**Effect of different modes of pollination on fruit yield and quality of wild and cultivated (GKVK-1 and GKVK-2) types of jamun (*Syzygium cumuni* L. skeels)**

**Abstract**

The impact of different pollination modes on fruit yield and quality of wild and cultivated types of jamun (Syzygium cumini) showed that wild type of jamun had higher fertilization rates and better fruit retention under hand pollination, whereas open pollination showed improved fruit weight and quality parameters like total soluble sugars and phenol content. In contrast, cultivated types (GKVK-1 and GKVK-2) exhibited superior fruit set and pulp content under open pollination. Bagging consistently resulted in lowest fruit retention and quality among wild and cultivated types. Fruit biochemical parameters such as sugars and phenolics were generally highest in open-pollinated fruits in cultivated types, while wild types had slightly better performance under hand pollination. The findings underscore the importance of pollinator activity and suggested different pollination management for wild and cultivated types to optimize fruit yield and quality.

**1. Introduction**

*Syzygium cumini* L. is an important evergreen tropical wild fruit yielding tree species in the flowering plant family Myrtaceae. It is native to the tropics, particularly to tropical America and Australia. It is known from many countries including South Africa, South America, South East Asia and Australia. The *Syzygium* genus *c*omprises about 1,100 species and has native range that extends from Africa and Madagascar through Southern Asia east through the Pacific. The highest levels of its diversity occur from Malaysia to north eastern Australia, where many species are very poorly known and not been described taxonomically (Wrigley and Fagg, 2003).

*S. cumini* is considered as medicinally important fruit tree but it’s still an under explored indigenous fruit crop of India. 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 upto an altitude of 1300 meters.

The estimated world production of jamun is around 13.5 million tonnes, of which 15.4 per cent is contributed by India (Singh *et al*., 2011). India is the second largest producer of jamun in the world. It is being grown in Punjab, Haryana, Uttar Pradesh, Maharashtra, Rajasthan, Gujarat, Madhya Pradesh, Bihar, Chhattisgarh, Jharkhand, Karnataka, Kerala, Tamil Nadu and Andhra Pradesh of which, the Maharashtra is the largest producer of jamun followed by Uttar Pradesh, Tamil Nadu, Gujarat and Assam. The jamun trees are found in the gardens as avenue plantations in all the districts of Karnataka and it is also grown as shade tree for coffee in a few districts.

The hand pollination experiments in *S. alternifolium* revealed that autogamy and geitonogamy were non functional, proving its self - incompatible and an obligate out- crosser. The xenogamy was the only mode of pollination with 56 per cent fruit set as against 11 per cent in open pollination mode (Solomon Raju *et al*., 2014).

The studies on fruit set of nine jamun genotypes revealed that in open pollination, it 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 (Saurabh Singh *et al*., 2019).

The number of fruits per branchlet of nine selected genotype of Jamun ranged from 64 to 126, the per cent fruit retention ranged from 22.75 to 53.70 per cent. The number of fruits retained at maturity was maximum (101) in S-9 and lowest (32) in S-6 (Saurabh Singh *et al*., 2019).

There was no significant variation with respect to the percent fruit set and fruit drop among genotypes of *Syzygium cumini* Skeels. The percent fruit set (28.51) was lowest in AJG-20 and highest (59.07) in JG-45. The percent fruit drop was maximum (53.92) in AJG-58 and minimum (36.92) in AJG-85 genotypes of jamun (Chongthanallaylaydevi *et al*., 2016).

The fruit set in flowers of *Syzygium occidentale* exclusively visited by ant species, *Technomyrmex albipe*s S. was significantly higher than those visited by any other visitor. The day and night exclusive pollination experiments allowing only *T. albipes* indicated diel pollination by *T. albipes*, which was the only active flower visitor during the night. Among the different pollination treatments tested in *Syzygium occidentale,* the proportion of flowers which developed into fruits was significantly high (62%) in Xenogamy followed by Geitonogamy (44%), open (41%) and lowest (7%) was recorded in apomixis (Giby Kuriakose *et al*., 2018).

The fruit set of *S. cumini* was maximum under open pollination by wind, insects and gravity. The fruit drop of around 84.63 and 81.81 per cent was also recorded 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 (Misra and Bajpai., 1984). Studies on the performance of minor fruits in West Bengal revealed that around sixty three days were required for fruit maturity after flowering and the fruit retention was only 5.72 per cent (Tarai *et al*., 2006).

The fruit set of jamun was initiated subsequent to anthesis and pollination. The flowers pollinated with pollen of same tree resulted in 30-40 per cent fruit set, while   
40 - 50 per cent fruit set was recorded with cross pollination (Anju Bajpai *et al.,* 2012).

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). Many workers also reported variability of yield attributes in jamun (Keskar *et al*., 1989; Kundu *et al*., 2001 and Singh and Singh, 2005). All the fruits in a bunch of jamun did not mature at once and they required 4-5 pluckings for complete harvest of ripened fruits (Lawande *et al.,* 2014).

The earlier studies stated that the flowers of *S. cumini* exhibited Self-incompatibility and requires cross pollination. In view of all these scientific investigations, the present study aims to document the effect of different modes of pollination on fruit yield and quality of wild and cultivated type of jamun (*Syzygium cumuni* L. skeels).

**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 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., GKVK-1 (Plate 1-a) and GKVK-2 (Plate 1-b) in jamun orchard which were six years old, planted at the spacing of 5m x 5m and also on naturally grown wild *S. cumini* (Plate 1-c)trees of more than fifteen year age at experimental site, RHREC, College of Horticulture; UHS sub-campus, GKVK, Bengaluru. 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).

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**c. wild of *S. cumini***

a. GKVK-1

b. GKVK-2

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

b. GKVK-2

**c. wild of *S. cumini***

a. GKVK-1

**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,

|  |  |  |  |
| --- | --- | --- | --- |
| Per cent fertilized flowers | = | Total number of fertilized flowers per inflorescence | x 100 |
| Total number of flowers per inflorescence |

**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,

|  |  |  |  |
| --- | --- | --- | --- |
| Per cent flower drop | = | Total number of flowers that dropped per inflorescence | x 100 |
| Total number of flowers present in the inflorescence |

**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,

|  |  |  |  |
| --- | --- | --- | --- |
| Per cent fertilized flower drop | = | Total number of fertilized flower dropped per inflorescence | x 100 |
| Total number of fertilized flower per inflorescence |

**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,

|  |  |  |
| --- | --- | --- |
| Per cent fruit retained = | Total number of fruits present per inflorescence | x 100 |
| Total number of flowers per inflorescence |

**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,

|  |  |
| --- | --- |
| Seed to pulp ratio = | Mean seed weight |
| Mean pulp weight |

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

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,

|  |  |  |
| --- | --- | --- |
| Per cent dry weight of fruit = | Mean dry weight of fruits | x 100 |
| Mean fresh weight of fruits |

**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,

Moisture content = Fresh weight - dry weight×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 GKVK**

**Number of flowers per inflorescence**

The mean number of flowers per inflorescence was significantly highest in bagged condition (78.80/inflorescence), followed by open pollination (61.20/inflorescence) and hand pollination which recorded 50.00/inflorescence (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 GKVK**

The mean number of flowers fertilized per inflorescence was significantly highest in hand pollination (69.20%), followed by open pollination (56.80%) and the lowest number of flowers fertilized was recorded when inflorescences were kept in bagged (11.53%) condition (Table 1). Similarly, the mean number of flower drop per inflorescence was significantly highest in bagged condition (88.47%) followed by open pollination (43.19%) and hand pollination (30.80%).

**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 GKVK**

The mean number of fertilized flowers that dropped per inflorescence was significantly highest in bagged condition (75.39%) followed by open pollination (44.30%) and hand pollination (29.50%). Similarly the percentage of fruits retained per inflorescence at maturity was significantly highest in hand pollination (48.80%), followed by open pollination (31.57%) and the least percent fruit retention per inflorescence at maturity was recorded in the inflorescences which were kept in bagged (2.83%) condition (Table 1).

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

The mean fruit weight and pulp weight was significantly highest in open pollination (51.88 and 35.04g), followed by hand pollination (51.68 and 33.52 g) and the lowest was recorded in bagged condition (43.80 and 27.96 g), respectively (Table 1). The mean seed weight was significantly highest in fruits of hand pollination (18.16 g), followed by that in open pollination (16.84 g) and the fruits kept in bagged condition (15.84g). The seed: pulp ratio of fruits was significantly highest in bagged condition (56.69) followed by hand pollination (54.20) and the lowest were recorded in the fruits where flowers were subjected to open pollination (48.05).

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

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

The per cent total soluble solids, total soluble sugars, total reducing sugars and total phenol content were significantly highest in the fruits of open pollinated flowers   
(11.78%, 26.36, 31.32 and 22.02 mg/g), followed by that of hand pollinated flowers   
(11.76%, 25.37, 28.60and 15.48mg/g) and the fruits produced under bagged condition (9.84%, 13.99, 15.49 and 12.84 mg/g), respectively (Table 1a).

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

The mean dry weight of fruits was significantly highest in open pollination (13.86 %) followed by hand pollination (11.98%) and the lowest of 9.71 per cent was recorded in case of bagged condition. The moisture content of the fruits was significantly highest in hand pollination (76.82%) followed by open pollination (73.36 %) as compared to 59.84 per cent moisture in the fruits whose flowers were kept under bagged condition. The electrical conductivity was significantly highest in the fruits of hand pollination (1.58 mS/cm), followed by that in case of flowers whose fruits were kept in bagged condition (1.25mS/cm) and it was lowest in open pollination (1.19 mS/cm). However, no significant differences were observed in the pH content of the fruits among different modes of pollination (Table 1a), which ranged from 3.43 to 3.50.

**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 | 61.20ab | 34.80a | 56.80b | 26.40b | 43.19b | 15.40a | 44.30b | 19.40b | 31.57b | 51.88a | 16.84b | 35.04a | 48.05c |
| Hand pollination | 50.00b | 34.60a | 69.20a | 15.40b | 30.80c | 10.20b | 29.50c | 24.40a | 48.80a | 51.68a | 18.16a | 33.52b | 54.20b |
| Bagged condition | 78.80a | 9.00b | 11.53c | 69.80a | 88.47a | 6.80c | 75.39a | 2.20c | 2.83c | 43.80b | 15.84c | 27.96c | 56.69a |
| **SE(m)** | 6.0 | 1.81 | 1.07 | 5.01 | 1.07 | 0.95 | 1.50 | 1.16 | 0.97 | 0.49 | 0.12 | 0.38 | 0.43 |
| **CD@5%** | 18.50 | 5.60 | 3.30 | 15.44 | 3.30 | 2.94 | 4.63 | 3.58 | 3.00 | 1.50 | 0.38 | 1.17 | 1.31 |
| **CV (%)** | 21.19 | 15.54 | 5.22 | 30.13 | 4.43 | 19.78 | 6.75 | 16.96 | 7.86 | 2.21 | 1.61 | 2.64 | 1.80 |

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 | 11.78a | 26.36a | 31.32a | 22.02a | 13.86a | 73.36b | 3.43 | 1.19b |
| Hand pollination | 11.76a | 25.37a | 28.60b | 15.48b | 11.98b | 76.82a | 3.44 | 1.58a |
| Bagged condition | 9.84b | 13.99b | 15.49c | 12.84c | 9.71c | 59.84c | 3.50 | 1.25b |
| **SE(m)** | 0.16 | 1.01 | 0.60 | 0,55 | 0.24 | 0.66 | 0.06 | 0.04 |
| **CD@5%** | 0.48 | 3.12 | 1.86 | 1.70 | 0.75 | 2.02 | NS | 0.12 |
| **CV (%)** | 3.15 | 10.33 | 5.37 | 7.35 | 4.59 | 2.10 | 3.68 | 6.66 |

NS- Non -significant

**3.3 Effect of different modes of pollination on fruit set and yield attributing characters of cultivated type of *S. cumini*, GKVK-1**

**Number of flowers per inflorescence**

The mean number of flowers per inflorescence was significantly highest in open pollination (76.60/inflorescence), followed by bagged condition (69.80/inflorescence) and the mean of 50 flowers were subjected to hand pollination (Table 2).

**Number of fertilized flowers, per cent fertilized flowers, number of flower drop and per cent flower dropper inflorescence in cultivated type of *S. cumini,* GKVK-1**

The mean number of flowers fertilized per inflorescence was significantly highest in hand pollination (64.80%) as compared to open pollination (56.33%) and none of the flowers were fertilized in bagged condition (Table 2). All the flowers present in the inflorescence kept under bagged condition completely dropped (100%), which was significantly highest as compared to that in open pollination (40.23%) and hand pollination (35.20%).

**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*, GKVK-1**

There was no significant differences in the mean number of fertilized flowers drop per inflorescence among open pollination (45.95%) and hand pollination (42.65%), whereas, the mean number of fruits retained per inflorescence at maturity was significantly highest in hand pollination (37.2%) compared to open (32.02%) pollination (Table 2).

**Fruit weight, seed weight, pulp weight and seed: pulp ratio in cultivated type of *S. cumini*, GKVK-1**

There was no significant difference in the mean weight of the fruits in open (89.34g) and hand pollination (85.8 g), whereas, the pulp weight was significantly highest in open pollination (70.00g) as compared to hand pollination (62.12 g).

**3.4 Effect of different modes of pollination on fruit quality and its associated parameters of cultivated type of *S. cumini*, GKVK-1**

**Total soluble solids, total soluble sugars, total reducing sugars and total phenols content of fruits in cultivated type of *S. cumini*, GKVK-1**

The per cent total soluble solids content was significantly highest in the fruits whose flowers were subjected to hand pollination (13.52%) as compared to open pollination   
(11.20 %,), whereas, total reducing sugars was significantly highest in the fruits of open pollination treatment (51.52mg/g) as compared to hand pollination (36.32 mg/g). There were no significant differences in the total soluble sugars and total phenol content of the fruits in open (17.41and 9.58mg/g) and hand (15.40 and 9.63mg/g) pollination. All the flowers in the inflorescence kept in bagged treatment dropped off; hence the qualitative parameters could not be assessed in bagged treatment (Table 2a).

**Dry weight, moisture content, pH and EC of the fruits of cultivated type of *S. cumini*, GKVK-1**

The mean dry weight of fruits was significantly highest in open pollination (22.15 %) as compared to hand pollination (17.38%). Similarly, the moisture content of the fruits in hand pollination (79.81 %) was significantly highest as compared to open pollination   
(75.14 %). There were no significant differences in the pH and EC content of the fruits between open pollination (4.38 & 0.72 mS/cm) and hand pollination (4.29 & 0.70mS/cm) treatments. All the flowers in the inflorescence kept in bagged treatment dropped off; hence the qualitative parameters could not be estimated in bagged treatment (Table 2a).

**Table 2: Effect of different modes of pollination on fruit set and yield attributing characters of cultivated type of *S. cumini,* GKVK-1**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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 | 76.60a | 31.20a | 40.23a | 45.40 | 56.33 | 20.80 | 45.95 | 24.60 | 32.02 | 89.34 | 19.34 | 70.00 | 27.58 |
| Hand pollination | 50b | 17.6b | 35.2a | 32.4 | 64.8 | 13.8 | 42.68 | 18.6 | 37.2 | 85.8 | 23.68 | 62.12 | 38.13 |
| Bagged condition | 69.80a | 0.00 | 0.00 | 69.80 | 100.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **SE(m)** | 3.73 | 3.19 | 6.32 | - | - | - | - | - | - | - | - | - | - |
| **CD@5%** | 11.50 | 9.83 | 19.48 | - | - | - | - | - | - | - | - | - | - |
| **CV (%)** | 12.75 | 18.05 | 19.71 | - | - | - | - | - | - | - | - | - | - |
| **t(st**at) **v**a**lue** | - | - | - | 5.25\*\* | -2.5\* | 6.44\*\* | 1,25 | 3.15\* | -2.42\* | 1.75 | -4.67\*\* | 6.67\*\* | -10.37\*\* |
| **Sig (Prob)** | - | - | - | 0.0008 | 0.036 | 0.0002 | NS | 0.0135 | 0.0421 | NS | 0.0016 | 0.0002 | 0.0001 |

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,* GKVK-1**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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 | 11.20 | 17.41 | 51.52 | 9.58 | 22.15 | 75.14 | 4.38 | 0.72 |
| Hand pollination | 13.52 | 15.40 | 36.32 | 9.63 | 17.38 | 79.81 | 4.29 | 0.70 |
| Bagged condition | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| t (stat) value | -7.05\*\* | 1.47 | 22.29\*\* | -0.09 | 6.19\*\* | -4.01\*\* | 2.00 | 1.62 |
| Sig (Prob) | 0.0001 | NS | 0.0001 | NS | 0.0003 | 0.0039 | NS | NS |

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*, GKVK-2**

**Number of flowers per inflorescence**

The mean number of flowers per inflorescence was significantly highest in bagged condition (88.20/inflorescence), followed by open pollination (77.00/inflorescence) and the mean of 50 flowers subjected to hand 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*, GKVK-2**

The mean number of flowers fertilized per inflorescence was significantly highest in open pollination (67.68%), followed by hand pollination (62.80%) and the lowest number of flowers fertilized was recorded when inflorescences were kept in bagged (13.77%) treatment (Table 3). Similarly, the mean flower drop per centage was significantly highest in bagged condition (86.23 %), followed by hand pollination (37.20%) and open pollination (32.33%).

**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*, GKVK-2**

The mean number of fertilized flower drop per inflorescence was significantly highest in bagged treatment (79.55%), followed by open pollination (31.71%) and hand pollination (27.04 %). Similarly the mean number of fruits retained per inflorescence at maturity was significantly highest in open pollination (46.18 %), followed by hand pollination (38.40%) and the least number of fruits retained per inflorescence at maturity was recorded in the inflorescences kept in bagged (2.86%) condition (Table 3).

**Fruit weight, seed weight, pulp weight and seed: pulp ratio in cultivated type of *S. cumini*, GKVK-2**

The mean fruit weight, seed weight and pulp weight was significantly highest in open pollination (94.96, 17.84and 77.12 g), followed by hand pollination (86.48, 17.32 and69.16 g) and the lowest was recorded in bagged condition (56.92, 16.06 and 40.82 g), respectively. The seed: pulp ratio of fruits was significantly highest in bagged condition (39.14) followed by hand pollination (25.19) and the lowest were recorded in the fruits of open (23.19) pollination (Table 3).

**3.6 Effect of different modes of pollination on fruit quality and its associated Parameters of cultivated type of *S. cumini*, GKVK-2**

**Total soluble solids, total soluble sugars, total reducing sugars and total phenols content of fruits in cultivated type of *S. cumini*, GKVK-2**

The percent total soluble solids and total phenol content were significantly highest in the fruits of hand pollination (12.64% and 9.75 mg/g), followed by open pollination (10.44% and 8.85 mg/g) the least was observed in bagged condition (9.68% and 6.14 mg/g), respectively (Table 3a). Similarly the mean total soluble sugars and total reducing sugars were significantly highest in the fruits of open pollination (18.24 and 51.66 mg/g) followed by hand pollination (16.72 and 36.35 mg/g) and the least was found in the fruits of bagged condition (14.94 and 31.24mg/g).

**Dry weight, moisture content, pH and EC of the fruits in cultivated type of *S. cumini*, GKVK-2**

The mean dry weight of fruits was significantly highest in open pollination (22.65 %) followed by hand pollination (20.32%) and the lowest of 12.20 per cent was recorded in bagged condition. However, the moisture content of the fruits was significantly highest in hand pollination (76.59%), followed by open pollination (75.04 %) and bagged condition(71.66%).There was no significant differences in the pH (3.47 to 3.66)and electrical conductivity (1.50 to 1.67 mS/cm) of the fruits among different modes of pollination evaluated (Table 3a).

**Table 3: Effect of different modes of pollination conditions on fruit set and yield attributing characters of cultivated type of *S. cumini,* GKVK-2**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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 | 77.00a | 51.60a | 67.68a | 25.40b | 32.33b | 16.60a | 31.71b | 35.00a | 46.18a | 94.96a | 17.84a | 77.12a | 23.19b |
| Hand pollination | 50.00b | 31.40b | 62.80a | 18.60b | 37.20b | 12.20ab | 27.04b | 19.20b | 38.40a | 86.48a | 17.32a | 69.16b | 25.19b |
| Bagged condition | 88.20a | 12.00c | 13.77b | 76.20a | 86.23a | 9.40b | 79.55a | 2.60c | 2.86b | 56.92b | 16.06b | 40.82c | 39.14a |
| **SE(m)** | 7.72 | 3.95 | 1.80 | 4.98 | 1.8 | 2.05 | 3.08 | 3.24 | 3.89 | 2.78 | 0.39 | 2.52 | 0.66 |
| **CD @ 5%** | 23.78 | 12.16 | 5.54 | 15.34 | 5.5 | 6.30 | 9.50 | 9.98 | 12.0 | 8.55 | 1.21 | 7.76 | 2.02 |
| **CV (%)** | 24.06 | 27.87 | 8.36 | 27.79 | 7.75 | 35.93 | 14.95 | 38.27 | 29.88 | 7.81 | 5.14 | 9.04 | 5.03 |

Note: infl-Inflorescence

**Table 3a: Effect of different modes of pollination on fruit quality and its associated parameters of cultivated type of *S. cumini,* GKVK-2**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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 | 10.44b | 18.24a | 51.66a | 8.85a | 22.65a | 75.04ab | 3.48 | 1.66 |
| Hand pollination | 12.64a | 16.72a | 36.35b | 9.75a | 20.32b | 76.59a | 3.47 | 1.67 |
| Bagged condition | 9.68b | 14.94b | 31.24c | 6.14b | 12.20c | 71.66b | 3.66 | 1.50 |
| **SE(m)** | 0.35 | 0.83 | 0.91 | 0.35 | 0.63 | 1.16 | 0.06 | 0.75 |
| **CD@5%** | 1.08 | 2.56 | 2.80 | 1.06 | 1.95 | 3.58 | NS | NS |
| **CV (%)** | 7.18 | 11.18 | 5.11 | 9.36 | 7.69 | 3.49 | 4.04 | 10.53 |

NS- Non -significant

**3.7 Overall fruit set and yield attributing characters of wild and cultivated types of *S. cumini* as influenced by different modes pollination**

The fruit set and yield attributing characters of wild and cultivated types of   
*S. cumini* among different modes pollination revealed that significantly lowest mean number of fertilized flowers per inflorescence was recorded in the inflorescence kept in bagged conditions (0.00 to 13.77%) as compared to hand pollination (35.20 to 69.20%) and open (40.25 to 67.68%) pollination conditions respectively.

Similarly the per cent flower drop and per cent fertilized flower drop was significantly highest in the inflorescence kept in bagged conditions (86.23 to 100 and 0.00 to 79.55) as compared to hand pollination (30.80 to 64.80 and 27.04 to 42.68) and open pollination (32.33 to 56.33 and 31.77 to 45.95), respectively. The complete flower drop (100%) in the cultivated type of *S. cumini,* GKVK-1, GKVK-2 (86.23%) and in wild type (88.47%) that were kept in bagged condition indicated their higher degrees of self-incompatibility. The present findings are in agreement with those of Solomon Raju *et al*., (2014), Andrapradesh, India, who stated that in *S. alternifolium,* autogamy and geitonogamy are non-functional proving its self-incompatibility and an obligate out–crosser. Similarly, Anju Bajpai, *et al.,* (2012) also stated that jamun is self- compatible and requires pollen from different flowers of the same plant for pollination. The maximum fertilized flowers in open pollination were due to pollination from the abundant pollen brought by the different species of floral visitors. The transfer of pollen grains from the other flower of the same plant resulted in higher number of fertilized flowers in hand pollination. It is clear that in addition to flower drop, even after fruit set, the dropping of fertilized flowers (Plate 3) may be due improper pollination or due to wind currents.



c

b

a

**Plate 3: View of flower drop and fertilized flower drop in different pollination treatments among wild and cultivated types of *S. cumini* a) Flowers drop b) Fertilized flower/ fruit drop c) View of fruits upon drying.**

The significantly least number of fruits were retained in the inflorescence kept in bagged conditions (2.83 to 2.86%) as compared to hand (37.2 to 48.80%) and open   
(31.50 to 46.18%) pollination. These findings are supported by that of Saurabh Singh *et al*., (2019) who recorded maximum fruit set in open pollination (37.50 to 53.50%), followed by hand pollination (7.40 to 29.45 %) and it was negligible (0.33 to 0.80 %) under bagged condition in the nine selected jamun genotypes. In the present study, least number of fruit set was observed in the inflorescence kept under bagged conditions which might be due to pollination of flowers by ants especially, the resident nectar forager, *Tapinoma* sp. which is present inside the flower in fewer numbers, in addition to wind pollination. These findings are in agreement with that of Giby Kuriakose *et al*., (2018) who suspected that the flowers of *Syzygium occidentale* were visited exclusively by ant species, *Technomyrmex albipes* S. which resulted in significantly higher fruit set than those visited by any other insect forager.

The weight of fruits obtained from the inflorescence kept in bagged conditions   
(0.00 to 56.92g) weighed significantly lesser weight compared to the weight of the fruits obtained from open pollination (51.88 to 94.96g) and hand pollination (51.68 to 96.48g). The differences in the weight of fruits were attributed to variation in the efficacy in transferring pollen grains from other flowers of the same plant. The seed and pulp of the fruits of open pollinated (16.84 to 17.84 and 35.4 to 77.12 g) and hand pollinated (17.32 to 23.68 and 33.52 to 69.16g),treatments had significantly higher weight than the seed and pulp weight of fruits obtained from the inflorescence kept in bagged conditions (0.00 to 16.06 and 0.00 to 40.82g). The variation in the weight of the seed and pulp depends on the development of the seed and also fruit which in turn depends on effectiveness of the mode of pollination in operation. Similarly, significantly lowest seed: pulp ratio was recorded in the fruits obtained from the inflorescence kept in bagged conditions (0.00 to 56.69) compared to open pollination (23.19 to 48.05) and hand pollination (25.19 to 54.24). The variation in the seed to pulp ratio can be attributed to variation in the development of seed and fruit among different modes of pollination. The findings are in conformity with the earlier findings of Chongthanallaylaydevi *et al*., (2016) who recorded significant differences in fruit, seed and pulp weight but no variation was observed with respect to pulp to seed ratio and fruit to seed ratio of selected *S. cumini* genotypes. Singh and Singh, (2012) also stated that, the higher pulp: seed ratio of jamun fruits is one of the desirable traits of table purpose fruits.

**3.8 Overall fruit quality and its associated parameters of wild and cultivated types of *S. cumini* amon*g* different modes of pollination.**

Fruit quality and its associated parameters of wild and cultivated types of *S. cumini* among different pollination modes revealed that fruit juice obtained from open pollination (10.44 to 11.78% and 17.41 to 26.36 mg/g) and hand pollination (11.76 to 13.52% and 15.40 to 25.37mg/g) treatments had significantly higher soluble solids and total soluble sugars compared to bagged condition (0.00 to 9.84% and 0.00 to 14.94 mg/g).Similarly, the total reducing sugars and total phenol contents were significantly higher in the extracted fruit juice sample of open pollination (9.58 to 51.52 and 8.85 to 51.66 mg/g) and hand pollination (9.63 to 36.32 and 9.75 to 36.35 mg/g) as compared to bagged condition(0.00 to 15.49 and 6.14 to 31.24 mg/g). The pollination of flowers by floral visitors and hand pollination resulted in better fruit formation which in turn leads to better accumulation of total soluble solids, total soluble sugars, total reducing sugars and phenol contents in the fruits of open pollination and hand pollination treatments as compared to bagged condition. Further, this variation is also linked with the genetic makeup of respective wild and cultivated types of *S. cumini*. The earlier reports on chemical properties of jamun fruits published by Ghosh *et al.,* (2016) who also reported more or less similar findings on total solids (20.33 ± 0.34%), total soluble sugar (14.86 ± 1.47%), total sugar (7.88 ± 0.41 mg/g) and total phenol (203.76 ± 9.84mg/g) content in the fruits.

The fruits obtained in bagged condition had significantly lowest dry weight and moisture content (0.00 to12.20% and 0.00 to 71.66%) as compared to open pollination (13.86 to 22.65% and 73.36 to 75.14%) and hand pollination (11.98 to 20.32 % and 76.59 to 79.81%). The variation in the dry weight and moisture content might be attributed to variation in the pulp content of the fruits among different modes of pollination. The earlier studies on chemical properties of jamun fruits made by Ghosh *et al.,* (2016) who also reported around 79.212.27 per cent moisture content in the fruits of jamun. No much variation was observed in pH and electrical conductivity of fruits among different pollination modes. However, electrical conductivity of fruits ranged from 0.72 to 1.66, 0.70 to 1.67 and 0.00 to 1.50 in open pollination, hand pollination and in bagged conditions, respectively. The EC values indicated the salt content of the fruits. Similarly, pH values of the fruits ranged from 3.42 to 4.38, 3.44 to 4.29 and 0.00 to 3.66 in open pollination, hand pollination and in bagged conditions, respectively. The observed pH values indicated acidic nature of fruits and the low pH values was responsible for more astringency in taste. Ghosh *et al.,* (2016) while studying chemical properties of jamun fruits also reported pH of 3.87 ± 0.01 in ripened jamun fruit which is similar to the present findings.

**4. Conclusion:**

The results demonstrated that Syzygium cumini is predominantly cross-pollinated and shows poor performance under self or bagged pollination, underscoring its self-incompatibility. Open and hand pollination significantly improved fertilization, fruit retention, yield parameters and overall fruit quality. Among the different pollination methods, open pollination ensured better pulp weight, reducing sugar content and dry matter accumulation. The findings emphasize the importance of pollinators, especially honey bees, in ensuring optimal fruit production. Enhancing pollinator activity in jamun orchards could thus serve as a viable strategy to increase yield and quality sustainably. Therefore, pollination management should be integrated into jamun cultivation practices for improved productivity.

**5. References:**

Anju Bajpal, Singh, A.K. and Ravishankar, H. (2012). Reproductive phenology, flower biology and pollination in jamun (*Syzygium cumini* L.). *Indian Journal of Horticulture*, **69**(3):416-419.

Anonymous. (2016). Directorate of Economics and statistics, Department of agriculture, embryo abortion in *Syzygium cumini* (L) Skeels (Myrtaceae). *International Journal of* Government of India, http;//eands,dacnet.nic.in. *Plant sciences*, **157**:49-52.

Anyasi, AfamI. O., Jideani, Godwin, R.A., and Mchau. (2015). Effect of organic acid   
prê-treatment on some physical, functional and anti-oxidant properties of ﬂour obtained from three unripe banana cultivars, *Food chemistry*,**172**:515-522.

Chongthanallaylaydevi, G.S.K., Swamy and Nagesh naik. (2016)**.** Studies on flowering and fruit characters of jamun genotypes (*Syzygium cumini* Skeels). *Biosciences Biotechnology Research* Asia, **3(**4): 2085-2088.

Ghosh, P., Ramachandrapradan, Sabyasachi Mishra, Avinash sigh patel and Abhijitkar. (2016). Physicochemical and nutritional characterization of jamun (*S.cumini). Current Research in Nutrition and Food science,***5(**1):25-35.

Giby Kuriakose, PalattyAlleshSinu and Shivanna, K.R. (2018). Ant pollination of *Syzygium occidental,* an endemic tree species of tropical rain forest of the Western Ghats, India. <http://doi.org/10.1007/s11829-018-9613-1>.

Keskar, B, G., Karale, A. R., Dhawale, B.C. and Chodhary, K.G. (1989). Improvement of jamun (*Syzygium cumini* Skeels) by selection. *Maharashtra journal of Horticulture,* **4:**117-120.

Kunda, S., Ghosh, D. K. and Maiti, S.C. (2001). Evaluation of some local types of jamun (*Syzygium cumini* (L.) Skeels*)* of West Bengal*. Environment Ecology,* **19**: 872-874*.*

Lawande, P.M., Haldankar, N., Dalvi, V. and Parulekar, Y.R. (2014). Effect of pruning on flowering and yield of jamun cv, Konkan Bahadoli. *Journal of Plant Studies*, **3(**1): 114-118.

Marshall, J.D. (1986). Drought and shade interact to cause fine root mortality in douglas –fir seedlings *Plant* and *Soil*,**91**:51-60

Misra, R. S. and Bajpai, P. N. (1984). Studies on pollination, fruit set, and fruit development in Jamun (*Syzygium cumini* Skeel). *Progressive Horticulture,* **16** (1): 1-5.

Ranganna, S. (1997). Hand book of analysis and quality control for fruits and vegetable products (2nd Ed).Tata Mc Grow Hill Publishing Company Ltd, New Delhi.pp.12-16.

Saurabh Singh, Singh, S. P., Vaibhav Singh and Kumari Shikha. (2019). Studies on floral biology, fruit set and fruit drop of different genotypes of jamun (*Syzygium cumini* Skeels). *The Pharma Innovation Journal,* **8(**1**)**:558-561.

Singh, S. and Singh, A. K. (2005). Genetic variability in jamun (*Syzygium cumini* Skeels) in Gujarat. *Prog. Hort*., **37**: 144-148.

Singh, S. and Singh, A. K. (2012). Studies on variability in jamun from Gujarat. *Asian Journal of horticulture,***7** (1):186-189.

Singh, S., Singh, A.K., Singh, H.P., Bagle.B.G. and More, T.A. (2011). Jamun. Indian council of agricultural research, New Delhi, pp.46.

Solomon Raju, A. J., Radha Krishna, J. and Haresh Chandra, P. (2014). Reproductive ecology of *syzygium alternifolium* (Myrtaceae), an endamic and endangered tropical tree species in the Southern Eastern Ghats of India. *Journal of Threatened Taxa* /www.threarenedtaxa.org/26 august 2014/ **6(**9):6153 – 6171.

Tarai, R. K., Kundu, S., Ghosh, B. and Mitra, S. (2006). Performance of some minor fruits in west Bengal. *Proceedings of national symposium on production , utilization and export of underutilized fruits with commercial potentialities*, 2-24 November 2006, Bibhan Chandra Krishi Vishwavidyalaya, West Bengal. pp.79-82

Wrigley, J. W and fagg, M.A. (2003). Australians native plants: cultivation use in landscaping and propagation. Reednew Holland, Australia, 696pp.