Diversity of Potato Varieties in Bangladesh

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ABSTRACT

A study based on completely randomized design with three replications was carried out at Tuber Crops Research Centre (TCRC), Bangladesh Agricultural Research Institute (BARI), Gazipur with a view to evaluating and classifying agro-morphological traits in 12 potato varieties to enumerating the genetic diversity. Discriminant function analysis (DFA) was done to determine the set of discriminatory functions contributed to separating 12 potato varieties into four distinct clusters. Discriminant function analysis showed that, function 1 explained 78.21% and function 2 explained 21.79% of total variance. The first function was more related to leaf area (having coefficient value of 0.661) and second function was more related to minituber per plant and plant height (having coefficient value of 0.644 and 0.523, respectively). Among 4 clusters, cluster II showed the highest distance (29.79) with cluster III followed by the distance between clusters III and IV (24.70) so the varieties in these clusters were genetically diverse. Based on mean value of the six quantitative characters for each of the four clusters and the inter cluster distance the cluster III and IV might be selected for future breeding program as a better parent to get positive heterosis. Cluster III contained six varieties BARI Alu 29, BARI Alu 35, BARI Alu 36, BARI Alu 37, BARI Alu 7 (Diamant), BARI Alu 8 (Cardinal) and which were characterized by lowest plant height and average values for other characters. Cluster IV contained three potato varieties BARI Alu 41, BARI Alu 46 and BARI Alu 53 which was characterized by highest plant height and second highest leaf area.

Keywords: Potato, Agro-morphological traits, Discriminant Function Analysis, Cluster Analysis and yield.

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I. INTRODUCTION

Potato (*Solanum tuberosum* L.) is an autotetraploid ($2n = 4x = 48$), vegetatively propagated, short-day and a C_3 plant grown in temperate, subtropical and tropical regions [1]. It is one of the most important vegetable crops, which ranked fourth after rice, wheat and maize in the world [2]. After rice potato is the second most important crop in Bangladesh [3]. It is consumed as vegetable in Bangladesh contributing alone as much as 54% of the total annual vegetable production of this country. The total potato production in Bangladesh is 109.494 lakh metric tons, total area is 4,69,245 hectare and yield is about 23.3 metric tons per hectare and ranking first among the vegetables in terms of area and production in Bangladesh [4]. In our country about 91 potato varieties are available. The most popular potato varieties are: Diamant, Cardinal, Asterix, Courage, Granola and Lady Rosetta [5].

Maintaining the potato varieties with agronomically important traits, higher yield and good keeping quality is one of the challenges for potato breeders because potato has a tendency to reduce its yield by virus infestation [6]. Minitubers are small seed potato tubers produced after acclimatization from plants propagated *in vitro* and planted at high density in the glasshouse or net house in seed bed or containers using different substrate mixtures. Minitubers are virus free and principally used for the production of pre-basic or basic seed by direct field planting [7]. Minitubers are generally smaller in size (5-25 mm) than the traditional seed tubers but larger than micro-tuber produced under aseptic conditions on artificial media [8].

Potato tubers naturally tend to accumulate and transmit viral, bacterial, and fungal diseases to the next generations, and which reduces the yield potentially of potato varieties after few years of cultivation. Hence for sustaining the yield

potentially, genetic diversity helps identify appropriate parents. Genetic diversity in a population is a prerequisite for an effective plant-breeding program. Genetic divergence is a useful tool for an efficient choice of parents for hybridization to develop high yield potential cultivars. Evaluation of genetic divergence is important to know the source of genes for a particular trait within the available germplasm [9].

Multivariate analysis by means of Mahalanobis D^2 statistics is a useful tool in quantifying the degree of genotypic divergence among biological populations and to assess the relative contribution of different components to the total divergence both at inter and intra-cluster levels [10]-[14]. Many researchers have adopted this D^2 technique for measuring divergence among the genotypes [15]-[17]. The D^2 statistics can help in selecting desirable parents for achieving desired goal by the breeder. The purpose of this study was identifying the effective traits on yield of potato minituber and classifying the varieties for future potato improvement program.

II. MATERIALS AND METHODOLOGY

A. Experimental Site

The experiment was conducted at the Tuber Crops Research Centre (TCRC), Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh during 2013-14. The soil of the experimental field was having silty clay soil of Madhupur Tract in Agro-ecological Zone 28 (AEZ 28). The soil contains 1.28% organic matter and p^H 6.00. The total N, available P, S, B, Zn and exchangeable Ca, Mg and K were 0.07%, 28 ppm, 10 ppm, 0.20 ppm, 0.70 ppm and 6.00 meq/100 g soil, 2.00 meq/100 g soil and 0.11 meq/100 g soil, respectively. The experimental zone was situated in a sub-tropical climate zone and Table I represented the meteorological conditions of the experimental site during the study period and it was noted from the meteorological station of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

TABLE I: METEOROLOGICAL CONDITIONS OF THE EXPERIMENTAL SITE DURING OCTOBER 2013 TO APRIL 2014

Month	Air Temperature ($^{\circ}C$)		Humidity (%)		Rainfall (mm)
	Max. (Average)	Min. (Average)	Max. (Average)	Min. (Average)	
October	31.5	23.23	88.74	76.29	179.00
November	29.87	16.38	88.30	68.73	0.00
December	24.28	13.73	88.83	69.96	3.00
January	24.29	12.06	87.35	64.51	0.00
February	26.96	13.65	84.57	53.64	38.00
March	31.97	18.83	81.64	42.03	4.00
April	36.25	22.79	89.16	47.56	43.00

Source: Meteorological Station, BARI, Joydebpur, Gazipur, Bangladesh.

B. Plant Materials, Experimental Design and Layout

The *In vitro* plantlet cuttings of 12 potato varieties named BARI Alu 25, BARI Alu 28, BARI Alu 29, BARI Alu 35, BARI Alu 36, BARI Alu 37, BARI Alu 40, BARI Alu 41, BARI Alu 46, BARI Alu 53, BARI Alu 7 (Diamant) and BARI Alu 8 (Cardinal) were used in the experiment as treatment (Table I). The experiment was laid out in Completely Randomized Design (CRD) with three replications. The entire experimental field was divided into 36 unit plots for 12 treatments and one plot received 100 individuals of each variety. The *in vitro* plantlets were

developed by following a plantlet development protocol [18]. The *in vitro* plantlets were collected from the Tissue Culture Laboratory, Tuber Crops Research Center, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Then for hardening, the plantlets were transferred to hardening containers and kept in the shady condition in net house for 2 weeks. Transferred plantlets were irrigated with small hand sprayer for initial one week and there after irrigated judiciously with the help of watering can taking care to avoid over or under irrigation. Urea solution @ 0.5 % was applied to the plantlets with watering can. The plantlets were placed on 1st November 2013 for production of minituber.

TABLE II: VARIETIES EMPLOYED AND THEIR CHARACTERISTICS

Varieties	Common Name	Origin	Year of Release	Yield (t/ha)	Special Characters
BARI Alu 25	Asterix	Netherland	2005	25-30	Suitable for processing
BARI Alu 28	Lady Rosetta	Netherland	2008	25-30	Suitable for processing
BARI Alu 29	Courage	Netherland	2008	20-26	Suitable for processing
BARI Alu 35	-	Bangladesh	2012	30-45	Suitable for processing and consumption
BARI Alu 36	-	Bangladesh	2012	30-40	Suitable for processing and consumption
BARI Alu 37	-	Bangladesh	2012	30-40	Suitable for processing and consumption
BARI Alu 40	-	Bangladesh	2012	35-55	Suitable for processing and consumption
BARI Alu 41	-	Bangladesh	2012	38-44	Suitable for processing and consumption
BARI Alu 46	-	Peru	2013	35-40	Resistant to Late Blight disease
BARI Alu 53	-	Chile	2014	35-40	Resistant to Late Blight disease
BARI Alu 7 (Diamant)	Diamant	Netherland	1993	25-35	Resistant to Blight and Viral diseases
BARI Alu 8 (Cardinal)	Cardinal	Netherland	1993	25-35	Resistant to Blight and Viral diseases

Source: [19].

C. Land Preparation and Fertilization

The treatments were assigned randomly to unit plots of the field. The size of unit plot was 1×1 m. The field was prepared by mechanical ploughing followed by laddering and

levelling. Full doses of cow dung (10 t ha⁻¹), TSP (220 kg ha⁻¹), MP (270 kg ha⁻¹), Gypsum (120 kg ha⁻¹), Boric acid (6 kg ha⁻¹) and half doses of Urea (175 kg ha⁻¹) were applied at the final land preparation. The rest half doses of

Urea (175 kg ha⁻¹) were applied at top dressings as 30 DAP followed by earthing up and light irrigation [18]. The plantlets were transferred from the hardening container to the bed. After establishment of the plantlets, ridges were made up by earthing up of side soils. The spacing was 10×10 cm. Intercultural operations were following [20]. The minitubers were harvested at proper maturity after around 90 days of planting.

D. Data Collection

Data on different growth and yield contributing characters were recorded on the following parameters from the sample plants of each plot during the course of experiment. The plants in the outer row were excluded during random selection. Ten plants were randomly selected from each plot to record data on mortality (%), plant height (cm), leaf area (cm²), minitubers per plant, weight of minitubers per plant (g), minituber yield per m², grade of minitubers (by % No.) and minituber grade by weight (%).

E. Statistical Analysis

Descriptive analysis including range, mean and Coefficient of variation was employed to estimate and describe the performance of the genotypes in terms of each character. Non-hierarchical K-mean cluster and Discriminant Function Analysis (DFA) was performed to classify the genotypes into a number of groups. The cluster analysis indicates the grouping of a large number of genotypes into several clusters having similar characteristics on the basis of variables considered in the analysis. Discriminant Function Analysis (DFA) was employed for conformity of the results on grouping the genotypes. DFA has indicated whether a particular set of variables is useful in separating in previously delineated groups. In addition, the precession level of

clustering can also be assessed through DFA. The discriminatory functions play the vital role in identifying the set of variables contributed more to clustering a large number of genotypes into homogeneous groups. Through stepwise procedures of DFA, chi-square test, structure matrix of variables, test of equality of group means were done.

III. DISCUSSION

A. Clustering of Potato Varieties through Multivariate Analysis

To make statistically homogenous groups K-mean non-hierarchical cluster analysis was done using six quantitative plant traits for clustering 12 potato varieties. For this two dendrograms were prepared on the basis of hierarchical clustering procedure (Fig. 1) and cluster analysis (Fig. 2). Thus, obtained tree-plot was cut at the rescaled distance of 5 that produced four distinct clusters of genotypes showing much related plant characters of interest and served our purpose better. A list of four clusters of 12 potato varieties with accession is given in Table III.

The grouping of different potato varieties according to clusters for the quantitative traits is presented in Table II. Cluster I comprised of one variety i.e., BARI Alu 40, which represented 8.3% of the total plant materials. The cluster II contained two varieties (viz. BARI Alu 25 and BARI Alu 28) and accounts for 18.7% of the population. Cluster III includes six varieties viz. BARI Alu 29, BARI Alu 35, BARI Alu 36, BARI Alu 37, BARI Alu 7 (Diamant), BARI Alu 8 (Cardinal) and represents 50.0% of the total varieties. The cluster IV comprised of three potato varieties i.e., BARI Alu 41, BARI Alu 46, BARI Alu 53 and contributed 25.0% of the total.

Fig. 1. Dendrogram of six potato varieties derived from average linkage cluster analysis.

TABLE III: GROUPING OF POTATO VARIETIES BASED ON FOUR CLUSTERS FOR SIX TRAITS

Cluster	Frequency (f)	Percentage (%)	Cluster membership
I	1	8.3	BARI Alu 40
II	2	18.7	BARI Alu 25, BARI Alu 28
III	6	50.0	BARI Alu 29, BARI Alu 35, BARI Alu 36, BARI Alu 37, BARI Alu 7 (Diamant), BARI Alu 8 (Cardinal)
IV	3	25.0	BARI Alu 41, BARI Alu 46, BARI Alu 53

The distribution pattern of the potato variety under different clusters indicated that the maximum number of varieties (6) was concentrated in cluster III followed by cluster IV (3) and cluster II (2), while cluster I comprised of

only one (1) potato varieties. The total number of genotypes for each cluster and mean of each cluster for the six plant characters are presented in Table IV.

The variety in cluster I is characterized by the highest number of minituber/plant (35.00), weight of minituber/plant (244.12 g) and tuber yield (12.12 kg/m²) but has the smallest leaf area (851.67 cm²), while the Cluster II was characterized by the highest mortality rate (27.00) and leaf area (1225.67 cm²). In contrast, they were characterized by the lowest number of minituber/plant (6.10), lowest weight of minituber/plant (48.58g) and tuber yield (2.43 kg/m²). The Cluster III presented average values for the analyzed parameters, except plant height (cm), which was the lowest value 64.43 cm compared to other clusters. Cluster IV was characterized by the highest plant height (77.93 cm) and second highest leaf area (1139.67 cm²). They were also having the lowest mortality rate. However, the overall yield performance was medium giving 5.57 kg m⁻² tuber production. Grouping of large number of genetic resources based on plant traits using multivariate techniques are widely used to identify resources with desirable traits [21]-[23]. It is important to select the lines that are superior in terms of

genetic diversity and agronomical properties during the improvement studies [24]-[26].

B. Discriminant Function Analysis

The contribution of each of two canonical discriminant functions for explaining the variance along with their Eigen values (Latent root) and correlation coefficient of the variables with eigenvectors have been summarized in Table V. Eigenvalues indicates that first two discriminant functions explained 100 percent of total variance. The plants trait leaf area was loaded on function 1 and its contribution was greater (having coefficient value of 0.661) in explaining 78.21% of total variance in plant traits of 12 potato varieties. The coefficients of minituber per plant (0.644) and plant height (0.523) were higher in function 2 indicating that the contribution of these variables to function 2 was higher in explaining 21.79% of total variance. DFA is particularly useful in defining groups of the varieties as prior classification criteria. Moreover, it provides a graphical output illustrating the existence of groups [27].

TABLE IV. MEAN VALUES OF SIX QUANTITATIVE PLANT CHARACTERS FOR EACH OF THE FOUR CLUSTERS IDENTIFIED IN 12 POTATO VARIETIES. THE NUMBER OF VARIETY(S) INCLUDED IN EACH CLUSTER IS GIVEN IN BRACKETS

Variables	Cluster I (n=1)	Cluster II (n=2)	Cluster III (n=6)	Cluster IV (n=3)
Mortality (%)	16.29	27.00	23.82	11.78
Plant height (cm)	67.27	70.27	64.43	77.93
Leaf area (cm ²)	851.67	1225.67	931.3	1139.67
Minituber/plant (no.)	35.00	6.10	22.70	29.52
Weight of minituber/plant (g)	244.12	48.58	110.84	115.00
Yield (kg m ⁻²)	12.21	2.43	5.54	5.75

TABLE V: EIGENVALUES AND EIGENVECTORS OF THE FIRST TWO DISCRIMINANT FUNCTIONS AXIS AS OBSERVED IN 12 POTATO VARIETIES

	Discriminant function	
	1st	2nd
Extracted Eigenvalues	21.66	6.03
Percentage variance	78.21	21.79
Eigenvectors		
Plant height (cm)	0.293	0.523
Leaf area (cm ²)	0.661	0.030
Minituber/plant (no.)	-0.204	0.644
Mortality	-0.242	-0.315
Weight of minituber/plant (g)	-0.012	0.044
Yield (kgm ⁻²)	-0.012	0.044

The graphical presentation of the potato varieties how are they classified into four clusters according to the first two discriminatory functions (Fig. 2). The varieties scattered on the right side of the diagram had higher leaf area and plant height compared to that of the varieties on the left side based on X ordinate. Therefore, function 1 separated cluster I and cluster III very clearly from cluster II and cluster IV based on leaf area and plant height. On the other hand, the varieties scattered on the upper part of the diagram had higher tubers per plants than that of the varieties on the lower part based on Y ordinate. Therefore, function 2 separated clusters I and cluster IV very clearly from cluster II followed by group III.

Fig. 2. Graphic illustration of the discriminatory analysis of four groups of potato varieties. The encircled varieties indicate the groups (clusters) obtained through cluster analysis.

C. Mahalanobis Distance

The four clusters were statistically different from each other at 0.001 levels according to the Mahalanobis distance (D^2) among clusters calculated by DFA (Table VI). D^2 analysis indicated that the clusters differed significantly from each other. Among 4 clusters, cluster II showed the highest distance (29.79) with cluster III followed by the distance between clusters III and IV (24.70), so the varieties in these clusters were genetically diverse and could be useful for hybridization as a better parent to get positive heterosis [28]. On the other hand, cluster I also showed higher distance (24.08) with cluster II and lowest distance (2.84) was

observed between clusters I and III. This indicated that the varieties in cluster I and III had a close relationship. All the four clusters showed the minimum intra cluster distance (0.00) which revealed that the varieties within the cluster were very much similar to each other.

TABLE VI: PAIRWISE MAHALANOBIS DISTANCE (D₂) COMPARISONS BETWEEN FOUR CLUSTERS OF 12 POTATO VARIETIES

Cluster	I	II	III	IV
I	0.00			
II	24.08	0.00		
III	2.84	29.79	0.00	
IV	13.17	11.85	24.70	0.00

IV. CONCLUSION AND RECOMMENDATION

Considering the mean value of the six quantitative characters for each of the four clusters and the inter cluster distance the cluster III and IV might be selected for future breeding program. Cluster III contained six varieties BARI Alu 29, BARI Alu 35, BARI Alu 36, BARI Alu 37, BARI Alu 7 (Diamant), BARI Alu 8 (Cardinal) and which were characterized by lowest plant height and average values for other characters. Cluster IV contained three potato varieties BARI Alu 41, BARI Alu 46 and BARI Alu 53 which was characterized by highest plant height and second highest leaf area.

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