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M Prashanthi
Research Scholar, Department of Vegetable Science, College of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Telangana, India

D Lakshminarayana
Associate Professor, Department of Horticultural, College of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Telangana, India

S Mallesh
Assistant Professor, Department of Horticultural, College of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Telangana, India

BSK Nikhil
Assistant Professor, Department of Genetics and Plant Breeding, College of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Mojerla, Telangana, India

G Sathish
Assistant Professor, Department of Agricultural Statistics, College of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Mojerla, Telangana, India

Corresponding Author:
M Prashanthi
Research Scholar, Department of Vegetable Science, College of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Telangana, India

Genetic diversity in onion (*Allium cepa* L.)

M Prashanthi, D Lakshminarayana, S Mallesh, BSK Nikhil and G Sathish

Abstract
A field experiment was conducted during *Rabi* season of 2021 at College of Horticulture, Rajendranagar, Hyderabad to estimate the genetic diversity of onion. Forty genotypes of onion were evaluated for ten characters in a randomized block design to study the genetic divergence. D2 statistic indicated that the genotypes studied were genetically diverse. Based on D2 values, the genotypes were grouped into twelve clusters. The maximum inter cluster D2 value of was observed between cluster VIII and VII (150.67) followed by cluster X and VIII (149.97), while the lowest was between cluster III and II (13.56). Cluster VIII showed maximum intra cluster diversity followed by cluster V.
There were seventeen genotypes in cluster I, six genotypes in cluster V, five genotypes in cluster VIII, four genotypes in cluster IV and the cluster II, III, VI, VII, IX, X, XI and XII contained solitary genotype. D2 analysis suggested that 1770, 1774, Bhima Shwetha, W-125 and 1772 were the most diverse parents. These genotypes could be utilized as parents in breeding programme to enhance the productivity of onion.

Keywords: Genetic diversity, D2 analysis, cluster, germplasm

Introduction
Onion (*Allium cepa* L, 2n = 2x = 16) is a bulb crop belonging to the family Alliaceae and locally known as Pyaj. Central Asia is the primary center of its origin and the Mediterranean area is the secondary center for large type of onion (McCollum. 1976) [6]. It is one of the important spice and vegetable crop grown in tropical, sub-tropical and temperate regions of the world (Katyal. 1985). It is a highly cross-pollinated crop, biennial for seed production and annual for bulb production. It is cultivated year round, but maximum area is cultivated during *Rabi* season in our country. It displays great morphological diversity in bulb and leaf size, colour and shape, flower colour, fertility and bulbil (top set) development (Pooler and Simon., 1993) [10]. Two types of onion are commercially grown in India. The first type is common onion *(Allium cepa* L), whose bulbs are large, normally single, and its plants are propagated through seeds. The second type is multiplier onion (*Allium cepa* L. *var aggregatum* Don.) which produces small sized bulbs, many in number to form an aggregated cluster.
Onion belongs to the genus Allium which possesses enormous wealth of genetic diversity. Extent of genetic diversity determines the success level of crop improvement programme. Maximum diversity can be noticed among different cultivars available in India and outside with respect to shape, size, yield, quality and other traits. Collection and maintenance of the genetic diversity in onion is important to avoid genetic erosion. Besides the identification of species, the characterization and evaluation of genotypes are of fundamental importance. Among the various methods identified/developed to study the genetic divergence in the genotypes, the Mahalanobis D^2 (Mahalanobis., 1936) [5] is reliable and most frequently used.
Genetic divergence analysis estimates the extent of diversity present among the genotypes and these could help the plant breeder in selecting the diverse parents for purposeful hybridization. It is an efficient tool for an effective choice of parents for hybridization programme. Therefore, the present study has been undertaken to estimate the genetic diversity of onion genotypes.

Materials and Methods
The experiment was carried out at College of Horticulture, Rajendranagar, Hyderabad, Telangana during *Rabi* season of 2021. The experimental site is situated at the altitude of the 542.3m above the mean sea level on 17o 191 North latitude and 79o 231 East longitude. The material comprised of forty genotypes of onion (*Allium cepa* L.). The experiment was laid out in a randomized block design (RBD) with three replications. The unit plot size was 1.5 x 3.0 m2. Row to row distance was 15cm and plant to plant distance was 10 cm.

Five plants were selected at random in each plot to record plant height, number of leaves per plant, days to maturity, neck thickness, equatorial bulb diameter, polar bulb diameter, average bulb weight, yield, bulb colour, bulb shape, ascorbic acid content and TSS. The data subjected to Mahalanobis D2 statistics to measure the genetic divergence as suggested by Rao (1952) [11].

Results and Discussion

The analysis of variance showed significant difference among all fortygenotypes for all the traits indicating sufficient genetic diversity among the genotypes.

D2 statistics, a concept developed by Mahalanobis (1936) [5] helps the plant breeder to classify the genotypes into different groups based on genetic divergence between them. Rao (1952) [11] suggested the application of this technique for the assessment of genetic diversity in plant breeding. In the present study, the estimates of D2 values ranged from 0 to 150.67 in onion. The high range for D2 values indicated the presence of great amount of diversity in onion genotypes under study. High range for D2 values were also obtained by Patil (1984) [9] and Shintre (1994) [13].

The genotypes under study were grouped into twelve clusters (Table 1). Cluster I contained 17 genotypes, followed by cluster V (6 genotypes), cluster VIII (5 genotypes) and cluster IV (4 genotypes). The clusters II, III, VI, VII, IX, X, XI and XII were monogenotypic. Similar work reported by Mohanty and Prusti (2002) [8], Gurjar *et al.* (2003) [2] and Rashid *et al.* (2012) [12].

Intra and inter cluster D2 values were worked out using D2 values from divergence analysis presented in Table 2. The minimum inter-cluster distance was observed in the cluster III and II (D2 = 13.56), followed by cluster X and VII (D2 = 22.06) and cluster VI and II (D2 = 25.07). Genotypes falling between cluster VIII and VII exhibited maximum inter-cluster distances (D2 = 150.67) followed by cluster X and VIII (D2 = 149.97) and cluster XII and XI (D2 = 132.73) indicating that genetic makeup of genotypes falling in this cluster may be entirely different from one another. The minimum intra-cluster distance was found in cluster I (D2 = 20.44). The maximum intra cluster distance was observed for the genotype falling in cluster VIII (D2 = 35.94) followed by V (D2 = 29.83). This implies that these clusters have the genotype with varied genetic architecture. The clusters II, III, VI, VII, IX, X, XI and XII showed zero intra cluster distance due to monogenotypic nature.

The cluster means for ten characters reveled wide range of variability among the clusters for the characters plant height (49.55 to 57.46), number of leaves per plant (8.53 to 11.73), days to maturity (103.00 to 120.33), neck thickness (0.96 to 1.80), equatorial bulb diameter (5.12 to 6.23), polar bulb diameter (4.53 to 5.67), ascorbic acid (8.37 to 11.99), TSS (10.87 to 13.86), average bulb weight (58.97 to 116.53) and yield per hectare (26.20 to 52.80) presented in Table 3. Earlier workers Singh *et al.* (2013) [14] and Kale *et al.* (2014) also reported wide variability among the clusters for yield and most of the yield contributing characters.

Each trait contributed in different proportions to total genetic diversity. Numberof times each of ten traits appeared in first rank and its respective per cent contribution towards genetic divergence are presented in Table 4. Total Soluble Solids contributed maximum (28.33%)towards diversity by taking 221 times first ranking, followed by neck thickness(24.36%) by 190 times, ascorbic acid (21.15%) by 165 times average bulbweight (14.10%) by 110 times, yield per hectare (4.87%) by 38 times, days tomaturity (4.10%), number of leaves per plant (1.92%) by 15 times, plant height(0.64%) by 5 times and equatorial bulb diameter (0.51%) by 4 times. Incontrast, the remaining traitviz., polar bulb diameter did not contribute tothe total divergence. Mohanty (2001) [7] also reported highest contribution from bulb weight. Dhotre *et al.* (2010) [1] revealed that equatorial bulb diameter and bulb yield as maximum contributing traits towards genetic diversity.

Table 1: Clustering pattern of forty genotypes of onion

Cluster	No. of genotypes	Genotypes
I	17	Bhima Shubra, W-464, W-045, W-364, W-444,Bhima Kiran, 1785,W-182, W-226cp, Bhima Red, Bhima Super, W-390, W-1786,BhimaSafed,1768,W-500,BhimaRaj
II	1	BhimaShakti
III	1	1771
IV	4	1774, 1772,1742,1784
V	6	W-253cp,W-246cp, 1773,W-203, W-398,W-405cp
VI	1	W-498
VII	1	W-405
VIII	5	W-125,BhimaShwetha,1770, 1744,1745
IX	1	W-177
X	1	W-210
XI	1	W-507
XII	1	1769

Table 2: Average intra (bold) and inter-cluster D2 values for twelve clusters in forty genotypes of onion

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
I	20.44	27.66	30.09	52.14	52.27	30.36	43.74	72.49	46.06	37.5	42.92	50.48
II		0	13.56	76.8	64.69	25.07	71.00	48.65	51.06	72.12	74.62	61.19
III			0	60.56	79.61	34.22	91.57	54.76	38.44	75.73	93.03	32.29
IV				20.93	52.88	92.61	101.11	70.02	53.22	97.15	71.26	63.15
V					29.83	100.85	50.73	100.37	103.96	77.93	54.89	98.4
VI						0	78.16	77.74	30.49	49.91	56.91	68.93
VII							0	150.67	131.08	22.06	41.27	101.83
VIII								35.94	59.84	149.97	116.03	107.2
IX									0	81.65	61.85	76.71

X										0	24.21	97.76
XI											0	132.73
XII												0

Table 3: Mean values of clusters for ten characters in forty onion genotypes

Cluster	Plant height (cm)	No. of leaves per plant	Days to maturity (days)	Neck thickness (cm)	Equatorial bulb diameter (cm)	Polar bulb diameter (c m)	Ascorbic acid (mg 100-1g)	TSS (oBrix)	Average bulb weight (g)	Yield (t ha-1)
I	55.52	10.48	110.16	1.35	5.66	4.97	10.60	12.09	86.78	39.03
II	57.46	10.53	118.00	1.76	5.71	4.91	11.02	11.53	89.75	40.52
III	49.55	11.73	120.33	1.55	5.82	5.16	10.31	11.03	100.50	44.66
IV	52.73	10.88	109.75	1.16	6.23	5.61	9.70	13.06	114.00	51.58
V	54.71	10.50	116.28	1.36	5.68	5.00	9.74	13.86	89.27	39.67
VI	55.21	8.53	112.33	1.48	5.67	4.98	11.99	10.87	84.03	37.35
VII	55.22	10.80	103.00	1.23	5.12	4.53	10.06	13.3	58.97	26.2
VIII	56.00	11.00	104.20	1.80	6.37	5.67	11.42	12.18	116.53	52.8
IX	57.01	10.13	118.67	1.23	6.07	5.34	11.95	11.23	111.60	49.59 28.35 34.23 45.74
X	54.21	11.60	110.67	0.96	5.32	4.74	11.06	12.27	63.80	
XI	56.54	10.27	112.33	1.03	5.5	4.92	11.97	13.3	77.03	
XII	57.00	9.93	110.67	1.33	5.94	5.27	8.37	11.00	102.93	

Table 4: Per cent contribution of different characters towards genetic divergence in forty onion genotypes

S. No	Source	Times ranked 1st	Contribution (%)
1	Plant height (cm)	5	0.64
2	No. of leaves per plant	15	1.92
3	Days to maturity (days)	32	4.10
4	Neck thickness (cm)	190	24.36
5	Equatorial bulb diameter (cm)	4	0.51
6	Polar bulb diameter (cm)	0	0.00
7	Ascorbic acid (mg 100-1 g)	165	21.15
8	Total Soluble Solids (oBrix)	221	28.33
9	Average bulb weight (g)	110	14.10
10	Yield per hectare (t ha-1)	38	4.87

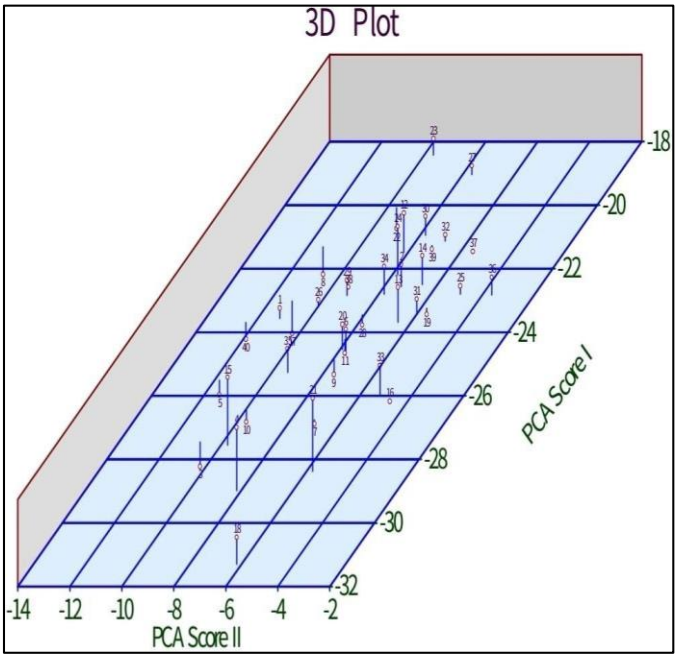

Fig 1: Dendrogram showing clustering pattern for divergence of forty onion genotypes

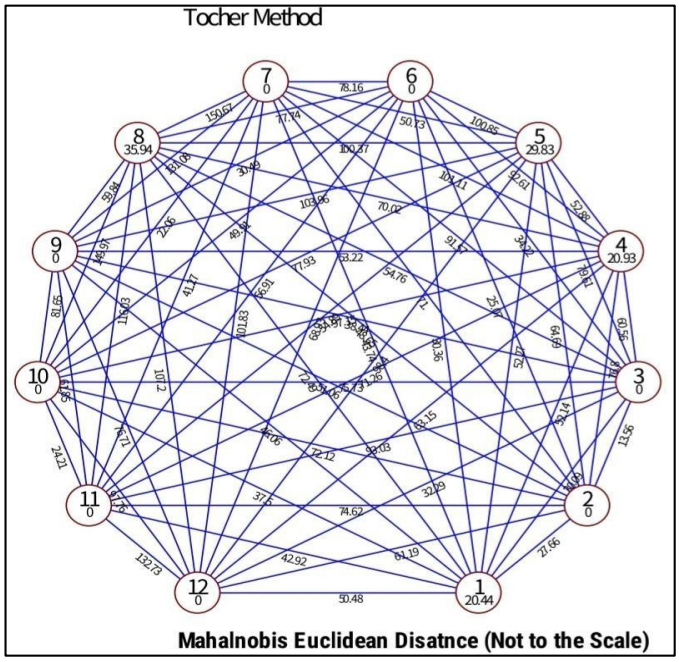

Fig 2: Three - dimensional plot showing clustering pattern for divergence of forty onion genotypes

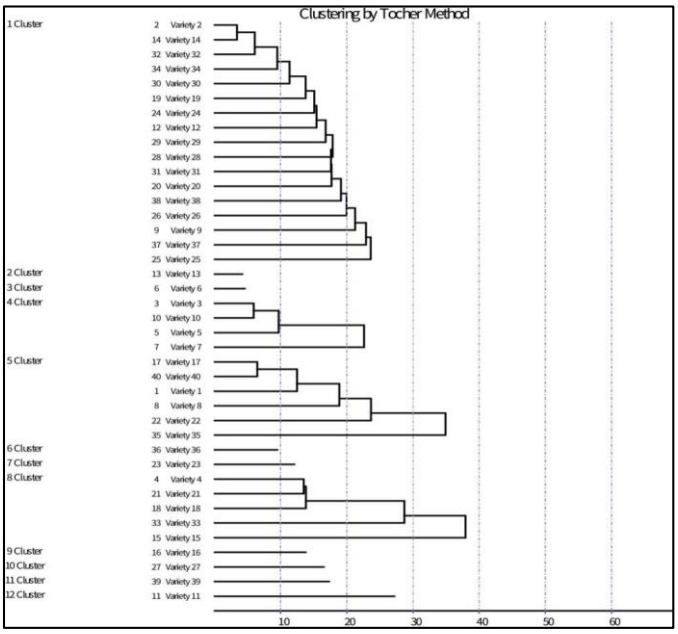

Fig 3: Cluster diagram showing average intra and inter-cluster D2 values of onion genotypes

Conclusion

In overall D2 analysis for onion suggested genotypes 1770, 1774, Bhima Shwetha, W-125 and 1772 were the most diverse parents which could be used in crossing programme. The superior most diverse genotypes identified could be utilized in breeding programmes to improve and to widen the genetic base of onion for the selection of superior lines. Genotypes with multiple superior traits could be utilized for simultaneous transfer of multiple genes in crop improvement.

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