DOI : 10.5958/0974-0112.2018.00065.8

Indian J. Hort. 75(3), September 2018: 376-383

Morphological variability in jackfruit grown under agro-forestry system of Tripura

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ABSTRACT

A study was carried out to assess the genetic varability in jackfruit grown in agroforestry homestead gardens of Tripura, India for selection of elite types of jackfruit germplasm. Forty two jackfruit genotypes were selected from 20 major jackfruit growing locations surrounded by forest. The genotypes of jackfruit was characterized by using 42 standardized morphological descriptors of International Plant Genetic Resources Institute (IPGRI). Significant variation was found in tree size (5-30 m), fruit colour (greenish, yellowish, reddish yellow), fruit weight (1.5-10.5 kg), fruit yield (15-250 fruits/plant), fruit shape (round to long), pulp colour (creamy white to coppery red), pulp thickness and consistency (soft to firm), number of flakes (5-207/fruit), flake length (3-7 cm) and TSS (6-25°Brix). Variation was also observed in leaf size (8.5-17.78 cm), leaf width (4-10 cm), stalk length (5-30 cm), tree growth habit (erect to spreading type) and fruit bearing habit (regular/twice a year) at the tree age range of 10-55 years. Exterior rind colour varied from green to yellow-reddish yellow. Accessions were significantly different in respect to weight of seed and edible portion. Ten genotypes (WTJF-03, WTJF-02, WTJF-10, STJF-02, STJF-04, STJF-10, NTJF-02, NTJF-08, NTJF-11, DJF-09) out of 42 genotypes were found superior type on the basis of fruit shape, pulp quality, TSS of pulp, rind:pulp:seed ratio and seasonal availability. The results suggest that selected elite genotypes of jackfruit can be used for vegetable, dessert, processing purposes and also to conserve and use them for breeding programmes for development of superior cultivars.

Keywords: *Artocarpus heterophyllus*, Genetic variability, Morphological characteristics, Northeastern India.

INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* Lam.) is one of the most important underutilized fruits belonging to the family Moraceae. It is native to India and now found in many agroforestry system of Southeast Asia, in the evergreen forest zone of West Africa, and in Northern Australia as well (Azad *et al.*, 1). It is quite popular in Eastern, Southern and Northeastern India, and is more widely grown in agroforestry homestead gardens of West Bengal, Andaman and Nicobar Islands, Andhra Pradesh, Karnataka, Kerala, Maharashtra, Tamil Nadu, Assam and Tripura states of India. Jackfruit is a medium-sized evergreen tree, typically reaching 8-25 m in height, producing heavier yields than any other tree species and bearings the largest (up to 35 kg) edible fruit (Shyamalamma *et al.*, 17). It is a multipurpose species providing food, timber, fuel, fodder, medicinal and industrial products (Rahman *et al*., 15). Despite numerous advantages, the popularity of jackfruit as a commercial crop is arguable to wide variations in fruit quality. Several studies have been reported diversity in jackfruit which was based mainly on morphological characteristics (Jagadeesh *et al*., 11; Mitra and Mani, 13; Das and Das, 4). There are no well-defined varieties in specific localities. Local varieties available in forest area have different names based on their variability in yield, fruit shape, flake color, total sugars, and so on. The information on genetic diversity of different jackfruit germplasm available in agro-forestry homestead gardens of Northeastern India is very limited (Cavagnaro *et al.*, 3; Mitra and Mani, 13; Das and Das, 4). Hence, a comprehensive understanding of genetic diversity and morphological characterization of jackfruit germplasm is needed for formulating appropriate sampling and management strategies.

In Northeastern India, the leading jackfruit producing states are Tripura, Meghalaya, Sikkim, Manipur and Assam. The area under jackfruit cultivation in homestead gardens of Tripura state is approximately 2200 ha and the production is 12,500 MT. The flesh and seeds are consumed by the people while the outer skin is used as feed for livestock. Lot of diversity is found in jackfruit types of Tripura in terms of fruit size, shape, colour of bulb, taste, aroma and processing qualities. These genetic variations need to be identified to put them to indented purpose and also to conserve and use them for crop improvement purpose (Das and Das, 4). Morphological characteristics play a very important role in classification or analysing

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variability in any species. This study focuses on assessing morphological descriptors of jackfruit grown in agroforestry homestead gardens of Tripura.

MATERIALS AND METHODS

The present study was conducted in Tripura state (Northeastern India) having a total geographical area of 10491 km^2 comprising of four undivided districts viz. North Tripura, South Tripura, West Tripura and Dhalai. Forest accounts for 60 per cent of the state's land area, which includes classified and unclassified village woodlots and rubber gardens. The climate of study area is greatly influenced by the presence of the Himalayan mountain range in the north and the Bay of Bengal in the south. The average annual rainfall is 2428 mm (long term average). During winter, temperature ranges from 13 to 27°C (55 to 81°F), while in summer they fall between 24 and 36°C (75 to 97°F). The maximum and minimum relative humidity is 85% and 57% in the month of July and January, respectively.

The study was conducted in three agro-climatic sub-zones (humid dissected mound and valleys, sub-humid hills, and sub-humid denuded hills) of Tripura during the peak harvesting season (June-July) of the year 2013, 2014 and 2015. A total of 42 jackfruit accessions were collected from 21 major jackfruit growing localities covering South Tripura (Birchandramanu, Dakshin Takmachara, Laxmicharra, Moghpushkarani), West Tripura (Chebri, Baltoli, Jagabandhu Para, North Ramchandraghat, Lakhinarayan para, Sonatala), North Tripura (Churaibari, Kadamtala, West Panisagar, Agnipasha, Madhabpur, Bhallukchara), and Dhalai district (Paija Bari, Jaganathpur, Mogpara, Baligaon, Chotosurma). The details of location in terms of longitude and latitude of accession collecting sites are given in Table 1.

The sampling was done from 10 healthy trees of varying ages (7-90 years) of each genotype, grown in well drained acidic soil (sandy to silty loam in texture). Commonly, jackfruit ripens during June-July, while certain trees bear fruit twice a year (Jan-Feb and June-July). Morphological variation among trees was assessed using jackfruit descriptors from the International Plant Genetic Resources Institute (IPGRI, 10). The descriptors included 26 qualitative and 16 quantitative measures of vegetative and reproductive characters (Tables 2 and 3). Stalk length was measured from the base of the peduncle to the base of fruit at maturity. Stalk length and diameter, leaf blade length and width, fruit diameter and weight, rind weight, bulb and seed weight were measured as per IPGRI guidelines. Edible part of the fruit was calculated by subtracting the weight of edible part from weight of complete fruit.

Latex exudation was determined qualitatively at the time of detaching mature fruits and fully developed leaves for each accession and categorised as low, medium and high depending on the excretion of milky white liquid of each accession. Determination of Total soluble solid (TSS) was done using analog Brix Refractometer (Acmas ACB-1RF04) with temperature correction (Ranganna, 16). Superior type genotypes were selected on the basis of fruit shape, pulp quality, TSS of pulp, rind:pulp:seed ratio and seasonal availability. It includes the farmers' criteria like market demand, fruit quality, sweetness, early fruiting types and off-season types. The effects of the location and genotype were analysed using pooled data of different years. A two-way ANOVA was applied with genotype and location as the two variables, and using the data from different years as replications.

RESULTS AND DISCUSSION

There was a wide variation among qualitative traits of jackfruit in the study area (Table 2). Out of 42 genotypes of jackfruit, 9 genotypes showed early fruiting season, 28 genotypes showed medium fruiting season, 2 genotypes showed late fruiting season and only 4 genotypes were bearing fruits twice a year. There was a significant variation regarding fruit shape and size such as ellipsoid, oblong, spheroid, obloid, irregular, clavate. Latex exudation was found high in 6 genotypes, low in 11 genotypes and medium in 25 genotypes. Five different colour of pulp such as creamy white, light yellow, yellow, deep yellow and coppery red were observed at ripe stage. Majority of jackfruit pulp was in the range of light yellow to pure yellow in colour (Fig. 1a). Only one genotype was found coppery red in colour (STJF-03). Pulp with medium thickness and soft consistency was observed in majority of the fruit. The thickness of pulp in 14 genotypes was thin and 8 were thick. Pulp consistency of 22 fruits was found soft, 7 were slimy, 5 were medium and only 8 were firm. Exterior rind colour varied from green to yellow-reddish yellow. Viviparous germination of seeds was observed in both mid-season and late variety of jackfruit. Viviparous germination is generally common in late variety (Karim *et al*., 10). Majority of fruits were juicy and only 6 fruits were found under category 'not juicy'.

Quantitative morphological characters of jackfruit tree are given in Table 3. Leaf size of jackfruit varied from 8.5 (NTJF-07) to 17.78 cm (STJF-11) in length and 4 (DJF-04) to 10 cm (NTJF-09) in width. In most of jackfruit trees with less than 15 years of age, it was noticed that leaf length was 10-15 cm, with leaf width

Table 1. Location details of jackfruit germplasm in Tripura.

District	Genotypes number	Location of collecting site	DMS Format		Decimal Format	
			Latitude	Longitude	Latitude	Longitude
South Tripura	STJF-01	Birchandramanu	23°22′2.30″N	91°31′27.80″E	23.3673056	91.5243889
	STJF-02	Birchandramanu	23°22′2.30″N	91°31′27.80″E	23.3673056	91.5243889
	STJF-03	Takmacharra (S)	23°21′57.92″N	91°31′41.04″E	23.3660889	91.5280667
	STJF-04	Laxmicharra	23°17′1.32″N	91°36′9.16″E	23.2837	91.6025444
	STJF-05	Laxmicharra	23°17′36.42″N	91°35′58.94″E	23.29345	91.5997055
	STJF-07	Moghpushkarani	23°28′38.04″N	91°26′52.69″E	23.4772334	91.4479694
	STJF-08	Moghpushkarani	23°28′38.04″N	91°26′52.69″E	23.4772334	91.4479694
	STJF-09	Moghpushkarani	23°28′38.04″N	91°26′52.69″E	23.4772334	91.4479694
	STJF-10	Moghpushkarani	23°28′38.04″N	91°26′52.69″E	23.4772334	91.4479694
	STJF-11	Moghpushkarani	23°28′38.04″N	91°26′52.69″E	23.4772334	91.4479694
West Tripura	WTJF-01	Chebri	24°1′29.73″N	91°38′6.30″E	24.024925	91.6350833
	WTJF-02	Chebri	24°1′27.95″N	91°38′5.13″E	24.0244306	91.6347583
	WTJF-03	North Chebri	24°1′39.70″N	91°37′58.83″E	24.0276945	91.6330084
	WTJF-04	North Chebri	24°1′39.70″N	91°37′58.83″E	24.0276945	91.6330084
	WTJF-05	North Tablabari	24°1′52.35″N	91°38′35.98″E	24.0312084	91.6433277
	WTJF-06	Baltoli	24°1′12.60″N	91°36′33.55″E	24.0201667	91.6093194
	WTJF-07	Jagabandhu para	24°1′10.07″N	91°36′23.67″E	24.0194639	91.606575
	WTJF-08	Ramchandraghat	24°2′7.54″N	91°35′58.89″E	24.0354277	91.5996916
	WTJF-09	Ramchandraghat	24°2′7.54″N	91°35′58.89″E	24.0354277	91.5996916
	WTJF-10	Sonatala	24°2′31.16″N	91°36′53.82″E	24.0419889	91.61495
Dhalai	DJF-01	Paija Bari	23°55′37.78″N	91°52′29.52″E	23.9271611	91.8748667
	DJF-02	Paija Bari	23°55′37.78″N	91°52′29.52″E	23.9271611	91.8748667
	DJF-03	Paija Bari	23°55′37.78″N	91°52′29.52″E	23.9271611	91.8748667
	DJF-04	Jaganathpur Mogpara	23°54′36.6″N	91°51′20.11″E	23.9101667	91.8555861
	DJF-05	Baligaon	24°12′14.55″N	91°49′4.35″E	24.2040417	91.817875
	DJF-06	Baligaon	24°12′14.55″N	91°49′4.35″E	24.2040417	91.817875
	DJF-07	Baligaon	24°12′20.86″N	91°49′4.48″E	24.2057944	91.8179111
	DJF-08	Baligaon	24°12′20.86″N	91°49′4.48″E	24.2057944	91.8179111
	DJF-09	Chotosurma	24°9′41.13″N	91°50′46.93″E	24.161425	91.8463694
	DJF-10	Chotosurma	24°9′41.13″N	91°50′46.93″E	24.161425	91.8463694
	DJF-11	Chotosurma	24°9′22″N	91°50′59.57″E	24.1561111	91.8498805
North Tripura	NTJF-01	Churaibari	24°26′23.64″N	92°14′56.98″E	24.4399	92.2491611
	NTJF-02	Kadamtala	24°27′14.61″N	92°12′57.52″E	24.4540583	92.2159778
	NTJF-03	Kadamtala	24°27′21.30″N	92°12′54.53″E	24.4559167	92.2151472
	NTJF-04	Kadamtala	24°27′21.30″N	92°12′54.53″E	24.4559167	92.2151472
	NTJF-05	West Panisagar	24°16′6.05″N	92°8′36.39″E	24.2683473	92.1434416
	NTJF-06	West Panisagar	24°16′6.05″N	92°8′36.39″E	24.2683473	92.1434416
	NTJF-07	West Panisagar	24°16′6.69″N	92°8′38.15″E	24.268525	92.1439305
	NTJF-08	West Panisagar	24°16′7.79″N	92°8′34.23″E	24.2688306	92.1428416
	NTJF-09	Agnipasha	24°14′55.84″N	92°9′32.49″E	24.2488444	92.159025
	NTJF-10	Madhabpur	24°15′54.54″N	92°10′49.61″E	24.26515	92.1804473
	NTJF-11	Bhallukcharra	24°14′30.73″N	92°12′44.28″E	24.2418694	92.2123

Table 2. Qualitative parameter of fruit and pulp of jackfruit in Tripura.

Genotypes number	Fruit Shape	Fruit Rind Colour[a]	Latex exudation	Pulp Thickness	Pulp Colour[a]	Pulp Juiciness	Pulp consistency
STJF-01	Ellipsoid	RY	Medium	Medium	CW	Juicy	Soft
STJF-02	Oblong	GY	High	Thin	LY	Very juicy	Soft
STJF-03	Ellipsoid	G	Low	Medium	CR	Very juicy	Soft
STJF-04	Spheroid	G	Medium	Thick	CW	Not juicy	Firm
STJF-05	Ellipsoid	GY	Low	Thick	Y	Not juicy	Medium
STJF-07	Ellipsoid	Y	Medium	Medium	LY	Juicy	Slimy
STJF-08	Ellipsoid	Y	Low	Medium	LY	Juicy	Firm
STJF-09	Ellipsoid	Y	Medium	Medium	LY	Juicy	Soft
STJF-10	Spheroid	RY	Low	Thick	LY	Not juicy	Firm
STJF-11	Ellipsoid	RY	High	Thin	DY	Juicy	Soft
WTJF-01	Ellipsoid	G	Medium	Thin	CW	Juicy	Soft
WTJF-02	Obloid	G	Medium	Thick	CW	Not juicy	Firm
WTJF-03	Obloid	GY	Medium	Thin	LY	Juicy	Soft
WTJF-04	Ellipsoid	GY	Medium	Medium	Y	Juicy	Soft
WTJF-05	Ellipsoid	GY	High	Thin	DY	Juicy	Soft
WTJF-06	Spheroid	DY	Medium	Medium	DY	Juicy	Soft
WTJF-07	Ellipsoid	DY	Medium	Medium	DY	Juicy	Soft
WTJF-08	Irregular	Y	Low	Medium	Y	Juicy	Soft
WTJF-09	Clavate	Y	Medium	Thin	Y	Very juicy	Slimy
WTJF-10	Spheroid	Y	Low	Medium	Y	Juicy	Medium
DJF-01	Oblong	GY	Low	Thin	Y	Juicy	Slimy
DJF-02	Ellipsoid	GY	High	Thin	LY	Juicy	soft
DJF-03	Ellipsoid	GY	Medium	Medium	Y	Very juicy	Slimy
DJF-04	Ellipsoid	RY	High	Medium	Y	Juicy	Soft
DJF-05	Spheroid	GY	Medium	Thick	LY	Not juicy	Firm
DJF-06	Ellipsoid	GY	Medium	Medium	Y	Very juicy	Slimy
DJF-07	Ellipsoid	GY	Medium	Thick	LY	Not juicy	Firm
DJF-08	Oblong	RY	Medium	Medium	LY	Juicy	Soft
DJF-09	Spheroid	GY	Low	Medium	Y	Juicy	Soft
DJF-10	Ellipsoid	GY	Medium	Medium	Y	Juicy	Soft
DJF-11	Clavate	Y	Medium	Thin	LY	Very juicy	Slimy
NTJF-01	Oblong	GY	Medium	Medium	LY	Juicy	Firm
NTJF-02	Spheroid	GY	Low	Medium	DY	Very juicy	Soft
NTJF-03	Spheroid	G	Low	Medium	LY	Juicy	Medium
NTJF-04	Ellipsoid	GY	Medium	Thin	Y	Juicy	Soft
NTJF-05	Obloid	GY	High	Medium	Y	Juicy	Firm
NTJF-06	Ellipsoid	GY	Medium	Thin	Y	Very juicy	Slimy
NTJF-07	Spheroid	GY	Medium	Thin	LY	Juicy	Medium
NTJF-08	Ellipsoid	GY	Medium	Thick	Y	Juicy	Soft
NTJF-09	Spheroid	GY	Medium	Thin	DY	Very juicy	Soft
NTJF-10	Oblong	RY	Low	Thick	LY	Juicy	Medium
NTJF-11	Oblong	GY	Medium	Thin	CW	Juicy	Soft

[a] W: White; G: Green; Y: Yellow; R: Red; GY: Greenish yellow; RY: Reddish yellow; CW: Creamy white; LY: Light Yellow; DY: Deep yellow

Table 3. Quantitative morphological characteristics of jackfruit tree of Tripura.

Genotypes number	Tree age (yr)	Leaf length (cm)	Leaf breadth (cm)	Stalk length (cm)	Fruit length (cm)	Fruit weight (kg)	Seed weight (kg)	Edible part (%)	TSS (°Brix)
STJF-01	30	13	7.5	9	30	2.2	0.26	34.22	19
STJF-02	45	14	5	7	45	4.9	0.58	48.57	21
STJF-03	80	10	6.5	5	19	1.5	0.14	34.00	17
STJF-04	55	10.16	7.62	5	30	5.5	0.36	55.09	14
STJF-05	33	14	8.9	6.35	17	1.6	0.09	33.13	19
STJF-07	18	15.24	8.89	12.7	17	1.4	0.17	44.14	19
STJF-08	18	15.24	7.62	8.89	35	5.5	0.33	36.91	15
STJF-09	18	15.24	9.14	12.7	17	3.7	0.51	61.07	19
STJF-10	18	15.24	6.35	7.62	35	5	0.53	49.00	14
STJF-11	18	17.78	8.89	8.89	35	6.2	1.20	72.58	18
WTJF-01	16	15	5.5	18	35	5.8	0.60	56.90	17
WTJF-02	15	13	9.5	15	26	4.1	0.33	34.62	14
WTJF-03	17	14.5	7.4	7	31	5.7	0.52	46.96	15
WTJF-04	17	16.8	7.2	5	30	1.5	0.03	10.67	13
WTJF-05	40	11	5.7	10	35	3.5	0.53	52.57	19
WTJF-06	10	12	7	7	22	3.2	0.21	40.31	14
WTJF-07	80	13	6	10	30	5.2	0.63	60.00	16
WTJF-08	9	15	9	10	40	4.2	0.18	16.90	22
WTJF-09	30	15	9	15	40	4.2	0.58	41.88	17
WTJF-10	18	12.5	5	6	35	4.9	0.54	43.67	25
DJF-01	40	10	6	10	45	2.2	0.39	41.33	11
DJF-02	40	14	8	15	40	7.7	0.83	42.71	12
DJF-03	40	16	8	7	25	3.5	0.36	48.86	20
DJF-04	15	10	4	20	38	5.5	0.44	38.00	21
DJF-05	50	12	6.5	16	30	3	0.1	21.67	15
DJF-06	50	12	6	6	32	4.2	0.40	50.82	18
DJF-07	40	15	7	20	40	8.5	0.55	38.59	17
DJF-08	40	15	9.5	20	35	4.9	0.69	43.47	22
DJF-09	65	11	7	7	25	3.5	0.22	62.57	22
DJF-10	70	13	8	10	35	5.5	0.64	55.27	19
DJF-11	50	10	5	25	32	3.2	0.47	58.75	15
NTJF-01	40	12.8	5.4	15	45	6.5	0.63	55.38	17
NTJF-02	70	10	6	5	22	2.7	0.55	62.18	23
NTJF-03	15	10	7	12.7	26	4.0	0.25	12.50	22
NTJF-04	15	12.7	8	15	32	5.5	0.24	20.73	6
NTJF-05	16	12	6	15	45	5.7	0.33	21.39	14
NTJF-06	8	15	9	20	35	5.0	0.35	42.00	16
NTJF-07	7	8.5	5.5	10.16	22	2.5	0.23	39.20	20
NTJF-08	90	11	7.7	12.7	30	3.1	0.24	46.00	25
NTJF-09	25	13	10	30	35	5.5	0.65	66.36	20
NTJF-10	50	13	8	25	35	10.5	1.04	46.86	20
NTJF-11	15	15.4	7	10	40	7.0	1.00	69.75	23
Range	--	8.5 -17.8	4-10	5-30	17-45	1.4-10.5	0.03-1.20	10.7-72.6	6-25
Mean ± SE	--	13.1 ± 0.34	7.2 ± 0.23	12.2 ± 0.94	32.1 ± 1.19	4.51 ± 0.04	0.45 ± 2.30	44.2 ± 0.60	17.7 ± 3.41
CV%	--	16.88	20.53	49.94	24.18	42.83	57.35	33.74	22.13

Range= minimum-maximum; SE= Standard error; CV%= Coefficient of variation

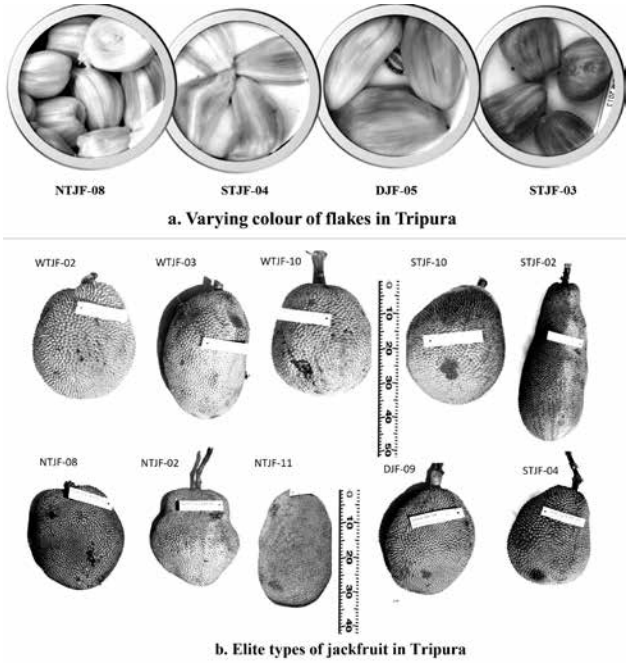

Fig. 1. (a) Colour of flakes and (b) Elite types of jackfruit in mid-tropical plain zone of Tripura for value addition, vegetable and table purpose.

of 4-9 cm. In the plant age of between 15-30 years, leaf size was bigger and varied from 12 to 16.8 cm in length and 6.3 to 9.14 cm in width. After 30 years of old, leaf length of most of the trees was 10-16 cm and width was 5-10 cm. Stalk length and stalk diameter of fruit varied from 5 (WTJF-04, NTJF-02) to 30 cm (NTJF-09) and 1.2 to 5.08 cm, respectively. Similarly, fruit yield per tree also varied significantly among all 42 genotypes (data not provided in table). Number of fruits per tree was about 200-250 in 5 genotypes, 100-170 in 13 genotypes, 40-75 in 15 genotypes, and 15-35 in 9 genotypes. Wide variation was noted in the number of fruits ranging from 15-250 per tree per season. Genotypes were significantly different in respect to weight of seed and edible portion. Maximum weight of seeds and edible portion were 1.2 kg per fruit and 72.58% per fruit (WTJF-11), respectively. It was observed that the maximum weight of non-edible portion was 89.33% per fruit with minimum weight of bulb i.e., 0.13 kg per fruit (WTJF-04). In Bangladesh, the maximum weight of edible portion was found up to 55.65%, while the minimum weight of edible portion was 23.22% (Oldfield and Alcorn, 11). Among all collected fruits of jackfruit, WTJF-10, NTJF-08, NTJF-11 and DJF-09 were found the sweetest accession with a Brix level of 25, 25, 23 and 22, respectively. The total soluble solids (TSS) were varied from 11 (DJF-01) to 25°Brix (NTJF-08) except in one fruit (NTJF-04) which contained only 6°Brix.

All measured traits had good variability among genotypes (i.e. differences between lowest and highest values), but also between locations. To evaluate the effect of location and genotype on the measured parameters, only the data for the genotypes common to all locations were considered. The ANOVA gave significant effects of genotype, location and year on all parameters considered (Table 4). Furthermore, there was significant interaction between genotypes, year and location for leaf size, edible part and TSS of fruits. A significant interaction implies that the effect of the location was different for the different genotypes. Fruit weight, fruit length and seed weight had non-significant interactions, implying that the environmental effects were similar on all genotypes. No relation could be established between jackfruit plant age, number of fruits and size of the fruits. However, number of fruits per tree was consistent between 15-20 years, 30-40 years and after 60 years of plant age. Wide variation was observed when plant was at the age range of 10-15 years, 20-30 years and 40-55 years. Several investigators also reported similar genetic variation on jackfruit in Asia-Pacific region (Elevitch and Manner, 5; Sultana *et al*., 18; Ullah and Rahman, 19; Firoz and Rahman, 6; Haq, 9; Goswami *et al.*, 7). Most morphological traits are influenced by environmental factors and many quantitative traits are of polygenic inheritance and expressed only after several years of growth (Hamrick and Godt, 8).

Considering both qualitative and quantitative characteristics, some elite types of jackfruit were worked out in three agro-climatic sub-zones of Tripura. Ten genotypes were found superior which can be considered good for vegetable purpose, table purpose and for value added products (Table 5). Three genotypes were early maturing, one was late-maturing and one belonged to the off-season type. Six genotypes were normal season yielders. Among them, three genotypes were for vegetable type, two for both vegetable and value added product and remaining five for table as well as value added product purposes. A high total soluble solids (TSS) and pulp ratio is desirable for the national market of fresh fruits and value added products (Azad, 2).

The result from agromorphological analysis indicated the existence of variability in jackfruit genotypes with respect to leaf size, fruit shape and size, colour, fruit bearing (age and seasonality), sweetness, thickness, flavour, texture, juiciness, consistency and fibre content of pulp. In this study, 10 distinct type jackfruit was identified (WTJF-03, WTJF-02, WTJF-10, STJF-02, STJF-04, STJF-10, NTJF-02, NTJF-08, NTJF-11, DJF-09) which may be used to take up breeding programs for development of superior cultivars, conservation of biological

Table 4. Analysis of variance (ANOVA) for jackfruit variability in Tripura.

Effect	Df[1]	Leaf length		Leaf breadth		Stalk length		Fruit length		Fruit weight		Seed weight		Edible part		TSS	
		MS	F value	MS	F value	MS	F value	MS	F value	MS	F value	MS	F value	MS	F value	MS	F value
Genotype	41	4.87	0.49^{ns}	2.18	0.67*	37.22	0.62*	60.23	0.06^{ns}	3.73	2.04*	0.06	0.08*	212	0.04*	15.41	0.63*
Location	3	10.11	2.35^{ns}	0.76	0.33**	113	4.04^{ns}	76.2	1.26*	3.72	0.99*	0.06	0.08**	86.95	0.39**	2.15	0.13**
Year	2	3.53	5.35^{ns}	2.11	0.75*	42.34	0.49*	53.72	2.61^{ns}	4.29	0.04**	0.06	0.47**	190	1.84^{ns}	14.84	0.39**
Genotype × Location	123	5.13	1.36*	2.17	0.82*	32.58	1.24*	60.25	2.36^{ns}	3.56	1.75^{ns}	0.04	2.21^{ns}	202	1.40*	14.43	1.24*
Year × Genotype	82	27.6	6.41**	2.28	1.05*	24.18	0.64*	24.42	0.40*	0.91	0.24**	0.004	0.06**	827	3.99^{ns}	22.93	1.51*

df = degrees of freedom; MS = means square; *, **, n.s. indicates that the effect is significant at $p \leq 0.05$, $p \leq 0.01$, and not significant, respectively.

Table 5. Characteristics of elite type jackfruit germplasm of Tripura.

Genotypes number	Purpose of use	% of edible part	TSS (°Brix)	Fruit Status (Rind:Pulp:Seed)	Fruit availability	Latex exudation	Flake Thickness	Fruit Shape	Fruiting season
WTJF-03	Vegetable	46.96	15	53:38:9	60	Medium	Thin	Obloid	Late
STJF-04	Vegetable	55.09	14	45:49:6	60	Medium	Thick	Spheroid	Medium
WTJF-02	Vegetable	34.62	14	65:27:8	60	Medium	Thick	Obloid	Medium
STJF-10	Vegetable, Papad	49	14	51:38:11	60	Low	Thick	Spheroid	Early
NTJF-02	Vegetable, Jam, Squash	62.18	23	38:42:20	120	Low	Medium	Spheroid	Medium
STJF-02	Table, Chips	48.57	21	51:37:12	60	high	Thin	Oblong	Medium
NTJF-11	Table, Chips	69.75	23	30:57:13	60	Medium	Thin	Oblong	Medium
NTJF-08	Table, Jam, Squash	46	25	54:38::8	60	Medium	Thick	Ellipsoid	Medium
DJF-09	Table, Papad	62.57	22	38:56:6	60	low	Medium	Spheroid	Early
WTJF-10	Jam, Squash, Table, Papad	43.67	25	56:33:11	60	low	Medium	Spheroid	Early

diversity, as well as part of our effort to popularize jackfruit as a commercial crop.

ACKNOWLEDGEMENTS

We are thankful to Department of Biotechnology (NER Division), Ministry of Science and Technology, Government of India, for providing financial assistance under 'DBT programme for the NE' titled "A value chain on jackfruit and its value added products".

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Received : September, 2016; Revised : July, 2018; Accepted : August, 2018