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RESEARCH PAPER

Study of fruit morphometric traits from *Syzygium malaccense*

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Abstract: *Syzygium malaccense* L. (Myrtaceae) is a fruit bearing tree, locally known as "*Jambe hannu*" (Kannada) and commonly known as Malay apple. In India, the tree is distributed in southern parts reported from Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu states. These trees are grown along the boundaries of horticulture crop plantations or home gardens as a fruit species all along the tropical sites of Western Ghats. The present study was aimed to understand the variation in morphological traits of *S. malaccense* growth, fruit and seed parameters from 25 sites in Uttara Kannada district. The study measured tree height, girth at breast height (GBH), fruit length, width, weight, shape, and colour, as well as seed length, width, weight, and number of seeds per fruit. A total of 750 fruits from 50 trees were sampled. Tree heights ranged from 6 to 22 meters and GBH varied between 61 to 128 cm, with significant differences between sites. Fruit length ranged from 41.39 mm to 63.40 mm and fruit weight from 31.73 g to 74.20 g, showing substantial variability. Three fruit shapes were identified, *viz.,* pyriform (96.53%), oblong (2.53%) and round (0.93%). The predominant fruit colour was white striped crimson (56.40%), followed by reddish pink (31.47%) and white (12.13%). Seed length varied between 7.30 mm to 21.32 mm, while seed weight ranged from 1.63 g to 7.33 g. The study observed single-seeded or seedless fruits in few sites. These morphological variations highlight significant diversity in *S. malaccense*. The results underscore the species potential for addressing nutritional security and enhancing biodiversity in tropical regions.

Key words: Malay apple, Morphological variation, *Syzygium malaccense*, Western Ghats

Introduction

An underutilized plant species is the one which offers value but is not widely grown, rarely available in the market, or not developed commercially (Chandra *et al.,* 2020). Effective use of underutilized fruit species helps to improve nutrition and fight against hunger. Many edible fruit spices belonging to genus *Syzygium* were reported to be underutilized from different parts of the world. *Syzygium malaccense* (L.) Merr. & L. M. Perry (family Myrtaceae) is also one the underutilized species from the genus *Syzygium*. It is a fruit bearing tree known as Malay apple, Mountain Apple, Red Jambo or Otaheite apple in English and in Kannada it is known as "*Jambe or Jambe Hannu*". The species is indigenous to Southeast Asia. *Syzygium malaccense*is is a popular edible fruit species in South East Asia (Vadu *et al.,* 2023). In India, *S. malaccense* is distributed in Southern parts, reported from Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu states. It is planted for its pleasant flavoured, fleshy, delicious edible fruits.

Syzygium malaccense is an evergreen tree that grows to a height of 6 to 20 m with deep green glossy foliage (Plate 1a). The flowers are produced in cymes on older branches. Sessile pink flowers consist of numerous long stamens which detach from the flower and fall off (Plate 1c). The fruit were oblong to pyriform in its shape with a size from 6 to 10 cm in length. Fruits were pink, reddish pink/ dark pink or white striped crimson pink (Plate 1b). The fruits are juicy with white flesh, one or two large seeds (Radha and Mathew, 2007; Lim, 2012).

Syzygium malaccense trees are grown along the boundaries of horticulture crop plantations or home garden as a fruit species all along the tropical sites of Western Ghats (Nigam and Nigam, 2012) for its delicious, mildly sour tasted sweet flavoured fruits. Fruits can be consumed as fresh fruits or processed into juice, squash, jam, sauce, preserves and wine (Hegde, 2021). Different parts of the *S. malaccense* (fruit, leaf, seed, bark, wood and root) are mentioned for different ethnobotanical uses. The leaves, bark, root and seeds are traditionally used in Indian systems of medicine to treat various diseases like blood pressure issues, respiratory issues, cracked tongues and itching (Hegde, 2021; Rampilla *et al.,* 2020). The ripe raw fruits of *S. malaccense* are sold in the local market of Uttara Kannada district of Karnataka and elsewhere. Morphological variation in the fruits of this species was reported from different parts of India and outside (Jayasree *et al*., 2022; Vadu *et al*., 2023). Hence, the present study was designed to understand the variation present in *S. malaccense* fruits.

Material and methods

The present study was carried out in Uttara Kannada district of Karnataka. A total of 25 study sites were randomly selected in the study area. From each site two trees were identified for the research. Five fruits from each individual tree with three replications (15 fruits from each tree) were collected for fruit morphometric study.

Collection of plant material

A preliminary survey indicated that the trees are grown in the boundaries of Arecanut plantations, Betta lands or in the homestead gardens by the farmers or common public in Uttara Kannada district. Presence of maximum 2 to 4 individual trees were noted in the locations. Hence, *S. malaccense* individual

trees were considered as samples and fruit morphometric traits as treatments.

Following is the description of study details:

Study area : Uttara Kannada
Sampling sites : 25 sites
Sampling size : 2 individual trees in each site (50 trees)
Replications : 3 (15 fruits from an individual tree)
Total samples : 750
Design : Factorial RBD

Study the morphometric variation in the *S. malaccense*

Morphological parameter of tree (Tree height and Girth at breast height), fruit parameter (fruit length, width, weight, shape, colour and number of fruits in a cluster) and seed parameter (seed length, width, weight and number of seed per fruit) were studied for individual tree. Detailed methodology followed in the present study was mentioned below.

Growth parameter

The growth parameters were recorded from the trees, which have Girth at Breast Height (GBH) of 20 cm or more. Tree height and GBH are the growth parameter recorded for each individual tree (total sample size is 50). Tree height was measured by Ravi altimeter and expressed in m. GBH was recorded with the help of measuring tape (Chaturvedi and Khanna, 2015).

Fruit parameters

Ripened fruits were collected randomly during peak fruiting season (February-March and October-November). Fruits of varied sizes (from small to large sizes) were selected during the study. Three replicate recordings of five fruits were selected from each tree for morphometric records. A total of 15 fruits was the sample size for a tree (Saran *et al.,* 2022). Fruit length and width were measured by using digital callipers and values were expressed in millimeters (mm). Fruit weight was measured by using digital weighing balances and expressed in g. Fruit shape and colour was recorded by visual observations (Widodo 2013). Number of fruits in a cluster was also counted as per the method mentioned by Arora and Shah (2019).

Plate 1. *Syzygium malaccense* tree (a:Tree,b: Fruit, c: Flower, d; Seed)

Seed parameter

Seeds were separated from collected 15 fruits from individual trees by splitting up the fruits (Plate 1d). Following seed parameters were recorded (Saran *et al.* (2022). Seed length and width was measured by using digital callipers and average values were expressed in millimeters (mm). Seed weight was measured by using a digital weighing machine and average values were expressed in grams (g) and total number of seeds in each fruit was counted.

Statistical analysis

The data collected on various morphometric traits of trees during field study were statistically analysed by Factorial Randomized Block Design (FRBD). OP STAT data analysis software (developed by CCS, HAU Hissar Haryana) was used for statistical analysis. Two factor ANOVA was carried out for fruit and seed parameters.

Results and discussion

Plate 1 shows the habit and different parts of *S. malaccense* by which the species can be easily identified. It was noted that various animals and birds eat the fruits. The study results were presented as follows.

Growth parameter

Tree height measured in 25 sites of Uttara Kannada district was represented in Table 1. The mean tree height of 25 sites

Table 1. Variation in growth parameter of *S. malaccense*

Treatment	Growth parameter	
	Tree height (m)	Tree GBH (cm)
S_1	11.0	85.0
S_2	18.0	105.5
S_3	16.5	81.5
S_4	10.0	76.5
S_5	17.5	104.5
S_6	18.0	96.0
S_7	12.5	98.0
S_8	12.0	84.5
S_9	16.5	105.0
S_{10}	20.5	117.5
S_{11}	8.0	90.0
S_{12}	13.0	93.0
S_{13}	16.0	85.5
S_{14}	12.0	68.0
S_{15}	13.0	84.5
S_{16}	12.0	89.5
S_{17}	9.0	80.0
S_{18}	12.5	84.5
S_{19}	9.5	79.0
S_{20}	17.0	90.0
S_{21}	11.5	79.5
S_{22}	14.5	99.0
S_{23}	11.5	83.5
S_{24}	16.0	99.0
S_{25}	9.5	85.5
Mean	13.2	89.7
S.D.	2.7	9.2
C.V.	20.7	16.6

(S- Sites, S.D.- Standard deviation, C.V.- Coefficient of variance)

ranged from 8.0 m (S_{11}) to 20.5 m (S_{10}). The maximum mean tree height was observed in S_{10} (20.5 m) followed by S_2 (18.0 m) and S_6 (18.0 m). The lowest mean tree height was in S_{11} (8.0 m). Average mean of tree height from all the sites was 13.22 m. A mature *S. malaccense* tree is reported to grow up to a height of 16 m (Hosein *et al.,* 2015). Whistler and Elevitch (2006) reported the tree height of 16 m or more, however under cultivation a tree height of only 5-12 m was observed.

Girth at Breast Height noted during the study was shown in Table 1. Mean GBH among the trees ranged from 68.0 cm (S_{14}) to 117.5 cm (S_{10}). Maximum mean GBH was observed in S_{10} (117.5 cm) followed by S_2 (105.5 cm) and S_9 (105 cm). Minimum mean GBH was observed in S_{14} (68 cm). In New Guinea, trees typically grow to a height of 5-20 m, while specimens as tall as 30 m and 100 to 200 cm of GBH have also been observed (Hosein *et al.,* 2015). The earlier study reports indicated that *S. malaccense* tree height and GBH vary from one geographical region to another, as well as within the region. The vegetative characters such as height and girth are highly influenced by the site specific eco-geographical conditions. However, genetic variability also plays a significant role in tree height and GBH.

Fruit parameter

Average fruit length in *S. malaccense* ranged from 61.30 mm (S_{13}) to 45.98 mm (S_{25}). The highest average fruit length among the sites was in S_{13} with 61.30 mm followed by S_{14} (58.69 cm) and S_9 (56.76 mm). The minimum fruit length was observed S_{25} with 45.98 mm. Statistical analysis showed significant differences among 25 sites (Table 2). Jayasree *et al.* (2022) reported 61.0 mm of average fruit length in *S. malaccense* from Maharashtra. Nunes *et al.* (2016) reported the fruit length of *S. malaccense* ranged between 48.10 to 49.20 mm from two locations of Brazil.

Table 2. Morphometric variation in *S. malaccense* fruit parameter

Treatment	Fruit parameters				
	Length (mm)	Width (mm)	Weight (g)	No.of fruits in a cluster	
				Maximum	Minimum
S_1	49.17	42.70	38.15	6.0	4.0
S	52.26	45.30	50.22	6.5	3.5
S^2	48.57	40.87	36.82	6.0	2.0
S^3	48.32	41.53	37.87	5.5	2.5
S^4	51.93	44.31	43.90	6.0	3.5
S^5	52.91	44.87	47.32	6.0	2.5
S^6	49.13	41.25	33.17	6.0	2.5
S^7	50.23	43.45	43.64	6.0	3.5
S^8	56.76	48.71	37.29	6.0	4.0
S^9	49.91	39.98	37.35	6.5	3.0
S^{10}	52.97	42.09	41.90	4.5	1.5
S^{11}	54.70	44.19	38.75	6.5	4.0
S^{12}	61.30	48.01	70.54	6.0	4.0
S^{13}	58.69	45.36	63.33	6.0	2.0
S^{14}	47.56	40.73	38.74	6.0	3.5
S^{15}	50.24	42.86	44.02	5.5	1.5
S^{16}	47.48	40.31	53.59	5.5	3.0
S^{17}	50.27	43.67	34.30	5.0	1.5
S^{18}	55.56	50.58	37.74	5.5	1.5
S^{19}	52.27	45.09	34.10	5.5	2.0
S^{20}	52.86	46.44	47.85	5.5	1.5
S^{21}	48.23	41.95	44.39	5.5	2.0
S^{22}	57.92	52.28	45.90	4.5	2.0
S^{23}	49.09	44.87	48.57	5.0	2.0
S^{24}	45.98	39.79	54.77	5.5	2.0
S_{25}					
S.Em.+	1.87	1.87	2.02	-	-
C.D. @5%	5.27	5.25	5.67	-	-

Table 2 diplay the results of fruit width. The mean fruit width ranged from 39.79 mm (S_{25}) to 52.28 mm (S_{23}) in the study area. The highest mean fruit width (52.28 mm) was recorded from S_{23}, followed by S_{19} (50.58 mm) and S_9 (48.71 mm). The lowest mean fruit width (39.97 mm) was observed in S_{10} (Table 2). Jayasree *et al.,* (2022) reported the mean fruit width was 54.00 mm from Maharashtra. Fruit width and fruit length showed variation as reported by different researchers from different sites (Jayasree *et al.* Nunes *et al.,* 2016). This amount of variation was common in fruit parameters (Hegde *et al*., 2013). Present study also indicated significant variation in fruit parameters and this could be attributed to the diverse topography and climatic conditions of research sites.

The mean fruit weight in 25 sites ranged from 33.17 g (S_7) to 70.54 g (S_{13}). The maximum mean fruit weight 70.54 g was reported in S_{13} followed by S_{14} (63.33 g) and S_{25} (54.77 g). The lowest mean fruit weight observed in S_7 (33.17 g). Results of analysis revealed a significant difference between the 25 sites (Table 2). Senevirathna *et al.* (2020) reported fruit morphometric variation in *S. malaccense* fruit length, width and weight from 35.1 to 43.4 mm, 36.5 to 51.5 mm and 41.86 to 38.2 g, respectively. Jayasree *et al.* (2022) reported 54.4 g of fruit weight from Maharashtra.

Three different shapes of fruits of *S. malaccense* were identified during the study *viz.,* pyriform, round and oblong. Fig 1 depicts percent share of fruits for their shape. Pyriform shaped fruits were found dominating (96.53%) followed by oblong (2.53%) and round (0.93%). Lim *et al.* (2012) noted that *S. malaccense* fruits have oblong, pyriform or bell-shapes. Whistler and Elevitch (2006) reported large, fleshy and oval shaped fruit in *S. malaccense*. Nunes *et al.* (2016) found that the shape was influenced by the ratio of fruit length to diameter, which varies depending on the geographical origin of the fruit. However, the round shaped fruits in this study were also reported, indicating a notable change in the fruit shape of *S. malaccense* species.

Depending on the observation fruits were divided into three categories for colour variations *viz.,* white striped crimson, reddish pink and white coloured fruits. Fig 2 displays the percent share of fruit colour. In total, white striped crimson-coloured fruits were commonly found (56.40%), followed by reddish pink (31.47%) coloured fruits. However, white (12.13%) coloured fruits were not common in the study area. Lim *et al.* (2012) mentioned that *S. malaccense* fruit colour varies from pink, reddish pink or white striped crimson pink. White colour fruits were also reported in *S. malaccense* (Whistler and Elevitch, 2006; Fernandes and Rodrigues, 2018). The variation in fruit colour across the study sites likely reflects a combination of genetic diversity and environmental influence.

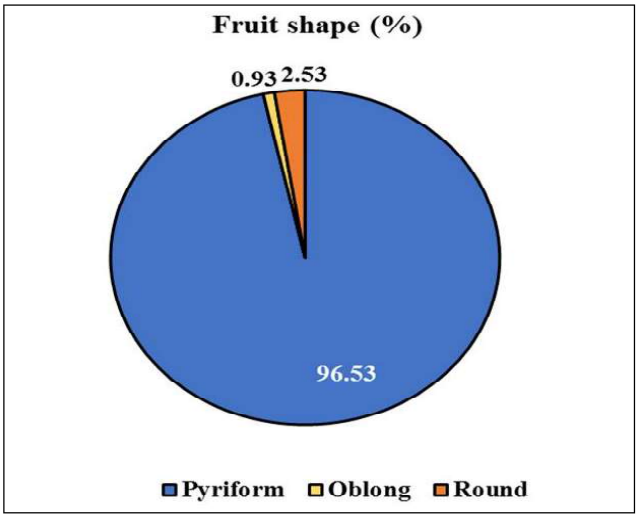

Fig 1. Percent share of *S. malaccense* fruits for different shapes

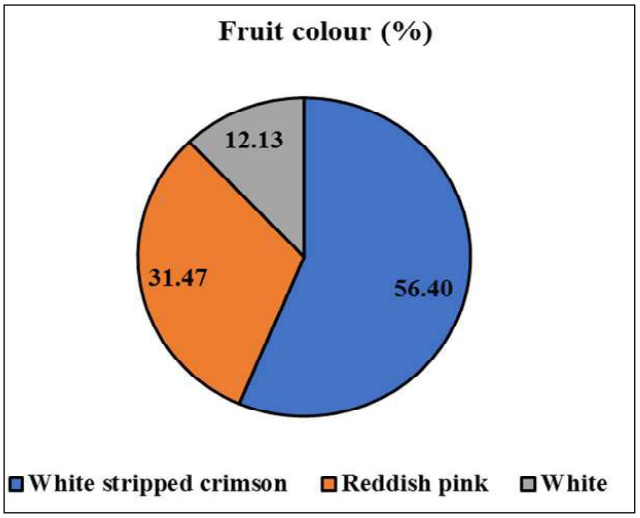

Fig 2. Percent share of *S. malaccense* fruits for colour variations

Number of fruits in a cluster varied from 1 - 7 and the mean number of fruits in a cluster for different sites was represented in Table 2. Widodo, (2013) reported the number of fruits in a cluster ranges from 3 - 5 in *S. malaccense*. The other related species in the genus *Syzygium* consists of 4-5 and 3-12 fruits in a cluster for the species *S. samarangense* (Moneruzzaman *et al.,* 2015) and *S. cumini* (Deepika, 2016).

Seed parameter

The analysed result for the seeds length, width, weight and number of seeds per fruit were presented in Table 3. The mean seed length in the 25 sites ranged from 8.52 mm (S_7) to 18.81 mm (S_{18}). The maximum mean seed length was observed in S_{18} (18.81 mm) followed by S_4 (18.10 mm) and S_{17} (17.83). Minimum mean seed length was observed in S_7 (8.52 mm). Senevirathna *et al.* (2020) reported dissimilarity in seed length of *S. malaccense* from 12.9 to 13.8 mm. The mean seed width ranged from 9.99 mm (S_3) to 20.96 mm (S_{18}). The maximum mean seed width (20.96 mm) was recorded from S_{18} and the minimum was in S_3 (9.99 mm). Lim *et al.* (2012) stated that *S. malaccense* shows seed width of 16.00 to 20.00 mm. The highest mean seed width observed was 6.80 g (S_{13}) and the lowest mean seed weight was 2.59 g (S_{17}). Jayasree *et al.* (2022) reported that seed length (17.4 mm), width (17.8 mm) and weight (2.62 g) of *S. malaccense.* Nacata and Andrade (2018) reported the *S. malaccense* fruit weight is 1.71 g. Fernandes and Rodrigues, (2018) reported that *S. malaccense* seed weight is up to 7.00 g.

The fruits in the study area consist of single seed or no seed. The decimal values in the number of seeds per fruit indicate the averaged values, where the number varied from zero to one (Table 3). Oliveira *et al.* (2011) reported that *S. malaccense* fruits consist of single seeds and some trees produce fruits with no seeds. Yusnita *et al.* (2017) large fruits often have one or two large sub globose to hemispherical seeds. Some trees produce fruits that are completely seedless. Some *S. malaccense* fruits may not have seeds due to various reasons and one common cause is parthenocarpy. Janick and Paul (2008) also mention the environmental conditions, such as lack of pollinators, unfavourable weather or nutrient deficiencies will interfere with pollination, leading to incomplete seed development. According to the authors, if the fruit was harvested before maturity, seeds may not have had time to develop and stress developed on the plant because of drought, disease or physical damage can affect seed formation, causing the fruit to be seedless (Janick and Paul, 2008). The trees might have developed the seedless fruits

Table 3. Morphometric variation in *S. malaccense* seed

Treatment	Seed parameter			
	Length	Width	Weight	No.of seeds
	(mm)	(mm)	(g)	per fruit
S_1	13.54	14.62	4.89	0.60
S_2	17.04	18.43	5.57	0.69
S_3	9.87	9.99	3.10	0.43
S_4	18.10	17.16	4.24	0.84
S_5	14.26	17.09	5.78	0.64
S_6	15.35	17.04	5.80	0.67
S_7	8.52	10.26	3.04	0.40
S_8	12.83	14.32	4.50	0.60
S_9	13.69	15.48	4.14	0.67
S_{10}	12.59	15.79	4.32	0.80
S_{11}	10.34	12.41	2.70	0.70
S_{12}	10.93	13.51	4.17	0.70
S_{13}	17.51	20.84	6.80	0.97
S_{14}	15.94	18.52	5.17	0.83
S_{15}	12.34	14.16	4.49	0.73
S_{16}	13.82	15.24	4.87	0.64
S_{17}	17.83	20.05	2.59	0.80
S_{18}	18.81	20.96	4.57	0.84
S_{19}	16.10	18.03	2.60	0.80
S_{20}	13.03	15.26	4.05	0.87
S_{21}	11.21	13.07	4.34	0.77
S_{22}	14.03	16.50	3.95	0.94
S_{23}	15.85	17.91	4.12	0.90
S_{24}	15.95	16.30	2.75	0.87
S_{25}	16.86	18.85	2.65	0.97
S.Em.±	1.67	1.68	0.25	0.06
C.D.@5%	4.69	4.73	0.70	0.19

(S- Sites)

in the study area may be because of any of the above reasons otherwise fruits with one seed are common in study area.

Conclusion

Morphological variations were observed in growth, fruit and seed parameters of *S. malaccense*. Significant variations were observed in *S. malaccense* fruit length, width and weight across 25 sites. Study also revealed differences in the number of fruits in a cluster, fruit shape and colour. The seed length, weight and number of seeds per fruit also varied in the study sites. The observed variations indicate a significant level of morphological diversity in *S. malaccense* across the study sites in Uttara Kannada district. Detailed molecular studies may provide insights about the genetic factors responsible for the variations in *S. malaccense*. These variations in growth, fruit and seed characteristics have important implications in cultivation, conservation and breeding programs, especially for site-specific management and selection of superior phenotypes for fruit production.

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