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GENETIC DIVERGENCE IN POTATO *(Solanum tuberosum* L.)

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Abstract

Twenty eight genotypes of potato representing different sources collected from TCRC, BARI, Gazipur were tested for genetic divergence utilizing multivariate analysis. The genotypes were grouped into five clusters. No relationship was found between genetic divergence and geographic distribution. Number of tubers per plant and yield contributed maximum, while average weight of a tuber and weight of tubers per plant contributed high towards total divergence which offered due attention to these characters while selecting for increased tuber yield. The inter-cluster distance (D^2) was maximum (36.29) between III and IV. The highest and the lowest intracluster distances (D^2) were 9.64 and 2.48 in cluster III and II, respectively.

Keywords: Potato, selection, genetic divergence, cluster analysis, tuber yield.

Introduction

Potato *(Solanum tuberosum* L.) is one of the most important food crops of Bangladesh as well as of many countries of the world. It ranks first among the vegetables in terms of area and production in Bangladesh. The yield level of this crop in Bangladesh is low compared to other potato growing countries of the world (Anon., 2007). Among the various factors responsible for low yield in Bangladesh, the performance of a variety plays a great role. There is a vast scope of increasing the yield per hectare through the introduction of high yielding potato varieties possessing good keeping quality and resistant to pests and diseases. Genetic variability with respect to genetic diversity is considered as an important factor as well as essential prerequisite for crop improvement programmes for obtaining high yielding progenies.

Estimation of genetic diversity is an important factor to know the source of genes for a particular trait within the available genotypes. Genetic diversity among the segregating population also helps select suitable types as parents and also for commercial cultivation. The present investigation was carried out in order to find out the above mentioned qualities in a group of potato genotypes collected at the TCRC from different sources.

Materials and Method

The investigation was carried out at the Tuber Crops Research Centre (TCRC) of BARI, Gazipur during 2004-2005. Twenty eight genotypes were used in the

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study of which 24 were of CIP origin and the rest four were commercial varieties of Bangladesh originated in the Netherlands. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The seed tubers were sown on 28 November 2004 in 3m x 3m plots at 60 x 25 cm spacing. Fertilizers and other cultivation practices were applied as per recommendation of the TCRC. Data were recorded from 10 plants, randomly selected from the plot of each replication on plant vigour, plant height, compound leaves/plant, days to maturity, number of tubers/plant, average weight of a tuber, dry matter content, and yield/plant. D^2 statistic was used for estimating genetic divergence. Both individual and pooled analyses were performed. The data were subjected to multivariate analysis (Rao, 1952). Group constellation of clusters was done as outlined by Singh and Chaudhary (1985).

Results and Discussion

The first five eigen values for principal component axes of genotype accounted for 99.4 cumulative percentage (Table 1). The first two axes scored about 64.6% and 15.1% of the total variation, respectively. Based on principal component axes I and 2, a two dimensional scattered plotting diagram (Z_1 and Z_2) of the genotypes are presented in Fig. 1. The scattered diagram revealed that apparently there were mainly five clusters. The pattern of distribution of genotypes in the scattered diagram revealed considerable variability among the lines.

Table 1. Eigen values and percentage of variation for corresponding 17 characters in 28 genotypes of potato.

Sl. No.	Principal component axis	Eigen values	Percentage	
			of total variation accounted for	Cumulative
1.	Plant vigour (1-10)	64.63	64.63	64.63
2.	Plant height (cm)	15.08	15.08	79.71
3.	Number of stems/plant	11.38	11.38	91.09
4.	Days to maturity	5.84	5.84	96.93
5.	Average wt of a tuber (g)	2.45	2.45	99.38
6.	Number of tubers/plant	0.25	0.25	99.63
7.	Weight of tubers/plant (g)	0.18	0.18	99.81
8.	Dry matter content of tubers (%)	0.11	0.11	99.92
9.	No. of compound leaves/main stem	0.02	0.02	99.94
10.	Area of leaf (cm^2)	0.01	0.01	99.95
11.	Fresh wt/leaf (g)	0.01	0.01	99.96
12.	Foliage coverage at 40 DAP (%)	0.01	0.01	99.97
13.	Foliage coverage at 60 DAP (%)	0.01	0.01	99.98
14.	No. of tubers under <28 mm grade (%)	0.01	0.01	99.99
15.	No. of tubers under 28-45 mm grade (%)	0.01	0.01	100.00
16.	No. of tubers under >*45* mm grade (%)	0.00	0.00	0.00
17.	Tuber yield (t/ha)	0.00	0.00	0.00

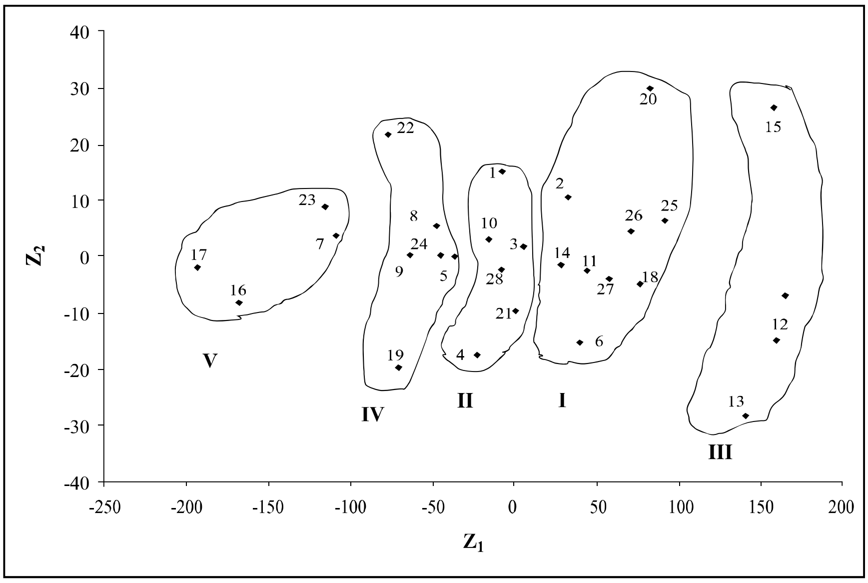

Fig. 1. Scatter distribution of 28 potato genotypes based on their principal component scores superimposed with clustering.

On the basis of D^2 analysis, 28 genotypes of potato were grouped into five clusters (Table 2). Cluster I contained the highest number of genotypes having nine followed by cluster II and cluster IV having six genotypes, while cluster III and cluster V having 3 and 4 genotypes, respectively. The clustering pattern revealed that the genotypes collected from the different region (Peru and the Netherlands) were grouped into different clusters. Similar opinions were also exhibited by Anand and Rawat (1984) in brown mustard, Mannan *et al.* (1993) in Panikachu, Patel *et al.* (1989) in safflower, Singh and Singh (1979) in okra. Shanmugam and Rangasamy (1982) reported that falling of materials of same origin into different clusters was an indication of the broader genetic base of the genotypes belonging to that origin.

Table 2. Distribution of 28 genotypes of potato into different clusters.

Clusters	No. of genotypes	Genotypes
I	9	CIP 377852.2, CIP 385499.11, CIP 678019, CIP 720025, CIP 82006.25, CIP 379666.501, Cardinal, Diamant, Multa.
II	6	CIP 374080.5, CIP 377857.5, CIP 377964.5, CIP 678011, CIP 377957.5, Patrones
III	3	CIP 700124, CIP 703240, CIP 709005
IV	6	CIP 380700.79, CIP 386611.5, CIP 386612.5, CIP 84007.67, CIP 381381.20, CIP 800946
V	4	CIP 385500.3, CIP 384112.14, CIP 384112.8, CIP 720045

The intra and inter-cluster D^2 values have been presented in Table 3. The maximum inter-cluster distance was observed between cluster III and cluster V (36.29) followed by cluster III and cluster IV (27.5) and cluster II and cluster III (25.75). Intermediate or moderate inter-cluster distance was observed between cluster I and cluster V (18.94) followed by cluster land III (18.11), II and V (11.07), and I and IV (10.24). The minimum inter-cluster distance was observed between cluster II and II (2.48) indicating that the genotypes of these clusters were genetically closed. The intracluster divergence varied from 2.48 to 9.64 in cluster II and III, respectively.

Table 3. Inter and intra (bold) cluster distances (D^2) in potato obtained by canonical variate analysis.

Cluster	I	II	III	IV	V
I	**4.59**	7.93	18.11	10.24	18.94
II		**2.48**	25.75	2.89	11.07
III			**9.64**	27.5	36.29
IV				**7.25**	8.82
V					**5.50**

With the help of D^2 values within and between clusters an arbitrary cluster diagram was constructed, which shows the relationship between different genotypes (Fig. 2). However, the diagram was not drawn following the exact scale. It was apparent *from* the figure that the genotypes included in the cluster III were far diverse from genotypes of the cluster V and IV where the genotypes belonging to clusters IV and II were least diverse.

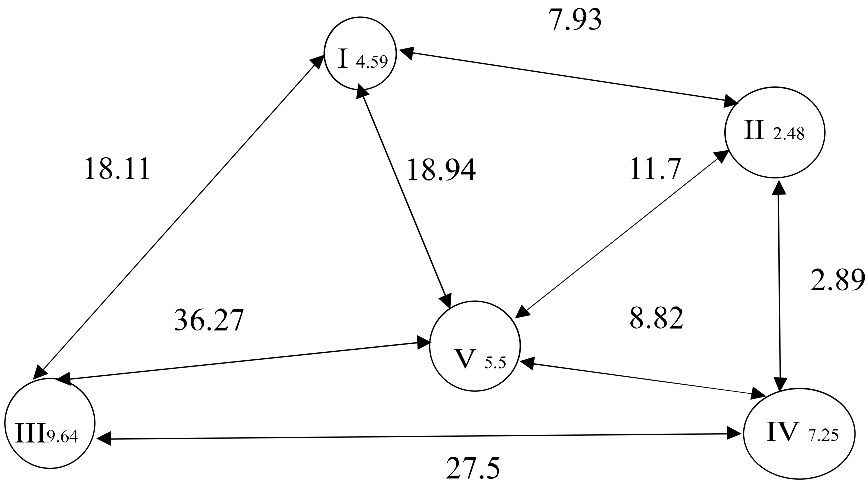

Fig. 2. Diagram showing intra and inter cluster distances of 28 genotypes in potato.

Cluster means are presented in Table 4. Plant vigour had the highest mean value in the cluster V followed by cluster IV and I. The genotypes of cluster III produced poor plant vigour. The highest plant height was produced by the genotypes under the cluster V followed by I and IV. The lowest mean values of this trait were shown by III and II. Number of stems per plant had the highest mean value in the cluster II followed by V and I. The genotypes of cluster III produced the lowest number of stems per plant. The maximum days required for maturity of tubers of cluster I followed by V and III. The minimum days required for maturity was in cluster II.

The highest average tuber weight was produced in cluster II followed by V and IV. The lowest average tuber weight was produced in cluster III. The highest number of tubers per plant was harvested from the genotypes included in cluster V followed by IV and II. The lowest number of tubers was harvested in cluster III. The highest weight of tubers per plant was produced by the genotypes of cluster V followed by IV and II. The lowest weight of tubers per plant was produced by the genotypes of cluster III. The maximum dry matter content of tubers was recorded by cluster V followed by I and IV. The minimum dry matter content was recorded for tuber of III.

The highest number of compound leaves per plant was produced by the genotypes under the cluster V followed by III. The lowest mean values of this trait were shown by cluster I. The maximum area of leaf was found in cluster V followed by I and IV. The smallest area of leaf was found in cluster III. The maximum fresh weight per leaf was recorded in cluster III. The highest foliage coverage (%) at 40 DAP was measured in cluster V followed by IV and II. The lowest was measured in cluster Ill. The highest foliage coverage (%) at 60 DAP was measured in cluster II.

The maximum percentage of tuber under <28 mm was recorded in cluster I followed by V and II. The minimum percentage was recorded in cluster III. The maximum percentage of tuber under 28-45 mm was found in cluster III followed by IV and II. The highest amount of tuber was produced by the genotypes included in cluster V followed by IV and IL The lowest amount of tuber was produced in cluster III. (12.25). It was observed that the genotypes of cluster IV recorded maximum percentage of tuber under >45 mm grade and same was the days to maturity (91.55). The cluster II had the highest number of stems per plant (3.74) and the highest average tuber weight (36.5 g). Cluster V recorded minimum percentage of tuber under >45 mm grade. Cluster V produced moderately long plant type, maximum plant vigour, the highest number of tubers per plant (16.64), maximum amount of dry matter content (18.06), the highest number of compound leaves per plant (12.25), maximum amount (34.39 g) of fresh weight per leaf, the highest amount (31.24 cm^2) of area of leaf, maximum foliage coverage at 40 DAP (81.25%) and 60 (87.08%), and highest tuber yield (29.98 t/ha).

Table 4. Cluster means for 17 characters of 28 potato genotypes.

Sl. No.	Characters	I	II	III	IV	V
1.	Plant vigour (1-10)	6.65	6.36	6.00	7.30	7.87
2.	Plant height (cm)	57.58	54.8	48.73	55.93	59.5
3.	No. of stems/plant	3.62	3.74	3.04	3.58	3.63
4.	Days to maturity	91.55	85.72	90.67	88.61	91.25
5.	Average wt of a tuber (g)	33.34	36.5	34.01	34.92	36.15
6.	No. of tubers/plant	10.44	13.29	8.39	13.95	16.64
7.	Wt of tubers/plant (g)	232.45	297.39	140.55	346.06	434.34
8.	Dry matter content of tubers (%)	17.36	16.63	15.22	16.73	18.06
9.	No. of compound leaves/main stem	10.93	11.00	12.00	11.00	12.25
10.	Area of leaf (cm^2)	31.01	28.42	13.6	28.54	31.24
11.	Fresh wt/leaf (g)	32.16	31.17	26.97	31.69	34.43
12.	Foliage coverage at 40 DAP (%)	54.45	67.5	38.67	69.45	81.25
13.	Foliage coverage at 60 DAP (%)	78.7	73.06	73.33	86.67	87.08
14.	No. of tubers sunder <28mm grade (%)	6.19	5.51	4.65	5.28	5.69
15.	No. of tubers under 28-45 mm grade (%)	5.26	5.48	6.15	5.62	4.87
16.	No. of tubers under >45 mm grade (%)	4.65	4.64	4.39	4.99	4.33
17.	Tuber yield (t/ha)	15.6	19.44	9.29	23.34	29.98

Contribution of characters towards divergence was obtained from the canonical variate analysis (CVA) and presented in Table *5.* The values of Vector I and Vector II revealed that both the vectors had positive values for average weight of a tuber (g), dry matter content (%), number of compound leaves per plant, fresh weight per leaf (g), foliage coverage (%) at 60 DAP, tuber grades (<28 mm and 28-45 mm) and yield (t/ha). The results indicated that these eight characters had the highest contribution towards divergence among the 17 characters of 28 genotypes of potato.

Plant vigour (1-10) and foliage coverage (%) at 40 DAP contributed positive impact on divergence as they showed positive value only in vector II (the second axis of differentiation).

Negative values in both the vectors were for plant height, number of stems per plant, days to maturity, number of tubers per plant, weight of tubers per plant, area of leaf (cm^2) and tuber grade (>45 mm) which indicated that these characters had the lowest contribution to the total divergence.

Table 5. Latent vectors for 17 characters of 28 potato genotypes.

Sl. No.	Characters	Vector-I	Vector-IT
1.	Plant vigour (1-10)	-0.1017	0.4215
2.	Plant height (cm)	-0.1577	-0.0784
3.	No. of stems/plant	-2.8554	-.1.2087
4.	Days to maturity	-0.0271	-0.000 1
5.	Average wt of a tubers (g)	0.080 1	0.0763
6.	No. of tubers/plant	-0.4024	-0.0802
7.	Wt of tubers/plant (g)	-0.1754	-0.0445
8.	Dry matter content of tubers (%)	0.589	0.0603
9.	No. of compound leaves/main stem	1.2544	0.2652
10.	Area of leaf (cm^2)	-0.2811	-0.1546
11.	Fresh wt/leaf (g)	0.4903	0.0735
12.	Foliage coverage at 40 DAP (%)	-0.0053	0.0248
13.	Foliage coverage at 60 DAP (%)	0.1381	0.0656
14.	No. of tubers under <28 mm grade (%)	0.025 1	0.1245
15.	No. of tubers under 28-45 mm grade (%)	2.0623	0.20 13
16.	No. of tubers under >45 mm grade (%)	-0.5406	-0.8773
17.	Tuber yield (t/ha)	1.1043	0.6991

Desai and Jaimini (1997) reported that tubers per plant and weight of tuber were the major contributor towards divergence in potato. Similar results were also obtained by Elias *et al.* (1992) in potato and Masud (1995) in pumpkin and Singh and Singh (1979) in okra.

The crosses involving parents belonging to the maximum divergent clusters were expected to manifest maximum heterosis and also wide variability in genetic architecture. Ramanujam *et al.* (1994) in mungbean, and Mian and Bahl (1999) in chickpea reported that parental clusters separated by medium D^2 values exhibited significant and positive heterosis for seed yield and some of its components.

The genotypes V_I, V_{17}, and V_{22} showed very good performance in the field in respect of growth and yield performance as well as cumulative effect of different major traits. These genotypes should be studied further and may be recommended for release as potato varieties in Bangladesh.

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