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THE JAMUN

(Syzygium cuminii Skeels)

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1. INTRODUCTION

Jamun (*Eugenia jambolana* or *Syzygium cuminii* Skeels) is an important but under - exploited indigenous fruit tree of India. It is a very common, large, evergreen beautiful tree of the Indian subcontinent. It belongs to the myrtaceae family. The other common names of jamun are java plum, black plum, jambul and Indian blackberry. Jamun has promising therapeutic value due to its various phyto-constituents such as tannins, alkaloids, steroids, flavonoids, terpenoids, fattyacids, phenols, minerals, carbohydrates and vitamins. Its pharmacological properties like hypoglycaemic, diuretics, analgesic, anti-inflammatory, antiplaque, antimicrobial, antidiarrhoeal, antioxidant, gastro-protective and astringency have been proven on animal systems. Diabetes management through use of *Syzygium cuminii* has been demonstrated. Majority of the studies of *Syzygium cuminii* as anti-diabetic agent with its possible mechanism of action and delaying complications of diabetes such as cataract and neuropathy have been conducted but detailed studies on isolation of bioactive compounds and clinical trials followed by standardization are seriously required to know the full potential of plant and fruits. The pharmacological trials were mainly carried out using seeds of *Syzygium cuminii* but the potential of other parts of the tree need to be explored.

Jamun fruit has considerable nutritive value. It is a good source of iron apart from being the source of minerals, sugars and other phytochemicals (Singh *et al.*, 1967). The fruits have sub-acid spicy flavour and commonly used as dessert. Apart from eating as fresh, it can also be used for the preparation of delicious beverages, jelly, jam, squash, wine, vinegar and pickles (Ochse *et al.*, 1961).

Origin and History

It has originated from Indonesia and India, now growing abundantly in Southern Asia (Periyathambi, 2007).

Species distribution in the country

Species	Common name and use	Distribution
<i>S. aquem</i>	Watery Rose-apple, fruits edible	A small tree distributed in Assam and Meghalaya
<i>S. amottlanum</i>	Fruits edible	Western Ghats, The Nilgris, Palani and Anamalai hills
<i>S. aromaticum</i>	Clove, dried flower buds commercially important	Evergreen trees cultivated in Tamil Nadu and Kerala
<i>S. claviflorum</i>	Fruits edible	The Andamans
<i>S. fruticosum</i>	Wild jamun	Avenue tree
<i>S. jambos</i>	Rose-apple	Many parts of India

<i>S. mappaceum</i>	Ornamental plant	Assam, Meghalaya, Arunachal Pradesh and Tamil Nadu
<i>S. samarangense</i>	Wax Jambu, Fruits edible	The Andamans and many parts of India
<i>S. zeylanicum</i>	Fruits edible	Maharastra, Karnataka, Orissa, Kerala and Andamans
<i>S. javanica</i>	Water apple	South India and West Bengal
<i>S. zeylanicum</i>	Fruits edible	Western Ghats of India.

***Syzygium cuminii* (Java plum, Jamun):** Large, evergreen beautiful tree of the Indian subcontinent but has also naturalized throughout Southeast Asia and the Pacific Islands. It is widely cultivated in Haryana as well as the rest of the Indo-Gangetic plains on a large scale. Fruits are generally ovoid to oblong in shape, deep purple or bluish in colour, having juicy, sweet pulp and a small stone.

***Syzygium jambos* (Rose apple):** Trees are medium, evergreen and grown in Assam, Bihar, Andhra Pradesh, Tamil Nadu, West Bengal, coastal areas of Maharashtra and Gujarat. Leaves have very small petiole and calyx persistent. Fruits are light yellow- white in colour, rose scented and seeds are polyembryonic.

***Syzygium fruticosum*:** Trees are suitable for windbreak and have straight growth habit. Fruits are edible and small.

***Syzygium densiflora*:** Suitable for use as rootstock for *Syzygium cuminii*. It is resistant to termites attack.

***Syzygium uniflora* (Surinam cherry or Pitanga cherry):** A small tree and bears small-sized fruits having bright red colour and aromatic flavour. The tree is found in South India.

2. USES

Jamun tree besides its nutritive fruits is useful in many ways. The foliage serves as fodder for cattle, especially during drought. The twigs form good datoon (tooth brush) and as rough painting brush. The timber is used in buildings, agricultural implements, railway sleepers and well work as it resists the action of water. Most commonly it is found planted along the avenues or as a wind break on the boundary of the orchards and also for fruits (Anon., 1976).

Jamun (*Syzygium cuminii* Skeels) is a nutritious fruit with a variety of uses (Table 1). The nutritive properties of the species have been extensively studied, particularly with reference

to the pulp and seed. The fruit is a good source of anthocyanins, iron, pectin, phenols and protein. Fully ripe fruits are eaten fresh and can be processed into a variety of products like jelly, jam, squash, wine, vinegar and pickles. Fruit has sub-acid spicy flavour and squash is a very refreshing drink for quenching the thirst in summer season. Unripe fruit is used for making vinegar. The juice is also carminative, diuretic and gives a soothing effect to the human digestive system. The juice of ripe fruit is used for preparing sauces as well as beverages. It is also dried with salt and preserved as a digestive powder or churan.

Jamun fruit is known to reduce the blood sugar levels and is acclaimed very good for the management of *Diabetes mellitus*. Seeds contain glucoside “jamboline” and “ellagic acid” possessing abilities to check the conversion of starch into sugar in cases of excess production of glucose. “Shaligram Nighantu Pharmacopeia” in ancient India also recommended the use of jamun seeds for the management of diabetes as it reduced urine sugar quickly. Other constituents of the fruit include resin, albumen, gallic acid, essential oil and tannic acids (<http://www.healthandyoga.com/html/product/diabetic.html>). Tribals are long known to use the leaves as such further studies are needed to show the efficacy of the leaves in amelioration of diabetic conditions. A mixture of jamun and mango juices in equal quantity is very good for quenching thirst commonly seen in diabetic patients. A little quantity of fruit syrup is much useful for curing diarrhoea. The vinegar prepared from juice extracted from slightly unripe fruit is stomachic, carminative and diuretic apart from having cooling and digestive properties. Small jamun fruits, which constitute a large proportion of the genetic diversity, not suitable for table can be exploited in the beverage industry as they contained appreciable amounts of acid, tannins and anthocyanins.

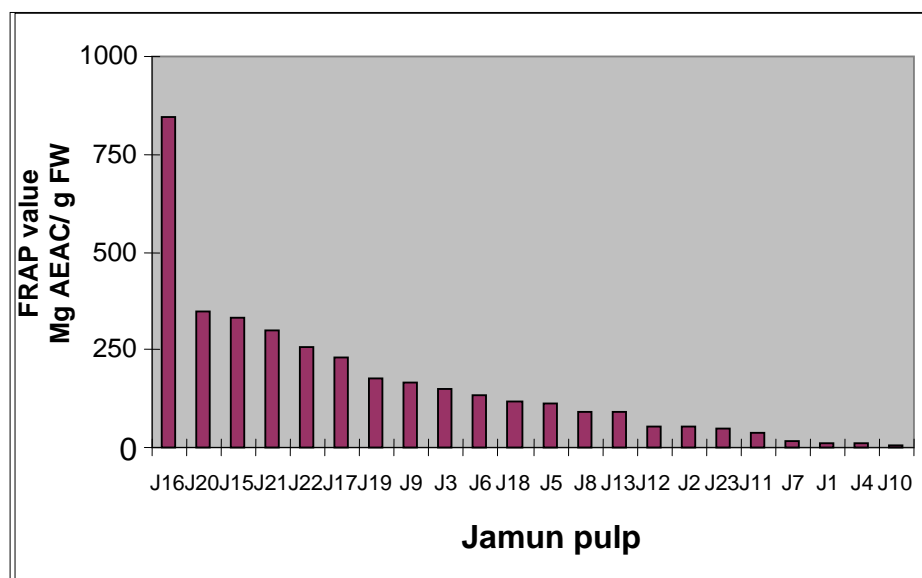
The seed as well as bark have found several applications in Ayurveda, Unani and Chinese systems of medicine. The seed is rich in protein and carbohydrates besides containing traces of calcium. These are widely used as cattle feed, a medicine against hyperglycemic conditions and antidote in soft-food poisoning. The fruit is a good source of carbohydrates, protein, vitamins, anthocyanins, pectin, minerals and tannins.

Table 1. Nutritive value of jamun fruits (per 100g of edible portion)

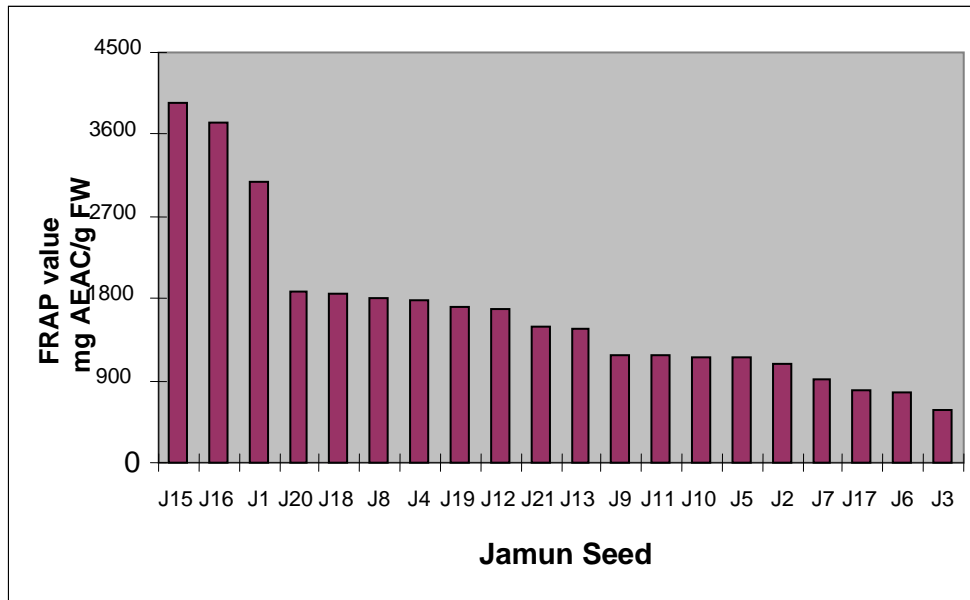
Moisture (%)	83.7 - 86.4
Energy (kcal)	62 - 39
Acidity (%)	0.524 -0.772
Total sugar (%)	8.41 – 10.68
Reducing sugar (%)	8.40 – 9.85
Protein (%)	0.53-0.65
Carbohydrates (%)	14.0

Fat (%)	0.15
Crude Fiber (%)	0.6-1.2
Mineral matter (%)	0.4
Pectin (%)	2.3-3.7
TSS (%)	9.0 – 17.4
Anthocynins (mg/100g)	115.38- 210.76
Tannins (mg/100g)	201.50 - 386.25
Antioxidant value (FRAP mg AEAC/g)	112.38 - 907.75
Flavonoid (mg/g)	0.50 - 1.54
Carotenoid (mg /100g)	12.38 - 22.34
Vitamin C (mg/100g)	10.70 – 29.52
Amino acids (mg/100g)	7.2 - 9.0
Vitamin A (IU)	73 – 100 IU
Thiamine (mg)	0.008-0.03
Riboflavin(mg)	0.009-0.01
Niacin (mg)	0.2-0.29
Calcium (mg)	8.3 - 15
Iron (mg)	0.8 - 1.2
Magnesium (mg)	4- 35
Phosphorus (mg)	15 - 30
Sodium (mg)	26.2-- 34.1
Potassium (mg)	55 - 50
Copper (mg)	0.23 mg
Sulfur (mg)	13 mg

Source: Bose *et al*, 2001 and Anon., 2008



Total antioxidant value in fruit pulp of different accessions



Total antioxidant value in seeds of different jamun accessions

3. Genetic diversity

Diversity exists in respect of vegetative growth, aspects of spread, leaf shape and fruiting habit and maturity (June - August). However, very little work has been carried out to understand and exploit the genetic resources of jamun. The crop is facing severe threat of genetic erosion as a result of urbanization and intensive agriculture. The genetic diversity of the related wild *Syzygium spp.* is of particular value in search for sources of resistance to races/pathotypes of fungi, bacteria, viruses and nematodes besides winter hardiness and resistance to drought and salinity.

A number of seedling strains with considerable variation available in respect of fruit shape, size, pulp colour, TSS, acidity and earliness particularly in Uttar Pradesh, Gujarat and Maharashtra can offer good scope for selection of better varieties. Percy and Bose (1965) noted that F₁ hybrid from a cross between the Alba variety of water apple (*S.javanicum*) and rose apple (*S. jambos*) had prolific bearing with large fruits than those of the parents. The fruits contained fragrance and sweetness of rose apple.

Majority of jamun trees available in India are of seedling origin. Owing to cross-pollination and seed propagation, there is enormous variability in respect of fruit morphology, fruit quality, maturity and productivity. Explorations carried out, particularly in the eastern Uttar Pradesh, indicated considerable variability in respect of fruit shape (round, oval, oblong, perform), fruit base (flat, necked), fruit apex (flat, pointed), skin colour (deep purple, purple-

pink, bluish-black, black), flesh colour (purple, purple-pink, white), fruit weight (5.77 - 19.73 g), fruit length (2.06 - 3.81 cm), fruit diameter (1.94 - 2.98 cm), seed weight (0.141 - 1.94 g), seed length (1.6 - 2.4 cm), seed diameter (0.8 – 1.3 cm), pulp content (54.29 – 85.71 %), TSS (4.5 – 17 °Brix), acidity (0.524 - 0.832 %), pulp: seed ratio (3.03 - 46.38), moisture (84.5 - 86.4 %), total sugars (5.32 - 11.10 %) which need to be characterized for utilization in crop improvement (Anon., 2007).

Ashraf *et al.* (1987) reported that fruit shape varied from round to oblong and apex of fruits from flat to pointed. They also observed great variability in physico-chemical characteristic of fruits, offering possibility of selecting varieties suitable for fresh market and processing. Small seed size and high pulp content with better chemical parameters are considered ideal. Singh *et al.* (1999) evaluated eight accessions of jamun under Faizabad conditions and reported that oblong types had more fruit weight with relatively lesser seed weight. Among the locally available types in West Bengal, Selection No.1 (oval shaped large fruit) and Selection No.2 (cylindrical shaped medium sized fruit) proved better on the basis of yield and fruit quality attributes. Surveys undertaken in Karnataka to investigate the nature and extent of variability present in seedling progenies indicated good variability in respect of plant girth, leaf area, petiole length and leaf length to petiole length ratio (Prabhuraj *et al.*, 2002). A survey in north Goa indicated a wide range variation in fruit weight (3.42 - 13.67 g), length (3.31 - 5.26 cm), girth (5.21- 9.82 cm), pulp (58.57 - 84.55 %), TSS (12.00 -26.8 °Brix), titratable acidity (0.59 - 1.63 %), total sugars (6.87 - 25.31 %) and sugar: acid ratio (15.39 - 27.92) (Devi *et al.*, 2002).

3.1 Genetic improvement

i) Clonal selection

Improvement is needed for higher productivity and quality of fruits in terms of edible portion, colour, shape, taste and flavour. Since, jamun is predominantly raised through seeds, wide variability prevails in seedling populations in different regions resulting into non-availability of recognized cultivars. Different types are found growing with considerable variations in respect of bearing habit, size, shape of fruits, and quality. This provides ample scope for clonal selection, which can form the immediate basis for crop improvement. Central Institute for Sub-tropical Horticulture, Lucknow has identified two promising selections, *viz.* CISH J – 37 and CISH J – 42 (seedless), by adopting this approach.

ii) Biotechnological interventions

Biotechnological approaches for improvement in crop hold great promise. Advances in plant biotechnology including micropropagation, somatic embryogenesis and association mapping could be gainfully exploited. Micropropagation and somatic embryogenesis rely on cell and tissue culture. Marker aided selection (MAS) could offer precise approach to make crosses in order to introgress targeted characters into prevailing heterozygosity and genetic maps of *Syzygium* could be prepared for further improvement.

Molecular characterization of available germplasm in jamun was carried out at CISH, Lucknow by using multilocus marker system, as there is dearth of sequence information. The cluster analysis (UPGMA) based on 133 RAPD markers produced a dendrogram of genetic relatedness of the selected jamun accessions. The accessions could be discriminated with the help of these primers. Accession Nos. J -33 and J -30 clustered together and were most similar (similarity coefficient 0.898). The dendrogram separated the accessions into four main clusters according to their geographical origin. The Nos. J -34 and J -37, which are selections from seedling populations of Lucknow region, shared close similarity. J-36 and J-22 occupied distant branches sharing the least similarity with other accessions (Anon, 2007).

iii) Variety wealth

There are no standard varieties available in the country and a common type grown in north India is popularly known as '*Rajamun*'. Another type with large sized fruits, known as 'Paras' in Gujarat, is also popular. A selection Narendra Jamun -6, identified with desirable traits at Faizabad, however, is yet to be popularised.

In recent years under ICAR funded National Network Project on Underutilized Fruits (NNPUF) intensive work on jamun was carried out at CISH, Lucknow. As a result, the following superior accessions have been identified and established in the field gene bank. The following are the salient attributes of the identified selections:

CISH J-37: A superior accession selected at Central Institute for Subtropical Horticulture, Lucknow derived from the mother tree with a height of 12 – 15m, trunk girth 1.95 m, canopy spread E – W 14.10 m and N – S 12.70 m, yield 200 – 300 kg plant⁻¹ (about 45 years old) and mid season maturity during the second week of June. The fruit is oblong and has average weight 24.05 g, length 3.90 cm, diameter 3.03 cm,



CISH J – 37

pulp 92.26 per cent, TSS 16.4 °Brix, ascorbic acid 49.88 mg/100g and total antioxidant value 38.30 mg AEAC/g (Anon, 2007).

CISH J-42: Seedless accession selected by Central Institute for Subtropical Horticulture, Lucknow during 2008 from Chandauli district of U.P. It was multiplied by vegetative propagation and established in the field gene bank. The mother tree has a tree height 10 – 11.5 m, trunk girth 1.50 m, canopy spread E – W 10.20 m and N – S 11.70 m, yield 180 – 250 kg tree⁻¹ (about 65 years old tree) and mid season maturity during the second week of June. The fruit is round shaped and has average weight 6.87 g, length 2.57 cm, pulp 97.9 per cent, TSS 14.7 °Brix, ascorbic acid 34.14 mg/100g and total antioxidant value 15.54 mg AEAC/g and has better shelf life (Anon, 2007).



CISH J – 42 (Seedless)

Jamun GJ-2: It was collected from Ode village in Anand district of Gujarat. Peak period of flowering is in the month of March. It is an early type, matures in the fourth week of May; fruits are oblong shaped with an average 20.0 g fruit weight, 85.00 per cent pulp, 18.0 °Brix TSS, 0.38 per cent acidity, 12.50 per cent total sugars and 45.43 mg/100g ascorbic acid. Fruit yield per plant was 28.00 kg at seventh year of age.



GJ – 2



Jamun GJ - 2

Jamun GJ-8: The accession was collected from Ode village of Anand, Gujarat. The peak period of flowering is in the month of March. It is also an early type, fruit is oblong in shape and matures in the first week of June having 17.0 g average weight, 83.33 per cent pulp, 16.0 °Brix TSS, 0.40 per cent acidity, 11.20 per cent total sugars and 47.12 mg/100g vitamin C. The observed fruit yield per plant was 12.00 kg at sixth year of age.

Rajamun: It bears large-sized (length 2.5-3.5cm), oblong, deep purple fruits having purple pink, juicy and sweet pulp and small seed. Fruit matures in June-July.

Late maturing type: It bears a small sized (length 1.5-2.0 cm and diameter 1-1.5cm), slightly round fruit, deep purple or blackish in colour at full ripe stage. The stone is comparatively large in size. Fruits matures in the month of August.

A seedling selection Paras: It is a seedling selection which yields sweet fruits. Considerable tree variation exists in Pune and Ahmednagar districts of Maharashtra. Extracts of stems, leaves, buds and flowers possess moderate antibiotic activity against *Micrococcus*.

Konkan Bahadoli: It is a seedling selection identified by RFRS, Vengurla. The average weight of fruit is 14 to 16 g with 16 ° Brix TSS.

4. Botany

Jamun belongs to the important genus *Syzygium* having chromosome number $2n = 40$ of the family Myrtaceae (Chundawat, 1990). Genus *Syzygium* consists of about 75 indigenous species of which only a few are of commercial significance. The *Syzygium cuminii* Skeels is a large evergreen tree producing dark purple date-like fruits with prominent elongated seeds. Other related species is *S. jumbos* (rose-apple or safed jamun). It is found in the lower ranges of the Himalayas up to an elevation of 1300 meters and in the Kumaon hills up to 1600 meters. It is widely grown in the larger parts of India from the Indo-Gangetic plains in the North to Tamil Nadu in the South. Its fruits are light yellow in colour with good aroma and sub-sweet taste. Other species *S. fruiticosum* and *S. uniflora* bear small-sized edible fruits, whereas *S. densiflora* is free from termite attack, thus, making it suitable for use as rootstock for *S. cuminii* (Singh and Srivastava, 1999).

Vegetative and flowering

New vegetative shoots emerge as terminal growth on the previous seasons branchlets. The new shoots emerge in two distinct flushes, i.e., from February to May and August to October. The flush, which appears in the month of February, provides maximum growth and flowering. Flower bud differentiation occurs on 5 to 10 months old branches starting from the last week of January and continues for 43 days (Misra and Bajpai, 1971). Under natural conditions, pollination is effected by honeybees, houseflies and wind. It is a cross pollinated fruit crop hence keeping bee hives (10-12/ha) is desirable for maximum fruit set and high yield.

Flower biology

Flowers are borne in terminal and axillary inflorescences on about 5 months to one-year-old branches. In North India, perfect flowers are borne during March - April. The panicle emergence usually occurs from 1st week of March and maximum flowering from 15th March to 21st April. Each inflorescence has 40-50 flowers, which are club shaped. Flowers are regular, bisexual, polysepalous and polypetalous having 5 calyx, 5 corolla, 8 stamens and a simple style. Before opening, the flower buds attain a size of 5.2 mm in length and 5.0 mm in diameter and require 28 to 30 days from the appearance of flower bud to flower opening.

Anthesis starts at around 8 am and lasts approximately 10 hours peaking between 10 am - 12 noon. Maximum number of flowers open between 5 and 6 pm. Anthesis in some flowers was also noted in the morning between 5 and 6 am. Dehiscence of anthers starts just after the opening of flowers. Pollens are triangular, fertile, 15 – 20 µm in size and creamish white in colour. The pollen fertility is high in the beginning of the season and decreases as the season advances. The pollen could be stored successfully for 9 months at a temperature of 23 °C in completely dry atmosphere. The stigma becomes receptive, a day prior to anthesis and remains so up to 5 days after. The maximum receptivity, however, lasts a day after anthesis (Misra and Bajpai, 1975). Selfing by bagging results in good fruit set and usually fruit set starts from 12th April and lasts up to 10th May. Fruit set by hand pollination indicated that 45-50 per cent occurs by self-pollination and 30-40 per cent by cross-pollination.

Flower morphology

Parameter	Range
Number of flowers/ inflorescence	100-200
Length of stamen	5.83 – 7.88 mm
No. of active anthers in a flower	59.80 – 62.40
Anther size	0.63 – 0.67 mm
Pollen shape	Triangular in dry, while circular when hydrated.
Pollen size	15 - 20 µm (dry), 20 µm (hydrated)
Pollen viability	90 - 95 %
Length of style	8.29 – 8.37 mm
Width of gynoecium	3.17 – 3.49 mm
Stigma receptivity	One day prior to anthesis and remains receptive up to 2 to 4 days after anthesis

Fruiting habit

Fruits are borne terminally/axillary on 5-12 months growth. On the basis of fruit shape, fruits can be categorised into ovoid and oblong types. The ovoid types have flat base and apex, whereas oblong types have mostly necked base and pointed apex. In general, the oblong types have more fruit weight and relatively less seed weight. Pectin content is also more in the oblong type.



Flowering panicle in full bloom

Flowering and fruiting



Initial fruit set

The number of days taken for bud development to complete flower was maximum (49.2 days) in western direction followed by north and south directions (48.6 and 46.4 days, respectively) of the tree, while minimum (46.0 days) was required in eastern direction. The period of full blooming of a panicle was (7.0 days) in western direction followed by northern southern and eastern (6.8, 6.6, 6.4 days respectively) direction of the tree. The days required for bud emergence to full bloom of a panicle were 56.2, 55.4, 52.8, and 52.0 days, respectively in western, northern, southern and eastern directions of the tree. The time required for bud initiation to anther dehiscence in western direction was maximum (50.2 to 57.2 days) followed by northern (49.6 to 56.4 days) and southern (47.2 to 53.8 days) directions, while minimum (47.0 to 53.0 days) was recorded in eastern direction of the tree. The maximum period from anthesis to fruit ripening was 70.2 days in western direction of the tree followed by northern southern and eastern (69.6, 67.9 and 67.0 days respectively) directions of the tree.

5. CLIMATE AND SOIL

Due to wider adaptability jamun can be grown successfully under tropical and subtropical climates. It is hardy and can tolerate both short periods of drought as well as heavy rainfall and can also withstand floods (Chovatia and Singh, 2000). It can be grown successfully in semi-arid subtropical regions with an annual rainfall varying from 350 to 500 mm. It is also found growing in the lower ranges of the Himalayas up to an altitude of 1300 meters. However, in early periods of growth, protection from frost is needed. Its cultivation can be introduced in arid and semiarid, resource-poor and wasteland areas where other crops are difficult to grow. It requires dry weather at the time of flowering and fruit setting. In subtropical areas, early rain is beneficial for proper development of fruit size, colour, maturity and taste.

Jamun can be grown on wide range of soils. Vigorous growth and high yield, however, could be obtained only when grown on deep loam and well drained soils but have the capacity to retain good soil moisture. It tolerates sodic and saline soils and can also be grown in ravines and degraded lands. Plants are reported to survive even in alkali soils up to 10.5 pH. Plantations in very heavy and light soils should be avoided

6. QUALITY PLANTING MATERIAL

Seed propagation is widely practised in different regions. Vegetative propagation is essential in order to propagate true to type trees of improved and selected accessions types. The enormous variation found in different regions is due to sexual propagation and cross-pollination (Priya Devi *et al.*, 2002). Rootstock selection for vegetative propagation of jamun

is important as it controls the vigour and balances the growth, yield and quality. Dwarfing rootstocks are required to manage critical cultural operation, hence focussed work is to be initiated and standardized for different agro-climatic conditions. The different methods of vegetative propagation, have been optimised at CISH, Lucknow. The details are furnished below:

a) Raising of rootstocks

Raising of rootstocks in open nursery beds and lifting grafted plants for supply with earth ball in sandy soils is practically difficult. Further, transportation of plants over long distances may also cause high mortality particularly under semi-arid and arid environments. In order to reduce the time for raising rootstock seedlings and to avoid damages during handling and transportation, containerization in polythene bags could be adopted on a commercial scale. Generally, polythene bags (16" x 6") and polythene tubes (10" x 4") with perforation in the bottom and sides are used for raising the rootstocks. They are filled with standard potting mixture for raising rootstock seedlings. Seeds are sown in each bag and then placed in trenches, so that it can be irrigated easily and for appropriate microclimate.

b) Soft wood grafting

Soft wood grafting was performed during each calendar months of the year at the Institute. Seedling rootstocks raised in containerized nurseries with solarized potting mixture were maintained with regular cultural care for 10-12 months to attain graftable size (pencil thickness). Activated scion sticks (about 7-10 days earlier to grafting) of matching size and 6-8 inches length were sourced in the months of July and August. The rootstock seedling was cut to a length of about 9 inches from the level of soil in polybags and a wedge prepared to a depth of about 2.5 inches. The activated scion stick with matching slant cuts of 2"-2.5" length on either side to form wedge was placed into the cut of similar length made on the rootstock to perfectly match the respective cambiums and firmly secured with a polythene tape of 100 gauge. The grafts were then placed in climate controlled polyhouses to facilitate union and growth. The time taken for bud sprout was minimum (16 days) in the months of February and March. Maximum success rate (80 %) in grafting was recorded during the months of March, April and July (Anon., 2007). This method was found better for *in situ* grafting under rainfed conditions. Soft wood grafting was successful for multiplication under Karnataka conditions (Madalageri *et. al.*, 1991). Chovatia and Singh (2000) recorded 41.67 per cent success through soft wood grafting in the month of June under Gujarat conditions.



Soft wood grafting in jamun

c) Veneer grafting

Veneer grafting was performed on 8-10 months old rootstocks during each calendar month of the year. Rootstocks were raised in polybags with solarized potting mixture and maintained for 10-12 months to attain graftable size (pencil thickness). Activated scion stick (about 7 – 10 days earlier to grafting) of matching size and 6-8 inches in length was sourced in the months of July and August. On the rootstock seedling, at a height of about 9 inches from the level of soil in the nursery, slanting veneer cut was made to a depth of about 2.5 inches. The activated scion stick with matching slant cuts on either side was placed into the veneer slot made on the rootstock and firmly secured with a polythene tape of 100 gauge. The prepared grafts were placed in climate controlled polyhouse for 15 days for facilitating union. Success rate of grafting was around 60 per cent when performed during the months of February and March followed by 50 per cent in the month of September (Anon., 2007).

d) Budding:

In situ and *ex situ* buddings performed on young seedlings of jamun at the institute showed 68 per cent success during the month of February (Anon., 2007). The bud wood sourced from 1 – 2 year old vigorously growing shoots when patch budded on one year old and 10 -12 mm thick rootstock during the months of July – August offered better success. Shield, patch and

Forkert methods of budding could be adopted successfully. Patch budding was found successful in the month of June under Gujarat conditions (Chovatia and Singh, 2000).



In – situ budding in jamun



Ex – situ budding in jamun

e) Inarching

One-year old seedling rootstocks were inarched with matching scions during the months of June-July. The propagation of plants through inarching has not been adopted commercially though it has high success rate (>90) as it is cumbersome and only limited number of plants could be produced. It also affects the vigour of the mother plant.

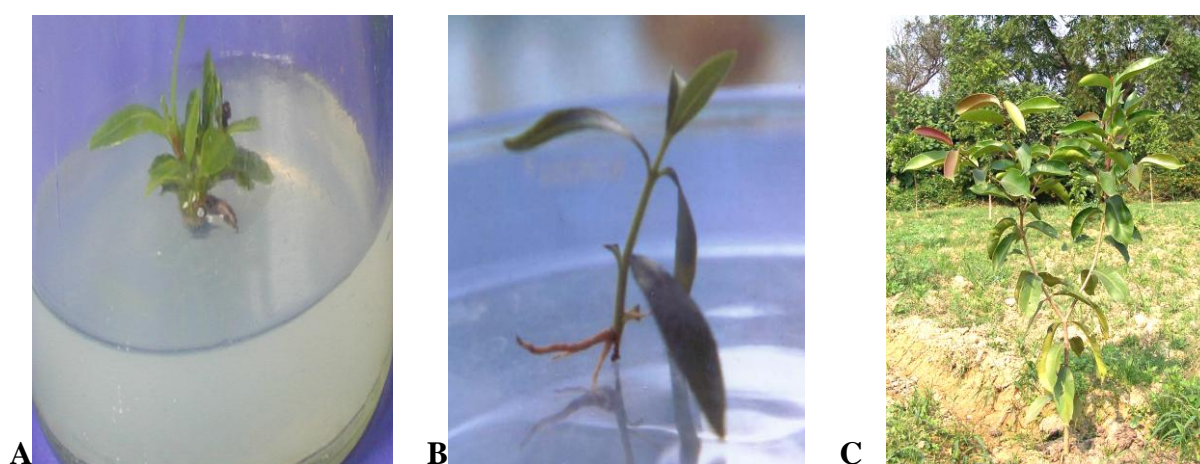
f) Top working

The old, unproductive trees or damaged young plants could be invigorated by top working employing scion wood or buds from superior clones in the months of July and August.

g) Micropropagation

Multiple shoots could be induced from nodal and shoot tip segments of 10-15 days old seedlings of *S. cuminii* on modified MS medium supplemented with BA singly and in combination with NAA or IBA (Yadav *et al.*, 1990). Excised shoots were placed for root induction on modified MS medium containing NAA or IBA and then transferred to MS basal medium to form complete plantlets. The plantlets were acclimatized and successfully transferred into the soil. Remashree *et al.* (2007) induced multiple shoots from nodal explants of 10 year old elite trees of *S. cuminii* on MS medium supplemented with 2.5 mg kinetin l⁻¹. Explants taken from *in-vitro* proliferated shoots produced further multiple shoots when cultured on the same basal medium containing 2.5 mg kinetin l⁻¹. Repeated subculture resulted into rapid shoot multiplication at an average of 10 shoots/subculture. Jain and Babbar

(2000) obtained multiple shoots from the epicotyl segments bearing scaly leaves, excised from *in-vitro* grown seedlings of *S. cuminii*, on MS medium supplemented with different concentrations of BA. Average of 8.6 shoots/explant was produced in 60 days after inoculation, following transfer to fresh medium after 30 days. The shoots were excised and the residual explants were transferred to fresh medium, where they again developed shoots. A protocol has been developed to raise plants of *S. cuminii* throughout the year. Somatic embryogenesis was found successful for multiplication of jamun plants (Litz, 1984). A successful micropropagation protocol, of *Syzygium cuminii*. Skeels has been optimized at CISH, Lucknow using nodal explants from mature trees.



Proliferation of microshoots (A), rooting of microshoot (B) and field establishment of micropropagated plant of jamun (C).

7. CULTURAL HINTS

Orchard establishment

Land is prepared by usual ploughing, harrowing and leveling. There should be a gentle slope to facilitate proper irrigation and drainage to avoid water stagnation during the rainy season. Jamun could also be grown under different cropping systems, i.e., either as pure crop or as a component of horti-silvi pastoral models or as a hedgerow. It is an excellent candidate as a windbreak when established on the periphery of any orchard. It is usually spaced at 8 x 8 m (156 plants ha⁻¹) in square system and planted in pits of 90 x 90 x 90 cm which are usually dug during summer months. While digging, it is necessary to keep the topsoil and subsoil separately in two heaps near each pit for about 2-4 weeks for weathering to destroy harmful soil microorganisms and pests. Well-decomposed organic matter is mixed with soil (1:3) and pits are filled. Planting is done during the rainy season when the soil in the pits has stabilized.

While planting, one should be careful to see that the earth ball of the nursery plant remains intact and graft union well above the ground level. The planting should preferably be done during cloudy weather in the evening and plants are staked followed by irrigation. The best time of planting is July-August. In the initial 2-3 years of orchard establishment, it is



Established orchard of jamun at CISH, Lucknow

advisable to protect plants against low temperature injury during severe winter by covering plants with of cover, while exposing the eastern side for light interception.

Spacing

No standard spacing is available for recommendation as exclusive commercial plantings are non-existent. The plants of jamun were planted at a distance of 10 x 5 m (200 plants/ha) and 5 x 5 m (400 plants/ha) for studies on canopy development, flowering, fruiting pattern and yield at CISH, Lucknow. The plants of CISH J-37 have also been planted under high density planting system at 2.5 x 2.5 m (1600 plants/ha) with canopy management for higher productivity.



High density planting of jamun at CISH, Lucknow

Canopy management

Jamun since is a vigorous tree, canopy management is required for ensuring maximum utilization of light, avoidance of the build-up of microclimate congenial for diseases and pests, ease of cultural operations and maximizing the productivity and quality. Basically, it starts with training as a potential tool, right from initial stage of



Palmette System



Open center

planting to manage the canopy architecture of the plant. Young plants should

be allowed 3-5 well spaced scaffold branches above 60 cm from the ground level to develop the main framework. It is followed by pruning to regulate tree size and shape to achieve a desired architecture of the canopy with a network of primary, secondary and tertiaries and also to reduce the foliage density by removing the unproductive branches. Regular pruning of jamun plant, however, is not required, restricting the operation

to only removal of dry, weak and diseased branches. Two systems of initial training, i.e., open center, palmette system and Y shape, have been adopted at CISH, Lucknow for evaluation.

Weed management

Weeds harm the crop production very slowly in a subtle way. Most weeds complete their life cycle in a shorter time compared to the fruit trees and compete for light, water and mineral nutrients impacting tree vigour leading to reduced yields. In new as well as old orchards hoeing, hand weeding and ploughing of the land 2-3 times a year are carried out to suppress weed growth and maintain tilth. Intercropping and mulching may also be followed to control weeds and additional income.

Water and nutrient management

Generally, jamun trees are not manured as they are hardy and are grown under little cultural care. Annual application of about 20 kg FYM per tree during the pre-bearing period and 50 - 80 kg per tree to bearing trees is considered beneficial. On very rich soils the trees have a tendency to put on more vegetative growth impacting fruiting. Under such conditions, the trees should not be manured, irrigation should be given sparingly and withholding water during the months of September - October and February - March. It helps in promoting fruit bud formation, blossoming and fruit setting.

Jamun leaf litter available below the canopy of the plant may form an integral part of the soil fertility management through *in situ* vermiculture in basins for degradation of the biomass. Mulching can be done with black polythene or any organic material. In general, mulching with rice husk and rice straw reduces weed population and conserves the moisture in the soil.

8. CROP PROTECTION

Some of the insects and diseases affecting Jamun production and their management are described below.

Insects

Leaf eating caterpillar (*Corea subtilis*): Caterpillars attack the leaves and tree becomes defoliated. In order to control the pest, spray of dimethoate 30 E.C. (0.06 %) or malathion (0.05 %) during active vegetative growth period is recommended.

White fly (*Dialeurijdes eugenia*): It damages the fruits. Affected fruits get wormy appearance on the surface. It could be managed satisfactorily by maintaining sanitation in the orchard, which consists of picking up the affected fruits and burying them deep in the soil. Area under the tree should be dug, so that the maggots in the affected fruits



and the pupae hibernating in the soil could be destroyed.

Bark eating caterpillar (*Inderbela tetraonis* and *Inderbela quadrinotata*): The larvae feed on live bark tissues, shelters under the covering of silken webbing during the night, later making a tunnel into the branch and stem and remain in the hole during the day time. As a result, the affected tree loses vitality and yield declines. It can be managed satisfactorily by maintaining sanitation in the orchard and injecting 2.0 ml petrol into the holes and then plugging them. Spraying with dimethoate 30 EC. (0.06 %) or acephate (1.5 g/l) at tri-weekly intervals can control the pest effectively.



Jamun leaf miner (*Acrocercops syngamma* and *Acrocercops phaeospora*): The pest causes damage during the reproductive phase, i.e., from April to September. The newly hatched caterpillar mines a narrow thread like silvery gallery on the leaf along the mid-rib upward. The pest can be controlled by dipping and burning of affected leaves followed by spraying of dimethoate 30 EC (0.06 %).

Jamun leaf roller (*Polychorosis cellifera*): The larvae web the leaves by folding the tip downwards on both the margins parallel to the mid-rib and feed inside. In case of severe attack 1/4th of the lamina is eaten up. The pest undergoes 3-4 generations between March - April and September - October in north India. The second generation is most harmful. Regular clipping and burning of affected leaves can keep the population under control. In case of severe attack, spraying of dimethoate 30 EC (0.06 %) is recommended.

Leaf webber (*Argyroplote aprobola* and *Argyroplote mormopa*): The newly hatched larvae in large numbers web together the tender leaves at shoot tips. Regular dipping and burning of affected leaves can keep the population under control. In case of severe attack, spraying with quinalphos (0.05 %) is recommended.

Fruit fly: Affected fruits are rendered unmarketable following attack of fruit fly. Infected fruits should be collected and buried deep into the soil and soil around the tree trunk dug up so that the maggots in the affected fruits and the pupae hibernating in the soil are destroyed. Birds also damage jamun fruits. For keeping them away, adopting different bird scaring approaches are useful.

Diseases

Leaf spot and fruit rot (*Glomerella cingulata*) have been reported in jamun. The disease affected leaves show small-scattered spots of light brown or reddish brown colour. Fruits

affected with fruit rot disease rot and shrivel. The diseases can be controlled by spraying of dithane Z -78 (0.2 %).

9. HARVESTING, POST- HARVEST MANAGEMENT AND MARKETING

Days to harvest

The number of days taken from anthesis to fruit maturity was maximum (70.2 days) in western direction of tree followed by north, south and east (69.6, 67.9 and 67.0 days, respectively), directions of the tree.

Maturity standards

Optimum stage of maturity based on physico - chemical composition of the fruit has been worked out. In jamun, three distinct phases of fruit growth, *viz.* during the first phase the rate of growth was slow (15-52 days after fruit set), in the second phase (52-58 days after fruit set) the rate of development was quite rapid and the third phase (58-60 days after fruit set) comprised slower growth with little increase in fruit weight, moisture content and total and reducing sugars. Singh and Prasad (1979) studied the respiration rate in developing fruits of jamun at frequent intervals from 15 to 61 days after fruit set. Initially, respiration rate (15-30 days) declined which rose at 56 days (climacteric peak) and again declined until harvest maturity at 60 days after fruit set. Jamun fruit followed a sigmoid curve with the first phase (7-14 days after fruit set), the second phase (14-35 days after fruit set) and the third phase (35-42 days after fruit set). It was also reported that fruit length, fruit weight, fruit volume and moisture content increased during maturation of jamun fruit. The total soluble solids and total and reducing sugars showed a continuous increase as the fruits developed with a marked increase during ripening. A similar trend was also exhibited by the moisture content and acidity. There was a gradual decrease in tannins, whereas pectin rose and then fell during the growth period. TSS: acid ratio and anthocyanin contents followed an increasing trend with advancing maturity and markedly increased during ripening (Garande *et al.*, 1998).

Harvesting

The seedling plants start bearing after 8-10 years, while grafted ones after 4-5 years of planting. The fruits ripen in the month of June –July depending upon the variety and agro-climate. The ripe fruit at full size is deep purple or black in colour and picked immediately once ripens, as it cannot be retained on the tree at that stage. The fruits are delicate and picked singly by hand and care should be taken to avoid any possible damages to fruits. For harvesting, the picker climbs on the tree with a bag of cotton on the shoulder. When the bag is full, either the picker comes down from the tree and empties it into baskets or with the

help of rope lowers the bag down to the ground and person standing below the tree empties the bag into baskets gently. The fruits are generally harvested daily and delivered to markets on the same day as they have very low shelf life. The average annual yield of fruit from a full-grown (20 years) seedling tree is about 80-100 kg and from a grafted one (10 years) it is around 60-70 kg.

Post-harvest handling

After the harvest, traders often place best quality fruits at the top of the containers but the practice neither helps the grower nor the consumer. Considerable variation exists in the quality of harvested fruit due to genetic, environmental and agronomic factors and, therefore, requires grading so as to get suitable returns. Systematic grading coupled with scientific packaging and storage reduces the post-harvest losses, which enables the producer to obtain a competitive price. Fruits should be graded on weight basis to fetch better prices.

Packaging is a vital component to assemble the produce in convenient units and to protect it from deterioration during handling and marketing. Proper packaging protects the fruits from physical, physiological and pathological deterioration in the marketing channel and retain their attractiveness. Fruits are highly perishable and are normally packed in bamboo baskets for transport to local markets. In high end markets, uniform fruits are organized into one kg. cardboard paper boxes.



Jamun fruits in bamboo

Physiological loss in weight (PLW), shrivelling, discolouration and rotting were minimum when packed in bamboo baskets using green leaves as liner. Among different types of containers, shallow plastic crates are better for transportation from field to market in order to prevent bruising losses.

Storage

Jamun fruit is highly perishable and can be kept satisfactorily for about 4-5 days under ambient conditions. A seedless jamun selection, identified by CISH, Lucknow has good shelf- life of 5 - 7 days under ambient conditions and 20 days at low temperature (4 °C), Since seedless jamun can be stored for longer periods with good keeping quality, this selection appears to have good potential for export to nearby countries.

Processing

Jamun has not been exploited commercially for the preparation of value added products. The fruits could be processed into jelly, jam, juice, squash, powder, dates/ raisins, vinegar and wine. Maximum yield of jamun juice with a high level of anthocyanin and other soluble constituents could be obtained by grating the fruits, pure juice may also be preserved by heat pasteurization. However, jamun juice is highly acidic and cannot be consumed as such. A ready to serve beverage having up to 25 per cent juice could be prepared (Khurdiya and Roy, 1985). Juice may also be either concentrated in open pan evaporator to 30 °Brix or in a vacuum concentrator. In a vacuum concentrator, it may be concentrated to 60 °Brix (Kadam, 2001).

Marketing and economics

Marketing problems are acute in jamun owing to their high degree of perishability and season- bound availability. An analysis of the marketing cost indicated that the commission and the transport charges accounted for 80-90 per cent of the total marketing cost (Krishnamurthy and Sudhakar Rao, 2001). Seventy five per cent of the farmers sell their produce at the farm gate to village merchants, retailers and big producers or to the pre-harvest contractors. They can not afford to transport their produce to distant markets due to limitation of costs involved and market forces. Information regarding demand, supply, price, market outlook, knowledge of the consumer's preference and marketing channels is important for satisfactory marketing.

Export potential

APEDA is assisting for enhancing the exports by developing the market intelligence and survey of the potential export markets through providing infrastructure at the growing centre and airports, strengthening of the quality control activities for installing ISO 9000 standards, developing packages of the international standards and air freight subsidy for the products of high value crops/ products. Jamun has tremendous scope for processing and products like juice, squash and vinegar may also be exported to earn foreign exchange.

The richness of genetic resources in jamun along with other fruits could be used to modify human food habits, improving health and even longevity. It is, therefore, necessary to make concerted efforts in collecting, conserving and documenting jamun germplasm and undertake studies on their utilization for crop improvement.

Future thrust:

- Development of early, medium and late maturing varieties.
- Standardization of production technology.
- Canopy architecture engineering for high productivity and agro techniques.
- Anti-diabetic activity guided fractionation and associated attributes in potential germplasm.
- Post -harvest handling and storage.
- Product diversification.

Jamun as known in regional languages

Sanskrit	:	Mahajambu, Ksudrajambu
Assamese	:	Jam
Bengali	:	Jaam, Kalajam
English	:	<i>Syzygium cuminii</i>
Gujarati	:	Gambu, Jamun
Hindi	:	Jamun
Malayalam	:	Njaval
Marathi	:	Jambul
Odiya	:	Jamu
Punjabi	:	Jaamun
Tamil	:	Naval
Urdu	:	Jamun
Kannada	:	Nerale

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