

MORPHOLOGICAL CHARACTERIZATION AND DIVERSITY ANALYSIS OF LOCAL MANGO (*Mangifera indica* L.) GENOTYPES FROM FAR WESTERN HILL OF NEPAL

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ABSTRACT

Mango is an important tropical fruit of Nepal. Nepal is rich in mango diversity and large numbers of local genotypes have been identified in different parts of the country. Such diversity of local mango genotypes are in verge of danger and needs to properly identified, evaluated and conserved. Morphological characterization is an important step in the characterization, evaluation and further utilization of genotypes. The current study aimed to characterize 33 local mango genotypes from Doti district of Far Western Region in Nepal using 14 quantitative morphological traits. The results of the study showed variation in terms tree, leaf, fruit, stone and seed character among the genotypes. The average fruit weight of genotypes was found to be 51.61g with maximum weight of 90.92g in Gude genotype. The four major principal components were formed with Eigen value >1 with cumulative diversity of 88.2%. Results of the cluster analysis grouped 33 mango genotypes into four major clusters with similarity level of 41.27% to 96.29% showing diversity among the genotypes. The variability seen among the genotypes in the present study can be a source of gene pool for systematic mango breeding program and thus these genotypes need to be properly conserved.

Keywords: Cluster Analysis, Local Mango, Principal Component Analysis.

INTRODUCTION

Mango (*Mangifera indica* L.), belonging to the family Anacardiaceae is an important fruit of tropical region and is well-cultivated in subtropical zone too (Yadav and Singh, 2017). Indo-Burma region is considered as origin of cultivated mango

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(Mukherjee, 1951). Mango is a major tropical fruit of Nepal with an area of 46,753 ha and an annual production of 328,271 metric tons and an average productivity of 9 metric tons ha⁻¹ (NCFD, 2018). A large number of local mango genotypes have been identified in Nepal (NARC, 2003; Budathoki et al., 2004; Subedi et al., 2005; Subedi et al., 2008). Far-Western districts such as Doti and Dadeldhura were identified as diversity sites for local mango genotypes (Subedi et al., 2008). The existing local mango genotypes are in verge of danger due to lack of proper conservation strategy, use of mango as firewood and timber purpose hence require proper evaluation and conservation for the use of future breeding programs (Subedi et al., 2008). Still there is no systematic mango breeding activity in Nepal, it is essential to utilize and bring efforts to conserve these genotypes as they can form a potential source of germplasm in mango crop improvement.

Improvement of mango is needed to cope up with pathological problems, improving quality and productivity. To do so, it is necessary to identify and maintain genetic resources. The primary step in identification and evaluation of such genetic resources is morphological characterization. Morphological characterization is regarded as simple tool for assessment of genetic resources (Khan et al., 2015). The requirement of gene pool for mango improvement is a crucial prerequisite as it serves as the source of variation. Thus, the present study was carried out to characterize the local mango genotypes for their identification and correct evaluation. Furthermore, it will aid in maintaining such resources as a source of gene pool for future mango improvement programs in Nepal.

MATERIALS AND METHODS

The present study was carried out during the year 2018-2019 in Far-Western Doti District of Nepal. An explorative survey was carried out to identify the location of mango germplasm and screened 33 local mango genotypes for morphological characterization. Key informants were identified after initial survey and interviewed for genotype name, location and necessary details. The name of the genotypes along with their detailed location is presented in Table 1. The 14 quantitative morphological traits were recorded on the basis of International Plant Genetic Resources Institute (IPGRI) descriptor (IPGRI, 2006). Data were analyzed using descriptive statistics using SPSS 25.0, principal component analysis (PCA) and cluster analysis using MINITAB 19.0. The principal components (PCs) with Eigen value > 1 were selected to explain the variation shown by the components and clustering was based on average Euclidean distance method.

Table 1. Name of mango genotypes, location along with elevation, latitude and longitude

S.N.	Name of mango genotypes	Location	Elevation (masl)	Latitude	Longitude
1.	Masino Surkulle	Ali-Autrali, Shikhar Municipality, Doti	733.61	29.246534°N	80.889742°E
2.	Hade	Ali-Autrali, Shikhar Municipality, Doti	708.87	29.244395°N	80.892604°E
3.	Pothe	Ali-Autrali, Shikhar Municipality, Doti	722.74	29.245254°N	80.891718°E
4.	Balde	Ali-Autrali, Shikhar Municipality, Doti	793.92	29.248111°N	80.890566°E
5.	Hinge	Ali-Autrali, Shikhar Municipality, Doti	710.76	29.244539°N	80.893006°E
6.	Kelkose	Chasi, Adharsha Rural Municipality, Doti	1090.32	29.309843°N	80.939400°E
7.	Kele	Ali-Autrali, Shikhar Municipality, Doti	778.58	29.246835°N	80.890338°E
8.	Sinure	Chasi, Adharsha Rural Municipality, Doti	1095.33	29.310319°N	80.938801°E
9.	Bannari	Chasi, Adharsha Rural Municipality, Doti	1087.59	29.310209°N	80.939523°E
10.	Kakune	Ali-Autrali, Shikhar Municipality, Doti	730.19	29.246863°N	80.888625°E
11.	Mude	Ali-Autrali, Shikhar Municipality, Doti	793.69	29.247458°N	80.889565°E
12.	Moto Surkulle	Ali-Autrali, Shikhar Municipality, Doti	758.72	29.246614°N	80.889763°E
13.	Supare	Ali-Autrali, Shikhar Municipality, Doti	721.83	29.245539°N	80.890425°E
14.	Bhadaure	Ali-Autrali, Shikhar Municipality, Doti	768.01	29.247163°N	80.889738°E
15.	Sanne	Ali-Autrali, Shikhar Municipality, Doti	716.19	29.244679°N	80.892283°E
16.	Kale	Ali-Autrali, Shikhar Municipality, Doti	733.84	29.246617°N	80.889740°E
17.	Dhulle	Ali-Autrali, Shikhar Municipality, Doti	783.32	29.247352°N	80.888789°E
18.	Batuli	Panawata, Dipayal Silgadi Municipality, Doti	1133.48	29.294597°N	80.937011°E
19.	Lode	Khullekh, Dipayal Silgadi Municipality, Doti	1024.34	29.287947°N	80.945512°E
20.	Patale	Khullekh, Dipayal Silgadi Municipality, Doti	1185.98	29.291969°N	80.947646°E
21.	Koke	Panawata, Dipayal Silgadi Municipality, Doti	1146.62	29.294342°N	80.937573°E
22.	Rulle	Ali-Autrali, Shikhar Municipality, Doti	754.79	29.247150°N	80.888853°E
23.	Gode	Chasi, Adharsha Rural Municipality, Doti	1138.99	29.311831°N	80.940405°E
24.	Chuke	Ali-Autrali, Shikhar Municipality, Doti	699.85	29.245138°N	80.894024°E
25.	Ginaune	Ali-Autrali, Shikhar Municipality, Doti	775.68	29.246369°N	80.888642°E
26.	Dhole	Ali-Autrali, Shikhar Municipality, Doti	764.90	29.246814°N	80.889848°E
27.	Rati-Rumal	Ali-Autrali, Shikhar Municipality, Doti	824.99	29.247162°N	80.889249°E
28.	Simte	Ali-Autrali, Shikhar Municipality, Doti	778.82	29.246620°N	80.890933°E
29.	Gude	Khullekh, Dipayal Silgadi Municipality, Doti	1018.24	29.287899°N	80.945761°E
30.	Mailadi	Khullekh, Dipayal Silgadi Municipality, Doti	1084.02	29.291316°N	80.946578°E
31.	Gane	Khullekh, Dipayal Silgadi Municipality, Doti	973.38	29.285717°N	80.946247°E
32.	Ghutke	Chasi, Adharsha Rural Municipality, Doti	1097.00	29.310997°N	80.939817°E
33.	Chamade	Khullekh, Dipayal Silgadi Municipality, Doti	1141.65	29.291368°N	80.948304°E

Note: masl = meters above sea level

RESULTS AND DISCUSSION

Quantitative tree and leaf characteristics

The trunk circumference among 33 mango genotypes varied from 1.2m to 5.6m with mean value of 3.06m and 31.6% coefficient of variation (C.V.) (Table 2). Raza et al. (2017) and Singh (2018) also reported variation in trunk circumference among mango genotypes.

With regard to quantitative leaf characteristics, leaf blade length was reported to have a minimum value of 10.87cm to maximum of 29.26cm with mean value of 18.91cm and 18.3% C.V. (Table 2). Similarly, leaf blade width was reported to have a minimum value of 3.43cm to maximum of 8.59cm with mean value of 5.40cm and 18.9% C.V. Likewise, petiole length ranges from 2.21-5.88cm with mean 3.61cm and 24.2% C.V. (Table 2). There were report of variation in leaf blade length, width and petiole length among mango genotypes (Rymbai et al., 2014; Toili et al., 2016; Raza et al., 2017).

Table 2. Quantitative tree, leaf, fruit characteristics of local mango genotypes

Genotype	Trunk circumference (m)	Leaf blade length (cm)	Leaf blade width (cm)	Petiole length (cm)	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)
Masino	2.44	18.10	5.05	2.98	25.64	4.45	3.09
Surkulle							
Hade	3.55	21.71	5.83	3.93	36.13	4.71	3.27
Pothe	1.90	19.31	5.02	4.22	32.83	4.30	3.42
Balde	3.60	29.26	8.59	5.69	64.33	5.22	5.22
Hinge	2.43	20.17	5.74	4.08	46.46	5.46	3.38
Kelkose	4.00	15.70	4.78	2.59	72.42	6.69	4.42
Kele	2.00	19.96	5.23	2.63	44.05	5.31	3.42
Sinure	3.64	10.87	3.43	2.30	58.64	5.65	4.41
Bannari	3.53	15.81	4.98	2.99	66.50	6.67	4.20
Kakune	5.60	17.86	5.36	3.36	37.45	4.61	3.38
Mude	1.20	19.43	5.98	4.42	62.00	5.52	4.06
Moto	2.94	23.78	7.68	4.93	26.50	4.36	2.93
Surkulle							
Supare	2.30	19.20	4.84	3.14	30.97	4.32	3.17
Bhadaure	2.30	17.87	4.10	3.44	56.90	6.19	3.63
Sanne	4.33	14.40	4.46	2.77	26.55	3.94	3.24
Kale	3.30	22.61	6.65	3.97	34.46	4.71	3.32
Dhulle	2.45	16.85	5.70	4.46	37.83	4.59	3.63
Batuli	2.16	15.33	4.57	2.59	81.67	5.73	4.90

Genotype	Trunk circumference (m)	Leaf blade length (cm)	Leaf blade width (cm)	Petiole length (cm)	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)
Lode	3.07	18.77	5.55	3.22	75.00	5.91	4.62
Patale	1.74	20.19	5.13	3.40	67.90	5.65	4.49
Koke	2.40	18.68	5.16	4.05	54.79	5.87	3.80
Rulle	2.40	15.55	4.35	3.31	32.96	4.07	3.55
Gode	2.74	16.47	4.23	3.93	62.50	5.86	4.38
Chuke	4.54	23.32	5.80	4.28	56.39	5.56	4.17
Ginaune	2.50	24.76	6.30	5.88	41.00	4.77	3.74
Dhole	2.40	21.29	6.68	3.37	51.94	5.03	3.91
Rati-Rumal	2.70	18.15	5.66	2.97	49.97	4.93	3.89
Simte	3.40	17.34	4.96	2.21	30.79	4.30	3.22
Gude	3.62	20.83	6.15	4.00	90.92	6.92	4.79
Mailadi	4.47	15.49	4.34	3.83	85.36	6.60	4.52
Gane	3.28	19.66	5.41	2.99	55.86	5.62	4.11
Ghutke	4.57	19.30	5.68	4.02	46.40	5.48	3.64
Chamade	3.42	16.17	5.02	3.10	60.15	6.64	3.87
Minimum	1.20	10.87	3.43	2.21	25.64	3.94	2.93
Maximum	5.60	29.26	8.59	5.88	90.92	6.92	5.22
Mean	3.06	18.91	5.40	3.61	51.61	5.32	3.87
C.V. (%)	31.6	18.3	18.9	24.2	34.7	15.8	15.1

Quantitative fruit characteristics

The fruit weight was reported to have a minimum value of 25.64g to maximum of 90.92g with mean value of 51.61g and 34.7% C.V (Table 2). Similarly, fruit length ranges from 3.94-6.92cm with mean value of 5.32cm and 15.8% C.V. Likewise, fruit diameter ranges from 2.93-5.22cm with mean 3.87cm and 15.1% C.V. (Table 2). Variation in fruit characteristics may be due to genotype as well as environmental factors. For example, the variation in fruit weight might be due to climatic conditions as well as the genetic attribute of the genotype (HimaBindu et al., 2017). Budathoki et al. (2004) also reported variation in fruit weight among local mango genotypes ranging from 21-2500g. Subedi et al. (2008) reported variation in fruit weight from 69.4g to 217.5g among mango genotypes from different parts of Nepal. Singh (2018) also reported variation in fruit weight among local mango accessions with minimum weight of 38.62g and maximum value of 236.99g. The result of this study was in line with the study of Budathoki et al. (2004), Subedi et al. (2005) and Singh (2018) which showed lower fruit weight of local mango germplasm. Subedi et al. (2008) reported variation in fruit length of mango genotypes from different region of Nepal

ranging from 5.8cm to 10.1cm, a range value higher than reported in the present study. Similarly, Singh (2018) also reported variation in fruit diameter from minimum of 3.81cm to 7.58cm among local mango germplasm which is higher than the range obtained in the present study.

Quantitative stone and seed characteristics

The stone weight was reported to have a minimum value of 5.33g to maximum of 17.95g with mean value of 11.61g and 27% C.V. (Table 3). Similarly, stone length varied from 3.47-5.69cm with mean value of 4.44cm and 14.2% C.V. Likewise, stone thickness ranges from 1.08-2.13cm with mean 1.65cm and 13.1% C.V. Stone diameter ranges between 1.72-2.92cm with mean 2.46cm and 10.1% C.V. (Table 3). The seed weight was reported to have a minimum value of 3.83g to maximum of 12.90g with mean value of 8.34g and 26.9% C.V. Similarly, seed length varied from 3.06-4.77cm with mean value of 3.85cm and 13.4% C.V. Likewise, seed thickness ranges from 1.08-1.87cm with mean 1.44cm and 11.1% C.V. (Table 3). The variation in stone and seed characters might be due to observed variation in fruit characters. Variation in stone weight, length, thickness, diameter and seed weight, length, seed thickness among mango genotypes were also reported by Subedi et al. (2005) and Singh (2018).

Table 3. Quantitative stone and seed characteristics of local mango genotypes

Genotype	Stone weight (g)	Stone length (cm)	Stone thickness (cm)	Stone diameter (cm)	Seed weight (g)	Seed length (cm)	Seed thickness (cm)
Masino Surkulle	5.33	3.53	1.26	1.72	3.83	3.10	1.08
Hade	9.59	4.11	1.60	2.27	6.64	3.54	1.36
Pothe	11.00	3.91	1.57	2.40	7.67	3.74	1.47
Balde	13.67	4.38	1.69	2.77	7.25	3.64	1.37
Hinge	10.09	4.39	1.53	2.41	7.80	3.91	1.43
Kelkose	11.00	5.36	1.55	2.48	8.50	4.61	1.40
Kele	6.75	4.51	1.27	2.15	5.06	3.72	1.13
Sinure	12.5	4.70	1.68	2.60	7.86	3.86	1.32
Bannari	15.75	5.31	1.08	2.63	9.25	4.60	1.37
Kakune	10.00	3.98	1.62	2.35	7.61	3.52	1.48
Mude	13.85	4.57	1.83	2.61	9.70	4.06	1.58
Moto Surkulle	8.56	3.78	1.59	2.18	6.65	3.29	1.40
Supare	8.10	3.62	1.57	2.27	6.21	3.21	1.43
Bhadaure	14.00	5.37	1.62	2.56	10.35	4.68	1.44
Sanne	8.13	3.59	1.55	2.16	5.75	3.19	1.37

Genotype	Stone weight (g)	Stone length (cm)	Stone thickness (cm)	Stone diameter (cm)	Seed weight (g)	Seed length (cm)	Seed thickness (cm)
Kale	10.14	4.13	1.50	2.39	7.91	3.64	1.36
Dhulle	8.42	3.93	1.48	2.40	5.75	3.30	1.32
Batuli	14.6	4.61	1.85	2.92	10.88	3.89	1.57
Lode	17.95	4.57	2.13	2.88	12.90	4.06	1.87
Patale	15.65	4.44	1.94	2.80	10.45	3.84	1.65
Koke	12.22	4.83	1.71	2.26	9.17	4.20	1.45
Rulle	8.57	3.47	1.73	2.48	6.67	3.06	1.47
Gode	14.5	4.65	1.76	2.76	10.50	3.89	1.37
Chuke	16.00	4.83	2.06	2.75	12.00	4.29	1.72
Ginaune	7.50	3.75	1.41	2.25	5.11	3.18	1.18
Dhole	11.56	4.01	1.76	2.51	9.22	3.56	1.52
Rati-Rumal	11.75	4.37	1.66	2.54	8.95	3.85	1.42
Simte	8.29	3.68	1.55	2.21	5.64	3.19	1.36
Gude	11.00	5.61	1.65	2.53	8.38	4.58	1.37
Mailadi	15.63	5.40	1.85	2.49	11.81	4.75	1.60
Gane	13.72	4.86	1.88	2.62	10.78	4.22	1.64
Ghutke	12.25	4.51	1.75	2.40	8.10	4.02	1.46
Chamade	15.00	5.69	1.73	2.32	10.90	4.77	1.59
Minimum	5.33	3.47	1.08	1.72	3.83	3.06	1.08
Maximum	17.95	5.69	2.13	2.92	12.90	4.77	1.87
Mean	11.61	4.44	1.65	2.46	8.34	3.85	1.44
C.V. (%)	27.0	14.2	13.1	10.1	26.9	13.4	11.1

Principal component analysis

The PCA results with Eigen value and Eigen vectors are shown in Table 4. The results showed that the first four principal components explained a cumulative variability of 88.2% observed in 33 local mango genotypes using 14 quantitative traits. PC1 explained 50%, PC2 explained 18.9%, PC3 explained 12% and PC4 explained only 7.4% of the total variation (Table 4).

Table 4. Eigen value and Eigen vectors of first four components using 14 quantitative morphological traits

	PC1	PC2	PC3	PC4
Eigen value	6.9982	2.6406	1.6737	1.0343
Proportion (%)	50%	18.9%	12%	7.4%
Cumulative (%)	50%	68.8%	80.8%	88.2%
Variable	Eigen Vectors			
Trunk circumference (m)	0.058	-0.061	0.096	-0.915
Leaf blade length(cm)	-0.063	0.560	0.167	-0.037
Leaf blade width(cm)	-0.066	0.543	0.185	-0.109
Petiole length (cm)	-0.038	0.512	0.191	0.012
Fruit weight (g)	0.344	0.003	0.184	0.154
Fruit length (cm)	0.320	-0.103	0.366	0.042
Fruit diameter (cm)	0.307	0.110	0.095	0.186
Stone weight (g)	0.353	0.073	-0.112	-0.010
Stone length (cm)	0.315	-0.116	0.363	-0.051
Stone thickness (cm)	0.239	0.184	-0.468	-0.113
Stone diameter (cm)	0.304	0.152	-0.200	0.190
Seed weight (g)	0.352	0.040	-0.180	-0.045
Seed length (cm)	0.319	-0.108	0.297	-0.094
Seed thickness (cm)	0.271	0.123	-0.437	-0.166

Majumder et al. (2013) showed the genetic diversity of 60 mango genotypes using PCA and cluster analysis and grouped into eight clusters and diversity was found to be based on morphological traits and not based on location distribution of the genotypes. The study showed considerable variation among the genotypes in terms of tree, leaf, fruit, stone and seed characteristics.

Cluster analysis

The results of cluster analysis based on 14 quantitative traits of 33 local mango genotypes were grouped into four main clusters (I, II, III, and IV). Similarity level ranging from 41.27% to 96.29% was observed among the four clusters showing diversity among the genotypes. The maximum numbers of genotypes were clustered under cluster III and only one genotype Balde falls under cluster II (Fig. 1). Clusters centroids are presented in Table 5. Dinesh et al. (2015) also reported variation among 44 indigenous mango genotypes using cluster analysis and grouped the genotypes into two main clusters and the grouping was based on location-wise.

Table 5. Centroid of clusters showing characteristics of the cluster

Variable	Cluster I	Cluster II	Cluster III	Cluster IV	Grand centroid
Trunk circumference (m)	3.0085	3.6	2.9975	3.4167	3.0582
Leaf blade length (cm)	19.3408	29.26	18.2406	17.2167	18.9148
Leaf blade width (cm)	5.4946	8.59	5.2081	5.02	5.4064
Petiole length (cm)	3.6762	5.69	3.4469	3.4733	3.6076
Fruit weight (g)	33.6277	64.33	58.9887	85.9833	51.6139
Fruit length (cm)	4.4954	5.22	5.7956	6.4167	5.3224
Fruit diameter (cm)	3.3369	5.22	4.0613	4.7367	3.8724
Stone weight (g)	8.4908	13.67	13.6119	13.7433	11.6082
Stone length (cm)	3.8454	4.38	4.7787	5.2067	4.4379
Stone thickness (cm)	1.5154	1.69	1.7294	1.7833	1.6488
Stone diameter (cm)	2.2485	2.77	2.5706	2.6467	2.4567
Seed weight (g)	6.1923	7.25	9.7769	10.3567	8.3409
Seed length (cm)	3.36	3.64	4.1512	4.4067	3.8473
Seed thickness (cm)	1.3392	1.37	1.5144	1.5133	1.4409

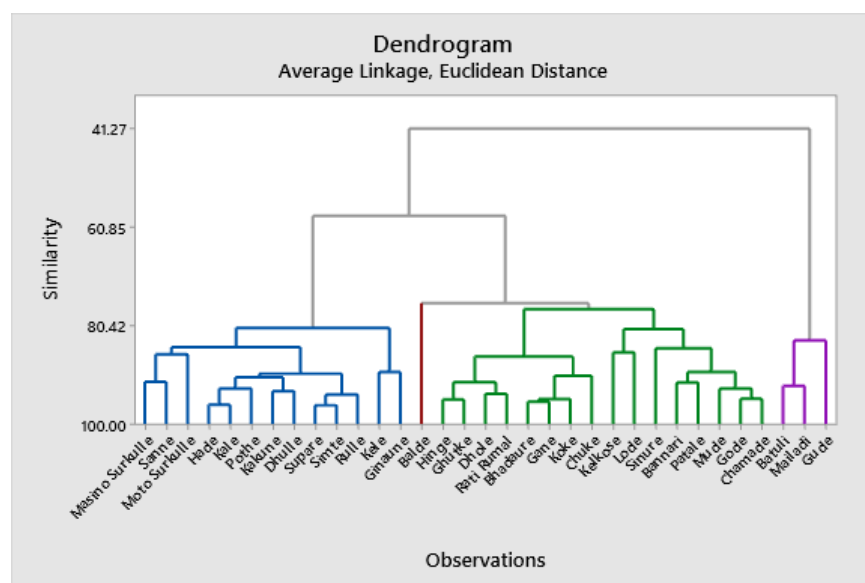


Figure 1. Cluster analysis of 33 local mango genotypes using average Euclidean distance method based on 14 quantitative traits (Blue-I, Brown-II, Green-III, Purple-IV)

CONCLUSION

The present study showed a considerable variation among local mango genotypes of Far Western Doti district of Nepal using morphological parameters. This study is able to establish the fact that Doti district is rich in local mango diversity. This provides possibilities for collection and selection of germplasm for starting systematic mango breeding program in Nepal. The variability seen among the genotypes in the present study can be a source of gene pool and thus these genotypes need to be properly conserved.

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