Original Research Article

Genetic variability studies of vegetable amaranth (*Amaranthus spp.*) for productivity traits

ABSTRACT

In the present investigation 60 different genotypes of vegetable amaranth were analysed for genetic variability in productivity traits and quality status and noticeable range of variability were reported in herbage yield and quality. The phenotypic coefficient of variation and genotypic coefficient of variation was maximum for number of leaves, stem weight (g), Stem to leaf ratio, herbage yield per plant (g), herbage yield per plot (kg), leaf area per plant (cm^2) and leaf size (cm^2) minimum in case of plant height and stem thickness as shown in table. High heritability was observed for all the traits, except plant height and stem thickness maximum was recorded for Herbage yield per hectare (99.45 %) and minimum was observed for stem thickness (1.07%). High heritability (h^2 = 99.45%) with high genetic advance (GA=92.47%) as percentage of mean was observed for herbage yield per hectare which indicated that additive gene effects were more important for that trait. High genetic advance as per cent of mean was observed for herbage yield per plant (g) however, lowest for stem thickness (0.27) which indicates the preponderance of additive genes and selection will be effective for improvement of these traits having high heritability with genetic advance as percent of mean.

Comment [mm1]: On abstract: please add introduction, prolems, aims, methods, results, and novelty

Keywords: Vegetable Amaranth, heritability, Genetic advance as percent of mean, Genetic advance, Heritability, PCV and GCV.

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1. INTRODUCTION

Amaranthus [*Amaranthus* spp. (L.)] belongs to the family amaranthaceae and genus *Amaranthus*. The word “Amaranthus” has derived from Greek language which means “one that does not wither” or “never fading” (Anjali *et al*., 2013). The genus *Amaranthus* consists of a large number of species that differ in morphology, yield and also nutrient status. There are two chromosome groups in amaranthus, n=16 and n=17. The species with n=16 are *Amaranthus hypochondriacus* and *A. caudatus* and the species with n=17 are *Amaranthus tricolor, A. spinosus, A. virdis, A. cruentus and A. blitum*. Cultivated amaranthus includes at least eight species grown for multiple purposes *viz., Amaranthus caudatus*L., *A. cruentus*L. and *A. hypochondriacus* L. for grain purpose (Costea *et al*., 2004); *A. dubious* L., *A. blitum*L., *A. hybridus* and *A. tricolor* L. as leafy vegetable (Omondi *et al*., 2016). Whereas, *A. retroflexus*L. (redroot pigweed), *A. albus* L. (tumble weed), *A. palmeri*S. Wats. (Palmer amaranth) and *A. spinosus* L. (spiny amaranth) are considered as weed species (Erum *et al*., 2012). Amaranthus being a C_4 plant exhibits higher photosynthetic activity and productivity than C_3 plants (Brown, 1999). Amaranthus exhibits broad genetic variability in plant type, number of inflorescences, seed colour, earliness, plant height, seed and green matter yield, resistance to pest and diseases and adaptability to soil, climate, rainfall and day length (Mujica and Jacobsen. 2003) etc., that are worldwide known, along with these there exists a great variability in case of nutrient content of amaranthus leaf. Amaranthus is a historically sustained nutritional crop which was disappeared for centuries but is now emerging again and showing great potential for food and nutritional security around the world (Das, 2016). As amaranthus can be used as both vegetable and grain crop and has the ability to be grown in varied climatic conditions, it is considered as a good source of nutritional security for a wide array of population (Das, 2016). In America (South America and Central America) where amaranth is thought to have originated (Sauer, 1950; Sauer, 1967, whereas the amaranth leaves and stems are used as vegetables in South Asian and African countries (Grubben and Denton, 2004; Rastogi and Shukla, 2013).

Further, there is a need to intensify the development of leafy amaranth cultivars with nutrient rich quality. To plan appropriate breeding programme and to evolve high yielding cultivars with higher nutritive value, the plant breeders must possess adequate knowledge on nutrient status of the amaranthus leaves and the variability existing. To develop such programmes there is a need to evaluate the available genotypes, hence the present study has been carried out with the objective of genetic variability for those traits in vegetable amaranth genotypes.

2. MATERIAL AND METHODS

The experiment was conducted in Department of Vegetable Science, College of Horticulture, Bengaluru, UHS, Bagalkot,Karnataka during summer *i.e.*, from January 2020 to March, 2022. The experiment consisted of 60 vegetable amaranth genotypes that were collected from KRCCH, Arabhavi, NBPGR New-Delhi, TNAU, Coimbtore and some local collections are BVA-4, BVA-15, BVA-14, BVA-28, BVA-34, BVA-36, BVA-38, BVA-26, BVA-1, BVA-24, BVA-2, BVA-30, BVA-21, BVA-23, BVA-31, BVA-29, BVA-A-1, BVA-A-4, BVA-A-8, BVA-A-9, BVA-A-6, BVA-A-7, BVA-A-10, BVA-A-3, BVA-A-5, BVA,BVA-39, BVA-40, BVA-41, BVA-42, BVA-43, BVA-44, BVA-45, BVA-46, BVA-18, BVA-19, BVA-22, BVA-53, BVA-52, BVA-5, BVA-7, BVA-10, BVA-11, BVA-12, BVA-13, BVA-14, BVA-15, BVA-16, BVA-17, BVA-49, BVA-32, BVA-33, BVA-28, BVA-27, BVA-25, BVA-20, BVA-A-2, BVA-47, BVA-6, BVA-8 and BVA-35 as follows (Table 1). The layout of experimental plot was prepared according to augmented block design II (Federer, 1956). The whole plot was divided into 4 blocks, wherein, each block contained 19 beds of 1m × 1m dimension, each representing different genotypes including four check varieties. The genotypes were sown in line at the spacing of 20 cm, accommodating 10 plants per line and hence each bed accommodated50 plants. All growth and yield parameters were recorded in five randomly selected and tagged plants of each genotype and mean was worked out for further statistical analysis. Variability parameters were worked out as per method given by Burton and Devane (1953), heritability in broad sense and genetic advance as percent of mean was calculated according to the formula given Johnson *et al*. (1995).

3. RESULTS AND DISCUSSION

The evidence from Table 2 depicts the significant difference among the vegetable amaranth genotypes for the different characters at 5% significance. The Table 4 depicts the growth and yield status of the leaf amaranth for plant height (23.10-46.00 cm), stem thickness (3.80-7.20), days to horticulture maturity (21.00-35.00 days), number of leaves per plant (7.30-20.10 g), leaf weight per plant (2.20-5.40 g), stem weight per plant (2.80-15.30 g), stem to leaf ratio (0.70-4.30), dry weight of plant (0.02-0.62 g), herbage yield per plant (1.80-28.40 g), herbage yield per hectare (2.70-42.60 tons), leaf size (20.10-47.50 cm^2) and leaf area per plant (29.33-159.84 cm^2). The estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for the growth and yield parameters of leafy amaranth genotypes are presented in Table 3 and Fig. 1. The magnitude of (PCV and GCV) were found high were noticed for the traits, *viz*., stem weight per plant, stem to leaf ratio, Herbage yield per plant, dry weight per plant and herbage yield per hectare, leaf area per plant and leaf size which was also confirmed in earlier studies on amaranthus by Varalakshmi and Reddy (1997), Ahammed *et al.* (2012), Chattopadhyay *et al.* (2013), Labiba *et al.* (2018) and Sheela *et al.* (2018). Moderate GCV and PCV were noticed for the traits, leaf weight per plant and days to horticultural maturity as noticed by Adeniji (2018), Banuprathap*et al.* (2018) in amaranthus crop. High PCV and moderate GCV were noticed for the traits number of leaves per plant and leaf weight per plant which was in agreement with interpretations of Hassan *et al.* (2013) and Onuoha *et al.* (2019) in amaranthus.

In the present study, traits with higher magnitude of GCV and PCV values, indicated the presence of high degree of variability in the studied accessions which provide ample scope for improvement through selection. Closeness of genotypic and phenotypic coefficients indicates that these characters are least affected by environment and are stable. However, for traits like plant height and stem girth, the PCV estimates were higher than the GCV estimates which suggested that a considerable portion of variability in these traits could be attributed mainly due to environmental influence.

The traits *viz.,* stem weight per plant, stem to leaf ratio, dry weight per plant, herbage yield per plant, herbage yield per hectare, leaf size and leaf area per plant were having the higher estimates of heritability and GAM as shown in table 3 and fig 2 pronouncing the presence of additive gene action and possibility of improvement of the traits through direct selection. These results are in close agreement with that of Anuja and Mohideen (2007), Ahemmed *et al.* (2012), Hassan *et al.* (2013), Bhanuprathap*et al.* (2018) and Sheela *et al.* (2018) in the amaranthus crop, whereas, the traits like herbage yield per plant and dry weight per plant were controlled by the non-additive gene action as they were of high heritability and low GAM, hence the direct selection based on this traits would become difficult as they indicated by the results of the studies from Chattopadhyay *et al.* (2013) that pronounced the same in amaranthus crop. The traits *viz.,* stem weight per plant, stem to leaf ratio, dry weight per plant, herbage yield per plant, herbage yield per hectare, leaf size and leaf area per plant showed high GCV, PCV, heritability and GAM pronouncing the additive gene action and possibility of improvement of the traits through direct selection (Anuja, 2010 and Panda *et al.*, 2017).

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Please mention all figures and tables as result of research on manuscript

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Table 1. List of amaranthus genotypes used in the study and their source of collection

Sl. No.	Genotype	Source of collection
1.	BVA -1	KRCCH, Arbhavi
2.	BVA -2	KRCCH, Arbhavi
3.	BVA -3	KRCCH, Arbhavi
4.	BVA -4	KRCCH, Arbhavi

Sl. No.	Genotype	Source of collection
5.	BVA -5	KRCCH, Arbhavi
6.	BVA -6	KRCCH, Arbhavi
7.	BVA -7	KRCCH, Arbhavi
8.	BVA -8	KRCCH, Arbhavi
9.	BVA -9	KRCCH, Arbhavi
10.	BVA -10	KRCCH, Arbhavi
11.	BVA -11	KRCCH, Arbhavi
12.	BVA -12	KRCCH, Arbhavi
13.	BVA -13	NBPGR, Selection -1 from IC-469722
14.	BVA -14	NBPGR, Selection- 2 from IC-469722
15.	BVA -15	NBPGR, Selection-3 from IC-469722
16.	BVA -16	NBPGR, Selection-4 from IC-469722
17.	BVA -17	Selection from Gagwad local
18.	BVA -18	NBPGR, Selection from IC-469694
19.	BVA -19	NBPGR, Selection from IC-553743
20.	BVA -20	NBPGR, Selection from IC-469558
21.	BVA -21	NBPGR, Selection from IC-551471
22	BVA -22	Belgaum local collection
23.	BVA -23	Selection from Arka Varna
24.	BVA -24	TNAU, Coimbatore, TN
25.	BVA -25	NBPGR, Selection from IC-469658
26.	BVA -26	NBPGR, Selection from IC-536714
27.	BVA -27	NBPGR, Selection from IC-551472
28.	BVA -28	Selection-2
29.	BVA -29	TNAU, Coimbatore, TN
30.	BVA -30	Selection from IC-469652
31.	BVA -31	Derivative of IC-553743×VA-16
32.	BVA -32	Bellary local collection
33.	BVA-33	Selection-4 local type
34.	BVA -34	Rajgiri red
35.	BVA -35	F6 derivative of Arka Suguna×IC-469645
36.	BVA -36	Selection-5 from local type
37.	BVA -37	F6 derivative of IC-469645×IC-551461
38.	BVA -38	Collection from Chitradurga local
39.	BVA -39	NBPGR Selection from IC-553744
40.	BVA -40	NBPGR Selection from IC-551463
41.	BVA -41	NBPGR Selection from IC-536714
42.	BVA -42	NBPGR Selection from IC-551473
43.	BVA -43	NBPGR Selection from IC-536698
44.	BVA -44	NBPGR Selection from IC-4696605

Sl. No.	Genotype	Source of collection
45.	BVA -45	Local collection
46.	BVA -46	NBPGR Selection from IC-522214
47.	BVA -47	NBPGR Selection from IC-553749
48.	BVA -48	Selection-3 from local type
49.	BVA -49	F4 derivative of CO-1×1/39
50.	BVA -53	Arka amaranth selection
51.	BVA -A-1	NBPGR Selection from IC-469579
52.	BVA -A-2	Kanakpura local collection
53.	BVA -A-3	NBPGR Selection from IC-469601
54	BVA –A-4	NBPGR Selection from IC-553731
55.	BVA –A-5	NBPGR Selection from IC-541407
56.	BVA –A-6	NBPGR Selection from IC-551472
57.	BVA -A-7	TNAU, Coimbatore, TN
58.	BVA –A-8	NBPGR Selection from IC-553737
59.	BVA –A-9	NBPGR Selection from IC-469579
60.	BVA –A-10	NBPGR Selection from IC-536713
61.	Check-1	Arka Arunima (IIHR, Bengaluru)
62.	Check-2	Arka Varna (IIHR, Bengaluru)
63.	Check-3	Arka Suguna (IIHR, Bengaluru)
64.	Check-4	Arka Samraksha (IIHR, Bengaluru)
IC Series from NBPGR, New Delhi **BVA: Bengaluru Vegetable Amaranth**		

Table 2. ANOVA for growth and yield parameter in vegetable amaranth genotypes

Sl. No.	Source	df	PH	ST	DHM	NOL	LW	SW	S:L	DW	HY/Pt	HY/Pl	HY/ha	LS	LA
1.	Treatment (ignoring Blocks)	63	24.08	0.83	10.71 *	5.69 *	0.49 *	8.50 **	0.46 **	0.01	25.50 **	0.58 **	57.50 **	152.21**	514.68*
2.	Treatment: Check	3	12.20	0.49	6.56	3.79	2.44 **	3.09 **	0.64 **	0.01	23.42 **	0.53 **	52.8 **	144.0**	374.13
3.	Treatment: Test vs. Check	1	179.9 *	22.1 **	76.0**	2.16	5.66 **	66.0 **	1.27 **	0.01	179.90 **	4.06 **	405.5 **	376.60**	2230.96**
4.	Treatment: Test genotypes	59	22.04	0.48	9.81 *	5.85 *	0.30	7.80 **	0.44 *	0.01	23.06 **	0.52 **	51.80 **	132.40**	492.74*
5.	Block (eliminating Treatments)	3	18.3	0.33	0.56	1.80	0.08	0.48	0.04	0.003	0.19	0.004	0.47	5.08	77.95
6.	Error	9	19.5	0.48	2.51	1.50	0.10	0.16	0.03	0.004	0.13	0.002	0.28	152.20**	

Significant * if p ≤ 0.05 Highly significant ** if p ≤ 0.01

df: Degrees of freedom LW: Leaf weight (g) HY/Pt: Herbage yield per plant (g)
PH: Plant height (cm) SW: Stem weight (g) HY/ha: Herbage yield per hectare (t)
SD: Stem thickness (mm)S:L: Shoot to leaf ratio LS: Leaf size (cm^2)
DHM: Days to horticulture maturity DW: Dry weight (kg)LA: Leaf area per plant (cm^2)
NOL: No. of leaves per plantHY/Pl: Herbage yield per plot (kg)

Table 3. Estimates of genetic variability characteristics for growth and yield parameters in vegetable amaranth genotypes

Sl. No.	Trait	Range	Mean	PCV (%)	GCV (%)	h^2_{bs} (%)	GA	GAM (%)
A.	**Growth parameters**							
1.	Plant height (cm)	23.10-46.00	34.76	13.51	4.55	11.35	1.1	3.16
2.	Stem thickess (mm)	3.80-7.20	5.67	12.24	1.27	1.07	0.02	0.27
3.	Days to hortulture maturity	21.00-35.00	26.86	11.66	10.06	74.45	4.81	17.91
B.	**Green yield and its component traits**							
4.	Number of leaves per plant	7.30-20.10	10.51	23.00	19.83	74.36	3.71	35.28
5.	Leaf weight per plant (g)	2.20-5.40	3.89	14.13	10.99	60.47	0.68	17.63
6.	Stem weight per plant (g)	2.80-15.30	7.12	39.22	38.81	97.93	5.64	79.23
7.	Stem to leaf ratio (%)	0.70-4.30	1.82	36.43	35.24	93.56	1.28	70.32
8.	Dry weight of plant (g)	0.02-0.62	0.20	56.15	44.51	62.86	0.15	72.81
9.	Herbage yield per plant (g)	1.80-28.40	10.64	45.13	45.01	99.43	9.85	92.58
10.	Herbage yield per hectare (tons)	2.70-42.60	15.98	45.07	44.95	99.45	14.78	92.47
11.	Leaf size (cm^2)	20.10-47.50	46.84	24.34	23.86	96.09	10.40	48.25
12.	Leaf area per plant (cm^2)	29.33-159.84	72.27	30.72	24.90	65.71	30.90	41.64

GCV: Genotypic coefficient of variation (%), PCV: Phenotypic coefficient of variation (%), GAM: Genetic advance as per cent over mean (%), h^2_{bs}: Heritability (broad sense) (%),GA: Genetic advance

Table 4. Performance of vegetable amaranth genotypes for growth and yield parameters

Sl. No.	Genotype/ Traits	PH	ST	NOL	LW	SW	S:L	DW/ Pl	HY/ Pt	HY/ Pl	HY /ha	DHM	LS	LA
1.	**Arka Arunima**	31.00	6.40	9.30	5.40	8.70	1.60	0.20	13.30	2.00	20.10	24.00	67.60	70.92
2.	**Arka Varna**	30.20	7.20	11.10	4.80	9.20	2.00	0.30	16.80	2.50	25.30	23.30	48.10	86.825
3.	**Arka Suguna**	33.75	7.12	10.82	4.35	10.52	2.43	0.28	11.23	1.68	16.87	26.25	46.09	93.50
4.	**Arka Samraksha**	31.70	6.90	10.40	4.80	9.50	2.00	0.20	13.80	2.10	20.70	24.50	53.90	87.65

Sl. No.	Genotype/ Traits	PH	ST	NOL	LW	SW	S:L	DW/ Pl	HY/ Pt	HY/ Pl	HY /ha	DHM	LS	LA
5.	**BVA-32**	37.00	5.40	10.20	4.10	3.60	0.90	0.17	10.00	1.50	15.00	26.00	81.20	76.54
6.	**BVA-33**	45.00	5.40	10.20	4.10	6.40	1.60	0.10	7.60	1.20	11.50	28.00	68.60	69.03
7.	**BVA-34**	40.00	5.40	10.80	4.10	4.80	1.20	0.29	12.60	1.90	19.00	24.00	51.30	65.84
8.	**BVA-35**	46.00	5.40	8.60	4.10	9.40	2.30	0.11	13.30	2.00	20.00	30.00	53.20	61.46
9.	**BVA-36**	36.00	5.80	8.40	3.90	9.70	2.50	0.05	2.60	0.40	4.00	30.00	37.40	38.47
10.	**BVA-37**	43.00	5.10	10.80	4.00	5.20	1.30	0.24	10.60	1.60	16.00	28.00	44.40	83.03
11.	**BVA-38**	36.00	5.20	9.60	5.00	10.00	2.00	0.18	17.60	2.70	26.50	26.00	53.80	68.22
12.	**BVA-39**	34.00	5.00	9.20	4.10	8.20	2.00	0.20	6.90	1.00	10.40	30.00	32.00	54.78
13.	**BVA-40**	32.50	5.20	10.60	3.70	14.80	4.00	0.12	6.80	1.00	10.30	28.00	45.60	77.59
14.	**BVA-41**	39.00	5.50	10.40	4.00	2.80	0.70	0.31	16.50	2.50	24.80	28.00	45.30	69.18
15.	**BVA-42**	36.00	5.30	10.60	4.20	8.40	2.00	0.12	6.70	1.00	10.00	28.00	44.20	77.10
16.	**BVA-43**	31.00	5.10	11.00	4.00	6.40	1.60	0.31	13.30	2.00	20.00	35.00	55.70	77.64
17.	**BVA-44**	29.20	4.90	9.80	3.30	5.90	1.80	0.32	11.70	1.80	17.60	30.00	48.00	79.73
18.	**BVA-45**	36.30	4.50	10.40	4.10	7.40	1.80	0.08	4.50	0.70	6.70	24.00	35.60	80.12
19.	**BVA-46**	39.10	4.80	14.00	3.00	3.60	1.20	0.28	14.80	2.20	22.30	24.00	44.60	91.03
20.	**BVA-18**	32.50	6.90	7.90	4.20	5.40	1.30	0.04	4.70	0.70	7.00	30.00	48.10	68.90
21.	**BVA-19**	33.80	6.40	7.50	3.00	6.00	2.00	0.05	5.70	0.90	8.50	26.00	44.10	38.31
22.	**BVA-20**	37.00	6.80	11.80	4.50	9.00	2.00	0.09	5.80	0.90	8.80	32.00	57.20	96.43
23.	**BVA-21**	37.00	7.00	8.60	4.20	8.40	2.00	0.05	2.00	0.30	3.00	30.00	60.90	78.88
24.	**BVA-22**	40.50	6.00	7.80	3.90	9.70	2.50	0.03	1.80	0.30	2.70	30.00	40.90	48.81
25.	**BVA-23**	40.00	6.00	11.20	4.10	11.20	2.70	0.15	6.70	1.00	10.00	31.00	58.00	87.92
26.	**BVA-24**	39.50	5.30	11.10	3.90	8.20	2.00	0.07	7.30	1.10	11.00	31.00	31.50	48.95
27.	**BVA-25**	42.00	6.70	14.30	4.10	8.90	2.30	0.10	6.30	0.90	9.40	24.00	63.30	117.37
28.	**BVA-26**	35.00	4.70	10.20	4.10	11.20	2.80	0.27	9.60	1.40	14.30	32.00	37.20	51.31
29.	**BVA-27**	33.00	6.00	10.00	4.10	8.20	2.00	0.20	8.50	1.30	12.80	30.00	67.10	90.26
30.	**BVA-28**	36.00	6.30	8.80	4.10	6.10	1.50	0.24	8.30	1.30	12.50	27.00	46.20	55.97
31.	**BVA-29**	34.00	7.00	9.40	4.10	3.20	0.80	0.34	14.00	2.10	21.00	26.00	46.10	60.01
32.	**BVA-30**	31.00	4.50	9.60	4.10	7.30	1.80	0.27	10.30	1.50	15.50	24.00	33.10	43.53
33.	**BVA-31**	33.00	5.80	9.60	4.30	7.80	1.80	0.05	5.70	0.90	8.50	28.00	52.20	68.29
34.	**BVA-47**	34.20	5.20	9.20	4.10	6.50	1.60	0.29	10.80	1.60	16.10	25.00	55.20	69.64
35.	**BVA-53**	23.10	6.10	9.90	2.60	5.00	1.90	0.26	10.00	1.50	15.00	22.00	50.30	60.49
36.	**BVA-52**	34.00	5.00	9.20	4.10	8.20	2.00	0.20	6.90	1.00	10.40	30.00	32.00	97.66
37.	**BVA-A-1**	33.50	5.90	19.10	3.40	4.00	1.20	0.26	10.30	1.50	15.50	24.00	39.40	97.39
38.	**BVA-A-2**	44.80	6.60	20.10	5.00	9.20	1.80	0.31	13.30	2.00	20.00	22.00	63.50	68.34
39.	**BVA-A-3**	32.00	5.40	9.10	2.20	4.00	1.80	0.32	16.50	2.50	24.80	24.00	33.50	73.54
40.	**BVA-A-4**	28.30	5.40	16.20	3.00	4.50	1.50	0.33	11.70	1.80	17.60	21.00	36.00	53.76
41.	**BVA-A-5**	31.00	6.70	14.10	3.40	5.80	1.60	0.11	13.30	2.00	20.00	27.00	48.50	119.57
42.	**BVA-A-6**	36.00	5.50	8.90	3.40	4.80	1.40	0.24	10.60	1.60	16.00	24.00	43.10	159.84
43.	**BVA-A-7**	26.00	5.60	9.20	3.20	4.20	1.30	0.22	17.60	2.70	26.50	29.00	43.10	45.83
44.	**BVA-A-8**	37.00	4.60	12.60	2.60	4.20	1.60	0.37	17.00	2.60	25.50	23.00	32.50	96.88
45	**BVA-A-9**	30.00	5.80	7.30	3.40	3.80	1.10	0.34	17.30	2.60	26.00	29.00	18.10	100.90
46.	**BVA-A-10**	41.00	5.70	10.60	3.80	6.40	1.70	0.24	10.60	1.60	16.00	30.00	53.70	57.96
47.	**BVA-1**	32.50	5.40	7.90	3.30	5.20	1.60	0.31	13.30	2.00	20.00	24.00	37.00	53.99
48	**BVA-2**	31.20	5.00	9.90	3.00	3.40	1.10	0.29	7.70	1.20	11.60	23.00	42.70	67.71
49.	**BVA-48**	37.00	5.00	11.40	4.00	2.90	0.70	0.22	10.40	1.60	15.60	24.00	46.00	29.33
50.	**BVA-4**	30.20	5.80	9.90	4.40	3.50	0.80	0.04	4.70	0.70	7.00	24.00	47.90	66.84
51.	**BVA-5**	35.10	5.10	9.00	3.60	15.30	4.30	0.12	7.80	1.20	11.70	25.00	46.80	64.57
52.	**BVA-6**	34.00	5.60	10.10	4.20	11.20	2.60	0.37	17.20	2.60	25.80	28.00	63.40	96.03
53.	**BVA-7**	33.90	5.90	11.10	3.90	10.40	2.70	0.30	14.70	2.20	22.10	23.00	41.40	66.18
54.	**BVA-8**	32.10	6.10	10.10	3.70	7.40	2.00	0.15	9.00	1.40	13.50	26.00	59.50	82.17
55.	**BVA-9**	34.30	6.20	12.00	3.90	7.00	1.80	0.18	12.80	1.90	19.20	29.00	38.70	67.42
56.	**BVA-10**	35.50	6.90	10.20	4.90	10.20	2.10	0.62	28.40	4.30	42.60	23.00	57.20	84.17
57.	**BVA-11**	39.20	5.00	8.60	3.70	7.40	2.00	0.15	9.60	1.40	14.40	24.00	43.10	59.43
58.	**BVA-12**	40.10	5.30	8.40	3.80	7.60	2.00	0.16	10.00	1.50	15.00	30.00	43.10	41.78
59.	**BVA-13**	29.20	5.00	10.70	4.30	5.50	1.30	0.16	12.40	1.90	18.60	26.00	32.50	59.88
60.	**BVA-14**	30.50	5.70	9.80	4.30	10.70	2.50	0.11	11.40	1.70	17.10	30.00	38.70	63.17
61.	**BVA-15**	26.90	6.30	9.80	3.80	4.90	1.30	0.08	4.40	0.70	6.60	32.00	24.80	52.67
62.	**BVA-16**	32.60	3.80	10.40	4.00	7.60	1.90	0.22	14.70	2.20	22.10	29.00	40.60	67.00

Sl. No.	Genotype/ Traits	PH	ST	NOL	LW	SW	S:L	DW/ Pl	HY/ Pt	HY/ Pl	HY /ha	DHM	LS	LA
63.	**BVA-17**	39.50	5.20	14.00	3.20	5.10	1.60	0.20	14.00	2.10	21.00	25.00	48.90	102.42
64.	**BVA-49**	30.50	5.10	11.10	4.00	5.50	1.40	0.07	3.80	0.60	5.70	26.00	54.80	93.20
	Mean	34.76	5.67	10.51	3.89	7.12	1.82	0.20	10.64	1.60	15.98	26.86	46.84	73.30
	S.E m ±	6.99	1.09	1.94	0.55	0.64	0.27	0.11	0.57	0.08	0.84	2.50	3.56	2.78
	C.D (5%)	15.81	2.47	4.38	1.23	1.44	0.60	0.25	1.29	0.19	1.90	5.66	8.06	46.69
	CV (%)	12.93	11.77	11.71	8.66	5.39	9.01	33.51	3.23	3.16	3.16	5.97	4.70	17.51

PH: Plant height (cm) LW: Leaf weight (g) HY/Pt: Herbage yield per plant (g)
ST: Stem thickness (mm) SW: Stem weight(g) HY/ha: Herbage yield per hectare (t)
DHM: Days to horticulture maturity S: L: Shoot to leaf ratio LS: Leaf size (cm^2)

NOL: No. of leaves per plant DW: Dry weight (kg)LA: Leaf area per plant (cm^2)
S. E m**±**: Standard error of mean HY/Pl: Herbage yield per plot (kg)
C.D: Critical difference (%) CV: Coefficient of variation (%)

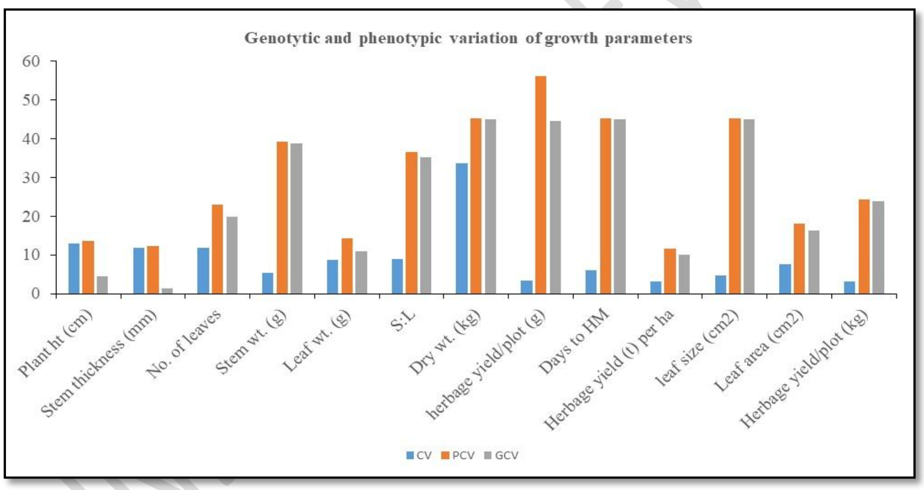

Fig. 1:Genotypic and phenotypic co-efficient of variation (GCV % and PCV %) of growth and yield parameters

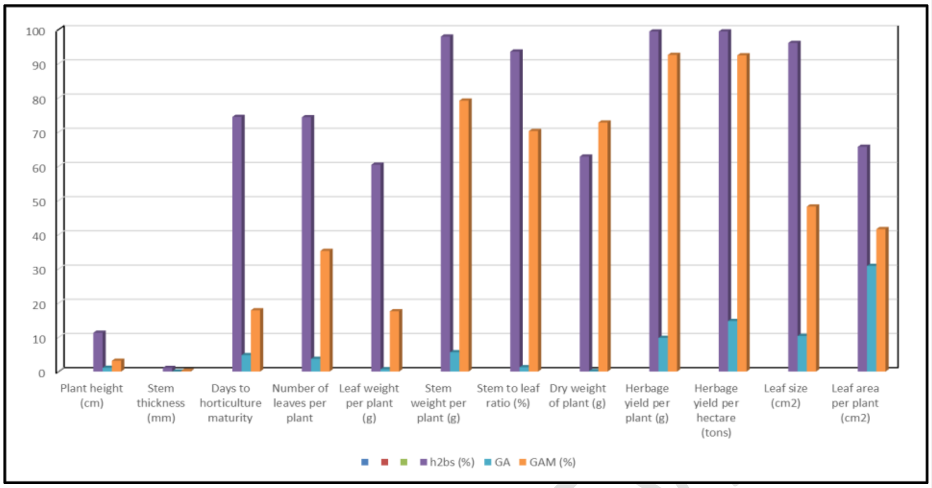

Fig. 2. Heritability, genetic advance and genetic advance as percent of mean of growth and yield parameter

4. CONCLUSION

Amaranthus being an underutilized crop is one of the major source of essential nutrients to the human diet. The parameters like stem to leaf ratio, herbage yield per plot, herbage yield per plant, herbage yield per hectare, stem weight, number of leaves per plant, dry weight, leaf size, showed the higher levels of PCV and GCV highlighting the respective levels of variability for the traits within genotypes. Further, the traits like plant height, stem to leaf ratio, dry weight of plant, herbage yield per plant, per hectare and per plot, stem weight and number of leaves, exhibited higher levels of heritability coupled with the higher GAM indicating the action of additive genes confirming the positive effect of direct selection based on respective traits, while the traits like days to horticultural maturity and leaf weight were with the higher heritability united with the moderate GAM and the trait leaf moisture exhibited he higher heritability linked with the low levels of GAM revealed the effect of non-additive gene action.

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