Multiple Correspondence Analysis of Qualitative Traits of Jackfruit (*Artocarpus heterophyllus* Lam.) Germplasm of Northern Tripura Region, India

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Abstract: The genetic diversity, existing among the indigenous germplasm of jackfruit (*Artocarpus heterophyllus* Lam.) of northern Tripura state, was observed on the light Multiple Correspondence Analysis (MCA), depending on 24 (twenty-four) numbers qualitative attributes. It revealed that the Qualitative traits of jack fruit like fruit bearing habit, alternate bearing, leaf blade shape, fruit clustering habit, inflorescence colour and pulp colour have expressed relatively large values on both dimension 1 and dimension 2 of the discrimination measures plot. Whereas, the Object score plot specially helped to spot outlier accessions such as JF-24, JF-48, JF-1, JF-32, JF-45, JF-21, JF-35, JF-26, JF-19, JF-12, JF-3 etc. Category quantification plots identified irregular fruit shape, elliptical crown shape, acidic pulp taste and flat shape of spine act as large discriminants along Dimension 1, along with bitter and sweet pulp taste, weak pulp flavour, fruit bearing on primary branches and pyramidal crown shape with Dimension 2.

Keywords: – Category quantification, Dimension, Jackfruit, MCA, Object score, PCA, Qualitative traits, Tripura.

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1. Introduction

The jackfruit (*Artocarpus heterophyllus* L.) is a commercially important minor fruit crop of India. The jackfruit also popularly known as the “poor man’s fruit”, is a species of tree in the Fig, Mulberry and Breadfruit family Moraceae and originated in the rainforests of the Western Ghats of India (Chandler, 1958; Purseglove, 1968; Popenoe, 1974). The genus *Artocarpus* includes about 50 species with a milky latex in the tropical Asia and Polynesia (Corner, 1988; Campbell, 1984; Barrau, 1976), 18 of these species are found in the Philippines (Merrill, 1912). The jackfruit is a multi-purpose tree providing food, fodder, timber, fuel, medicinal and industrial products. Its leaves, barks, inflorescences, seeds and their latex are also used additionally in traditional medicines. India is the second largest producer of the fruit and is widely distributed in the states of Assam, Tripura, Bihar, Uttar Pradesh, the foothills of Himalayas, Kerala, Karnataka and Tamil Nadu (APAARI, 2012). In North-eastern India, the leading jackfruit producing states are Tripura, Assam, Meghalaya, Sikkim and Manipur (Singh *et al*., 2018).

Tripura being under Eastern Himalayan Agro-Climatic Region produces a major share of jackfruit in India. In Tripura, it is one of the major fruit crops. The largest jackfruit producing districts are West Tripura and South Tripura out of total eight districts. Roy (2008) reported that till date no research study has been conducted on jackfruit of Tripura despite it is being produced in bulk with rich genetic diversity. In Tripura, there is a high potential for increasing the area, production and processing as a rainfed fruit crop, but it is grown non-scientifically or not having a commercial or promising variety for this state, especially at northern part. Therefore, there is an urgent need for survey, collection, conservation and characterization of the threatened cultivars or clones of jackfruit in Northern Tripura for improvement and to increase the sustainable production and productivity at now or in future for food security in the district. For undertaking any improvement programme, the knowledge of various aspects of morphology, floral biology and fruit characters of jackfruit is in fact of great significance. Keeping in mind the above, the present investigation was carried out to assess various qualitative traits of jackfruit for genetic diversity determination with special reference to Multiple Correspondence Analysis (MCA).

2. Materials and Methods

The region of Northern parts of Tripura State was covered for the study including the hilly zone. Fifty different jackfruit genotypes were identified from eight blocks namely, Kadamtala, Jubrajnagar, Kalacherra, Laljuri, Panisagar, Damchera, Dasda, Jampui Hills in the state (Table – 1), following the Bio-diversity International Jackfruit Descriptor 2000, during the years 2019-2021. More than 70% of this area is hilly and forest covered. The terrain is mostly undulating & hilly with small water streams (cherras), rivers and fertile valleys intervening. The climate of this region is tropical in nature and is generally warm and humid. The hilly regions enjoy higher temperature in summer and lower temperature in winter in comparison with the plains. The climatic temperature generally ranges in between 10^0C and 35^0C. Soil is acidic in nature (pH 5.4 – 6.1). Twenty-four numbers various qualitative traits related to tree morphology and yield attributes were measured as per Bio-diversity International Jackfruit Descriptor 2000.

Multiple Correspondence Analysis [MCA] (Escofier and Pages, 1992) is a data analysis technique for nominal categorical data, used to detect and represent underlying structures in a data set. It is done by representing data as points in a low-dimensional Euclidean space.

There are K nominal variables, each nominal variable has J_k levels and the sum of the J_k is equal to J. There are I observations. The I × J indicator matrix is denoted X.

The J × J table obtained as $B = X^TX$ is called the Burt matrix associated to X. This table is important in MCA because using CA on the Burt matrix gives the same factors as the analysis of X but is often computationally easier. But the Burt matrix also plays an important theoretical role because the Eigen values obtained from its analysis give a better approximation of the inertia explained by the factors than the Eigen values of X.

MCA codes data by creating several binary columns for each variable with the constraint that one and only one of the columns gets the value 1. This coding scheme creates artificial additional dimensions because a categorical variable is coded with several columns. As a consequence, the inertia (i.e. variance) of the solution space is artificially inflated and therefore, the percentage of inertia explained by the first dimension is severely under estimated. In fact, it can be shown that all the factors with an Eigen value less or equal to 1 K simply code these additional dimensions.

Two corrections formulas are often used, the first one is due to Benzécri (1979), the second one to Greenacre (1993). These formulas take into account that the Eigen values smaller than 1 K are coding for the extra dimensions and that MCA is equivalent to the analysis of the Burt matrix, whose Eigen values are equal to the squared Eigen values of the analysis of X. Specifically, if Eigen values obtained from the analysis of the indicator matrix are denoted by λ_ℓ, then the corrected eigenvalues, denoted by c^λ are obtained as

$$c^\lambda \ell = \begin{cases} \left[\left(\frac{K}{K-1}\right)\left(\lambda\ell - \frac{1}{K}\right)\right]2 & \text{if, } \lambda_\ell > \frac{1}{K} \\ 0 & \text{if, } \lambda_\ell \leq \frac{1}{K} \end{cases}$$

Using this formula gives a better estimate of the inertia, extracted by each Eigen value. Greenacre (1993), who suggested that instead of evaluating the percentage of inertia relative to the average inertia of the off-diagonal blocks of the Burt matrix. This average inertia, denoted by $\mathcal{J}$ and can be computed as

$$\mathcal{J} = \frac{K}{K-1} X \left(\sum_l \lambda_l^2 - \frac{J-K}{K}\right)^2$$

According to this approach, the percentage of inertia would be obtained by the ratio

$$\tau c = \frac{c\lambda}{\mathcal{J}} \text{ instead of } \frac{c\lambda}{c\lambda l}$$

Multiple Correspondence Analysis of qualitative data (Categorical) was done using SPSS v. 24.0.

3. Results and Discussion

3.1 Multiple Correspondence Analysis (MCA) of qualitative traits

The objective of Multiple Correspondence Analysis (MCA) is to provide interpretable visualization of complex-variable space. The meaning given to the axes (Dimensions) and analysis of proximities between variables and conditions are usually made from the factorial planes. The first two dimensions allowed explaining about 25.00% of the original variance (19.326% dimension 1 and 5.674% dimension 2). The first and second dimensions having, respectively, Eigen values: 5.288 and 4.060; inertia: 0.220 and 0.169; and Cronbach's alpha: 0.846 and 0.786 [Table - 2].

3.2 Discrimination measures

Table – 3 shows that strongly correlated traits to the first axis (Dimension) were pulp taste (0.619), crown shape (0.566), adherence of seed coat to kernel (0.475), fruit bearing position (0.470), fruit attractiveness (0.393), pulp flavour (0.373), fruit quality (0.338), seed shape (0.257) and apical dominance (0.203). The best-represented characters in the Dimension 2 were pulp (flake flesh) colour (0.420), pulp taste (0.414), pulp flavour (0.388), crown shape (0.307), adherence of seed coat to kernel (0.274), fruiting season (0.250), fruit shape (0.222) and fruit bearing position (0.213).

Twenty-four qualitative characteristics of fifty jackfruit genotypes were subjected for multiple correspondence analysis. The discrimination measures plot [Fig. - 1] showed that the first dimension was related to variables namely, apical dominance, latex exudation, fruit quality, fruit attractiveness, leaf colour, seed shape, shape of spine and female flower aroma. These variables have large discrimination measures on the first Dimension and small discrimination measures on the second Dimension. Thus, for these variables, the categories were spread mostly along the first Dimension only. Whereas, fruit bearing habit, alternate bearing, leaf blade shape, fruit clustering habit, inflorescence colour and pulp colour revealed a large value on the second dimension, but a small value on the first dimension. However, traits like pulp taste, pulp flavour, crown shape, adherence of seed coat to kernel, fruit bearing position, tree growth habit, flake shape, fruit shape and seed shape had been plotted almost as equidistant manner from both the Dimensions, would express very little affinity to either of the dimensions.

3.3 Object scores and object score plot

Examining the object scores [Table – 4] and object score plot [Fig. - 2], it could be described quite clearly that the first Dimension (the horizontal axis) discriminates accessions JF-28 (0.360), JF-24 (0.308), JF-48 (0.264), JF-1 (0.175), JF-32 (0.175), JF-44 (0.175), JF-45 (0.173), JF-21 (0.166), JF-35 (0.161), JF-26 (0.126), JF-19 (0.122), JF-15 (0.108) and JF-12 (0.108) from rest of the genotypes, which form the cluster at the centre approximately. It was easily visible in the plot since these two sets of accessions lie on two opposite ends of the horizontal axis.

The second Dimension (the vertical axis) differentiated JF-32 (0.273), JF-16 (0.227), JF-1 (0.164), JF-3 (0.151), JF-48 (0.116), JF-28 (0.109), JF-2 (0.098), JF-18 (0.098), JF-45 (0.087), and JF-8 (0.073) from the genotypes that clustered nearer to the origin.

The distant manner of arrangement of accessions on object score plot as per object scores of jackfruit germplasm based on multiple correspondence analysis of qualitative traits, might be revealing the distinctness of the subjected genotypes from the others with respect to the genotypic features that controlled the expression of qualitative morphologies of jackfruit germplasm.

3.4 Category quantification plot

Category quantification plot [Fig.- 3] represents an alternative way to demonstrate discrimination of variables that can determine category relationships. The spread of the category quantifications for a variable reflected the variance and thus, indicated how well that variable was discriminated in each dimension. In this plot, the coordinates of each category on each dimension are displayed. Thus, one can determine which categories are similar for each variable. The category irregular (6) fruit shape, elliptical (6) crown shape, acidic (2) pulp taste and flat (3) shape of spine act as the large discriminants along Dimension 1.

In the present category quantification plot parameter such as pulp colour that showed five categories; out of them four clustered at the centre of the plot and only category 6, that represents white colour pulp of ripe jackfruit, expressed a large discrimination in both the dimensions. Similarly, category 4 (i.e., very high > 75%) of alternate bearing, fruit bearing on main trunk and primary branches (4), twisted (3) flake shape and difficult to separate seed coat to kernel (3) exhibited large discrimination along both the dimensions. For fruit quality category 4 i.e., excellent acted as a large discriminant along both the dimensions. Similarly, the large discrimination for erect (1) tree growth habit along both the dimensions is a result of this one category being very different from the other categories of tree growth habit. For apical dominance, the category weak (3) is a bit far from the other categories of that variable in discrimination along both the dimensions.

Focusing on Dimension 2, for variable bitter (3) and sweet (4) pulp taste, weak pulp flavour (1), fruit bearing on primary branches (2) and pyramidal crown shape (1) showed considerable discrimination.

Perrier *et al.* (2003) and Temegne *et al.* (2016) also accepted importance of multiple-correspondence analysis (MCA) technique in genetic diversity analysis of qualitative traits.

4. Conclusion

Multiple Correspondence Analysis (MCA) of qualitative traits revealed that the first and second dimensions presented high Eigen value and Cronbach's alpha. The strongly correlated traits to the first axis (Dimension) were pulp taste, crown shape, adherence of seed coat to kernel, fruit bearing position, fruit attractiveness, pulp flavor and texture, fruit quality, seed shape and apical dominance. The best represented characters in the dimension 2 were pulp (flake flesh) colour, pulp taste, pulp flavour, crown shape, adherence of seed coat to kernel, fruiting season, fruit shape and fruit bearing position. Qualitative traits like fruit bearing habit, alternate bearing, leaf blade shape, fruit clustering habit, inflorescence colour and pulp colour have expressed relatively large values on both dimension 1 and dimension 2 of the discrimination measures plot.

The genotypes under present study had been differentiated in Object score plot based on dimension 1 and dimension 2. Object score plot specially helped to spot outlier accessions i.e., JF-24, JF-48, JF-1, JF-32, JF-44, JF-45, JF-21, JF-35, JF-26, JF-19, JF-15, JF-12, JF-16, JF-3 and JF-28.

Category quantification plots identified irregular fruit shape, elliptical crown shape, acidic pulp taste and flat shape of spine act as large discriminants along Dimension 1. Similarly, bitter and sweet pulp taste, weak pulp flavour, fruit bearing on primary branches and pyramidal crown shape showed acted as the large discriminants along Dimension 2. However, parameters like very high alternate bearing, fruit bearing on main trunk and primary branches, twisted flake shape, difficult to separate seed coat to kernel and excellent fruit quality exhibited large discrimination along both the dimensions.

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Table – 1: Location details of various Jackfruit germplasm samples chosen for the present study

Sl. No.	Genotypes	Place of collection	Geographical location	
			Latitude (North)	Longitude (East)
1	JF-1	Krishi Vigyan Kendra, Panisagar, Tripura, India	$24^0$15'17.2"	$92^0$9'14.5"
2	JF-2	Prasenjit Das, Roa, Tripura, India	$24^0$15'42.9"	92^0 10'14.6"
3	JF-3	Anup Nath, Laxmipur, Dasda, Tripura, India	23°57' 40.1"	92°12'7.9"
4	JF-4	Md. Khalil Uddin, Pekucherra, Tripura India	24^0 15'19.5"	92^0 10'21.1"
5	JF-5	Himadri Sekhar Das, Bilthoi, Tripura, India	24^0 16'43.5"	92^0 8'59.1"
6	JF-6	Lalnunpuia, Purba Hmunpui, Jampui, Tripura, India	24^0 3'8.2"	92^0 16'36.8"
7	JF-7	Lalhriatpuia, Vanghmun, Jampui, Tripura, India	$24^0$0'15.9"	$92^0$16' 43.1"
8	JF-8	Narayan Bhowmik, Pratyekroy, Tripura, India	$24^0$24'41.8"	$92^0$11'58.4"
9	JF-9	Bikash Chandra Reang, Satnala, Kanchanpur, Tripura, India	$23^0$59'38.1"	$92^0$12'48.1"
10	JF-10	Aisharai Reang, Laljuri, Tripura, India	$24^0$9'5.0"	$92^0$12'39.8"
11	JF-11	Biswadeep Chakraborty Kameswar, Tripura, India	$24^0$22'54.2"	$92^0$11'18.5"
12	JF-12	Sujit Pal, Baruakandi, Ragna, Tripura, India	$24^0$24'25.1"	$92^0$8'44.8"
13	JF-13	Jamal Hachaini, Rajnagar, Tripura, India	$24^0$19'31.9"	$92^0$7'56.2"
14	JF-14	Barun Rupini, Rahumchhara, Tripura, India	$24^0$14'39.7"	$92^0$15'56.1"
15	JF-15	Subhash Bhowmik, Damcherra, Tripura, India	$24^0$14'38.7"	$92^0$16'40.6"
16	JF-16	Superintendent of Agriculture Office, Kadamtala, Tripura, India	$24^0$27'9.5"	$92^0$13'7.5"
17	JF-17	Utpal Nath, Mantala, Dharmanagar Jail Road, Tripura, India	$24^0$22'9.2"	$92^0$8'46.5"
18	JF-18	Sarat Kumar Halam, Purba Halam Para, Ujan Machmara, Tripura, India	$24^0$8'2.7"	$92^0$13'12.6"
19	JF-19	Bikash Debnath, Purba Tilthoi, Tripura, India	$24^0$18'6.7"	$92^0$8'48.1"
20	JF-20	Buddhimantra Singha Sanicherra, Tripura, India	$24^0$22'44.7"	$92^0$14'6.4"
21	JF-21	Dhirendra Das, Algapur, Dharmanagar, Tripura, India	$24^0$22'49.9"	$92^0$8'31.0"
22	JF-22	Kutub Ali, Bishnupur, Tripura, India	$24^0$26'1.0"	$92^0$11'8.3"

23	JF-23	Taj Uddin, Jubarajnagar, Tripura, India	24^{0}19'20.8"	92^{0}8'28.4"
24	JF-24	Surendra Nath, Noagaon, Purba Tilthoi, Tripura, India	24^{0}18'22.4"	92^{0}8'36.0"
25	JF-25	Lamlingul Halam, Paschim Tilthoi, Tripura, India	24^{0}16'35.5"	92^{0}6'13.3"
26	JF-26	Pritesh Malakar, Maheshpur, Tripura, India	24^{0}27'1.1"	92^{0}1'10.9"
27	JF-27	Abdul Hannan, Jubarajnagar, Tripura, India	24^{0}19'6.9"	92^{0}8'21.8"
28	JF-28	Vanchungngir Halam, Laxminagar, Tripura, India	24^{0}24'26.3"	92^{0}14'19.2"
29	JF-29	Nantu Ghosh, Hurua, Tripura, India	24^{0}22'25.4"	92^{0}12'40.7"
30	JF-30	Arjun Nath, Uttar Padmabil, Tripura, India	24^{0}17'56.6"	92^{0}10'57.5"
31	JF-31	Darsunliyn Halam, Vati Sailen Bari, Bilthoi, Tripura, India	24^{0} 15'23.4"	92^{0}7'23.6"
32	JF-32	Goutam Datta, Chandrapur, Dharmanagar, Tripura, India	24^{0} 23'49.2"	92^{0} 9'27.6"
33	JF-33	Ayub Ali, Purba Halflong, Tripura, India	24^{0}19'26.1"	92^{0}8'7.7"
34	JF-34	Anjana Rani Reang, Ahalyapur, Kanchanpur, Tripura, India	24^{0} 3'9.7"	92^{0} 12'24.1"
35	JF-35	Khetrajoy Reang, Piplacherra, Damcherra, Tripura, India	24^{0}14'17.5"	92^{0}17'34.1"
36	JF-36	Pintu Nath, Pratyekroy, Tripura, India	24^{0}24'36.8"	92^{0}12'57.6"
37	JF-37	Basudeb Ghosh, Ganganagar, Tripura, India	24^{0}22'24.6"	92^{0}12'39.9"
38	JF-38	Sulaka Nath, laljuri Paper Area, Tripura, India	24^{0}7'7.6"	92^{0}12'12.6"
39	JF-39	Dahanjoy Reang, Hemsukla Para, Ujanc Machmara, Tripura, India	24^{0}6'45.8"	92^{0}13'48.6"
40	JF-40	Rahul Nath, Dakshin Padmabil, Tripura, India	24^{0}17'22.3"	92^{0}11'5.6"
41	JF-41	Ranamoy Das, Helenpur, Dasda, Laxmipur, Tripura, India	23^{0}56'13.3"	92^{0}13'16.3"
42	JF-42	Amir Uddin, Challish Drone, Kadamtala, Tripura, India	24^{0}27'54.8"	92^{0}12'50.5"
43	JF-43	Madhu Debnath, Deocherra, Ramnagar, Tripura, India	24^{0}18'13.7"	92^{0}9'36.8"
44	JF-44	Prasenjit Malakar, Churaibari, Kadamtala Road, Tripura, India	24^{0}26'14.0"	92^{0}14'43.0"
45	JF-45	Toniwa Goswami,East Chandrapur, Dharmanagar, Tripura, India	24^{0}23'35.6"	92^{0}09'57.0"
46	JF-46	Subir Malakar,Padmapur, Dharmanagar, Tripura, India	24^{0}21' 28.0”	92^{0}9' 39.1”
47	JF-47	Dipti Debbarma,Uptakhali,Tripura, India	24^{0}19' 37.1”	92^{0}12' 3.9”
48	JF-48	Tingpaikhup Halam,madhuban word 3,Paschim Tilthoi,Tripura, India	24^{0}16' 28.3”	92^{0}6' 24.5”
49	JF-49	Bappu Chakroborty, Damcherra, Tripura, India	24^{0}14' 18.9”	92^{0}17' 14.7”
50	JF-50	Nishikanta Nath, Mathabpur, Jalebasha, Tripura, India	24^{0}15' 39.7”	92^{0}11' 40.7”

Table – 2: Cronbach's Alpha, Eigen value and Inertia of first two dimensions of multiple correspondence analysis (MCA)

Dimension	Cronbach's Alpha	Variance accounted for		
		Total (Eagen value)	Inertia	% of Variance
1	0.846	5.288	0.220	19.326
2	0.786	4.060	0.169	5.674
Total	-	9.348	0.389	-
Mean	0.820[a]	4.673	0.195	12.500
a- Mean Cronbach's Alpha is based on the mean Eagen vaqlue				

Table – 3: Multiple correspondence analysis (MCA) for first two dimensions of jackfruit (*Artocarpus heterophyllus* Lam.) germplasm based on qualitative traits

Traits	D1	D2	Traits	D1	D2
Tree growth habit	0.167	0.150	Fruit clustering habit	0.037	0.087
Crown shape	0.566	0.307	Fruit shape	0.152	0.222
Branching pattern	0.125	0.150	Shape of spine	0.125	0.126
Apical dominance	0.203	0.015	Latex exudation	0.089	0.012
Leaf blade shape	0.101	0.165	Fruit quality	0.338	0.065
Leaf colour	0.114	0.058	Fruit attractiveness	0.393	0.054
Female flower aroma	0.097	0.054	Flake shape	0.190	0.162
Inflorescence colour	0.037	0.063	Pulp taste	0.619	0.414
Alternate bearing	0.077	0.188	Pulp flavour	0.373	0.388
Fruiting season	0.159	0.250	Pulp (flake flesh) colour	0.053	0.420
Fruit bearing habit	0.073	0.155	Seed shape	0.257	0.066
Fruit bearing position	0.470	0.213	Adherence of seed coat to kernel	0.475	0.274

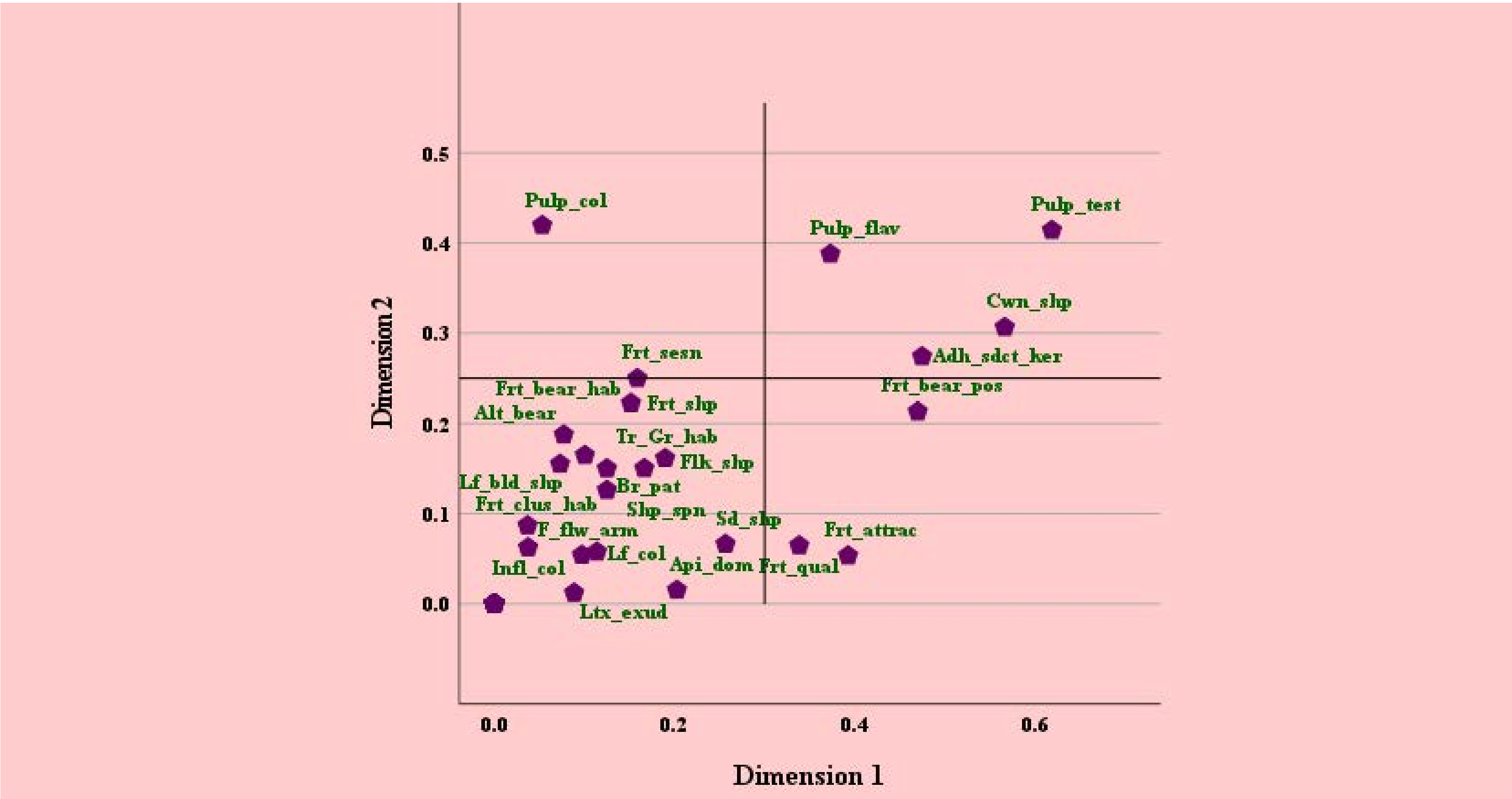

Fig. – 1: Discrimination measures plot of qualitative traits of various jackfruit (*Artocarpus heterophyllus* Lam.) genotypes

N.B. -

Abbreviation	Full form	Abbreviation	Full form	Abbreviation	Full form	Abbreviation	Full form
Pulp_col	Pulp colour	**Flk_shp**	Flake shape	**F_fiw_arm**	Female flower aroma	**Frt_attrac**	Fruit attractiveness
Frt_sesn	Fruiting season	**Lf_bld_shp**	Leaf blade shape	**Lf_col**	Leaf colour	**Frt_bear_pos**	Fruit bearing position
Frt_bear_hab	Fruit bearing habit	**Br_pat**	Branching pattern	**Infl_col**	Inflorescence colour	**Adh_sdct_ker**	Adherence of seed coat to kernel
Frt_shp	Fruit shape	**Frt_clus_hab**	Fruit clustering habit	**Api_dom**	Apical dominance	**Cwn_shp**	Crown shape
Alt_bear	Alternate bearing	**Shp_spn**	Shape of spine	**Ltx_exud**	Latex exudation	**Pulp_flav**	Pulp flavour
Tr_Gr_hab	Tree growth habit	**Sd_shp**	Seed shape	**Frt_qual**	Fruit quality	**Pulp_test**	Pulp taste

Table – 4: Object scores of jack fruit (*Artocarpus heterophyllus* Lam.) germplasm based on multiple correspondence analysis of qualitative traits

Sl. No.	Accession codes of Genotypes	Dimension		Sl. No.	Accession codes of Genotypes	Dimension	
		1	2			1	2
1	JF-1	0.175	0.164	26	JF-26	0.126	0.005
2	JF-2	0.029	0.098	27	JF-27	0.000	0.043
3	JF-3	0.035	0.151	28	JF-28	0.360	0.109
4	JF-4	0.003	0.000	29	JF-29	0.005	0.007
5	JF-5	0.044	0.002	30	JF-30	0.008	0.013
6	JF-6	0.003	0.003	31	JF-31	0.004	0.012
7	JF-7	0.018	0.070	32	JF-32	0.175	0.273
8	JF-8	0.045	0.076	33	JF-33	0.032	0.020
9	JF-9	0.033	0.027	34	JF-34	0.000	0.002
10	JF-10	0.033	0.008	35	JF-35	0.161	0.072
11	JF-11	0.053	0.073	36	JF-36	0.099	0.029
12	JF-12	0.101	0.011	37	JF-37	0.010	0.041
13	JF-13	0.063	0.022	38	JF-38	0.001	0.024
14	JF-14	0.020	0.013	39	JF-39	0.001	0.006
15	JF-15	0.108	0.041	40	JF-40	0.015	0.013
16	JF-16	0.037	0.227	41	JF-41	0.000	0.050
17	JF-17	0.001	0.000	42	JF-42	0.045	0.001
18	JF-18	0.029	0.098	43	JF-43	0.001	0.056
19	JF-19	0.122	0.054	44	JF-44	0.175	0.018
20	JF-20	0.068	0.035	45	JF-45	0.173	0.087
21	JF-21	0.166	0.001	46	JF-46	0.024	0.053
22	JF-22	0.013	0.055	47	JF-47	0.003	0.041
23	JF-23	0.016	0.035	48	JF-48	0.264	0.116
24	JF-24	0.308	0.009	49	JF-49	0.001	0.000
25	JF-25	0.047	0.043	50	JF-50	0.054	0.006

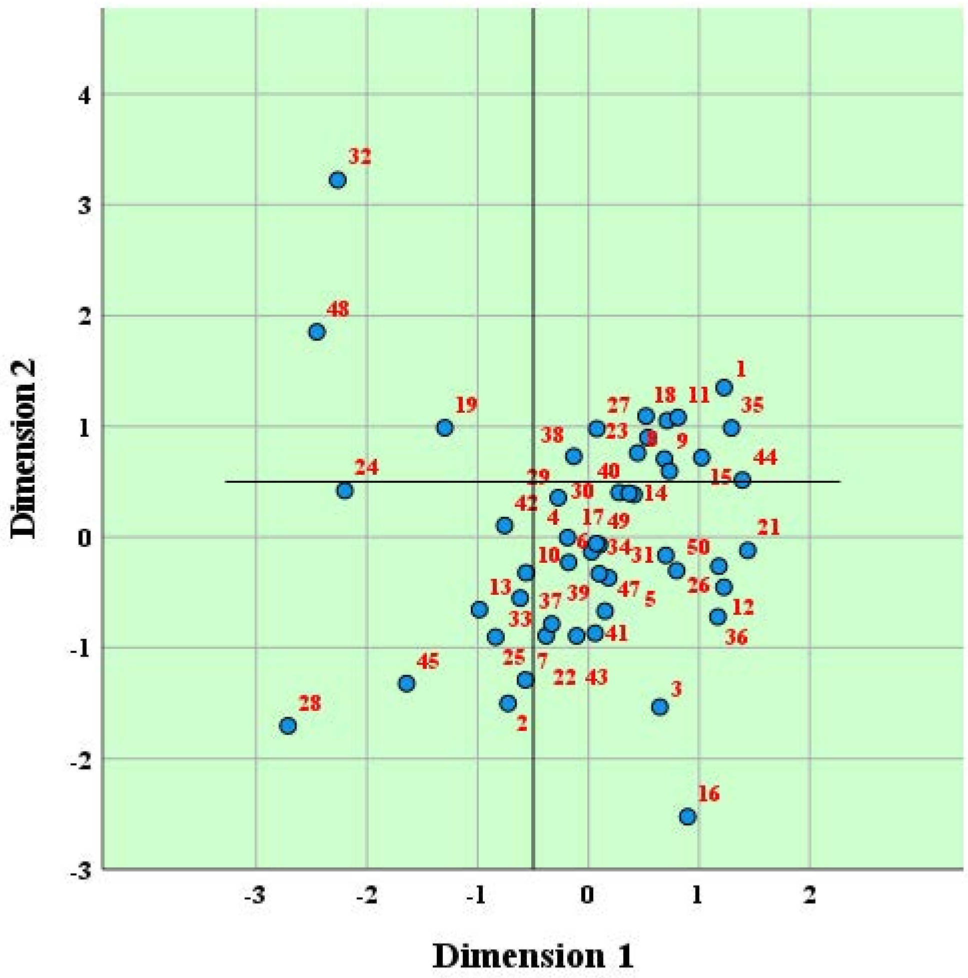

Fig. – 2: Object score plot based on different qualitative traits of various jackfruit (*Artocarpus heterophyllus* Lam.) genotypes

N.B. -

1 =	JF-1	6 =	JF-6	11 =	JF-11	16 =	JF-16	21 =	JF-21	26 =	JF-26	31 =	JF-31	36 =	JF-36	41 =	JF-41	46 =	JF-46
2 =	JF-2	7 =	JF-7	12 =	JF-12	17 =	JF-17	22 =	JF-22	27 =	JF-27	32 =	JF-32	37 =	JF-37	42 =	JF-42	47 =	JF-47
3 =	JF-3	8 =	JF-8	13 =	JF-13	18 =	JF-18	23 =	JF-23	28 =	JF-28	33 =	JF-33	38 =	JF-38	43 =	JF-43	48 =	JF-48
4 =	JF-4	9 =	JF-9	14 =	JF-14	19 =	JF-19	24 =	JF-24	29 =	JF-29	34 =	JF-34	39 =	JF-39	44 =	JF-44	49 =	JF-49
5 =	JF-5	10 =	JF-10	15 =	JF-15	20 =	JF-20	25 =	JF-25	30 =	JF-30	35 =	JF-35	40 =	JF-40	45 =	JF-45	50 =	JF-50

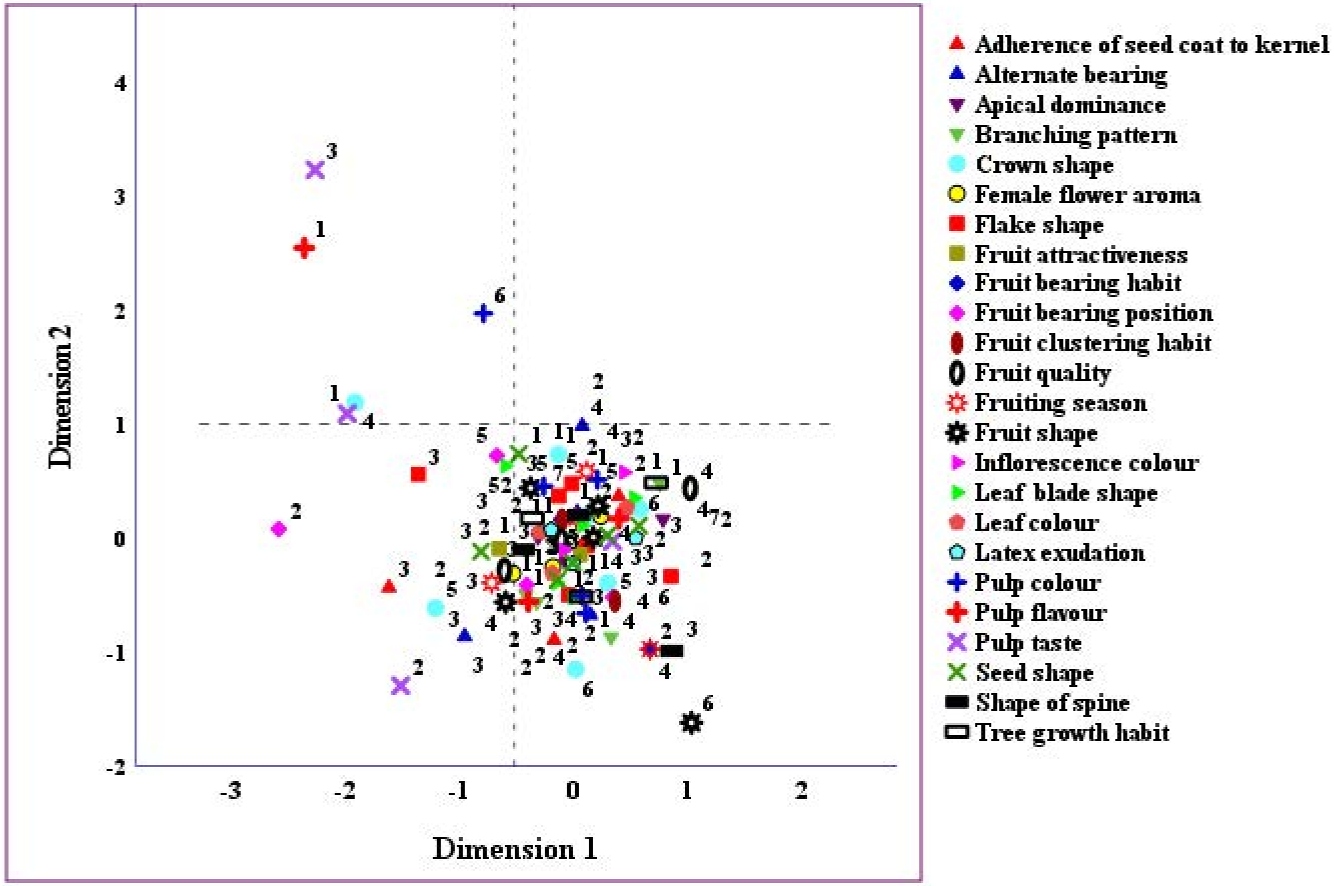

Fig. – 3: Category quantification plot of qualitative traits of various jackfruit (*Artocarpus heterophyllus* Lam.) genotypes