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EVALUATION AND GENETIC VARIABILITY STUDIES IN GERMPLASM OF JACKFRUIT AVAILABLE IN CERTAIN DISTRICTS OF ANDHRA PRADESH

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Abstract

An investigation was conducted at HRS, Venkataramannaguem to evaluate and explore the variability in morphological and biochemical characters of jack fruit through a comprehensive survey. Thirteen genotypes in East Godavari district, 9 genotypes in Visakhapatnam and 11 genotypes were available at HRS, Venkataramanagudem, West Godavari district were identified and observations were recorded in the field and laboratory and the data obtained was subjected to variability studies. Highest fruit weight coupled with highest number of flakes per fruit, weight of flakes per fruit, fruit length, fruit diameter, results in high edible portion (flake:fruit ratio) with medium flake length, width and weight and less number of fruits per tree was recorded in genotype CS – 2. The range of phenotypic coefficient of variation estimated from 3.94 to 80.12 and genotypic coefficient of variation from 3.52 to 78.77 for fruit and biochemical characters. It can be concluded that genotypes with wide range of genotypic and phenotypic variation for the characters studied could be exploited through clonal selection for their improvement.

Key words: Jackfruit, germplasm, evaluation, variability, Heritability

Introduction

Jackfruit (*Artocarpus heterophyllus* Lam.) is one of the most important fruit of the Moraceae family which is an evergreen, monoecious, latex producing tree with a dense canopy. Jackfruit is rarely grown on plantation scale, but it is preferred as a shade tree around dwellings and in orchards as a mixed crop. Jackfruit is indigenous to India and it is also widely distributed in most parts of the tropical countries like Sri Lanka, Mayanmar, Indonesia, Bangladesh, Malaysia, Thailand, Brazil and the Philippines (Manjunath, 1948). In India jackfruit is cultivated principally in Karnataka, Assam, Tripura, U. P. and other states like Andhra Pradesh and Tamil Nadu (Butani, 1978). Jackfruit is known for its exceptionally big sized fruits with high yield per tree weighing up to 50 kg each. The ripe jackfruit contains yellow pulp rich in carotene, vitamins and minerals. Other parts of the fruit contain pectin which has high value for preparation of jelly. The seeds are rich in carbohydrates and also contain minor amounts of minerals and vitamins.

Jackfruit is a highly heterozygous, cross pollinated fruit and as such seedlings exhibit a wide range of variations which aids in the selection of the superior desirable types. Due to cross pollination and predomination of seed propagation over a long period of time, species diversity and genetic diversity within the species by their influence on the evolutionary process of extinction, selection, gene drift, gene flow and mutation increasing the diversity in the existing population. Wide variations were observed in sweetness, flavour, taste, size, shape and bearing habit. Narasimhan (1990) stated that there are different cultivated types of jackfruit which vary widely in size, shape appearance and taste. Researchers at the International Centre for Underutilized Crops, U.K., in collaboration with the Bangladesh Agricultural Research Institute have made significant progress in characterizing the genetic diversity of the jackfruit trees of Bangladesh (Azad and Haq, 1998).

Most of the choicest types grown in India are low in productivity, poor in keeping and processing quality. A well planned jackfruit improvement programme should aim at evolving ideal types through breeding and genetic manipulation. For any crop improvement programme, the knowledge about genotypic diversity is a prerequisite and is considered to be the key for crop improvement

programme either by selection or by hybridization and the exploited hybrid vigour may be perpetuated through vegetative propagation. Trees possessing high yield potential with better quality, tolerance to biotic and abiotic stresses will be of great value for commercialization of jackfruit cultivation. Champion trees are available and majority of them are of seedling origin. As a preliminary step in crop improvement as well as for commercial exploitation, it is desirable to investigate the nature of divergence in terms of vegetative, fruiting and biochemical characters. Surveys have to be made to identify the elite trees having good agronomic and economic traits with commercial and industrial uses for further colonal multiplication.

Heritability indicates the relative degree at which a character is transmitted from parent to offspring. High heritability values indicate that the character under study is less influenced by environment in their expression and such characters could be improved by adopting simple selection methods (Uma *et al*., 2000). A relative comparison of heritability and expected genetic advance expressed as per cent mean also gives as an idea about the nature of gene action governing a particular character. The phenotypic and genotypic coefficient of variation provides a measure of the variability present for different characters. Further, heritability has to be considered in conjunction with genetic advance to get an idea about expected genetic gain in the next generation. In a fruit crop like jackfruit very few attempts were made to study the extent of variability and heritability and no attempts were made to study the germplasm available in Andhra Pradesh.

Hence, a systematic investigation was conducted at Horticultural Research Station, Venkataramannaguem, during the year 2011-2012 to characterize and explore the variability through a comprehensive survey in East Godavari, West Godavari and Visakhapatnam districts of Andhra Pradesh to identify the ideal genotype.

Materials and Methods

Survey work was carried in three districts (West Godavari, East Godavari and Visakhapatnam) of Andhra Pradesh for selection of elite trees. Information regarding elite trees were collected from the Horticultural officers, farmers, fruit traders and weekly mandies in those districts. GPS coordinates of the trees was collected and presented in passport data (table-1). Thirteen elite genotypes were identified in East Godavari district, 9 genotypes from Visakhapatnam and 11 genotypes which are available at HRS, Venkataramanagudem, West Godavari district were used in the present study.

Timely and periodical observations were recorded in the field starting from 2011 to 2012 for various characters. The harvested fruits were brought to the laboratory and the morphological observations were taken as per the descriptor for developed by IPGRI (2000). A number of observations consisting of some quantitative characters of trees and qualitative parameters of fruits were recorded and obtained data was subjected to variability studies. The total soluble solids were determined by using hand refractometer after extraction of the juice from the pulp and the data was expressed in ^{o}Brix (Ranganna, 1986). Reducing sugars and total sugars were determined by Lane and Eyon method (AOAC, 1965) and non reducing sugars were calculated by deducting the reducing sugars from total sugars and expressed in percentage.

Results and Discussion

The analysis of variance of various characters had revealed significant difference among the 33 genotypes studied for all characters, indicating the existence of sufficient variability in the germplasm (table-2). Wide variation was noticed in terms of biometric characters of the fruit. An overall perusal of results revealed that highest fruit weight coupled with highest number of flakes per fruit, weight of flakes per fruit, fruit length, fruit diameter, results in high flake:fruit ratio (edible portion) with medium flake length, width and weight and less number of fruits per tree was recorded in genotype CS–2. Jagadeesha *et al.* (2010) reported that the percentage of edible portion was maximum in UDK-5 (43.55 %) followed by UDP-17 (42.75 %), DKB-7 (41.91 %) and minimum in UDK - 6 (14.24 %). The genotypes BS–6 and MS–1 were recorded with greater fruit weight, weight of flakes per fruit but with less number of flakes per fruit due to greater flake length, width and weight. Similarly, BS–9 and CS – 4 genotypes were recorded with greater fruit weight, weight of flakes per fruit and more number of flakes per fruit while, CS–5 recorded lower flake weight, lesser flake length and flake width which accommodates more number of flakes per fruit next to CS–2.

The number of fruits per tree was more in PS–1, CS–6 and BS–1 which were small to medium in size and have better household consumer acceptance. The small and medium sized fruits were also observed in genotypes BS–4 and Palur–1 with high flake:fruit ratio which aids in effective selection for breeding programmes. The total soluble solids, total sugars and reducing sugars were high in the genotypes namely, DS–2, BS–5, CS–1, Singapore and Palur–1 indicating superior quality genotypes. Similarly, Jagadeesha *et al.* (2010) surveyed and studied the natural variability in fruit weight of 30 jackfruit

Table 1: List of different jackfruit accessions identified after survey

S.No	Genotypes	Village/ Block	District	Latitude (N/S)	Longitude (E/W)	Altitude (m)
1	BS-1	Boduluru	East Godavari	N17^{0}41.720'	E081^{0}42.215'	470
2	BS-2	Boduluru	East Godavari	N17^{0}41.773'	E081^{0}42.253'	476
3	BS-3	Boduluru	East Godavari	N17^{0}41.696'	E081^{0}42.192'	487
4	BS-4	Boduluru	East Godavari	N17^{0}41.761'	E081^{0}42.294'	477
5	BS-5	Boduluru	East Godavari	N17^{0}41.787'	E081^{0}42.283'	477
6	BS-6	Boduluru	East Godavari	N17^{0}41.771'	E081^{0}42.299'	477
7	BS-7	Boduluru	East Godavari	N17^{0}41.767'	E081^{0}42.252'	473
8	BS-8	Boduluru	East Godavari	N17^{0}41.711'	E081^{0}42.235'	467
9	BS-9	Boduluru	East Godavari	N17^{0}41.665'	E081^{0}42.306'	468
10	BS-10	Boduluru	East Godavari	N17^{0}41.665'	E081^{0}42.305'	470
11	MS-1	Maraedumalli	East Godavari	N17^{0}36.217'	E081^{0}42.129'	432
12	DS-1	Dosakayapalli	East Godavari	N17^{0}07.275'	E081^{0}51.249'	117
13	DS-2	Dosakayapalli	East Godavari	N17^{0}07.380'	E081^{0}51.336'	108
14	CS-1	Chinabarada	Visakhapatnam	N17^{0}48.227'	E082^{0}27.697'	811
15	CS-2	Pedabarada	Visakhapatnam	N17^{0}48.909'	E082^{0}27.709'	795
16	CS-3	Rajupakula	Visakhapatnam	N17^{0}49.893'	E082^{0}28.598'	784
17	CS-4	Chinabarada	Visakhapatnam	N17^{0}48.160'	E082^{0}28.086'	857
18	CS-5	Chinabarada	Visakhapatnam	N17^{0}48.065'	E082^{0}27.532'	824
19	CS-6	Chitralgoppa	Visakhapatnam	N17^{0}48.163'	E082^{0}28.270'	817
20	CS-7	Chitralgoppu	Visakhapatnam	N17^{0}48.157'	E082^{0}28.351'	811
21	CS-8	Chinabarada	Visakhapatnam	N17^{0}48.162'	E082^{0}27.503'	808
22	CS-9	Chitralgoppa	Visakhapatnam	N17^{0}48.090'	E082^{0}28.353'	813
23	PS-1	Prakasaraopalem	West Godavari	N16^{0}54.168'	E081^{0}26.624'	58
24	BCKV – 1	V. R. Gudem	West Godavari	N16^{0}53.275'	E081^{0}27.401'	51
25	BCKV – 39	V. R. Gudem	West Godavari	N16^{0}53.258'	E081^{0}27..418'	44
26	BCKV – 40	V. R. Gudem	West Godavari	N16^{0}53.271'	E081^{0}27.411'	47
27	Gumless Jack	V. R. Gudem	West Godavari	N16^{0}53.280'	E081^{0}27.389'	43
28	Muttam Varikka	V. R. Gudem	West Godavari	N16^{0}53.281'	E081^{0}27.405'	40
29	NJ-1	V. R. Gudem	West Godavari	N16^{0}53.246'	E081^{0}27.325'	41
30	Palur-1	V. R. Gudem	West Godavari	N16^{0}53.285'	E081^{0}27.382'	51
31	Pechiparai-1	V. R. Gudem	West Godavari	N16^{0}53.298'	E081^{0}27..370'	50
32	Singapore	V. R. Gudem	West Godavari	N16^{0}53.267'	E081^{0}27.405'	48
33	Swarna Manohar	V. R. Gudem	West Godavari	N16^{0}53.242'	E081^{0}27.388'	49

selections from Coastal zone of Karnataka and recorded that the maximum fruit weight was noted in UKB-24 (18.74 kg) followed by DKB-(14.86 kg), UDK-4 (14.32 kg), UDK-1 (12.62 kg) and minimum in UDB-14 (2.15 kg). An overall perusal of results revealed that greater emphasis should be made on small sized fruits of 3 kg (BS-1, BS-4, Muttam Varikka, PS-1 and BS-7) and medium sized fruits of less than 10 kg (Palur-1, CS-1, BS -3, CS-7 and BS-7) having high TSS, number of fruits per tree, number of flakes per fruit, flake:fruit ratio, weight of flakes per fruit and less 100-seed weight was recorded which increases the household consumer acceptance where as the genotypes like CS-3, CS-4, CS-8, CS-5, MS-1, BS-6 and CS-2 having fruit weight greater than 10 kg with high TSS, more number of flakes per fruit, weight of flakes per fruit, flake:fruit ratio can be utilized for industries, street vendors and for home level processing units.

The genetic parameters, namely, general mean, range, phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV), heritability in broad sense and genetic advance as per cent of mean were estimated for all characters in 33 genotypes of jackfruit under study and the results were presented in table 3. The estimates of general mean and range for different physical characters revealed that there was a great scope for improvement of these types by selection. Among the physical characters studied, higher magnitudes of genotypic and phenotypic variances were observed for number of fruits per tree and number of flakes per fruit.

Table 2: Fruit quality of different selected jackfruit genotypes

S. No	Genotypes	TSS (°Brix)	Reducing Sugars (%)	Non Reducing Sugars(%)	Carotene (mg /100 g)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight	No. of flakes /fruit	weight of flakes /fruit (kg)	No. of fruits /tree	Flake length (cm)	Flake width (cm)	Flake / fruit (%)
1	BS-1	26.75	8.56	13.70	0.48	25.75	17.25	3.06	63.00	1.17	191.00	4.33	3.32	28.52
2	BS-2	24.00	12.67	8.84	0.45	37.25	26.50	9.32	116.00	3.04	65.50	6.04	2.94	16.80
3	BS-3	28.50	9.90	13.52	0.49	39.50	18.75	5.98	122.00	2.60	87.50	4.61	3.36	26.09
4	BS-4	24.50	7.92	13.30	0.46	23.75	17.25	2.90	102.50	1.54	90.00	4.71	3.00	43.33
5	BS-5	31.50	10.21	13.87	0.46	41.75	21.00	6.72	48.00	1.03	103.50	6.14	3.09	10.45
6	BS-6	25.25	7.19	14.31	0.48	41.00	25.50	19.48	282.50	10.75	43.50	10.08	5.27	41.89
7	BS-7	23.25	6.35	14.00	0.49	31.25	15.50	3.04	100.00	1.22	63.00	3.72	2.29	27.06
8	BS-8	20.00	6.05	12.75	0.51	35.00	23.00	6.90	135.00	1.95	101.00	4.85	3.09	15.20
9	BS-9	19.70	10.31	8.34	0.49	54.00	31.00	18.82	351.00	7.85	35.00	7.35	3.97	29.26
10	BS-10	25.50	9.75	12.20	0.46	32.25	25.25	7.73	77.00	1.56	53.50	5.85	4.04	15.44
11	MS-1	26.50	10.27	12.24	0.48	38.75	27.50	17.01	160.00	6.30	45.50	9.00	4.42	26.43
12	DS-1	21.50	9.70	10.72	0.46	37.00	22.25	7.34	140.50	3.33	25.00	6.45	3.38	32.31
13	DS-2	31.55	10.05	12.89	0.47	27.75	16.50	4.32	93.50	1.30	38.50	5.36	2.60	18.32
14	CS-1	30.75	9.05	14.75	0.46	27.25	25.25	7.34	142.50	3.38	115.00	5.83	3.30	31.33
15	CS-2	23.75	7.10	13.22	0.49	56.75	31.00	27.12	512.00	14.45	18.50	5.79	3.60	43.95
16	CS-3	27.10	10.60	12.25	0.48	33.25	25.75	10.13	170.50	5.32	77.50	7.14	3.82	37.91
17	CS-4	27.65	7.00	15.55	0.48	52.00	23.75	18.57	245.00	7.96	61.00	6.63	3.40	34.22
18	CS-5	26.50	8.05	14.44	0.45	47.00	27.75	14.60	493.50	6.80	55.00	5.53	2.63	25.96
19	CS-6	23.75	6.77	14.60	0.47	45.00	24.25	9.16	375.00	4.67	210.00	5.16	2.39	32.40
20	CS-7	28.00	7.20	15.71	0.44	39.00	24.25	7.80	180.00	3.10	153.50	4.99	2.75	26.95
21	CS-8	26.85	7.00	16.00	0.46	37.00	28.00	11.37	202.00	5.78	34.50	6.86	3.42	38.30
22	CS-9	25.75	6.86	15.14	0.47	42.60	25.75	10.40	200.00	4.13	93.50	5.50	2.75	27.29
23	PS-1	20.60	6.35	12.40	0.48	23.50	17.70	3.16	27.00	0.84	217.50	6.28	4.54	23.88
24	BCKV - 1	24.50	7.39	14.12	0.44	29.25	18.25	4.93	105.00	2.50	77.50	4.38	3.70	40.34
25	BCKV - 39	27.00	9.75	12.93	0.48	35.75	24.50	6.38	68.50	2.44	152.50	6.09	4.81	25.93
26	BCKV - 40	26.00	6.80	14.45	0.44	31.50	20.50	4.63	80.00	1.90	43.50	4.53	3.35	25.40
27	Gumless Jack	26.25	7.15	14.31	0.46	32.00	18.00	4.92	118.50	2.39	62.50	4.42	3.17	28.82
28	Muttam Varikka	26.50	6.85	14.40	0.44	30.35	16.25	3.31	63.50	1.28	77.50	4.84	3.44	23.88
29	NJ - 1	30.10	10.05	13.71	0.45	32.50	21.00	5.84	240.00	2.53	107.50	3.90	2.32	27.05
30	Paluru-1	27.60	12.75	10.15	0.49	28.75	22.35	6.45	189.50	3.53	56.00	5.53	2.89	43.71
31	Pechiparai-1	30.00	6.65	15.10	0.48	40.75	21.75	7.92	145.00	2.74	24.00	5.50	3.10	22.23
32	Singapore	28.15	13.36	9.71	0.46	38.00	25.75	6.79	147.00	2.92	53.50	6.01	3.53	26.13
33	Swarna Manohar	27.45	8.95	13.70	0.46	36.75	20.75	6.04	292.50	2.86	103.50	4.16	2.56	30.12
	Mean	**26.14**	**8.62**	**13.25**	**0.47**	**36.48**	**22.72**	**8.77**	**175.39**	**3.79**	**82.92**	**5.68**	**3.34**	**28.69**
	Range Min.	19.70	6.05	8.34	0.44	23.50	15.50	2.90	27.00	0.84	18.50	3.72	2.29	10.45
	Max.	31.55	13.36	16.00	0.51	56.75	31.00	27.12	512.00	14.45	217.50	10.08	5.27	43.95
	SE+/-	0.91	0.47	0.71	0.006	2.51	1.39	1.18	22.37	0.39	3.38	0.50	0.18	2.85
	CD (O.O5)	2.63	1.38	2.06	0.017	7.27	4.04	3.19	64.74	1.13	9.79	1.45	0.52	8.27

In the present investigation, heritability values for fruit and biochemical characters ranged from 75.26 to 99.15 per cent. High heritability and genetic advance was recorded for all characters except β-carotene content. Higher heritability values were noticed for all the traits studied namely number of fruits per tree, weight of flakes per fruit, number of flakes per fruit, fruit weight and total soluble solids. Identical results on heritability were reported earlier for fruit weight and number of bulbs per fruit in jackfruit by Sharma *et al.* (2005). Analysed data also indicated that the fruit characters *viz.*; number of fruits per tree, weight of flakes per fruit, number of flakes per fruit, fruit weight, fruit length, fruit diameter, flake:fruit ratio, flake length, flake width, total soluble solids, reducing and non-reducing sugars exhibited high values for heritability and genetic advance indicating these

Table 3: Genetic variability in jackfruit genotypes for fruit morphological and biochemical characters

S. No.	Character	General mean	Range	Variance		Coefficient of variation		Heritability % (Broad sense)	Genetic advance as % of mean
				Genotypic	Phenotypic	Genotypic	Phenotypic		
1	Fruit length (cm)	36.48	23.5 - 56.75	60.73	73.38	21.36	23.48	83	40.03
2	Fruit diameter (cm)	22.72	15.5 - 31	16.03	19.99	17.62	19.68	80.18	32.5
3	Fruit weight (kg)	8.77	2.89 - 27.12	31.38	33.82	63.88	66.31	92.16	126.76
4	No. of flakes per fruit	175.39	27 - 512	13646.89	14648.16	66.6	69	93.16	132.43
5	Weight of flakes per fruit (kg)	3.79	0.83 - 14.44	8.92	9.23	78.77	80.12	97	159.54
6	Flake length (cm)	5.68	3.71 - 10.08	1.6	2.11	22.29	25.56	76.02	40.03
7	Flake width (cm)	3.34	2.29 - 5.27	0.47	0.53	20.43	21.84	88	39.37
8	Flakes/ fruit (%)	28.69	10.44 - 43.94	63.98	80.32	27.88	31.24	80.00	51.26
9	Number of fruits/ tree	82.92	18.50 -217.50	2669.01	2691.93	62.3	62.57	99.15	127.79
10	TSS (° Brix)	26.14	19.7 - 31.55	8.37	10.03	11.07	12.12	83.45	20.83
11	Reducing Sugars (%)	8.62	6.05 - 13.36	3.76	4.21	22.48	23.8	89.17	43.72
12	Non Reducing Sugars (%)	13.25	8.34 - 16.00	3.09	4.11	13.27	15.3	75.26	23.72

characters are clearly governed by additive gene action, hence the breeder can rely on these characters and in passing generations simple selection process for improvement of the above characters in jackfruit will be rewarding. The high heritability and genetic advance indicated that the effectiveness of direct phenotypic selection for genetic improvement of these traits. It is necessary that greater emphasis should be given for improving the traits like number of flakes per fruit, weight of flakes per fruit, flake:fruit ratio, flake length and flake width which shows significant correlation.

The genotypic coefficient of variation measures the range of variability available in a crop and also enables to compare the amount of variability present in different characters. The phenotypic expression of the character is the result of interaction between genotype and environment. Hence, the total variance needs to be partitioned into heritable and non-heritable components to assess the inheritance pattern into particular character under study (Sivasubramanian and Menon, 1973). From these genetic studies it can be inferred that there is prevalence of high variability (as evident from high PCV and GCV values) in the jackfruit germplasm and still there is scope for further enriching the germplasm. Higher phenotypic coefficient of variation over genotypic coefficient of variation were recorded which indicated the influence of environment over the character. The range of phenotypic coefficient of variation estimated was from 3.94 to 80.12 and genotypic coefficient of variation from 3.52 to 78.77 for fruit and biochemical characters. High PCV and GCV was recorded for all characters while, it was medium for fruit diameter, TSS, non-reducing sugars and β-carotene content and significant correlation was observed for yield traits. Similar trends regarding variability of PCV and GCV in jackfruit were observed by Maiti *et al.* (2003), Sharma *et al.* (2005) and Jagadeesh *et al.* (2010).

The genetic advance as per cent mean ranged from 6.47 to 159.54 for fruit morphological and biochemical characters. High genetic advance as per cent mean was recorded for all the fruit morphological and biochemical characters studied except β-carotene content in the present investigation indicating all the traits are heritable in nature, therefore the breeder can rely on these characters. Similar values of genetic advance as per cent mean were reported in jack fruit for fruit weight, number of bulbs per fruit by Sharma *et al.* (2005).

Conclusion

It can be concluded that the values for fruit characters of the selected genotypes showed wide range of variation (both genotypic and phenotypic) and could be exploited through clonal selection for its improvement. From the study of genetic variability, heritability, genetic advance indicated genetic drift and natural selection under different environmental condition could cause considerable diversity than geographical distance which is utilized in breeding programmes for new genotypes by selecting elite trees.

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