

Flower morphology and fruit maturity of four minor fruits (*Diospyros peregrina*, *D. discolor*, *Muntingia calabura* and *Careya arborea*) of Tropics and subtropics

MSA Fakir^{1*}, M M Rahman², M M Hasan², S Moonmoon² and MM Rahman¹

¹Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, Bangladesh

²Department of Crop Botany and Tea Production Technology, Sylhet Agricultural University, Sylhet, Bangladesh

*Email: fakirmsa@gmail.com

Received : 03.05.17 ; Revised : 29.4.18 ; Accepted : 10.5.18

ABSTRACT

Floral biology and morphological features are essential for crop improvement and harvesting fruit at right time. Deshi (*Diospyros peregrina* Gurke) and bilatigab (*Diospyros discolor* Gurke), china cherry (*Muntingia calabura* L.) and kumbhi (*Careya arborea* Roxb.) are minor edible fruits of tropics and subtropics. A study was conducted at the Botanical Garden of Bangladesh Agricultural University, Mymensingh to investigate floral morphology and maturity indices of the four fruit species during 2008 to 2011. The flowers are incomplete, regular, polysepalous and poly petalous with numerous stamens and superior ovary in deshi gab; and multicarpellary ovary in bilati gab. The flowers are hermaphrodite, complete, polysepalous, polypetalous, numerous stamen with superior ovary in china cherry and inferior ovary in kumbhi. Fruit growth study revealed that maximum dry mass accumulation in seed i.e. physiological maturity (PM) was obtained when the fruit weight (dry) also reached highest in all species. Visual indices of PM were also recorded by changes in pericarp colour. These indicated the appropriate fruit harvesting stage. Results showed that fruits may be harvested at physiological maturity by observing fruit size and visual colour change of the pericarp.

Keywords: Minor fruits, floral biology, physiological and harvest maturity, 'gab', china cherry, 'kumbhi'.

INTRODUCTION

Deshi gab (*Diospyros peregrina* Gurke) and Bilati gab (*D. discolor* Gurke) are minor tropical edible fruits belong to family Ebenaceae. Flowers of deshi gab are small, unisexual and incomplete with persistent calyx. The sticky pulp of its fruit is extensively used to smear with fishing nets to make them durable under water. The peak flowering and fruiting season ranges from April to June (Das and Alam, 2001). The blackish cover of berries gradually disappear indicating fruit maturity. Bilati gab is originated from Philippines (Singh, 1998). This fruit is found in the district of Kushtia, Jessore, Faridpur, Rajshahi, Barisal, Pirozpur, and Chittagong Hill Tracts regions of Bangladesh. The fruit is very attractive for its beautiful reddish colour at maturity. Immature fruits are astringent, while ripe fruits have sweet smell and are eaten as table fruits (Ahmed *et al.* 2011). Fruits are nutritionally rich that contain (per 100 g of edible portion) calories 113, water 69.6 g, carbohydrates 26.6 g, fibre 1.5 g, fat 0.1 g, protein 1.4 g, minerals 0.8 g, calcium 58 mg (Mondal, 2000). Mature

leaves of deshi and bilati gab are reported to be edible (Sankar, Pers. comm.).

China cherry (*Muntingia calabura* L.) is another minor but well-known tropical and edible fruit that belongs to Muntingiaceae (Watson & Dallwitz, 1992). It is a very fast-growing tree, reaching 25 to 40 ft in height in 6-8 years, with spreading, nearly horizontal branches. The leaves are evergreen, alternate, lanceolate or 2's or 3's in the leaf axils with 1.25 to 2 cm wide. A 100 g edible portion of the berries contain approximately 76.3 g water, 2.1 g protein, 2.3 g fat, 17.9 g carbohydrates, 6.0 g fiber, 1.4 g ash, 125 mg calcium, 94 mg phosphorus, 0.015 mg vitamin A and 90 mg vitamin C. The energy value is 380 KJ/ 100 g (Verheij, 1992). Ripened fruits are used into jams and in tarts. Because of its ability to grow quickly on poor soils and rapid dispersal by birds and bats, the cherry tree is being considered as a candidate for reforestation for environmental protections. Although the plants bear fruits throughout the year, the pick flowering and fruiting season is mainly ranges from April to July.

Kumbhi (*Careya arborea* Roxb.), belongs to the family Lecythidaceae and sub family Planchonioideae, is also an important minor fruit trees considering its foliage, shade and windbreak properties in the tropics and subtropics (Shastri et al., 2002). Ripe fruits of kumbhi become juicy and the juice is reported to edible and sedative in nature. Kumbhi is traditionally used in the treatment of tumours, bronchitis, epileptic fits, astringents, antidote to snake venom and skin disease (Kirtikar and Basu, 1975). It is also used as remedy for diarrhea (Sikarwar et al., 1994). Methanol extract of kumbh's barks can be used as natural antimicrobial and antioxidant (Kumar et al., 2006). The plant is also investigated as feeds and fodder. As a fodder it contains 6.44% dry matter, 50.06% organic matter, 19.94% total ash, 15.57% crude protein, 42.81% neutral detergent fibre, 40.41% acid detergent lignin, 2.26% calcium and 0.70% phosphorus (Upreti and Shrestha, 2006). There were details information on growth of some minor fruits (fruit size, fruit and seed weight, AGR of fruits, pulp to fruit ratio etc.) in Bangladesh viz., deshi and bilati gab (Hasan et al., 2014); chalta (Hasan et al., 2016); china cherry (Rahman et al., 2010); kumbhi (Rahman 2009); and cowphal (Roy et al., 2010) but little information is available on details of flower morphology and visual indices of fruit maturity for harvesting. So, the current study was carried out to investigate floral morphology (qualitative and quantitative) and harvesting maturity indices of the four fruit species, Deshi (*Diospyros peregrine* Gurke) and bilati gab (*D. discolor* Gurke), china cherry (*Muntingia calabura* L.) and kumbhi (*Careya arborea* Roxb)..

MATERIALS AND METHODS

Three each of deshi gab and bilati gab; six china cherry, and five kumbhi trees were selected in the Botanical Garden, Bangladesh Agricultural University, Mymensingh (24°26' and 24°54' N and 90°15' and 90°30' E) to study inflorescence type, size of floral parts and fruits of china cherry from April to July of 2008, during April to July of 2008 in kumbhi, between April and June of 2011 in deshi gab, and between May and July of 2011 in bilati gab. Different coloured woolen threads were loosely fastened in the pedicel of first opening (days after tagging) to record the data. In deshi gab,

tagging of flowers was started at 25th April and continued till end of May, while in bilati gab, tagging was started at 22nd May and continued up to end of June. In case of kumbhi plants, buds were tagged when the length and diameter was e"1.44 cm and e"5.12 cm, respectively. Ten opened flowers of each species were randomly collected to study the flower morphology. The flowers were carefully examined under the simple microscope and the number of sepals, petals and stamens were recorded. Cross section of the ovary was examined in the light microscope to observe the placentation and number of carpels. The length and breadth of 20 sepals and petals, stamens and styles was measured using ruler. Sepal and petal area was also estimated by $L \times B$. At each DAT, at least 20 fruits (four replication, five in each replicate) were harvested and measured for fruit length, diameter and fresh weight of fruit. The length and diameter of fruits were measured using threads and ruler. The physiologically matured fruits were harvested by observing colour changes. The mean differences were compared by least significant difference (LSD) test (Gomez and Gomez, 1984).

RESULTS

Flower morphology

Deshi gab: The inflorescence is axillary cymes, solitary or clusters of two to seven flowers arises from the leaf axile and light green in colour. Flowers are unisexual and small, dioecious, incomplete, regular, ebracteate, hypogynous, pedicellate; female flowers are solitary and larger than male flowers, 4-5 sepal or petal, calyx persistent, stamen numerous with monocarpellary ovary. The qualitative characters of inflorescence and flower of deshi gab is shown in Table 1.

Sepal length of deshi gab varied between 0.8-0.11 cm with a mean value of 0.95 ± 0.03 cm; sepal breadth from 0.6-0.8 cm with a mean value of 0.69 ± 0.02 cm (Table 2). Sepal area varied between 0.48-0.88 cm² with a mean value of 0.66 ± 0.03 cm². Petal length varied between 1.7-2.2 cm with a mean value of 2.0 ± 0.04 cm and petal breadth from 0.6-0.11 cm with a mean value of $0.0.85 \pm 0.04$ cm. Petal area varied between 1.02-2.42 cm² with a mean value of 1.77 ± 0.09 cm². Stamens number varied from 25-55 with a mean value of 41.4 ± 2.14 and stamen length between 0.4-0.7 cm with a mean of 0.54 ± 0.02 cm (Table 2).

Bilati gab: The inflorescence is axillary cymes, solitary or clusters of three to seven flowers arises from the leaf axile. Flowers are unisexual, dioecious, incomplete, regular, bracteate, hypogynous, 3-5 sepals, calyx persistent, 4-5 petal, stamen 3-5, stigma 4 with multicarpellary superior ovary. The qualitative characters of inflorescence and flower of bilati gab is shown in Table 3. Sepal length of Bilati gab varied between 0.8-1.3 cm with a mean value of 1.04 ± 0.037 cm and sepal breadth from 0.8-1.2 cm with a mean value of 1.03 ± 0.031 cm (Table 4). Sepal area varied between 0.64-1.56 cm² with a mean value of 1.09 ± 0.058 cm². Petal length varied between 1.5 -2.0 cm with a mean value of 1.78 ± 0.035 cm and petal breadth from 2.0-2.6 cm with a mean value of 2.32 ± 0.041 cm. Petal area varied between 3.01-5.20 cm² with a mean value of 4.31 ± 0.160 cm². Stigma length varied from 0.3-0.6 cm with a mean value of 0.46 ± 0.020 cm (Table 4).

China cherry: The inflorescence of china cherry is solitary or clusters of two rarely three flowers. Bud arises from the axile of leaf and light green in colour. Flowers are regular, pedicillate, polysepalous, hermaphrodite, epigynous, carpel: 5-7 with persistent stout capitates style. Small to medium size flower with light green sepal and creamy whitish petals. The detailed of qualitative characters of inflorescence and flower of china cherry is shown in Table 5.

Sepal length of china cherry varied between 0.7-0.95 cm with a mean value of 0.80 ± 0.064 cm and sepal breadth varied between 0.20-0.25 cm with mean value of 0.216 ± 0.040 cm (Table 6). Sepal area varied between 0.14-0.20 cm² with the mean of 0.173 ± 0.039 cm². Petal length varied between 1.1-1.3 cm with mean of 1.14 ± 0.083 cm and the petal breadth varied between 0.75-0.90 cm with mean of 0.86 ± 0.086 cm. Petal area varied between 0.82-1.08 cm² with a mean of 0.98 ± 0.11 cm². Number of stamens/flower varied between 102-151 with a mean value of 121.2 ± 1.95 the stamen length varied between 0.4-0.6 cm with a mean value of 0.481 ± 0.09 cm (Table 6).

Kumbhi: The inflorescence of kumbhi appears at the end of March when the tree more or less leafless. Spike inflorescences appear clustered at the end of branches. Buds are dark green color.

Flower does not open completely and some shed shortly after opening. Flowers are medium to large, pinkish, hermaphrodite, regular, polysepalous, polypetalous, ovary inferior, carpels 4-5, placentation axile with thick and persistent calyx and possess a bad smell. The flower morphology is shown in the Table 7.

Sepal length varied between 0.8-1.3 cm with mean of 1.03 ± 0.09 cm and the sepal breadth varied between 1.2-1.5 cm with mean of 1.34 ± 0.07 cm (Table 8). The sepal area varied between 0.96 and 1.82 cm² depending on the sepal length and breadth with mean value of 1.39 ± 0.13 cm². Petal length varied between 1.4-5.4 cm with mean of 4.68 ± 0.18 cm and the breath varied between 1.7-2.5 cm with mean of 2.14 ± 0.12 cm. The petal area varied between 6.12-4.31 cm² with mean of 10.04 ± 0.33 cm². Number of stamens/flower varied between 510-615 with mean of 566.5 ± 1.86 and stamen length varied between 3.0-3.8 cm with mean of 3.51 ± 0.11 cm. The style is persistent and the length varied between 4.9 and 6.1 cm with mean of 5.84 ± 0.19 cm (Table 8).

Fruit growth and visual colour change

In Deshi gab, fruit size (length and diameter) increased with increasing ages (DAT). The fruit length was 5.45 cm at 49 DAT, then grew rapidly and reached a steady state between 60 and 63 DAT (average 5.78 cm) (Table 9). The diameter followed similar pattern of length and remained constant between 60 and 63 DAT (average 4.58 cm) (Table 9). Near physiological maturity (63 DAT), seed and fruit weight reached 3.22 and 11.25 g, respectively (Table 9). Around two months from flowering, a berry of deshi gab turn yellowish green with the loss of blackish hairs, which is developed earlier on fruit surface (Fig. 1 A, B, C). Like deshi gab, fruit growth increased with increasing ages (DAT) in bilati gab. The fruit length and diameter also increased gradually and reached a steady state at 85 DAT (9.10 and 7.60 cm, respectively) (Table 9). At 85 DAT (PM stage), seed and fruit weight reached 9.13 and 35.78 g, respectively. After three months from flowering, fruits turn into dark red colour indicating visual index of fruit harvest (Fig. 1 D, E, F). In case of china cherry, fruit length and diameter was almost similar at 35 DAT (average 0.53 cm) followed by gradual increase and reached

steady at 55 DAT (at PM) (1.00 and 1.17 cm, respectively) with an average fruit dry weight of 0.53 g (Table 9). Harvest maturity of china cherry was attained around 53 DAT when the deep green berries turned into yellowish pink (Fig. 1 G, H, I). The fruit diameter of kumbhi increased twice than length at different ages and at 67 DAT (harvesting stage) fruit size attained about 7.48 and 19.72 cm, respectively (Table 9). Seed and fruit dry weight was recorded the maximum at 67 DAT and obtained 3.22 and 30.42 g, respectively (Table 9). Slight colour development on the shoulders and falling of one or two ripe fruits naturally from the plant was considered as the harvesting index of kumbhi (Fig. 1 J, K, L).

DISCUSSION

Deshi gab is a fast growing tree reaches 3-10 m in height, with spreading nearly horizontal branches. Flower characteristics were investigated by closely observing the flower. The flowers are small, whitish brown axillary cymes, solitary or clusters of 2-7, unisexual and small, dioecious, incomplete, regular, ebracteate, hypogynus, pedicellate, female flowers, solitary, larger than male flowers (Table 1).

The present findings are similar to the results reported by Sasidharan (2004) and Das and Alam (2001). They reported that the flowers of deshi gab are borne singly or in cluster, unisexual, small and dioecious. Sepal length varied between 0.8-0.11 cm and that of breadth between 0.6 and 0.8 cm, respectively. Petal length varied between 0.48-0.88 cm and that of breadth from 1.7-2.2 cm, respectively. Stamen number/ flower varied between 25 and 55 and that of stamen length varied from 0.4-0.7 cm.

Previous researchers (Sashidaran, 2004; Das and Alam, 2001) described a few features of flower. In the present study, detailed qualitative and quantitative floral characters are described (Tables 1 and 2). Fruit growth was investigated by measuring length, diameter and weight from 7 DAT to full maturity with a duration 60-65 days after flowering in deshi gab. Fruit length and diameter became greater (5.75 cm and 4.57 cm, respectively) at 60 DAT with an approximate weight of 60 g/ fruit and remained more or less unchanged till 63 DAT indicating maximum fruit size at maturity

stage. This signifies that when the berry reaches to approximately 5.8 cm in length or 4.6 cm in diameter, berries can be harvested. Around two months age from DAT, a berry of deshi gab turn yellowish green colour and devoid of blackish hairs on fruit surface indicating visual index of fruit harvest. These indices are important for harvesting berries at right time.

Flower characteristics of bilati gab were investigated by closely observing the flower. The flowers are small, whitish, axillary cymes, solitary or clusters of 2-7, unisexual and larger than deshi gab, dioecious, incomplete, regular, bracteate, hypogynus, sessile, female flowers, solitary, larger than male flowers (Table 1). The present findings are similar to Chong *et al.* (2009) and Morton (1987). They reported that the flowers of bilati gab are borne singly or in cluster, unisexual, small and dioecious. Sepal length varied between 0.8 and 1.3 cm and that of breadth from 0.8-1.2 cm, respectively. Petal length varied between 1.5 and 2.0 cm and that of breadth between 2.0 and 2.6 cm, respectively. Stamen length varied from 0.3-0.6 cm.

Previous researchers (Chong *et al.*, 2009; Morton, 1987; Das and Alam, 2001) described a few features of flower excluding growth study. In the present study, qualitative and quantitative floral characters and fruit growth were studied (Tables 3 and 4). Fruit growth was investigated by measuring length, diameter and weight from 35 DAT to full maturity with a varied duration. Fruit length and diameter became greater (9.08 cm and 7.59 cm, respectively) at 83 DAT with an approximate weight of 220 g/fruit and remained more or less unchanged till 85 DAT indicating maximum fruit size at maturity stage. This signifies that when the fruit reaches to approximately 9.1 cm in length or 7.6 cm in diameter, fruit can be harvested. Around at three months age from DAT, a fruit of bilati gab turn dark red colour indicating visual index of fruit harvest. These indices are important for harvesting fruit at right time.

The flowers of China cherry are small, white, borne singly or cluster of 2 or 3. Flowers are regular, sepal and petal 5-6, polypetalous, stamen numerous, syncarpous ovary superior with 5-7 carpels (Table 5). The present findings are similar to Morton

Table 1. Morphological characters of flower of Deshi gab (*Diospyros peregrina*)

Inflorescence	Flower	Calyx	Corolla	Androecium	Gynoecium	Fruit	Seed
Axillary, cymes, solitary or cluster of 2-7	Unisexual and small, dioecious, incomplete, regular, ebracteate, hypogynous, tri or pentamerous, pedicellate, female flowers larger than male ones	Sepal 3-5, light green, polypetalous, persistent, aestivation imbricate	Petal 3-5, yellowish, polypetalous, aestivation imbricate	Stamen numerous (25-55), free, anther lobed, light blackish in colour	Ovary superior, globose, glabrous or hairy, monocarpellary, ovule 2-8, placentation axile	Berry, slightly longer than wide, green when immature, yellowish green at maturity	Seeds 4-8, elliptical, smooth compressed, embedded in the gelatinous pulp

Table 2. Floral morphology of *Deshi gab* (quantitative)

	Sepal length (L) cm	Sepal breadth (B) cm	Sepal area (L×B) cm ²	Petal length (L) cm	Petal breadth (B) cm	Petal area (L×B) cm ²	Stamens/ flower (No.)	Stamen length (cm)
Mean	0.95	0.69	0.66	2.0	0.85	1.77	41.4	0.54
Range	0.8-0.11	0.6-0.8	0.48-0.88	1.7-2.2	0.6-0.11	1.02-2.42	2.5-55	0.4-0.7
Standard error mean	±0.03	±0.02	±0.03	±0.04	±0.04	±0.09	±2.14	±0.02

Table 3. Morphological characters of flower of Bilati gab (*D. discolor*)

Inflorescence	Flower	Calyx	Corolla	Androecium	Gynoecium	Fruit	Seed
3-7 flowered cymes, creamy white flowers, flowers arise from leaf axile	Flower unisexual, larger than deshi gab, dioecious, incomplete, regular, bracteate, 3-4 bracts, hypogynous, 3-5 merous, sessile, creamy white in colour, female flowers are solitary, larger than male flowers	Sepal 3-5, light green, polypetalous, persistent, aestivation valvate	In male flower petal 5, polypetalous, in female flower petal 4 and gamopetalous, creamy white in colour	Stamens 3-5, free	Stigma 4, united, covered by hairs, ovary superior, carpel 4, syncarpous	Round berry, globose, velvety, brownish red and densely covered with short, golden brown hairs, dark red at maturity	Seed 2-8, dark or blackish brown, elliptical

Table 4. Floral morphology of Bilatigab (quantitative)

	Sepal length (L) cm	Sepal breadth (B) cm	Sepal area (L×B) cm ²	Petal length (L) cm	Petal breadth (B) cm	Petal area (L×B) cm ²	Stamens/ flower (No.)	Stamen length (cm)
Mean	1.04	1.03	1.09	1.78	2.32	4.31	0.46	
Range	0.8-1.3	0.8-1.2	0.64-1.56	1.5-2.0	2.0-2.6	3.01-5.20	0.3-0.6	
Standard error mean	±0.037	±0.031	±0.058	±0.035	±0.041	±0.160	±0.020	

Table 5. Morphological characters of flower of China cherry

Inflorescence	Flower	Calyx	Corolla	Androecium	Gynoecium	Fruit	Seed
Solitary or cluster of two, arises from leaf axile.	Hermaphrodite, regular, pedicellate, bud green, 1.25-2 cm wide.	Sepal 5-6, light green, polysepalous, aestivation valvate	Petal 5-6, whitish, polypetalous, arises from the join of two sepals, aestivation valvate, last only one day,	Stamen numerous, free, filament long, anther lobed yellow in colour, glabrous at the base from where the stamen arise.	Carpel 5 – 7, syncarpous, ovary superior, style short or reduced, stigma capitate, 5 – 7 lobed, persistent, placentation axile.	Edible berry, numerous tiny seeded, green when immature but red or pink when ripe, juicy pulp sweet in taste.	Numerous, minute, round, tiny, embedded in the pulp.

Table 6. Floral morphology of China cherry (quantitative)

	Sepal length (L) cm	Sepal breadth (B) cm	Sepal area (L×B) cm ²	Petal length (L) cm	Petal breadth (B) cm	Petal area (L×B) cm ²	Stamens/ flower (No.)	Stamen length (cm)
Mean	0.80	0.216	0.173	1.14	0.86	0.989	121.2	0.481
Range	0.7 – 0.95	0.2 – 0.25	0.14–0.20	1.1–1.3	0.75–0.90	0.82–1.08	102–151	0.4–0.6
Standard error mean	±0.064	±0.040	±0.039	±0.083	±0.086	±0.11	± 1.95	± 0.09

Table 7. Morphological characters of flower of Kumbhi

Inflorescence	Flower	Calyx	Corolla	Androecium	Gynoecium	Fruit	Seed
Spike, clustered at the terminal of the stem when the tree is more or less leafless.	Hermaphrodite, regular, bud green.	Sepal 4 or 5, green, thick, triangular, polysepalous, aestivation valvate, persistent.	Petal 4 or 5, pinkish, green, oval shaped, polypetalous, aestivation valvate.	Stamen numerous (>500), free, outer ones long and pinkish, inner ones short and whitish, filament long, anther bilobed, basifixed base of the stamen.	Carpel 4, rarely 5, syncarpous, ovary inferior, style long and persistent. stigma 4 lobed, placentation axile.	Berry, green, few (1-9) or no seeded, become juicy and light green when ripe.	Round or oval, brown in colour, cotyledon absent.

Table 8. Floral morphology of Kumbhi (quantitative)

	Sepal length (L) cm	Sepal breadth (B) cm	Sepal area (L×B) cm ²	Petal length (L) cm	Petal breadth (B) cm	Petal area (L×B) cm ²	Stamens/ flower (No.)	Stamen length (cm)	Style length (cm)
Mean	1.03	1.34	1.39	4.68	2.14	10.04	566.5	3.51	5.84
Range	0.8-1.3	1.2-1.5	0.96-1.82	3.4-5.4	1.7-2.5	6.12-14.31	510-615	3.0-3.8	4.9-6.1
Standard error mean	±0.09	±0.07	±0.13	±0.18	±0.12	±0.33	± 1.86	± 0.11	± 0.19

Table 9. Fruit size and seed and fruit dry weight (DW) at different ages (days after tagging, DAT) in four minor fruits of Bangladesh

Age (DAT)	Deshi gab		
	Fruit size	Seed DW (g Fruit ⁻¹)	Fruit DW (g Fruit ⁻¹)
	Length x Diameter (cm)		
49	5.45×3.88 c	2.65 b	10.24 b
56	5.62×4.27 b	3.06 a	10.68 b
60	5.77×4.56 a	3.17 a	11.02 a
63	5.80×4.61 a	3.22 a	11.25 a
Bilati gab			
70	8.34×6.24 c	8.89 b	33.85 b
77	9.03×6.78 b	9.02 a	35.23 a
83	9.08×7.59 a	9.11 a	35.68 a
85	9.09×7.62 a	9.13 a	35.78 a
China cherry*			
35	0.53×0.52 c	-	0.14 c
45	0.74×0.79 b	-	0.23 b
53	0.99×1.17 a	-	0.33 a
55	1.00×1.17 a	-	0.35 a
Kumbhi			
45	6.64×15.74 c	2.21 c	26.45 c
55	7.25×18.57 b	2.59 b	28.77 b
65	7.45×19.71 a	3.15 a	30.25 a
67	7.48×19.72 a	3.22 a	30.42 a

In a particular fruit, figures within in a column with uncommon letter(s) differ significantly at $P \leq 0.05$. *: Seeds were very minute, hence, inseparable from fruit.

(1987) who also reported that the flowers of china cherry borne singly or in group of 2's or 3's in the leaf axils and 1.25-2 cm wide with many prominent stamens. Rahman *et. al.*, (2009) reported that the flowers borne singly or in groups of two in leaf axils with 5-6 green sepals and 5-6 white petals and many (>100) prominent yellow stamens, ovary superior with 5-7 syncarpous carpels and axile placentation. Sepal length varied between 0.70 and 0.95 cm and that of breadth between 0.2 and 0.25 cm respectively. The petal length varied between 1.1 and 1.3 cm and that of breadth between 0.75 and 0.90 cm, respectively. The length of stamen varied between 0.4 and 0.6 cm with mean of 0.48 ± 0.09 cm. The present result is similar to the report of Stone (1970) who reported that the petal is about 1.2 - 1.3 cm long and the stamen is about 0.6 cm long.

Previous researchers (Stone, 1970; Morton, 1987; Verheij, 1992) described a few features of flower.

In the current study, detailed qualitative and quantitative floral characters are described in Table 5 and 6. Fruit growth was investigated by measuring length, diameter and weight beginning from fruit set to full maturity with a duration about 2 months. Fruit length and diameter became greater (0.99 cm and 1.17 cm, respectively) at 53 days after tagging (DAT) and remain more or less unchanged till 55 DAT indicating maximum fruit size at maturity stage. This signifies that when the berry reaches to approximately 1.0 cm in length or 1.17 cm in diameter, berries could be harvested. The present result is similar to the report of Rahman *et al.* (2009) who also observed that matures berries of china cherry is 1.0- 1.2 cm in length or diameter. Flowers of Kumbhi are medium to large; pink clustered at the end of branches and had a bad smell. Sepal and petals 4 or 5, polysepalous, sepals thick and dark green, petals pinkish green, stamen numerous, pink or white, ovary inferior,

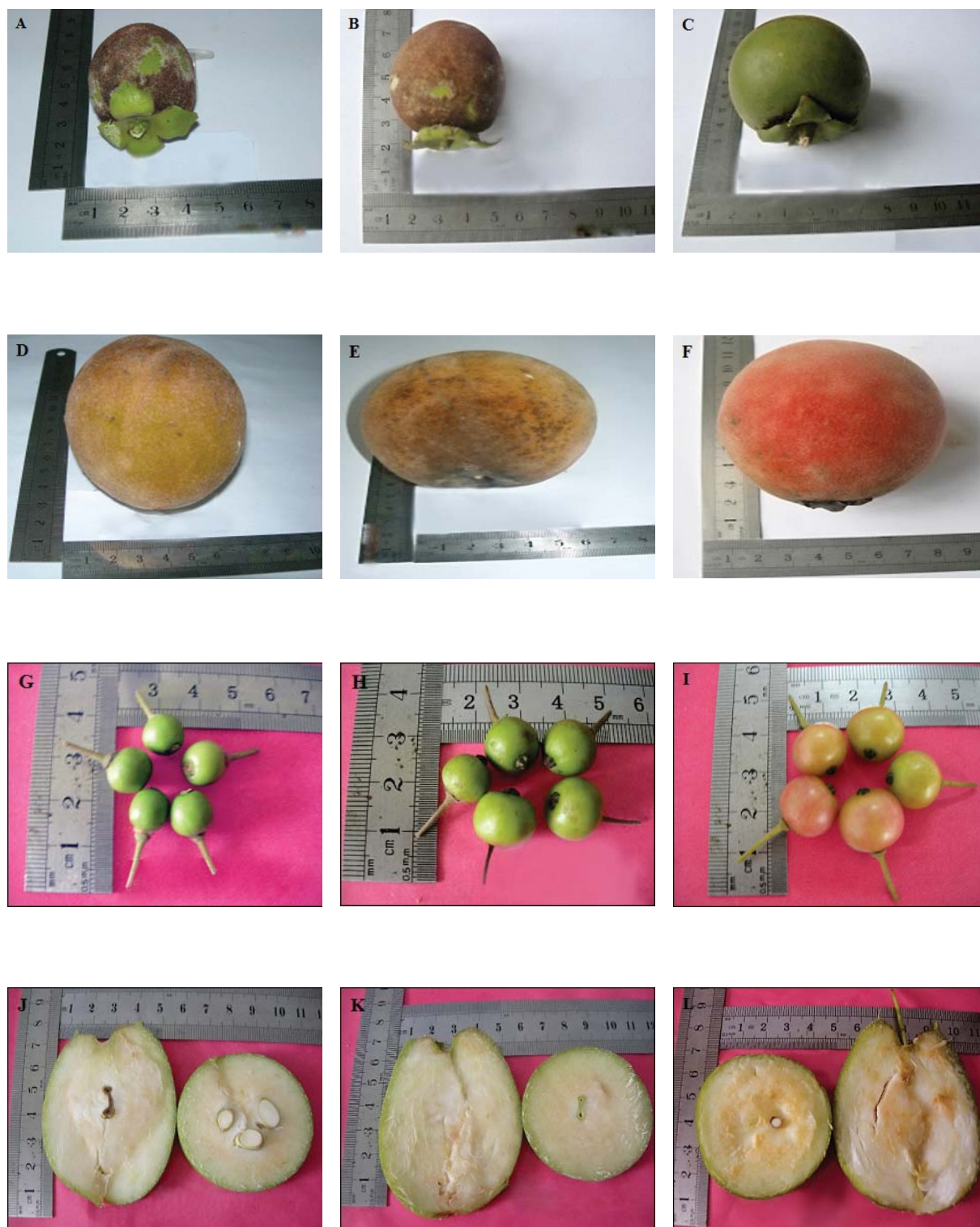


Figure 1. Changes in fruit size and colour at different ages: (A, B & C at 49, 56 & 63-65 DATs, respectively) in deshi gab; (D, E, & F at 70, 77 & 83-85 DATs, respectively) in bilati gab; (G, H, & I at 35, 45, & 53-55 DATs, respectively) in china cherry; and (J, K, L at 45, 55, & 65-67 DATs, respectively) in kumbhi.

placentation axile, style long and persistent (Table 7). Rahman *et al.* (2009) also described the flower of kumbhi borne in a cluster of raceme, bisexual, large, sepals 4-5, petals 4-5, free, stamen long and many (500), stigma long, ovary 4-5 locular inferior with many ovules. Das and Alam (2001) also reported that flowers are large, 5-10 cm across, white and pink, with an unpleasant smell in few flowered clustered at the end of branches. Das and Alam (2001) and Rahman *et al.* (2009) described a few floral characters but in the present study the detailed qualitative and quantitative floral characteristics had been studied in Table 7 and 8. Locally juices from light green fleshy ripe fruits are reported to edible but sedative in nature. Like the china cherry, fruits of kumbhi also required around 2 months (65 DAT) to mature. The length and diameter of fruit reached maximum (7.45 cm and 19.71 cm for length and diameter, respectively) at 65 DAT. The fresh and dry weights of fruits and seeds also reached maximum at 65 DAT. The present result is similar to Rahman *et al.* (2009) who reported that berry of kumbhi was 7.48 cm long 19.71 cm diameter and attained maturity around 65 DAT.

In summary, inflorescence is axillary cyme, solitary or cluster of 2-7 in deshi and bilati gab; solitary or cluster of two in china cherry, and spike in kumbhi. Flowers are monoecious in deshi and bilati gab, and hermaphrodite in china cherry and kumbhi but fruits are berry in all species. In deshi gab, floral parts consist of 3-5 sepals and petals in both male and female flowers, 25-55 stamens in male and monocarpellary ovary in female; in bilati gab, sepals and stamens are 3-5 in either sex, petals are 5 in male flower but 4 in female flower, syncarpous ovary with 4 carpels; in china cherry, sepals and petals are 5-6, stamen numerous with 5-7 carpels; and in kumbhi, sepals and petals are 4 or 5, stamen numerous with 4 carpels. In deshi gab, average size of sepal was 0.95cm x 0.69 cm (length x diameter), petal was 2.0 cm x 0.85 cm, and stamen was 0.54 cm long; in bilati gab, sepal was 1.04 cm x 1.03 cm (length and diameter), petal was 1.78 cm x 2.32 cm and stamen was 0.46 cm long; in china cherry, sepal was 0.80 cm x 0.216 cm (length and diameter), petal was 1.14 cm x 0.86 cm and stamen was 0.481 cm long; and in kumbhi, sepal was 1.03 cm x 1.34 cm (length and diameter), petal was 4.68

cm x 2.14 cm and stamen was 5.84 cm long. Results also show that all the morphological characters of fruits were increased gradually with increasing ages (days after tagging) and fruits may be harvested at physiological maturity by observing fruit size (11.2, 35.33, 0.33 and 30.25 g fruit⁻¹ at 60, 83, 53 and 65 DAT in deshi gab, bilati gab, china cherry and khumbi, respectively) and visual colour change.

REFERENCES :

- Ahmed, M., Mozumder, S.N., Firoz, Z.A. and Faisal, S.M. 2011. Variability and performance of superior velvet apple (*Diospyros discolor*) germplasm in hilly region. Bangladesh. *J. Agril. Res.* **36**(2): 223-230.
- Chong, K.Y., Tan, H.T.W. and Corlett, R.T. 2009. *A Checklist of the Total Vascular Plant Flora of Singapore: Native, Naturalised and Cultivated Species*. Raffles Museum of Biodiversity Research, National University of Singapore, Singapore. p. 273.
- Das, D.K. and Alam, M.K. 2001. Trees of Bangladesh, Bangladesh Forest Res. Inst., Chittagong. p. 83; 116-118; 155-156.
- Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research*. John Wiley and Sons, New York. p. 97-111.
- Hasan M.M., Fakir M.S.A., Rahman M.M. and Naznin S. 2014. Fruit growth and proximate composition of deshi (*Diospyros peregrina*) and bilati gab (*D. discolor*). *J. Bangladesh Agril Uni.*, **12**(2): 261-266.
- Hasan M.M., Fakir M.S.A., Rahman M.M., Moonmoon S. and Naznin S. 2016. Fruit growth and proximate composition of *Dillenia indica* Linn. *Int. J. Minor Fruits, Medicinal and Aromatic Plants*, **2**(1): 19-24.
- Kirtikar K.R. and Basu B.D. 1975. *Indian Medicinal Plants*. Vol.2, 2nd edn, Bishen Singh, R.1998. Fruits. National Book Trust, A-5, Green Park, New Delhi, India. p. 200.
- Kumar, R.S., Sivakumar, T., Sundaram, R.S., Sivakumar, P., Nethaji, R., Gupta, M. and Mazumdar U.K. 2006. Antimicrobial and Antioxidant Activities of *Careya arborea* Roxb. Stem Bark. *Iranian J. Pharma. Therapeutics*, **5**(1):35-41.

- Mondal, M.F. 2000. Production and Storage of Fruits (in Bangla). Mrs. Afia Mondal, BAU Campus, Mymensingh-2202. p. 212.
- Morton, J. 1987. Japanese Persimmon In: Fruits of warm climates. Miami, FL (Eds.), p. 411–416.
- Rahman, M.M. 2009. Flower morphology and fruit growth in china cherry (*Muntingia calabura*) and kumbhi (*Careya arborea*). M. S. Thesis. Dept. Crop Botany, Bangladesh Agric. Univ., Mymensingh.
- Rahman, M.M., Fakir, M.S.A. and Rahman, M.M. 2010. Fruit Growth in China cherry (*Muntingia calabura*). *Botany Res. International*, **3**(2): 56-60.
- Roy, D.K., Fakir, M.S.A., Rahman, M.M. and Rahman, M.M. 2010. Fruit growth in cowphal (*Garcinia cowa*). *J. Agrofor. Environ.*, **3**(2): 57-59.
- Sasidharan. 2004. Biodiversity documentation for Kerala- Tagging Plants, part 6. The Western Ghats Press Ltd. India. p. 271.
- Shastri, C. M., Bhat, D. M., Nagaraja, B. C., Murali, K. S. and Ravindranath, N. H. 2002. Tree species diversity in a village ecosystem in Uttara Kannada district in Western Ghats, Karnataka, *Current Science*, **82**(9):1080-1084.
- Sikarwar R. L. S., Bajpai A.K., Painuli R. M., 1994. Plants used as veterinary medicines by aboriginals of Madha Pradesh India. *Int J Pharma-cog.*, **32**(3):251-5.
- Singh, R. 1998. Fruits. National Book Trust, A-5, Green Park, New Delhi, India. p. 200.
- Stone, B.C. 1970. The flora of Guam. *Micronesica*, **6**:404-405.
- Upreti, C. R. and Shrestha, B.K. 2006. Nutrient Contents of Feeds and Fodder in Nepal. Animal Nutrition Division, NARC Kathmandu, Nepal. Website: www.narc-nepal.org.
- Verheij, E.W.M. 1992. *Muntingia calabura* L. In Coronel, R.E. & Verheij, E.W.M. (Eds.): Plant resources of South-East Asia. No. 2: Edible fruits and nuts. *Prosea Foundation, Bogor, Indonesia*, pp.223-225.
- Watson, L. and Dallwitz, M.J. 1992. The families of tagging plants: descriptions, illustrations, identification, information retrieval. <http://delta-intkey.com>.