Gregor Mendel Foundation Proceedings 2007: 27-32.

Genetic divergence studies in grain amaranth (*Amaranthus spp.* L.)

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Abstract: *Euclidean cluster analysis was used for the characterization of germplasm of different geographical origin of grain amaranth (Amaranthus spp, L.). A quantitative assessment of genetic divergence for thirteen characters using Mahalonobies D^2 statistics revealed the presence of considerable genetic diversity. The 100 genotypes were grouped into sixteen clusters with variable number of genotypes. The clustering pattern revealed cluster II to be the largest consisting 31 genotypes followed by Cluster IX with 20 genotypes. Intra cluster distance was the highest in Cluster VIII followed by Cluster IX and Cluster I. The inter cluster D values ranged from 15.12 between Cluster XI and XV to 186.98, indicating presence of high divergence among the genotypes. Seed yield per plant contributed more towards divergence with 35.35% followed by dry weight of panicle (25.43%) and fresh weight of panicle (20.08%). Among the plant attributes, seed yield per plant, dry weight of panicle, panicle length, harvest index and number of spikes per panicle were found to be important. Accessions GP-BGA-3, IC-38127 and IC-423400 from cluster VIII and IC-452224, IC-415250, IC- 519558, IC-415387 and IC-415318 from the cluster XV were identified as potential parents in future hybridization programmes for genetic improvement in grain amaranth.*

Key Words: Grain amranth, genetic divergence, cluster, cluster means

INTRODUCTION

Grain amaranth belongs to the family Amaranthaceae and genus *Amaranthus*. In relation to major crops in many developing areas of the world the carrying capacity of the land is rapidly being exceeded because of increasing population growth. In maintaining sustainability in production and food security, underutilized pseudocereals like grain amaranth plays a very important role through its high nutritional value. Archeological findings in Thuacan in Puebbla, Mexico show that they were cultivated over 6000 years ago. The crude protein content of grain amaranth is reported to vary from 8% to 22%, which is comparable to any other common grains except soybean. Since the food uses of grain amaranth are similar to that of cereal grain grasses like wheat and oat, grain amaranth is also called a 'pseudocereal'. Though there has been an increasing trend in area, production and productivity of grain amaranth in the country from decades, concerted efforts are still required towards breeding highly productive cultivars to bridge the gap between the domestic and international level of productivity. Study of genetic divergence among a set of genotypes will therefore enable a plant breeder to choose suitable parents and plan an appropriated hybridization programme. D^2 statistics has proved to be a powerful tool in determining genetic divergence based on multiple growth characters, in asserting relative characters and assessing relative contribution of different components to total divergence (Bhatt, 1973). The present study was conducted to determine the magnitude of variability in yield and its attributing traits for identifying the promising genotypes of grain amaranth.

MATERIALS AND METHOD

The material used in the current study comprises of 100 genotypes of three different species of grain amaranth of different geographical origin obtained from AICRIP on Underutilized Crops, Main Agricultural Research Station, Hebbal, Bangalore, India. The experiment was laid out at Main Agricultural Research Station, Hebbal, Bangalore in 10 x 10 simple lattice design with two replications and the investigation was carried out during *kharif* 2006, to assess the genetic divergence of the crop.

RESULTS AND DISCUSSION

The results from the analysis of variance revealed highly significant differences among genotypes for all the 13 characters studied. The 100 genotypes were grouped into sixteen clusters with variable number of genotypes. The clustering pattern revealed cluster II to be the largest of all consisting of 31 genotypes followed by cluster IX with 20 genotypes and cluster XVI with 14 genotypes. The distribution pattern of genotypes into various clusters is shown in Table 1. Intra cluster distance was the highest in Cluster VIII with D^2 value of 7706.24 followed by Cluster IX (7175.65) and Cluster I (5875) (Tables 2&3). The study of intracluster distances indicated that, the maximum amount of heterosis was expected in the cross combination involving the genotypes of most divergent cluster. These results were in accordance with results of Lohithaswa (1992) and Asthana *et al.* (1998).

The minimum inter cluster D value (15.12) was observed between cluster VII and XI, indicating close genetic association between the genotypes of these two clusters. Cluster XV was the most diverse cluster as many clusters except VIII showed maximum inter cluster distance with it. Hence, it would be logical to incorporate genotypes from these clusters in further breeding programmes. These observations are also in accordance with the reports of earlier workers like Khumkar and Singh (2002) and Indra Singh and Garg (2003). Seed yield per plant contributed the highest towards divergence with 35.35% followed by dry weight of panicle (25.43%) and number of leaves (0.02%) was the least contributing trait towards total divergence (Table.3).These observations are also in accordance with the reports of earlier workers (Joshi and Rana, 1995; Bergale *et al.*, 2001; Shiv Datt and Mani, 2003). Greater emphasis should be laid on those characters contributing maximum to the D^2 values for the purpose of further selection and choice of parents for hybridization.

The genotypes in cluster IV were the earliest to flower within 43 days, while the genotypes in cluster XV were late to mature in 98 days. The lowest number of leaves per plant (35) was found in cluster IV. The genotype with low mean value for number of branches per plant (16) was found in cluster XI, while highly branched genotypes with the highest mean value (20) were accumulated in cluster VII. The shortest genotype (176cm) was included in cluster XV. Cluster XV recorded the highest (44.32g) seed yield per plant (Table.5). The same results were noticed by the earlier workers Waghmode *et al.* (1997) and Datta and Mukherjee (2004).

Rational choice of parents on the basis of their genetic diversity can provide the scope for rapid improvement. Hybridization between the genetically divergent genotypes will result in accumulation of favourable genes and produce a wide spectrum of variation in the segregating progeny (Shiva Datta and Mani, 2003). In the present study, among the plant attributes, seed yield per plant, dry weight of panicle, panicle length, harvest index and number of spikes per panicle were found to be important. Accessions GP-BGA-3, IC-38127 and IC-423400 from cluster VIII and IC-452224, IC-415250, IC-519558, IC-415387 and IC-415318 from cluster XV were identified as potential parents in future hybridization programmes for genetic improvement in grain amaranth.

Table 1. Composition of grain amaranth genotypes in different clusters

Clusters	Numbers	Genotypes
I	7	EC-519544,IC-42311, IC-37316, IC-415448, IC-415449, IC-415322, GP-BGA-16
II	31	IC-415290, IC-415266,IC-415272,IC-415264, IC-423448, EC-519554, IC-415318, IC-415297, IC-415262, IC-413426, EC-519549, EC-519526, EC-519522, IC-423408, GP-BGA-19, GP-BGA-20, GP-BGA-14, GP-BGA-12, GP-BGA-11, GP-BGA-27, GP-BGA-28, GP-BGA-24, GP-BGA-18, GP-BGA-9, GP-BGA-25, GP-BGA-8, GP-BGA-22, GP-BGA-5, GP-BGA-21, IC-415314, IC-415462
III	2	IC-415433, IC-519542
IV	2	IC-519549, EC-519532
V	2	GP-BGA-21, IC-415252
VI	2	IC-415271, IC-415274
VII	2	IC-415290, Annapurna
VIII	3	GP-BGA-3, IC-38127, IC-423400
IX	20	IC-GP-BGA-6, GP-BGA-1, GP-BGA-23, GP-BGA-26, GP-BGA-17, GP-BGA-7, GP-BGA-4, IC-415258, IC-98312, IC-415232, KBGA-1, IC-415317, IC-423408, EC-519526, IC-415258, IC-415284, IC-415331, IC-403548, IC-423398, IC-519512
X	2	IC-519543, EC-524457
XI	2	IC-415282, IC-415243
XII	2	IC-415266, IC-415316
XIII	2	IC-415220, IC-415320
XIV	2	IC-415236, IC-415466
XV	5	IC-415224, IC-415250, IC-519558, IC-415387, IC-415318
XVI	14	EC-519554, IC-519527, EC-519517, IC-415272, EC-519531, IC-415254, IC-423410, IC-415297, EC-519592, IC-519548, IC-423544, IC –421885, IC-415284, IC-415448

Table 2. Average inter cluster (above diagonal) and intra-cluster (diagonal) D^2 values for 16 clusters in grain amaranth.

Clusters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	IX	XV	XVI
I	**5875.43**	5465.52	5797.57	7203.60	7647.82	9104.78	3182.05	14414.10	6183.94	4160.64	3517.09	3084.93	3754.12	6248.19	15760.07	5875.81
II		**5109.72**	3928.46	4910.81	5136.01	6256.13	3002.02	18428.23	6346.66	3519.80	3026.68	2776.79	2959.68	4329.99	20321.15	4964.87
III			**84.10**	500.27	471.11	1152.78	1776.41	24952.43	6888.12	1411.14	1157.96	1733.07	892.00	348.77	27500.73	2667.23
IV				**102.03**	874.39	1738.00	2722.90	26794.81	7975.72	1600.63	2008.99	2480.25	1922.24	241.96	29932.11	3396.40
V					**108.70**	294.73	3454.44	29200.31	8508.95	3010.34	2665.31	3328.55	1743.07	904.40	32001.70	3696.71
VI						**123.**50	4888.75	32164.67	9874.59	4611.81	3941.82	4736.94	2672.84	1795.22	34961.62	4733.31
VII							**128.33**	14896.94	4486.08	520.65	228.63	238.44	580.36	2131.59	16628.88	2596.85
VIII								**7706.24**	15422.96	17294.48	16907.04	14769.29	18473.80	25038.20	5105.36	20882.54
IX									**7175.65**	5423.50	4896.00	4129.18	4969.15	7250.38	17060.37	7062.52
X										**180.10**	410.08	530.28	967.62	1239.57	19564.93	2641.21
XI											**196.99**	317.63	474.17	1424.60	18785.17	2342.92
XII												**210.79**	688.11	1957.69	16696.19	2576.66
XIII													**250.94**	1389.85	20350.41	2326.63
IV														**284.87**	27863.95	2914.06
XV															**5670.30**	22963.57
XVI																4549.49

Table 3. Inter and intra cluster distances in grain amaranth

Clusters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
I	**76.65**	73.93	76.14	84.87	87.45	95.42	56.41	120.06	78.64	64.50	59.31	55.54	61.27	79.05	125.54	76.65
II		**71.48**	62.68	70.08	71.67	79.10	54.79	135.75	79.67	59.33	55.02	52.70	54.40	65.80	142.55	70.46
III			**9.17**	22.37	21.71	33.95	42.15	157.96	83.00	37.57	34.03	41.63	29.87	18.68	165.83	51.65
IV				**10.10**	29.57	41.69	52.18	163.69	89.31	40.01	44.82	49.80	43.84	15.56	173.01	58.28
V					**10.43**	17.17	58.78	170.88	92.24	54.87	51.63	57.69	41.75	30.07	178.89	60.80
VI						**11.11**	69.92	179.35	99.37	67.91	62.78	68.83	51.70	42.37	186.98	68.80
VII							**11.33**	122.05	66.98	22.82	15.12	15.44	24.09	46.17	128.95	50.96
VIII								**87.79**	124.19	131.51	130.03	121.53	135.92	158.24	71.45	144.51
IX									**84.71**	73.64	69.97	64.26	70.49	85.15	130.62	84.04
X										**13.42**	20.25	23.03	31.11	35.21	139.88	51.39
XI											**14.04**	17.82	21.78	37.74	137.06	48.40
XII												**14.52**	26.23	44.25	129.21	50.76
XIII													**15.84**	37.28	142.66	48.24
XIV														**16.88**	166.93	53.98
XV															**75.30**	151.54
XVI																**67.45**

Values in bold are intra-cluster distances

Table 4. Contribution of the characters towards genetic divergence in grain amaranth

Sl. No.	Characters	Rank	Contribution in per cent
1.	Days to 50 % flowering	13	0.26
2.	Days to maturity	0	0.00
3.	Stem girth at collar region (cm)	0	0.00
4.	Number of leaves	1	0.02
5.	Number of branches	0	0.00
6.	Plant height (cm)	16	0.34
7.	Panicle fresh weight (g)	994	20.08
8.	Panicle length (cm)	436	8.80
9.	Number of spikelets per panicle	19	0.38
10.	Dry weight of panicle (g)	1259	25.43
11.	Dry weight of stem (g)	164	3.32
12.	Harvest index (%)	298	6.02
13.	Seed yield per plant (g)	1750	35.35

Table 5. Cluster mean values for 13 different characters in grain amaranth

Clusters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
I	52.91	93.44	5.74	41.85	17.26	175.27	248.15	83.69	76.69	137.74	106.59	12.43	30.12
II	51.03	94.41	6.01	38.39	18.97	170.36	225.79	80.15	73.34	127.59	99.85	12.13	27.37
III	47.14	93.13	5.93	42.65	19.63	165.22	199.29	79.26	65.64	91.76	103.40	12.64	24.65
IV	42.66	94.75	5.53	34.53	19.56	159.68	195.82	59.68	65.33	89.40	102.50	12.72	24.40
V	51.60	96.35	5.85	41.03	17.02	160.13	183.78	82.27	48.86	89.42	98.67	10.51	19.75
VI	51.60	89.44	5.31	39.28	19.04	133.72	173.28	89.93	45.93	87.33	96.25	9.33	17.07
VII	47.15	96.35	6.28	41.39	20.41	174.80	245.81	78.92	65.48	114.48	91.80	15.44	31.83
VIII	48.31	93.78	5.82	41.19	18.43	178.19	351.92	67.44	90.09	197.89	93.00	15.06	43.94
IX	48.95	95.23	5.94	38.04	18.98	168.11	241.66	77.29	74.99	148.27	94.27	12.03	29.11
X	48.21	91.63	5.96	34.90	16.11	180.02	238.95	62.01	75.10	103.90	102.36	14.98	30.89
XI	48.39	96.33	5.95	46.56	15.65	164.57	235.85	78.58	76.51	106.14	100.07	14.48	29.86
XII	48.34	96.36	5.48	40.75	17.87	172.74	239.68	73.42	81.61	120.06	91.01	14.33	30.17
XIII	52.56	89.38	6.11	37.25	19.51	167.34	227.95	85.28	53.46	110.05	98.67	12.22	25.43
XIV	46.39	94.29	6.20	41.20	16.98	155.02	200.54	64.99	67.45	91.92	116.08	11.76	24.38
XV	48.60	97.75	5.64	39.89	16.45	175.63	362.47	79.92	87.65	201.22	99.83	14.68	44.32
XVI	49.74	91.61	5.88	40.57	17.53	164.52	222.94	78.30	67.86	107.23	107.83	12.42	26.73

X_1 - Days to 50% flowering; X_6- Plant height (cm); X_{11}-Dry weight of stem(g)
X_2 - Days to maturity; X_7- Panicle fresh weight (g); X_{12}-Harvest index (%)
X_3- Stem girth at collar region (cm); X_8- Panicle length (cm); X_{13}- Seed yield per plant (g)
X_4 - Number of leaves; X_9- Number of Spikels per panicle
X_5- Number of branches per plant; X_{10}- Dry weight of panicle

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