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Morpho-physiological characterization of jackfruit (*Artocarpus heterophyllus* Lam.) accessions in Bangladesh

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ABSTRACT : Bangladesh is one of the potential hotspots for the diversity of jackfruit tree (*Artocarpus heterophyllus*), which is widely grown in almost every homestead. Jackfruit is a multipurpose tree, the fruits are an important source of nutrients; it also provides good timber, and possesses pharmacological properties which are widely used in medicine to treat a range of ailments. Despite this importance, the rich local genetic resource has been degrading due to high anthropogenic pressure before being fully documented and utilized for potential crop improvement. The present study was aimed to collect superior accessions from the major jackfruit growing areas of Bangladesh through *in-situ* evaluation and document them based on morphological (qualitative and quantitative) data in order to conserve the best local races. Twenty-eight jackfruit accessions were collected during 2015-2016. The data on 26 important quantitative and 36 qualitative characters were analyzed following the IPGR, 2000 procedure. Results of correlation coefficient of quantitative features demonstrated that out of 325 coefficients; 136 and 53 were significant at P<0.05 and P<0.01 levels, respectively, and others (136) were found non-significant. Hierarchal cluster analysis grouped both accessions and variables into four clusters and heat-map analysis indicated that wide range of variations exists among the accessions as well as variables levels. Wide range of variations were found in most important features like fruiting season, fruit-bearing, shape, rind color and surface, flake-shape and texture, pulp-taste, flavor, juiciness, and color, vivipary seed coat adherence to kernel. Genetic diversity was found to be higher in the studied jackfruit accessions which indicates scope for tree breeding planning.

Key words: Agroforestry, genetic diversity and tree improvement.

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1. INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* Lam., family Moraceae) is a tropical evergreen tree, producing largest edible fruit (Naik, 1949; Sturrock, 1959; Simmonds and Preedy, 2016). The place of origin of this fruit tree is still unclear, it is stated to be indigenous to the rain forests of the Western Ghats of India (APAARI, 2012). It is extensively cultivated throughout the tropical lowlands in South and Southeast Asia, parts of Central and Eastern Africa, and Brazil (Morton, 1987; Rahman *et al*., 1999; APAARI, 2012). Bangladesh is one of the countries with high jackfruit production in the world, along with China, India, Indonesia, Malaysia, Myanmar, Philippines, Sri Lanka, Thailand and Vietnam. It is the national fruit of Bangladesh and is consumed by all classes of rural people. In Bangaldesh, its demand is increasing gradually due to its use as a dessert fruit and several value added products are being prepared from it which has market with in the country and other Southeast Asian countris (APAARI, 2012).

Jackfruit is popularly referred to as a "nutritional jackpot", as the ripe fruit flakes provide significant amount of potassium, calcium and carbohydrates (Sammadar, 1985; Shyamalamma *et al*., 2008). The fruit is also rich in pectin, carotene, ascorbic acid, lignins, isoflavones, saponins as well as substantial amount of fiber, besides being a good source of vitamin A, B, C, iron, proteins and minerals (Chanda *et al*., 2009; Simmonds and Preedy, 2016). All of these properties make jackfruit a balanced source of nutrition, which improves health and strengthens the disease fighting capacity of the human body (Soobrattee *et al*., 2005; Simmonds and Preedy, 2016). Seeds of jackfruit are also very nutritious and eaten in different forms, boiled, roasted or as flour.

Jackfruit tree wood is highly durable, resistant to termites and decay and possesses an orange or red-brown color (Elevitch and Manner, 2006). An orange-red dye is obtained from the wood chips, which is used extensively to color the robes of Buddhist priests (Craig and Harley, 2006). Its leaves and fruit wastes are used as fodder for livestock, mainly cattle, pigs and goats. Bark, roots, leaves and fruits have pharmaceutical properties (Hakim *et al*., 2005; Arung *et al*., 2006).

In Bangladesh, jackfruit is popularly alluded as *Kathal*. It is their national fruit, and is commonly referred to as "poor man's food", due to its relatively low market price as well as abundant availability (Rahman *et al*., 1995). It is widely distributed throughout the country and is particulary abundant in the Central Terrace Ecosystem (Miah *et al*., 2018). Jackfruit accounts for about 21% of total fruit production of the country and is next only to mango (*Mangifera indica*). During 2016-17, Bangladesh produced 1,050,000 tons of jackfruit covering about 14000 ha area with a yield of 2596 kg ha^{-1} (Yearbook of Agricultural Statistics, 2017). These qualities make jackfruit as one of the desirable tree species for fruit-based agroforestry systems in Asia. Some of the reported successful agroforestry systems are agrisilviculture and intercropping with fruit crops in Bangladesh (Hasan *et al*., 2008), India (Kumar *et al*., 1998; Shastri *et al*., 2002), Sri Lanka (Perera and Rajapakse, 1991), Malaysia (Acedo, 1992), homestead and homegardens in tropics (Haq, 2003; Issac and Nair, 2006; Pandey *et al.*, 2006), as a shade and support tree for spices (Kumar *et al*., 1998; Salem *et al*., 1991; George, 2004) and as a component of silvipastoral system (Das *et al*., 2002; Das and Ghosh, 2001; Dey *et al*., 2006). The high nutritive value and palatability of leaves make it an ideal fodder tree (Das and Ghosh, 2001).

Despite these numerous advantages, jackfruit tree is not commercially grown as a crop because of high variability in fruit quality, mainly because of the cross-pollinated nature of the species and the dependence on seed propagation (APAARI, 2012). Genetic improvement of existing germplasm to overcome these problems, may expand the potential of jackfruit cultivation on commercial lines.

Given the large variability of genetic resources and the possibility of its losses (Haq, 2002), Bangladesh is one of the hotspots of jackfruit diversity. This wide range of tree diversity needs to be identified, documented and conserved on-farm for long term sustainable uses (Haque *et al*., 2004; Sarker and Zuberi, 2012). Climatic menaces like flooding and anthropogenic activities such as felling of mature trees for construction purpose together with the high anthropogenic pressures have decreased the genetic diversity of jackfruit in the country. Therefore, the present study was aimed to collect the superior accessions from the major jackfruit growing areas of Bangladesh and document the on-farm jackfruit diversity, based on morphological features. Such an information and analysis would be useful for genetic improvement of the species.

2. MATERIALS AND METHODS

Plant material selection and collection

Preliminary, three major jackfruit growing areas, namely Gazipur, Narsingdi and Bandarban districts/regions were selected. Then members of the research team physically visited major jackfruit gardens and talked to the farmers about the good accessions based on their experiences. At the same time, observations on 36 qualitative characters *viz*., propagating material, tree vigor, trunk surface, crown shape/habit, tree growth habit, tree nature, branching density, branching pattern, leaflet/leaf blade shape, leaflet apex, leaf base shape, leaf color, fruiting season, extent of fruit drop, fruit bearing habit, fruit bearing, fruit bearing position, fruit shape, stalk attachment to fruit, fruit rind color, fruit surface, shape of spine, spine density, flake shape, flake texture, pulp taste, pulp flavor, pulp juiciness, pulp (fresh flake) color, vivipary, shape of seed, seed surface pattern, seed coat color, adherence of seed coat to kernel, disease infestation, pest infestation for each accession was recorded. Afterwards, based on morphological characterizations using the descriptors provided by the International Plant Genetic Resource Institute (IPGRI, 2000), 30, 25 and 10 accessions of jackfruit from Gazipur, Narsingdi and Bandarban districts, respectively, were collected during 2015-2016. At the time of collection, geographical location of the accession were recorded (Table 1). From these collected accessions, finally, 28 accessions from three districts were selected based on a number of criteria, like fruiting seasons, fruit colour, fruit shape, fruit number, fruit weight, flake shape, flake texture and brix value. Selected accessions were planted at the agroforestry research field of the Bangabandhu Sheikh Mujibur Rahman Agricultural University (24° 09´ N; 90° 26´ E) in the month of August, 2016 for conservation purpose. The size of the pit was 1 m × 1 m × 1 m (L × W × H). Each accession was replicated three times by maintaining 4 m × 4 m distance from the plant to plant in order to grow lower storey crops as an agroforestry system. The soils of the pit were prepared by mixing cowdung, sand and soil at the ratio of 1:0.5:2 (in weight basis). Furthermore, nitrogen, triple superphosphate and muriate of potash (250 g in each case) were applied to the soils in each pit and left for fifteen days. The plants after planting were maintained through intercultural operations like fertilizer and pesticide applications, manuring, irrigation and weeding as and when necessary. The observations on survival and growth characteristics of the plants were recorded periodically. Jackfruit shows a considerable range of variation in morpho-agronomic traits, therefore, to understand the extent of genetic diversity for morphological characters and to select superior types of jackfruit, the traits such as growth habit, canopy structure, leaf size, fruit shape, size, colour, fruit bearing (age and seasonality), maturity and other parameters were studied.

Table 1. List of jackfruit accessions collected from major jackfruit growing areas of Bangladesh for morpho-physiological characterization with their geographical location.

Accession code number	Latitude	Longitude
MO1	24°16´35.6´´ N	90°24´45.7´´ S
MO2	24°16´29.1´´ N	90°24´31.6´´ S
MO3	24°03´29.8´´ N	90°49´33.4´´ S
MO4	24°16´23.9´´ N	90°24´30.5´´ S
MO5	24°03´34.9´´ N	90°50´16.7´´ S
MO6	24°06´48.7´´ N	90°49´9.7´´ S
MO7	24°16´39.9´´ N	90°24´47.2´´ S
MO8	24°03´44.4´´ N	90°49´41.8´´ S
MO9	24°06´48.1´´ N	90°49´1.0´´ S
MO10	24°16´44.9´´ N	90°24´44.8´´ S
MO11	24°16´28.6´´ N	90°24´31.0´´ S
MO12	24°16´21.9´´ N	90°24´34.3´´ S
MO13	24°16´25.3´´ N	90°24´30.3´´ S
MO14	24°03´35.0´´ N	90°50´20.1´´ S
MO15	24°16´25.7´´ N	90°24´40.1´´ S
MO16	24°16´44.6´´ N	90°24´43.5´´ S
MO17	24°16´29.9´´ N	90°24´45.7´´ S
MO18	24°03´15.8´´ N	90°49´30.5´´ S
MO19	24°16´25.8´´ N	90°24´45.7´´ S
MO20	24°16´25.3´´ N	90°24´50.2´´ S
MO21	24°06´45.8´´ N	90°48´59.4´´ S
MO22	24°16´20.8´´ N	90°24´49.9´´ S
MO23	22°07´38.1´´ N	92°13´42.1´´ S
MO24	22°08´06.9´´ N	92°13´49.4´´ S
MO25	22°08´12.9´´ N	92°13´39.4´´ S
MO26	22°12´53.5´´ N	92°13´11.8´´ S
MO27	22°07´39.6´´ N	92°13´42.2´´ S
MO28	22°07´27.1´´ N	92°13´31.4´´ S

Statistical analysis

Analysis of genetic variation of the accessions was performed with the program SPSS (version 23.0) following the procedure described by Al-Hadi *et al*. (2017). Pearsons's coefficient was utilized to estimate the degree of correlation among the different characters of the trees. Coefficients higher than 0.5 were considered as linear associations representing natural variation patterns and to gain broad impressions, the extent of correlation was classified as strongly correlated ($r = \geq 0.5$) and weakly to moderately correlated ($r = 0.5$). Heatmap was generated after normalizing the mean values by using MeV version 4.9.0 (http://mev.tm4.org/). A heatmap is a graphical representation of data where the individual values contained in a matrix are represented as colors. The heatmap and hierarchical clustering were performed to understand the accessions-variable relationship in the 28 jackfruit accessions. Quantitative values of 26 morpho-physiological features of these accessions were normalized for clustering. This was followed by performing the hierarchical clustering using the Spearman's rank correlation algorithm.

3. RESULTS AND DISCUSSION

The study on morpho-agronomic traits in jackfruit shows a considerable range of variation. The correlation coefficient among the plant characters showed that of the 325 coefficients, 53 were highly significant at $P<0.01$, 136 were significant at $P<0.05$, while 136 were insignificant (Table 2). Among morphological characters, the highest, strong and significantly positive correlation corresponded to trunk girth with North-South and East-West tree spreading. Positive significant correlation was also found for age and tree height with trunk girth, East-West tree spreading, and North-South tree spreading. However, stalk length and diameter showed negative correlation with almost all morphological characters, except trunk height and number of days from flowering to maturity.

Correlation coefficient of 26 plant characters of 28 jackfruit accessions collected from major jackfruit growing areas of Bangladesh as presented in Table 2 clearly indicated that fruit weight of jackfruit was strongly interconnected with fruit length, fruit diameter, rachis length and yield per tree. Also, yield per tree was significantly influenced by fruit weight, fruit rind weight and rachis length. Similarly, number of fruits per tree was strong and positively correlated with tree age, tree height, trunk height and tree spreading at North-South and East-West directions as well as

Table 2. Correlation coefficient of 26 plant characters of 28 jackfruit accessions collected from major jackfruit growing areas of Bangladesh.

	Age[$]	TH	Trh	Trg	Trsew	Trsns	NDFM	SL	SD	FL	FD	FW	FRW	FRT	NFPKF	WFFWS	WFFWoutS	FBV	RL	RD	NSPKF	SWidth	SL	100 SW	YPT	NFPT
Age	1.00																									
TH	.717**	1.00																								
Trh	-0.12	-0.04	1.00																							
Trg	.842**	.666**	-0.23	1.00																						
Trsew	.803**	.607**	-0.20	.844**	1.00																					
Trsns	.755**	.537**	-0.17	.866**	.843**	1.00																				
NDFM	-0.11	-0.07	0.31	-0.14	0.04	-0.09	1.00																			
SL	-0.09	-0.04	0.07	-0.27	-0.21	-.441*	0.37	1.00																		
SD	-0.22	-0.13	0.09	-.547**	-.434*	-.479**	0.12	.440*	1.00																	
FL	0.17	0.20	-0.37	0.17	-0.01	0.08	-0.06	0.17	.441*	1.00																
FD	0.23	0.09	-0.24	0.32	0.18	0.17	-0.05	0.00	-0.04	.416*	1.00															
FW	0.36	0.15	-0.11	0.36	0.14	0.13	-0.18	0.04	-0.01	.625**	.503**	1.00														
FRW	.453*	0.25	-0.09	.561**	0.35	.395*	-0.20	-0.19	-0.27	.519**	.410*	.903**	1.00													
FRT	-0.06	-0.13	0.17	-0.09	0.17	0.10	.411*	-0.20	0.02	-0.19	-0.20	-0.19	-0.03	1.00												
NFPKF	-.401*	-0.19	0.05	-0.34	-0.34	-0.29	0.03	0.05	0.32	0.15	-0.09	-0.13	-0.18	0.04	1.00											
WFFWS	-0.13	-0.21	0.18	-.445*	-0.31	-.392*	0.20	0.25	.603**	-0.04	-0.37	-0.13	-0.34	0.12	-0.20	1.00										
WFFWoutS	-0.16	-0.24	0.17	-.475*	-0.35	-.424*	0.21	0.26	.639**	-0.01	-0.33	-0.12	-0.35	0.13	-0.17	.997**	1.00									
FBV	0.10	0.27	-0.18	-0.10	0.08	-0.05	-0.04	0.04	.410*	0.07	-.379*	-0.29	-0.35	0.00	.422*	0.25	0.25	1.00								
RL	0.30	0.27	-0.34	.407*	0.10	0.28	-0.20	-0.06	0.11	.888**	.385*	.654**	.693**	-0.23	0.11	-0.29	-0.26	-0.09	1.00							
RD	-0.18	-0.09	0.02	-.469*	-0.35	-.424*	0.08	0.34	.869**	.403*	0.07	0.05	-0.25	0.03	0.23	.556**	.586**	.454*	0.02	1.00						
NSPKF	-0.11	0.14	-0.06	0.15	0.00	0.06	0.05	-0.33	-.394*	0.14	0.31	0.16	0.25	-0.11	0.20	-.578**	-.549**	-0.20	0.32	-0.36	1.00					
Swidth	0.07	-0.01	0.04	-0.23	-0.06	-0.19	0.08	0.14	.509**	0.01	-.386*	-0.07	-0.19	0.32	-0.21	.872**	.858**	0.33	-0.20	.517**	-.646**	1.00				
SL	0.13	-0.15	-0.17	0.02	-0.06	-0.02	-0.12	0.30	0.20	0.14	0.22	0.27	0.11	-0.20	-0.19	0.30	0.30	-0.12	-0.03	0.20	-.445*	0.26	1.00			
100 SW	0.02	-0.15	0.21	-0.36	-0.14	-0.25	0.09	0.34	.551**	-0.18	-.387*	-0.20	-0.37	0.13	-0.23	.830**	.805**	0.29	-.431*	.526**	-.870**	.799**	.399*	1.00		
YPT	.703**	.529**	-0.05	.727**	.561**	.599**	-0.19	-0.18	-0.13	.391*	0.36	.638**	.730**	-0.03	-0.06	-0.23	-0.25	-0.01	.531**	-0.12	0.08	-0.06	0.13	-0.19	1.00	
NFPT	.653**	.576**	-0.12	.717**	.727**	.746**	-0.21	-0.25	-0.27	0.02	0.20	0.11	0.26	0.07	-0.03	-0.31	-0.33	0.12	0.14	-0.20	0.04	-0.12	-0.06	-0.19	.744**	1.00

**Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed).

[$]Age; TH: tree height (m); Trh: trunk height (m); Trg: trunk girth (m); Trsew: tree spread (east-west); Trsns: tree spread (north-south); NDFM: number of days from flowering to maturity; Sl: stalk length (cm); SD: stalk diameter (mm); FL: fruit length (cm); FD: fruit diameter (cm); FW: fruit weight (kg); FRW: fruit rind weight (kg); FRT: fruit rind thickness (mm); NFPKF: number of flakes (bulbs) per kg fruit; WFFWS: weight of fresh flake with seed (g); WFFWoutS: weight of fresh flakes without seed (g); FBV: flake brix value; RL: rachis length (cm); RD: rachis diameter (mm); NSPKF: number of seeds per kg fruit; SW: seed width (mm); SL: seed length (mm); 100 SW: 100 seed weight (g); YPT: yield per tree (kg per tree); NFPT: number of fruits per tree.

yield per tree. Another desired trait, number of flakes per kg of fruit was moderately positively correlated with fruit brix value and moderately negatively associated with age of tree. Fresh flakes weight without seed, which is an important trait was found to be having a strong positive association with stalk diameter, weight of fresh flakes with seed, rachis diameter, seed width and 100 seed weight, while strong negative correlation was recorded in number of seeds per kg of fruit.

Clustering of morpho-physiological features

The heatmap and hierarchical clustering at the accessions level revealed four distinct hierarchical clusters and at variable levels, four hierarchical clusters.

In respect of accessions, cluster A represents 10 accessions *viz*., MO4, MO13, MO1, MO6, MO5, MO8, MO17, MO12, MO14 and MO18, while cluster B denotes 5 accessions *viz*., MO9, MO19, MO3, MO7 and MO21 (Table 4). On the other hand, 5 accessions- MO16, MO2, MO11, MO20 and MO22 were grouped into cluster C, while cluster D represents 8 accessions- MO10, MO15, MO23, MO26, MO24, MO25, MO27 and MO28.

Out of 1 to 4 variables, cluster 1 like trunk height, days to flowering to maturity and fruit rind thickness were higher in the accessions MO10, MO18 and MO6, respectively, while lowest were recorded in MO20, MO7 and MO5, respectively. However, lowest fruit rind thickness was also recorded in MO5 and MO7 accessions.

Cluster 2 represents the variables of brix value, stalk diameter, rachis diameter, stalk length, seed length, fresh flake weight- with and without seed, seed width and 100 seed weight. These variables are prominent in 9 accessions *viz*., MO1, MO27, MO27, MO16, MO16, MO24, MO26, MO26 and MO26, but dull in 9 accessions *viz*., MO2, MO18, MO28, MO6, MO13, MO1, MO1, MO11 and MO16. Variables in cluster 3 indicates number of flakes and seeds per kg of fruit, which showed elevated value in MO1 and MO11, respectively, while the lowest gradient was recorded in MO3 and MO26, respectively. Cluster 4 epitomizes the maximum characters (12) like fruit diameter, fruit weight, fruit rind weight, fruit length, rachis length, tree height, age, tree spreading in both North-South and East-West direction, trunk girth, number of fruits and yield per tree. These features showed highest prominence in the accessions- MO17, MO8, MO8, MO8, MO8, MO12, MO12, MO12, MO12, MO12, MO24 and MO8, while lowest was found in the accessions- MO24, MO28, MO28, MO24, MO24, MO15, MO15, MO16, MO25, MO28, MO20 and MO28.

Varietal improvement in jackfruit is limited to selection of high yielding and better quality genotypes. To initiate selection, standard characterization and identification of trees with desirable characteristics as attempted in this study is helpful.

Selection of jackfruit accessions for tree breeding

Jackfruit tree is a multipurpose tree and a number of studies (Haq, 2003; Azad *et al*., 2007; APAARI, 2012) have been done to identify characters preferred by the farmers. In Bangladesh, the tree is grown primarily for fruits and timber as secondary product. While selecting accessions for tree breeding program, it is a good practice to take the farmers choice in to consideration. Farmer preferred traits were high yield, fruit quality, sweetness, early fruiting types and off-season types (Haq, 2006; Azad *et al*., 2007). The correlation analysis of the plant characters, clearly showed positive correlation with these preferred traits (Table 2).

Combining traits with positive influence and correlation (Table 2) with the genotype-variable through hierarchical clustering, highlighted the accessions with highest and lowest values (Table 3). Accession MO8 of cluster A had highest value for fruit weight, fruit length, rachis length, fruit rind weight and yield per tree, which have positive direct correlation with yield. MO28 and MO24 had the lowest values for these traits. MO17 accession had the highest and MO24 had the lowest value for fruit diameter, a trait with positive correlation to yield (Table 3). Fruit diameter is a consumer demand specific trait, as at places higher diameter is in demand, while at other, small diameter fruits are preferred. MO12, MO1 and MO10 were the other accessions with highest value for farmers' desired traits.

Age of tree had negative correlation with number of flakes (Table 2), and MO15 with lowest hierarchical value and MO12 with highest value stood promising for this character.

Thus, five accessions with highest and seven with lowest value for desired traits could be preferred candidates for further genotypic studies and analysis to decide for the parents for hybridization program.

Qualitative features-induced characterization of jackfruit accessions

Out of 36 qualitative characters, irrespective of clusters and accessions, no distinct variations were

Table 3. Accessions suitable for breeding to develop desirable traits.

Desirable traits by farmers	Traits with positive influence and correlation	Genotype variable through hierarchical clustering	
		Highest	**Lowest**
Yield	Fruit Weight	MO8	MO28
	Fruit Length	MO8	MO24
	Fruit diameter	MO17	MO24
	Rachis length	MO8	MO24
	Yield per tree	MO8	MO28
Yield per tree	Fruit weight	MO8	MO28
	Fruit rind weight	MO8	MO28
	Rachis length	MO8	MO24
Number of fruits per tree	Tree age	MO12	MO15
	Tree height	MO12	MO15
	Trunk height	MO10	MO20
	Tree spread	MO12	MO16 (NS)
			MO25 (EW)
	Yield per tree	MO8	MO28
Number of flakes	Fruit brix	MO1	MO2
	Age of tree (negative)	MO12	MO15

noticed in eight characters *viz*., propagating material, tree nature, leaf color, fruit bearing habits, pulp taste, seed surface pattern and disease and pest infestations types (Table 4-7). Variations to various extent was observed in remaining 28 characters. Tree vigor was categorized into three types *viz*., high, medium and low. However, in respect of high, medium and low tree vigor, cluster A had sum of 7, 2 and 1 accessions, and cluster B had 3 and 2, except for absence of medium tree vigor (Table 4 and 5). On the other hand, sum of 1, 3 and 1 accessions were recorded in cluster C and cluster D denotes 1, 7 and 1 accession (Table 6 and 7). Majority of the accessions had rough trunk surface, while smooth surface was recorded in 10 accessions *viz*., MO4, MO13, MO11, Mo16, MO10, MO15, MO23, MO24, MO25 and MO27. But cluster B had no smooth surface accessions (Table 5). In respect of crown shape, most of the accessions had broadly pyramidal shape (total of 7, 4, 1 and 2 accessions in the cluster of A, B, C and D, respectively), followed by pyramidal (total of 7, 4, 1 and 2 accessions in the cluster of A, B, C and D, respectively) and spherical (total of 1 and 3 accessions in the cluster of A and D, respectively) shape. In case of tree growth habit, cluster A had total of 7 and 3 accessions of spreading and semi-erect habit, respectively, while sum of 3 and 2 accessions, respectively were recorded in cluster B (Table 4 and 5). Cluster C had sum of 4 accessions of semi-erect and 1 accession of spreading nature tree, while total of 5, 2 and 1 accessions of spreading, semi-erect and erect nature tree, respectively were recorded in cluster D (Table 6 and 7).

In case of branching density, most of the accessions of cluster A and B had dense branching (Table 4 and 5), while cluster C had low, and medium densities branching were recorded in cluster D (Table 6 and 7). Different branching pattern like verticillate (total of 5, 2, 1 and 5 accessions were recorded in cluster of A, B, C and D, respectively), horizontal (total of 3, 1, 1 and 2 accessions were recorded in cluster of A, B, C and D, respectively) and erect (total of 2, 1 and 3 accessions were recorded in cluster of A, B and C, respectively) were found in respect of different clusters accessions (Table 4-7). However, total of 1 accession of both opposite and irregular branching pattern were recorded in clusters B and D (Table 5 and 7).

With respect to leaf blade shape, cluster A had trees with oblanceolate, obovate, ovate, elliptic, oblong and orbicular shape (Table 4). Trees in cluster B had elliptic, obovate, oblanceolate, obcordate shape, while cluster C had obovate and elliptic and cluster D had elliptic, narrowly elliptic and lyrate (wavy) shape (Table 5-7). Cluster A included tree with apiculate, obtuse, round, short-apiculate and cuspidate leaflet

Table 4. Qualitative characterization of cluster A accessions from major jackfruit growing areas of Bangladesh.

Characters	MO1	MO4	MO5	MO6	MO8	MO12	M013	MO14	M017	MO18
Propagating material	Seed	Seed	Seed	Seed	Seed	Seed	Seed	Seed	Seed	Seed
Tree vigor	Medium	Low	High	Medium	High	High	High	High	High	High
Trunk surface	Rough	Smooth	Rough	Rough	Very Rough	Rough	Smooth	Rough	Rough	Rough
Crown shape/habit	Broadly Pyramidal	Pyramidal	Broadly Pyramidal	Broadly Pyramidal	Broadly Pyramidal	Broadly Pyramidal	Pyramidal	Broadly Pyramidal	Spherical	Broadly Pyramidal
Tree growth habit	Spreading	Semi erect	Spreading	Spreading	Spreading	Spreading	Semi erect	Spreading	Semi erect	Spreading
Tree nature	Evergreen	Evergreen	Evergreen	Evergreen	Evergreen	Evergreen	Evergreen	Evergreen	Evergreen	Evergreen
Branching density	Medium	Low	Dense	Dense	Dense	Dense	Dense	Dense	Dense	Dense
Branching pattern	Verticillate	Erect	Verticillate	Verticillate	Horizontal	Verticillate	Erect	Horizontal	Verticillate	Horizontal
Leaflet/leaf blade shape	Oblanceolate	Obovate, Oblanceolate	Ovate	Elliptic	Obovate	Elliptic, Oblong	Elliptic	Orbicular	Elliptic	Oblong
Leaflet apex	Apiculate	Obtuse, Round	Apiculate	Short Apiculate	Cuspidate	Apiculate, Obtuse	Apiculate	Short apiculate	Apiculate	Round
Leaf base shape	Cuneate	Cuneate	Rounded	Cuneate	Aculilateral	Aculilateral, acute	Cuneate	Rounded	Oblique	Round
Leaf color	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green
Fruiting season	Early	Early	Mid	Mid	Early	Mid	Early	Late	Late	Early
Extent of fruit drop	Medium	Low	Low	Low	Medium	Low	Low	Low	Low	Low
Fruit bearing habit	Regular	Regular	Regular	Regular	Regular	Regular	Regular	Regular	Regular	Regular
Fruit bearing	Medium	Medium	High	High	Medium	High	Medium	High	Medium	High
Fruit bearing position	Trunk and secondary branch	Trunk, primary and secondary branch	Trunk, primary and secondary branch	Primary and secondary branch	Primary and secondary branch	Trunk, primary and secondary branch	Trunk, primary and secondary branch	Trunk, primary and secondary branch	Trunk, primary and secondary branch	Trunk, primary and secondary branch
Fruit shape	Ellipsoid	Ellipsoid	Spheroid	Ellipsoid	Irregular	Spheroid	Spheroid	Clavate	Ellipsoid	Clavate
Stalk attachment to fruit	Depressed	Depressed	Depressed	Depressed	Depressed	Depressed	Inflated	Depressed	Depressed	Depressed
Fruit rind color	Greenish yellow	Green	Reddish yellow	Greenish yellow	Greenish yellow	Yellow	Yellowish green	Coppery red	Greenish yellow	Greenish yellow
Fruit surface	Spiny	Spiny	Spiny	Spiny	Spiny	Spiny	Spiny	Spiny	Spiny	Spiny
Shape of spine	Sharp pointed	Sharp pointed	Sharp pointed	Sharp pointed	Intermediate	Intermediate	Intermediate	Sharp pointed	Intermediate	Intermediate
Spine density	Dense	Dense	Medium	Dense	Dense	Dense	Dense	Dense	Medium	Dense
Flake shape	Obovate, oblong	Obovate, oblong, irregular	Obovate, ellipsoid	Broad obovate, obovate, Oblong	Ellipsoid	Rectangular, Irregular, Ellipsoid	Oblate, rectangular, broad obovate	Oblate, obovate, Irregular	Obovate, Oblong with curved tip, Irregular, Ellipsoid	Obovate, Irregular
Flake texture	Soft	Soft	Intermediate	Hard	Soft	Soft	Soft	Soft	Hard	Hard
Pulp taste	Sweet	Sweet	Sweet	Sweet	Sweet	Sweet	Sweet	Sweet	Sweet	Sweet
Pulp flavor	Intermediate	Weak	Weak	Weak	Strong	Strong	Strong	Strong	Intermediate	Weak
Pulp juiciness	Very Juicy	Very juicy	Juicy	Not Juicy	Juicy	Very juicy	Very Juicy	Very juicy	Not Juicy	Not juicy
Pulp (fresh flake) color	Light yellow	Light yellow	Light yellow	Deep yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light Yellow	Light Creamy white
Vivipary	Absent	Absent	Absent	Absent	Present	Absent	Present	Absent	Present	Absent
Shape of seed	Oblong, irregular, narrowly ovate	Irregular, Reniform, Ellipsoid	Reniform, ovate	Ovate, irregular, ellipsoid	Irregular, Ellipsoid	Ellipsoid, irregular, Reniform	Obovate, Ellipsoid	Obovate, Ellipsoid, Reniform	Reniform, Irregular, Ovate	Reniform, Irregular
Seed surface pattern	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth
Seed coat color	Dull brown	Reddish brown	Reddish brown	Reddish brown	Reddish brown	Reddish brown	Brown	Dull brown	Reddish brown	Reddish brown
Adherence of seed coat to kernel	Easily separable	Easily separable	Easily separable	Easily separable	Easily separable	Intermediate	Intermediate	Intermediate	Easily separable	Easily separable
Disease infestation	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage
Pest infestation	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer

apex; while cluster B had apiculate, obcordate and short-apiculate; cluster C and D had apiculate and short-apiculate shape with the exception of acute shape in cluster D (Table 4-7). On the other hand, accessions of cluster A had cuneate, rounded, acuilateral, acute and oblique leaf base shape; while cluster B had cuneate and acuilateral shape; cluster C had cuneate, rounded, acuilateral and oblique shape; and cluster D had cuneate, rounded and acuilateral leaf base shape (Table 4-7).

Table 5. Qualitative characterization of cluster B accessions from major jackfruit growing areas of Bangladesh.

Characters	MO3	MO7	MO9	MO19	MO21
Propagating material	Seed	Seed	Seed	Seed	Seed
Tree vigor	High	High	Low	Low	High
Trunk surface	Rough	Rough	Rough	Rough	Rough
Crown shape/habit	Broadly Pyramidal	Broadly Pyramidal	Broadly Pyramidal	Pyramidal	Broadly Pyramidal
Tree growth habit	Semi erect	Spreading	Spreading	Semi erect	Spreading
Tree nature	Evergreen	Evergreen	Evergreen	Evergreen	Evergreen
Branching density	Dense	Dense	Low	Medium	Dense
Branching pattern	Erect	Horizontal	Verticillate	Opposite	Verticillate
Leaflet/leaf blade shape	Elliptic	Obovate	Oblanceolate	Elliptic, Obcordate	Elliptic
Leaflet apex	Apiculate	Short Apiculate	Short apiculate	Apiculate, Obcordate	Apiculate
Leaf base shape	Cuneate	Aculilateral	Cuneate	Aculilateral	Cuneate
Leaf color	Dark green	Dark green	Dark green	Dark green	Dark green
Fruiting season	Late	Late	Early	Mid	Late
Extent of fruit drop	Low	Medium	Low	Low	Low
Fruit bearing habit	Regular	Regular	Regular	Regular	Regular
Fruit bearing	Medium	Medium	Low	Medium	Low
Fruit bearing position	Primary and secondary branch	Primary and secondary branch	Trunk, primary and secondary branch	Primary and secondary branch	Trunk, primary and secondary branch
Fruit shape	Spheroid	High spheroid	Oblong	Obovate	Clavate
Stalk attachment to fruit	Depressed	Flattened	Depressed	Depressed	Depressed
Fruit rind color	Reddish yellow	Greenish yellow	Greenish yellow	Greenish yellow	Greenish yellow
Fruit surface	Spiny	Spiny	Spiny	Spiny	Spiny
Shape of spine	Intermediate	Intermediate	Intermediate	Sharp pointed	Intermediate
Spine density	Medium	Dense	Medium	Medium	Dense
Flake shape	Obovate, irregular, oblong with curbed tip	Obovate	Rectangular, oblate, irregular	Oblate, Broad obovate, irregular, rectangular	Obovate, Irregular, Crescent, ellipsoid
Flake texture	Hard	Intermediate	Soft	Intermediate	Soft
Pulp taste	Sweet	Sweet	Sweet	Sweet	Sweet
Pulp flavor	Weak	Intermediate	Strong	Strong	Strong
Pulp juiciness	Juicy	Juicy	Very juicy	Juicy	Juicy
Pulp (fresh flake) color	Deep yellow	Light yellow	Light yellow	Light yellow	Deep yellow
Vivipary	Present	Absent	Absent	Absent	Absent
Shape of seed	Irregular, ovate	Irregular, Oblong, Elongate	Broad ovate, irregular, ovate, Reniform	Broad Ovate	Ellipsoid, Reniform, spheroid
Seed surface pattern	Smooth	Smooth	Smooth	Smooth	Smooth
Seed coat color	Dull brown	Brown	Dull brown	Reddish brown	Brown
Adherence of seed coat to kernel	Easily separable	Easily separable	Intermediate	Easily separable	Intermediate
Disease infestation	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage
Pest infestation	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer

Fruiting seasons were categorized into early, mid and late. Cluster A had total of 5, 3 and 2 accessions in respect of early, mid and late fruiting seasons; while cluster B had 1, 1 and 3; cluster C had 1, 2 and 2; and cluster D had 5, 2 and 1 accessions, respectively (Table 4-7). Irrespective of clusters, most of the accessions had low (19) extent of fruit drop, followed by medium (9). In respect of fruit bearing, cluster A included tree with high to medium bearing capacity; while cluster B and C includes medium to low; and cluster D includes low, medium and higher bearing capacity accessions (Table 4-7).

Regardless of clusters, majority of the accessions bear fruits on trunk and primary and secondary branches. Wide variations were noticed in different accessions in respect of fruit shape. Cluster A had trees with ellipsoid, spheroid, irregular and clavate fruit shape; whereas, cluster B had spheroid, oblong, obovate, and clavate shape; cluster C had ellipsoid, spheroid, ovate and clavate shape; and cluster D had

Table 6. Qualitative characterization of cluster C accessions from major jackfruit growing areas of Bangladesh.

Characters	MO2	MO11	MO16	MO20	MO22
Propagating material	Seed	Seed	Seed	Seed	Seed
Tree vigor	Medium	Medium	Medium	Low	High
Trunk surface	Rough	Smooth	Smooth	Rough	Rough
Crown shape/ habit	Pyramidal	Pyramidal	Broadly Pyramidal	Pyramidal	Pyramidal
Tree growth habit	Semi erect	Semi erect	Spreading	Semi erect	Semi erect
Tree nature	Evergreen	Evergreen	Evergreen	Evergreen	Evergreen
Branching density	Medium	Low	Low	Low	Dense
Branching pattern	Erect	Erect	Horizontal	Erect	Verticillate
Leaflet/leaf blade shape	Obovate, Elliptic	Elliptic	Elliptic	Elliptic	Elliptic
Leaflet apex	Short Apiculate	Short apiculate	Apiculate	Apiculate	Apiculate
Leaf base shape	Cuneate	Aculilateral	Cuneate	Rounded, Aculilateral	Oblique, rounded
Leaf color	Dark green	Dark green	Dark green	Dark green	Dark green
Fruiting season	Early	Late	Late	Mid	Mid
Extent of fruit drop	Medium	Low	Low	Low	Low
Fruit bearing habit	Regular	Regular	Regular	Regular	Regular
Fruit bearing	Low	Low	Medium	Low	Low
Fruit bearing position	Primary branch	Trunk, primary and secondary branch	Primary and secondary branch	Secondary branch	Primary and secondary branch
Fruit shape	Clavate	Spherical	Ellipsoid	Ovate	Clavate
Stalk attachment to fruit	Depressed	Depressed	Flattened	Depressed	Inflated
Fruit rind color	Green	Yellow	Greenish yellow	Green	Reddish yellow
Fruit surface	Spiny	Spiny	Spiny	Spiny	Spiny
Shape of spine	Sharp pointed	Intermediate	Intermediate	Sharp pointed	Intermediate
Spine density	Dense	Dense	Sparse	Dense	Low
Flake shape	Oblate, Irregular, Ellipsoid	Rectangular, oblate, obovate, irregular	Obovate	Rectangular, Obovate	Spheroid, irregular
Flake texture	Soft	Hard	Hard	Intermediate	Soft
Pulp taste	Sweet	Sweet	Sweet	Sweet	Sweet
Pulp flavor	Strong	Weak	Very weak	Strong	Strong
Pulp juiciness	Very Juicy	Not juicy	Not juicy	Very juicy	Very Juicy
Pulp (Fresh flake) color	Light yellow	Light yellow	Deep yellow	Light yellow	Light Yellow
Vivipary	Present	Absent	Present	Absent	Absent
Shape of seed	Ovate, Irregular	Elongate, Irregular, Obovate	Oblong, Ovate, Obovate	Ellipsoid	Reniform, ellipsoid
Seed surface pattern	Smooth	Smooth	Smooth	Smooth	Smooth
Seed coat color	Brown	Dull brown	Brown	Light Brown	Light Brown
Adherence of seed coat to kernel	Easily separable	Easily separable	Easily separable	Easily separable	Intermediate
Disease infestation	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage
Pest infestation	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer

Table 7. Qualitative characterization of cluster D accessions from major jackfruit growing areas of Bangladesh.

Characters	MO10	MO15	MO23	MO24	MO25	MO26	MO27	MO28
Propagating material	Seed	Seed	Seed	Seed	Seed	Seed	Seed	Seed
Tree vigor	Medium	Low	Medium	Medium	High	Medium	Medium	Medium
Trunk surface	Smooth	Smooth	Smooth	Smooth	Smooth	Rough	Smooth	Rough
Crown shape/ habit	Broadly Pyramidal	Broadly Pyramidal	Spherical	Spherical	Pyramidal	Spherical	Pyramidal	Pyramidal
Tree growth habit	Spreading	Spreading	Erect	Spreading	Semi-erect	Semi-erect	Spreading	Spreading
Tree nature	Evergreen	Evergreen	Evergreen	Evergreen	Evergreen	Evergreen	Evergreen	Evergreen
Branching density	Medium	Low	Sparse	Medium	Dense	Medium	Medium	Medium
Branching pattern	Horizontal	Horizontal	Verticillate	Verticillate	Verticillate	Verticillate	Irregular	Verticillate
Leaflet/leaf blade shape	Elliptic	Elliptic	Narrowly Elliptic	Narrowly elliptic	Lyrate (Wavy)	Elliptic	Elliptic	Elliptic
Leaflet apex	Acute	Apiculate	Short Apiculate	Short Apiculate	Apiculate	Apiculate	Apiculate	Short Apiculate
Leaf base shape	Cuneate	Cuneate	Aequilateral	Cuneate	Round	Aequilateral	Aequilateral	Round
Leaf color	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green
Fruiting season	Late	Early	Mid	Early	Early	Mid	Early	Early
Extent of fruit drop	Low	Low	Low	Medium	Medium	Medium	Medium	Medium
Fruit bearing habit	Regular	Regular	Regular	Regular	Regular	Regular	Regular	Regular
Fruit bearing	Low	Low	High	Medium	Medium	Medium	Medium	Medium
Fruit bearing position	Primary and secondary branch	Primary and secondary branch	Main, Primary and secondary branch	Main trunk, Primary branch	Trunk, primary and secondary branch	Main and secondary branch	Main trunk, Primary branch	Main trunk, Primary branch
Fruit shape	Globose	Spheroid	Ellipsoid	Spheroid	Clavate	Ellipsoid	Ellipsoid	Ellipsoid
Stalk attachment to fruit	Depressed	Depressed	Flattened	Flattened	Flattened	Flattened	Depressed	Flattened
Fruit rind color	Greenish brown	Brownish Red	Reddish	Green	Green	Green	Green	Reddish yellow
Fruit surface	Spiny	Smooth	Smooth	Spiny	Spiny	Spiny	Spiny	Spiny
Shape of spine	Flat	Flat	Flat	Sharp pointed	Intermediated	Intermediate	Intermediated	Intermediated
Spine density	Low	Very low	Sparse	Dense	Dense	Sparse	Dense	Dense
Flake shape	Obovate, irregular, Twisted, ellipsoid	Rectangular, Spheroid, Oblong with curved tip	Spheroid, Obovate, irregular	Cordate, Rectangular, Obovate	Obovate, oblong with curved tip, Cordate, Rectangular, Twisted	Twisted, Rectangular, Broadly obovate	Rectangular, Twisted, Obovate	Spheroid, Obovate
Flake texture	Hard	Very soft	Soft	Intermediated	Intermediated	Intermediated	Soft	Soft
Pulp taste	Sweet	Sweet	Sweet	Sweet	Sweet	Sweet	Sweet	Sweet
Pulp flavor	Strong	Strong	Intermediate	Strong	Intermediate	Strong	strong	Strong
Pulp juiciness	Juicy	Very Juicy	Very Juicy	Not Juicy	Juicy	Juicy	Very Juicy	Very Juicy
Pulp (Fresh flake) color	Light yellow	Light yellow	Creamy white	Deep yellow	Yellow	Yellow	Yellow	Deep yellow
Vivipary	Present	Present	Absent	Present	Present	Absent	Absent	Absent
Shape of seed	Reniform, Ellipsoid	Irregular, Ellipsoid	Spherical	Irregular	Oblong, Reniform, Obovate, Irregular	Elongate, Oblong, Ellipsoid, Spheroid,	Reniform, Obovate, Cordate, Elongate, Ellipsoid	Ellipsoid, Reniform, Ovate
Seed surface pattern	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth
Seed coat color	Reddish brown	Light brown	Off-white	Brown	Light brown	Off white	Off-white	Brown
Adherence of seed coat to kernel	Easily separable	Intermediate	Difficult to separable	Easily separable	Easily separable	Easily separable	Difficult to separable	Easily separable
Disease infestation	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage	Rotten of fruits, Bud fall at early stage		Anthracnose	Anthracnose	Rotten of fruits, Bud fall at early stage	Anthracnose
Pest infestation	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer	Bark eating caterpillar, Jackfruit borer		Bark borer, shoot and fruit borer	Bark borer	Bark eating caterpillar, Jackfruit borer	Bark borer

globose, spheroid, ellipsoid, and clavate fruit shapes (Table 4-7).

In all the clusters, most of the accessions had depressed type of stalk attachment to fruit, except for inflated in cluster A (MO13) and flattened in cluster B, C and D (MO7, MO16, MO23, MO24, MO25, MO26 and MO28). Fruit rind color varied with respect to different clusters. Cluster A had fruits with greenish yellow, reddish yellow, yellowish green, yellow, yellowish red and coppery red colored fruit rind (Table 4). On the other hand, cluster B had reddish and greenish-yellow colored rind; cluster C had reddish and greenish-yellow colored together with sole green and yellow colored rind; and cluster D had sole green, greenish brown, brownish red, sole reddish and reddish yellow colored fruit rind (Table 5-7). Irrespective of accessions of different clusters, almost all accessions had spiny fruit surface, except for smooth surface in the accessions of MO15 in cluster D (Table 7). Majority of the accessions of cluster A, B and C had sharp pointed to intermediated shape of spine, while cluster D in addition to these two, also had flat shape spine. Regardless of clusters, most of the accessions had dense to medium spine density, except for low (MO22 and MO10) and very low (MO15) in clusters C and D (Table 6 and 7).

Wide range of variations were noticed in flake shape of different accessions of different clusters. Cluster A and B had fruit with obovate, oblong, irregular, ellipsoid, broadly-obovate, rectangular, oblate and oblong with curved tip flake shapes, except for crescent shape in cluster B (MO21). On the other hand, accessions of cluster C had fruit with obovate, irregular, rectangular, oblate, ellipsoid and spheroid shape and cluster D had obovate, irregular, rectangular, oblate, ellipsoid, spheroid, oblong with curved tip, twisted, cordate and broadly-obovate flake shape. It is interesting to note that almost all clusters had soft, intermediate and hard type flake texture fruit accessions. Unrelatedly to clusters, majority of the accessions had fruit with strong pulp flavor, followed by intermediate and weak. However, very weak pulp flavor was noticed in the accession of MO16 (Table 6) in cluster C.

Pulp juiciness did not vary in respect to different accessions with the exception of not juicy in cluster A (MO6, MO17 and MO18), cluster C (MO11 and MO16) and in cluster D (MO24). Pulp i.e. fresh flake color was of light yellow to deep yellow in cluster A, B and C with the exception of light creamy white color in the accession of MO18 (cluster A). However, cluster D had fresh flake with sole yellow and creamy white color besides having light yellow to deep yellow color (Table 7). In case of vivipary, accessions of MO8, MO13 and MO17 of cluster A; accession of MO3 of cluster B; accessions of MO2 and MO16 of cluster C; and accessions MO10, MO15, MO24 and MO25 of cluster D showed presence.

Most common shapes of seed present in almost all clusters were oblong, irregular, reniform, ovate, ellipsoid and obovate. However, additional shape includes in cluster A was narrowly-ovate; cluster B were elongate, broad-ovate, spheroid; cluster C was elongate; and cluster D were cordate and elongate shaped seed (Table 4-7). Most of the accessions of all clusters had brown, dull brown, reddish brown and light brown colored seed, except for off-white color in the accessions MO23, MO26 and MO27 in cluster D (Table 4-7). Adherence of seed coat to kernel seemed to be easily separable in most of the accessions of all clusters, with exception of accessions MO23 and MO27 in cluster D, which seemed difficult to separate.

4. CONCLUSION

The present study clearly indicates that a wide range of morphological diversity had been found among the selected 28 accessions from the major jackfruit growing areas of Gazipur, Narsingdi and Bandarban divisions in Bangladesh. Varietal improvement in jackfruit is limited to selection of high yielding, better quality genotypes. To initiate selection, standard characterization and identification of trees with desirable characteristics as attempted in this study is helpful. In the present study, there were no distinct variations among accessions for 8 characters (propagating material, tree nature, leaf color, fruit bearing habits, pulp taste, seed surface pattern and disease and pest infestations types), but variations to different extent was recorded for remaining 28 characters. Regardless of hierarchical clusters, majority of the accessions bear fruits in trunk, primary and secondary branches; fruit shape varied widely; had spiny fruit surface except for accession MO15 in cluster D with smooth surface; and fruit with strong pulp flavor. Based on correlation value and genotype variable hierarchical clustering, five accessions (MO8, MO17, MO12, MO10 and MO1) with highest values were most promising for genetic studies, while seven accessions (MO 28, MO24, MO15, MO20, MO16, MO25 and MO2) had lowest value for the traits desired by the farmers. Furthermore, the complete documentation of such a diversity is crucial to better understand the variations in different accessions for successful crop breeding and domestication of jackfruit tree, especially for commercial usage. Such studies will be extremely important to harness the full potential of jackfruit through agroforestry.

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