Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; SP1: 409-415

Bhanupratap Jangde
Department of Vegetable Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Bhagwat Saran Asati
Department of Vegetable Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Pooja Sahu
Department of Vegetable Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Barsha Tripathy
Department of Vegetable Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Correspondence
Bhanupratap Jangde
Department of Vegetable Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Correlation and path coefficient analysis in vegetable amaranthus (*Amaranthus tricolor* L.)

Bhanupratap Jangde, Bhagwat Saran Asati, Pooja Sahu and Barsha Tripathy

Abstract
In the present study, correlation and path coefficient analysis with quantitative and qualitative characters in amaranthus. The experiment was comprised of twenty three genotypes of amaranthus, laid out in Randomized Block Design (RBD) with three replications was carried out at Pt. KLS College of Horticulture and Research Station, Rajnandgaon, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *kharif* season 2015-16. Analysis of variance revealed that mean sum of squares due to genotypes was highly significant for all characters. Observations were recorded for the characters *viz.*, plant height, number of branch per plant, Stem base diameter, number of leaves per plant, leaf length, leaf width, Leaf area, petiole length, Plant fresh weight, Fresh leaf weight, Fresh stem weight, Dry leaf weight, Dry stem weight, Dry plant weight, Foliage yield (kg/plot), Fe, K, Zn, Fiber, Chlorophyll a, Chlorophyll b, Total Chlorophyll, TSS, and Dry matter percentage. Correlation coefficient correlation studies revealed that leaf yield kg per plot showed positive and significant correlation with number of leaves per plant and fresh stem weight for quantitative characters. Chlorophyll a showed significant positive correlation with Total Chlorophyll at both phenotypic and genotypic levels. It also showed significant negative correlation with Chlorophyll b at genotypic level only. Chlorophyll b showed significant positive correlation with Total Chlorophyll at both phenotypic and genotypic levels. Path coefficient analysis revealed that fresh stem weight (1.100) and number of leaves per plant(0.014) showed the highest positive direct effect on leaf yield, whereas direct negative effect on leaf yield *viz.* Plant height (-0.071) for quantitative characters.

Keywords: Correlation, path co-efficient, Genotypes, leaf yield and Amaranthus.

Introduction
The genus, *Amaranthus*, a member of Amaranthaceae, includes a complex array of wild, weedy and domesticated species and consists of approximately 60 species. In India, the principal species grown for grain purpose are *Amaranthus hypochondriacus*, *A. cruentus*, *A. caudatus* and species grown for vegetable purpose are *A. tricolor*, *A. dubius*, *A. lividus*, *A. spinosus* and occasionally *A.viridus* and *A.hybridus* (Rana *et al*., 2005) [14]. They are tall, soft-wooded annuals, extensively grown throughout India for their green leaves and succulent stem **(**Aruna *et al.,* 2009) [4]. In the last 20 years amaranthus has been rediscovered as a promising food crop mainly due to its resistance to heat, drought, diseases and pests, and the high nutritional value of both seeds and leaves (National Research Council, 1984) [10].
The Amaranthus is a rich source of nutrients it serves as an alternative source of nutrition for people in developing countries. (Prakash and Pal, 1991 and Shukla *et al*., 2003) [12, 17, 19]. Tender stems and leaves contains moisture (85.70 %), protein (4.0 g), fat (0.50 g), carbohydrates (6.30 g), calcium (397.0 mg), iron (25.5mg), phosphorus (83.0 mg), vitamin A (9200IU), and vitamin C (99 mg), (Rai and Yadav, 2005) [13, 14]. It is also a good source of dietary fiber. Amaranth can grow round the year under varied soil and agro-climatic conditions (Katiyar *et al*., 2000 and Shukla and Singh, 2000) [8, 16], however most suitable time for its cultivation are during summer and rainy season. It is one of the suitable crop for kitchen garden and it can be cultivated in various crop rotation. Amaranthus produce high edible matter per unit area and time. It can be use as food, fodder and as medicine in various pharmaceutical and cosmetic products. (Prakash and Pal, 1991, Shukla *et al*. 2003) [12, 19, 17].
Correlation coefficient analysis is a handy technique, which elaborates the degree and extent of relationship among important plant characters and it provides basic criteria for selection which leads to directional model based on yield and its components in the field experiments. Path coefficient analysis, on the other hand, is an efficient statistical technique specially designed to quantify the interrelationship of different components and their direct and indirect effects on yield. Through this technique yield contributing characters and specific traits producing a given correlation can be categorized (Islam *et al.*, 2010) [6].

Materials and Methods

The study was carried out at Pt. KLS College of Horticulture and Research Station, Rajnandgaon, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *kharif* season 2015-16. The experiment was comprised of twenty three genotypes of amaranthus *viz.* AMAR-1, AMAR-2, AMAR-3, AMAR-4, AMAR-5**,** AMAR-6, AMAR-7, AMAR-8, AMAR-9, AMAR-10, AMAR-11, AMAR-12, AMAR-13, AMAR-14, AMAR-15, AMAR-16, AMAR-17, AMAR-18, AMAR-19, AMAR-20, AMAR-21, AMAR-22, AMAR-23. The experiment was comprised of twenty three genotypes of amaranthus, laid out in Randomized Block Design (RBD) with three replications. Genotype seeds are grown in plot size (1 x 1 m^2) and spacing between 15 x 5 cm row and plant. Observation was recorded on the five randomly selected plants, for different genotypes and was used for calculating the mean performance for different traits. Observation was recorded plant height, number of branch per plant, Stem base diameter, number of leaves per plant, leaf length, leaf width, Leaf area, petiole length, Plant fresh weight, Fresh leaf weight, Fresh stem weight, Dry leaf weight, Dry stem weight, Dry plant weight, Foliage yield (kg/plot), Fe, K, Zn, Fiber, Chlorophyll a, Chlorophyll b, Total Chlorophyll, TSS, and Dry matter percentage. The path analysis was originally developed by Wright (1921) [24] and elaborated by Dewey and Lu (1959) [5]. Path coefficient analysis splits the genotypic correlation coefficients into the measures of direct and indirect effects. It measures the direct and indirect contribution of independent variables to dependent variable.

Results and Discussion

The analysis of variance of all the characters under study is presented in Table 1(A & B). This analysis of variance revealed that mean sum of squares due to genotypes was highly significant for all the studied characters. This is an indication of existence of sufficient variability among the genotypes for leaf yield and its component traits. 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. These findings are in general agreement with the findings of Varalakshmi (2004) [22], Shukla *et al*. (2005) [18] and Joshi *et al.* (2011) [7]. The genotypic and phenotypic correlation for leaf yield and its component in amaranthus are presented in Table: 2. Plant height showed significant negative correlation leaf stem ratio, harvest index % at both phenotypic and genotypic levels. it also showed significant negative correlation with number of branches per plant, leaf length, leaf width at genotypic levels only. Number of branches per plant showed significant positive correlation with harvest index % at genotypic level only. It also showed significant negative correlation with petiole length at genotypic level only.

Stem base diameter showed significant positive correlation with plant fresh weight, fresh stem weight at genotypic level only. Number of leaves per plant showed significant positive correlation with fresh stem weight at both phenotypic and genotypic levels. it also showed significant positive correlation with petiole length, leaf yield at genotypic level only. it also showed significant negative correlation with leaf length, leaf stem ratio, harvest index at genotypic levels only.

Leaf length showed significant positive correlation with leaf width, leaf area, leaf stem ratio, harvest index % at both phenotypic and genotypic levels. It also showed significant positive correlation with fresh leaf weight, dry leaf weight at genotypic levels only. Leaf width showed significant positive correlation with leaf area, leaf stem ratio at both phenotypic and genotypic levels. It also showed significant positive correlation fresh leaf weight, harvest index at genotypic levels only. Leaf area showed significant positive correlation with fresh leaf weight, leaf stem ratio, harvest index % both phenotypic and genotypic levels. It also showed significant positive correlation dry leaf weight at genotypic levels only. Petiole length showed significant positive correlation with plant fresh weight, fresh stem weight, dry stem weight, dry plant weight at genotypic levels only. Plant fresh weight showed significant positive correlation with fresh leaf weight, dry leaf weight at genotypic levels only. Fresh leaf weight showed significant positive correlation with dry leaf weight, dry plant weight at both phenotypic and genotypic levels. it also showed significant positive correlation leaf stem ratio, at genotypic levels only. Fresh stem weight showed significant positive correlation with foliage yield, at genotypic levels only. Dry leaf weight showed significant positive correlation with leaf stem ratio both phenotypic and genotypic levels. it also showed significant positive correlation dry plant weight at genotypic levels only. Leaf stem ratio showed significant positive correlation with harvest index% at both phenotypic and genotypic levels. The findings clearly indicated that genotypic correlations were of higher magnitude to the corresponding phenotypic ones, thereby establishing strong inherent relationship among the characters studied. The low phenotypic value might be due to appreciable interaction of the genotypes with the environments. An overall observation of correlation coefficient analysis revealed that number of leaves per plant and fresh stem weight exhibited the significant positive correlation with leaf yield (kg/ plot) at genotypic level only. Hence, direct selection for these traits may lead to the development of high yielding genotypes of amaranthus. The genotypic and phenotypic correlation for qualitative characters in amaranthus are presented in Table: 3. Chlorophyll a showed significant positive correlation with Total Chlorophyll at both phenotypic and genotypic levels. It also showed significant negative correlation with Chlorophyll b at genotypic level only. Chlorophyll b showed significant positive correlation with Total Chlorophyll at both phenotypic and genotypic levels. The findings clearly indicated that genotypic correlations were of higher magnitude to the corresponding phenotypic ones, thereby establishing strong inherent relationship among the characters studied. The low phenotypic value might be due to appreciable interaction of the genotypes with the environments. The present findings are in conformity with Varalakshmi and Reddy (1994) [20] who reported that leaf yield per plot had strong positive association with leaf width, stem girth and leaf stem ratio. Similar results were also reported by Navangburuka and Denton (2012) [11], Ahammed *et al.* (2013) [1] Akaneme and Ani (2013) [2] and Arif *et al*. (2013) [3]. The effect of residual factor (0.4712) on leaf yield per plot was negligible, thereby, suggested that no other major yield component is left over. The path coefficient analysis which splits total correlation coefficient of different characters into direct and indirect effects on leaf yield per plot in such a manner that the sum of direct and indirect effects is equal to total genotypic correlation as presented in Table 4. Data revealed that fresh stem weight of plant showed the highest positive direct effect (1.100) on Fresh stem weight followed by dry leaf weight (0.766), petiole length (0.686), leaf length (0.519), harvest index % (0.344), leaf area (0.050) and number of leaves per plant (0.014) whereas, the leaf stem ratio (-0.781), dry stem weight (-0.741), plant fresh weight (-

0.524), plant height (-0.355), stem base diameter (-0.306), number of leaves per (-0.073), leaf width (-0.065), fresh leaf weight (-0.037), showed maximum negative direct effects on leaf yield kg per plot. In present investigation, fresh stem weight followed by number of leaves per plant showed high positive and direct effect had significant positive correlation with leaf yield kg per plot. Therefore, the higher fresh stem weight and number of leaves per plant should be considered in selection criteria for increasing leaf yield kg per plot. The present study suggested that more emphasis should be given to selecting genotypes with high fresh stem weight and number of leaves per plant. Directly or indirectly all characters showed positive effect on leaf yield per plant, which is in confirmation to the finding of Shukla and Singh (2003) [17], Varalakshmi and Devaraju (2010) [21], Kendre *et al*. (2013) [9], Sarker *et al*. (2014) [15] and Venkatesh *et al.* (2014a) [23].

Table 1 (A): Analysis of variance for leaf yield and its quantitative characters in amaranthus

Character	**Mean sum of square**		
	Replication	**Treatment**	**Error**
(DF)	**2**	**22**	**44**
01 Plant height (cm)	8.162	6.489**	2.648
02 No. of branches per plant	7.708	0.116**	5.528
03 Stem base diameter (cm)	207.901	18.018**	489.003
04 No. of leaves per plant	0.595	0.804**	0.331
05 Leaf length (cm)	5.810	0.963**	0.252
06 Leaf width (cm)	0.156	0.609**	0.162
07 Leaf area (cm^2)	0.302	40.470**	4.977
08 Petiole length (cm)	0.341	0.433**	0.139
09 Plant fresh weight (gm)	2.246	0.989**	0.125
10 Fresh leaf weight (gm)	4.555	0.222**	5.005
11 Fresh stem weight (gm)	4.026	0.487**	2.762
12 Dry leaf weight (gm)	3099.441	98.002**	987.98
13 Dry stem weight (gm)	9864.568	52.477**	153.034
14 Dry plant weight (gm)	2.541	2.536**	14.538
15 Foliage yield (kg/plot)	655.000	8822.181**	2539.002
16 Leaf stem ratio	2.079	0.183**	1.432
17 Harvest Index (%)	23.671	723.211**	45.320

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

Table 1 (B): Analysis of variance for qualitative characters in amaranthus

Character	**Mean sum of square**		
	Replication	**Treatment**	**Error**
(df)	**2**	**22**	**44**
01 Fe(mg 100g)	1080.000	408775.68**	728.886
02 K (mg 100g)	1.257	14.086**	1.797
03 Zn (mg 100g)	10.312	245.953**	6.849
04 Fiber (%)	23.193	1.285**	57.520
05 Chlorophyll a	89.378	0.102**	98.092
06 Chlorophyll b	872.612	5.969**	41.202
07 Total Chlorophyll	1.350	0.260**	94.505
08 TSS (%)	64.544	8.753**	1.001
09 Dry matter (%)	2.420	8.090**	1.101

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

Table 2: Genotypic and phenotypic correlation coefficient between leaf yield and its quantitative characters in amaranthus

Characters		01. Plant height (cm)	02. No. of Branches per plant	03. Stem base diameter (cm)	04. No. of leaves Per plant	05. Leaf length (cm)	06. Leaf width (cm)	07. Leaf Area (cm^2)	08. Petiole length (cm)	09. Plant fresh weight (gm)	10. Fresh Leaf weight (gm)	11. Fresh stem weight (gm)	12. Dry Leaf weight (gm)	13. Dry stem weight (gm)	14. Dry plant weight (gm)	15. Foliage yield (kg/plot)	16. leaf stem ratio	17. Harvest Index (%)
01	P G	**1.000** **1.000**	-0.305 -0.659 **	0.282 0.028	0.198 0.534	-0.061 -0.720**	0.067 -0.502*	-0.154 -0.462	0.181 0.407	0.185 0.389	-0.072 -0.048	0.325 0.539	-0.133 -0.348	0.100 0.173	0.040 0.127	0.069 -0.071	-0.512* -0.828**	-0.528* -0.843**
02	P G		**1.000** **1.000**	-0.175 0.129	-0.164 -0.254	-0.017 0.390	0.071 0.340	0.136 0.322	-0.040 -0.491*	-0.206 -0.365	0.076 -0.043	-0.035 0.178	0.024 -0.238	-0.032 -0.015	0.024 0.115	-0.018 0.150	0.095 0.320	0.226 0.675**
03	P G			**1.000** **1.000**	0.276 0.516	0.342 0.211	0.250 0.378	0.140 0.199	0.270 0.431	0.279 0.483*	0.167 0.242	0.460 0.633**	0.010 0.112	0.128 0.205	0.233 0.347	0.229 0.281	0.054 0.227	0.202 0.299
04	P G				**1.000** **1.000**	-0.167 -0.506*	-0.283 -0.812	-0.453 -0.810	0.294 0.710**	0.101 0.302	-0.074 -0.189	0.492* 0.852**	-0.148 -0.200	0.210 0.307	0.222 0.262	0.283 0.490*	-0.226 -0.507*	-0.294 -0.488*
05	P G					**1.000** **1.000**	0.711** 0.904**	0.811** 0.936**	0.227 0.220	0.313 0.477	0.468 0.868**	-0.058 -0.081	0.441 0.757**	0.075 0.096	0.346 0.474	0.254 0.416	0.586* 0.927**	0.547* 0.895**
06	P G						**1.000** **1.000**	0.727** 0.983**	0.050 -0.011	0.201 0.259	0.358 0.580	-0.116 -0.129	0.329 0.459	0.103 0.049	0.257 0.379	0.114 0.077	0.493* 0.784**	0.403 0.800**
07	P G							**1.000** **1.000**	-0.047 -0.096	0.234 0.328	0.523* 0.753**	-0.226 -0.259	0.477 0.640**	-0.052 -0.084	0.274 0.298	0.156 0.128	0.614** 0.795**	0.605* 0.814**
08	P G								**1.000** **1.000**	0.316 0.503*	0.234 0.456	0.328 0.518*	0.055 0.090	0.445 0.700**	0.363 0.697**	0.112 0.368	-0.085 -0.192	-0.120 -0.045
09	P G									**1.000** **1.000**	0.454 0.705**	0.163 0.211	0.360 0.488*	0.020 0.006	0.247 0.379	0.150 0.222	0.056 0.064	-0.042 -0.067
10	P G										**1.000** **1.000**	-0.122 -0.095	0.598* 0.852**	0.175 0.300	0.483* 0.690**	0.149 0.225	0.374 0.506	0.319 0.477
11	P G											**1.000** **1.000**	-0.192 -0.202	0.063 0.082	0.202 0.240	0.437 0.834**	-0.290 -0.344	-0.170 -0.220
12	P G												**1.000** **1.000**	0.053 0.071	0.418 0.528*	0.161 0.275	0.493* 0.612**	0.252 0.344
13	P G													**1.000** **1.000**	0.389 0.129	-0.073 -0.197	-0.130 -0.147	-0.009 0.003
14	P G														**1.000** **1.000**	0.201 0.254	0.252 0.310	0.159 0.167
15	P G															**1.000** **1.000**	0.093 0.125	0.156 0.226
16	P G																**1.000** **1.000**	0.725** 0.882**
17	P G																	**1.000** **1.000**

Table 3: Genotypic and phenotypic correlation coefficient between different qualitative components in amaranthus

Characters		01. Fe (mg 100g)	02. K (mg 100g)	03. Zn (mg 100g)	04. Fiber (%)	05. Chlorophyll a	06. Chlorophyll b	07. Total Chlorophyll	08. TSS (%)	09. Dry matter (%)
01	P G	1.000 1.000	-0.279 -0.281	0.268 0.282	0.014 0.015	-0.197 -0.234	-0.266 -0.296	-0.275 -0.296	-0.336 -0.392	0.043 0.051
02	P G		1.000 1.000	0.229 0.241	-0.028 -0.030	0.099 0.114	0.082 0.092	0.099 0.103	0.003 -0.006	-0.427 -0.523
03	P G			1.000 1.000	0.146 0.165	-0.284 -0.338	-0.322 -0.394	-0.334 -0.369	-0.116 -0.107	-0.036 -0.049
04	P G				1.000 1.000	-0.187 -0.213	-0.513 -0.568	-0.392 -0.415	0.105 0.112	-0.317 -0.385
05	P G					1.000 1.000	0.473 0.678*	0.888** 0.929**	0.043 0.080	0.123 0.239
06	P G						1.000 1.000	0.809** 0.902**	-0.071 -0.124	0.015 0.013
07	P G							1.000 1.000	-0.028 -0.027	0.110 0.153
08	P G								1.000 1.000	0.126 0.195
09	P G									1.000 1.000

Table 4: Direct and indirect effect of component character on leaf yield in amaranthus (*Amaranthus tricolor* L.)

Characters	**Plant height (cm)**	**No. of Branches per plant**	**Stem base diameter (cm)**	**No. of leaves Per plant**	**Leaf length (cm)**	**Leaf width (cm)**	**Leaf area (cm^2)**	**Petiole length (cm)**	**Plant fresh weight (gm)**	**Fresh leaf weight (gm)**	**Fresh stem weight (gm)**	**Dry leaf weight (gm)**	**Dry stem weight (gm)**	**Dry plant weight (gm)**	**leaf stem ratio**	**Harvest Index (%)**	**Foliage yield (kg/plot)**
Plant height (cm)	**-0.355**	0.048	-0.009	0.007	-0.373	0.032	-0.023	0.279	-0.204	0.002	0.593	-0.266	-0.128	-0.031	0.647	-0.290	-0.071
No. of branches per plant	0.234	**-0.073**	-0.040	-0.004	0.202	-0.022	0.016	-0.336	0.191	0.002	0.196	-0.182	0.011	-0.028	-0.250	0.232	0.150
Stem base diameter (cm)	-0.010	-0.009	**-0.306**	0.007	0.110	-0.024	0.010	0.295	-0.253	-0.009	0.696	0.085	-0.151	-0.085	-0.177	0.103	0.281
No. of leaves per plant	-0.190	0.019	-0.158	**0.014**	-0.263	0.052	-0.041	0.487	-0.159	0.007	0.938	-0.153	-.228	-0.065	0.396	-0.168	0.490
Leaf length (cm)	0.256	-0.029	-0.065	-0.007	**0.519**	-0.061	0.047	0.151	-0.250	-0.032	-0.089	0.579	-0.071	-0.117	-0.724	0.308	0.416
Leaf width (cm)	0.178	-0.025	-0.116	-0.011	0.487	**-0.065**	0.049	-0.008	-0.136	-0.022	-0.142	0.351	-0.036	-0.093	-0.612	0.275	0.077
Leaf area	0.164	-0.024	-0.061	-0.011	0.486	-0.063	**0.050**	-0.066	-0.172	-0.028	-0.285	0.490	0.062	-0.073	-0.621	0.280	0.128

(cm^2)																	
Petiole length (cm)	-0.144	0.036	-0.132	0.010	0.114	0.001	-0.005	**0.686**	-0.264	-0.017	0.570	0.069	-0.519	-0.172	0.150	-0.015	0.368
Plant fresh weight (gm)	-0.138	0.027	-0.148	0.004	0.247	-0.017	0.016	0.345	-**0.524**	-0.026	0.232	0.374	-0.004	-0.093	-0.050	-0.023	0.222
Fresh leaf weight (gm)	0.017	0.003	-0.074	-0.003	0.450	-0.037	0.038	0.313	-0.370	**-0.037**	-0.105	0.652	-0.222	-0.170	-0.395	0.164	0.225
Fresh stem weight (gm)	-0.192	-0.013	-0.194	0.012	-0.042	0.008	-0.013	0.355	-0.111	0.004	**1.100**	-0.155	-0.061	-0.059	0.269	-0.076	0.834
Dry leaf weight (gm)	0.124	0.017	-0.034	-0.003	0.392	-0.030	0.032	0.062	-0.256	-0.032	-0.223	**0.766**	-0.052	-0.130	-0.478	0.199	0.275
Dry stem weight (gm)	-0.062	0.001	-0.063	0.004	0.050	-0.003	-0.004	0.480	-0.003	-0.011	0.090	0.054	**-0.741**	-0.106	0.115	0.001	-197
Dry plant weight (gm)	-0.045	-0.008	-0.106	0.004	0.246	-0.024	0.015	0.478	-0.199	-0.026	0.265	0.404	-0.318	**-0.246**	-0.242	0.057	0.254
Leaf stem ratio	0.294	-0.023	-0.069	-0.007	0.481	-0.051	0.040	-0.132	-0.034	-0.019	-0.379	0.469	0.109	-0.076	**-0.781**	-0.304	0.125
Harvest Index(%)	0.299	-0.050	-0.092	-0.007	0.464	-0.052	0.041	-0.031	0.035	-0.018	-0.242	0.264	-0.002	-0.041	-0.689	**0.344**	0.226

Residual value: 0.4712, Diagonal and bold underline figures shows direct effect on leaf yield

References

1. Ahammed U, Rahman MM, Mian MAK. Multivariate analysis in stem amaranth (*Amaranthus tricolor*). Bangladesh J. Pl. Bre. and Gen. 2013; 26(1):11-17.
2. Akaneme FI, Ani GO. Morphological assessment of genetic variability among accessions of *Amaranthus hybridus.* The Sci. Tech., J. of Sci. and Tech. 2013; 2(2):26-30.
3. Arif M, Jatoi SA, Rafique T, Ghafoor A. Genetic divergence in indigenous spinach genetic resources for agronomic performance and implication of multivariate analyses for future selection criteria. Sci. Tech. and Dev. 2013; 32(1):7-15.
4. Aruna P. Correlation and path analysis in amaranthus. The Asian Journal of Horticulture. 2009; 4(2):361-363.
5. Deway DR, Lu, KH. A correlation and path coefficient analysis of components of crested wheat grass and seed production. Agron. J. 1959; 5:515-518.
6. Islam BMR, Ivy NA, Rasul MG, Zakaria M. Character association and path analysis of exotic tomato (Solanum lycopersicum L.) genotypes. Bangladesh Journal of Plant Breeding and Genetics. 2010; 23(1):13-18.
7. Joshi V, Vijaya M, Sireesha K, Madhavi P. Characterization and preliminary evaluation of Vegetable amaranth (*Amaranthus spp*.) Vegetable Science. 2011; 38(2):239-240.
8. Katiyar RS, Shukla S, Rai S. Varietal performance of grain amaranth *(A. hypochondriacus*) on sodic soil. *Proc Nat Acad Sci*. (India). 2000; 70:185-187.
9. Kendre V, Dod VN, Nagre PK, Kale VS, Potdukhe NR. Correlation and path analysis in leafy *Amaranthus tricolor* L., Ann. Pl Physi. 2013; 27(1/2):27-29.
10. National Research Council. Amaranth modern prospects for an ancient crop. National Academy Press, 1984.
11. Navangburuka CC, Denton OA. Heritability character association and genetic advance in six agronomic and yield related characters in leaf *Corchorus olitorius*, International journal of agricultural research. 2012; 7(7):367- 375.
12. Prakash D, Pal M. Nutritional and anti-nutritional composition of vegetable and grain amaranth leaves. J. Sci. Food Agric. 1991; 57:573-583.
13. Rai N, Yadav DS. Advances in vegetable production. Research Book Centre New Delhi. 2005; 530-531.
14. Rana JC, Yadav SK, Mandal S, Yadav S. Genetic divergence and interrelationship analysis in grain amaranth (*Amaranthus hypochondriacus* L.) germplasm. Indian Journal of Genetics and Plant Breeding. 2005; 65(2):99-102.
15. Sarker U, Islam T, Rabbani G, Oba S. Genotypic variability for nutrient, antioxidant, yield and yield contributing traits in vegetable amaranth Journal of Food, Agriculture & Environment. 2014; 12(3):168-174.
16. Shukla S, Singh SP. Studies on genetic parameters in vegetable Amaranth. J. Genet. Breed. 2000; 54:133-135.
17. Shukla S, Singh, SP. Correlation and path analysis in grain amaranth (*Amaranthus spp*.). Indian Journal of Genetics and Pant Breeding. 2003; 63(2):163–174.
18. Shukla S, Bhargava A, Chatterjee A, Srivastava A, Singh SP. Estimates of genetic variability in vegetable amaranth (*A. tricolor*) over different cuttings, HORT. SCI. (PRAGUE). 2005; 32(2):60-67.
19. Shukla S, Pandey V, Pachauri G, Dixit BS, Banerji R, Singh, SP. Nutritional contents of different foliage cuttings of vegetable amaranth. Pl. Food Hum. Nutr. 2003; 58:1-8.
20. Varalakshmi B, Pratap Reddy VV. Variability, heritability and correlation studies in vegetable amaranth. South Indian Hort. 1994; 42(6):361-364.
21. Varalakshmi B, Devaraju. Genetic variability in Indian spinach (*Basella alba* L.), J. Hortl. Sci. 2010; 5(1) 21-24.
22. Varalakshmi B. Characterization and preliminary evaluation of vegetable Amaranth (*Amaranthus* spp.) germplasm. Pl. Gene. Reso. Newsletter. 2004; (137):55-57.
23. Venkatesh L, Murthy N, Manjappa, Nehru SD. Character association and path co-efficient analysis for various traits in grain amaranth (*Amaranthus* spp.). Asian J. of Bio Sci. 2014a; 9:97-10.
24. Wright S. Correlation and causation. J. Agric. Res. 1921; 20:557-585.