Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(3): 463-466
Received: 25-03-2019
Accepted: 27-04-2019

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Genetic divergence studies in aggregatum onion (*Allium cepa* L. var. *aggregatum* Don.) genotypes using Mahalanobis D^2 analysis

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Abstract
Twenty genotypes of aggregatum onion were evaluated for eighteen growth, yield and quality characters to estimate the genetic diversity among them by Mahalanobis D^2 statistics. The genotypes were grouped into seven clusters. Cluster V contained maximum number of genotypes (six genotypes) followed by cluster IV (four genotypes), cluster III (Three genotypes), cluster VI, II and I (Two genotypes).Cluster VII was monogenotypic. The clusters IV and VII had highest inter cluster distance. The maximum mean values for plant height, leaf length and yield per plot was observed by the genotypes of clusters II. The maximum number of leaves and number of tillers was recorded by the genotypes of the cluster V. Maximum leaf girth and maximum bulb length was observed by the genotypes of cluster VII. The genotypes of cluster I has shown maximum bulb diameter. The genotypes of cluster IV and VI recorded maximum number of bulbs. Maximum chlorophyll content and yield per plant was recorded by the genotypes of the cluster IV. Therefore it was concluded that these clusters and their genotypes could be intercrossed in order to achieve more variability.

Keywords: Aggregatum onion, *Allium cepa* L. var. *aggregatum* Don, genotypes, genetic divergence, Mahalanobis D^2 analysis

Introduction
Onion (*Allium cepa* L.) is one of the important vegetable crops of Alliaceae family. 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 (Hanlet, 1990) [3]. Tamil Nadu accounts for five percent of country's area under onion and more than 70 percent of the area is cultivated by small onion. Around 90 percent of country's small onion is produced from Tamil Nadu and 10 percent from Karnataka (Visalakshi, 2018) [10]. The present study was undertaken with an objective to study the genetic diversity of bulb yield and its components in aggregatum onion using Mahalanobis D^2 analysis statistics.

Materials and Methods
The present investigation was carried out with twenty genotypes of aggregatum onion collected around Tamil Nadu region. The experiment was conducted in Randomized Block Design with two replications at Western farm, Department of vegetable crops, Horticultural College and Research Institute, Periyakulam located on 10.126' North latitude, 77.58 East longitude and at an altitude of 426.76 m above Mean Sea Level. Data was recorded on the five randomly selected plants for eighteen characters *viz*., plant height (cm), Leaf length (cm), Number of tillers, Number of leaves, Leaf girth (cm), bulb length (cm), bulb diameter (cm), number of bulbs per clump, root length (cm), Total soluble solids (^{b}rix), ascorbic acid (mg100g^{-1}), pyruvic acid (µ mol g^{-1}), protein content (%), chlorophyll content (mg g^{-1}), fresh weight of bulb (g), dry weight of bulb (g), curing percentage, yield per plot (kg). The data for eighteen quantitative and qualitative characters were statistically analyzed to study genetic diversity by Mahalanobis D^2 statistic as per Rao, 1952 [6].

Results and discussion
Divergence analysis is performed to identify the diversity in genotypes. (Mahalanobis, 1936) [4]. In the present study, the high variability among the types was confirmed by D2 analysis, in that all the twenty genotypes were distributed over seven clusters according to Tocher's method The twenty genotypes were grouped into seven clusters. Cluster V was the largest cluster which comprised six genotypes followed by cluster IV with four genotypes.

The cluster III contains three genotypes, cluster I, II and VI contains two genotypes respectively, cluster VII contain least genotype with only one (Table 1). Genotypes falling in the highly divergent groups will help in broadening the existing genetic base and may produce new genotypes with previous unknown combinations. The clustering pattern indicated that the genotypes did not cluster as per the geographical distribution but due to genetic differences. This is in agreement with the result of Bharti *et al*., 2000 [1], Chandanshive Aniket Vilas, 2010 [2] in garlic.

He cluster means reveal the best cluster for various characters. The clustering pattern could be utilized in choosing parents for cross combinations likely to generate the highest possible variability for various characters (Chandanshive Aniket Vilas, 2010 [2]. If a breeding programme is aimed at producing high yield that should utilize cluster I with maximum bulb diameter, maximum curing percentage, with the maximum plant height, leaf length. The qualitative characters were high in the cluster IV (Total soluble solids and chlorophyll content), Cluster I (Pyruvic acid), Cluster VII (Protein content), Cluster VI (Ascorbic acid content) (Table 2). The results obtained are in agreement with earlier reports of Mohanty and Prusti, 2002 [5] in onion and Shashidhar and Dharmatti, 2005 [7], Chandanshive Aniket Vilas, 2010 [2] in garlic.

The highest inter cluster distance and values were observed in the cluster IV with 96.388 and 9290.64 respectively. The lowest D^2 distance and D values recorded in cluster II with 18.387 and 338.092 respectively. The highest intra cluster distance and values recorded in the cluster VI with 30.883 and 953.757 respectively and the lowest intra cluster distance and values were observed in the cluster I with 7.286 and 53.086 respectively (Table 3,Fig 1).

Ranking character wise D^2 values and adding the ranks for each character for all the entries identified the variable contribute towards the total divergence. The rating technique was adopted to rank the characters based in its contribution to its total genetic divergence. The highest contribution to genetic divergence was by bulb yield per plot (79.47 per cent) followed by dry weight of bulb per plant (13.68%), Protein content (3.68%), Total soluble solids (2.13%), Pyruvic acid content (0.52%) and curing percentage (0.52%) (Table 4). Thus the characters which are highly contributing towards the genetic diversity will help while selecting elite genotypes for further improvement in onion. This is in accordance with the findings reported by Singh *et al*., 2010 [8] in and Sopal singh *et al*., 2018 [9] in garlic.

Table 1: Clustering pattern of twenty onion genotypes

Cluster	Number of Genotypes	Genotypes	Place of Collection
1	2	Ambilikai	Coimbatore
		Surandai	Tirunelveli
2	2	Kundadam	Dindigul
		Aathakovil	Theni
3	3	Puttarasal	Palladam
		Theni local	Theni
		Rottupudhur	Theni
4	4	Aalandhurai	Theni
		Kedayarumbu	Dindigul
		Ottanchathiram-1	Dindigul
		Gnanamedu	Cuddalore
5	6	Thurayur-1	Trichy
		Thurayur-2	Trichy
		Thurayur-3	Trichy
		P.N.Patti	Theni
		Namakkal	Namakkal
		Ottanchathiram-2	Dindigul
6	2	Co(On)-5	Dindigul
		Alagupatti	Theni
7	1	Mutlur	Cuddalore

Table 2: Cluster means for twenty onion genotypes

Characters and cluster	I	II	III	IV	V	VI	VII
Plant height (cm)	30.25	33.97	33.46	33.26	32.86	29.51	32.47
Leaf length (cm)	28.27	31.87	31.03	30.96	30.85	27.76	30.25
Number of tillers	5.55	5.25	5.53	5.62	5.64	5.45	3.15
Number of leaves	23.65	22.40	25.23	25.21	25.67	24.28	15.10
Leaf girth (cm)	2.41	2.21	2.41	2.38	2.64	2.56	2.67
Bulb length (cm)	3.19	2.62	2.81	2.81	2.88	3.18	3.60
Bulb diameter (cm)	3.34	2.81	3.03	3.05	2.87	2.72	2.07
Number of bulbs per clump	2.95	2.95	2.97	3.00	2.85	3.00	2.80
Root length (cm)	4.69	4.86	4.84	4.87	4.93	5.02	4.82
TSS (^{o}brix)	11.24	12.97	11.37	15.18	12.28	14.22	12.22
Ascorbic acid(mg100g^{-1})	7.48	7.52	8.13	7.97	8.02	9.17	8.05
Pyruvic acid(µ mol g^{-1})	2.46	2.23	2.42	2.40	2.39	2.45	2.38
Protein content (%)	16.75	16.25	16.68	16.81	15.74	16.00	17.20
Chlorophyll content(mg g^{-1})	0.66	0.67	0.65	0.67	0.66	0.66	0.57
Fresh weight of bulb per plant(g)	47.31	63.24	49.15	54.63	51.45	67.25	38.47
Dry weight of bulb per plant (g)	36.15	42.44	30.37	40.68	36.46	42.21	29.28
Curing per centage	77.33	69.89	66.84	74.24	71.45	63.00	77.15
Yield per plot	4.34	5.02	3.62	4.73	4.27	4.98	3.44

Table 3: D^2 values and distance of inter and intra clusters

Clusters	I	Ii	Iii	Iv	V	Vi	Vii
I	53.08 (7.28)	1867.57 (43.21)	503.47 (22.43)	2096.31 (45.78)	426.79 (20.65)	487.73 (22.08)	3209.87 (56.65)
II		101.76 (10.08)	1803.78 (42.47)	338.09 (18.38)	1456.80 (38.16)	1294.87 (35.98)	9058.29 (95.17)
III			357.95 (18.92)	1725.46 (41.53)	525.83 (22.93)	783.06 (27.98)	3897.05 (62.42)
IV				447.94 (21.16)	1590.16 (39.87)	1522.73 (39.02)	9290.64 (96.38)
V					584.10 (24.16)	600.22 (24.50)	4255.88 (65.23)
VI						953.75 (30.88)	4527.06 (67.28)
VII							0

- Values in bracket () indicates inter and intra cluster D^2 distances
- Diagonal value indicates intra cluster divergence
- Off diagonal value indicates inter cluster divergence

Table 4: Contribution of characters to divergence of onion genotypes

Characters	Rank	Per cent contribution
Plant height	0	0
Leaf length	0	0
Number of tillers	0	0
Number of leaves	0	0
Leaf girth	0	0
Bulb length	0	0
Bulb diameter	0	0
Number of bulbs per clump	0	0
Root length	0	0
TSS	4	2.1053
Ascorbic acid	0	0
Pyruvic acid	1	0.5263
Protein content	7	3.6842
Chlorophyll content	0	0
Fresh weight	0	0
Dry weight of bulb	26	13.6842
Curing per centage	1	0.5263
Yield per plot	151	79.4737
TOTAL	190	100

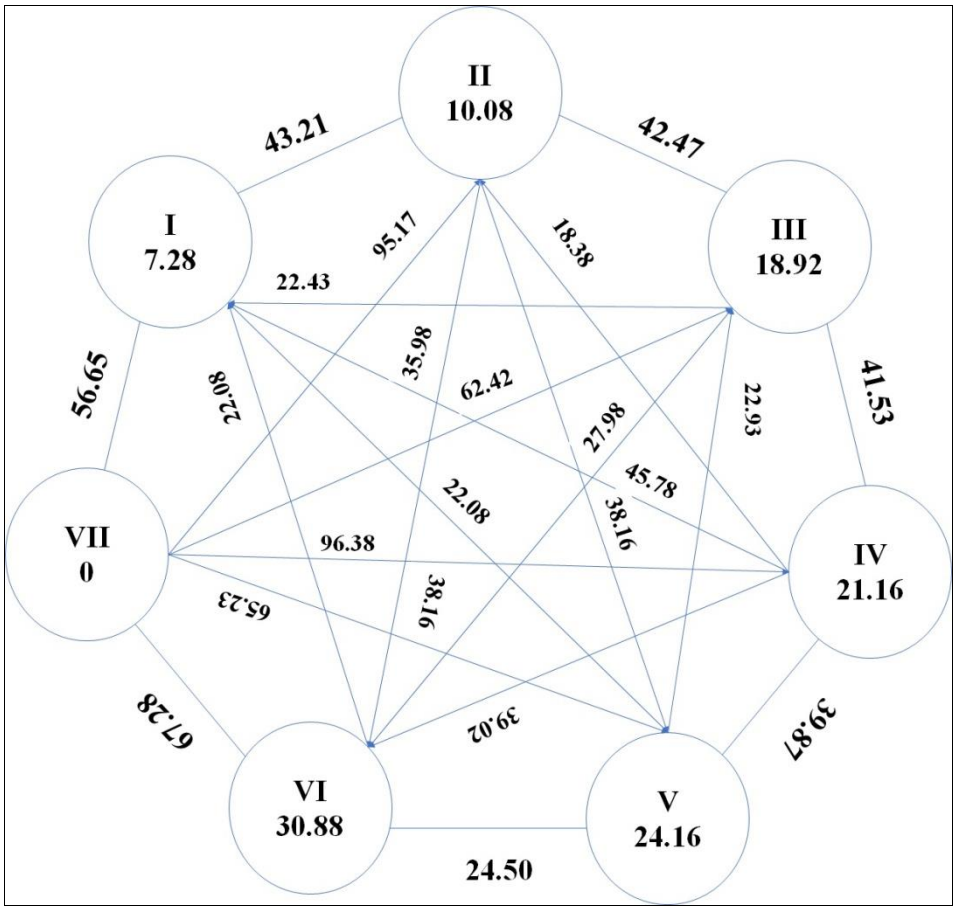

Fig 1: Inter and Intra cluster D^2 values in onion

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