

Original Research Article

Effect of different modes of pollination on fruit yield and quality of wild and cultivated (K-45 and N-20) types of jamun (*Syzygium cumuni* L. skeels)

Abstract

The study evaluated the influence of open, hand and bagged pollination methods on fruit yield and quality of wild type at Ponnampet and cultivated jamun types (K-45 and N-20) at GKVK, Bengaluru. Open and hand pollination resulted in significantly higher fruit set, retention, and yield compared to bagging. Among wild type, hand pollination resulted in better fruit retention (48.80%) and higher pulp content, while open pollination showed better fruit quality parameters like total soluble solids and phenols. Cultivated types K-45 and N-20 also responded best to open pollination with higher fruit weight and sugar content. Bagged conditions showed negligible fruit set, confirming self-incompatibility. Differences in sugar, phenol, and moisture content further emphasized the importance of pollination mode in enhancing jamun fruit quality.

تعليق عليه [B1]: Add the experiment design

1. Introduction

Syzygium cumini L. Skeels belonging to family Myrtaceae is an important evergreen tropical fruit bearing plant. Jamun is native to Asia especially India. It is considered as medicinally important fruit tree but it's still an under explored indigenous fruit crop of India (Singh *et al.*, 2011). The species range across India, Bangladesh, Pakistan, Nepal, Sri Lanka, Malaysia, the Philippines and Indonesia. In India, it is present in both moist and dry situations, seen in the tropical wet evergreen forests, tropical semi evergreen forests, tropical moist deciduous forests, littoral and swamp, tropical dry deciduous, tropical dry evergreen, subtropical broad-leaved hills and subtropical pine forests. It is also found growing in the lower ranges of the Himalayas up to an altitude of 1300 meters (Wrigley and Fagg, 2003).

In recent years, jamun fruits are becoming popular due to their rich medicinal properties particularly for their antidiabetic properties. The medicinal value is due to the presence of malic acid, oxalic acid, gallic acid and tannins. The fruits are rich sources of anti-oxidant compounds, including flavonoids, phenolics, carotenoids and vitamins, which are all considered beneficial to human health, for decreasing the risk of degenerative diseases by reduction of oxidative stress and for the inhibition of macromolecular oxidation (Ayyanar and Subash-Babu, 2012).

Jamun, an economically and nutritionally significant minor fruit crop, has gained prominence due to its adaptability and health benefits. The estimated global production of jamun is approximately 13.5 million tonnes, with India contributing 15.4% of this total (Singh *et al.*, 2011), making it the second-largest producer in the world. It is cultivated extensively in various Indian states including Maharashtra, Uttar Pradesh, Tamil Nadu, Gujarat, and Assam, of which Maharashtra ranks as the leading producer. In Karnataka, jamun trees are commonly grown as avenue plantations and as shade trees in coffee plantations.

Pollinator activity plays a crucial role in fruit set. In *S. occidentale*, ant species *Technomyrmex albipes* was identified as a key nocturnal pollinator, leading to a fruit set of 62% under xenogamy, followed by 44% in geitonogamy and 41% in open pollination (Giby Kuriakose *et al.*, 2018). Earlier findings by Misra and Bajpai (1984) also reported high fruit set under open pollination, though fruit drop rates exceeded 80% in some years. Anju Bajpai *et al.*

(2012) further corroborated these findings, reporting 30–40% fruit set in self-pollinated flowers and up to 50% in cross-pollinated flowers.

Despite its wide distribution, fruit set and yield in jamun are significantly influenced by the mode of pollination. Several studies have confirmed that *S. cumini* exhibits self-incompatibility and relies heavily on cross-pollination for effective fruit set. For instance, hand pollination studies in *Syzygium alternifolium* indicated that both autogamy and geitonogamy were non-functional, while xenogamy alone resulted in a fruit set of 56%, compared to just 11% under open pollination (Solomon Raju *et al.*, 2014). Similarly, Saurabh Singh *et al.* (2019) reported that among nine jamun genotypes, fruit set under open pollination ranged from 37.5% to 53.5%, dropped significantly under hand pollination (7.40–29.45%), and was negligible (0.33–0.80%) under bagged conditions—indicating the requirement for external pollination agents.

Time to fruit maturity varies with region and genotype. For instance, in West Bengal, jamun fruits required approximately 63 days from flowering to maturity, with a very low retention rate of 5.72% (Tarai *et al.*, 2006). Lawande *et al.* (2014) noted that jamun fruits on a single tree do not mature uniformly and usually require multiple harvests (4–5 pluckings).

Fruit retention and yield potential also vary significantly among genotypes. The number of fruits per branchlet ranged from 64 to 126, with retention rates between 22.75% and 53.70%, the highest being 101 fruits in genotype S-9 and the lowest in S-6 (Saurabh Singh *et al.*, 2019). Chongthanallaylaydevi *et al.* (2016) observed that while the percent fruit set ranged from 28.51% to 59.07%, fruit drop varied from 36.92% to 53.92% among different genotypes.

Overall, these studies underscore the self-incompatible nature of jamun and the vital role of cross-pollination, especially insect-mediated in achieving optimum fruit yield and quality. In this context, the present investigation was undertaken to evaluate the influence of different pollination modes (open, hand, and bagged) on fruit set, yield components, and quality traits in wild and cultivated types of *Syzygium cumini*.

2. Materials and methods

2.1 Study area

The study was carried out at Regional Horticultural Research and Extension Centre, College of Horticulture (RHREC); UHS sub campus, GKVK, Bengaluru-560 065 and at College of Forestry, Ponnampet, Kodagu district during the flowering period of 2018-19.

2.2 Wild and Cultivated Types of *S. cumini*

The study on effect of different modes of pollination on fruit yield and quality was conducted on cultivated type of *S. cumini* viz., K-45 (Plate 1-a) and N-20 (Plate 1-b) in jamun orchard which were six years old, planted at the spacing of 5m x 5m at experimental site, RHREC, College of Horticulture; UHS sub-campus, GKVK, Bengaluru and also on naturally grown wild *S. cumini* (Plate 1-c) trees of more than twelve year age at College of Forestry, Ponnampet, Kodagu district. In the field experiment, three different treatments viz., open pollination, hand pollination and bagging method were employed in wild and cultivated varieties of *S. cumini* to record the effect of floral visitors on fruit set and yield attributing characters and also on fruit quality and its associated parameters. In both open and bagging method, four inflorescences facing different directions were selected and replicated five times were tagged. In bagging method, tagged inflorescences were enclosed in perforated (1 mm size) nylon bags (Plate 2). In hand pollination, fifty flowers were emasculated before anther dehiscence and were bagged by using perforated nylon bags and replicated five times were tagged. Pollination of the flowers were done with pollen grains collected from different flowers of the same plant between 9.00 A.M and 10.0 A.M and were covered immediately with perforated nylon bags to avoid the contamination by foreign pollen grains. The fruit set in open pollination and bagging method was determined on the basis of total number of flowers in each inflorescence where as in case of hand pollination, the fruit set was determined on the basis of total number of flowers pollinated by following the method suggested by Anonymous (2016).

Plate 1: Wild and cultivated types of *S. cumini* selected for study

تعليق [B3]: Mention to the number of plant per treatment and number of plant per all experiment

Plate 2: Enclosed inflorescence of wild and cultivated types of *S. cumini* in bagging method

2.3 Yield attributing characters of wild and cultivated types of *S. cumini* as influenced by open pollination, hand pollination and bagging method

The yield attributing observations such as number of fertilized flowers per inflorescences, per cent fertilized flowers, number of flowers that dropped, per cent flower drop, number of fertilized flowers dropped, per cent fertilized flowers dropped, number of fruits retained at maturity, per cent fruit retained at maturity, fruit weight, seed weight, pulp weight and seed to pulp ratio were recorded.

2.3.1 Number of fertilized flowers per inflorescence

The number of flowers setting with very small immature fruits was counted in all the treatments and replications. The per cent fertilized flowers per inflorescence was calculated by using the formula,

$$\text{Per cent fertilized flowers} = \frac{\text{Total number of fertilized flowers per inflorescence}}{\text{Total number of flowers per inflorescence}} \times 100$$

2.3.2 Number of flowers that dropped per inflorescence

Out of total number of flowers in the inflorescence of all the treatments and replications, the number of flowers that dropped was counted and per cent flower drop was calculated by using the formula,

$$\text{Per cent flower drop} = \frac{\text{Total number of flowers that dropped per inflorescence}}{\text{Total number of flowers present in the inflorescence}} \times 100$$

2.3.3 Number of fertilized flowers that dropped per inflorescence

Out of the flowers setting with very small immature fruits in the inflorescence of all the treatments and replications, the number of immature fruits that dropped were counted before ripening and per cent fertilized flower drop was calculated by using the formula,

$$\text{Per cent fertilized flower drop} = \frac{\text{Total number of fertilized flower dropped per inflorescence}}{\text{Total number of fertilized flower per inflorescence}} \times 100$$

[B4]: Add reference

[B5]: Add reference

[B6]: Add reference

2.3.4 Number of fruits retained per inflorescence at maturity

Total number of fruits present per inflorescence of all the treatments and replications were counted at fully ripened stage before harvest and per cent fruit retained was calculated by using the formula,

$$\text{Per cent fruit retained} = \frac{\text{Total number of fruits present per inflorescence}}{\text{Total number of flowers per inflorescence}} \times 100$$

2.3.5 Fruit weight

Ten ripened fruits selected randomly from all the treatments and replications were weighed with the help of digital weighing balance and mean weight per fruit was computed and expressed in grams.

2.3.6 Seed weight

The surrounded pulp of randomly selected ten ripened fruits from all the treatments and replications were removed with the help of a knife without damaging the seeds and were weighed with the help of digital weighing balance and mean weight of seed was computed and expressed in grams.

2.3.7 Pulp weight per fruit

The removed pulp of ten ripened fruits from all the treatments and replications were weighed with the help of digital weighing balance and mean pulp weight was computed and expressed in grams.

2.3.8 Seed: pulp ratio

The recorded seed and pulp weight of each sample was utilized and seed to pulp ratio was calculated by using the formula,

$$\text{Seed to pulp ratio} = \frac{\text{Mean seed weight}}{\text{Mean pulp weight}}$$

2.4 Fruit quality parameters of wild and cultivated types of *S. cumini*

تعليق [B7]: Add reference عليه

تعليق [B8]: Ten ripened fruits selected randomly from each treatments and replications Or only 10 fruit selected to evaluated the fruit weight Check that .

The observations on fruit quality and its associated parameters such as total soluble solids, total soluble sugars, total reducing sugars, total phenols, dry weight, moisture content, pH and EC of fruits were also recorded.

2.4.1 Total soluble solids of fruits

Total soluble solids, in the juice of representative samples from all the treatments and replications were determined by using a “Hand Refractometer” of 0-32 per cent range and the data was expressed in percentage.

2.4.2 Total soluble sugars of fruits

Anthrone (200mg) was dissolved in chilled 100ml concentrated sulphuric acid used for the quantitative determination of different carbohydrates. Quantitative determination is only possible where the identity of sugar components is known because colour development varies with the different sugars. Nevertheless, the anthrone method is widely used for the determination of starch and soluble sugars in plant material. Generally sugars and carbohydrates are extracted from dried and ground plant material. First soluble sugars are extracted with aqueous ethanol; later starch is extracted with an acid. Acidic starch extracts are typically clear; however ethanolic sugar extracts may be green (leaves) or brown (roots). To remove these interfering colours first pre-extract plant material with 100 per cent acetone (Marshall, 1986).

2.4.2.1 Extraction: Ripened fruit 100mg of wild and cultivated types of jamun- samples were ground by using a pestle and mortar. Sugar was extracted with 80 per cent ethanol by homogenizing the samples. Homogenized samples were centrifuged at 8000rpm for 10minutes. Supernatant was collected in a separate beaker and re-extraction was done 5 times and collected supernatant was incubated in water bath at 60⁰ C to allowed ethanol to evaporate and samples dried were dissolved in 2ml of double distilled water. Dissolved samples were kept for sugar analysis.

2.4.2.2 Estimation of sugars: In the test tubes 0.5 or 1.0ml of aliquot was taken from extracted sample and volume was made upto 2 ml with double distilled water kept in ice cold. To the diluted sample 4ml of anthrone reagent was added and heated under boiling water bath for

about 8-10 min. After heating it was rapidly cooled down and absorption was recorded at 630nm. Glucose was used as standard in the concentration of 100mic.g/ml.

2.4.3 Total reducing sugars

Reducing sugars have potentially free aldehyde or ketone group and are able to reduce metal ions under alkaline condition; some of these are glucose, galactose, maltose *etc.* DNS (3, 5-dinitrosalicylic acid) in alkaline condition reduces to 3-amino-5-nitrosalicylic acid which can be read at 510nm.

The sample of 0.1g was extracted from ripened fruits of wild and cultivated types of *S. cumini* by using 80 per cent hot ethanol and it was centrifuged (4000 rpm for 5minutes). The supernatant was collected and pooled in beaker then it was kept on water bath for evaporation of ethanol. 10ml of double distilled sterile water was added to the extract to solubilize the sugar. Aliquots of 0.5 or 3ml ml of alcohol free extract were used for the quantification. Series of test tubes containing 0.2, 0.4, 0.6, 0.8 and 1ml of working standard was pipetted into the test tubes and volume was made upto 3ml for every tube by using double distilled water, separate 3 ml of water was used as blank. To every tube 3 ml of DNS reagent was added and mixed thoroughly and placed in boiling water bath for 5 minute. The tubes were cooled and checked for color development, 1 ml of 40 per cent alkaline copper tartrate (Rochelle's salt) solution was added when it was still warm. Finally the tubes were cooled to room temperature and absorbance was read at 510nm (Rangana, 1997).

2.4.4 Total phenol content of fruits

The ripened fruits of wild and cultivated types of *S. cumini* were subjected to spectroscopic analysis for phenol content; the aliquot taken was 0.2ml for the analysis and the volume was made up with distilled water to 3ml. One normal Folin Ciocalteu Reagent (FCR) was added to the reaction mixture. After the 3 minute of incubation, 20 per cent 2ml Sodium Carbonate was added into each tube. The reaction mixtures were mixed thoroughly and the tubes were placed into boiling water for exactly one minute, the tubes were allowed to cool at normal room temperature and the absorbance was measured at 650nm. The total phenolics were determined by using the Folin Ciocalteu reagent method with light modifications as stated in the work of Anyasi *et al.*, (2015). Ethanol was used as an extraction solvent, while Gallic acid

was used as the standard phenolic compound. Final results of total phenolics were expressed as Gallic acid equivalent mg (GAE/100 g d.w)

2.4.5 Dry weight of fruits

The fresh weight of ten randomly picked ripened fruits from all the treatments and replications was recorded by using digital weighing balance and was air dried in hot air oven at 50-60⁰ C until constant weight was obtained and it was expressed in per cent. The dry weight of the fruit was calculated by using the formula,

$$\text{Per cent dry weight of fruit} = \frac{\text{Mean dry weight of fruits}}{\text{Mean fresh weight of fruits}} \times 100$$

2.4.6 Moisture content of fruits

The fresh weight of ten randomly picked ripened fruits from all the treatments and replications were recorded by using digital weighing balance and were air dried in hot air oven at 50-60⁰ C until some constant weight was obtained and it was expressed in per cent (Ranganna, 1997). The moisture content of the fruit was calculated by using the formula,

$$\text{Moisture content} = \frac{\text{Fresh weight} - \text{dry weight}}{\text{Fresh weight}} \times 100$$

2.4.7 pH of fruits

pH of the fruit juice of representative samples from all the treatments and replications were recorded with the help of digital pH meter.

2.4.8 EC of fruits

EC of the fruit juice of representative samples from all the treatments and replications was recorded with the help of an electrical conductivity meter and expressed in milli siemens per centimetre (mS/cm).

Analyses of data

The data was analysed statistically and descriptive statistics were done using SPSS 12.0 (SPSS Inc., an IBM Company, Chicago, USA) and graphs were generated using Sigma Plot 7 (Systat Software Inc., Chicago, USA).

3. Results and discussion

3.1 Effect of different modes of pollination on fruit set and yield attributing characters of wild *S. cumini* at Ponnampet

Number of flowers per inflorescence

The mean number of flowers per inflorescence was significantly highest in bagged condition (81.20/inflorescence), followed by open pollination (72.6/inflorescence) and least (50) was recorded in case of hand pollination (Table 1).

Number of fertilized flowers, per cent fertilized flowers, number of flower drop and per cent flower drop per inflorescence in wild *S. cumini* at Ponnampet

The mean number of flowers fertilized per inflorescence was significantly highest in hand pollination (71.60%), followed by that in case of open pollination (62.11%) and the least number of flowers fertilized (11.15%) was recorded when inflorescences were bagged (Table 1). Similarly, the mean number of flower drop per inflorescence was significantly highest in bagged condition (88.85%), followed by that in case of open pollination (37.87%) and hand pollination (28.40%).

Number of fertilized flower drop, per cent fertilized flower drop, number of fruits retention at maturity and per cent fruit retention per inflorescences at maturity in wild *S. cumini* at Ponnampet

The mean number of fertilized flower drop per inflorescence was significantly highest in bagged condition (77.39%), followed by that in case of open pollination (45.46%) and hand pollination (19.64 %). Similarly, the mean number of fruits retained per inflorescences at maturity was significantly maximum in hand pollination (53.20%), followed by that in case of open pollination (33.85%) and the least number of fruits retained per inflorescence at maturity (1.67%) was recorded in the inflorescences which were kept in bagged condition (Table 1). These findings are supported by Saurabh Singh *et al.*, (2019) who reported that fruit set in open pollination ranged from 37.50 to 53.50 per cent, in hand pollination from 7.40 to 29.45 per cent and it was negligible (0.33 to 0.80 per cent) under bagged condition.

تعليق [h14]: 3.1.1 Number of flowers / inflorescence

تعليق [h15R14]:

تعليق [h16R14]:

تعليق [h17]: 50 inflorescence

تعليق [h18R17]:

تعليق [h19]: 3.1.2 Number of fertilized flowers
The mean number of fertilized flowers per inflorescence was significantly highest in open pollination (45), followed by hand pollination (35.80) and the least number fertilized flowers (9.00) was recorded when inflorescences were bagged

تعليق [h20R19]:

تعليق [h21R19]:

تعليق [B22R19]:

تعليق [h23]: 3.1.3 per cent fertilized flowers

تعليق [h24R23]:

تعليق [h25]: 3.1.4 number of flowers drop
the mean number of fertilized flower drop per inflorescence was significantly highest in bagged condition (72.20), followed by that in case of open pollination (27.6) and hand pollination (14.20).

تعليق [h26R25]:

تعليق [h27R25]:

تعليق [h28]:

تعليق [h29R28]:

تعليق [h30R28]:

تعليق [h31]: 3.1.5 per cent flower drop / inflorescence
The mean per cent flower drop per inflorescence was low in open pollination (37.87), followed by hand pollination (28.40) and the higher number flowers drop was (88.85) was recorded when inflorescences were bagged

تعليق [h32R31]:

تعليق [h33R31]:

تعليق [h34]:

تعليق [h35]: 3.1.6 Number of fertilized flower drop
The mean number of fertilized flower drop per inflorescence was significantly lowest in bagged condition (7.00%), followed by that in case of hand pollination (9.20%) and open pollination (20.4) %

تعليق [h36R35]:

تعليق [h37]: 3.1.7 per cent fertilized flower drop
The mean number of fertilized flower drop per inflorescence was significantly highest in bagged condition (77.39%), followed by that in case of open pollination (45.46%) and hand pollination (19.64 %).

تعليق [h38R37]:

تعليق [h39]: 3.1.8 number of fruits retention at maturity

تعليق [h40R39]:

تعليق [h41]: 3.1.9 per cent fruit retention per

تعليق [h42R41]:

تعليق [h43]:

تعليق [h44]: 3.1.10 Fruit weight g
The mean fruit weight was significantly maximum in open pollination (51.92), followed by that in case of hand pollination (43.12g) and the lowest was recorded in bagged condition (30.48g)

3.1.11 seed weight
The mean seed weight was significantly maximum in open pollination (22.86 g), followed by that in case of hand pollination (19.02 g) and the lowest was recorded in bagged condition (12.16 g),

3.1.12pulp weight g
The mean pulp weight was significantly maximum in open pollination (29.06g), followed by that in case of hand pollination (24.10 g) and the lowest was recorded in bagged condition (18.32g),

تعليق [h45R44]:

تعليق [h46]: 3.1.13 pulp ratio in wild *S. cumini* at Ponnampet
Significantly maximum seed: pulp ratio of fruits was recorded in hand pollination (78.92), followed by open pollination (78.71) as compared to bagged (66.40) condition (Table 1).

تعليق [h47R46]:

تعليق [h48R46]:

Fruit weight, seed weight, pulp weight and seed: pulp ratio in wild *S. cumini* at Ponnampet

The mean fruit weight, seed weight and pulp weight was significantly maximum in open pollination (51.92, 22.86 and 29.06g), followed by that in case of hand pollination (43.12, 19.02 and 24.10 g) and the lowest was recorded in bagged condition (30.48, 12.16 and 18.32g), respectively. Significantly maximum seed: pulp ratio of fruits was recorded in hand pollination (78.92), followed by open pollination (78.71) as compared to bagged (66.40) condition (Table 1). Studies on morphological and physico-chemical traits of accessions of jamun revealed wide variation with respect to physical parameters which included individual fruit weight which ranged from 4.80 - 17.60 g, length from 2.22 - 4.51 cm, diameter from 1.66 - 3.04cm, seed weight from 1.30 - 2.36 g and pulp content from 68.75 - 86.59 per cent (Singh *et al.*, 2007; Singh and Singh, 2012).

3.2 Effect of different modes of pollination on fruit quality and its associated parameters of wild *S. cumini* at Ponnampet

تعليق [B49]: 3.2.1 Total soluble solids
3.2.2 total soluble sugars
3.2.3 totla reducing sugars
3.2.4 total phenols content of fruits in wild

Total soluble solids, total soluble sugars, total reducing sugars and total phenols content of fruits in wild *S. cumini* at Ponnampet

The per cent total soluble solids, total soluble sugars, total reducing sugars and total phenols were significantly highest in the fruits of open pollination (10.80%, 20.26, 32.56 and 18.11mg/g) followed by that in case of hand pollination (10.22%, 18.31, 28.37 and 17.21mg/g) compared to the fruits kept in bagged condition (8.44%, 13.72, 18.54 and 13.15 mg/g), respectively (Table 1a). The total soluble solids among different accessions varied from 12.2 - 18.40 C B (Singh *et al.*, 2007; Singh and Singh, 2012).

تعليق [B50]: 3.2.5 Dry weight
3.2.6 moisture content
3.2.7 pH
3.2.8 EC of fruits of wild

Dry weight, moisture content, pH and EC of the fruits of wild *S. cumini* at Ponnampet

The mean dry weight of fruits was significantly maximum in open pollinated condition (11.92%), followed by hand pollination (9.26%) and the lowest (9.18 %) was recorded in bagged condition. However, the mean moisture content of fruits was significantly highest in hand pollination (78.43%), followed by open pollination (77.10 %) as compared to 69.82 per cent moisture in the fruits enclosed in bagged condition. The electrical conductivity was significantly highest in the fruits kept in bagged condition (1.63 mS/cm), followed by hand pollination (1.41 mS/cm) and it was lowest in open pollination (1.17 mS/cm). No significant differences were observed in the pH content of the fruits among the different modes of pollination (Table 1a), however, it ranged from 3.52 to 3.67. The differences in chemical properties of jamun fruits and seeds were recorded viz., moisture (%), total soluble sugar (%), total solids (%), pH, total sugars (mg/g) and total phenols (mg/g) content of riped jamun fruits and seeds were 79.21 ± 2.27 and 52.24 ± 3.17 , 14.86 ± 1.47 and 1.4 ± 0.15 , 20.33 ± 0.34 and 47.75 ± 3.17 , 3.87 ± 0.01 and 2.5 ± 0.1 , 7.88 ± 0.41 and 5.54 ± 0.69 , 203.76 ± 9.84 and 386.51 ± 10 , respectively. The weight of whole fruit was 8.99 ± 1.89 gm and that of seed was the 1.64 ± 0.21 gm (Ghosh *et al.*, 2016).

Table 1: Effect of different modes of pollination on fruit set and yield attributing characters of wild type of *S. cumini*

Treatments	No. of flowers/ infl	No. of fertilized flowers/ infl	Per cent fertilized flowers	No. of flowers drop	Per cent flowers drop	No. of fertilized flower drop	Per cent fertilized flower drop	No. of fruits retained at maturity	Per cent fruit retention at maturity	Fruit weight (g)	Seed weight (g)	Pulp weight (g)	Seed/ pulp ratio
Open pollination	72.6 ^a	45 ^a	62.11 ^b	27.6 ^b	37.87 ^b	20.4 ^a	45.46 ^b	24.6 ^a	33.85 ^b	51.92 ^a	22.86 ^a	29.06 ^a	78.71 ^a
Hand pollination	50.00 ^b	35.80 ^b	71.60 ^a	14.20 ^c	28.40 ^c	9.20 ^b	19.64 ^c	26.60 ^a	53.20 ^a	43.12 ^b	19.02 ^b	24.10 ^b	78.92 ^a
Bagged condition	81.20 ^a	9.00 ^c	11.15 ^c	72.20 ^a	88.85 ^a	7.00 ^b	77.39 ^a	2.00 ^b	1.67 ^c	30.48 ^c	12.16 ^c	18.32 ^c	66.40 ^b
SE(m)	4.13	1.94	0.91	2.76	0.91	0.85	2.32	1.22	0.62	0.19	0.18	0.18	1.06
CD@5%	12.73	5.99	2.81	8.52	2.80	2.64	7.15	3.78	1.93	0.60	0.57	0.55	3.26
CV(%)	13.59	14.52	4.22	16.27	3.93	15.70	10.93	15.48	4.72	1.05	2.31	1.68	3.17

Note: infl-Inflorescence

Table 1a: Effect of different mode of pollination on fruit quality and its associated parameters of wild type of *S. cumini*

Treatments	Total soluble solids (%)	Total soluble Sugars (mg/g)	Total reducing sugars (mg/g)	Total phenols (mg/g)	Dry weight of fruits (%)	Moisture content (%)	pH	EC (mS/cm)
Open pollination	10.80 ^a	20.26 ^a	32.56 ^a	18.11 ^a	11.92 ^a	77.10 ^a	3.52	1.17 ^b
Hand pollination	10.22 ^b	18.31 ^b	28.37 ^b	17.21 ^a	9.26 ^b	78.43 ^a	3.67	1.41 ^{ab}
Bagged condition	8.44 ^c	13.72 ^c	18.54 ^c	13.15 ^b	9.18 ^b	69.82 ^b	3.56	1.63 ^a
SE(m)	0.13	0.31	0.71	0.53	0.38	0.92	0.05	0.09
CD@5%	0.39	0.94	2.18	1.64	1.18	2.85	NS	0.27
CV (%)	2.91	3.92	5.98	7.08	8.46	2.75	3.46	13.80

NS- Non -significant

3.3 Effect of different modes of pollination on fruit set and yield attributing characters of cultivated type of *S. cumini*, K-45

تعلق عليه [B52]: 3.3.1 Number of flowers per inflorescence

Number of flowers per inflorescence

The mean number of flowers subjected to hand pollination were significantly highest (50 flowers) compared to bagged condition (44.6/inflorescence) and open (37.00 / inflorescence) pollination (Table 2).

تعلق عليه [B53]: 3.3.2 Number of fertilized flowers per inflorescence

Number of fertilized flowers, per cent fertilized flowers, number of flower drop and per cent flower dropper inflorescence in cultivated type of *S. cumini*, K-45

تعلق عليه [B54]: 3.3.3 per cent fertilized flowers

تعلق عليه [B55]: 3.3.4 number of flower drop

تعلق عليه [B56]: 3.3.5 per cent flower dropper inflorescence

The mean number of flowers fertilized per inflorescence was significantly highest in open pollination (72.62 %), followed by hand pollination (66.40%) and the lowest number of flowers fertilized was recorded when inflorescences were kept in bagged (15.13%) condition (Table 2). Similarly, the mean number of flower drop per inflorescence was significantly highest in bagged condition (84.00 %), followed by hand pollination (33.60%) and the least was observed in open pollination (27.38%).

تعلق عليه [B57]: Check it and correct it

تعلق عليه [B58]: 3.3.6 Number of fertilized flower drop

تعلق عليه [B59]: 3.3.7 per cent fertilized flower drop

تعلق عليه [B60]: 3.3.8 number of fruits retention at maturity

تعلق عليه [B61]: 3.3.9 per cent fruit retention at maturity per inflorescence

Number of fertilized flower drop, per cent fertilized flower drop, number of fruits retention at maturity and per cent fruit retention at maturity per inflorescence in cultivated type of *S. cumini*, K-45

The mean number of fertilized flowers that dropped per inflorescence was significantly highest in bagged condition (75.04%), followed by hand pollination (40.03%) and the least was seen in open pollination (23.96 %). Similarly, the mean number of fruits retention per inflorescence at maturity was significantly highest in open pollination (55.32 %), followed by hand pollination (40.00%) and the least number of fruits retention per inflorescence at maturity was recorded in the inflorescences which were kept in bagged (3.67%) condition (Table 2).

تعلق عليه [B62]: ?

تعليق عليه [B63]: 3.3.10 Fruit weight

تعليق عليه [B64]: 3.3.11 seed weight

تعليق عليه [B65]: 3.3.12 pulp weight

تعليق عليه [B66]: 3.3.13 seed: pulp ratio in cultivated

Fruit weight, seed weight, pulp weight and seed: pulp ratio in cultivated type of *S. cumini*, K-45

The mean fruit weight and seed weight was significantly highest in open pollination (92.36 and 19.16 g), followed by hand pollination (87.58 and 16.72 g) and the least was recorded in bagged condition (61.08 and 16.12 g), respectively. The pulp weight was significantly highest in the fruits of hand pollination (73.92g), followed by open pollination (73.20g) as compared to fruits kept in bagged condition (44.96g). The seed: pulp ratio of fruits was significantly highest in bagged condition (35.85) followed by open pollination (26.16) and the lowest were recorded in the fruits of hand (22.75) pollination treatment (Table 2). Total of 37.40 kg of fruits which accounted to 8500 fruits per tree were recorded in fruit performance studies of *S. cumini* (Tarai *et al.*, 2006). The mean seed weight and seed: pulp ratio of fruits was significantly highest in the fruits developed by hand pollination (23.68 g and 38.13) as compared to those developed from open (19.34 g and 27.58) pollination (Table 2). The pulp to seed ratio ranged from 5.65 (T.C-85) - 2.42 (Konkan Bahadoli) and fruit to seed ratio ranged from 4.04 - 3.14, respectively in AJG-45 and T.C.-85 genotypes (Chongthanallaylaydevi *et al.*, 2016).

تعليق عليه [B67]: Check it

3.4 Effect of different modes of pollination on fruit quality and its associated parameters of cultivated type of *S. cumini*, K-45

تعليق عليه [B68]: 3.4.1 Total soluble solids

تعليق عليه [B69]: 3.4.2 total soluble sugars

تعليق عليه [B70]: 3.4.3 total reducing sugars

تعليق عليه [B71]: 3.4.4 total phenols content of fruits

Total soluble solids, total soluble sugars, total reducing sugars and total phenols content of fruits in cultivated type of *S. cumini*, K-45

The mean total soluble solids were significantly highest in the fruits of hand pollination (13.92%), followed by open pollination (13.56%) and bagged (12.50%) condition. Similarly, the mean total soluble sugars and total reducing sugars were significantly highest in the fruits of open pollination (36.28 and 48.22 mg/g), followed by hand pollination (31.35 and 45.14 mg/g) and least in the fruits obtained from bagged condition (25.19 and 26.10 mg/g), respectively. There were no significant differences in the total phenol content of fruits among different modes pollination (Table 2a). However, it ranged from 15.40 to 17.50mg/g of fruits.

تعلق عليه [B72]: 3.4.5 Dry weight

تعلق عليه [B73]: 3.4.6 moisture content

تعلق عليه [B74]: 3.4.7 pH

تعلق عليه [B75]: 3.4.8 EC of the fruits

تعلق عليه [B76]: 11.74%

Dry weight, moisture content, pH and EC of the fruits of cultivated type of *S. cumini*, K-45

The mean dry weight of fruits was significantly highest in open pollination (19.05%), followed by hand pollination (17.36%) and the lowest of 11.74 per cent dry weight of fruits was recorded in bagged condition. However, the moisture content of the fruits was significantly highest in hand pollination (80.27%), followed by open pollination (79.51%) and least (74.92%) moisture content was recorded in the fruits of bagged condition. There were no significant differences in the pH (3.27 to 3.43) and electrical conductivity (1.34 to 1.40 mS/cm) of the fruits among different modes of pollination treatments (Table 2a).

UNDER PEER REVIEW

Table 2: Effect of different modes of pollination on fruit set and yield attributing characters of cultivated type of *S. cumini*, K-

45

Treatments	No. of flowers/ infl	No. of fertilized flowers/ infl	Per cent fertilized flowers	No. of flowers drop	Per cent flowers drop	No. of fertilized flower drop	Per cent fertilized flower drop	No. of fruits retained at maturity	Per cent fruit retention at maturity	Fruit weight (g)	Seed weight (g)	Pulp weight (g)	Seed/pulp ratio
Open pollination	37.00 ^b	26.80 ^b	72.62 ^a	10.20 ^c	27.38 ^b	6.40 ^b	23.96 ^c	20.40 ^a	55.32 ^a	92.36 ^a	19.16 ^a	73.20 ^a	26.16 ^b
Hand pollination	50.00 ^a	33.20 ^a	66.40 ^a	16.80 ^b	33.60 ^b	13.20 ^a	40.03 ^b	20.00 ^a	40.00 ^b	87.58 ^b	16.72 ^b	73.92 ^a	22.75 ^c
Bagged condition	44.60 ^a	6.80 ^a	15.13 ^b	37.40 ^a	84.00 ^a	5.20 ^b	75.04 ^a	1.60 ^b	3.67 ^c	61.08 ^c	16.12 ^c	44.96 ^b	35.85 ^a
SE (m)	2.27	1.42	2.08	1.64	2.12	0.64	3.31	1.25	2.31	0.66	0.15	1.90	0.48
CD @ 5%	6.99	4.36	6.42	5.04	6.54	1.98	10.20	3.86	7.12	2.03	0.47	5.85	1.49
CV (%)	11.57	14.23	9.06	17.05	9.82	17.39	15.97	20.03	15.66	1.83	1.96	6.63	3.83

Note: ** Significant at 1 %, * Significant at 5% and NS- Non –significant, infl-Inflorescence

Table 2a: Effect of different modes of pollination on fruit quality and its associated parameters of cultivated type of *S. cumini*, K-45

Treatments	Total soluble solids (%)	Total soluble Sugars (mg/g)	Total reducing sugars (mg/g)	Total phenols (mg/g)	Dry weight of fruits (%)	Moisture content (%)	pH	EC (mS/cm)
Open pollination	13.56 ^a	36.28 ^a	48.22 ^a	15.53	19.05 ^a	79.51 ^a	3.43	1.36
Hand pollination	13.92 ^a	31.35 ^b	45.14 ^b	17.50	17.36 ^b	80.27 ^a	3.27	1.40
Bagged condition	12.50 ^b	25.19 ^c	26.10 ^c	15.40	11.74 ^c	74.92 ^b	3.37	1.34
SE(m)	0.21	1.28	0.85	1.0	0.29	0.5	0.09	0.05
CD @ 5%	0.64	3.93	2.63	NS	0.89	1.55	NS	NS
CV (%)	3.46	9.22	4.79	13.98	4.00	1.44	6.28	7.67

Note: ** Significant at 1 %, * Significant at 5% and NS- Non -significant

3.5 Effect of different modes of pollination on fruit set and yield attributing characters of cultivated type of *S. cumini*, N-20

Number of flowers per inflorescence

No significant differences were observed variations was observed in the mean number of flowers per inflorescence among open pollination (53.6/inflorescence), bagged condition (50.6/inflorescence) and the hand (50 flowers) pollination (Table 3).

Number of fertilized flowers, per cent fertilized flowers, number of flower drop and per cent flower drop per inflorescence in cultivated type of *S. cumini*, N-20

The mean number of fertilized flowers per inflorescence was significantly highest in hand pollination (72.80%), compared to open pollination (63.01%) and none of the flowers in bagged condition were got fertilized (Table 3). All the flowers present in the inflorescence that were kept in bagged condition completely dropped off (100%) which was significantly highest as compared to open pollination condition (36.98%) and hand pollination (27.20%).

Number of fertilized flower drop, per cent fertilized flower drop, number of fruits retention at maturity and per cent fruit retention per inflorescence at maturity in cultivated type of *S. cumini*, N-20

The mean number of fertilized flowers drop per inflorescence was significantly highest in the open pollination (43.05%) as compared to hand pollination (24.14%). Similarly, the mean number of fruits retained per inflorescence at maturity was significantly highest in hand pollination (55.20%) as compared to open (35.88%) pollination (Table 3).

Fruit weight, seed weight, pulp weight and seed: pulp ratio in cultivated type of *S. cumini*, N-20

The mean fruit weight and pulp weight was significantly highest in open (100.52 and 74.72 g) pollination compared to hand pollination (96.98 and 71.88g), respectively (Table 3). No significant differences were observed in the seed weight and seed: pulp ratio of fruits in open pollination (25.80g and 34.53) and hand pollination (25.10 g and 34.92), respectively.

تعليق عليه [B77]:

تعليق عليه [B78]: 3.5.1 Number of flowers per inflorescence

تعليق عليه [B79]: 3.5.2 Number of fertilized flowers

تعليق عليه [B80]: Correct that like upper note

3.6 Effect of different modes of pollination on fruit quality and its associated Parameters of cultivated type of *S. cumini*, N-20

Total soluble solids, total soluble sugars, total reducing sugars and total phenols content of fruits in cultivated type of *S. cumini*, N-20

The mean total soluble solids and total reducing sugar content were significantly highest in the fruits of open pollination (13.80% and 90.50mg/g) compared to hand pollination (13.30% and 65.91mg/g.). Significantly highest total soluble sugar content was recorded in the fruits of hand pollination (31.22mg/g) as compared to open pollination (30.48 mg/g) treatments. There were no significant differences in the total phenol content of the fruits among open pollination (12.38mg/g) and hand (10.64mg/g) pollination treatments. All the flowers in the inflorescence kept in bagged conditions dropped off; hence the observations on qualitative parameters could not be recorded in the bagged condition (Table 3a). The results of the studies on physico-chemical characters of tropical underutilized fruits especially in jamun were found to vary, physical characters included fruit weight (5.35g), fruit length(2.88cm), fruit diameter (1.65cm), pulp weight (3.91g), seed weight (1.42g), pulp/seed ratio (2.75), edible portion (77.08) and the chemical characters included total soluble solids (10.80 C Brix), acidity (0.38%), TSS/acid ratio (28.42), total sugar (9.52%), reducing sugars(8.16%), non-reducing sugars (1.29%) and ascorbic acid (16.78mg/100g) (Pathak and Chakraborty,2006).

Dry weight, moisture content, pH and EC of the fruits in cultivated type of *S. cumini*, N-20

The mean dry weight of fruits was significantly highest in open pollination (18.72 %) as compared to hand pollination (17.13%). However, there were no significant differences in the moisture content of fruits in open pollination (81.35 %) and hand pollination (82.33 %).The pH and EC of the fruits was significantly highest in hand (3.49 and 1.23mS/cm) compared to open pollination (3.42 and 1.15mS/cm). All the flowers in the inflorescence kept in bagged conditions dropped off; hence qualitative parameters could not be estimated in bagged condition (Table 3a).

تعليق عليه [B81]: 3.6.1 Total soluble solids

تعليق عليه [B82]: 3.6.2 total soluble sugars

تعليق عليه [B83]: 3.6.3

تعليق عليه [B84]: Add discussion with reference

Table 3: Effect of different modes of pollination conditions on fruit set and yield attributing characters of cultivated type of *S. cumini*, N-20

Treatments	No. of flowers/ infl	No. of fertilized flowers/ infl	Per cent fertilized flowers	No. of flowers drop	Per cent flowers drop	No. of fertilized flower drop	Per cent fertilized flower drop	No. of fruits retained at maturity	Per cent fruit retention at maturity	Fruit weight (g)	Seed weight (g)	Pulp weight (g)	Seed/ pulp ratio
Open pollination	53.60	20.00 ^a	36.98 ^a	33.60	63.01	14.60	43.05	19.00	35.88	100.52	25.80	74.72	34.53
Hand pollination	50.00	13.60 ^a	27.20 ^a	36.40	72.80	8.80	24.14	27.60	55.20	96.98	25.10	71.88	34.92
Bagged condition	50.60	0.00	0.00	50.60	100.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE (m)	4.82	2.94	5.92	-	-	-	-	-	-	-	-	-	-
CD @ 5%	NS	9.06	18.23	-	-	-	-	-	-	-	-	-	-
CV (%)	20.99	23.42	18.44	-	-	-	-	-	-	-	-	-	-
T (stat) value	-	-	-	-0.65	-7.15**	2.52*	7.93**	-3.82**	-12.75**	4.05**	1.80	4.68**	-0.88
Sig (Prob)	-	-	-	NS	0.0001	0.036	0.0001	0.0051	0.0001	0.0037	NS	0.0016	NS

Note: infl-Inflorescence

Table 3a: Effect of different modes of pollination on fruit quality and its associated parameters of cultivated type of *S. cumini*, N-20

Treatments	Total soluble solids (%)	Total soluble sugars (mg/g)	Total reducing sugars (mg/g)	Total phenols (mg/g)	Dry weight of fruits (%)	Moisture content (%)	pH	EC (mS/cm)
Open pollination	13.80	30.48	90.50	12.38	18.72	81.35	3.42	1.15
Hand pollination	13.30	31.22	65.91	10.64	17.13	82.33	3.49	1.23
Bagged condition	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
t (stat) value	5.25**	3.15*	-2.42*	1.75	6.44**	1.28	-2.5*	2.75*
Sig (Prob)	0.0008	0.0135	0.042	NS	0.0002	NS	0.036	0.025

NS- Non -significant

3.7 Overall Interpretation

The study reveals that pollination mode significantly influences fruit set, yield attributes, and quality traits in both wild and cultivated types of *Syzygium cumini*. Open and hand pollination markedly outperformed the bagged condition across all types (wild, K-45, N-20). In the wild type, hand pollination resulted in the highest fertilization rate (71.6%) and fruit retention (53.2%), while open pollination yielded the highest fruit weight and pulp content. In contrast, the bagged condition led to severe reductions in fertilization and fruit retention, indicating a strong dependence on cross-pollination mechanisms.

For the cultivated types K-45 and N-20, open pollination consistently resulted in better fruit weight and sugar accumulation. The K-45 type under open pollination had the highest total soluble solids (13.56%) and sugars (36.28 mg/g), indicating superior fruit quality. Notably, the N-20 type under bagged conditions showed complete fruiting failure.

Across all types, the bagged condition drastically reduced or eliminated fruit development and quality traits, highlighting the essential role of insect-mediated cross-pollination. The significant variations in sugar, phenol, and pulp content under different treatments underline the biochemical impact of pollination modes. These findings suggest that pollinator availability and management are critical for maximizing productivity and quality in *S. cumini* cultivation.

Conclusion:

Open and hand pollination significantly improved yield and quality parameters in both wild and cultivated jamun types, with open pollination showing superior results in fruit size, pulp content and sugar levels. Bagged flowers performed poorly, supporting the species' cross-pollination requirement. Therefore, encouraging natural pollinators and adopting assisted pollination practices can enhance productivity and quality of jamun cultivation.

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