Indian Journal of Agricultural Sciences **91** (3): 378–81, March 2021/Article
https://doi.org/10.56093/ijas.v91i3.112468

Genetic variability and correlation studies for morphological and biochemical traits of *Annona* genotypes

JNAPIKA, K H[1,2]*, NAYAN DEEPAK G[2], OYING JAMOH[1,3], RAKESH KUMAR PANDEY[2], RAVI GAUTAM[2] and ASHOK DHAKAD[2]

University of Horticultural Sciences, Bagalkote, Karnataka 587 104, India

Received: 15 April 2020; Accepted: 13 November 2020

ABSTRACT

The present study was carried out for genetic variability and correlation studies for morphological and biochemical traits of *Annona* genotypes. The maximum plant height (4.35 m), fresh fruit weight (FFW) (346.66 g), fruit length (8.11 cm) and pulp weight (237.76) were observed in the genotype No.1. Similarly in Arka Sahan, the highest total soluble sugars (TSS) (27.17^0 B) and total sugars (26.13%) were recorded. Most of the traits exhibited a heritability of more than 50% depicting their higher heritability. The highest values for phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were observed for traits like fruit weight, fruit diameter, pulp weight, rind weight, seed weight, number of seeds and seed percentage (SPER). Biochemical traits like TSS (6.86^{0}B), reducing sugar (5.14%) showed the lowest GCV values. The highest genetic advance as per cent mean (GAM) was found for fruit diameter (167.19%) followed by pulp weight (129.28 g), number of fruits/plant (124.52) and FFW (96.09 g). The highest GAM for biochemical traits was exhibited by titratable acidity (TA) (73.21%).Pearson correlation matrix revealed that plant height, fruit diameter, number of seeds/fruit exhibited positive correlation with fruit weight. However, seed weight, TSS, total sugars, number of fruits/plant parameters were negatively correlated to plant height. Based on the desirable fruit characters, viz. high pulp percentage, low SPER with minimum number of seeds, the genotypes No. 1, Island Gem, No. 2 Arka Sahan and Balanagar found highly promising genotypes.

Keywords: *Annona*, Correlation, Genetic variability, Heritability.

Annona belongs to the family Annonaceae, it is one of the largest living families of primitive angiosperms of Magnoliales (Gupta *et al.* 2015). Larranaga and Hormaza (2015) reported that the genus *Annona* consists of 166 species of which six species produce edible fruits, viz. *Annona squamosa* L, (Sitaphal, Sharifa, Sugar apple, Sweet sop), *A. reticulate* (Bullock's Heart), *Cherimoya (A. cherimola), A. muricata* (Guanabana or soursop), *A. atemoya* (a natural hybrid of *A. squamosa x A. cherimola*) and *A. glabra* (pond apple). The fruit of *Annona* is a wholesome fruit contains majority of the vitamins, minerals, healthy fatty acids and having high calorific value (Gyamfi *et al*. 2011). However, the yield of *Annona* cultivars is very low in India as compared to other countries due to lack of high yielding cultivars due to heavy fruit drop, primarily associated with moisture stress, poor nutrition, temperature fluctuations, hormonal imbalance, higher wind velocity, insect pest and diseases etc. India is considered as the secondary centre of origin for *Annona squamosa*. This offers the greater variability among the *Annona* species.

Several authors studied the genetic variability in *Annona* species (Jalikop and Kumar 2000, Mathakar 2005). A critical assessment to find out the magnitude of variability and character association is a pre-requisite to make efficient breeding approach to improve. Greater variability increases the genetic potential and gives wider scope for selection. The information related to nature and extent of association among various attributes is helpful in formulating effective breeding strategy. Hence, the present study was designed to extensively characterize the 12 *Annona* genotypes belonging to four *Annona* species for genetic variability and correlation studies for morphological and biochemical traits to detect the promising genotype/s.

MATERIALS AND METHODS

The present experiment was conducted during 2017–19 at the Fruit Orchard, University of Horticultural Sciences, Bagalkote, Karnataka. The orchard is located at 16°12′N, 75°45′E an altitude of 610 m. The climate is warm and dry throughout the year and rainfall is scarce with an average annual rainfall of 518 mm and belongs to semi-arid tropical region. Twelve diverse genotypes, viz. Balanagar, Arka Sahan, No. 1, No. 2, Atemoya, Red

[1]University of Horticultural Sciences, Bagalkote, Karnataka; [2]ICAR-Indian Agricultural Research Institute, New Delhi; [3]College of Horticulture and Forestry, Pasighat, Arunachal Pradesh. *Corresponding author e-mail: jnapi.sk@gmail.com.

Sitaphal, Atemoya × Balanagar, Island Gem, Red & Pink, Chance Seedling, Pink Mammoth and Ramphal were used. Important morphological and biochemical attributes were recorded. The data was subjected to estimate the genetic variability, principal component analysis such as GCV, PCV and to know the extent of heritability of these traits to next generation, the heritability components such as heritability analysis (h^2 broad sense) and the GAM with the help of Windowstat (version 8.2) software. Heritability in broad sense was computed as the ratio of genetic variance to the total phenotypic variance (Riaz and Chowdhry 2003) and expressed as percentage. Genetic advance (Rosmaina *et al.* 2016); phenotypic correlations (Abou *et al.* 2009) and Pearson's correlation coefficient were evaluated for morpho-biochemical traits.

RESULTS AND DISCUSSION

The genetic variability and heritability for selected traits (Table 1), all the studied characters revealed moderate to high PCV and GCV. The traits like fruit weight, pulp weight, seed weight, number of seeds, total sugars, TSS, number of fruits/plant of *Annona* genotypes exhibited a heritability of more than 50% depicting their higher heritability. Traits like fruit length (90.24%) and fruit breadth (96.03%) exhibited heritability of greater than 90% however the highest values of both PCV and GCV were recorded for traits like fruit weight, fruit breadth, pulp weight, rind weight, seed weight, number of seeds and SPER. Fruit breadth trait exhibited the highest GCV (64.62%) and PCV (65.94%) values and lowest for plant height and stem girth traits. Biochemical traits like TSS (6.86°B), reducing sugar (5.14%) showed the lowest GCV values. Whereas, low to moderate level of genetic variation was recorded for fruit volume, shelf life, rind weight and seed parameters like SPER, number of seeds and seed weight. The highest GAM for morphological trait was recorded for fruit diameter (167.19%) followed by pulp weight (129.28 g), number of fruits/plant (124.52) and FFW (96.09 g). Among the biochemical traits, the highest GAM was exhibited by TA (73.21%), whereas the lowest values of GAM for morphological and biochemical traits were recorded in plant height (15.37 m) and TSS of the juice (16.11°B) respectively. These results are in agreement with the previous findings of Kumar *et al.* (2018), Jeevan *et al*. (2018) and Chandel *et al.* (2018) for fruit morphology and quality parameters of custard apple germplasm.

Further, the correlation analysis for morpho-biochemical traits was presented (Table 2). The plant height was found to have significant positive correlation with traits like stem girth, fruit breadth, number of seeds and reducing sugars. Similarly, non-significant negative correlation was observed with traits like seed weight, TSS, total sugars and SPER. Fruit length, pulp weight and TA traits were positive, but non-significant with plant height. Stem girth was found to have significant positive correlation with FFW, fruit diameter, number of seeds while as negatively correlated with fruit length, seed weight, TSS, total sugars, reducing sugar and SPER. Parameters like pulp weight and TA were positive, but non-significant with stem girth. Fruit weight exhibited significant positive correlation with fruit breadth, number of seeds, SPER and negatively correlated with fruit length. Parameters like pulp weight, TA, total sugars and reducing sugar showed positive correlation, but non-significant to FFW. Among biochemical parameters; total sugar exhibited significant positive correlation with reducing sugars.A positive correlation existed between reducing sugar and TSS.FFW exhibited non-significant negative correlation with the traits like fruit diameter, TA, reducing sugars and number of fruits/plant. It was positively correlated with the parameters like pulp weight, rind weight, fruit volume.Fruit length was non-significant and negatively correlated with stem girth, fruit diameter, number of seeds, TA, reducing sugars, SPER and number of fruits/plant while fruit diameter exhibited non-significant and negative correlation with pulp weight, seed weight and rind weight. Fruit volume exhibited non-significant and negative correlation with the traits like plant height, number of seeds, seed weight and shelf life while as it was significant and positively correlated with fruit length, fruit diameter, pulp weight and rind weight. Biochemical traits like total sugars, TSS and reducing sugars exhibited non-significant and negative correlation with plant height, stem girth, fruit weight, number of seeds, total sugars, SPER, fruit volume and number of fruits/plant. Shelf life was non-significant and negatively correlated to number of seeds, acidity percentage, fruit volume and number of fruits/plant. The present findings were in agreement with Hirdayesh *et al*. (2017) and Keny and Paulo (2010).

Table 1 Genetic variability and heritability for morphological and biochemical traits evaluated for different *Annona* genotypes

Trait	GCV (%)	PCV (%)	h^2b.s (%)	GAM
Plant height (m)	08.40	12.11	48.07	015.37
Stem girth (cm)	09.77	13.86	49.73	018.19
Fresh fruit weight (g)	42.50	49.64	73.32	096.09
Fruit length (cm)	19.49	20.51	90.24	048.87
Fruit breadth (cm)	64.62	65.94	96.03	167.19
Fruit volume (cm^3)	28.82	42.84	45.25	051.18
Pulp weight (g)	56.01	64.08	76.42	129.28
Seed weight (g)	34.51	40.85	71.37	076.97
SPER (%)	23.71	36.05	43.27	041.18
Shelf life	18.73	28.95	41.87	032.01
Number of seeds	35.05	43.62	64.58	074.37
Rind weight (g)	27.73	39.81	48.50	050.98
Titratable acidity (%)	37.07	49.56	55.95	073.21
Total sugars (%)	18.98	30.75	83.10	030.93
Reducing sugars (%)	05.14	38.63	57.80	018.10
TSS (°Brix)	06.86	07.71	79.09	016.11
No. of fruits/plant	50.78	54.68	86.26	124.52

Table 2 Pearson phenotypic correlation matrix (above diagonal) and genotypic correlation matrix (below diagonal) among morpho-biochemical traits for *Annona* genotypes

	PH	SG	FFW	FL	FB	PW	SN	SW	TSS	TA	TS	RS	SPER	FV	SL	RW	FNPL
PH	1.000	0.782	0.836**	-0.038NS	0.953**	0.860**	-0.067	0.380*	0.725**	-0.221 NS	0.417	1.357	-0.781 NS	-0.09NS	0.571	0.708	-0.067 NS
SG	0.367	1.000	0.800**	0.673**	-0.158 NS	0.667**	0.353*	1.000	0.701**	-0.349 NS	0.109	-0.247 NS	-0.350 NS	0.255	0.497	0.938	-0.254 NS
FFW	0.290NS	0.367*	1.000	0.784**	-0.207 NS	0.978**	-0.015NS	0.487**	0.513**	-0.575 NS	0.315	0.821	-0.702 NS	0.244	0.630	0.909	-0.315 NS
FL	0.002NS	-0.053NS	-0.383*	1.000	-0.406 NS	0.715**	-0.062NS	0.543**	0.226	-0.579 NS	0.335	-0.173 NS	-0.188 NS	0.375	0.499	0.744	-0.546 NS
FB	0.672**	0.465**	0.551**	0.238NS	1.000	-0.21	0.360	-0.187	0.375*	0.261	0.500	-0.224	0.157	0.507	0.094	-0.54	0.7873
PW	0.091NS	0.037NS	0.009NS	0.269NS	0.079NS	1.000	-0.172	0.333	0.455**	-0.476**	0.293	1.106	-0.799	0.220	0.527	0.829	-0.344
SN	0.359*	0.404*	0.493**	0.155NS	0.361*	0.65**	1.000	0.703	0.435**	-0.301	0.352	-1.975	0.559	-0.207	-0.11	0.185	0.673
SW	-0.25NS	-0.163NS	-0.43**	0.278NS	-0.398*	0.06NS	-0.20NS	1.000	0.560**	-0.491**	0.133	-0.437	0.192	-0.199	0.189	0.554	0.009
TSS	-0.06NS	-0.138NS	-0.419*	0.205NS	0.260NS	0.26NS	-0.339*	0.356*	1.000	-0.492**	0.214	-0.892	-0.008	-0.157	0.37	0.444	0.178
TA	0.257NS	0.018N+S	0.189NS	0.301NS	0.184NS	0.19NS	0.068NS	0.12NS	-0.12NS	1.000	0.163	0.421	0.090	0.077	-0.67	-0.60	0.284
TS	-0.03NS	-0.074NS	0.107NS	0.369*	0.064NS	0.40*	0.156NS	0.17NS	-0.06NS	0.265NS	1.000	0.457	-0.025	0.556	0.085	0.390	0.340
RS	0.337*	-0.025NS	0.072NS	0.183NS	0.242NS	0.240NS	-0.136NS	0.02NS	0.069NS	0.274NS	-0.34	1.000	-2.208	-1.812	0.307	0.215	-2.22
SPER	-0.12NS	-0.060NS	0.341*	0.247NS	0.066NS	0.07NS	-0.04NS	0.02NS	0.087NS	0.194NS	0.387	0.069NS	1.000	-0.143	-0.89	-0.682	0.259
FV	-0.096	0.255	0.244**	0.375**	0.507**	0.220	-0.207	-0.199	0.077	0.556	-1.812	0.514	0.307	1.000	-0.68	0.521	0.035
SL	0.571**	0.497**	0.630**	0.510**	0.094	0.527**	-0.118	0.189	0.375	-0.675	0.085	0.307	0.172	-0.683	1.000	0.8798	-0.088
RW	0.708**	0.938**	0.909**	0.743**	-0.04	0.829**	0.185	0.554	0.444	-0.596	0.390	0.215	-0.142	0.521	0.879	1.000	-0.158
FNPL	-0.067	-0.254	-0.315	-0.546**	0.787**	-0.344*	0.673	0.009	0.178	0.284	0.340	-2.224	0.259	0.035	-0.08	-0.158	1.000

*- correlation is significant at the 0.05 level, **- Correlation is significant at the 0.01 level, NS- Non significant, PH =Plant height, SG =Stem girth, FFW=Fresh fruit weight, FL=Fruit length, FB=fruit breadth, PW=Pulp weight, SN=Number of seeds, SW=Stone weight, TSS=Total soluble sugars, TA=Titratable acidity, TS=Total sugars, RS=Reducing sugars, SPER=Seed percentage, FV=Fruit volume, SL=Shelf life, RW=Rind weight, FNPL=Number of fruits/plant.

Based on the desirable fruit characters, viz. high pulp percentage, low SPER with minimum number of seeds the genotypes No. 1, Island Gem, No. 2 Arka Sahan and Balanagar found highly promising genotypes.

REFERENCES

Abou Bakari Kouassi, Kate Evans and Walter Guerra. 2009. Estimation of genetic parameters and prediction of breeding values for apple fruit-quality traits using pedigreed plant material in Europe. *Tree Genetics and Genomes* **5**: 659–72.

Chandel S S, Dikshit, S N and Sharma H G. 2017. Collection and evaluation of custard apple (*Annona squamosa* L.) genotypes in Chhattisgarh plains. Doctoral dissertation, Indira Gandhi Krishi Vishwavidhyalaya, Raipur.

Gupta Y, Pathak A K, Singh K, Mantri S S, Singh S P and Tuli R. 2015. De novo assembly and characterization of transcriptomes of early-stage fruit from two cultivars of *Annona squamosa* L. with contrast in seed number. *Biomed Central Genomics* **16**(1): 86.

Gyamfi K, Sarfo D, Nyarko B, Akaho E, Serfor-Armah Y and Ampomah-Amoako E. 2011. Assessment of elemental content in the fruit of graviola plant, *Annona muricata*, from some selected communities in Ghana by instrumental neutron activation analysis. *Elixir International Journal* **41**: 567–75.

Hirdayesh Anuragi, Bharat Taindu Jain, Haresh L Dhaduk and Sushil Kumar. 2017. Genetic association studies for fruit yield and its components and qualitative phytochemical screening in promising *Annona* genotypes. *Research Journal of Agricultural Sciences* **8**(1): 222–27.

Jalikop S H and Kumar S P. 2000. New fruit cultivars for arid regions - pomegranate 'Ruby' and custard apple 'Arka Sahan'. *Indian Horticulture* **45**(2): 19–20.

Jeevan Lal Nag, Shukla N and Ajay Tiwari. 2018. Characterization of custard apple (*Annona squamosa* L.) genotypes at Northern Bastar of Chhattisgarh, India. *International Journal of Current Microbiology and Applied Sciences* **7**(2): 1700–07.

Keny Henrique Mariguelea and Paulo Sergio Lima e Silva. 2010. Relationship between fruit traits of custard apple (*Annona squamosa* L.) trees. *Revista Ceres* **57**(4): 476–79.

Kumar Yashwant, Chandra Ajay Kumar, Dubey Ashutosh and Gajera H P. 2018. Fruit morphology and quality parameter studies of global custard apple (*Annona squamosa* L.) germplasms. *International Journal of Current Microbiology and Applied Sciences* **7**(10): 1297–1311.

Larranaga N and Hormaza J I. 2015. DNA barcoding of perennial fruit tree species of agronomic interest in the genus *Annona* (Annonaceae). *Frontiers in Plant Science* **6**: 589.

Mathakar T D. 2005. 'Assessment of custard apple (*Annona squamosa* L.) hybrids' MSc (Agriculture) thesis, Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra), India.

Riaz R and Chowdhry M. 2003. Estimation of variation and heritability of some physio-morphic traits of wheat under drought conditions. *Asian Journal of Plant Science* **2**(10): 748–55.

Rosmaina, Syafrudin, Hasrol, Yanti F, Juliyanti and Zulfahmi. 2016. Estimation of variability,heritability and genetic advance among local chilli pepper genotypes cultivated in peat lands. *Bulgarian Journal of Agricultural Science* **22**: 431–36.

Singh S P, Singhara G S, Parray G A and Bhat G N.2005. Genetic variability and heritability in rice (*Oryza sativa* L.) *Environmental Economics* **23**: 549–51.

Syed Imran Hashmi and V N. Pawar. 2012. Studies on physical and chemical characteristics of custard apple fruit pulp from different locations. *Asian Journal of Dairy and Food Research* **31**:117–20.