

## Original Research Article

<https://doi.org/10.20546/ijcmas.2017.608.291>**Genetic Studies in Amaranthus Germplasm**

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**A B S T R A C T**

An investigation was carried out to study genetic studies in amaranthus germplasm of 10 germplasm of amaranthus at Horticulture Instructional cum Research Farm of Department of Horticulture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (CG) during the period from October, 2014 to February, 2015. The experiment was laid out in the Randomized Complete Block Design with four replications. The data were analyzed to work out the variability, correlation coefficient and path analysis for character viz., number of leaves per plant, leaf length (cm), leaf width (cm), plant height (cm), stem girth (cm), stem weight (gm), leaf weight (gm), stem weight (gm), petiole length (cm), panicle length (cm), plant weight (gm), number of cutting, leaf yield (kg/plot), seed yield (gm/plant), 1000 seed weight (gm) and crop duration (sowing to last harvest). The analysis of variance indicated that the mean sum of square due to genotypes were highly significant for all the sixteen characters. Significant mean sum of squares due to leaf yield and attributing characters revealed existence of considerable variability in material studied for improvement of various traits. The highest leaf yield kg per plot was recorded in genotype 2012/AMVAR-4 followed by 2012/AMVAR-7 (17.41 kg/plot), CG Amaranthus-1 (17.36 kg/plot). Moderate estimates of phenotypic and genotypic coefficient of variation for almost all traits except leaf weight show the high genotypic and phenotypic variation indicated that there was high variability offering ample scope for selection of desired variability. Heritability along with genetic advance as percent of mean for all the tested characters indicated that these characters were under additive gene action and there were excellent chances of effective selection for improvement of these traits. Highly significant and positive correlation with leaf yield was observed with plant height, plant weight, stem girth and seed yield, whereas leaf length and petiole length showed negative association with green yield. Path coefficient analysis revealed that stem weight, 1000 seed weight, number of leaves, intermodal length and panicle length were the most important yield components. Selection programme based on these characters is suggested for further improvement.

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**Introduction**

Amaranthus or chaulai (*Amaranthus sp.*) is a very popular leafy vegetable in India as well tropical and sub-tropical areas of globe and it can be grown throughout the year because it has very fast growth habit in short duration and large produce of edible matter per unit area, it fits well in a crop rotation hence amaranthus is the largest produced as leafy

vegetable in the world. The word "Amaranth" is basically derived from Greek word "Anthos" which means "everlasting" according to Sankaran (1943). *Amaranthus tricolor* is an important vegetable amaranthus cultivated in India and numbers of domesticated forms are available in India especially in Tamil Nadu, Andhra Pradesh,

Karnataka and Kerala states. Amaranthus preferred for both urban and rural population and it's also considered to be the cheapest leafy vegetable in the market and it could be rightly described as a "poor man's vegetable" (Varalakshmi, 2004). The amaranth can grow under varied soil and agro climatic conditions (Katiyar *et al.*, 2000; Shukla and Singh, 2000) are resistant from heat and drought with no major disease problems. Beside its adaptable nature in various climatic conditions, the amaranth plant also has important nutritional and medicinal properties (Lakshmi and Vimala, 2000). Due to use of amaranth as vegetable and grain crop, it can be a cheap alternative rich source of protein and nutrient for poor people in developing countries (Prakash and Pal 1991; Prakash *et al.*, 1995; Shukla *et al.*, 2006). The protein component of amaranth is quite close to the level recommended by the FAO/WHO for balance diet in human. The protein in leaf is up to 14.3g/kg with an average of 12.4g/kg (Shukla *et al.*, 2003, 2006; Prakash and Pal 1991). A large number of necessary minerals have also been reported in amaranthus. The genetic improvement of any crop depends upon the available genetic variability for quantitative traits and its judicious exploitation through efficient breeding methods. India is the center of origin of *Amaranthus sp.*, hence wide genetic variability is available for utilization to developed high yielding varieties. The available variability in trait of amaranthus population can be partitioned into heritable and non-heritable parts with the aid of genetic parameters such as GCV, PCV, heritability and genetic advance. Correlation coefficient helps to identify the relative contribution of component characters towards yield. The correlation between yield and a component character may sometimes be misleading. Thus splitting of total correlation into direct and indirect effects would provide a more meaningful interpretation of such association. Path coefficient, which is a standard partial

regression coefficient, specifies the cause and effect relationship and measures the relative importance of each variable. Therefore, correlation in combination with path coefficient analysis will be an important tool to find out the association and quantify the direct and indirect influence of one character upon another and in Chhattisgarh state available wide genetic variability of amaranths in the local land races there is urgent need to develop or identify with categorized high yielding varieties. Therefore present investigation under taken to find out the Genetic Studies in Amaranthus Germplasm between various component characters and their showing the possibilities of further genetic improvement in amaranthus.

### **Materials and Methods**

The experimental material consisted of 10 genotypes of *Amaranthus sp.* selected from a germplasm collection maintained under AICRP on vegetable crops at the Department of Horticulture, IGKV, Raipur (C.G.). The material was grown in a randomized block design with four replications in winter (October, 2014). The genotypes were raised in flat beds of size 3 x 2 m<sup>2</sup> and evaluated under irrigated condition. Observations were recorded on 10 plants in each replication for the 16 characters *viz.*, plant height, plant weight, number of leaves, leaf length, leaf width, leaf weight, stem weight, stem girth, internodal length, petiole length, panicle length, number of cutting, 1000 seed weight, seed yield, crop duration and leaf yield. The analysis of variance was carried out for each character separately as per method of Panse and Sukhatme (1967). The coefficient of variation for different characters was estimated by formula as suggested by Burton (1952). The heritability was estimated as per the formula suggested by Burton and De Van (1953) and the expected advance was

calculated by the formula given by Johnson *et al.*, (1955). The Genotypic and phenotypic correlation coefficients were worked out using the formulae suggested by Miller *et al.*, (1958) and path analysis was carried out as suggested by Dewey and Lu (1959) so as to study the direct and indirect contribution of component characters on green yield of amaranthus species.

## Results and Discussion

The analysis of variance for all the characters under study is presented in table 1. These analyses of variance revealed that mean sum of squares due to genotypes were highly significant for all characters. This is an indication of existence of sufficient variability among all the genotypes for leaf yield and its components traits. Similar result reported by Raut *et al.*, (2014).

The observation on ten plants from each genotype of all four replications for leaf yield and its components characters were used for calculating the mean performance. The observations were first averaged for ten plant taken randomly for each genotype in each replication and were later averaged over all the four replications. The mean performance of different genotype are presented character wise in table 2.

The plant height ranged from 8.39 cm (2012/AMVAR-2) to 12.15 cm (CG Amaranthus-1) with an overall mean of 10.10 cm. higher plant height was recorded in the genotype CG Amaranthus-1 (12.15 cm). The Plant weight ranged from 52.50 gm (2012/AMVAR-1) to 70.50 gm (2012/AMVAR-7) with an overall mean of 62.20 gm. Higher plant weight was recorded in 2012/AMVAR-7 (70.50 gm). The number of leaves ranged from 18.56 (2012/AMVAR-6) to 26.36 (CG Amaranthus-1) with an overall mean of 20.88. Higher number of

leaves was recorded in CG Amaranthus-1 (26.36). The leaf length ranged from 4.83 cm (2012/AMVAR-1) to 8.98 cm (Arun) with an overall mean of 6.14 cm. higher leaf length was recorded in Arun (8.98 cm). The leaf width ranged from 3.45 cm (2012/AMVAR-1) to 5.06 cm (CG Amaranthus-1) with an overall mean of 4.35 cm. higher leaf width was recorded in CG Amaranthus-1 (5.06 cm). The leaf weight ranged from 1.27 gm (2012/AMVAR-2) to 2.84 gm (Arun) with an overall mean of 1.88 gm. higher leaf weight was recorded in Arun (2.84 gm). The stem weight ranged from 7.38 gm (2012/AMVAR-1) to 11.49 gm (CG Amaranthus-1) with an overall mean of 8.79 gm. higher stem weight was recorded in CG Amaranthus-1 (11.49 gm). The stem girth ranged from 1.47 cm (2012/AMVAR-2) to 2.39 cm (CG Amaranthus-1) with an overall mean of 1.66 cm. higher stem girth was recorded in CG Amaranthus-1 (2.39 cm). The internodal length ranged from 1.36 cm (2012/AMVAR-1) to 2.51 cm (Arka Saguna) with an overall mean of 1.78 cm. higher intermodal length was recorded in Arka Saguna (2.51 cm). The petiole length ranged from 2.50 cm (2012/AMVAR-1) to 3.70 cm (2012/AMVAR-4) with an overall mean of 3.14 cm. Higher petiole length was recorded in 2012/AMVAR-4 (3.70 cm). The panicle length ranged from 9.75 cm (CG Amaranthus-1) to 14.17 cm (2012/AMVAR-1) with an overall mean of 12.99 cm. Higher panicle length was recorded in 2012/AMVAR-1 (14.17 cm). The number of cutting ranged from 3.75 (2012/AMVAR-7) to 5.75 (CG Amaranthus-1) with an overall mean of 4.40. Higher number of cutting was recorded in CG Amaranthus-1 (5.75). The 1000 seed weight ranged from 0.73 gm (2012/AMVAR-5) to 0.85 gm (2012/AMVAR-6) with an overall mean of 0.79 gm. Higher 1000 seed weight was recorded in 2012/AMVAR-6 (0.85 gm). The seed yield per plant ranged from 8.52 gm (2012/AMVAR-2) to 11.54 gm

(2012/AMVAR-1) with an overall mean of 10.18 gm. Higher seed yield per plant was recorded in 2012/AMVAR-2 (11.54 gm). The crop duration ranged from 100.25 days (2012/AMVAR-5) to 122.50 days (2012/AMVAR-4) with an overall mean of 117.48. Higher crop duration was recorded in 2012/AMVAR-4 (122.50 days). The leaf yield ranged from 10.13 kg/plot (Arun) to 17.83 kg/plot (2012/AMVAR-4) with an overall mean of 14.87 kg/plot. Higher leaf yield was recorded in 2012/AMVAR-4 (17.83 kg).

Genotypic and phenotypic coefficients of variation of different characters are presented in table 3. High magnitude of genotypic as well as phenotypic coefficient of variations were recorded for traits *viz.*, leaf weight (35.01 and 35.63), leaf length (19.69 and 24.50) and intermodal length (18.46 and 22.99) suggested the substantial improvement on amaranthus through selection for these traits. Moderate GCV and PCV were recorded for petiole length (13.59 and 14.46), stem weight (13.44 and 14.47), leaf width (13.36 and 15.12), leaf yield per plot (13.31 & 21.67), number of cutting (12.79 and 20.42) and number of leafs per plant (11.48 and 13.15) suggested existence of considerable variability in the population. The traits which showed high phenotypic and genotypic coefficient of variations are of economic importance and there is scope for improvement of these traits through selection. The present investigation high magnitude of heritability was recorded for most of characters. The highest heritability was recorded for the characters leaf weight (96.6%) stem weight (86.2%), petiole length (86.1%), leaf width (78.1%) and number of leaf per plant (76.2%). The moderate heritability was observed for leaf length (64.5%), intermodal length (64.5%) and Low heritability was observed for 1000 seed weight (38.5%), panicle length (38.1%), leaf

yield kg per plot (37.7%), number of cutting (37.7%), seed yield per plant (37.0%), plant weight (27.4%), plant height (26.8%) and crop duration (26.2%). The heritability value alone however, provides no indication of the amount of genetic improvement that would result from selection of superior genotypes. The heritability estimates would be reliable if it is limited in broad sense, additive and non-additive gene effect are accompanied with high genetic advance. To facilitate the comparison of progress in various characters of different genotypes genetic advance was calculated as percentage of mean. Genetic advance as percentage of mean was observed high for leaf weight (71.2%), leaf length (32.5%), stem girth (30.3%), leaf width (25.7%), intermodal length (25.7%) and number of leafs per plant (20.6%). The high value of genetic advance for these traits showed that these characters are governed by additive genes and selection will be rewarding for the further improvement of such traits. Moderate genetic advance for the traits suggest that both the additive and non-additive variance are operating in these traits.

Heritability estimates along with genetic advance are more useful than the heritability value alone for selecting the best individual. High heritability coupled with high genetic advance was observed for number of leafs per plant, leaf width and leaf weight indicating that most likely the heritability is due to additive gene effects and selection may be effective. Therefore, selection based on phenotypic performance of these traits would be effective to select desirable genotypes and Ahammed *et al.*, (2012) were also estimated higher heritability for leaf weight per plant (91.10%) and stem weight per plant (82.56%).

Genotypic and phenotypic coefficients among 16 quantitative characters are presented in table 2. Significant and positive correlation of leaf yield was observed with plant height,

plant weight, stem girth and seed yield at genotypic level. Similarly Anuja (2012) reported that plant height and stem girth are significant positive correction with leaf yield.

Plant height showed positive and significant correlation with number of leaves per plant, stem weight, stem girth, 1000 seed weight, seed yield and significant negative correction with petiole length and panicle length at genotypic level only. Plant weight showed positive and significant correlation with leaf yield at genotypic level only.

Number of leaves per plant showed positive and significant correlation with leaf length at phenotypic level only whereas, significant positively correlated with plant height, leaf weight, stem weight, stem girth and number of cutting and its significant negatively correlated with panicle length and crop duration at genotypic level only. Leaf length exhibited significant positive correlation with leaf weight at both genotypic and phenotypic

level while significant positive correlated with number of leaves per plant, leaf width, internodal length, petiole length and significant negatively correlated with seed yield and leaf yield at genotypic level only.

Leaf width had positive and significant correlation with leaf length and 1000 seed weight at genotypic level only.

Leaf weight showed positive and significant correlation with leaf length and number of cutting at both genotypic and phenotypic level while significant positively correlated with number of leaves per plant at genotypic level only.

Stem weight showed positive and significant correlation with stem girth at both genotypic and phenotypic level while positive and significant correlation with plant height, number of leaves per plant, number of cutting and significant negatively correlated with panicle length at genotypic level only.

**Table.1** Analysis of variance for leaf yield and its component characters in *Amaranthus*

S. NO.	Character (df)	Mean sums of square		
		Replication 3	Treatment 9	Error 27
1	Plant height (cm)	5.674	5.862*	2.381
2	Plant weight (gm)	46.667	133.489*	53.148
3	Number of leaf/plant	0.899	24.774**	1.795
4	Leaf length (cm)	0.454	6.588**	0.802
5	Leaf width (cm)	0.753	1.172*	0.514
6	Leaf weight (gm)	0.008	1.756**	0.015
7	Stem weight (gm)	0.137	5.808**	0.223
8	Stem girth (cm)	0.036	0.320**	0.025
9	Internodal length (cm)	0.018	0.492**	0.060
10	Petiole length (cm)	0.061	0.874**	0.107
11	Panicle length (cm)	0.975	8.920**	2.578
12	Number of cutting	0.467	1.789**	0.522
13	1000 seed weight (gm)	0.005	0.006**	0.002
14	Seed yield (gm/ plant)	3.811	4.776**	1.428
15	Crop duration	6.958	170.081*	70.236
16	Leaf yield (kg/plot)	92.737	22.131**	6.468

\*: Significant at 5%, \*\*: Significant at 1%

**Table.2** Mean performance for leaf yield and its components in Amaranthus

Characters Genotypes	Plant height (cm)	Plant weight (gm)	Number of leafs/ plant	Leaf length (cm)	Leaf width (cm)	Leaf weight (gm)	Stem weight (gm)	Stem girth (cm)	Internodal length (cm)	Petiole length (cm)	Panicle length (cm)	Number of cutting	1000 seed weight (gm)	Seed yield (gm/ plant)	Crop duration (Days)	Leaf yield (kg/plot)
2012/AMVAR-1	10.49	52.50	20.52	4.83	3.45	1.66	7.38	1.54	1.36	2.50	14.17	4.25	0.77	11.54	120.50	14.67
2012/AMVAR-2	8.39	62.50	18.87	5.75	4.38	1.27	8.50	1.47	1.39	3.39	13.95	4.25	0.80	8.52	118.50	13.61
2012/AMVAR-3	9.61	65.25	18.61	5.33	4.05	1.39	8.27	1.54	1.58	2.68	12.94	4.25	0.82	10.83	121.50	14.69
2012/AMVAR-4	9.77	62.50	19.98	6.15	4.50	1.48	8.14	1.69	2.21	3.70	14.08	4.00	0.74	11.02	122.50	17.83
2012/AMVAR-5	9.06	70.00	23.79	5.57	3.82	1.67	8.33	1.49	1.72	3.43	12.71	4.00	0.73	9.44	100.25	15.84
2012/AMVAR-6	10.39	56.75	18.56	5.37	4.24	1.42	8.13	1.49	1.84	3.47	11.63	4.00	0.85	10.98	119.25	13.56
2012/AMVAR-7	11.97	70.50	20.67	5.35	4.04	1.48	10.13	1.57	1.67	2.71	13.77	3.75	0.83	9.91	120.50	17.41
Arka saguna	9.17	64.75	19.83	7.78	5.00	2.82	9.34	1.55	2.51	3.38	12.19	5.50	0.78	9.35	121.00	13.62
Arrun	9.99	57.00	21.63	8.98	4.98	2.84	8.23	1.86	1.84	3.59	14.70	4.25	0.77	8.89	116.00	10.13
CG Amaranthus-1	12.15	60.25	26.36	6.30	5.06	2.82	11.49	2.39	1.72	2.57	9.75	5.75	0.81	11.37	114.75	17.36
Mean (x)	<b>10.10</b>	<b>62.20</b>	<b>20.88</b>	<b>6.14</b>	<b>4.35</b>	<b>1.88</b>	<b>8.79</b>	<b>1.66</b>	<b>1.78</b>	<b>3.14</b>	<b>12.99</b>	<b>4.40</b>	<b>0.79</b>	<b>10.18</b>	<b>117.48</b>	<b>14.87</b>
SEm±	0.771	3.645	0.670	0.448	0.359	0.062	0.236	0.079	0.122	0.164	0.803	0.361	0.021	0.597	4.190	9.927
CD (p=0.05)	2.2386	10.5772	1.9440	1.2994	1.0406	0.1797	0.6856	0.228	0.3542	0.4747	2.3296	1.0485	0.0599	1.7337	12.1592	3.69
CV (%)	15.28	11.721	6.417	14.589	16.485	6.576	5.373	9.476	13.702	10.421	12.363	16.424	5.235	11.735	7.134	17.104

**Table.3** Genetic parameter of variability for leaf yield and its component character in Amaranthu

S.No.	Characters	Mean	Range		Coefficient of Variation (%)		Heritability (h <sup>2</sup> %)	GA as percent of Mean
			Min <sup>m</sup>	Max <sup>m</sup>	GCV	PCV		
1	Plant height (cm)	10.10	8.39	12.15	9.24	17.87	26.8	9.8
2	Plant weight (gm)	62.20	52.50	70.50	7.21	13.76	27.4	7.76
3	Number of leafs/plant	20.88	18.56	26.36	11.48	13.15	76.2	20.6
4	Leaf length (cm)	6.14	4.83	8.98	19.69	24.50	64.5	32.5
5	Leaf width (cm)	4.35	3.45	5.06	13.36	15.12	78.1	25.7
6	Leaf weight (gm)	1.88	1.27	2.84	35.01	35.63	96.6	71.2
7	Stem weight (gm)	8.79	7.38	11.49	13.44	14.47	86.2	11.4
8	Stem girth (cm)	1.66	1.47	2.39	9.55	15.46	38.1	30.3
9	Internodal length (cm)	1.78	1.36	2.51	18.46	22.99	64.5	25.7
10	Petiole length (cm)	3.14	2.50	3.70	13.59	14.65	86.1	12.3
11	Panicle length (cm)	12.99	9.75	14.70	9.60	15.71	38.1	16.1
12	Number of cutting	4.40	3.75	5.75	12.79	20.42	37.7	16.8
13	1000 seed weight (gm)	0.79	0.73	0.85	4.14	6.68	38.5	5.06
14	Seed yield (gm/ plant)	10.18	8.52	11.54	8.99	14.78	37.0	11.2
15	Crop duration	117.48	100.25	122.50	4.25	8.31	26.2	4.4
16	Leaf yield (kg/plot)	14.87	10.13	17.83	13.31	21.67	37.7	16.8

**Table.4** Genotypic and phenotypic correlation coefficient between leaf yield and its component

Character		01. Plant height (cm)	02. Plant weight (gm)	03. Number of leaves/ plant	04. Leaf length (cm)	05. Leaf width (cm)	06. Leaf weight (gm)	07. Stem weight (gm)	08. Stem girth (cm)	09. Internodal length (cm)	10. Petiole length (cm)	11. Panicle length (cm)	12. Number of cutting	13. 1000 seed weight (gm)	14. Seed yield (gm/ plant)	15. Crop duration	16. Leaf yield (kg/plot)
1	P	1.000	0.025	0.193	-0.127	0.146	0.106	0.529	0.503	0.082	-0.354	-0.149	0.122	0.150	0.315	0.024	0.326
	G	1.000	-0.238	0.703*	-0.175	0.424	0.320	0.747**	0.783**	-0.297	-0.872**	-0.631*	0.225	0.720**	0.814**	0.324	0.569*
2	P		1.000	-0.056	-0.039	-0.204	-0.155	0.246	-0.023	0.154	0.049	-0.019	-0.036	-0.096	-0.227	-0.264	0.166
	G		1.000	0.206	-0.183	-0.322	-0.229	0.447	-0.326	0.221	0.067	-0.082	-0.230	-0.073	-0.543	0.414	0.735**
3	P			1.000	0.990**	0.060	0.488	0.479	0.424	-0.069	-0.204	-0.304	0.222	-0.208	0.032	-0.313	0.236
	G			1.000	0.172	0.080	0.582*	0.669*	0.918**	-0.029	-0.241	-0.632*	0.641*	-0.337	0.187	-0.898**	0.387
4	P				1.000	0.406	0.657*	0.106	0.077	0.476	0.408	0.078	0.257	-0.191	-0.378	-0.013	-0.344
	G				1.000	0.645*	0.869**	0.142	-0.041	0.614*	0.581*	0.118	0.491	-0.374	-0.607	0.007	-0.746**
5	P					1.000	0.474	0.258	0.168	0.195	0.263	-0.154	0.181	0.353	-0.172	0.145	-0.376
	G					1.000	0.503	0.359	0.362	0.300	0.306	-0.477	0.334	0.556*	-0.019	0.185	-0.487
6	P						1.000	0.428	0.296	0.374	0.090	-0.264	0.580*	-0.116	-0.101	-0.066	-0.236
	G						1.000	0.487	0.528	0.510	0.093	-0.398	0.900**	-0.228	-0.176	-0.151	-0.356
7	P							1.000	0.636*	0.156	-0.324	-0.442	0.381	0.147	0.001	-0.031	0.339
	G							1.000	0.869**	0.149	-0.353	-0.803**	0.778**	0.457	0.080	-0.072	0.519
8	P								1.000	0.119	-0.362	-0.380	0.322	0.149	0.200	-0.067	0.267
	G								1.000	-0.151	-0.504	-0.974**	0.953**	0.226	0.641*	0.002	0.602*
9	P									1.000	0.362	-0.099	0.329	-0.169	-0.063	0.122	0.055
	G									1.000	0.508	-0.233	0.390	-0.356	-0.115	0.182	-0.014
10	P										1.000	0.222	-0.044	-0.168	-0.442	-0.180	-0.388
	G										1.000	0.213	-0.268	-0.418	-0.791**	-0.347	-0.607*
11	P											1.000	-0.346	-0.152	-0.329	-0.038	-0.234
	G											1.000	-0.972**	-0.576*	-0.424	0.468	-0.380
12	P												1.000	0.084	0.226	-0.013	0.008
	G												1.000	0.017	-0.014	0.088	0.024
13	P													1.000	0.206	0.243	-0.085
	G													1.000	0.195	0.647*	0.012
14	P														1.000	0.066	0.348
	G														1.000	0.526	0.655*
15	P															1.000	-0.083
	G															1.000	0.039
16	P																1.000
	G																1.000

**Table.5** Direct and indirect effect of component character on leaf yield in Amaranthus

Character	01. Plant height (cm)	02. Plant weight (gm)	03. Number of leaves/ Plant	04. Leaf length (cm)	05. Leaf width (cm)	06. Leaf weight (gm)	07. Stem weight (gm)	08. Stem girth (cm)	09. Internodal length (cm)	10. Petiole length (cm)	11. Panicle length (cm)	12. Number of cutting	13. 1000 seed weight (gm)	14. Seed yield (gm/ plant)	15. Crop duration	16. Leaf yield (kg/plot)
Plant height(cm)	<b>-0.110</b>	0.015	0.317	-0.027	-0.115	-0.416	0.961	0.096	-0.131	-0.038	-0.179	-0.016	-0.236	0.395	0.053	0.569
Plant weight (gm)	0.026	<b>-0.062</b>	0.093	-0.028	0.087	0.298	0.575	-0.040	0.097	0.003	-0.023	0.016	0.024	-0.264	-0.068	0.735
Number of leaves/plant	-0.077	-0.013	<b>0.450</b>	0.026	-0.022	-0.758	0.861	0.113	-0.013	-0.011	-0.179	-0.046	0.110	0.091	-0.147	0.387
Leaf length (cm)	0.019	0.011	0.077	<b>0.152</b>	-0.175	-1.131	0.183	-0.005	0.270	0.026	0.033	-0.035	0.122	-0.295	0.001	-0.746
Leaf width (cm)	-0.047	0.020	0.036	0.098	<b>-0.271</b>	-0.655	0.462	0.044	0.132	0.013	-0.135	-0.024	-0.182	-0.009	0.030	-0.487
Leaf weight (gm)	-0.035	0.014	0.262	0.132	-0.136	<b>-1.301</b>	0.627	0.065	0.224	0.004	-0.113	-0.064	0.075	-0.085	-0.025	-0.356
Stem weight (gm)	-0.082	-0.028	0.301	0.022	-0.097	-0.634	<b>1.287</b>	0.107	0.065	-0.016	-0.227	-0.055	-0.150	0.039	-0.012	0.519
Stem girth (cm)	-0.086	0.020	0.413	-0.006	-0.098	-0.687	1.119	<b>0.123</b>	-0.067	-0.022	-0.276	-0.068	-0.074	0.311	0.000	0.602
Internodel length(cm)	0.033	-0.014	-0.013	0.093	-0.081	-0.663	0.191	-0.019	<b>0.440</b>	0.022	-0.066	-0.028	0.117	-0.056	0.030	-0.014
Petiole length (cm)	0.096	-0.004	-0.109	0.088	-0.083	-0.122	-0.454	-0.062	0.223	<b>0.044</b>	0.060	0.019	0.137	-0.384	-0.057	-0.607
Panicle length (cm)	0.069	0.005	-0.285	0.018	0.129	0.518	-1.034	-0.120	-0.102	0.009	<b>0.283</b>	0.069	0.189	-0.206	0.077	-0.380
Number of cutting	-0.025	0.014	0.289	0.074	-0.090	-1.171	1.001	0.117	0.171	-0.012	-0.275	<b>-0.071</b>	-0.006	-0.007	0.014	0.024
1000 seed weight(gm)	-0.079	0.005	-0.152	-0.057	-0.151	0.297	0.588	0.028	-0.157	-0.018	-0.163	-0.001	<b>-0.328</b>	0.095	0.106	0.012
Seed yield (gm/plant)	-0.089	0.034	0.084	-0.092	0.005	0.229	0.103	0.079	-0.051	-0.035	-0.120	0.001	-0.064	<b>0.486</b>	0.086	0.655
Crop duration	-0.036	0.026	-0.404	0.001	-0.050	0.197	-0.093	0.000	0.080	-0.015	0.133	-0.006	-0.212	0.255	<b>0.163</b>	0.039

Stem girth showed positive and significant correlation with stem weight at both genotypic and phenotypic level while positive and significant correlation with plant height, number of leaves, number of cutting, seed yield and leaf yield and significant negatively correlated with panicle length at genotypic level only. Internodal length exhibited positive and significant correction with leaf length at genotypic level only (Table 4).

Petiole length showed significant positive correlation with leaf length while negative and significant correlation with seed yield per plot and leaf yield at genotypic level. Panicle length showed significant negative correlation with plant height, number of leaves per plant, number of cutting and 1000 seed weight at genotypic level only (Plant 5).

Number of cutting had positive and significant correlation with leaf weight at both genotypic and phenotypic level while positive and significant correlation with number of leaves per plant, stem weight and stem girth and it is significant negatively correlated with panicle length at genotypic level only.

1000 seed weight exhibited positive and significant correlation with plant height, leaf weight and crop duration while significant negatively correlated with panicle length at genotypic level only.

Seed yield per plant had positive and significant correlation with plant height, stem girth and leaf yield while significant negative correlated with leaf length and petiole length at genotypic level only. Crop duration had positive and significant correlation with 1000 seed weight while significant negatively correlated with number of leaves per plant at genotypic level only.

Path coefficient analysis is an important tool for partitioning the correlation coefficients

into the direct and indirect effects of independent variables on a dependent variable. In this analysis, leaf yield was taken as dependent variable and the rest of the characters were considered as independent variables.

The path coefficient analysis which splits total correlation coefficient of different characters into direct and indirect effects on leaf yield kg per plot in such a manner that the sum of direct and indirect effects is equal to total genotypic correlation as presented in table 3.

The data revealed that stem weight showed the highest positive direct effect (1.287) on leaf yield and indirect positive effected through number of leaves, leaf length, stem girth, internodal length, seed yield, whereas it was negative effect through plant height, plant weight, leaf width, leaf weight, petiole length, panicle length, number of cutting, 1000 seed weight, crop duration. Similarly Aruna (2010) reported that stem weight direct effect on leaf yield.

Plant height showed direct negative effect on leaf yield and indirect positive effect through plant weight, number of leaves, stem girth, stem weight seed yield, crop duration, whereas it was negative effect through leaf length, petiole length, panicle length, leaf width, leaf weight, internodal length, number of cutting, 1000 seed weight. Kendre *et al.*, (2013) also finding that plant height had the direct negative effect on leaf yield.

Plant weight had direct negative effect on leaf yield and this trait indirect positive effect through plant height, number of leaves, leaf width, leaf weight, stem weight, internodal length, panicle length, number of cutting, 1000 seed weight, whereas its effect was negative leaf length, stem girth, panicle length, seed yield, crop duration.

Number of leaves had exhibited positive direct effect on leaf yield and this trait was influenced indirect positive effect through leaf length, stem weight, stem girth, 1000 seed weight, seed yield, whereas negative effect through leaf width, leaf weight, internodal length, number of cutting, crop duration.

Leaf length had direct positive effect on leaf yield and it was also exerted indirect positive effects through plant height, plant weight, number of leaves, stem weight, internodal length, panicle length, petiole length, 1000 seed weight, crop duration, whereas negative effect through leaf width, leaf weight stem girth, number of cutting, seed yield.

Leaf width had negative direct effect towards leaf yield and its indirect positive effect through plant weight, number of leaves, leaf length, stem weight, stem girth, internodal length, panicle length, crop duration, whereas it was indirect negative effect through plant height, leaf weight, panicle length, number of cutting, 1000 seed weight, seed yield.

Leaf weight showed highest direct negative effect on leaf yield and its indirect positive effect through plant weight, number of leaves, leaf length, stem weight, stem girth, internodal length, panicle length, 1000 seed weight, whereas negative effect through plant height, leaf weight, panicle length, number of cutting, seed yield, crop duration.

Stem girth had positive direct effect on leaf yield and positive indirect effect through plant weight, number of leaves, stem weight, seed yield, whereas its negative effect through plant height, leaf length, leaf width, leaf weight, internodal length, panicle length, petiole length, number of cutting, 1000 seed weight.

Internodal length showed positive direct effect on leaf yield and positive indirect effect

through plant height, leaf length, stem weight, petiole length, 1000 seed weight, crop duration, whereas its negative effect through plant weight, number of leaves, leaf weight, leaf width, stem girth, panicle length, number of cutting, seed yield.

Petiole length had exhibited positive direct effect on leaf yield and indirect positive effect through plant height, leaf length, internodal length, panicle length, number of cutting, 1000 seed weight, whereas negative effect through plant weight, number of leaves, leaf width, leaf weight, stem weight, stem girth, seed yield, crop duration.

Panicle length had positive and direct effect on leaf yield and indirect positive effect through plant height, plant weight, leaf length, leaf width, leaf weight, petiole length, number of cutting, 1000 seed weight, crop duration, whereas it was negative effect through number of leaves, stem weight, stem girth, internodal length, seed yield.

Number of cutting had direct negative effect on leaf yield and its indirect positive effect through plant weight, number of leaves, leaf length, stem weight, stem girth, internodal length, crop duration, whereas indirect negative effect through plant height, leaf width, leaf weight, petiole length, panicle length, 1000 seed weight, seed yield.

1000 seed weight showed negative direct effect on leaf yield, whereas it was positive indirect effect through plant weight, leaf weight, stem weight, stem girth, seed yield, crop duration and negative effect through plant height, number of leaves, leaf length, leaf width, internodal length, petiole length, panicle length, number of cutting.

Seed yield had positive direct effect on leaf yield and its positive indirect effect through plant height, number of leaves, leaf length,

leaf width, stem weight, stem girth, number of cutting, crop duration, whereas negative indirect effect through plant height, leaf length, internodal length, petiole length, panicle length, 1000 seed weight.

Crop duration had direct and positive effect on leaf yield and indirect positive effect through plant weight, leaf length, internodal length, panicle length, seed yield, whereas it was indirect negative effect through plant height, number of leaves, leaf width, stem weight, petiole length, number of cutting, 1000 seed weight.

Conclusion of this study is the analysis of variance shows that considerable variability existed among the genotypes for most of the traits showing possibilities of further genetic improvement in amaranthus. The mean performance for leaf yield kg per plot of 2012/AMVAR-4 was superior among all the genotype. Higher heritability estimates coupled with high genetic advance as percent of mean were observed for leaf weight, leaf width and number of leaves per plant. Correlation studies revealed that leaf yield kg per plot showed the highest positive and significant correlation with plant weight and seed yield per plant at genotypic level only. Path analysis revealed that stem weight was highly positive direct effected on leaf yield thus its character show the play important role for improvement programme of amaranthus vegetable.

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