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Genotypic variability in grain amaranthus (*Amaranthus hypochondriacus* L.) under varied plant densities

S. Ramesh Kumar* and G. Mohammed Yassin[1]

*Department of Horticulture, Vanavarayar Institute of Agriculture, Manakkadavu, Tamil Nadu Agricultural University, Pollachi,-642 103. [1]Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Tamil Nadu Agricultural University, Karaikal – 609 603, U.T. of Puduchery. *E-mail: rameshamar06@gmail.com*

Abstract

In grain amaranthus (*Amaranthus hypochondriacus* L.) ten genotypes were evaluated for twelve characters under four plant density levels *viz.,* very high-30 × 20 cm (D_1), high-30×30 cm (D_2), normal-45×20 cm (D_3) and low plant density-45×30 cm (D_4) levels to study the different selection parameters for grain yield and its eleven contributing morphological and quality traits. The study was conducted at College Orchard, Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, TNAU, Karaikal during *rabi* 2007. The results revealed that the GCV was maximum in high plant density when compared to very high, normal and low plant density levels for the characters *viz.,* fresh weight of the inflorescence, length of the rachis per inflorescence, grain yield per plant and total carbohydrates. In all the four plant density levels, leaf area at 50 per cent flowering, fresh weight of the inflorescence, number of secondary branches per inflorescence and total carbohydrates recorded high magnitude of genetic variability in combination with high heritability and genetic advance as per cent of mean.

Key words: *Amaranthus hypochondriacus*, grain yield, variability parameters, selection

Introduction

Among the various unexploited vegetable crops grain amaranthus is such a crop which is grown as leafy vegetable during summer and rainy season in India (Khurana, 2013). It is hardy, fast growing and is rich in seed protein, carotene and ascorbic acid. Amaranthus seed is a rich source of essential amino acid lysine and produces high quality seed protein up to 160g per kg seed being much higher than non-legume grain crops. In spite of the fact that vegetable amaranth is used as a cheap source of protein and staple food crop in many parts of the world, negligible efforts have been made for its genetic improvement (Shukla *et al.,* 2010). Recently, current interest in grain amaranth resides in the fact that it has a great amount of genetic diversity and phenotypic plasticity. Grain amaranths is extremely adaptable to adverse growing conditions, resist heat and drought, has no major disease problem and is among the easiest of plants to grow. Grain amaranth (*Amaranthus hypochondriacus* L.) remains a subsidiary under utilized crop for grain purpose. The genotypic and phenotypic coefficient of variation, heritability and genetic advance enable the plant breeders to study its genetic variability and potential genotypes. Since, many economic traits are quantitative in nature and highly influenced by the environment, it will be useful to partition the overall variability into its heritable and non-heritable components to know whether superiority of selection is inherited to the progenies (Parveen *et al*., 2013). Therefore to fill the lacuna, an experiment was carried out to study the different selection parameters for grain yield and its important yield contributing traits.

Materials and methods

The materials used in the present study comprised of ten genotypes of grain amaranthus received from the germplasm of NBPGR being maintained at University of Agricultural Sciences, Bangalore and Forestry College and Research Institute, Mettupalayam (Table 1).

The crop was raised during *rabi*, 2007 in a Randomized Block Design with three replications. Each genotype was raised in a bed size of 2 m x 1.5 m. The seeds were sown in line. The plants were thinned 15 days after sowing to maintain different levels of spacing *viz*., very high density (30 x 20 cm), high density (30 x 30 cm), normal density (45 x 20 cm) and low density (45 x 30 cm) (Table 2).

Table 1. Details of the genotypes studied

Genotypes	Source	Status
RMA 3	Rajastan	Released variety
BGA 2	NBPGR	Released variety
EC 519554	NBPGR	Exotic accession
SKNA 21	Gujarat	Released variety
Annapurna	New Delhi	Released variety
SKNA 601	Gujarat	Released variety
GA 2	Gujarat	Released variety
RMA 4	Rajastan	Released variety
I C 415290	NBPGR	Breeding line
PRA 2004 - 2	NBPGR	Breeding line

NBPGR: National Bureau of Plant Genetic Resources, New Delhi.

The recommended package of practices was followed as per the TNAU crop production guide (2005). Observations were recorded on five randomly selected plants of each genotype in each replication under different population densities for twelve characters *viz.,* plant height, days to percent flowering, length of the primary inflorescence, diameter of the inflorescence, leaf

Table 2. Spacing and plant population at different plant density levels

Density levels	Spacing (cm)	Plant population (plants m^{-2})	Plant population (plants ha^{-1})
D_1 – very high density	30 x 20	50	5,00,000
D_2 – high density	30 x 30	33	3,33,000
D_3 – normal density	45 x 20	30	3,30,000
D_4 – low density	45 x 30	22	2,22,222

area at 50 per cent flowering, fresh weight of the inflorescence, number of rachis per inflorescence, length of the rachis per inflorescence, number of secondary branches per inflorescence, grain yield per plant, total carbohydrates and protein content were analysed. For quality traits, composite samples drawn from five random plants of genotypes under different population densities were used for analysis.

Estimates of variability and genetic parameters: Phenotypic and genotypic coefficient of variation were estimated using the formula suggested by Burton (1952) and expressed in percentage. The estimates of PCV and GCV were categorized based on the scale suggested by Sivasubramanian and Menon (1973). Heritability in broad sense (h^2) was calculated according to Lush (1940) and expressed in per cent. The range of heritability, genetic advance and genetic advance as per cent of mean was calculated as suggested by Johnson *et al*. (1955).

Results and discussion

Variability is the most important characteristic feature of any population. Estimation of variability is an important prerequisite for realizing the response to selection as the progress in the breeding depends upon its amount, nature and magnitude. In the present investigation, the variability available for the twelve characters in the population of ten genotypes were analysed using the above three parameters in the four plant density levels. Allard (1960) was in the opinion that the difference between GCV values of different environments will give a best picture about the effect of environments on the genetic variability. On this basis, the effect of plant density levels on the genetic variability of characters was assessed in the present study. In general GCV was maximum in high plant density when compared to very high, normal and low plant density levels for the characters of fresh weight of the inflorescence, length of the rachis per inflorescence, grain yield per plant and total carbohydrates (Tables 3, 4, 5, 6). Similar findings were also obtained by Akaneme and Ani (2013). Plant height had the maximum variability in very high plant density and normal plant density. While leaf area at 50 per cent flowering had maximum variability at low plant density level. Normal and low plant density levels had high GCV for length of the primary inflorescence. Very high and high density showed high GCV for diameter of the inflorescence. Number of secondary branches per inflorescence recorded high GCV in normal density. For days to 50 percent flowering, very high plant density level showed higher GCV value than other plant density levels. High GCV was found in low plant density for protein content. These results indicated that expression of genetic variability was altered by different plant densities. In general, greater variability was found in high plant density followed by normal and low plant density. But, very high plant density expressed higher GCV for three traits only. The differential response of genotypes due to the competition among the plants could be responsible for the realization of greater genetic variability in the higher population density levels when compared to other plant density levels.

In the present study, the traits *viz.,* grain yield per plant, leaf area at 50 per cent flowering, fresh weight of the inflorescence, number of secondary branches per inflorescence and total carbohydrate content in that order registered high magnitude of GCV of more than 20 per cent in all the four plant density levels. Thus it could be inferred that, the selection for the improvement of these characters would be effective in all the plant density levels under study. Priya (2007) obtained high PCV and GCV for the above mentioned traits from her study. Plant height, length of the rachis per inflorescence and number of rachis per inflorescence exhibited a moderate amount of genetic variability of 10–19 per cent GCV in all the four plant density levels, revealing a considerable scope for improving these characters in desirable direction through a selection programme in all the four plant density levels. Sarker *et al*. (2014) reported high PCV and GCV for plant height, leaves per plant, diameter of stem base, fiber content, leaf area and foliage yield per plot seemed to be effective for the improvement of amaranth. Days to 50 per cent flowering recorded high GCV in very high and high plant density. Whereas, normal and low plant density levels this trait recorded low GCV. Moderate GCV was recorded for protein content in very high and high plant densities. In normal and low plant density levels it showed the high GCV for protein content. The results revealed that, these characters have limited utility in selection for improvement of the crop.

Table 3. Estimates of variability parameters for twelve characters in very high density (D_1 – 30 x 20 cm)

Characters	Range	Mean	PV	GV	PCV (%)	GCV (%)	h^2 (%)	GA as % of mean
Plant height (cm)	53.94 – 106.56	81.57	263.64	262.80	19.90	19.87	99.00	40.87
Days to 50 per cent flowering	31.15 – 59.47	44.45	132.32	131.87	25.87	25.83	99.66	53.12
Leaf area at 50 per cent flowering (sq.cm)	841.98 – 2131.57	1273.88	269769.18	269550.00	40.77	40.75	99.92	83.92
Length of the primary inflorescence (cm)	39.10 – 69.77	40.10	133.09	102.04	23.02	20.16	76.67	36.36
Diameter of the inflorescence (cm)	59.74 – 164.31	20.90	10.41	8.442	15.43	13.89	81.03	25.77
Fresh weight of the inflorescence (g)	80.25-150.36	87.62	1237.31	1116.52	36.03	34.22	90.24	66.98
Number of rachis per inflorescence	28.87 – 61.49	49.38	138.98	70.67	23.87	17.02	50.85	25.00
Length of the rachis per inflorescence (cm)	30.25 – 53.43	42.08	86.252	60.51	22.06	18.48	70.15	31.89
Number of secondary branches per inflorescence	3.29 – 8.28	4.70	2.475	2.03	33.42	30.31	82.27	56.65
Grain yield per plant (g)	6.13 – 24.63	13.33	46.53	36.37	51.15	45.22	78.17	82.36
Total carbohydrates content (g / 100g)	26.69 – 47.20	35.41	56.09	55.39	21.15	21.01	98.74	43.02
Protein content(g / 100g)	10.30 – 15.60	12.35	3.28	2.97	14.66	13.95	90.65	27.37

Table 4. Estimates of variability parameters for twelve characters in high density (D_2 – 30 x 30 cm)

Characters	Range	Mean	PV	GV	PCV (%)	GCV (%)	h^2 (%)	GA as % of mean
Plant height (cm)	59.16 – 99.04	72.87	227.24	132.27	20.68	15.78	58.21	24.80
Days to 50 per cent flowering	31.48 – 60.19	44.45	59.29	55.61	21.77	21.08	93.79	42.06
Leaf area at 50 per cent flowering (sq.cm)	834.22 – 2172.53	1282.88	260891.17	259998.93	39.81	39.74	99.66	81.73
Length of the primary inflorescence (cm)	36.90 – 64.59	48.63	130.52	60.10	23.49	15.94	46.05	22.28
Diameter of the inflorescence (cm)	15.10 – 25.74	21.58	6.44	4.48	15.43	13.89	81.03	25.27
Fresh weight of the inflorescence (g)	58.52 – 143.30	93.86	1161.40	1078.49	36.30	34.98	92.86	69.45
Number of rachis per inflorescence	38.61 – 63.25	51.49	76.20	48.20	16.95	13.48	63.26	22.09
Length of the rachis per inflorescence (cm)	29.79 – 52.02	43.38	82.11	73.89	20.88	19.81	89.98	38.71
Number of secondary branches per inflorescence	3.40 – 9.02	4.74	2.87	2.67	35.73	34.50	93.21	68.61
Grain yield per plant (g)	4.78 – 23.97	14.02	51.00	42.95	50.90	46.71	84.21	88.30
Total carbohydrates content (g / 100g)	27.35 – 47.29	35.36	135.88	135.14	26.22	26.14	99.46	53.72
Protein content(g / 100g)	10.62 – 15.21	12.43	2.75	2.37	13.33	12.39	86.33	23.72

Table 5. Estimates of variability parameters for twelve characters in normal density (D_3 – 45 x 20 cm)

Characters	Range	Mean	PV	GV	PCV (%)	GCV (%)	h^2 (%)	GA as % of mean
Plant height (cm)	62.54 – 106.78	81.28	251.36	249.75	19.50	19.44	99.36	39.92
Days to 50 per cent flowering	30.85 – 59.80	44.39	2.89	2.69	13.65	13.18	93.31	26.24
Leaf area at 50 per cent flowering (sq.cm)	845.19 – 2223.55	1312.49	276111.50	275819.21	40.03	40.01	99.89	82.38
Length of the primary inflorescence (cm)	33.99 – 69.06	51.38	209.49	142.98	28.17	23.27	68.25	39.60
Diameter of the inflorescence (cm)	16.98 – 24.23	21.58	7.51	3.71	12.70	8.93	49.42	12.93
Fresh weight of the inflorescence (g)	67.01 – 145.15	96.08	1239.44	1070.09	36.63	34.04	86.34	65.16
Number of rachis per inflorescence	40.87 – 75.86	53.46	131.00	95.18	21.40	18.24	72.66	32.04
Length of the rachis per inflorescence (cm)	33.94 – 52.98	46.16	46.58	43.04	14.78	14.21	92.40	28.13
Number of secondary branches per inflorescence	3.82 – 10.61	5.45	4.59	4.29	39.29	38.01	92.55	75.73
Grain yield per plant (g)	7.16 – 26.47	15.16	52.72	44.97	47.86	44.21	85.30	84.11
Total carbohydrates content (g / 100g)	25.16 – 46.89	34.79	65.93	63.25	23.33	22.69	94.58	45.46
Protein content(g / 100g)	10.34 – 15.32	12.45	130.22	128.40	25.70	25.52	98.60	52.21

Table 6. Estimates of variability parameters for twelve characters in low density (D_3 – 45 x 30 cm)

Characters	Range	Mean	PV	GV	PCV (%)	GCV (%)	h^2 (%)	GA as % of mean
Plant height (cm)	54.04 – 99.24	71.98	468.69	122.75	31.07	15.39	26.19	16.22
Days to 50 per cent flowering	30.99 – 58.89	44.44	3.44	2.90	14.94	13.71	84.17	25.91
Leaf area at 50 per cent flowering (sq.cm)	841.39 – 2456.66	1269.00	317523.59	290019.09	44.40	42.43	91.34	83.54
Length of the primary inflorescence (cm)	24.55 – 54.46	38.12	131.72	64.66	30.10	21.09	49.09	30.44
Diameter of the inflorescence (cm)	16.76 – 25.69	21.03	9.14	5.91	14.38	11.56	64.66	19.15
Fresh weight of the inflorescence (g)	58.77 – 147.72	87.49	1173.31	950.39	39.15	35.24	81.05	65.36
Number of rachis per inflorescence	36.11 – 60.90	50.40	84.12	45.44	18.19	13.37	54.01	20.24
Length of the rachis per inflorescence (cm)	32.57 – 55.55	45.33	54.34	50.89	16.26	15.73	93.65	31.37
Number of secondary branches per inflorescence	3.72 – 9.78	5.05	3.47	3.35	36.88	36.26	96.65	73.43
Grain yield per plant (g)	6.70 – 23.01	13.99	43.17	36.31	46.94	43.05	84.10	81.33
Total carbohydrates content (g / 100g)	25.23 – 46.34	34.52	63.52	61.25	23.08	22.67	96.43	45.86
Protein content(g / 100g)	10.42 – 15.59	12.42	131.20	130.04	25.77	25.66	99.11	52.62

Contrary to the situation observed for the variability among the four plant density levels, the extent of heritability in the present study was generally in the order of low > normal > high > very high plant density levels for the characters days to 50 per cent flowering, leaf area at 50 per cent flowering and fresh weight of the inflorescence. This indicate that though relatively greater genetic variability was available in the higher plant density levels, the heritable component of this variability was increased when resorted for normal and low plant density levels. All the characters recorded high magnitude of heritability estimates of above 60% under all four plant density levels except plant height, diameter of the inflorescence, length of the inflorescence and number of

rachis per inflorescence The present results are supported by the findings of Parveen *et al.* (2014). Plant height registered low heritability in low plant density and recorded high heritability in very high and normal densities. Moderate heritability was observed for length of the primary inflorescence in high and low plant density level and high heritability in other two plant density levels. Moderate broadsense heritabilities in amaranthus was reported by Akaneme and Ani (2013). Number of rachis per inflorescence recorded moderate amount of heritability in very high and low plant density levels, where as other plant densities had higher estimates of heritability.

The trend observed for heritability was not noticed in genetic advance as per cent of mean. Each density contributed high GA as percent of mean for all characters except for plant height and diameter of the inflorescence. According to Johnson *et al.* (1955) high heritability combined with high GA would be more useful in predicting the performance of the progenies of selected lines. In the present investigation, high heritability coupled with high GA as percent of mean was observed for all the characters except plant height, length of the primary inflorescence, diameter of the inflorescence and number of rachis per inflorescence. High heritability combined with high GA observed for grain yield and other component traits mentioned above in all the four plant density levels indicated that the preponderance of fixable additive gene action for these traits and these traits would response effectively for selection in all the four plant density levels. High heritability alone does not signify an increased genetic advance (Chaudhary *et al*., 1977). In the present study, moderate heritability with moderate GA was observed for plant height and number of rachis per inflorescence in low plant density and number of rachis per inflorescence exhibited moderate heritability in very high plant density. High heritability with moderate GA as per cent of mean was observed for diameter of the inflorescence in low plant density whereas moderate heritability with moderate amount of GA was noticed in normal density for this trait. Length of the primary inflorescence registered moderate heritability with high GA as per cent of mean in high and low plant densities The results suggested that the presence of non additive gene action for these traits and therefore, these traits could not be improved through simple selection.

Burton (1952) suggested that the GCV together with high heritability and genetic advance would give the best picture on the extent of advance expected from selection. The characters grain yield per plant, leaf area at 50 percent flowering, fresh weight of the inflorescence, number of secondary branches per inflorescence and total carbohydrates content recorded high amount of genetic variability along with heritability and genetic advance in all the four plant density levels. This finding reveals that there is a greater scope for improving these characters by simple phenotypic selection in all the four plant density levels *viz.,* very high, high, normal and low. Such a possibility also exists for protein content and length of the rachis per inflorescence in all the four plant density levels as these traits recorded an exploitable amount of moderate variability combined with high heritability and GA. Days to 50 per cent flowering registered high GCV, heritability and GA in very high and high plant density levels.

Whereas in case of normal and low plant density levels, this trait recorded moderate GCV with heritability and genetic advance. Length of the primary inflorescence exerted high GCV, heritability and GA in very high and normal density. In high plant density this trait recorded moderate GCV, heritability and GA as per cent of mean. Under low plant density high GCV, moderate heritability and high GA as per cent of mean were recorded. Diameter of the inflorescence showed moderate GCV with genetic advance in very high and high plant densities. Number of rachis per inflorescence registered moderate GCV with high heritability and GA as per cent of mean in high and normal plant density levels.

From the foregoing discussion on variability analysis it could be concluded that all the three genetic parameters *viz.,* variability, heritability and genetic advance were influenced by plant densities, while the variability and genetic advance was maximum in high plant density levels. Simple phenotypic selection would improve the grain yield and its component characters *viz.,* leaf area at 50 per cent flowering, fresh weight of the inflorescence, number of secondary branches per inflorescence and total carbohydrates as these traits recorded high magnitude of genetic variability in combination with high heritability and genetic advance as per cent of mean in all the four plant density levels.

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