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Morphological characterization of custard apple (*Annona reticulata*) grown in Brahmaputra valley of Assam

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Abstract

An experiment was carried out during 2017-2019 to study the morphological characterization of custard apple (*Annona reticulata*) grown in Brahmaputra valley of Assam. The experiment was conducted in the laboratory with custard apple fruits collected from 10 different locations of Assam *i.e.* CA-1: Bokajan, CA-2: Guwahati, CA-3: Titabor, CA-4: North Lakhimpur, CA-5: Biswanath Chariali, CA-6: Narayanpur, CA-7: Sadiya, CA-8: Sivasagar, CA-9: Nagaon and CA-10: Tezpur. The experiment was laid out in completely randomized design (CRD) with three replications. The leaves of custard apple collected from different locations of Assam shows lanceolate leaf blade shape with entire leaf margin, acuminate apex and acute base. The colour of the leaves varies from light green to dark green. The leaf length of custard apple leaves collected from different places ranges from 16.73 cm to 24.27 cm, leaf breadth ranges from 2.83 cm to 4.63 cm with petiole length ranged from 0.90 cm to 1.53 cm. The plants of Bokajan and Guwahati recorded early flowering and harvesting among the custard apple plants of other locations in the present study. The fruit characters of custard apple namely fruit shape, colour, length, diameter, volume, weight and pulp colour was also varies in all the fruits. The colour of the fruits was observed to be greenish yellow, yellowish, reddish and yellowish red in colour. The fruits of North Lakhimpur recorded maximum length (8.90 cm) and diameter (8.63 cm) while the fruits of Guwahati recorded minimum length and diameter of 6.10 cm and 5.80 cm, respectively. Again, the fruit weight ranges from 145.00 g to 443.33 g and volume ranges from 114.67 to 385.00 cc. The colour of the seeds varies from brown to dark brown and black. The length and girth of the seeds ranges from 0.80 cm to 1.40 cm and 0.23 cm to 0.73 cm, respectively. The total seed number per fruit ranges from 30.33 to 82.33 while the weight of ten seeds was found to be 1.14 g to 2.03 g. The variation in the results of the present investigation in morphological and biochemical characters among the custard apple fruits might be due to the different climatic conditions and management practices.

Keywords: Custard apple, morphological, *Annona reticulata*

Introduction

The N.E region of India is the home of nature's unique flora and fauna. It is believed that N.E region of India is the origin of many commercial and minor fruit crops. The Brahmaputra Valley Zone of Assam has a wide range of soil and climatic conditions due to which the fruit crops of this region exists a large variability. Custard apple is one of the highly nutritious minor fruit crops which are found in different parts of the Brahmaputra Valley Zone of Assam. Custard apple is an important dry land fruit crop in India which belongs to the family 'Annonaceae' having chromosome number $2n = 14$. The important species of Annonaceae which contains edible fruit are *Annona reticulata* (bullock's heart), *Annona squamosa* (sugar apple), *Annona muricata* (soursop), *Annona cherimola* (cherimoya) and *A. cherimola x A. squamosa* (atemoya). Annona fruits have edible, soft, juicy sugary pulp with mild flavor and acidity. Being rich in carbohydrate (23.0 g/100g) and possessing a pleasant flavor, custard apple fruits are used in making ice-creams (Maurya and Singh, 2006; Nath *et al.*, 2008) [13]. The fruit is reported to contain moisture 70.5%, protein 1.6 g, fat 0.4 g, minerals 0.9 g, fiber 3.1 g, calcium 17.0 mg, riboflavin 0.17 mg, niacin 1.30 mg, vitamin C 37.0 mg and energy 104 Kcal per 100 g of fruit (Gopalan *et al.*, 1987) [8].

Materials and Methods

Morphological and phenological observations of custard apple plants were recorded in the selected locations of the Brahmaputra valley where the plants were found in the homestead

gardens of the people at Bokajan, Guwahati, Titabor, North Lakhimpur, Narayanpur, Sadiya, Sivasagar, Nagaon and Tezpur.

Climatic condition

The climatic condition of Assam is sub-tropical humid having hot and dry summer followed by a cold winter. The intensity of rainfall is highest during monsoon particularly during June-July. The annual maximum average temperature in different districts of Assam is between 30 °C – 35 °C while the minimum average temperature ranges from 6 °C – 12 °C. The total annual rainfall is around 2300 mm and average humidity ranges from 74% - 87 %.

Height of the plant: Height of the tree was measured from ground level to the top of the tree using a graduated pole and expressed in meters.

Age of the plant: Age of the trees was recorded based on information provided by the owner of the tree.

Leaf characters: All the leaf characters were recorded by collecting the fully expanded and healthy leaves at 5th or 6th position from the tip of the actively growing shoots. From one plant, 10 leaves were collected and observations were recorded from the average of 10 leaves.

Leaf length: The length of fully grown leaf was measured using a scale from the base of leaf lamina to the tip along the midrib. The average values of 10 leaves were recorded and were expressed in cm.

Leaf breadth: The width of fully grown leaf at the broadest place of leaf lamina was measured using a scale. The average value of 10 leaves was recorded and was expressed in cm.

Leaf colour: The colour of the leaf was described as light green, green and dark green as per descriptor (Anon, 2008)^[1].

Leaf blade shape: The leaf blade shape was observed as ovate, elliptic, obovate and lanceolate as per the descriptor of custard apple published by IPGRI (Anon, 2008)^[1].

Leaf apex: Leaf apex shape was recorded as per the descriptor (Anon, 2008)^[1]. The apex shape was recorded as acute, rounded and acuminate.

Leaf base: Leaf base was recorded as acute, rounded, obtuse and cordate according to the descriptor (Anon, 2008)^[1].

Leaf margin: The shape of leaf margin was recorded as entire and wavy (Anon, 2008)^[1].

Petiole length: The petiole length was measured from the base of petiole to the base of leaf blade and expressed in cm.

Phenological characters

Flowering season: The day of emergence of first flower in a tree was considered as beginning of the flowering season. The period from the first and last flower emergence was noted as the duration of flowering season.

Harvesting period: Harvesting period was noted from the month of commencement of first harvest of the fruit till the

month of last harvest of the fruit.

Duration from fruit set to harvesting: Duration of fruit set to harvesting was calculated from first fruit set in a selected tree to the harvesting of the last fruit and expressed in days.

Physical characters of the fruits: All observations were recorded when fruit was fully ripened, unless otherwise specified. Measurements were made on well-developed representative fruits at harvest time.

Fruit shape: The fruit shape was observed and recorded as per descriptor published by IPGRI (Anon, 2008)^[1].

Fruit length: Five numbers of representative fruits were selected from one plant and their length were measured from the base of the pedicel up to the tip along the dorsal curve and their mean length was expressed in cm.

Fruit breadth: The fruit breadth of five fruits of the same plant was measured by splitting the fruit longitudinally at the broadest point and the average was expressed in cm.

Fruit weight: The average weight of five representative fruits was measured by using a weighing balance and expressed in g.

Fruit volume: The volume of the fruit was measured by water displacement method and expressed in cc.

Fruit colour: Fruit colour was recorded as light green, green, yellowish green, yellowish red and reddish as per descriptor (Anon, 2008)^[1].

Pulp colour: It was observed as creamy white, pale red and reddish white as per descriptor (Anon, 2008)^[1].

Physical characters of the seed

Seed characters *viz.*, length, width and colour of five healthy seeds extracted from representative fruit were recorded.

Average number of seeds per fruit: All the seeds were removed from each representative fruit after ripening and total number of seeds was counted and the values were recorded.

Seed length: Seed length was measured by using a Vernier Caliper and expressed in cm.

Seed width: Seed width was measured at the broadest portion of seed by using a Vernier Caliper and expressed in cm.

Seed colour: The colour of freshly extracted seeds from the ripe fruits was recorded as black, dark brown and brown by visual observation.

Total seed weight: All the seeds extracted from a ripe fruit were weighed in a digital weighing balance and the weight of the seeds was expressed in g per fruit.

Weight of ten seeds: Ten uniform size seeds were selected from the seed lot of a fruit and weighed in a digital weighing balance and the weight was expressed in g per 10 seeds.

Seed percentage: The percentage of seed was worked out

from the average total weight of seed per fruit and the average weight of fruit.

Results and Discussion

Height and age of the custard apple plant: In the present study, the height of the plant recorded minimum (5.2 meter) in the youngest plant (10 years) and the maximum height was observed (8.5 meter) in the oldest plant (15 years). The present study reveals that plant height of the custard apple plant varies with age of the plants. The variation in plant height might be due to the juvenility factors like age of the plant or it might be due to soil and climatic conditions of the place or it might also be due to management practices of the plant. Chopra *et al.* (1998)^[6] reported that the custard apple plant could reach to the height of 10 meters which was later confirmed by the results of Pinto *et al.* (2005)^[14].

Leaf characters: There was a significant variation in leaf length, leaf breadth and petiole length of the custard apple leaves collected from different places. It shows lanceolate leaf blade shape, entire leaf margin, acuminate leaf apex and acute leaf base as per the descriptor for *Annona* (Anon, 2008)^[1]. The colour of the custard apple leaves varies from light green to dark green. In the present study leaf length was ranged from 16.7 cm to 24.3 cm, leaf breadth ranged from 2.83 cm to 4.63 cm and the petiole length ranged from 0.93 cm to 1.53 cm. These variations in leaf characters might be due to the genetic makeup of the plant or might be due to the variation in different factors of climate prevailing in the places from where the custard apple fruits were collected. Similar results in leaf blade shape, leaf length, leaf breadth and petiole length was also reported by Ghawade *et al.* (2018)^[7] in *Annona squamosa* and Kumar *et al.* (2008)^[11] in *Annona reticulata* plants.

Table 1: Leaf characters of custard apple

Treatments	Leaf shape	Leaf apex	Leaf base	Leaf margin	Leaf colour	Leaf length (cm)	Leaf breadth (cm)	Petiole length (cm)
CA-1	Lanceolate	Acuminate	Acute	Entire	Green	17.80	3.07	1.03
CA-2	Lanceolate	Acuminate	Acute	Entire	Green	16.73	2.83	0.90
CA-3	Lanceolate	Acuminate	Acute	Entire	Green	20.37	3.77	1.19
CA-4	Lanceolate	Acuminate	Acute	Entire	Green	24.27	4.63	1.53
CA-5	Lanceolate	Acuminate	Acute	Entire	Green	20.30	3.57	1.17
CA-6	Lanceolate	Acuminate	Acute	Entire	Green	17.73	3.60	0.93
CA-7	Lanceolate	Acuminate	Acute	Entire	Dark green	20.57	4.57	1.23
CA-8	Lanceolate	Acuminate	Acute	Entire	Dark green	22.67	4.53	1.30
CA-9	Lanceolate	Acuminate	Acute	Entire	Dark green	20.43	3.90	1.12
CA-10	Lanceolate	Acuminate	Acute	Entire	Green	20.67	3.53	1.20
S. Ed±	---	---	---	---	---	1.45	0.82	0.09
CD (P=0.05)	---	---	---	---	---	3.05	0.39	0.19

Phenological characters: Flowering season, harvesting season and days from fruit set to harvest were considered as phenological characters in the present investigation. A wide variability in time of flowering, time of harvesting and days from fruit set to harvest was observed in the custard apple plants of different localities selected for the study. The custard apple plants of Bokajan and Guwahati recorded earliest flowering and harvesting among all the places of collection of

custard apple fruits. The variation in flowering and harvesting period might be due to the variation in climatic and soil condition of the places. Further, it might be justified that early flowering and harvesting in Bokajan and Guwahati was due to scanty rainfall during February-March in those areas. The results were in conformity with the findings of Azeez and Folorunso (2014)^[2] and Jyolsna (2016)^[9].

Table 2: Phenological characters of custard apple

Treatments	Flowering season	Harvesting period	Days from fruit set to harvesting
CA-1:Bokajan	February -August	February-March	331.50
CA-2:Guwahati	February -August	February-March	335.67
CA-3:Titabor	May-October	April-May	355.67
CA-4:North Lakhimpur	May-October	April-May	368.90
CA-5:Biswanath Chariali	May-October	April-May	362.07
CA-6:Narayanpur	May-October	April-May	347.93
CA-7:Sadiya	April-September	April-May	341.06
CA-8 :Sivasagar	March-July	March-April	339.01
CA-9:Nagaon	March-July	March-April	336.45
CA-10:Tezpur	March-July	March-April	332.42

Physical characters of the fruit: The shape of custard apple fruits collected for the study was found to be cordate, broadly ovate and round in shape as per the descriptor of custard apple (Anon, 2008)^[1]. Being a complex and polygenic trait, morphological characters might have highly influenced by several environmental factors or varies with various developmental stages of the plant. The custard apple fruits collected from different locations shows wide variation in

colour of the fruits. The colour of the fruits collected for the investigation varies from light green to yellow colour. This might be attributed to the rate of interception of sunlight by the plants as the sunlight plays an important role in development of colour during fruit developing period. The custard apple fruit shows a wide variation in length of the fruits. The length of the collected custard apple fruits varies from 6.10 cm to 8.90 cm. The variation in fruit size was

influenced by different factors *viz.*, number of fruits on the tree, production of optimum photosynthates, soil moisture status and fertility of the soil. Gibberellins produced in the seeds might also influence the size of the fruit. These findings are in agreement with the study of Mathakar (2005) [12], Bakane *et al.* (2015) [3] and Chandel *et al.* (2018) [5] in custard apple. The present study reveals that the fruit diameter of custard apple fruits exhibits a significant variation among the custard apple fruits which were collected from different locations for the study. The diameter of the fruits varies from 5.80 cm to 8.63 cm. It might be due to the climatic factors of custard apple growing region or it might be due to accumulation of maximum seeds in horizontal plain of the fruit. Production of gibberellins in the seeds might also contribute in the growth, which also influences the size of the fruit. Similar results were also reported by Thakur and Singh (1967) [17], Mathakar (2005) [12] and Chandel *et al.* (2018) [5] in custard apple. The fruit weight of the custard apple varies from 145.00 g to 443.33 g. Maximum fruit weight might be

due to the higher canopy spread which contributed to the accumulation of higher photosynthates in fruit to attain optimum fruit size. The variation in fruit weight is also correlated with the length and breadth of the fruit which helps in attaining the good fruit size. Beside this, the age, vigour of plant and eco-physiological conditions may also influence the fruit weight. Similar results were also reported by Kad *et al.* (2016) [10] and Ghawade *et al.* (2018) [7]. They recorded fruit length ranges from 6.56 cm to 21.11 cm and fruit breadth ranged from 5.96 cm to 17.61 cm which indicates presence of variability in fruit volumes of custard apples. The pulp colour of the custard apple fruits was found to be creamy white colour in the present study which was in conformity with the findings of Bhatnagar *et al.* (2012) [4]. The variation in pulp texture of the fruit is mainly influenced by their genetic makeup as well as climatic factors. Similar findings were also obtained by Mathakar (2005) [12] and Sudhakar (2013) [15] in custard apple.

Table 3: Fruit characters of custard apple

Treatments	Fruit Length (cm)	Fruit diameter(cm)	Fruit volume (cc)	Fruit weight(g)	Fruit shape	Fruit colour	Pulp colour	Pulp texture
CA-1	8.17	8.25	310.00	340.67	Cordate	Yellowish green	Creamy white	Soft
CA-2	6.10	5.80	114.67	145.00	Cordate	Yellowish green	Creamy white	Granular
CA-3	7.51	7.23	288.33	306.67	Cordate	Yellowish	Creamy white	Soft
CA-4	8.90	8.63	385.00	443.33	Cordate	Reddish	Creamy white	Soft
CA-5	6.47	6.51	201.67	243.33	Round	Reddish	Creamy white	Soft
CA-6	7.93	7.06	243.33	264.33	Broadly ovate	Yellowish	Creamy white	Soft
CA-7	7.97	7.10	266.67	313.33	Broadly ovate	Yellowish red	Creamy white	Soft
CA-8	7.83	7.33	236.67	260.00	Cordate	Yellowish red	Creamy white	Granular
CA-9	8.23	7.90	296.67	326.67	Cordate	Yellowish red	Creamy white	Granular
CA-10	6.20	6.07	115.00	146.67	Cordate	Yellowish	Creamy white	Granular
S. Ed±	0.77	0.57	34.95	46.59				
CD (P=0.05)	1.62	1.21	73.42	97.87				

Physical characters of the seeds

Seed characters like seed colour, seed length, seed girth, and total number of seeds per fruit, total seed weight and weight of ten seeds were considered as morphological characters of the seeds of custard apple. The seed colour was observed as brown, dark brown and black in colour in the custard apple fruits collected from different locations of Assam. The fruits of North Lakhimpur recorded highest number of seed (82.33), weight of total seed (20.03 g), weight of 10 seed (2.03 g) while fruits of Nagaon recorded lowest number of seed (30.33) among the collected custard apple fruits. The present investigation indicated that the number of seed per fruit and the seed weight of the fruit increases with increasing size of

the custard apple collected from different localities fruit, but this was not always true. Again the seed length and the girth varied significantly in the custard apple fruits of different locations. The longest seed with highest girth was found in the fruits of North Lakhimpur. The fruits of Guwahati produced smallest seed in terms of length and girth. The minimum seed weight might be due to the accumulation of lesser photosynthates into the seeds or might be due to genetic variation or it might be due to variation in fruit size. In the present study, observations on seed characters were in accordance with the Chandel *et al.* (2018) [5], Sudhakar (2013) [15], Surendra *et al.* (2013) [16] and Mathakar (2005) [12].

Table 4: Physical characters of seeds

Treatments	Seed colour	Seed length (cm)	Seed girth (cm)	Total number of seed per fruit	Total seed weight (g)	10 seeds weight (g)	Seed percentage (%)
CA-1: Bokajan	Black	1.33	0.60	70.67	16.72	1.58	17.03
CA-2: Guwahati	Dark brown	0.80	0.23	39.00	6.05	1.14	24.05
CA-3: Titabor	Dark brown	1.33	0.63	71.33	17.53	1.83	17.41
CA-4: North Lakhimpur	Black	1.40	0.73	82.33	20.03	2.03	38.61
CA-5: Biswanath Chariali	Dark brown	1.20	0.60	66.67	11.83	1.54	25.40
CA-6: Narayanpur	Black	1.10	0.57	51.00	6.97	1.47	38.04
CA-7: Sadiya	Black	1.23	0.50	67.67	12.09	1.52	31.56
CA-8: Sivasagar	Brown	1.03	0.40	48.33	9.54	1.80	16.29
CA-9: Nagaon	Black	0.97	0.33	30.33	8.89	1.27	16.55
CA-10:Tezpur	Black	1.20	0.50	36.33	9.88	1.89	27.08
S. Ed±	---	0.11	0.06	5.05	2.04	0.24	5.97
CD (P=0.05)	---	0.23	0.14	10.61	4.28	0.50	12.55

Conclusion

The present investigation reveals that there is a large variation in the morphological characters of the custard apple of different location. The custard apple fruits collected from North Lakhimpur recorded the largest fruit in terms of size and weight with better qualitative characters. On the other hand, the fruits collected from Guwahati were smallest in size with inferior quality. This variation in the morphological characters of the fruits might be influenced by the climatic conditions prevailing in those respective locations and also influenced by some other factors namely, soil conditions, management practices particularly pruning and nutrient management. All the plants selected for the study were seedling origin which might be one of the reasons for variation in morphological characteristics of the custard apple fruits. Further study of custard apple fruits in future on the molecular level would give the accurate characterization of custard apple fruits of different locations of Assam.

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