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Morphological characterization of *Annona* species under northern dry zone of Karnataka

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Abstract

An investigation on 'Morphological characterization of *Annona* cultivars grown under northern dry zone of Karnataka' was carried out during 2018-19 at College of Horticulture, Bagalkot, Karnataka. The experiment was laid out in a Randomized Complete Block Design with twelve varieties replicated thrice. Twelve cultivars consisting of four different species of *Annona* were evaluated for morphological characters. All the morphological observations were recorded as per Cherimoya descriptor developed by Bioversity Internationale and CHERLA, 2008. In all the 12 cultivars of *Annona* species, the leaf blade shape was recorded as ovate, elliptic, obovate and lanceolate; the shape of leaf apex as acute, rounded and acuminate; the leaf base as acute, rounded, obtuse and cordate; leaf colour as light green, green, greyish green and dark green; the leaf margin as entire or undulate; trunk colour as light grey; grey and dark grey; ramification as one branch, two branches and three or more branches; fruit shape as round, oblate, cordate, broadly cordate and oval and exocarp type as Laevis (smooth), Impressa (slight depressions) and Umbonata (small protrusions); pulp colour as white, creamy and creamy white; seed weight and seed percentage were also recorded.

Keywords: Morphological, leaf blade, fruit shape, trunk colour, acute, seed weight

Introduction

Annona, belongs to the family Annonaceae, is one of the largest families of primitive Angiosperms of Magnoliales in the clade Magnolid (APGIII, 2009; Gupta *et al.* 2015)^[2, 6] of the tropics. The genus *Annona* consists of 166 species out of which six species produce edible fruits.

India is blessed with diverse agro climatic conditions and the people of this country are fortunate to consume diverse varieties of horticultural crops. Fruits belonging to custard apple are adorable by all the age groups due to its attractive and sweetish pulp. However, sufficient availability of these fruits in the market is not up to the extent of its requirement by the common people due to non-availability of good quality planting material or major constraints in the production and low productivity due to lack of suitable cultivars to different agro-climatic conditions.

The lower productivity is mainly due to early fruit dropping from initiation of fruit sets to fruit maturity, which is due to several factors *viz.*, moisture, stress, nutritional, temperature, hormonal imbalance, higher wind velocity, insect pest and diseases *etc.*

The major reason for dearth of crop improvement of these *Annona* species could be attributed to lack of knowledge of uniqueness or diversity in these species as well as the lack of proper characterization of available varieties for economic traits.

Genetic resources of arid fruit crops have not been given desired attention due to their comparatively less commercial importance and limited research on genetic improvement of cultivars. Moreover, understanding of the importance of richness of the genetic resources is possible by their extensive characterization and evaluation for various growths, developmental and economic characters either at the phenotypic or genotypic or both levels. Hence, characterization and evaluation of germplasm material is given prime importance in the plant breeding activities.

In addition, determination of the range of variability is existing in the morphological and other physical properties among twelve *Annona* cultivars and finding if there is any association between fruit properties, such as fruit weight, fruit length, fruit diameter, pulp percentage *etc.* will provide an opportunity to select the best cultivar (s) for cultivation and will help breeders

to select and hybridize cultivars with higher levels of desired properties to develop improved varieties. Phenotypic evaluation and estimation of genetic variation was done for different *Annona* species by various researcher's (Jalikap and Kumar 2000; Sahoo *et al.*, 2000; Onimawo *et al.*, 2002; Mathakar 2005; Pareek *et al.*, 2009))^[7, 12, 9, 8, 10] to understand the mean performance, range of variation for tree and fruit related characters. However, most of these traits are polygenic in nature, highly influenced by environmental factors and hence, reliability and effectiveness of selection based on the phenotype a major lacuna in fruit breeding. Considering the above points, the present investigation was taken up with the objective to study the morphological characterization of different *Annona* species.

Material and Methods

An investigation on 'Morphological characterization of *Annona* species under northern dry zone of Karnataka was carried out during 2018-19 at College of Horticulture, Bagalkot, Karnataka. The experiment was laid out in a Randomized Complete Block Design with twelve varieties replicated thrice. The plant material consisting of three different species in genus *Annona*. These cultivars were selected from the orchard established at University of Horticultural Sciences, Navanagar, Bagalkot planted seven years back. A total of twelve *Annona* cultivars were selected for the present study.

Experimental site

The established orchard at UHS Bagalkot was used as the experimental site. All the morphological observations were recorded as per Cherimoya descriptor developed by Bioversity Internationale and CHERLA, 2008. The morphological analysis was conducted at Department of Fruit Science and Department of Genetics and Plant Breeding, College of Horticulture, Bagalkot.

Climatic conditions

Bagalkot is located in the northern region of Karnataka and positioned at 16°12'N, 75°45'E the average elevation in this area reaches approximately 610 m. The climate is warm and dry throughout the year and rainfall is scarce with an average annual rainfall of 318 mm and belongs to semi-arid tropical region. The experimental design adopted for the present investigation was Randomized Complete Block (RCBD) with three replications involving 12 cultivars. Three plants for each replication were selected randomly and tagged for detailed observation during investigation.

Results and Discussion

In the present study, 12 cultivars consisting of four different species of *Annona* were evaluated for a total of 41 morphological characters. All morphological observations were recorded as per descriptor of Cherimoya published by Bioversity International and CHERLA, 2008. The observations were broadly classified into tree, leaf, fruit, pulp and seed characters. The results are presented below.

The tree characters indicate the adaptability of cultivar for cultivation. Horticulturists aim for better tree characters traditionally, which eventually determines the yield and also the longevity of the trees to a greater extent. In the present investigation, large variability was recorded for tree characters.

Out of 12 cultivars, Balanagar, Arka Sahan, Red Sitaphal, Attemoya x Balanagar, Chance Seedling, Pink Mammoth

exhibited pale grey trunk colour. Red and Pink, Island Gem cultivars exhibited light grey trunk, No. 1 and No. 2 exhibited medium grey colour trunk and *Attemoya* and Ramphal had dark grey trunk colour respectively.

Trunk ramification measured from the ground level upto a maximum 50 cm. Variability exhibited in trunk ramification as one branch, two branches and three or more branches (Table 1a.). Among 12 cultivars; Balanagar, Arka Sahan, No. 1, No. 2, Attemoya had four branches each. Red Sitaphal, Island Gem, Attemoya x Balanagar had three branches, Red and Pink, Pink Mammoth, Chance Seedling, Ramphal had two branches trunk ramification each.

There was no variation across the cultivars for either suckering tendency (which was absent in all the cultivars) and defoliation (all were partially defoliate types).

In general, six cultivars (50%) recorded as pale grey colour, five cultivars (41.67%) had four branch trunk ramification and four cultivars (33.34%) had pale green colour of young branch. This showed that, most of the cultivars had four branch ramifications, pale grey trunk colour with pale green colour young branches and it was predominant in cultivars Table (1b). Similar results were reported by Thakur and Singh (1967), Mathakar (2005)^[8] and Folorunso and Olorode (2006)^[4] for the above characters in their study.

The leaf parameters indicate the photosynthetic efficiency of the varieties which helps in the identification of particular cultivar. The larger leaf having dark green colour may have higher photosynthetic efficiency which has direct association with the productivity and growth of the plant to a greater extent. The details of the leaf related a trait screened across 12 cultivars is presented in Table 2a.

The trait showed narrow variation across the cultivars for the intensity of the leaf colour. Among 12 cultivars; Balanagar, Attemoya, Red Sitaphal, Attemoya x Balanagar, Red and Pink, Chance Seedling and Pink Mammoth exhibited light green leaves. Arka Sahan, No. 1, No. 2, Island Gem and Ramphal exhibited dark green colored leaves.

Among 12 cultivars; Balanagar, Arka Sahan, No. 1, Attemoya, Red Sitaphal, Island Gem, Chance Seedling and Pink Mammoth recorded entire margin whereas, Red and Pink, No. 2, Attemoya x Balanagar and Ramphal recorded undulated leaf margin (Table 2a).

Cultivars like Balanagar and Red Sitaphal recorded lanceolate leaf blade shape. Arka Sahan, Red and Pink recorded ovate shape, whereas, No. 1, Attemoya x Balanagar, Pink Mammoth and Ramphal recorded elliptic leaf blade shape. Cultivars like Attemoya, No. 2, Island Gem and Chance Seedling recorded obovate leaf blade shape.

Balanagar, No. 1, No. 2, Attemoya, Island Gem, Attemoya x Balanagar showed acute leaf apex. Red and Pink and Red Sitaphal cultivars exhibited obtuse leaf apex. Arka Sahan recorded with different mucronulate leaf apex.

Cultivars like Balanagar, Red sitaphal and Ramphal exhibited acute leaf base. Arka Sahan, Red and Pink, Island Gem and Pink Mammoth exhibited round leaf base. No. 1 and No. 2 cultivars recorded with obtuse leaf base. Attemoya x Balanagar exhibited cordate leaf base.

In general, from the leaf related characters screened across cultivars it was revealed that, the leaf shape could be broadly categorized into four groups i.e. obovate, lanceolate, ovate and elliptical (Table 2b). The obovate leaf blade shape was observed in 4 cultivars (33.34%), lanceolate in 2 cultivars (16.67%), ovate in 2 cultivars (16.67%) and elliptical leaf blade shape was observed in 4 cultivars (33.34%). This showed that obovate and elliptical leaf blade shape was

predominant in custard apple. The colour of leaf varied from dark green to pale green. The dark green colour was seen in 7 cultivars (58.33%) and light green in 5 cultivars (41.67%) The general categories of various leaf characters is presented in Table 2b.

For leaf apex seven cultivars (58.33%) recorded as acute, one as mucronulate (8.33%), three as obtuse (25%) and two cultivars (16.67%) recorded as acuminate leaf apex. Two cultivars had obtuse leaf base (16.67%), Four cultivars had acute leaf base (33.34%), two cultivars had cordate (16.67%) while, remaining four cultivars recorded as round base.

All the cultivars under study showed entire leaf margin and presence of pubescence on upper and lower leaf surface. Arka Sahan had denser pubescence on lower surface of leaf than any other cultivar.

The leaf characters are the important features for identifying a particular cultivar, as discussed in the preceding paragraph. Larger leaf area provides more surface area for pathogen activities. However, this is not a problem in custard apple since no major pest and diseases are known to attack custard apple leaves.

The data on fruit characters such as exocarp type, exocarp colour, shape, pulp colour, breadth, girth, symmetry, uniformity is presented in Table 3 a and 3 b. The descriptor was of Cherimoya was used as a reference for recording observations on these characters.

The exocarp type (Table 3a.) was recorded and categorized as Laevis, Impressa, Umbonata, Tuberculata and Mamillata. In all, 3 cultivars had laevis type exocarp namely Red and Pink, Pink Mammoth and Red Sitaphal while, Arka Sahan, No. 2 cultivars had impressa, Balanagar, Chance Seedling cultivars had

umbonata, Attemoya had Tuberculata shape. Attemoya x Balanagar had Mamillata type of exocarp, Island gem and No. 1 had Irregular fruit shape.

Among 12 cultivars; Balanagar, No. 1, No. 2, Island gem had bright green fruits. Arka Sahan, Attemoya, Red Sitaphal, Attemoya x Balanagar had light green colour fruits. Red and Pink, Chance seedling had grey green colour fruits. Pink Mammoth and Ramphal had light red colour fruits.

The fruit shape (Table 3b.) was recorded into eight different groups. The broadly cordate shape was observed in Balanagar and Arka Sahan. Red Sitaphal, Attemoya x Balanagar and Pink Mammoth had cordate fruit shape. No. 2 and Chance Seedling had round shape. Attemoya, Red and Pink cultivars had oval shaped fruits. No. 1, Island Gem and Ramphal had irregular shape.

Cultivars like Balanagar, Arka Sahan, Attemoya, Red Sitaphal, Attemoya x Balanagar, Red and Pink, Chance Seedling and Ramphal had creamy pulp while cultivars like No. 1, No. 2 and Island Gem had white pulp.

Among 12 cultivars; Balanagar, Arka Sahan, Attemoya x Balanagar, Red and Pink, Chance Seedling and Ramphal had symmetric fruits while No. 1, No. 2, Attemoya, Red Sitaphal, Island Gem had asymmetric fruits.

Fruit uniformity was absent in No. 1 and Island Gem, rest of the other 10 cultivars had fruits with uniformity.

The fruit characters governing external appearance (qualitative and quantitative characters) are most important as far as the consumer's acceptance is concerned. Market acceptance and the value of custard apple fruit was determined by exocarp colour and fruit shape. The symmetry and uniformity of the fruit is the most important that for deciding market price. The results obtained in this regard have been presented in the Table (3a).

The exocarp type was categorized as laevis, impressa, umbonata, tuberculata, impressa, mamillata. Out of 12 cultivars, 3 cultivars (25%) had laevis, 2 cultivars (16.67%) had impressa, 2 cultivars (16.67%) had umbonata, 1 cultivar (8.34%) had tuberculata, 1 had mamillata (8.34%) and 3 cultivars (25) had irregular type of exocarp. Mangave (1982) reported two fruit shapes viz. round and irregular in custard apple. Mathkar (2005) ^[8] reported the shape of areole as round, square, mammal and hexagonal in *Annona* hybrids. Girwani *et al.* (2009) ^[5] observed the shape of areole in *Annona* hybrids as round, flat, mammal, pointed, square and spiny (Table 3 b).

The exocarp colour is often an indication of quality. Uniformity of colour is an important factor, especially relevant to the breeder in making selection. The exocarp colour showed much variation and recorded into eight different groups. 4 cultivars (33.34%) recorded as bright green exocarp colour, 4 cultivars (33.34%) as light green, 2 cultivars (16.67%) as grayish green, and 2 cultivars (16.67%) light red. The fruit colour as greenish yellow and pinkish dark have been reported in *Annona squamosa* (Thakur and Singh 1967). Girwani *et al.* (2009) ^[5] reported light green, pale green, greyish green, yellowish green and red fruit colour. The yellow and white colour has very less role to play in attractiveness of fruit and the pink colour has some role in this regard.

Symmetry and uniformity of fruit has great market value. Seven cultivars (58.34%) recorded symmetric fruits while 5 cultivars (41.67%) were asymmetric. 9 cultivars (75.00%) recorded uniform fruits at harvest while, 3 cultivars (25%) recorded non uniform fruit (Table 3 b).

The shelf life was recorded from fruit ripening and it ranged from 2 to 5 days at ambient temperatures. The maximum shelf life of fruit was observed in Ramphal (5 days). No. 1 cultivar (4 days), Balanagar recorded 4 days shelf life. Shelf life is the major constraint in custard apple and need to be improved through selection and hybridization. Girwani *et al.* (2009) ^[5] found shelf life in *Annona* hybrids ranged from 3 to 4 days and highest shelf life was recorded in Hybrid-1 and Hybrid-4 which might be due to the thin leathery rind with fused carpel. A large sized fruit usually fetches a premium price for the farmers. The fruit size is decided by the fruit length, fruit diameter and fruit weight. However, amongst these, fruit weight appeared to be the better criterion to judge the fruit size because length and diameter do not reveal contribution towards edible matter. Hence, emphasis should be given on fruit weight. The top 5 cultivars in respect of above characters are summarized in Table 3 b. No. 1 (346.66 g), Island Gem (276g), No. 2 (193.91g) recorded the highest fruit weight among all cultivars.

The cultivars showed marked differences for fruit weight and it ranged from 69.2- 510.00 g (Table 3a). The top three cultivars for fruit weight were No. 1 (346.66g), Island Gem (276.00 g) and No. 2 (193.91g). Ripe fruit weight range varied from 65.25-425.00 g. Top 3 cultivars was No. 1 (284.93g), Island Gem (226.16g) and No. 2 (165.63g).

The fruit length showed range of variation from 4.05 to 10.00 cm. The top three cultivars for fruit length were Balanagar (0.28 cm), Island Gem (0.37 cm) and Red and Pink (0.27 cm). The fruit diameter varied from 3 to 12 cm and top three cultivars were Balanagar (2.08 cm), Attemoya (1.80 cm) and Arka Sahan (0.51 cm). Similar results were reported by Mathkar (2005) ^[8], Agustin *et al.* (2006) ^[1], Dikshit *et al.* (2008) ^[3] and Rao and Subramanyam (2011) ^[11] for fruit length, breadth, girth and weight.

The pulp percentage, which solely contributes towards edible portion of *Annona* fruits, varied greatly according to the fruit dimensions (length, breadth and girth), similar to that of seed and rind percentage. The high pulp percentage with attractive colour and creamy texture is the criterion for selection of desirable cultivars.

The pulp weight ranged from 34.1 to 330 g. Top three cultivars which recorded the highest weight were No. 1 (237.77g), Island Gem (146.93g) and No. 2 (102.18g).

Seed character criteria for desirable fruit are low seed percentage and minimum number of seeds. The seed percentage varied from 1.07-10 per cent and top three cultivars having low seed percentage were No. 1 (13%), Ramphal (14%) and Pink Mammoth (14.33%).

Seed weight ranged from 3.3-14 g. Among 12 cultivars, top three cultivars recorded the highest seed weight were No. 2 (16.68g), Island Gem (15.06g) and Red and Pink (12.26g).

Table 1a: Morphological characterization of 12 *Annona* cultivars belonging to 4 species for tree trunk characters

Sl. No.	Cultivars	Trunk colour	Trunk ramification	Suckering tendency	Defoliation
1	Balanagar	Pale grey	4 branches	Absent	Partial
2	Arka Sahan	Pale grey	4 branches	Absent	Partial
3	No. 1	Medium grey	4 branches	Absent	Partial
4	No. 2	Medium grey	4 branches	Absent	Partial
5	<i>Atemoya</i>	Dark grey	4 branches	Absent	Partial
6	Red Sitaphal	Pale grey	3 branches	Absent	Partial
7	<i>Atemoya</i> X Balanagar	Pale grey	3 branches	Absent	Partial
8	Island Gem	Light grey	3 branches	Absent	Partial
9	Red & Pink	Light grey	2 branches	Absent	Partial
10	Chance Seedling	Pale grey	2 branches	Absent	Partial
11	Pink Mammoth	Pale grey	2 branches	Absent	Partial
12	Ramphal	Dark grey	2 branches	Absent	Partial

Table 1b: Grouping of cultivars according to tree morphology

	Characters	Description	No. of Cultivars	Proportion (%)
Tree characters				
1	Trunk Colour	I. Pale grey	6	50.00
		II. Medium grey	2	16.67
		III. Dark grey	2	16.67
		IV. Light grey	2	16.67
2	Trunk ramification	I. 4 branches	5	41.67
		II. 3 branches	3	25.00
		III. 2 branches	4	33.34
3	Colour of young branches	I. Pale green	4	33.34
		II. Medium green	4	33.34
		III. Dark green	2	16.67
		IV. Light green	2	16.67

Table 2a: Morphological characterization of 12 *Annona* cultivars for qualitative leaf characters

Sl. No.	Cultivars	Leaf blade	Leaf apex	Leaf base	Leaf colour	Leaf margin
1	Balanagar	Lanceolate	Acute	Acute	Light Green	Entire
2	ArkaSahan	Ovate	Mucronulate	Round	Dark green	Entire
3	No. 1	Elliptic	Acute	Obtuse	Dark green	Entire
4	No. 2	Obovate	Acute	Obtuse	Dark green	Undulated
5	<i>Atemoya</i>	Obovate	Acute	Cordate	Light green	Entire
6	Red Sitaphal	Lanceolate	Obtuse	Acute	Light green	Entire
7	<i>Atemoya</i> X Balanagar	Elliptic	Acute	Cordate	Light green	Undulated
8	Island Gem	Obovate	Acute	Round	Dark green	Entire
9	Red & Pink	Ovate	Obtuse	Round	Light green	Undulated
10	Chance Seedling	Obovate	Obtuse	Acute	Light green	Entire
11	Pink Mammoth	Elliptic	Accuminate	Round	Light green	Entire
12	Ramphal	Elliptic	Accuminate	Acute	Dark green	Undulated

Table 2b: Grouping of cultivars according to leaf morphology

Sl. No.	Sl. No.	Characters	No. of Cultivars	Percentage
Leaf Shape				
1	Leaf Blade	I. Obovate	4	33.34
		II. Lanceolate	2	16.67
		III. Ovate	2	16.67
		IV. Elliptical	4	33.34
2	Leaf Apex	I. Acute	7	58.33
		II. Mucronulate	1	8.34
		III. Obtuse	3	25
		IV. Accuminate	2	16.67

3	Leaf Base	I.	Acute	4	33.34
		II.	Round	4	33.34
		III.	Obtuse	2	16.67
		IV.	Cordate	2	16.67
4	Leaf Colour	I.	Pale Green	7	58.33
		II.	Dark Green	5	41.67

Table 3a: Morphological characterization of 12 *Annona* cultivars for qualitative fruit characters

Sl. No.	Cultivars	Exocarp type	Exocarp colour	Fruit shape	Pulp color	Symmetry	Uniformity
1	Balanagar	Umbonate	Bright Green	Cordate	Cream	Yes	Yes
2	ArkaSahan	Impressa	Light Green	Cordate	Cream	No	No
3	No. 1	Irregular	Green	Irregular	White	No	No
4	No. 2	Impressa	Green	Round	White	No	Yes
5	<i>Atemoya</i>	Tuberculata	Light Green	Oval	Cream	No	Yes
6	Red Sitaphal	Laevis	Light Green	Cordate	Cream	No	Yes
7	<i>Atemoya</i> X Balanagar	Mamillata	Bright Green	Cordate	Cream	Yes	Yes
8	Island Gem	Irregular	Bright Green	Irregular	White	No	No
9	Red & Pink	Laevis	Grey Green	Oval	Cream	Yes	Yes
10	Chance Seedling	Umbonata	Deep Green	Round	Cream	Yes	Yes
11	Pink Mammoth	Laevis	Bright Red	Cordate	Cream	Yes	Yes
12	Ramphal	Irregular	Light Red	Irregular	Cream	Yes	No

Table 3b: Grouping of cultivars according to fruit morphology

Sl. No.	Description	Characters		No. of Cultivars	Percentage
		Fruit Characters			
1	Exocarp type	I.	Umbonate	2	16.67
		II.	Impressa	2	16.67
		III.	Irregular	3	25
		IV.	Tuberculata	1	8.34
		V.	Laevis	3	25
		VI.	Mamillata	1	8.34
2	Exocarp colour	I.	Bright green	4	33.34
		II.	Light Green	4	33.34
		III.	Grey Green	2	16.67
		IV.	Light Red	2	16.67
3	Fruit Shape	I.	Cordate	5	41.67
		II.	Irregular	3	25
		III.	Round	2	16.67
		IV.	Oval	2	16.67
4	Pulp Colour	I.	Cream	9	75
		II.	White	3	25
5	Symmetry	I.	Yes	7	58.34
		II.	No	5	41.67
6	Uniformity	I.	Yes	9	75
		II.	No	3	25
7	Shelf life	I.	5	2	16.67
		II.	4	6	50
		III.	3	4	33.34

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