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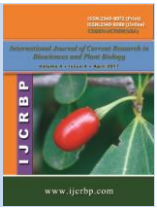

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Studies on Variability, Heritability and Genetic Advance Analysis for Yield and Yield Attributes of Garlic (*Allium sativum* L.)

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Abstract

The experiment was conducted in Augmented Block Design at Main Experimental Station of Department of Vegetable Science, Narendra Deva University of Agriculture, Narendra Nagar (Kumarganj), Faizabad (U.P.) during *Rabi* 2014-15 with the following objectives (1) To find out phenotypic and genotypic coefficient of variation (PCV & GCV), (2) to estimate heritability and genetic advance, Experimental material for the present study consisted of thirty genotypes. In single plot sized 2.0 X 0.30 cm with the distance of 30 cm row to row and 10 cm plant to plant. Observation were recorded on plant height (cm), leaves per plant, length of leaf (cm), width of leaf (cm), neck thickness of bulb (cm), cloves per bulb, weight of clove (g), length of clove (cm), length of bulb (cm), width of clove (cm), diameter of bulb (cm), total soluble solids (%) and bulb yield per plant (g).Analysis of variance for design of experiment indicated highly significant differences among treatments for all the characters, based on mean performance of genotypes, the NDG-43, NDG-49, Punjab Garlic, NDG-48 and NDG-45, were identified as most promising genotypes for bulb yield per plant. The higher magnitude of coefficient of variation at genotypic as well as phenotypic levels observed for leaves per plant, length of leaf, length of clove. High heritability coupled with high genetic advance in per cent of mean was recorded for number of cloves per bulb, Bulb yield per plant, weight of clove and width of leaf. It is suggested that selection for these traits will directly increase bulb yield per plant.

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Introduction

Garlic (*Allium sativum* L.) having diploid chromosome number 2n=2x=16 belongs to the family Amaryllidaceae (Alliaceae); known as *Lahsun* in Hindi, is one of the important bulb crop grown in India. It has long been recognized as a valuable spice and condiments in India. It is a frost hardy bulbous, erect annual herb with narrow flat leaves and bears small white flowers and bulbils (Janick, 1979). Garlic is a scapigerous foetid perennial

medicinal herb with underground compound bulbs covered by outer white thin scales with simple smooth round stem surrounded by the bottom by tublar leaf sheath. The leaves are simple, long, flat and linear. The flowers are small and white, arranged in round umbels mixed with small bulbils. The entire umbels are enclosed in a tear-drop shaped membranous spathe. Flowers are usually sterile. The seed stalk bears terminal inflorescence, which in terms bear bulbils instead of flowers. The shoot of garlic become flat and finally aborts after the development of bulbils in the inflorescence (Kothari and Shah, 1974). A compound bulb consists of smaller bulbils or a segment called "cloves" which are formed from auxiliary bulbs of the young foliage leaves and is surrounded by a thin white or pinkish papery sheath.

The history of garlic dates back to the time immemorial original abode of garlic is said to be Central Asia and Southern Europe, especially Mediterranean region. Garlic has long been known as cultivated plant in India and China. It was carried out to the western hemisphere by the Spanish, Portuguese and French. The major garlic growing countries are Spain, Egypt, France, Mexico and Brazil. Asia shared major part in total world's garlic production. China, Korea, Spain, Egypt and USA are the major garlic growing countries. China ranks first in area and production followed by India and Korea republic.

Hence in present investigation and attempt was needed to assess the variability of important pod yield contribution traits along with the indicate of variability *i.e.* genotypic coefficient variation (GCV), phenotypic coefficient variation (GCV), environment coefficient variation (ECV), Heritability IN Broad Sense (h^2b) and genetic advance (GA) per cent of mean.

Materials and methods

The experimental material for the present investigation comprised 38 genotypes of Garlic collected from different places in India and being maintained at main experiment station in the Department of Vegetable Science, N.D. University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.). Experiment was laid out in an **"Augmented Block Design".** The experimental field was prepared by harrowing and three cross ploughing with cultivator followed by planking. The field was well manures with FYM @ 30 tonnes per hectare 20 days before sowing. The irrigation channel was made between two blocks. Two row of 2.0m × 0.30m plot with the distance of 30cm row to row and plant to plant 10 cm. The cloves of each genotype were sown on 15 November in 2014. The first irrigation was done in just after sowing than irrigation was done at 15 days interval during crop growth. The recommended cultural practices and plant protection measures were applied to raise a healthy crop. All the recommended agronomic package of practices and plant protection measures were followed to raise a good crop. Observations were recorded on thirteen character *viz*. on plant height (cm), leaves per plant, length of leaf (cm), width of leaf (cm), neck thickness of bulb (cm), cloves per bulb, weight of clove (g), length of clove (cm), length of bulb (cm), width of clove (cm), diameter of bulb (cm), total soluble solids (%) and bulb yield per plant (g). The data obtained were subjected to analysis of variance to test significant according to the procedure given by Panse and Sukhatme (1967). Genetic variability calculated by the procedure given below by Burton and de Vane (1953). Heritability in broad sense (h^2_{bs}) was calculated according to the formula suggested by Burton and de Vane (1953). Genetic advance (Ga) was estimated by the method suggested by Johnson et al. (1955).

Results and discussion

Analysis of variance

The analysis of variance for different characters is presented in (Table 1). The mean sum of square due to genotype highly significant for all the characters but length of leaf and diameter of clove are significant. The variation due to genotypes was highly significant for all characters.

Mean performance of genotypes

In order to evaluate the listed sixty genotypes including check for thirteen characters is presented in (Table 2). A wide range of variation in mean performance of genotypes was observed for all characters under study. The comparison of mean performance of sixty genotypes for thirteen traits using critical differences revealed existence of very high level of variability in the listed genotypes.

The genotype NDG-43 (34.57 g) gave highly significant higher yield as compared to others genotypes as well as check variety. The high yielding genotype NDG-43 also showed high mean performance for clove per bulb.

Other entries with higher bulb yield per plant were NDG-49 (33.40 g), NDG-48 (32.15 g) and NDG-45 (31.52 g). These genotypes also showed high mean performance for some other characters besides higher bulb yield. These result suggested that above mentioned high yielding genotypes may be considered in varietal improvement programme for desired characters in garlic.

Table 1. Analysis of variance for thirteen characters in garlic.

S. No.	Characters	Source of variation		
		Blocks	Checks	Error
		d.f. (7)	d.f. (3)	d.f. (21)
1	Plant height (cm)	15.91**	29.54**	0.00
2	No of leaves per plant	1.61**	7.35**	0.02
3	Length of leaf (cm)	4.78*	20.98**	1.13
4	Width of leaf (cm)	0.04**	0.34**	0.00
5	Neck thickness of bulb (cm)	0.01**	0.02**	0.00
6	Diameter of bulb (cm)	0.10**	0.94**	0.00
7	Bulb yield per plant (g)	28.43**	31.61**	0.43
8	No of cloves per bulb	19.42**	159.57**	0.04
9	Weight of clove (g)	0.05**	0.32**	0.00
10	Length of clove (cm)	0.17**	0.23**	0.01
11	Diameter of clove (cm)	0.17*	0.47**	0.02
12	Length of bulb (cm)	0.12**	0.31**	0.00
13	Total soluble solids %	0.91**	10.53**	0.12

*, ** = Significant at 5% and 1% probability levels, respectively.

Variability, heritability and genetic advance

An insight into the magnitude of variability exists in a crop species of most importance, as it provides the basis of the effective selection. In general, the genotypic coefficient of variability was higher than phenotypic coefficient of variability for all the thirteen characters under study which indicates that environment played a considerable role in the expression of their traits. The range of variability of different traits alone does not allow a decision as to which character was showing the highest degree of variability. Therefore, accurate relative comparison can be made with the help of phenotypic and genotypic co-efficient of variation. Phenotypic variation was partitioned into genotypic and environmental component.

The significant differences were observed among genotypes for all the characters studied. The higher magnitude of co-efficient of variation at genotypic as well as phenotypic levels observed for plant height, leaves per plant, leaf length, weight of clove and clove per bulb. Phenotypic variation was highest for plant height, leaf length, and cloves per bulb, weight of clove, leaf width and leaves per plant. Similar results were reported by Sharma et al. (1990), Lopez-Frasca et al. (1997), Agrawal and Tiwari (2004) and Singh and Chand (2004).

Genotypic coefficient variation was also highest for clove per bulb followed leaf length. Korla et al. (1981), Mehta and Patel (1985) have also reported similar results in their studies. Moderate variation noted in case of weight of clove and diameter of bulb, while low GCV and PCV was observed for length of bulb. Moderate to low variation exerted for these traits revealed that there is a reasonable scope for improvement in these traits.

Heritability and genetic advance

Heritability in broad sense of a character is important to the breeder since it indicates the possibility and extent to which improvement is possible through selection. It also indicates direction of selection of selection pressure to be applied for the traits during selection because it measures relationship between parent and their progeny, widely used in determining the degree to which a character may be transmitted from parent to off spring. However, high heritability alone is not enough to make efficient selection in advanced generation unless accompanied by substantial amount of genetic advance (Burton and De-Vane, 1953).

Table 2. Mean performance of sixty genotypes for thirteen characters in garlic.

Genotypes	Plant height (cm)	Leaves/ Plant	Leaf length (cm)	Leaf width (cm)	Neck thickness of bulb (cm)	Diameter of bulb (cm)	Bulb yield/ Plant (g)	Cloves/ Bulb	Weight of clove (g)	Length of clove (cm)	Diameter of clove (cm)	Length of bulb (cm)	T.S.S (%)
NDG-1	58.003	9.994	41.914	1.517	1.071	4.216	24.144	19.502	1.240	1.594	1.170	3.071	40.853
NDG-2	60.603	10.194	39.494	1.467	1.121	3.686	30.334	25.902	1.170	2.304	1.140	4.151	36.703
NDG-3	62.403	10.394	42.024	1.437	1.261	3.666	16.734	14.662	1.090	2.694	1.020	4.551	38.903
NDG-4	54.123	7.194	32.414	1.627	1.341	4.116	21.884	21.462	1.020	1.424	0.860	3.941	39.433
NDG-5	59.603	10.594	36.414	1.577	1.301	4.066	30.054	23.302	1.290	3.004	0.920	3.051	37.763
NDG-6	51.603	10.294	36.794	1.537	1.151	3.686	25.074	23.652	1.060	2.364	1.380	4.641	38.683
NDG-7	58.233	8.794	38.994	1.487	1.001	3.896	23.504	18.262	1.290	2.704	0.960	4.671	39.843
NDG-8	59.965	9.319	41.787	1.507	1.263	3.661	28.882	24.302	1.190	2.409	1.035	4.346	38.216
NDG-9	59.165	7.319	39.557	1.577	1.223	3.851	31.212	30.282	1.030	2.439	1.455	4.646	34.296
NDG-10	60.965	9.219	40.977	1.677	1.333	3.831	27.842	22.682	1.230	2.429	0.995	3.446	39.336
NDG-11	61.505	7.719	38.877	1.477	1.423	4.211	18.012	10.282	1.770	3.109	1.225	4.646	39.156
NDG-12	63.565	9.519	41.257	1.437	1.033	3.721	12.012	9.692	1.230	2.469	1.035	5.056	41.596
NDG-13	59.565	8.719	39.547	1.807	1.003	3.981	17.032	16.642	1.030	2.619	1.325	3.656	34.536
NDG-14	50.365	7.219	37.577	1.307	1.063	3.961	22.032	20.852	1.060	2.329	0.895	4.656	38.296
NDG-15	51.830	7.969	33.577	1.372	1.201	3.303	18.702	10.754	1.707	2.244	1.170	3.661	35.626
NDG-16	55.430	8.369	37.977	1.502	1.321	3.563	25.672	20.314	1.257	2.314	1.220	5.071	37.186
NDG-17	57.030	8.769	38.657	1.602	1.071	2.963	25.502	20.344	1.247	2.244	1.130	4.091	38.326
NDG-18	54.630	8.369	37.647	1.262	1.061	4.573	22.922	19.504	1.167	2.174	1.110	4.191	38.306
NDG-19	62.230	9.569	40.637	1.512	1.201	3.573	27.442	20.914	1.307	2.294	1.300	4.851	37.576
NDG-20	65.430	8.769	42.637	1.322	1.341	3.513	27.752	20.324	1.187	1.454	1.110	3.971	39.626
NDG-21	61.430	8.769	40.357	1.562	1.301	3.363	24.072	22.694	1.057	1.304	1.130	3.131	38.226
NDG-22	65.578	9.069	42.369	1.452	1.463	3.788	27.029	26.637	1.015	2.459	1.675	4.121	38.366
NDG-23	58.378	9.269	39.569	1.382	1.223	4.298	28.849	26.847	1.075	2.069	1.165	3.711	35.866
NDG-24	56.578	9.169	36.769	1.562	1.123	3.658	27.689	21.237	1.305	2.709	1.175	5.141	36.936
NDG-25	59.978	10.269	39.839	1.522	1.203	4.368	31.309	28.847	1.085	2.399	0.995	4.711	41.366
NDG-26	55.978	10.069	37.799	1.472	1.093	3.608	19.309	16.477	1.175	2.349	1.565	3.911	38.366
NDG-27	65.378	10.669	42.599	2.482	1.123	3.658	30.169	24.437	1.235	1.919	0.975	4.161	37.936
NDG-28	62.178	9.469	41.469	1.522	1.343	3.428	29.209	26.677	1.095	1.939	0.935	4.561	38.706
NDG-29	55.388	8.269	38.009	1.350	0.931	3.788	16.552	14.452	1.150	2.904	1.137	4.978	40.236
NDG-30	52.588	7.869	34.769	1.730	1.001	2.698	19.572	15.462	1.270	2.304	0.958	3.848	38.336
NDG-31	53.588	7.869	36.799	1.630	1.331	4.158	18.672	14.212	1.310	2.284	1.037	4.158	39.306
NDG-32	52.788	7.369	44.099	1.460	1.431	4.318	27.122	20.412	1.330	2.484	1.067	4.698	37.996
NDG-33	60.588	9.369	42.099	1.670	1.381	4.298	25.712	24.072	1.070	2.764	0.947	4.838	40.256
NDG-34	57.988	9.669	39.839	1.490	1.271	3.788	17.652	14.932	1.190	2.744	1.167	3.958	38.126

Genotypes	Plant height (cm)	Leaves/ Plant	Leaf length (cm)	Leaf width (cm)	Neck thickness of bulb (cm)	Diameter of bulb (cm)	Bulb yield/ Plant (g)	Cloves/ Bulb	Weight of clove (g)	Length of clove (cm)	Diameter of clove (cm)	Length of bulb (cm)	T.S.S (%)
NDG-35	62.788	10.269	40.589	1.470	1.071	3.028	19.832	17.032	1.170	2.414	1.147	5.028	38.296
NDG-36	58.040	9.269	36.892	1.835	1.173	4.293	22.049	21.239	1.037	2.372	1.007	3.918	40.156
NDG-37	53.240	9.869	36.092	1.335	1.183	3.463	13.699	12.889	1.057	2.802	1.137	5.138	40.256
NDG-38	60.240	9.269	38.092	1.565	1.033	4.393	30.309	24.679	1.227	2.642	0.998	3.788	39.336
NDG-39	51.040	7.469	32.662	1.355	1.373	4.153	13.389	12.839	1.037	2.992	1.107	4.058	35.396
NDG-40	52.040	7.969	34.692	1.375	1.313	3.853	29.309	23.869	1.227	3.012	1.157	4.378	36.906
NDG-41	53.840	7.869	34.762	1.405	1.273	3.903	29.289	25.479	1.147	3.002	1.577	4.738	36.926
NDG-42	61.840	9.669	40.412	1.715	1.273	3.893	29.489	28.459	1.037	2.372	0.948	3.728	41.256
NDG-43	58.413	8.494	40.047	1.860	1.083	4.133	34.579	16.862	2.047	2.374	0.950	3.998	34.316
NDG-44	63.013	9.694	42.827	1.930	0.993	3.023	20.909	15.682	1.327	2.424	1.210	3.578	38.316
NDG-45	58.613	8.894	40.627	1.810	1.133	4.023	31.529	25.672	1.227	2.574	1.310	4.168	39.786
NDG-46	62.813	8.294	41.837	1.390	1.333	3.863	24.449	22.862	1.067	3.154	1.150	5.098	34.176
NDG--47	60.013	8.694	39.827	1.280	1.003	3.603	26.619	24.672	1.077	2.154	1.740	4.698	41.616
NDG-48	67.013	10.494	44.817	2.070	1.353	4.493	32.159	15.452	2.077	2.874	1.780	4.668	36.876
NDG-49	56.413	9.494	38.047	1.380	0.973	3.363	33.469	24.462	1.367	2.694	0.850	4.338	42.176
NDG-50	60.983	9.619	42.544	1.387	1.173	3.616	25.464	23.482	1.085	2.624	1.365	3.848	39.183
NDG-51	61.983	10.019	43.144	2.497	1.113	3.116	27.334	22.882	1.195	2.304	1.225	3.988	35.203
NDG-52	58.983	10.219	39.474	1.307	1.033	3.776	28.514	27.282	1.045	2.464	1.185	4.658	41.383
NDG-53	58.583	9.819	37.574	1.387	1.003	3.766	26.644	23.912	1.115	2.384	0.985	4.328	38.913
NDG-54	60.183	8.019	40.644	1.457	0.953	4.196	16.194	14.442	1.125	2.334	1.575	4.148	37.913
NDG-55	60.183	9.419	41.574	1.827	1.043	4.096	29.444	24.852	1.185	2.834	0.905	4.088	41.343
NDG56	58.383	8.419	39.894	1.497	1.053	4.116	29.694	17.442	1.705	2.624	0.805	3.768	39.143
G-41	58.565	8.438	38.818	1.821	1.121	3.050	30.955	23.036	1.344	2.624	1.303	3.967	38.731
G-50	57.816	7.463	37.416	1.356	1.071	3.348	31.097	20.457	1.520	2.335	1.232	3.827	38.530
G-282	62.194	9.800	41.316	1.549	1.194	3.837	28.374	24.429	1.161	2.711	1.076	4.265	40.382
Punjab Garlic	59.916	8.575	38.897	1.422	1.117	3.629	33.230	30.945	1.074	2.456	1.649	4.162	40.799
Mean	58.696	9.016	39.311	1.560	1.174	3.788	25.295	20.939	1.227	2.447	1.163	4.244	38.526
Std. Dev.	3.917	0.962	2.735	0.246	0.139	0.407	5.577	5.098	0.225	0.385	0.228	0.520	1.948
Std. Error	0.506	0.124	0.353	0.032	0.018	0.053	0.720	0.658	0.029	0.050	0.029	0.067	0.251
C.V. %	6.673	10.665	6.957	15.753	11.801	10.754	22.049	24.348	18.368	15.725	19.574	12.246	5.056
Lowest	50.365	7.194	32.414	1.262	0.931	2.698	12.012	9.692	1.015	1.304	0.805	3.051	34.176
Highest	67.013	10.669	44.817	2.497	1.463	4.573	34.579	30.945	2.077	3.154	1.780	5.141	42.176

Table 3. Estimates of range, grand mean, phenotypic and genotypic coefficient of variation (PCV & GCV), heritability and genetic advance genetic advance % of mean for thirteen characters in garlic.

S. No.	Characters	Range		Grand Mean	Coefficient of variation		Heritability in (broad sense)	Genetic advance	Genetic advance in % of mean
		Minimum	Maximum		Phenotypic (PCV%)	Genotypic (GCV %)			
1	Plant height (cm)	50.36	67.01	58.696	5.697	5.697	100.00	6.880	11.735
2	No of leaves per plant	7.19	10.66	9.016	9.150	9.049	97.69	1.667	18.432
3	Length of leaf (cm)	32.41	44.81	39.311	5.765	5.091	78.01	3.642	9.263
4	Width of leaf (cm)	1.26	2.49	1.560	13.405	13.379	99.62	0.429	27.508
5	Neck thickness of bulb (cm)	0.93	1.46	1.174	10.141	9.457	86.97	0.214	18.169
6	Diameter of bulb (cm)	2.69	4.57	3.788	8.884	8.702	95.94	0.669	17.558
7	Bulb Yield per plant (g)	12.01	34.57	25.295	18.320	18.129	97.93	9.199	36.956
8	No of clove per bulb	9.69	30.94	20.939	20.267	20.247	99.80	8.612	41.665
9	Weight of clove (g)	1.01	2.07	1.227	15.402	15.284	98.47	0.382	31.243
10	Length of clove (cm)	1.30	3.15	2.447	13.137	12.621	92.29	0.609	24.977
11	Diameter of clove (cm)	0.80	1.78	1.163	18.021	12.689	49.58	0.212	18.404
12	Length of bulb (cm)	3.05	5.14	4.244	10.400	10.368	99.39	0.906	21.292
13	Total soluble solids (%)	34.17	42.17	38.526	4.279	4.182	95.49	3.236	8.417

The genetic advance is commonly predicted as a product of heritability ratio and selection differentials. Panse and Sukhatme (1967) mentioned that where high heritability value is accompanied by high genetic advance. The progress realized by selection would be most appropriate. In the present investigation, the highest estimates of heritability were observed in case of plant height and the highest genetic advance showed in bulb yield plant. Singh (1984) and Gupta et al. (2007) have also reported similar results in their studies. High heritability coupled with high genetic advance in per cent of mean was recorded for no of clove per bulb, bulb yield per plant, and weight of clove, width of leaf and length of clove. This indicates that these traits were less influenced by environment. Similar results were reported by Mehta and Patel (1985), Kumar et al. (2006) and Sonkiya et al. (2012).

Conflict of interest statement

Authors declare that they have no conflict of interest.

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