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MULTIVARIATE ANALYSIS IN ONION (*Allium cepa* L.)

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Abstract

Thirty genotypes collected from India, Burma, and Bangladesh were studied for thier genetic divergence using Mahalanobi´s D^2 and Rao´s canonical analysis. Altogether five clusters were formed. The pattern of distribution of genotypes into five clusters was random demonstrating that the geographical isolation might not be the only factor causing genetic diversity. Leaf length and sulfur content contributed predominantly towards genetic divergence. Cluster III recorded the highest means for number of leaves per plant, leaf length, bulb length, plant height, and bulb yield. The results obtained from D^2 analysis were confirmed by canonical analysis. The genotype G_{12} showed highest mean performance for moisture content (88.49%), G_{13} for leaf length (39.06 cm), G_{15} for neck diameter at vegetative stage (11.21 mm), bulb length (49.09 mm), plant height (64.82 cm) and as well as bulb yield (13.17 t/ha), G_{19} for percent sulfur content (0.84) and G_{26} for number of leaves per plant (12), respectively.

Keywords: onion, multivariate analysis, genetic divergence.

Introduction

Onion (*Allium cepa* L.) belongs to the family Amaryllidaceae and is one of the most important spices as well as vegetable crop in the world. Onion ranks first among the spice crops grown in Bangladesh. Yield of any crop is a complex character which depends on a number of agronomic traits and is influenced by many factors which could be genetic or environmental (Uddin *et al*., 1985).

Information on genetic divergence among plant materials is vital to a plant breeder for selection of parents for hybridization. It is an established fact that genetically diverse parents are likely to contribute desirable segregants and/or to produce high heterotic cross. More diverse the parents, greater are the chances of obtaining higher heterotic F_1s and broader spectrum of variability in the segregating generations (Arunachalam *et al*., 1984). Improvement in yield and quality is normally achieved by selecting genotypes with desirable characters existing in the nature or by hybridization. The parent identified on the basis of

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divergence analysis would be more promising. Mohanthy (1999, 2001, 2002), Mohanty and Prusti (2002) have reported some related results in onion. Those studies did not include any Bangladeshi cultivars/genotypes. In Bangladesh context, the information on this aspect of onion is not sufficient. A study including some genotype collected from different sources would be very important in breeding varieties for Bangladesh. The present investigation was undertaken to estimate the nature and magnitude of genetic diversity of onion genotypes and subsequent use in onion improvement programs.

Materials and Method

Genetically pure and physically healthy seeds of these genotypes were obtained from Bangabandhu Sheikh Mujubur Rahman Agricultural University germplasm collections. One standard variety Taherpuri was used as the check variety. Source and bulb characteristics of the genotypes with thier origin are mentioned in Table 1.

Table 1. Bulb characteristics of 30 genotypes of onion with their origin.

SL No.	Accession number	Origin	Bulb characteristics
1	038	India	Medium, light brown red, closed neck, flat
2	012	Myanmar	Medium, light brown red, closed neck
3	019	Myanmar	Medium, brown red, closed neck
4	022	India	Large, light brown red, closed neck, flat
5	016	Burma	Medium, light red, closed neck round
6	001	Pabna	Medium, brown red, closed neck, flat
7	017	India	Medium, light brown red, closed neck
8	007	India	Large, light pink, almost flat neck
9	032	Rajshahi	Medium, light brown red, closed neck
10	035	Swandip	Very small, brown red, closed neck
11	033	Rajshahi	Medium, light brown, closed neck, flat
12	006	India	Large, elongate, close neck, pink
13	024	India	Large, deep pink, close neck, elongate
14	039	Bangladesh	Medium, brown red, flat
15	023	India	Medium, light brown branched
16	039self	Bangladesh	Medium, brown red, closed neck, round
17	011	Unknown	Large, deep pink, close neck,
18	021	Mymensingh	Medium, brown red, closed neck, flat
19	Selected/099	Burma	Medium-large, light brown red, flat
20	010	Burma	Medium, brown red, closed neck, round
21	014	Burma	Medium, brown red, open neck, flat
22	Taherpuri	Bangladesh	Medium, deep brown red, flat
23	003	Faridpur	Medium, light brown branched
24	004	India	Medium deep pink, close neck
25	018	India	Small, brown neck, close neck
26	015	India	Medium, brown red, closed neck, flat
27	002self	Pabna	Medium, light brown red, closed neck, flat
28	025	India	Large, brown red, flat type, closed neck
29	002	Pabna	Medium, brown red, closed neck, flat
30	040self	Bangladesh	Medium, light brown red, flat

Seedlings of each genotype were raised in 3 m × 1 m unit bed with normal care. Afterwards, 49 days old seedling were transplanted in the main field in a RCB design with three replications at the experimental field of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during rabi season of 2006-2007. Each genotype was grown in 10 rows of two-meter length with 20 cm × 8 cm spacing. The data were recorded from 10 competitive randomly selected plants from each plot on number of leaves per plant, leaf length, neck diameter at vegetative stage, bulb length, moisture content, sulfur content, plant height, and bulb yield. Plot means were used for statistical analysis. Genetic diversity was studied following Mahalanobis generalized distance (D^2) extended by Rao (1952). Canonical analysis was done according to Rao (1964) to confirm the results of cluster and D^2 analysis. Statistical analyses were carried out using MSTAT C Programme.

Results and Discussion

The analysis of variance showed significant differences among the 30 genotypes of onion at 1% level indicating the presence of notable genetic variability among the genotype and therefore, multivariate analysis was carried out. Thirty genotypes were morphologically characterized mainly on the basis of bulb character viz., bulb colour, shape, neck diameter, etc. All the genotype were different for considering characters and were recorded properly (Table 1). Mean performance of the genotypes are shown in Table 3. The genotype G15 (India) produced the highest bulb yield followed by G30 (Bangladesh) and G5 (Burma). Higher bulb yield of G15 genotype is related with the highest neck diameter at vegetative stage (mm) and the highest bulb length (mm). Genotype G15 also belongs with the largest leaf length (38.68 cm) and relatively higher number of leaves (11.43) which increases its photosynthetic areas as well as the highest bulb yield.

Table 2. Estimation of genetic components of 8 yield related characters in onion.

Component	NL	LL (cm)	NDV (mm)	BL (mm)	Water (%)	S (%)	PH (cm)	Bulb yield (t/ha)
Range	7.90-12.10	23.95-40.09	7.00-11.96	30.01-49.98	83.00 - 89.74	0.42 - 0.85	47.32 - 66.50	5.39 - 13.30
Mean	10.18	30.23	9.71	39.82	86.69	0.57	55.27	8.55
σ^2g	0.62	12.33	0.85	10.84	1.93	0.01	20.90	3.95
σ^2p	0.82	13.00	0.93	11.39	3.30	0.01	21.48	4.01
GCV	7.73	11.61	9.48	8.22	1.60	15.36	23.26	8.27
PCV	8.84	11.93	9.93	8.43	2.09	15.46	23.43	8.39
h^2b	75.65	94.86	91.27	95.13	58.54	98.79	97.29	98.54
GA(5%)	1.41	7.05	1.81	6.61	2.16	0.18	9.29	4.06
GA% mean	17.74	29.86	23.92	21.16	3.20	40.31	21.54	60.95
F-value	**	**	**	**	**	**	**	**
CV (%)	4.38	2.70	2.93	1.83	1.34	4.14	1.38	2.83

Table 3. Mean performance of different yield contributing character of onion.

Genotype	NL (no.)	LL (cm)	NDV (mm)	BL (mm)	Water (%)	S (%)	PH (cm)	Bulb yield (t/ha)
G1	10.47	31.26	9.43	41.54	86.08	0.52	53.21	10.25
G2	9.37	27.80	10.38	41.23	86.54	0.54	54.11	9.25
G3	10.30	33.80	10.60	47.50	87.65	0.58	63.45	10.38
G4	10.07	31.97	10.82	42.09	87.02	0.55	60.21	9.00
G5	10.99	31.08	9.95	45.72	87.52	0.58	58.77	11.95
G6	11.07	31.81	9.88	39.44	87.56	0.53	55.17	6.42
G7	10.00	25.40	10.95	41.28	86.98	0.56	56.70	7.13
G8	10.20	30.65	8.90	39.70	86.21	0.57	54.01	8.40
G9	9.47	29.30	8.47	35.69	84.60	0.48	49.71	7.38
G10	9.98	27.98	9.76	37.03	86.22	0.57	49.53	8.18
G11	9.10	29.15	10.20	35.22	88.49	0.47	48.31	8.07
G12	8.57	27.52	7.73	30.82	87.20	0.48	51.00	5.74
G13	11.13	39.06	10.35	41.99	84.72	0.51	59.53	8.22
G14	10.03	29.04	10.10	36.48	88.29	0.77	55.53	8.23
G15	11.43	38.68	11.21	49.09	86.16	0.72	64.82	13.17
G16	9.60	25.23	9.93	40.57	85.70	0.52	55.24	9.66
G17	10.80	25.67	8.57	40.66	87.06	0.44	55.77	7.25
G18	8.58	30.06	7.83	36.92	87.65	0.61	48.10	6.82
G19	9.85	28.46	8.35	39.03	88.42	0.84	58.94	8.11
G20	10.90	25.98	10.15	40.66	85.98	0.51	54.76	7.22
G21	9.90	28.05	9.18	37.97	85.25	0.58	57.09	5.82
G22	10.90	27.89	9.34	37.30	86.12	0.63	49.98	9.76
G23	9.77	31.08	10.08	36.67	87.65	0.62	53.12	9.69
G24	10.87	30.31	9.75	43.87	88.27	0.54	55.84	8.17
G25	10.57	29.48	9.22	39.78	85.19	0.57	50.21	6.73
G26	11.60	31.34	10.14	43.11	86.59	0.56	57.53	11.01
G27	9.67	28.13	8.94	37.04	86.68	0.60	50.19	6.41
G28	10.21	29.83	9.16	31.58	86.30	0.50	62.53	9.33
G29	8.77	33.52	11.03	43.02	86.44	0.61	53.02	5.79
G30	11.30	37.60	10.95	41.62	86.44	0.53	61.84	12.86

NL = Number of leaves per plant, LL = Leaf length (cm), NDV = Neck diameter at vegetative stage (mm), BL = Bulb length (mm), S = Sulfur percentages, PH = Plant height (cm).

Principal component analysis

Principal component analysis was carried out with 30 genotypes of onion. First 3 eigen values for 3 principal coordination axes of genotypes accounted for 58.96 cumulative percentage. The first 33.08 and the second 15.33 eigen values gave 48.41.

Table 4. Eigen values and percentage of variation for corresponding eight component characters in 30 genotypes of onion.

Principal component axis	Eigen values	Percentage of total variation account for	Cumulative percentages
Number of leaves per plant	5.2927	33.08	33.08
Leaf length (cm)	2.4531	15.33	48.41
Neck diameter at vegetative stage (mm)	1.6878	10.55	58.96
Bulb length (mm)	1.4798	9.25	68.21
Water content (%)	1.4590	9.12	77.33
Sulfur content (%)	1.3326	8.33	85.66
Plant height (cm)	1.2574	7.86	93.52
Bulb yield (t/ha)	1.0350	6.47	99.99

A two dimensional scattered plotting diagram (Fig. 1) was developed on the basis of the Z_1 and Z_2 values of two principal coordinates axes I and II (Fig. 1). In the scattered diagram, it is apparently shows that 30 genotypes are scattered in different clusters it confirms their clustering pattern, and differentiation of genotypes belonging to the different clusters.

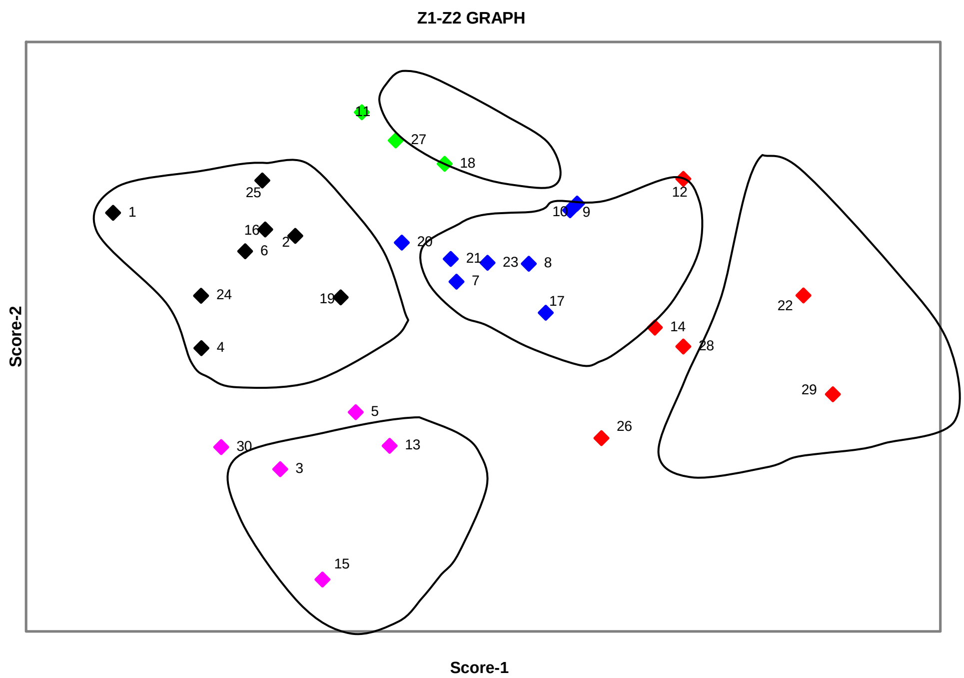

Fig. 1. Scatter distribution of 30 genotypes of onion based on their principal component scores super imposed with clustering.

Principal coordinate analysis

The results obtained from principal coordinate analysis showed that longest inter genotypic distance remained between G12 and G30 (1.2299) followed by G18 and G23 (1.1826) and the shortest between G3 and G5 (0.2055) followed by G5 and G26 (0.2551) (Table 5). These inter genotypic distances were used in computation of intra-cluster distances on the basis of the suggestion forwarded by Singh and Choudhary (1977). The highest genotypic distance belonging genotypes may be subjected to use in hybridization programmes. The genotype G18 and G15 may produce dream child of a breeder. The lowest genotypic distance belonging genotypes G3 and G16 may be used to obtain homozygous population.

Table 5. Ten (10) highest and 10 lowest distance among genotypes.

Genotype to Genotype	Distances
a.10 highest inter genotypic distances	
G12-006---G30-040Self	1.2299
G15-023---G18-021	1.1826
G18-021---G30-040Self	1.1675
G15-023---G27-002Self	1.1120
G27-002Self---G30-040Self	1.0485
G29-002---G30-040Self	1.0205
G15-023---G29-002	1.0038
G16-039Self---G29-002	1.0459
G15-023---G21-014	09969
G1-038---G29-002	0.9673
b.10 lowest inter genotypic distance.	
G6-001---G21-014	0.3688
G10-035---G11-033	0.3266
G6-001---G25-018	0.3142
G6-001---G24-004	0.3142
G4-022---G16-039Self	0.3110
G7-017---G20-010	0.2862
G9-032---G10-035	0.2679
G4-022---G24-004	0.2623
G5-016---G26-015	0.2551
G3-019---G5-016	0.2055

Clustering

Table 6 represents the clusters formed by 30 genotypes of onion. It shows that cluster I and IV contained the highest number of genotypes (eight) followed by cluster II (six genotypes), cluster III (five genotypes), and cluster V (three genotypes).

Table 6. Distribution of 30 genotypes of onion in five clusters.

Cluster	No. of genotypes	Genotypes and origin
I	8	G1 (India), G2 (Burma), G4 (India) G6 (Pabna), G16 (Burma), G19 (Burma), G24 (India), G25 (India)
II	6	G12 (India), G14 (Manikgonj), G22 (Taherpur), G26 (India), G28 (India), G29 (Pabna)
III	5	G3 (Burma), G5 (Burma), G13 (India), G15 (India), G30 (Bangladesh)
IV	8	G7 (India), G8 (Manikgonj), G9 (Taherpur), G10 (India), G17 (India), G20 (Burma), G21 (Burma), G23 (Faridpur)
V	3	G11 (Rajshahi), G18 (Mymensingh), G27 (Pabna)

Cluster means for eight characters for 30 genotypes are given in Table 7. Cluster I had the highest mean value for moisture content (87.17). It secured second for number of leaves per plant (10.23) and bulb yield (8.45 t/ha).

Table 7. Cluster mean for eight characters of 30 genotypes of onion.

Components	Cluster				
	I	II	III	IV	V
1 Number of leaves per plant	10.23	10.01	11.03	10.13	9.12
2 Leaves length (cm)	29.54	29.86	36.04	28.01	29.11
3 Neck diameter at vegetative stage (mm)	7.70	6.69	6.18	6.50	8.05
4 Bulb length (mm)	40.94	37.05	45.18	38.71	36.39
5 Moisture content (%)	87.17	86.10	87.10	86.45	86.62
6 Sulfur content (%)	0.58	0.59	0.58	0.54	0.56
7 Plant height (cm)	55.37	54.93	61.68	53.84	48.87
8 Bulb yield (t/ha)	8.45	8.31	11.32	7.63	7.10

Cluster II achieved the highest cluster mean values for sulfur content (0.59). However, this stood second in leaf length (29.86 cm). The highest sulfur containing genotype belongs to cluster II, but the largest bulb producing genotype belongs to cluster III which indicated that the largest bulb always not represent higher smell. Smaller bulb producing genotypes belong to cluster V but this cluster does not contain higher sulfur containing ones which indicated higher sulfur content is not associated with smaller size of bulb. Cluster III contains the highest cluster mean values for most of the characters viz., number of leaves per plant (11.03), leaf length (36.04), bulb length (45.18 mm), plant height (61.68 cm), and bulb yield (11.32 t/ha). Cluster V got the highest cluster mean for neck diameter at vegetative stage.

The highest inter-cluster distance was observed (Table 8) between clusters II and I (9.880), followed by II and V (8.715), II and III (7.941), III and V (7.338), and III, and IV (6.830). The intra cluster distance was the highest (0.694) in cluster II followed by that of cluster V (0.469), cluster I (0.463), cluster IV (0.438), and cluster III (0.436). The lowest inter-cluster distances were observed between cluster V (3.302) and I followed by that of cluster II and IV (4.373). Moderate or intermediate distances were found between clusters III and IV (6.830), cluster IV and cluster I (6.271) and V and IIII (7.338). Arunachalam *et al.* (1984) suggested that the magnitude of heterosis for yield and its components were higher in cross between intermediate divergences than extreme ones. Ramanujam (1974) suggested that there was a fair agreement between the extent of heterosis and the genetic divergence between parents.

Table 8. Average intra and inter cluster distances (D^2) for 30 genotypes of onion.

Cluster	I	II	III	IV	V
I	0.463	9.880	5.373	6.271	3.302
II		0.694	7.941	4.373	8.715
III			0.436	6.830	7.338
IV				0.438	4.411
V					0.469

Vector 1 obtained from PCA (Table 9) expressed that neck diameter at vegetative stage (0.1595), plant height (0.1210), and bulb yield (0.1030) were major characters that contribute to the genetic divergence. It was the reflection of first axis of differentiation. In vector 2, sulfur content (2.5490) showed their important role towards genetic divergence. Other characters played minor roles in determining genetic divergence.

Singh *et al.* (1995) reported individual bulb weight and neck diameter in onion, Mohanty (1999) for number of leaves per plant and Mohanty and Prusti (2001) for weight of bulb and neck thickness in onion contributed predominantly towards total divergence.

Table 9. Latent vectors for eight principal component characters of 30 onion genotypes.

Characters	Vector 1	Vector 2
Number of leaves per plant	0.3221	-0.0394
Leaf length (cm)	-0.1823	-0.2180
Neck diameter at vegetative stage (mm)	0.1595	-0.0253
Bulb length (mm)	-0.3033	-0.0580
Moisture content (%)	-0.0750	-.04519
Sulfur content (%)	-10.6057	2.5490
Plant height (cm)	0.1210	-0.0222
Bulb yield (t/ha)	0.1030	-0.3974

No parallel relationship was found between genetic and geographic divergence, which may be due to continuous exchange of germplasm from one place to another. Differently originated genotypes found in same cluster or genotypes from same origin were dispersed in different clusters. It was observed that group IV and I formed with eight genotypes originated in India, Burma, and Bangladesh. Group V occupied by three genotypes of Bangladesh origin. There are supportive reports made by Mohanty and Prusti (2002), Mohanty (2001) in winter onion, Mohanty (1999) in kharif onion.

Genotypes from India, Burma, and Bangladesh being in different clusters, indicated the broad genetic variability among the genotypes. There was evidence from Shanmugam and Rangasamy (1982) that materials from same origin distributed in different clusters is an indication of broad genetic base of the genotypes belonging to that region.

Considering cluster distance, cluster mean and mean performance of the genotypes for yield, the genotypes G1 and G16 from cluster I, genotypes G12 and G29 from cluster II, genotypes G15 and G30 from cluster III, genotypes G9, G10 and G17 from cluster IV, genotypes G18, G21 and G27 from cluster V may be considered better parents for future hybridization programme.

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