
Number of fruits per cluster	8.0	3.0	4.0	3.0	7.0	6.0	5.0	6.0	4.0
Specific gravity	1.03	0.98	0.95	0.98	1.11	1.08	1.09	1.07	0.94
Overall length of fruits (cm)	2.21	1.98	2.25	1.85	2.14	2.5	2.44	2.32	2.03
Maximum width (cm)	2.14	2.01	2.07	1.9	2.09	2.18	2.11	2.02	1.96
Fruit shape	Oblong	Oblong	Oblong	Oblong	Oblong	Oblong	Oblong	Oblong	Oblong
Firmness/Softness (kg cm^{-2})	8.19	4.68	5.85	5.26	7.31	6.14	5.56	6.43	4.38
Colour	Blackish purple	Blackish purple	Blackish purple	Blackish purple	Blackish purple	Blackish purple	Blackish purple	Blackish purple	Blackish purple
Pulp (%)	87.27	78.9	79.08	81.55	80.06	85.59	83.94	84.41	80.13
Seed (%)	12.72	21.09	20.91	18.44	19.93	14.4	16.05	15.58	19.86
Pulp/seed ratio	6.86	3.24	3.78	4.42	4.01	5.94	5.22	5.41	4.03
Juice content (%)	24	16	24	18	22	24	20	18	16
Yield/ tree (kg)	41.6	10	15	14.5	29	30.25	33.5	35	25.6

Table 5b. Fruit characters of jamun collection

Collection	Fruit characters of collections							
	KJ- 39	KJ- 43	KJ- 45	KJ- 46	KJ- 47	KJ- 48	KJ- 51	KJ- 52
Fruiting season	Mar-Apr	Apr-May	Mar-Apr	Apr-May	Mar-Apr	Mar-Apr	Mar-Apr	Mar-Apr
Days from flowering to fruit maturity	64	64	62	67	64	63	67	64
Days from fruit set to maturity	60	60	58	63	60	59	63	60
Fruit clustering habit	Cluster	Cluster	Cluster	Solitary	Cluster	Cluster	Solitary	Cluster
Fruit weight (g)	10.12	8.98	12.28	7.11	10	10.31	6.58	9.66
Fruit volume (cc)	9.3	8.0	11.4	7.8	8.9	9.5	5.32	8.5
Number of fruits per cluster	8.0	8.0	12.0	5.0	9.0	10	7.0	6.0
Specific gravity	1.08	1.12	1.07	0.91	1.12	1.08	1.23	1.13
Overall length of fruits (cm)	2.5	2.16	3.1	2.09	2.81	2.96	1.61	2.19
Maximum width (cm)	2.08	2.11	2.41	2.0	2.06	2.1	1.24	2.13
Fruit shape	Oblong	Oblong	Oblong	Oblong	Oblong	Oblong	Oblong	Oblong
Firmness/Softness (kg/cm^2)	8.48	7.6	9.94	5.26	7.9	7.02	4.09	6.73
Colour	Blackish purple	Blackish purple	Blackish purple	Blackish purple	Blackish purple	Blackish purple	Blackish purple	Blackish purple
Pulp (%)	88.14	77.5	90.39	83.12	84.9	87.87	80.85	83.02
Seed (%)	11.85	22.49	9.6	16.87	15.1	12.12	19.14	16.97
Pulp/seed ratio	7.43	5.0	9.41	4.92	5.62	7.25	4.22	4.89
Juice content (%)	32	30	44	18	26	38	14	30
yield/ tree	36.1	40.5	54	11	46.5	48.2	12	35

Fig 2. Dendrogram of fruit character

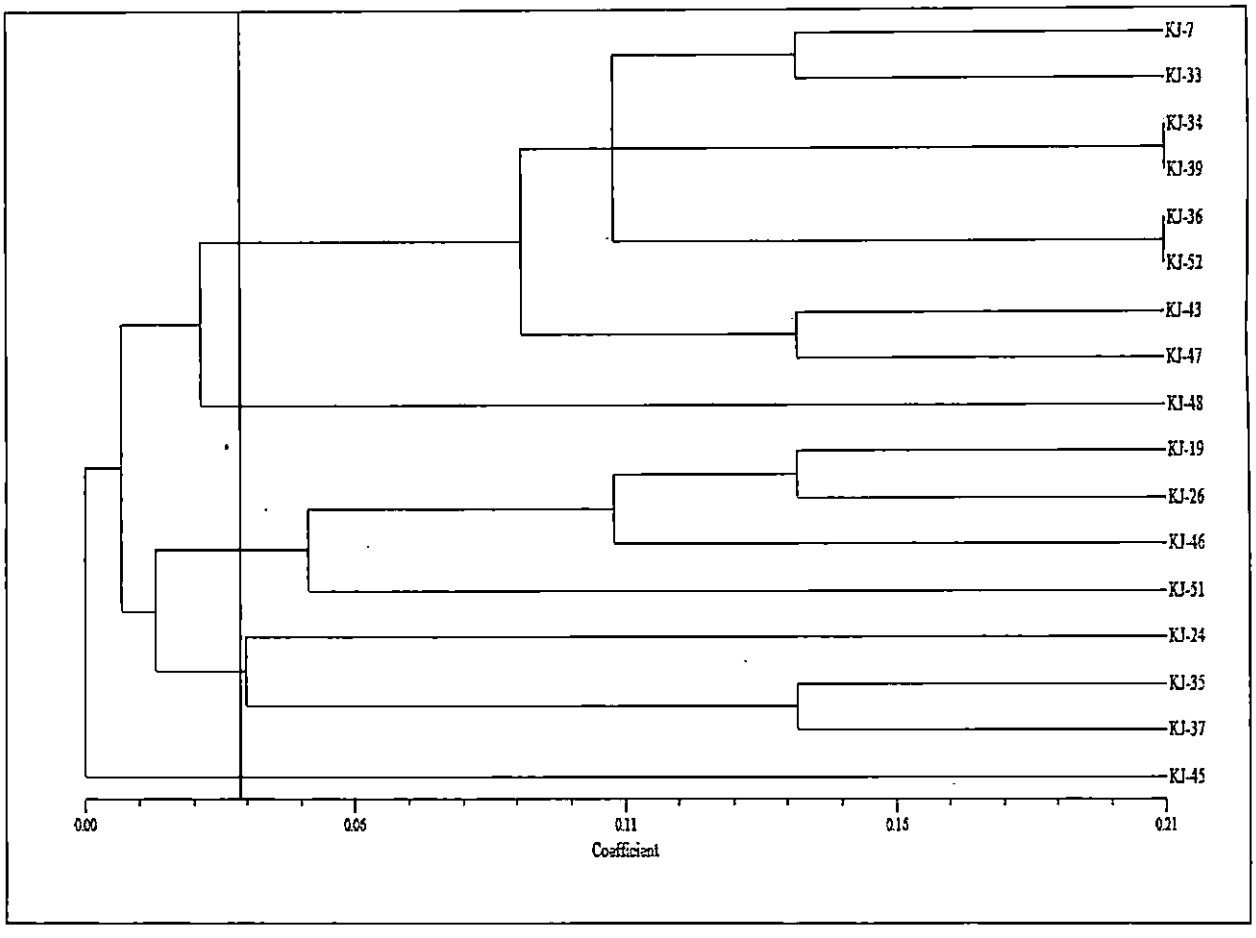


Table 6. Cluster wise listing of collection according to fruit characters

Clusters	List of collection
I	KJ- 7, KJ- 33, KJ- 34, KJ- 36, KJ- 39, KJ- 43, KJ- 47, KJ- 52
II	KJ- 48
III	KJ- 19, KJ- 26, KJ- 46, KJ- 51
IV	KJ- 24, KJ- 35, KJ- 37
V	KJ- 45

Table 7. Cluster wise summary statistics of fruit characters

Characters	Clusters				
	I	II	III	IV	V
Fruiting season	Mar-Apr, Apr-May	Mar-Apr	Mar-Apr, Apr-May	Mar-Apr, Apr-May	Mar-Apr
Days from flowering to fruit maturity	64	63	67	66.33 ± 1.52	62
Days from fruit set to maturity	60	59	62.75 ± 0.5	62 ± 1.73	58
Fruit clustering habit	Cluster	Cluster	Solitary	Cluster, Solitary	Cluster
Fruit weight (g)	9.24 ± 1.33	10.31	6.63 ± 0.52	8.19 ± 0.77	12.28
Fruit volume (cc)	8.42 ± 1.79	9.5	6.53 ± 1.09	8.23 ± 0.68	11.4
Number of fruits per cluster	7.25 ± 1.16	10	4.5 ± 1.91	4.33 ± 0.57	12
Specific gravity	1.09 ± 0.03	1.08	1.02 ± 0.14	0.99 ± 0.08	1.07
Overall length of fruits (cm)	2.35 ± 0.23	2.96	1.88 ± 0.20	2.24 ± 0.20	3.1
Maximum width (cm)	2.10 ± 0.04	2.1	1.78 ± 0.36	2.04 ± 0.07	2.41
Fruit shape	Oblong	Oblong	Oblong	Oblong	Oblong
Firmness/Softness (kg cm^{-2})	7.34 ± 0.84	7.02	4.82 ± 0.55	5.26 ± 0.77	9.94
Colour	Blackish purple	Blackish purple	Blackish purple	Blackish purple	Blackish purple
Pulp (%)	83.86 ± 3.58	87.87	81.10 ± 1.74	81.05 ± 2.55	90.39
Seed (%)	16.13 ± 3.58	12.12	18.88 ± 1.74	18.94 ± 2.55	9.6
Pulp/seed ratio	5.64 ± 1.09	7.25	4.20 ± 0.70	4.34 ± 0.76	9.41
Juice content (%)	25.75 ± 4.71	38	16.5 ± 1.91	20 ± 4	44
yield/ tree (kg)	36.5 ± 5.68	48	11.75 ± 1.70	24.33 ± 9.01	54

Cluster wise listing of collections according to fruit characters were listed in Table 6. Cluster I had maximum number of collections (8) and Cluster II and V had the minimum number of collection (1).

4.3.1 Fruiting season

Fruiting was observed in March-April and April-May. KJ- 7, KJ- 33, KJ- 34, KJ- 36, KJ- 37, KJ- 39, KJ- 45, KJ- 47, KJ- 48, KJ- 51 and KJ- 52, were fruited during March-April and KJ- 19, KJ- 24, KJ- 26, KJ- 35, KJ- 43 and KJ- 46 were fruited during April-May (Tables 5a and 5b).

Clusters I, III, and IV started fruiting during the month of March - April and April- May. Clusters II and V started fruiting during the month of March - April (Table 7).

4.3.2 Days from flowering to fruit maturity

The number of days taken from flowering to maturity varied from 62 days to 68 days. The lowest days from flowering to fruit maturity (62 days) was observed in KJ- 45 and highest days (68 days) observed in KJ- 24 (Tables 5a and 5b).

The cluster mean for days from flowering to fruit maturity ranged from 62 days to 67 days. Cluster V recorded the minimum days (62 days) and Cluster III recorded the maximum days (67days) for flowering to fruit maturity (Table 7).

4.3.3 Days from fruit set to maturity

The number of days taken from fruit set to maturity varied from 58 days to 64 days. The lowest days from fruit set to fruit maturity (58 days) was observed in KJ- 45 and highest days (64 days) observed in KJ- 24 (Tables 5a and 5b).

The cluster mean for days from fruit set to fruit maturity ranged from 58 days to 62.75 ± 0.5 days. Cluster V recorded the minimum days (58 days) and Cluster

Plate 3. Stages of fruit set development








III recorded the maximum days (62.75 ± 0.5 days) for fruit set to fruit maturity (Table 7).

4.3.4 Fruit clustering habit

Two types of fruit clustering habits were observed among the collections namely solitary and cluster. KJ- 7, KJ- 33, KJ- 34, KJ- 35, KJ- 36, KJ- 39, KJ- 43, KJ- 45, KJ- 47, KJ- 48 and KJ- 52 recorded the cluster bearing habit and KJ- 19, KJ-24, KJ- 26, KJ- 37, KJ- 46 and KJ- 51 recorded the solitary bearing habit (Tables 5a and 5b).

Clusters I, II and V had the cluster fruit bearing habit. Clusters III had the solitary fruit bearing habit and Cluster IV had both cluster and solitary fruit bearing habit (Table 7).

4.3.5 Fruit weight

The fruit weight of the collections varied from 5.91 g to 12.28 g. KJ- 45 recorded the highest fruit weight of 12.28 g and KJ- 26 recorded the lowest fruit weight of 5.91 g (Tables 5a and 5b).

The cluster mean for the fruit weight ranged from 6.63 ± 0.52 g to 12.28 g. The highest cluster mean value for fruit weight was recorded in Cluster V (12.28 g) and the lowest cluster mean value of 6.63 ± 0.52 g was recorded in Cluster III (Table 7).

4.3.6 Fruit volume

The fruit volume of the collections varied from 5.32 cc to 11.40 cc. The highest fruit volume of 11.40 cc was recorded in KJ- 45 and the lowest (5.32 cc) in KJ- 51 (Tables 5a and 5b).

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Plate 4. Different stages of fruit development

The cluster mean value for fruit volume ranged from 6.53 ± 1.09 cc to 11.40 cc. The highest mean value of 6.53 ± 1.09 cc was recorded in Cluster V and the lowest cluster mean value of 11.40 cc was recorded in Cluster III (Table 7).

4.3.7 Number of fruits per cluster

The number of fruits per cluster varied among the collections. The highest number of fruits per cluster (12) was recorded in KJ- 45 and the lowest number of fruits per cluster (3) recorded in KJ- 19 and KJ- 26 (Tables 5a and 5b).

The cluster mean for number of fruits per cluster ranged from 4.33 ± 0.57 to 12. The Cluster V recorded the highest mean value of 12 and the Cluster IV recorded the lowest mean value of 4.33 ± 0.57(Table 7).

4.3.8 Specific gravity

The highest specific gravity (1.23) was recorded in KJ- 51 and the lowest (0.91) in KJ- 46 (Tables 5a and 5b).

Mean specific gravity varied among different clusters. Highest specific gravity (1.09 ± 0.03) was observed in Cluster I and lowest (0.99 ± 0.08) in Cluster IV (Table 7).

4.3.9 Overall length of fruits

Overall length of the fruit varied from 1.61cm to 3.10 cm. Highest fruit length (3.10 cm) was recorded in KJ- 45 and the lowest fruit length (1.61cm) was recorded in KJ- 51 (Tables 5a and 5b).

The cluster mean for the fruit length ranged from 1.88 ± 0.20 cm to 3.10 cm. The highest cluster mean value (3.10 cm) recorded in Cluster V and the lowest cluster mean value (1.88 ± 0.20 cm) recorded in Cluster III (Table 7).

4.3.10 Maximum width

Width of the fruit varied from 1.24 cm to 2.41 cm. Highest fruit length (1.24 cm) was recorded in KJ- 45 and the lowest fruit length (2.41cm) was recorded KJ- 51 (Tables 5a and 5b).

Among the clusters, mean value for fruit width ranged from 1.78 ± 0.36 cm to 2.41 cm. The highest cluster mean value (2.41 cm) for width was recorded in Cluster V and lowest (1.78 ± 0.36 cm) in Cluster III (Table 7).

4.3.11 Fruit shape

Oblong fruit shape was observed in all the collections (Tables 5a and 5b).

4.3.12 Firmness/Softness

The firmness/softness of the fruit varied from 4.09 kg cm^{-2} to 9.94 kg cm^{-2}. Highest firmness of the fruit (9.94 kg cm^{-2}) was observed in KJ- 45 and the lowest (4.09 kg cm^{-2}) in KJ- 51(Tables 5a and 5b).

The cluster mean of firmness/ softness ranged from 4.82 ± 0.55 kg cm^{-2} to 9.94 kg cm^{-2}. The highest cluster mean value (9.94 kg cm^{-2}) was recorded in Cluster V and lowest (4.82 ± 0.55 kg cm^{-2}) in Cluster III (Table 7).

4.3.12 Colour

All the fruits were in blackish purple in colour (Tables 5a and 5b).

4.3.13 Pulp content

The pulp content of the fruit varied from 90.39 per cent to 77.50 per cent. Highest pulp content of the fruit (90.39 per cent) was observed in KJ- 45 and the lowest pulp content of (77.50 per cent) in KJ- 43 (Tables 5a and 5b).

Plate 5a. Fruit of jamun collection

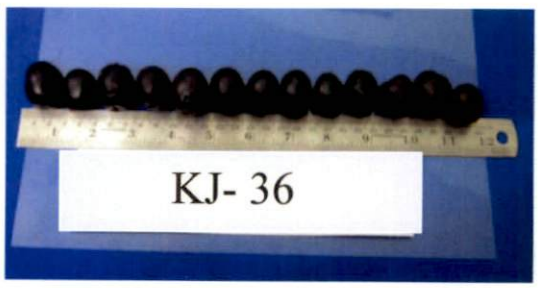
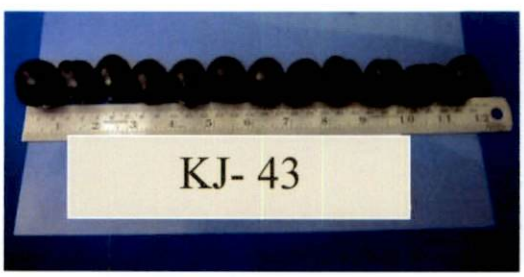


Plate 5b. Fruit of jamun collection



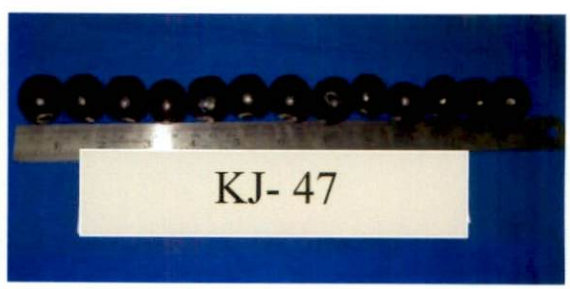


Plate 5c. Fruit of jamun collection

The cluster mean value of pulp content ranged from 81.05 ± 2.55 per cent to 90.39 per cent. The highest cluster mean value (90.39 per cent) was recorded in Cluster V and lowest (81.05 ± 2.55 per cent) in Cluster IV (Table 7).

4.3.14 Seed content

The seed content of the fruit varied from 22.49 per cent to 9.60 per cent. Highest seed content of the fruit (22.49 per cent) was observed in KJ- 43 and the lowest seed content of (9.60 per cent) in KJ- 45 (Tables 5a and 5b).

The cluster mean value of seed content ranged from 9.60 per cent to 18.94 ± 2.55 per cent. The highest cluster mean value (18.94 ± 2.55 per cent) was recorded in Cluster IV and lowest (9.60 per cent) in Cluster V (Table 7).

4.3.15 Pulp/seed ratio

The pulp/seed ratio of the fruit varied from 3.24 to 9.41. Highest pulp/seed ratio (9.41) recorded in KJ- 45 and lowest pulp/seed ratio (3.24) recorded in KJ- 19 (Tables 5a and 5b).

The cluster mean value of pulp/seed ratio ranged from 4.20 ± 0.70 to 9.41. The highest cluster mean value (9.41) recorded in Cluster V and the lowest cluster mean value (4.20 ± 0.70) in Cluster III (Table 7).

4.3.16 Juice content

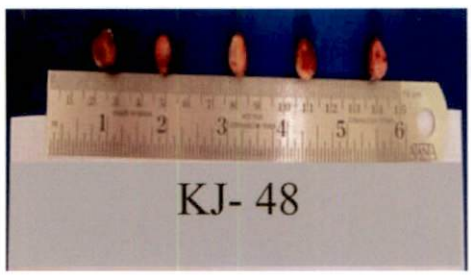
The juice content of the fruit varied from 14 per cent to 44 per cent. Highest juice content (44 per cent) recorded in KJ- 45 and lowest juice content (3.24 per cent) recorded in KJ- 51 (Tables 5a and 5b).

The cluster mean of the value of juice content ranged from 16.5± 1.91 per cent to 44 per cent. The highest cluster mean value recorded (44 per cent) in Cluster V and lowest cluster mean value (16.5 ± 1.91 per cent) recorded in Cluster III (Table 7).

Plate 6a. Seed of jamun collection

Plate 6b. Seed of jamun collection

Plate 6c. Seed of jamun collection



4.3.17 Yield

The yield per tree varied from 10 kg plant^{-1} to 54 kg plant^{-1}. Highest yield of 54 kg plant^{-1} was recorded in KJ- 45 and the lowest yield (10 kg plant^{-1}) in KJ- 19 (Tables 5a and 5b).

The cluster mean of yield per tree ranged from 11.75 ± 1.70 kg plant^{-1} to 54 kg plant^{-1}. The highest cluster mean value (54 kg plant^{-1}) was recorded in Cluster V and lowest yield (11.75 ± 1.70 kg plant^{-1}) in Cluster III (Table 7).

4.4 Quality attributes

The quality attributes of the collections are presented in Table 8. At the similarity coefficient status of 7 per cent, grouping of accessions was done which resulted in 12 non-overlapping clusters. Cluster wise listing of collections according to quality characters are listed in Table 9. Cluster IX had the maximum number of collections (3) and Clusters I, III, IV, V, VII, VIII, X and XI had the minimum number of collection (1).

4.4.17 Moisture content

Moisture content of the fruits varied from 65 per cent to 82.50 per cent. The lowest moisture content of 65 per cent per cent was recorded in KJ- 46 whereas the highest moisture content of 82.50 per cent was recorded in KJ- 45 (Table 8).

The cluster means for moisture content ranged from 65 per cent to 82.50 per cent. The minimum moisture content of 65 per cent was recorded in Cluster VII and the maximum moisture content of 82.50 per cent was recorded in Cluster IV (Table 10).

4.4.18 Acidity

Acidity of the fruits varied from 0.18 per cent to 0.58 per cent. KJ- 45 recorded the lowest acidity content of 0.18 per cent whereas KJ- 51 recorded the highest acidity content of 0.58 per cent (Table 8).

Table 8. Quality attributes of collection

Collection	Quality attributes of collection						
	Moisture (%)	Acidity (%)	Anthocyanin (mg $100g^{-1}$)	TSS (°Brix)	pH	Reducing sugar (%)	Total sugar (%)
KJ- 7	77.5	0.23	61.37	13.9	2.97	11.57	20.34
KJ- 19	72.5	0.31	44.64	13.1	3.05	11.06	18.91
KJ- 24	73.5	0.28	49.12	12.1	2.89	9.84	17.85
KJ- 26	68.9	0.46	50.89	11.6	2.24	7.57	15.18
KJ- 33	72.5	0.27	55.98	12.0	2.80	9.05	17.63
KJ- 34	71.9	0.44	53.47	11.6	1.96	8.33	16.82
KJ- 35	75.1	0.57	54.74	10.9	2.09	7.18	13.64
KJ- 36	73.0	0.42	52.13	11.1	2.54	7.86	15.52
KJ- 37	71.0	0.39	47.25	11.3	1.80	8.11	16.05
KJ- 39	79.5	0.21	56.14	14.8	3.17	13.73	19.33
KJ- 43	74.9	0.39	59.35	12.2	1.98	10.08	17.99
KJ- 45	82.5	0.18	63.35	15.5	3.03	20.16	22.95
KJ- 46	65.0	0.40	47.21	10.2	2.14	6.31	14.27
KJ- 47	80.6	0.32	62.1	12.8	2.99	10.5	18.27
KJ- 48	81.1	0.21	59.58	14.9	3.0	14.04	21.14
KJ- 51	69.8	0.58	45.62	9.20	2.18	5.89	12.82
KJ- 52	77.0	0.33	50.73	11.70	2.01	8.80	17.07

Fig 3. Dendrogram of quality attributes

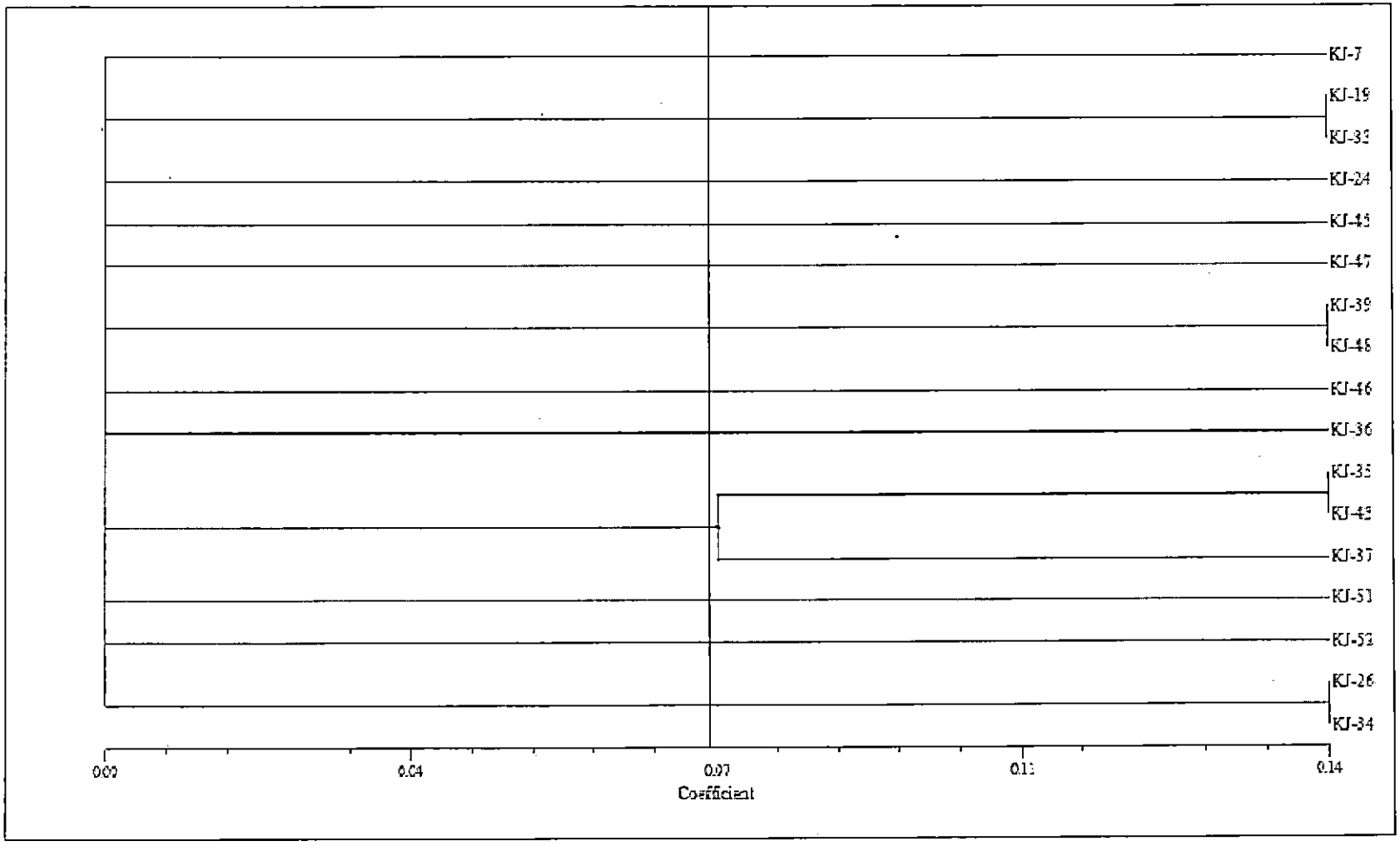


Table 9. Cluster wise listing of collection according to quality attributes

Clusters											
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
KJ- 7	KJ- 19	KJ- 24	KJ- 45	KJ- 47	KJ- 39	KJ- 46	KJ- 36	KJ- 35	KJ- 51	KJ- 52	KJ- 26
	KJ- 33				KJ- 48			KJ- 43			KJ- 34
								KJ- 37			

Table 10. Cluster wise summary statistics of quality attributes

Characters	Clusters											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Moisture (%)	77.5	72.5	73.5	82.5	80.6	80.3±1.13	65	73	73.6 ± 2.31	69.8	77	70.4 ± 2.12
Acidity (%)	0.23	0.29 ± 0.028	0.28	0.18	0.32	0.21	0.40	0.42	0.45 ± 0.10	0.58	0.33	0.45 ± 0.01
TSS (°Brix)	13.9	12.55 ± 0.77	12.1	15.5	12.8	14.85±0.07	10.2	11.1	11.46 ± 0.66	9.2	11.7	11.6
Anthocyanin (mg $100g^{-1}$)	61.37	50.31 ± 8.02	49.12	63.35	62.1	57.86 ± 2.43	47.21	52.13	53.78 ±6.10	45.62	50.73	52.18 ± 1.82
pH	2.97	2.92 ± 0.18	2.89	3.03	2.99	3.08 ± 0.12	2.14	2.54	1.95 ± 0.14	2.18	2.01	2.1 ± 0.19
Reducing sugar (%)	11.57	10.05 ± 1.42	9.84	20.16	10.5	13.8 ± 0.22	6.31	7.86	8.45 ± 1.48	5.89	8.8	7.95 ± 0.53
Total sugar (%)	20.34	18.27 ± 0.91	17.85	22.95	18.27	20.23 ± 1.28	14.27	15.52	15.89 ± 2.17	12.82	17.07	16 ± 1.16

The cluster means for acidity ranged from 0.18 per cent to 0.58 per cent. The minimum acidity value (0.18 per cent) was recorded in Cluster IV and the maximum value (0.58 per cent) in Cluster X (Table 10).

4.4.19 TSS

TSS of the collections varied from 9.20^{0}Brix to 15.50^{0}Brix. The lowest TSS (9.20^{0}Brix) was recorded in KJ- 51and the highest TSS content (15.5^{0}Brix) in KJ- 45 (Table 8).

The cluster means for TSS ranged from 9.20^{0}Brix to 15.50^{0}Brix. The minimum TSS content (9.20^{0}Brix) was recorded in Cluster X and the maximum TSS content (15.5^{0}Brix) Cluster IV in (Table 10).

4.4.20 Anthocyanin content

Anthocyanin content of the fruit varied from 44.64 mg 100 g^{-1} to 63.35 mg 100 g^{-1}. The lowest anthocyanin content (44.64 mg 100 g^{-1}) was recorded in KJ- 19 whereas the highest anthocyanin content (63.35 mg 100 g^{-1}) in KJ- 45 (Table 8).

The cluster means for anthocyanin ranged from 45.62 mg 100 g^{-1} to 63.35 mg 100 g^{-1}. The maximum anthocyanin content (63.35 mg 100 g^{-1}) was recorded in Cluster IV and the minimum anthocyanin content (45.62 mg 100 g^{-1}) in Cluster X (Table 10).

4.4.21 pH

pH of the fruit varied from 1.80 to 3.17. The lowest pH (1.80) was recorded in KJ- 37 and the highest pH (3.17) in KJ- 39 (Table 8).

The cluster means for pH ranged from 1.95 ± 0.14 to 3.08 ± 0.12. The minimum pH content was (1.95 ± 0.14) recorded in Cluster IX and the maximum pH (3.08 ± 0.12) in Cluster VI (Table 10).

4.4.22 Reducing sugar

Reducing sugar content of the fruit varied from 5.89 per cent to 20.16 per cent. The lowest reducing sugar content (5.89 per cent) was recorded in KJ- 51 and the highest reducing sugar content (20.16 per cent) in KJ- 45 (Table 8).

The cluster means for reducing sugar ranged from 5.89 per cent to 20.16 per cent. The minimum reducing sugar content (5.89 per cent) was recorded in Cluster X and the maximum reducing sugar content (20.16 per cent) in Cluster IV (Table 10).

4.4.23 Total sugar

Total sugar content of the fruit varied from 12.82 per cent to 22.95 per cent. The lowest total sugar content (12.82 per cent) was recorded in KJ- 51 and the highest total sugar content (22.95 per cent) in KJ- 45 (Table 8).

The cluster means for total sugar ranged from 12.82 per cent to 22.95 per cent. The minimum total sugar content (12.82 per cent) was recorded in Cluster X and the maximum total sugar content (22.95 per cent) in Cluster IV (Table 10).

4.4.24 Sensory evaluation

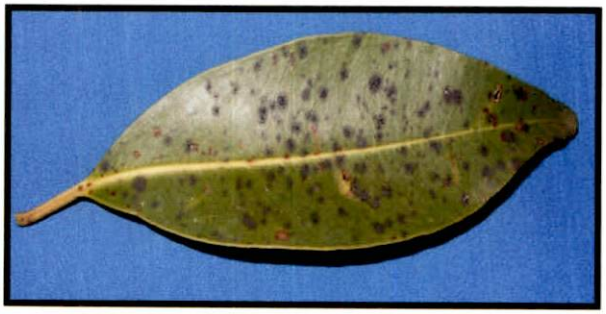
The quality attributes of jamun fruits are colour, sweetness, taste, appearance and texture contribute to the fruit quality. For quality assessment, sensory evaluation of ripe fruits was carried out on a nine point hedonic scale using score card for five attributes namely appearance, sweetness, colour, texture and taste. Each character was scored on the scale and ranking was given based on Kendall's coefficient of concordance (Table 11).

Among the seventeen collections, the highest mean rank for appearance was given for KJ- 45 (15.95) followed by KJ- 43 (14.80) and KJ- 48 (14.40). For colour, the highest mean rank was given for KJ- 45 (15.90) followed by KJ- 48 (14.45) and KJ- 43 (13.60). For sweetness, the highest mean rank was given for

Plate 7. Shelf life of jamun fruit

Plate 8. Pest and disease incidence

Leaf spot



Sooty mould

Gall midge

Table 11. Sensory evaluation of jamun collection

Sensory evaluation of jamun collections by Kendall's coefficient of concordance									
APPEARNCE		COLOUR		SWEETNESS		TASTE		TEXTURE	
	Rank Mean		Rank mean		Rank Mean		Rank Mean		Rank Mean
KJ- 45	15.95	KJ- 45	15.90	KJ- 45	16.85	KJ- 39	16.30	KJ- 47	14.85
KJ- 43	14.80	KJ- 48	14.45	KJ- 39	15.00	KJ- 45	15.85	KJ- 39	14.55
KJ- 48	14.40	KJ- 43	13.60	KJ- 48	14.20	KJ- 48	13.50	KJ- 48	13.15
KJ- 39	14.20	KJ- 39	13.00	KJ- 7	13.75	KJ- 43	13.05	KJ- 7	12.85
KJ- 47	13.75	KJ- 47	11.45	KJ- 43	12.90	KJ- 47	12.95	KJ- 45	12.70
KJ- 7	13.35	KJ- 35	11.25	KJ- 47	12.80	KJ- 7	12.15	KJ- 43	12.55
KJ- 37	8.35	KJ- 7	11.00	KJ- 35	8.80	KJ- 52	9.05	KJ- 36	10.10
KJ- 35	7.90	KJ- 36	8.30	KJ- 46	8.45	KJ- 34	8.45	KJ- 35	8.85
KJ- 36	7.80	KJ- 37	8.25	KJ- 52	8.25	KJ- 35	7.65	KJ- 34	8.35
KJ- 33	7.80	KJ- 33	8.15	KJ- 34	6.80	KJ- 37	7.45	KJ- 37	8.30
KJ- 46	6.45	KJ- 52	7.95	KJ- 37	6.80	KJ- 36	6.95	KJ- 46	7.75
KJ- 34	6.35	KJ- 46	7.60	KJ- 51	6.65	KJ- 33	6.75	KJ- 33	7.70
KJ- 52	6.10	KJ- 34	6.50	KJ- 24	5.75	KJ- 46	6.45	KJ- 24	7.00
KJ- 24	5.35	KJ- 51	6.05	KJ- 36	5.70	KJ- 51	6.20	KJ- 26	4.15
KJ- 51	4.50	KJ- 19	4.50	KJ- 33	4.75	KJ- 24	4.45	KJ- 52	4.15
KJ- 19	3.75	KJ- 26	2.85	KJ- 26	3.10	KJ- 19	3.40	KJ- 51	3.70
KJ- 26	2.20	KJ- 24	2.20	KJ- 19	2.45	KJ- 26	2.40	KJ- 19	2.30

KJ- 45 (16.85) followed by KJ- 39 (15.00) and KJ- 48 (14.20). KJ- 39 (16.30) recorded the highest mean rank for taste followed by KJ- 45 (15.85) and KJ- 48 (13.50). KJ- 47 (14.85) recorded the highest mean rank for texture followed by KJ- 39 (14.55) and KJ- 48 (13.15).

4.5 Observations on postharvest study

4.5.17 Shelf life in days

The maximum shelf life of the fruit was 3 days when stored in ambient temperature after harvest at ripened stage.

4.6 Observations on pest and disease incidence

During the entire period of study, there was not much severe incidence of pests and diseases. In all collections pest such as gall midge was observed. Leaf spot and sooty mould diseases were also common in all collections.

Discussion

5. DISCUSSION

The results of the study pertaining to the "Morphochemical evaluation of jamun (*Syzygium cuminii* Skeels) collections" are discussed under the five captions namely tree characters, inflorescence characters, fruit characters, fruit quality attributes, postharvest study and pest and disease incidence.

5.1. Morphological characters

5.1.1. Tree characters

Variation in the tree characters such as age of the tree, tree height, trunk girth, crown shape, leaf apex, leaf length, leaf width, leaf shape, leaf colour, shoot length and internodal length were recorded in 59 collections.

Most of the trees were in the age group ranging from 20 to 35 years. KJ- 44, KJ- 49, KJ- 50, KJ- 53, KJ- 54, KJ- 55, KJ- 56, KJ- 57, KJ- 58 and KJ- 59 recorded the highest age group of 35 years and the collections KJ- 34, KJ- 35 and KJ- 36 recorded the lowest age group of 20 years (Tables 1a and 1b). The cluster mean ranged from 20.66 ± 0.81 to 35 years. The Cluster V and VI had the highest age group of 35 years and the Cluster III recorded the lowest (20.66 ± 0.81) age group (Table 3). The tree height of the collections varied from 12 m to 20 m. The cluster mean of tree height ranged from 14.5 ± 0.71 m to 18.14 ± 1.14 m. Cluster VI (18.14 ± 1.14 m) recorded the highest tree height and the Cluster VII (14.5 ± 0.71 m) recorded the lowest tree height (Table 3). The trunk girth of the collections varied from 0.95 m to 4.1m. The cluster mean value ranged from 1.46 ± 0.30 m to 2.70 ± 0.88 m. The Cluster IX has the maximum girth of 2.70 ± 0.88 m and the minimum girth of 1.46 ± 0.30 m was recorded in Cluster XI (Table 3). Prabhuraj *et al.* (2002) observed the high degree of variability in plant girth of jamun. The tree characters *viz.*, height and girth are influenced by the age of the tree, nutritional and climatic factors.

Among the collections, different crown shapes like pyramidal, broadly pyramidal, spherical, semi-circular and irregular shapes were noticed among the collections. The study revealed that The Cluster I and III included the broadly

pyramidal and irregular crown shapes. Cluster II had the irregular crown shape. Broadly pyramidal and pyramidal crown shapes were noticed in the Cluster IV and VIII. Cluster V, VI, VII and XI had the pyramidal crown shape while the Cluster X had the broadly pyramidal crown shape. Broadly pyramidal, irregular and semi circular crown shapes were seen in Cluster IX and the Cluster XII had irregular, pyramidal and broadly pyramidal crown shapes (Table 3). The crown shape of the tree is influenced by shade, environmental parameters and genetic make-up of the tree.

Wide variations were observed with respect to leaf length, length width and leaf shape among the collections. The leaf length of the collections varied from 9.1 cm to 17.5 cm. The cluster mean ranged from 11.93 ± 2.29 cm to 16.9 ± 0.14 cm. The Cluster VII recorded the highest mean value of 16.9 ± 0.14 cm and the Cluster XI recorded the lowest mean value of 11.93 ± 2.29 cm (Table 3). The leaf width of the collections varied from 2.3 cm to 6.5 cm. The cluster mean value ranged 4.18 ± 0.98 cm to 6.1 cm. Cluster II recorded the highest mean value of 6.1 cm and the Cluster VI recorded the lowest value of 4.18 ± 0.98 cm (Table 3). Increase in leaf length and width increases the leaf area of plant. Broadly ovate and lanceolate leaf shapes were noticed among the collections. The results showed that the Clusters I, III, VI, VII, VIII, IX, X, XI and XII included both broadly ovate and lanceolate leaf shapes. Cluster IV and V had the lanceolate leaf shape whereas the Cluster II had broadly ovate leaf shape (Table 3). In case of leaf colour all the collections has dark green colour leaves. Both the genetic and phenotypic elements have a important role in determining various leaf characters.

Shoot length and internodal length of the newly developed branches showed wide variation. The shoot length of the collections varied from 7 cm to 26 cm. The cluster mean value ranged from 8.33 ±1.52 cm to 25 ± 1.41 cm. Cluster X (25 ± 1.41 cm) recorded the highest shoot length and the Cluster XI (8.33 ±1.52 cm) recorded the lowest mean values. The internodal length of the collections varied from 7.7 cm to 12.2 cm. The cluster mean value of internodal length ranged from 8.3 ± 0.85 cm to 10.86 ± 0.96 cm. The Cluster VII recorded lowest value of 8.3 ± 0.85 cm and the Cluster I recorded the highest value of 10.86 ± 0.96 cm (Table 3).

5.1.2. Inflorescence characters

Observations on inflorescence characters were recorded with respect to the position of inflorescence, flower composition in the inflorescence, flower colour, flowering season and duration of flowering (Table 4).

Only 17 trees were flowered during the period of study. All the collections possessed axillary position of inflorescence. Two types of flower compositions were observed among the collections *viz.*, solitary and cluster. KJ- 7, KJ- 24, KJ- 33, KJ- 34, KJ- 35, KJ- 36, KJ- 37, KJ- 39, KJ- 43, KJ- 45, KJ- 47, KJ- 48 and KJ- 52 recorded the cluster composition. KJ- 19, KJ- 46 and KJ- 51 recorded the solitary composition and KJ- 26 recorded both the solitary and cluster composition of inflorescence. The flower colour of all the collections showed the white colour as similar to the guava. In KJ- 7, KJ- 33, KJ- 34, KJ- 35, KJ- 36, KJ- 37, KJ- 39, KJ- 45, KJ- 46, KJ- 47, KJ- 48, KJ- 51 and KJ- 52 flowering was noticed in December. However, in KJ- 19, KJ- 24, KJ- 26 and KJ- 43 flowering was noticed in the month of January. Singh and Singh (2012) reported the two flowering seasons during the month of February and March in jamun. The duration of flowering was varied from 26 to 42 days.

5.1.3. Fruit characters

Various observations on fruit characters includes fruiting season, days from flowering to fruit maturity, days from fruit set to maturity, fruit clustering habit, fruit weight, fruit volume, number of fruits per cluster, specific gravity, overall length of fruits, maximum width, fruit shape. Firmness/softness, colour, pulp, seed, pulp/seed ratio, juice content and yield (Tables 5a and 5b).

Two fruiting season was observed among the 17 collections. All collections in the Clusters I, III, and IV started fruiting during the month of March - April and April - May. Clusters II and V started fruiting during the month of March – April (Table 7). Singh and Singh (2012) reported the two fruiting periods during May and June in jamun.

The number of days taken from flowering to maturity varied from 62 days to 68 days. The cluster mean for flowering to fruit maturity ranged from 62 days to 67 days.

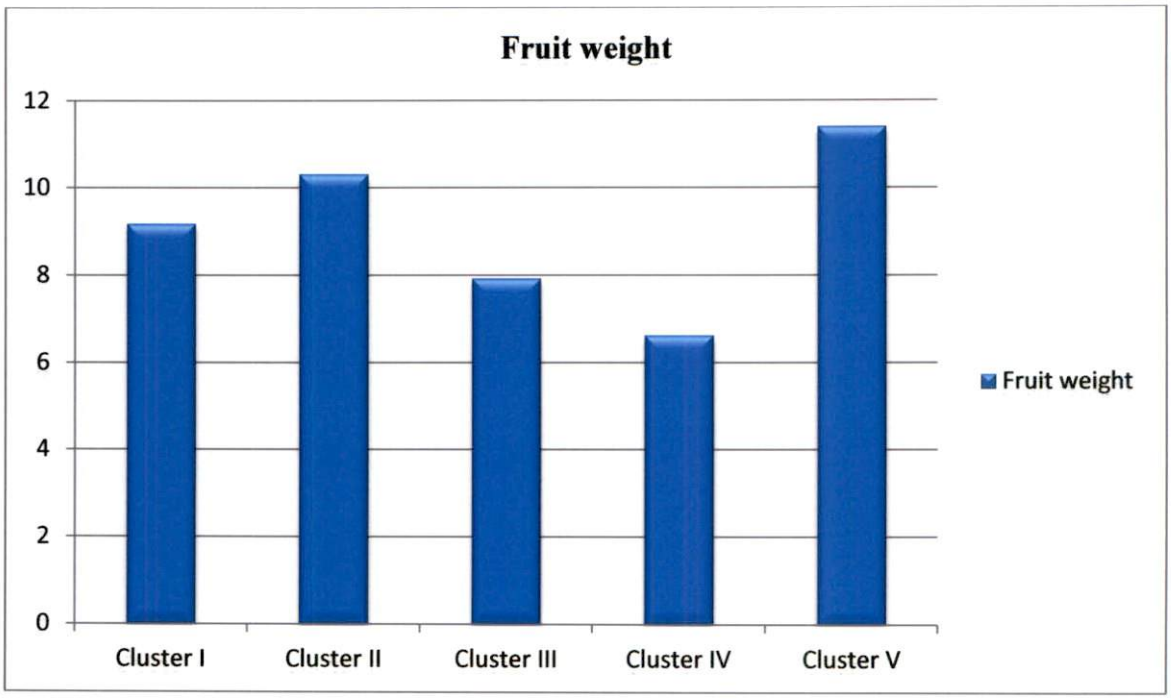


Fig. 4 Fruit weight in different clusters

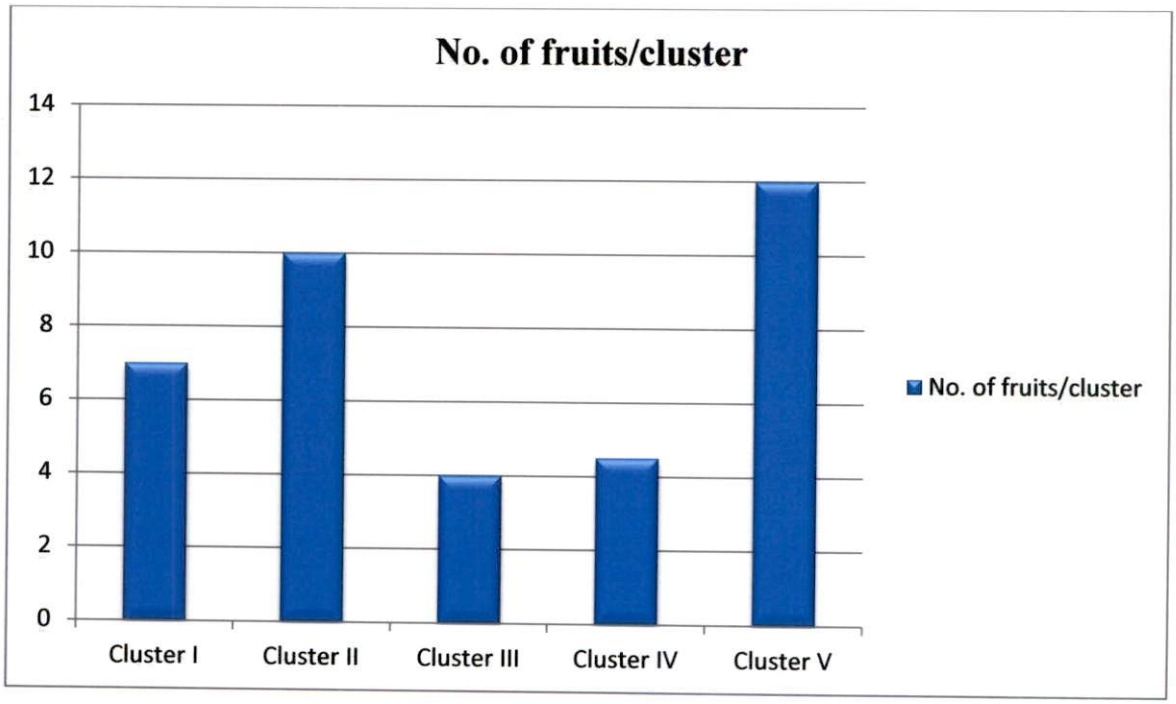


Fig. 5 No. of fruits per cluter in different clusters

Cluster V recorded the minimum days (62 days) and Cluster III recorded the maximum days (67 days) for flowering to fruit maturity (Table 7).

The number of days taken from fruit set to maturity varied from 58 to 64 days. The cluster mean for days from fruit set to fruit maturity ranged from 58 days to 62.75 ± 0.5 days. Cluster V recorded the minimum days (58 days) and Cluster III recorded the maximum days (62.75 ± 0.5 days) for fruit set to fruit maturity (Table 7). Haldankar *et al.* (2014) reported that after fruit set jamun tree takes about 60 days for harvesting.

Two types of fruit clustering habits were observed among the collections namely solitary and cluster. Clusters I, II and V had the cluster fruit bearing habit. Clusters III had the solitary fruit bearing habit and Cluster IV had both cluster and solitary fruit bearing habits (Table 7).

The fruit weight of the collections varied from 5.91 g to 12.28 g. The cluster mean for the fruit weight ranged from 6.63 ± 0.52 g to 12.28 g. The highest cluster mean value for fruit weight was recorded in Cluster V (12.28 g) and the lowest cluster mean value of 6.63 ± 0.52 g was recorded in Cluster III (Fig. 4). Ghojage *et al.* (2009) reported the fruit weight varied from 5.27 g in KJS- 24 to 13.45 g in KJS- 4. Variations in fruit weight were reported by Devi *et al.* (2002), Inamdar *et al.* (2002), Prabhuraj *et al.* (2003), Prakash *et al.* (2010), Patel *et al.* (2005) and Kundu *et al.* (2001) in jamun.

The fruit volume of the collections varied from 5.32 cc to 11.40 cc. The cluster mean value for fruit volume ranged from 6.53 ± 1.09 cc to 11.40 cc. The highest mean value for fruit volume was recorded in Cluster V (6.53 ± 1.09 cc) and the lowest mean value was recorded in Cluster III (11.40 cc). Similar observations were reported by Ghojage *et al.* (2009).

The number of fruits per cluster varied among the collections. The highest number of fruits per cluster (12) was recorded in KJ- 45 and the lowest number of fruits per cluster (3) recorded in KJ- 19 and KJ- 26. The cluster mean for number of fruits per cluster ranged from 4.33 ± 0.57 to 12. The Cluster V recorded the highest mean value of 12 and the Cluster IV recorded the lowest mean value of 4.33 ± 0.57 (Fig. 5).

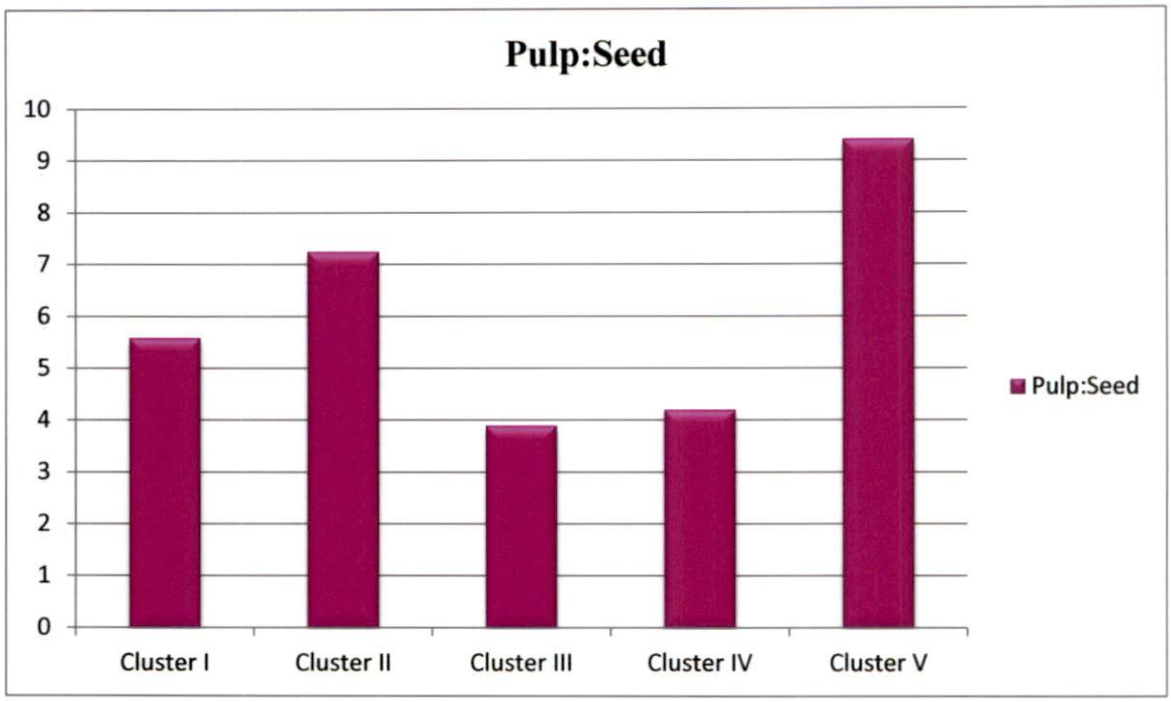


Fig. 6 Pulp:seed in different clusters

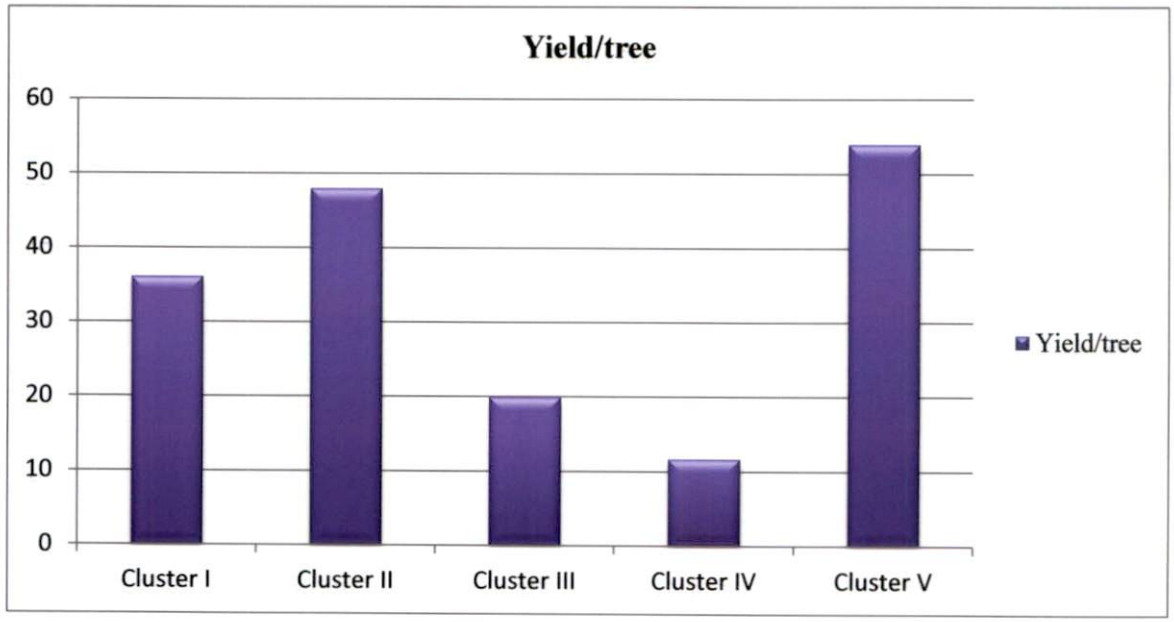


Fig. 7 Yield per tree in different clusters

Mean specific gravity varied from 0.91 to 1.23. Highest specific gravity (1.09 ± 0.03) was observed in Cluster I and lowest (0.99 ± 0.08) in Cluster IV (Table 7). Shanawaz and Sheik (2011) recorded specific gravity of 1.25 ± 0.048 in indigenous type of jamun.

Length of the fruit varied from 1.61 cm to 3.10 cm. The cluster mean for the fruit length ranged from 1.88 ± 0.20 cm to 3.10 cm. The highest cluster mean value (3.10 cm) recorded in Cluster V and the lowest cluster mean value (1.88 ± 0.20 cm) recorded in Cluster III. Width of the fruit varied from 1.24 cm to 2.41 cm. Among the clusters, mean value for fruit width ranged from 1.78 ± 0.36 cm to 2.41 cm. The highest cluster mean value (2.41 cm) for width was recorded in Cluster V and lowest (1.78 ± 0.36 cm) in Cluster III (Table 7). Prakash *et al.* (2010) and Patel *et al.* (2005) observed similar variations in length and width of the jamun fruit.

All fruits were oblong in shape and blackish purple in colour.

The firmness of the fruit in the collections ranged from 4.09 kg cm^{-2} to 9.94 kg cm^{-2}. The cluster mean of firmness/softness ranged from 4.82 ± 0.55 kg cm^{-2} to 9.94 kg cm^{-2}. The highest cluster mean value (9.94 kg cm^{-2}) was recorded in Cluster V and lowest (4.82 ± 0.55 kg cm^{-2}) in Cluster III (Table 7). Shanawaz and Sheik (2011) reported that firmness of the fruit was influenced by varieties, environment and the use of agro inputs.

The pulp percent content of the fruit varied from 90.39 per cent to 77.50 per cent. The cluster mean value of pulp content ranged from 81.05 ± 2.55 per cent to 90.39 per cent. The highest cluster mean value (90.39 per cent) was recorded in Cluster V and lowest (81.05 ± 2.55 per cent) in Cluster IV. Similar results were reported by Garanade *et al.* (1998) and Singh and Singh (2012) in jamun. The seed per cent of the collection varied from 22.49 to 9.60 per cent. The cluster mean value of seed content ranged from 9.60 per cent to 18.94 ± 2.55 per cent. The highest cluster mean value (18.94 ± 2.55 per cent) was recorded in Cluster IV and lowest (9.60 per cent) in Cluster V (Table 7). Patel *et al.* (2005) reported that seed per cent varied from 2.29 per cent to 41.8 per cent in jamun.

The pulp/seed ratio of the fruit varied from 3.24 to 9.41. The cluster mean value of pulp/seed ratio ranged from 4.20 ± 0.70 to 9.41. The highest cluster mean value (9.41) recorded in Cluster V and the lowest cluster mean value (4.20 ± 0.70) in Cluster III (Fig. 6). Higher pulp/seed ratio is a desirable trait for table purpose fruits (Singh and Singh, 2012). Srivastava *et al.* (2012) observed that pulp percentage was highly significant and positively correlated with pulp/seed ratio and fruit volume whereas negatively correlated with seed percentage. The seed percentage showed highly significant negative correlation with fruit volume and pulp/seed ratio.

The juice content of the collections varied from 14 per cent to 44 per cent. The cluster mean of the value of juice content ranged from 16.5 ± 1.91 per cent to 44 per cent. The highest cluster mean value recorded (44 per cent) in Cluster V and lowest cluster mean value (16.5 ± 1.91 per cent) recorded in Cluster III (Table 7). A similar result was also reported by Shanawaz and Sheik (2011) in jamun.

5.1.3.1 Yield

The yield per plant of the collections varied from 10 kg plant^{-1} to 54 kg plant^{-1}. The cluster mean of yield per tree ranged from 11.75 ± 1.70 kg plant^{-1} to 54 kg plant^{-1}. The highest cluster mean value (54 kg plant^{-1}) was recorded in Cluster V and lowest yield (11.75 ± 1.70 kg plant^{-1}) in Cluster III (Fig. 7). Wide variation in yield with different collections is due to the genetic makeup of plant and environmental factors such as location, maximum and minimum temperature, frequency of rainfall, and relative humidity (Singh and Singh, 2012). The yield of the plant KJ- 45 depends on number of fruits/cluster (12 fruit/cluster), fruit length (3.10 cm), fruit width (1.24 cm) and fruit weight (12.28 g). These findings are in agreement with findings of Kundu *et al.* (2001), Devi *et al.* (2002) and Prabhuraj *et al.* (2002) in jamun.

Singh and Singh (2012) revealed that maximum fruit yield was observed in GJ-2 (152 kg plant^{-1}) and the least fruit yield was recorded in GJ- 4 (90 kg plant^{-1}). However, in the present study, among the several jamun collections, it was observed that KJ- 45 (54 kg plant^{-1}) recorded higher yield followed by KJ- 48 (48.2 kg plant^{-1}) and KJ- 47 (46.5 kg plant^{-1}) and the lowest yield in KJ- 19 (10 kg plant^{-1}).

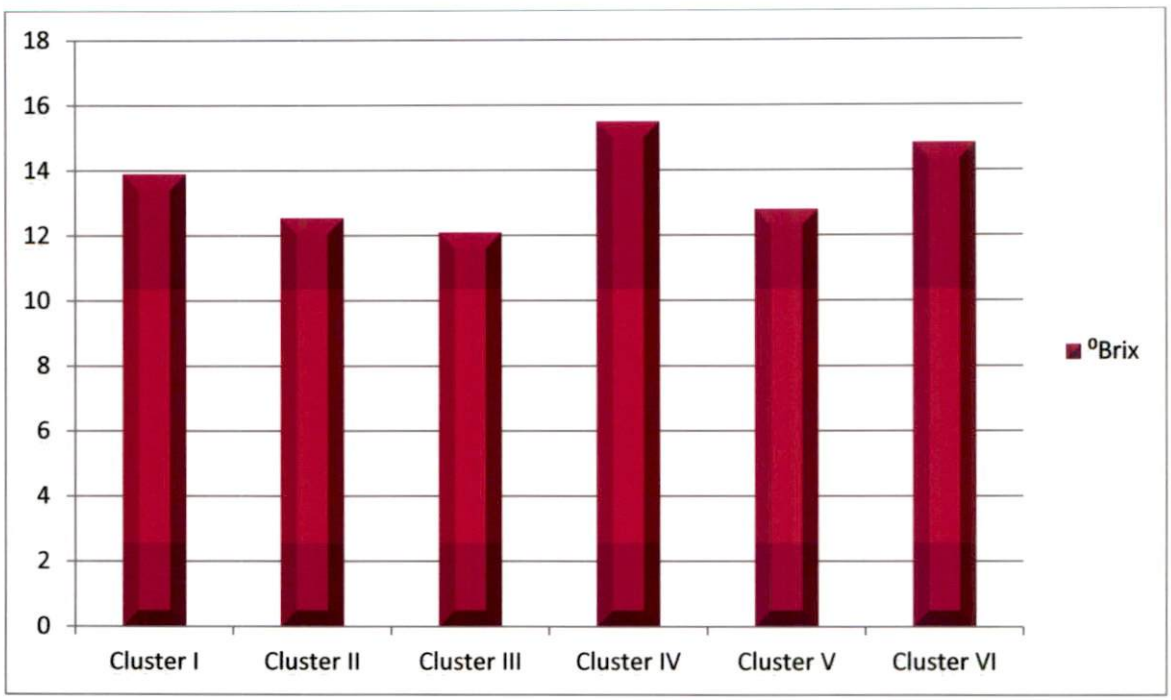


Fig. 8 TSS content of fruits in different clusters

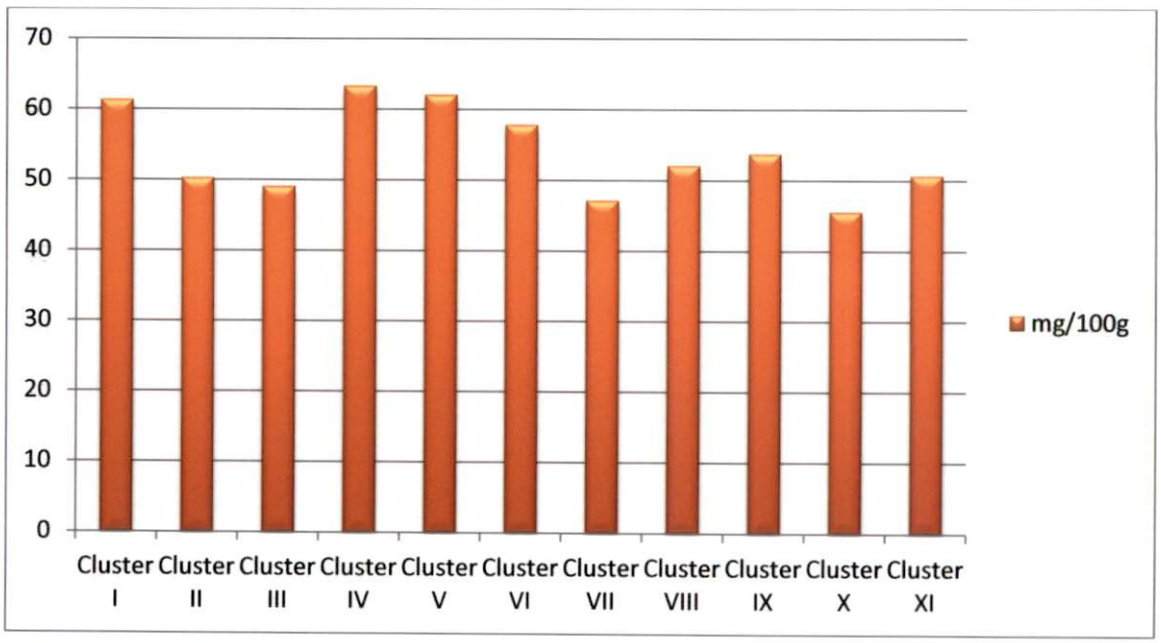


Fig. 9 Anthocyanin content of fruits in different clusters

5.1.4. Quality attributes

The collections showed wide variation for quality attributes such as moisture, acidity, TSS, anthocyanin, pH, reducing and total sugar content (Table 8).

The cluster means for moisture ranged from 65 per cent to 82.50 per cent. Cluster VII recorded the minimum value of 65.00 per cent and Cluster IV recorded the maximum value of 82.50 per cent (Table 10). The maximum moisture content in fruit is due to high pulp per cent (Prakash *et al.*, 2010).

The cluster means for TSS ranged from 9.20°Brix to 15.50°Brix. Cluster X recorded the minimum TSS (9.20°Brix) and Cluster IV recorded the maximum TSS (15.50°Brix) (Fig. 8). The variation in TSS is due to genetic makeup of the plant (Prakash *et al.*, 2010). Variation in TSS content was also reported by Kumar *et al.* (1993), Devi *et al.* (2002) and Singh *et al.* (2007) in jamun.

The cluster means for acidity ranged from 0.18 per cent to 0.58 per cent. Cluster IV recorded the minimum value of 0.18 per cent and Cluster X recorded the maximum value of 0.58 per cent (Table 10). The variation in acidity of fruits might be due to genetic makeup of the jamun plant (Singh *et al.*, 2007 and Prakash *et al.*, 2010).

Anthocyanin content of the fruit varied from 44.64 mg 100 g^{-1} to 63.35 mg 100 g^{-1}. The cluster mean value for anthocyanin ranged from 45.62 mg 100 g^{-1} to 63.35 mg 100 g^{-1}. The maximum anthocyanin content (63.35 mg 100 g^{-1}) was recorded in Cluster IV and the minimum anthocyanin content (45.62 mg 100 g^{-1}) in Cluster X (Fig. 9). Ghojage *et al.* (2009) reported that among the jamun genotypes highest anthocyanin content was recorded in KJS- 18 (1.393 OD value) and lowest in KJS- 1 (0.162 OD value).

pH of the fruit varied from 1.80 to 3.17. The cluster means for pH ranged from 1.95 ± 0.14 to 3.08 ± 0.12. Cluster IX recorded the minimum pH and cluster VI recorded the maximum pH (Table 10). Low pH was responsible for more astringency in taste (Shanawaz and Sheik, 2011).

Reducing sugar content of the fruit varied from 5.89 per cent to 20.16 per cent. The cluster mean value for reducing sugar ranged from 5.89 per cent to 20.16 per cent. The minimum reducing sugar content (5.89 per cent) was recorded in Cluster X and the

maximum reducing sugar content (20.16 per cent) in Cluster IV. Total sugar content of the fruit varied from 12.82 per cent to 22.95 per cent. The cluster means for total sugar ranged from 12.82 per cent to 22.95 per cent. The minimum total sugar content (12.82 per cent) was recorded in Cluster X and the maximum total sugar content (22.95) in Cluster IV (Table 10). Similar observations were noticed by Ghojage *et al.* (2009), Prakash *et al.* (2010) and Srivastava *et al.* (2012).

5.1.4. Sensory evaluation

Sensory qualities are very important from the consumer's point of view. Evaluation of organoleptic characters depends on quality parameters like colour, taste, texture, flavour, appearance, and sweetness showed significant variation among the collections (Table 11).

Among the seventeen collections, the highest mean rank for appearance was given for KJ- 45 (15.95) followed by KJ- 43 (14.80) and KJ- 48 (14.40). For colour, the highest mean rank was given for KJ- 45 (15.90) followed by KJ- 48 (14.45) and KJ- 43 (13.60). For sweetness, the highest mean rank was given for KJ- 45 (16.85) followed by KJ- 39 (15.00) and KJ- 48 (14.20). KJ- 39 recorded the highest mean rank for taste (16.30) followed by KJ- 45 (15.85) and KJ- 48 (13.50). KJ- 47 recorded the highest mean rank of 14.85 for texture followed by KJ- 39 (14.55) and KJ- 48 (13.15). From the sensory evaluation KJ- 45 was found to be promising types with respect to appearance, colour and sweetness. With respect to taste and texture KJ- 39 and KJ- 47 were found promising when compared with all collections.

5.1.5 Pest and disease

During the entire period of study, there was not severe incidence of pests and diseases. In all collections, mild incidence of pest (gall midge) and diseases (leaf spot and sooty mould) diseases was observed. By adopting suitable control measures, pests and disease were controlled.

5.1.6 Promising types

Thus in the present investigation, evaluation of collections have been made to understand the wide range of variability and similarity with the help of morphological, floral, fruit characters and quality attributes for identifying the promising types for further selection. Based on clustural analysis on quantitative and qualitative data, KJ-45 has higher yield (54 kg plant^{-1}), TSS (15.6°Brix), 12 fruits per cluster, single fruit weight of 12.28 g, pulp: seed (9.41) and anthocyanin content of 63.35 mg 100 g^{-1}. Hence, KJ- 45 is considered as superior collection followed by KJ- 48, 47 and 7. Thus it could be utilized for future breeding program, molecular characterization and also need to be evaluated to study the stability in performance under different ecosystems.

Summary

6. SUMMARY

The present study entitled "Morphochemical evaluation of jamun (*Syzygium cuminii* Skeels) collections" was conducted during August 2014 to December 2015 at the KAU main campus, College of Horticulture, Vellanikkara. The main objective of the study was to evaluate the morphological and chemical characters of jamun collections maintained in and around the KAU main campus for identifying the superior types. Fifty nine collections were used for the study. Standard descriptors prescribed by NBPGR were used as the guidline to observe the morphological characters of the jamun tree, inflorescence and fruits. Mature fruit samples were recorded for quality attributes and sensory evaluation.

The salient findings of the study are as follows:

The tree age of the collections varied from 20 to 35 years. KJ- 44, KJ- 49, KJ- 50, KJ- 53, KJ- 54, KJ- 55, KJ- 56, KJ- 57, KJ- 58 and KJ- 59 recorded the highest age group of 35 years and the collections KJ- 34, KJ- 35 and KJ- 36 recorded the lowest age group of 20 years.

The tree height of the collections varied from 12 m to 20 m. KJ- 13 recorded the lowest height of 12 m and KJ- 52 and KJ- 56 recorded the highest tree height of 20 m.

The trunk girth of the collections varied from 0.95 m to 4.1 m. KJ- 1 recorded the highest trunk girth of 4.1 m and the KJ- 10 recorded the lowest trunk girth of 0.95 m.

Among the several collections, different crown shapes like pyramidal, broadly pyramidal, spherical, semi-circular and irregular shapes were noticed among the collections. The study revealed that pyramidal shapes were recorded in KJ- 8, KJ- 10, KJ- 11, KJ- 12, KJ- 14, KJ- 17, KJ- 18, KJ- 19, KJ- 20, KJ- 21, KJ- 22, KJ- 23, KJ- 24, KJ- 25, KJ- 26, KJ- 27, KJ- 29, KJ- 31, KJ- 32, KJ- 38, KJ- 44, KJ- 46, KJ- 49,KJ- 50,KJ- 53, KJ- 54, KJ- 55, KJ- 56, KJ- 57, KJ- 58, and KJ- 59. Irregular crown shapes were recorded in KJ- 4, KJ- 13, KJ- 36, KJ- 43, KJ- 52 and KJ- 6 has semicircular crown shape. Broadly pyramidal crown shapes were recorded in KJ- 1, KJ- 2, KJ- 3,

KJ- 5, KJ- 7, KJ- 9, KJ- 15, KJ- 16, KJ- 28, KJ- 30, KJ- 33, KJ- 34, KJ- 35, KJ- 37, KJ- 39, KJ- 40, KJ- 41, KJ- 42, KJ- 45, KJ- 47, KJ- 48 and KJ- 51.

The leaf length of the collections varied from 9.1 cm to 17.5 cm. KJ- 41 recorded the maximum leaf length of 17.5 cm and the KJ- 3 and KJ- 10 recorded the minimum leaf length of 9.1 cm.

The leaf width of the collections varied from 2.3 cm to 6.5 cm. KJ- 12 recorded the highest mean value of 6.5 cm and the KJ- 53 recorded the lowest value of 2.3 cm.

Broadly ovate and lanceolate types of leaf shapes were noticed among the collections. Majority of the collections has lanceolate leaf shape. The collections KJ- 2, KJ- 3, KJ- 5, KJ- 10, KJ- 12, KJ- 17, KJ- 18, KJ- 19, KJ- 22, KJ- 23, KJ- 24, KJ- 26, KJ- 33, KJ- 43, KJ- 52, KJ- 53, KJ- 56 has lanceolate leaf shape and only KJ- 58 recorded the broadly ovate shape.

In case of leaf colour all the collections has dark green colour leaves.

The shoot length of the collections varied from 7 cm to 26 cm. KJ- 7 and KJ- 52 recorded the highest shoot length of 26 cm and KJ- 20 recorded the lowest shoot length of 7 cm.

The internodal length of the collections varied from 7.7 cm to 12.2 cm. KJ- 51 recorded the highest intermodal length of 12.2 cm and KJ- 21 recorded the lowest length of 7.7 cm.

Only 17 trees were flowered during the period of study. All the collections possessed axillary position of inflorescence. Two types of flower compositions were observed among the collections namely solitary and cluster. The flower colour of all the collections showed the white colour. Flowering season was noticed in December and January. The duration of flowering varied from 26 to 42 days. KJ- 26 recorded the lowest duration of 26 days and KJ- 45 recorded the highest duration of 42 days.

Two fruiting season was observed among the 17 collections. The collections KJ- 7, KJ- 33, KJ- 34, KJ- 36, KJ- 37, KJ- 39, KJ- 45,KJ- 47, KJ- 48, KJ- 51 and KJ- 52, were fruited during March-April and KJ- 19,KJ- 24, KJ- 26,KJ- 35, KJ- 43 and KJ- 46 were fruited during April-May.

The number of days taken from flowering to maturity varied from 62 days to 68 days. The lowest days from flowering to fruit maturity (62 days) was observed in KJ- 45 and highest days (68 days) observed in KJ- 24.

The number of days taken from fruit set to maturity varied from 58 days to 64 days. The lowest days from fruit set to fruit maturity (58 days) was observed in KJ- 45 and highest days (64 days) observed in KJ- 24.

Two types of fruit clustering habits were observed among the collections namely solitary and cluster. KJ- 7, KJ- 33, KJ- 34, KJ- 35, KJ- 36, KJ- 39, KJ- 43, KJ- 45, KJ- 47, KJ- 48 and KJ- 52 recorded the cluster bearing habit and KJ- 19, KJ- 24, KJ- 26, KJ- 37, KJ- 46 and KJ- 51 recorded the solitary bearing habit.

The fruit weight of the collections varied from 5.91 g to 12.28 g. KJ- 45 recorded the highest fruit weight of 12.28 g and KJ- 26 recorded the lowest fruit weight of 5.91 g.

The fruit volume of the collections varied from 5.32 cc to 11.40 cc. The highest fruit volume of 11.40 cc was recorded in KJ- 45 and the lowest (5.32 cc) in KJ- 51.

The number of fruits per cluster varied among the collections. The highest number of fruits per cluster (12) was recorded in KJ- 45 and the lowest number of fruits per cluster (3) recorded in KJ- 19 and KJ- 26.

Mean specific gravity varied among different clusters. The highest specific gravity of 1.23 was recorded in KJ- 51 and the lowest of 0.91 in KJ- 46.

Overall length of the fruit varied from 1.61 cm to 3.10 cm. Highest fruit length (3.10 cm) was recorded in KJ- 45 and the of 1.61cm was recorded in KJ- 51.

Width of the fruit varied from 1.24 cm to 2.41 cm. Highest fruit length(1.24 cm) was recorded in KJ- 45 and the lowest fruit length of 2.41cm was recorded KJ- 51.

Fruits of all the collections showed oblong shape and blackish purple colour.

The firmness/softness of the fruit varied from 4.09 kg cm^{-2} to 9.94 kg cm^{-2}. Highest firmness of the fruit of 9.94 kg cm^{-2} was observed in KJ- 45 and the lowest firmness of 4.09 kg cm^{-2} in KJ- 51.

The pulp content of the fruit varied from 90.39 per cent to 77.50 per cent. Highest pulp content of 90.39 per cent was observed in KJ- 45 and the lowest pulp content of 77.50 per cent in KJ- 43.

The seed content of the fruit varied from 22.49 per cent to 9.60 per cent. Highest seed content of 22.49 per cent was observed in KJ- 43 and the lowest seed content of 9.60 per cent in KJ- 45.

The pulp/seed ratio of the fruit varied from 3.24 to 9.41. Highest pulp/seed ratio of 9.41 was recorded in KJ- 45 and lowest pulp/seed ratio of 3.24 recorded in KJ- 19.

The juice content of the fruit varied from 14 per cent to 44 per cent. Highest juice content of 44 per cent was recorded in KJ- 45 and lowest juice content of 3.24 per cent was recorded in KJ- 51.

The yield per tree varied from 10 kg plant^{-1} to 54 kg plant^{-1}. Highest yield of 54 kg plant^{-1} was recorded in KJ- 45 followed by KJ- 48 (48.2 kg plant^{-1}), KJ- 47 (46.5 kg plant^{-1}), KJ- 7 (41.6 kg plant^{-1}) and the lowest yield of 10 kg plant^{-1} was recorded in KJ- 19.

Moisture content of the fruits varied from 65 per cent to 82.50 per cent. The lowest moisture content of 65 per cent per cent was recorded in KJ- 46 whereas the highest moisture content of 82.50 per cent was recorded in KJ- 45.

Acidity content of the fruits varied from 0.18 to 0.58 per cent. KJ-45 recorded the lowest acidity content of 0.18 per cent whereas KJ- 51 recorded the highest acidity content of 0.58 per cent.

TSS of the fruits varied from 9.20^{0}Brix to 15.50^{0}Brix. The lowest TSS of 9.20^{0}Brix was recorded in KJ- 51and the highest TSS content of 15.5^{0}Brix recorded in KJ- 45.

Anthocyanin content of the fruit varied from 44.64 mg 100 g^{-1} to 63.35 mg 100 g^{-1}. The lowest anthocyanin content of 44.64 mg 100 g^{-1} was recorded in KJ- 19 whereas the highest anthocyanin content of 63.35 mg 100 g^{-1} in KJ- 45.

pH of the fruit varied from 1.80 to 3.17. The lowest pH of 1.80 was recorded in KJ- 37 and the highest pH of 3.17 was recorded in KJ- 39.

Reducing sugar content of the fruit varied from 5.89 to 20.16 per cent. The lowest reducing sugar content of 5.89 per cent was recorded in KJ- 51 and the highest reducing sugar content of 20.16 was recorded per cent in KJ- 45.

Total sugar content of the fruit varied from 12.82 per cent to 22.95 per cent. The lowest total sugar content of 12.82 per cent was recorded in KJ- 51 and the highest total sugar content of 22.95 per cent was recorded in KJ- 45.

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KJ- 45 was found to be promising types with respect to appearance, colour and sweetness. KJ- 39 and 47 were found promising types with respect to taste and texture.

Based on clustural analysis on quantitative and qualitative data, KJ- 45 has higher yield (54 kg plant^{-1}), TSS (15.6°Brix), fruits per cluster (12), single fruit weight (12.28 g), pulp:seed (9.41) and anthocyanin content (63.35 mg 100 g^{-1}). Hence, KJ- 45 is considered as superior tree followed by KJ- 48, KJ- 47 and KJ- 7.

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MORPHOCHEMICAL EVALUATION OF JAMUN

(*Syzygium cuminii* Skeels)COLLECTIONS

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ABSTRACT OF THE THESIS

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ABSTRACT

Jamun possesses commercial importance as a minor fruit in tropical and subtropical conditions. It is a versatile fruit tree of best food and medicinal value. India ranks second in production of jamun in the world. It is an important under-exploited indigenous fruit tree of India. As majority of jamun trees are of seedling origin, they show tremendous variation in their morphology and physicochemical attributes. Assessment of the existing variability is a prerequisite for taking up successful crop improvement.

The study on "Morphochemical evaluation of jamun (*Syzygium cuminii* Skeels) collections" was carried from August 2014 to December 2015 at the KAU main campus, College of Horticulture, Vellanikkara, Thrissur, Kerala. The main objective of the study was to evaluate the morphochemical characters of jamun collections maintained in and around the KAU main campus for identifying the superior types. Fifty nine collections of jamun were maintained in the departmental orchard, in and around the KAU main campus were used for the study. All the collections were studied for morphological, physico-chemical and organoleptic properties.

All the collections showed variability in tree characters, inflorescence characters, fruit characters, quality attributes and pest and disease incidence. At the similarity coefficient status of 6 per cent, grouping of collections were done which resulted in 12 non-overlapping clusters. Tree characters *viz*., age of the tree (20 to 35 years), tree height (12 m to 20 m), trunk girth (0.95 m to 4.1 m), crown shape (pyramidal, broadly pyramidal, spherical, semi-circular and irregular), Leaf length (9.1 cm to 17.5 cm), leaf width (2.3 cm to 6.5 cm), leaf shape (broadly ovate and lanceolate), shoot length (7 cm to 26 cm) and internodal length (7.7 cm to 12.2 cm) were observed.

Only 17 trees were flowered during the period of study. Variation in flower characters such as position of inflorescence (axillary), flower composition in the inflorescence (solitary and cluster), flower colour (white), flowering season (December and January), duration of flowering (26 days to 42 days) were recorded.

At the similarity coefficient status of 40 per cent, grouping of collections were done based on fruit characters, which resulted in 5 non-overlapping clusters. Variation was observed with respect to fruiting season (March-April and April-May), days from flowering to fruit maturity (62 days to 68 days), fruit set to maturity (58 days to 64 days), fruit clustering habit (solitary and cluster), fruit weight (5.91 g to 12.28 g), fruit volume (5.32 cc to 11.40 cc), number of fruits per cluster (3 to 12), specific gravity (0.91 to 1.23), fruit length (1.61 cm to 3.10 cm), fruit width (1.24 cm to 2.41 cm), fruit shape (oblong), fruit colour (blackish purple), firmness/softness (4.09 kg cm^{-2} to 9.94 kg cm^{-2}), juice content (14 per cent to 44 per cent), pulp content (77.50 per cent to 90.39 per cent), seed weight (9.60 per cent to 22.49 per cent), pulp/seed ratio (3.24 to 9.41) and yield $tree^{-1}$ (10 kg $plant^{-1}$ to 54 kg $plant^{-1}$).

At the similarity coefficient status of 7 per cent, grouping of accessions was done based on quality attributes, which resulted in 12 non-overlapping clusters. The percentage of moisture (65 per cent to 82.50 per cent), acidity (0.18 per cent to 0.58 per cent), TSS (9.20° Brix to 15.50° Brix), anthocyanin (44.64 mg 100 g^{-1} to 63.35 mg 100 g^{-1}), pH (1.80 to 3.17), reducing sugar (5.89 per cent to 20.16 per cent) and total sugar (12.82 per cent to 22.95 per cent) were estimated. Sensory evaluation *viz.*, colour, sweetness, taste, appearance and texture were recorded based on 9 point hedonic scale. From the sensory evaluation KJ- 45 was found to be promising types with respect to appearance, colour and sweetness. With respect to taste and texture KJ- 39 and 47 were found promising when compared with all collections. Minor incidence of pest (gall midge) and disease (leaf spot and sooty mould) were observed during the study.

Among the collection, KJ- 45 has higher yield (54 kg $plant^{-1}$), TSS (15.6° Brix), fruits per cluster (12), fruit weight (12.28 g), pulp/seed ratio (9.41) and anthocyanin content (64.35 mg 100 g^{-1}). Hence, KJ- 45 is considered as superior tree followed by KJ- 48, KJ- 47 and KJ- 7.

Appendices

Appendix – I

Weather data Aug 2014 – Dec 2015 – Vellanikkara

Month	Temperature (°C)		Relative Humidity (%)	Rainfall (mm)
	Maximum	Minimum		
Aug 2014	29.5	23.2	87	599.8
Sep 2014	31.3	23.3	82	215.1
Oct 2014	31.9	23.7	81	224.6
Nov 2014	31.6	23.2	72	85.3
Dec 2014	31.9	23.2	65	9.6
Jan 2015	32.5	22.1	58	0.0
Feb 2015	34.3	23.0	55	0.0
Mar 2015	35.8	24.9	63	72.0
Apr 2015	34.0	24.6	77	162.2
May 2015	32.9	24.7	80	259.0
Jun 2015	31.0	23.9	85	629.8
Jul 2015	30.3	23.5	85	510.1
Aug 2015	31.0	23.7	83	320.8
Sep 2015	31.9	23.7	81	242.2
Oct 2015	32.5	24.1	79	203.8
Nov 2015	31.6	23.8	75	151.2
Dec 2015	32.3	23.3	65	88.3

Appendix – II

Score card for organoleptic evaluation

Name of the judge:

Date:

Characteristics	Scores				
	KJ- 1	KJ- 2	KJ- 3	KJ- 4	KJ- 5
Appearance					
Colour					
Texture					
Sweetness					
Taste					

9 point Hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1