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STUDIES ON GENETIC PARAMETERS IN GRAIN AMARANTHUS (*AMARANTHUS HYPOCHONDRIACUS* L.) AS INFLUENCED BY PLANT DENSITIES

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A B S T R A C T

Selection of genotypes with adequate combination of traits with high yield at the appropriate density level increased the productivity in amaranth. The study was therefore undertaken to estimate genetic attributes of different amaranth genotypes and to identify and select genotypes with adequate trait combination for improvement in yield. In grain amaranthus (*Amaranthus hypochondriacus* L.) ten genotypes were evaluated for twelve characters under four plant density levels viz., very high (D1), high (D2), normal (D3) and low plant density (D4) 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. Leaf area at 50 per cent flowering, fresh weight of the inflorescence, number of secondary branches per inflorescence and total carbohydrates are 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.

Keywords: Grain yield, variability, selection, amaranth.

INTRODUCTION

Grain amaranth (*Amaranthus hypochondriacus* L.) is a unique, nutritionally rich non-cereal crop capable of combating malnutrition and has been identified as an alternative crop to traditional grain crops (Bhuvaneswari *et al.*2001). Besides immense nutritional importance, it can also be successfully grown under varied soil and agro climatic conditions. Recently, current interest in grain amaranth resides in the fact that it has a great amount of genetic diversity and phenotypic plasticity. Grain amaranth 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 exploited crop for grain purpose. In spite of immense nutritional qualities, not much work has been done for its genetic improvement. Being a cheap source of nutrients (Tucker, 1986), recently the emphasis for its genetical improvement to enhance potentiality for grain yield through different contributing traits has been put up. Through collection and selection programs, a number of strains have been introduced and acclimatized, but the systematic evaluation for grain yield and its contributing quantitative and qualitative traits has not been conducted. Improvement of grain yield requires indepth knowledge of the magnitude of variation present in the available germplasm, interdependence of quantitative characters with yield, extent of environmental influence on these factors, heritability and genetic advance of various contributing traits. 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.

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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).

Table 1. Details of the genotypes studied

S.No.	Genotypes	Source	Status
1.	RMA 3	Rajastan	Released variety
2.	BGA 2	NBPGR	Released variety
3.	E C 519554	NBPGR	Breeding line
4.	SKNA 21	Gujarat	Released variety
5.	Annapurna	New Delhi	Released variety
6.	SKNA 601	Gujarat	Released variety
7.	GA 2	Gujarat	Released variety
8.	RMA 4	Rajastan	Released variety
9.	I C 415290	NBPGR	Breeding line
10.	PRA 2004 - 2	NBPGR	Breeding line

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

The crop was raised during *rabi*, 2007 in a Randomized Complete 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 cm x 20 cm), high density (30 cm x 30 cm), normal density (45 cm x 20 cm) and low density (45 cm x 30 cm) (Table 2). The Recommended packages of practices were followed as per 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 50 percent flowering, length of the primary inflorescence, diameter of the inflorescence, leaf 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 analyzed. For quality traits, composite samples drawn from five random plants of genotypes under different population densities were used for analysis.

Table 2. Plant density levels

	Density levels			
Particulars	**D_1 – very high density**	**D_2 – high density**	**D_3 – normal density**	**D_4 – low density**
Spacing	30 cm x 20 cm	30 cm x 30 cm	45 cm x 20 cm	45 cm x 30 cm
Plant Population / m^2	50 plants	33 plants	30 plants	22 plants
Plant Population / ha	5,00,000 plants	3,33,000 plants	3,30,000 plants	2,22,222 plants

Estimates of genetic parameters

The phenotypic and genotypic variances were estimated according to Lush (1940).

$$\text{Genotypic variance } (\sigma^2 g) = \frac{(MS^1 - MS^2)}{r}$$

Where, MS_1 = Mean sum of squares for genotypes.

MS_2 = Mean sum of squares for error.

r = Number of replications.

b) Phenotypic variance $(\sigma^2 ph) = \sigma^2 g + \sigma^2 e$

Where, $\sigma^2 g$ = Genotypic variance.

$\sigma^2 e$ = Error variance.

Phenotypic and genotypic coefficient of variations

The phenotypic and genotypic coefficients of variations were estimated using the formula suggested by Burton (1952) and expressed in percentage.

a) Phenotypic coefficient of variation (per cent)

$$PCV = \frac{(\text{Phenotypic variance})^{1/2}}{\text{General mean}} \times 100$$

b) Genotypic coefficient of variation (per cent)

$$GCV = \frac{(\text{Genetic variance})^{1/2}}{\text{General mean}} \times 100$$

The categorization of PCV and GCV was done as per the scale given by Sivasubramanian and Menon, 1973.

Category	Range
Low	< 10 per cent
Moderate	11 to 20 per cent
High	> 20 per cent

Heritability (h^2)

Heritability in broad sense was calculated according to Lush (1940) and expressed in percentage.

Heritability in broad sense h^2

$$= \frac{\text{Genoypic variance}}{\text{Phenotypic Variance}} \times 100$$

Where, Vg = Genotypic variance

Vph = Phenotypic variance.

The heritability for various traits estimated and categorized as proposed by Johnson *et al.* (1955).

Category	Range
Low	< 30 per cent
Moderate	30-60 per cent
High	> 60 per cent.

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. The genetic proportion of this variability measured in terms of genotypic coefficient of variation (GCV) alone represents the heritable component of total variability. Higher the GCV more will be chance for exploitation of that particular character in a selection programme. The genetic variability in terms of GCV alone is not sufficient for determination of amount of heritable variability. In addition, estimation of heritability and genetic advance as percent of mean is also needed to assess the extent of genetic gain expected from effective selection. As heritability in broad sense includes both additive and epistatic gene effects, it will be reliable only when it is accompanied with high genetic advance (Burton, 1952 and Johnson *et al.,* 1955). 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 opinions 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

Genetic advance (GA)

The genetic advance was worked out based on the formula given by Johnson *et al.* (1955).

$$\text{Genetic Advance (GA)} = \frac{\text{Vg}}{\text{Vph}} \times \text{K}$$

Where, Vg = Genotypic variance.

Vph = Phenotypic variance.

K = 2.06 (Selection differential at 5 per cent selection intensity)

Genetic advance as per cent of mean

$$= \frac{\text{GA}}{\text{Grand mean}} \times 100$$

The range of genetic advance as per cent of mean for various traits was grouped as suggested by Johnson *et al*. (1955).

Category	Range
Low	< 10 per cent
Moderate	11-20 per cent
High	> 20 per cent

was assessed in the present study (Tables 3 to 6 and Fig 1 to 3). 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 (Table 4). Similar findings were also obtained by Priya (2007) with high PCV and GCV for the above mentioned traits. 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 that 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.

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. 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. Joshi (1986) reported that moderate PCV and GCV for these traits. 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.

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 per cent under all four plant density levels except plant height, diameter of the inflorescence, length of the inflorescence and number of rachis per inflorescence. Plant height registered low heritability in low plant density and recorded high heritability in very high and normal densities and moderate heritability in high plant density levels. 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. 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).

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, 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.

Table 3. Estimates of variability parameters for twelve characters in very high density (D_1 – 30 cm 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	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
No. 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 cm 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
No. 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 cm 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
No. 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 cm 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
No. 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

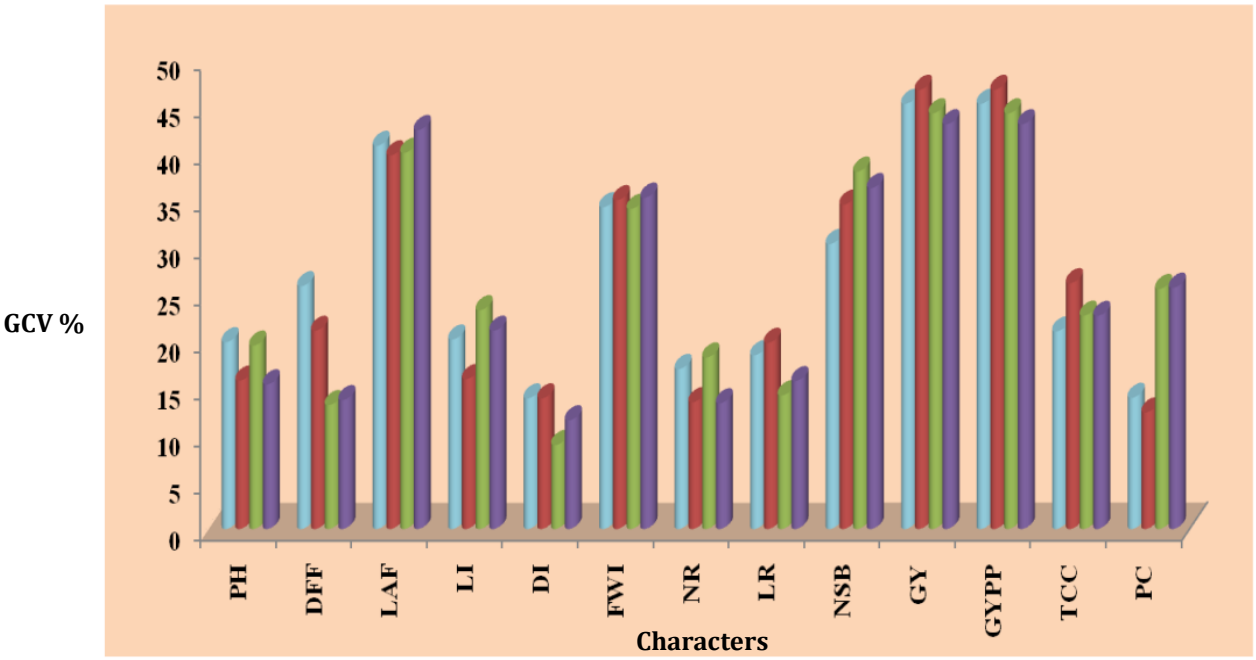

Figure. 1. Genotypic coefficient of variation for thirteen traits in grain amaranthus

PH-Plant height; DFF- Days to 50 per cent flowering; LAF- Leaf area at 50 per cent flowering;LI- Length of the primary inflorescence; DI- Diameter of the inflorescence; FWI- Fresh weight of the inflorescence; NR- Number of rachis per inflorescence; LR- Length of the rachis per inflorescence; NSB- Number of secondary branches per inflorescence; GYP- Grain yield per plant; GYYP- Grain yield per plot; TCC- Total carbohydrates content ;PC- Protein content.

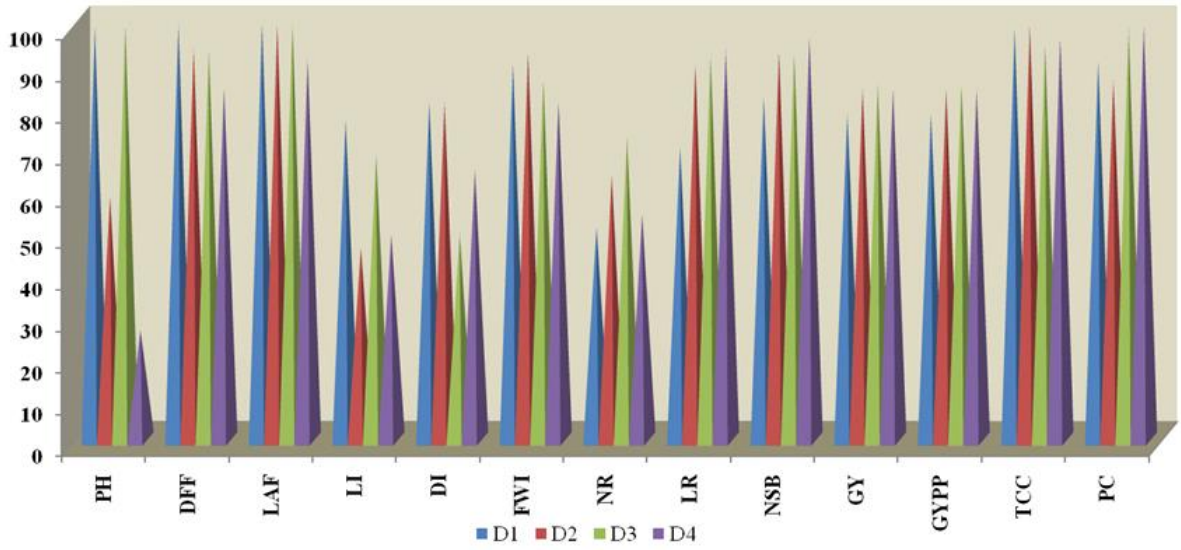

Figure. 2. Heritability for thirteen traits in grain amaranthus

PH-Plant height; DFF- Days to 50 per cent flowering; LAF- Leaf area at 50 per cent flowering;LI- Length of the primary inflorescence; DI- Diameter of the inflorescence; FWI- Fresh weight of the inflorescence; NR- Number of rachis per inflorescence; LR- Length of the rachis per inflorescence; NSB- Number of secondary branches per inflorescence; GYP- Grain yield per plant; GYYP- Grain yield per plot; TCC- Total carbohydrates content ;PC- Protein content.

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 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 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 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.

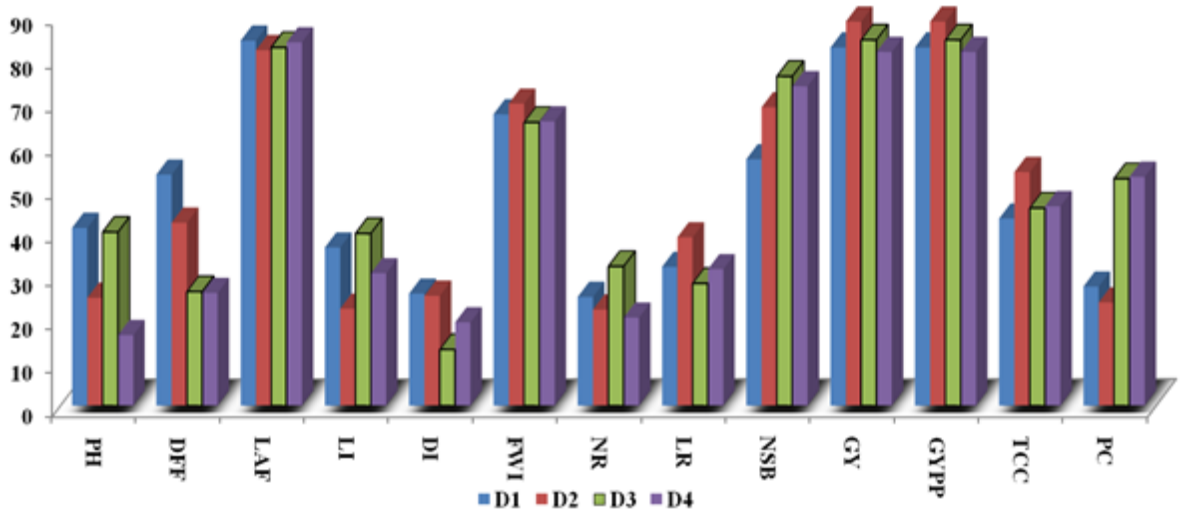

Figure.3. Genetic advances as percent of mean for thirteen characters in four plant density levels.

PH-Plant height; DFF- Days to 50 per cent flowering; LAF- Leaf area at 50 per cent flowering;LI- Length of the primary inflorescence; DI- Diameter of the inflorescence; FWI- Fresh weight of the inflorescence; NR- Number of rachis per inflorescence; LR- Length of the rachis per inflorescence; NSB- Number of secondary branches per inflorescence; GYP- Grain yield per plant; GYYP- Grain yield per plot; TCC- Total carbohydrates content ;PC- Protein content.

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