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Estimation of genetic variability, heritability and genetic advance in grain amaranth (*Amaranthus hypochondriacus* L.)

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Abstract

The present investigation was conducted to estimate the genetic variability, heritability and genetic advance of genotypes of grain Amaranth during kharif season 2015 at College of Forestry Ranichauri V.C.S.G. Uttarakhand University of Horticulture and Forestry, Bharsar, Uttarakhand. Thirty genotypes of grain Amaranth along with 5 checks (Annapurna, Durga, PRA-1, PRA-2 and PRA-3) were evaluated in an augmented block design for access their performances. High PCV and GCV were noticed for seed yield per plant (38.40%, 32.64%, respectively) and number of leaves per plant (22.13%, 20.95%, respectively). Moderate PCV and GCV value were studied for inflorescence length (17.68%, 14.72%, respectively), spikelet length (18.76%, 17.47%, respectively) and number of spikelet per plant (13.62%, 11.63%, respectively). High heritability coupled with high genetic advance was observed for number of leaves per plant. These characters may be used as early indicators in selection programmes of grain amaranth. Based on the performance, promising genotypes IC-321281, IC-278913, IC-313273, IC-32220, IC-278922 and IC-279965 have been found superior among the genotypes which can be used in breeding programmes for crop improvement.

Keywords: Amaranth, genetic variability, heritability and genetic advance

Introduction

Amaranth is non-grasses and is called pseudo-cereal because of their similarities to cereals in flavour and cooking. The genus Amaranthus has about 60 species worldwide which is characterized by a high degree of diversity and wide spectrum of adaptability to different agro-ecological conditions (Showemimo *et al*., 2021) [14]. Grain Amaranth is an important and largely used by hilly people. Its high productive genotype can be introduced in breeding programs of amaranth to enhance the productivity. Amaranth belongs to the family Amaranthaceae and genus *Amaranthus*. Generally two chromosome groups are found in Amaranth, n=16 and n=17. The species with n=16 are *A. hypochondriacus* and *A. caudatus* and n=17 are *A. tricolor*, *A. spinosu*, *A. virdis*, *A. cruentus* and *A. bilatum*. It is a short duration herb grown in almost all agro-climatic zones, mostly in temperate and tropical regions. Amaranthus species have distinct centres of domestication and origin. These are extensively distributed in North America, Central America, and South America, where the greatest genetic diversity is found (Xu and Sun, 2001) [19]. The major producing countries are South and Central America and in some countries of Asia and Africa like China, India, Ethiopia, Kenya and Nepals. In India the species of amaranth extensively cultivated as subsidiary food crop in both hills as well as plains covering state of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Chhatisgarh, Maharastra, Gujrat, Odisha, Karnataka, Kerala and Tamil Nadu (Venkatesh *et al*, 2014) [17]. It is one of those rare plants whose leaves are eaten as a vegetable while the seeds are used as cereals. Besides, it is also used as fodder, ornamental, organic red dye and for industrial purposes (Malaghan *et al.*, 2018) [13]. The grains are unique and nutritionally rich. The proteins are significantly richer in essential dietary amino acids, particularly lysine, which is often limited in other cereal grains (Oduwaye *et al.*, 2016) [8]. The genetic parameters like co-efficient of variation, heritability and genetic advance as per cent of mean provide a clear insight into the extent of variability and a relative measure of the efficiency of selection of genotypes based on phenotype, in a highly variable population (Sheela *et al.*, 2018) [12].

Genetic variability studies provide basic information regarding the genetic properties of the population based on which breeding methods are formulated for further improvement of the crop (Yadav *et al.,* 2014) [20]. The genetic parameter like coefficient variation, heritability and genetic advance provide a clear insight into the extent of variability and a relative measure of the efficiency of selection of genotypes based on phenotype, in a highly variable population (Venkatesh *et al.*, 2014) [17]. Genetic advance can be used to predict the efficiency of selection (Showemimo *et al*., 2021) [14]. The objective of this study was to determine variability, heritability and genetic advance for yield and its component traits in grain amaranth.

Materials and Methods

An experiment to determine variability, heritability and genetic advance for yield and yield contributing traits in grain amaranth was conducted at Crop Improvement Research Block of College of Forestry, Ranichauri, V.C.S.G. Uttarakhand University of Horticulture and Forestry during Kharif season 2015. The experimental material used in the present study comprised of 30 genotypes of grain amaranth including five check *viz*. Annapurna, Durga, PRA-1, PRA-2 and PRA-3, which were obtained from the Project Coordinator Unit of All India Coordinator Research Project on Potential Crops, NBPGR, regional station Shimla while the check PRA-1, PRA-2 and PRA-3 was received from Department of Crop Improvement, Ranichauri. The experiment was laid out in an augmented block design with five compact blocks. All checks were repeated five times after 5 genotypes, while the genotypes were unreplicated. There were two rows of each germplasm in each block with spacing 25×10 cm. Five plants were randomly selected and observations were recorded in respect to various parameters in each genotypes. The average values of observations taken from five plants were used as treatment mean in all statistical analysis The observation included days to 50 per cent flowering, days to maturity, plant height (cm), inflorescence length (cm), stem thickness (mm), number of spikelet per plant, number of leaves per plant, spikelet length (cm), 1000 seed weight (gm) and seed yield per plant (gm). Estimates of phenotypic, genotypic and environmental coefficient of variation, heritability and genetic advance were computed according Burton and Devane (1953) [3] and Johnson *et al*., (1955) [6]. The complete analysis of data has been processed by Windostat version 9.2 from indostat services Hyderabad.

Result and Discussion

The statistical analysis showed highly significant differences among the genotypes for all the characters studied, indicating considerable amount of genetic variation in genotypes. The mean, range, variance, co-efficient of variation, heritability and genetic advance for 10 traits including grain yield has been presented in the Table 1.

Table 1: Adjusted mean for different field parameters of grain amaranth

Sl. No.	Characters Genotypes	Days to 50% flowering	Plant height (cm)	Inflorescence length (cm)	No. of spikelet per plant	No. of leaves per plant	Spikelet length (cm)	Stem thickness (mm)	Days to maturity	1000 seed weight (g)	Seed yield per plant (g)
		1	2	3	4	5	6	7	8	10	9
1	IC-258250	69.080	110.192	50.976	55.776	66.760	21.824	8.594	144.128	0.868	17.635
2	IC-274451	77.080	96.192	49.376	47.176	77.360	17.024	9.894	136.128	0.776	9.155
3	IC-274467	78.080	95.592	37.376	38.176	46.560	16.624	7.154	142.528	0.828	7.105
4	IC-274471	71.080	101.392	51.776	39.776	59.760	19.424	7.844	137.528	0.916	17.845
5	IC-278913	68.080	109.392	60.176	44.776	87.160	25.024	13.674	138.728	0.612	39.415
6	IC-278919	69.680	110.032	57.616	52.936	61.720	25.664	8.772	137.088	1.049	22.509
7	IC-278921	72.680	104.632	55.816	62.736	46.120	23.264	9.962	140.688	0.741	18.489
8	IC-278922	69.680	99.432	67.816	52.136	66.720	27.464	12.032	140.288	0.861	34.209
9	IC-279965	73.680	109.032	50.216	41.136	91.520	12.064	11.172	137.488	0.985	30.849
10	IC-279966	68.680	111.232	66.816	35.136	62.720	25.864	9.662	135.088	0.809	27.379
11	IC-279968	75.280	116.592	49.896	47.576	87.000	15.704	10.164	139.928	0.831	28.435
12	IC-313265	73.280	120.792	47.696	51.776	74.400	18.504	7.644	136.128	0.839	26.915
13	IC-313269	65.280	122.392	34.896	41.976	35.000	16.904	9.284	135.328	1.155	10.615
14	IC-313273	65.280	117.392	53.496	53.576	81.000	23.104	11.254	138.128	1.023	39.185
15	IC-321281	70.280	112.792	54.296	54.176	77.200	21.704	13.284	138.328	1.043	39.495
16	IC-322201	68.680	113.352	58.736	58.296	93.600	22.864	10.678	144.408	0.864	37.541
17	IC-326896	68.680	97.152	50.736	55.696	91.000	21.264	9.818	140.608	0.968	42.031
18	IC-326898	70.680	86.552	45.536	38.496	72.400	20.064	7.488	141.008	0.844	27.981
19	IC-329550	68.680	92.752	32.736	47.296	40.600	16.464	9.068	135.808	0.908	16.601
20	IC-329588	72.680	92.352	38.936	61.096	61.000	14.264	10.598	137.808	0.792	10.831
21	IC-333108	75.280	112.032	49.776	60.216	81.520	12.344	7.922	140.848	0.631	12.729
22	IC-333173	75.280	87.232	38.576	43.416	34.920	11.144	7.032	143.848	0.815	12.399
23	IC-333211	76.280	94.032	33.776	56.216	48.720	11.944	8.112	138.448	0.839	22.929
24	IC-341551	73.280	98.032	36.576	59.616	42.320	14.544	6.412	143.848	0.863	19.139
25	ES-223650	71.280	90.032	38.976	62.016	47.120	14.144	8.862	140.448	1.067	24.409
26	Annapurna	73.800	93.800	51.000	48.760	79.120	19.200	9.106	141.520	0.993	28.148
27	Durga-35407	66.600	109.000	59.840	41.720	85.960	16.880	10.536	139.080	0.929	22.790
28	PRA-1	72.000	113.720	58.680	36.040	73.960	16.880	9.256	137.640	1.042	20.420
29	PRA-2	72.600	105.160	53.640	48.320	81.000	16.800	9.490	139.880	1.042	20.642
30	PRA-3	71.400	105.080	48.320	50.840	79.160	18.520	9.282	141.920	0.972	17.726
31	Mean	71.480	104.245	49.469	49.563	67.780	18.571	9.468	139.488	0.897	23.519
32	Std. Dev.	3.325	10.133	9.500	8.182	17.957	4.482	1.728	2.687	0.127	9.842

33	Std. Error	0.607	1.850	1.734	1.494	3.278	0.818	0.316	0.491	0.023	1.797
34	C. V.%	4.651	9.720	19.203	16.509	26.493	24.136	18.255	1.927	14.134	41.849
35	C. D.%	4.14	8.03	12.06	9.11	11.90	5.31	4.73	7.21	12.27	0.21
36	Lowest	65.280	86.552	32.736	35.136	34.920	11.144	6.412	135.088	0.612	7.105
37	Highest	78.080	122.392	67.816	62.736	93.600	27.464	13.674	144.408	1.155	42.031

Genotypic and phenotypic variances were highest for number of leaves per plant (187.53 and 209.42) followed by plant height (61.33 cm and 71.31 cm), inflorescence length (51.03 cm and 73.54 cm) and seed yield per plant (60.52 g and 83.79 g), Whereas, the environment variances were highest for inflorescence length (22.50 cm), number of leaves per plant (21.88) and seed yield per plant (23.26 g). High genotypic and phenotypic variances have also been reported by Kusuma *et al.*, (2003) [7] for spikelet length and seed yield, Parveen *et al*., (2013) [9] for seed yield per plant and inflorescence length, and Sarker *et al.*, (2016) [10] for plant height, number of leaves per plant in amaranth. Therefore, selection based on phenotypic performance of genotypes could be effective mechanism in improvement of population for desirable traits with high level of reproducibility in subsequent generations. The phenotypic coefficient of variances (PCV) were greater than their gene corresponding genotypic coefficient of variance (GCV) in respect to all quantitative traits indicating that apparent variance is not only due to genotypes but also due to influence of environment. In table 2 the maximum phenotypic coefficient of variation was observed for seed yield per plant followed by number of leaves per plant, stem thickness, spikelet length. Moderate phenotypic coefficient of variation were recorded for inflorescence length, spikelet length per plant, 1000 seed weight and days to maturity showed the lowest PCV. The maximum genotypic coefficient of variances (GCV) was observed for seed yield per plant followed by number of leaves per plant and spikelet length. Moderate genotypic coefficient of variation was recorded for inflorescence length, spikelet length per plant and days to maturity showed the lowest GCV. High value of PCV and GCV were noticed for seed yield per plant, number of leaves per plant, spikelet length and stem thickness indicating the presence of high variability in germplasm for selection. Hence, these characters can be relied upon and simple selection can be practiced for further improvement. Genetic variability is the basis for any heritable improvement in the crop plants. The magnitude of PCV was high as compared to the GCV for all the characters studied, indicating the important role of environmental variation in expression of different traits in grain amaranth. The results of present investigation were within agreement to the findings of Sravanthi *et al*., (2012), Parveen *et al*., (2013) [9], Venkatesh *et al*., (2014) [17] and Yadav *et al*., (2014) [20] in grain amaranth. ECV is a unit less value and can be used to measure relative variation existed among characters. This indicated low environmental effect on expression of characters. However, a relatively higher value of ECV was recorded for days to maturity and seed yield per plant. It is presumed that seed yield per plant was influenced by environment. Higher ECV value for seed yield per plant had also been indicated by Varalakshmi (2012) [16]. The values for heritability for different traits have been mentioned in Table 2.

Table 2: Estimation of variance and genetic parameters of different characters in grain amaranth

S. No	Characters	General mean	Variance			Coefficient of variation (%)			Heritability	Genetic advance
			Genotypic σ^2g	Phenotypic σ^2p	Environment σ^2e	Genotypic (GCV)	Phenotypic (PCV)	Environment (ECV)	h² (%)	GA
1.	Days to 50% flowering	71.48	6.63	9.29	2.66	3.60	4.26	2.28	71.00	5.74
2.	Plant height (cm)	104.24	61.33	71.31	9.97	7.52	8.11	3.03	86.00	19.17
3.	Inflorescence length (cm)	49.46	51.03	73.54	22.50	14.72	17.68	9.78	69.00	15.71
4.	No. of spikelet per plant	49.56	34.43	47.26	12.82	11.63	13.62	7.09	72.00	13.22
5.	No. of leaves per plant	67.78	187.53	209.42	21.88	20.95	22.13	7.15	89.00	34.21
6.	Spikelet length (cm)	18.57	10.75	15.11	4.35	17.47	18.76	11.12	71.00	7.30
7.	Stem thickness (mm)	9.46	0.66	3.29	2.63	8.61	19.20	17.17	20.00	0.96
8.	Days to maturity	139.48	0.021	8.053	8.032	1.22	24.00	24.00	0.261	1.52
9.	1000 seed weight (g)	0.897	0.006	0.013	0.007	8.88	13.03	9.54	46.00	0.14
10.	Seed yield per plant (g)	23.51	60.52	83.79	23.26	32.64	38.40	20.23	72.00	17.45

Highest heritability was recorded for all the characters except days to maturity and 1000 seed weight. High heritability for different traits indicated that large proportion of phenotypic variance was attributed to genotypic variance and therefore, reliable selection could be made for these traits on the basis of phenotypic expression. Similar results have also been reported by Verma *et al.*, (2001) [18] for seed yield per plant and plant height, Venkatesh *et al.*, (2014) [17] for days to 50% flowering, number of leaves per plant, plant height, and grain yield per plant, Parveen *et al*., (2013) [9] for seed yield per plant and inflorescence length per plant in amaranth. Further, the heritability estimate itself may not be solely and useful index of genetic potentiality of a character. Thus, high heritability estimates coupled with high genetic advance indicate that traits are governed mainly due to additive genetic effects therefore selection may be effective for these traits. According to Baraskar *et al.*, (2014) [3] genetic advance estimates can be divided into three classes such as high (>20%), moderate (10-19%) and low (<10%). Genetic advance is relative increase in mean value of population after selection. High values of genetic advance were recorded for number of leaves per plant and moderate for plant height, inflorescence length, number of spikelet per plant and seed yield per plant. Lowest value was recorded for days to 50 percent flowering; stem thickness, panicle length, days to maturity and 1000 seed weight (Table 2). High genetic advance has also been reported by Verma *et al.*, (2001) [18] for seed yield per plant and plant height, Chattopadhyay *et al.*,

(2013) [4] for number of leaves per plant and plant height and Venkatesh *et al.*, (2014) [17] for days to 50% flowering, number of leaves per plant, plant height and grain yield per plant in amaranth. In the present investigation high estimates of heritability coupled with high genetic advance was observed for number of leaves per plant. Similar results have also been reported by Venkatesh *et al*., (2014**)** [17] and Parveen *et al*., (2013) [9].

Average performance of genotypes

The highest genotypic, phenotypic and environment variances were recorded for quantitative characters such as number of leaves per plant, seed yield per plant, plant height, inflorescence length and spikelet length. Genotypes IC-322201, IC-326896, IC-313269, IC-278922 and IC-279965 showed superiority over other genotypes for these quantitative characters. High magnitude of genotypic and phenotypic coefficient of variation were recorded for seed yield per plant, number of leaves per plant, stem thickness, inflorescence length and spikelet length per plant in IC-326896, IC-322201, IC-278913, IC-279965 genotypes. Hence, these characters are more suitable for selection procedure.

Conclusion

On the basis of experimental finding it can be concluded that the inherent variability among the amaranths accessions is useful for selection and improvement purposes. The genotypic performance, variance and coefficient of variation components are indicators of variability among the test accessions for all the traits in this study. Selection of such characters which showed high genetic advance coupled with high heritability creates scope for improvement in terms of yield. Thus, based on these traits, some of the promising genotypes in the genetic stock studied are IC-321281, IC-278913, IC-313273, IC-32220, IC-278922 and IC-279965 which can be used in further breeding program for improvement of amaranth crop.

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