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Genetic Variability, Heritability and Genetic Advance for Bulb Yield and Yield Developmental Traits in Garlic (*Allium sativum* L.)

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ABSTRACT

The present investigation was undertaken to evaluate 34 garlic genotypes for yield and its contributing traits in order to assess genetic variability, heritability and genetic advance during *rabi* 2019-20 at Vegetable Research Farm, C. S. Azad University of Agriculture and Technology, Kalyanpur, Kanpur (Uttar Pradesh). Analysis of variance table revealed that the mean sum of squares due to genotypes were highly significant for all the traits. In general, estimates of phenotypic coefficients of variation (PCV) for all traits were slightly higher than their corresponding genotypic coefficient of variation (GCV). Characters average weight of bulb and average weight of cloves per bulb showed the higher phenotypic and genotypic coefficient of variation among all the characters. Highest heritability was observed for equatorial diameter, clove length, leaf length, average weight of bulb, polar diameter, average weight of cloves per bulb, marketable bulb yield, number of cloves per bulb, width of cloves and number of leaves per plant. High heritability coupled with high genetic advance as percent of mean (GAM) was observed for average weight of bulb, average weight of cloves per bulb, number of cloves per bulb, marketable bulb yield and width of cloves indicating the presence of additive gene action for the expression of these traits.

Keywords: Garlic, Genetic advance, Heritability, Genetic variability.

INTRODUCTION

Garlic (*Allium sativum* L.) is the second most widely cultivated bulb crop after the onion and belongs to the family Amaryllidaceae. It has long been recognized as a valuable spice and condiment in India. It is a monocotyledonous vegetable that has its origin in Central Asia (Kazakhstan), with secondary centers of origin in China and the Mediterranean area [1]. It has been so extensively domesticated and cultivated over thousands of years that there are no more wild forms found in nature related to the type of garlic humans now use. Garlic is one of the oldest cultivated vegetables and its positive effect on human beings has been known for thousands of years [2]. Garlic has high nutritive value. It has been considered as a rich source of protein, fat, calcium, potassium, phosphorous, sulfur, iodine and silicon, in addition to vitamins. Its pungent flavor makes it to be used mainly as foodstuff a spice, in the form of both green tops and bulbs. It also possesses medicinal value, which prevent infection of common colds, hay fever, asthma and provide relief from gastric problems because of its have been found to antifungal, antibacterial and antiviral properties.

Globally China is the leading country in area and production followed by India, Bangladesh, Republic of Korea and Egypt [3]. In India, the area under garlic is 352.13 thousand hectares with an annual production of 2944.16 thousand metric tones. Madhya Pradesh is the leading state in garlic production contributing, to 183.71 thousand hectare area with 1869.43 thousand metric tonnes production followed by Rajasthan, Uttar Pradesh, Gujarat, Punjab, Assam and Odisha. The area under Uttar Pradesh state is 34.31 thousand hectares having a production of 227.34 thousand metric tonnes with a productivity of 6.63 t/ha [4]. In Uttar Pradesh, Mainpuri has maximum area and production of garlic followed by Etah, Firozabad, Kasganj and Etawah districts.

Study of the extent of variability for yield and yield developmental characters is prerequisite for starting crop improvement programme in any crop. Selection of quantitative traits is rarely efficient, if it is based on phenotypic expression. Thus, it is necessary to assess the relative extent of genetic and non-genetic variability exhibited by individual characters. It can be achieved by estimation of genetic variability parameters like variances, genotypic coefficient of variation, heritability in broad sense and expected genetic advance for individual characters. Therefore, the present study was undertaken to understand the nature and magnitude of variability, heritability, and genetic advance for yield and its attributing characters to identify better performing genotypes in garlic.

MATERIAL AND METHODS

The experiment was carried out consisting of 34 genotypes of garlic at the Vegetable Research Farm, C. S. Azad University of Agriculture and Technology, Kalyanpur, Kanpur during *rabi* 2019-20 in a Randomized Complete Block Design (RCBD) with three replications. Each genotype was accommodated in 20 row plot of 3 m length with row to row and plant to plant spacing of 15 and 10 cm, respectively. The observations were recorded at 90 days after planting of crop on ten randomly selected plants in each genotype per replication for growth and developmental characters *viz.* plant height (cm), number of leaves per plant, leaf length (cm), leaf width (cm), pseudostem length (cm), pseudostem diameter (cm), days to harvest, polar diameter (cm), equatorial diameter (cm), number of cloves per bulb, average weight of bulb (g), average weight of 10 cloves (g), length of cloves (cm), width of cloves (cm), total bulb yield (q/ha), marketable bulb yield (q/ha), total soluble solids (%) and dry matter (%). The mean values of each genotype for different characters replication wise were subjected to analysis of variance (ANOVA) to determine the presence of statistically significant differences between genotypes for the traits under study [5]. Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) was estimated as per the formula given by [6] while heritability in a broad sense (h^2) and genetic advance (GA) were calculated by using the formula recommended by [7] and [8], respectively.

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant genotypic differences for all the characters studied, indicated the presence of considerable variability in the existing material for present investigation (Table 1). A wide range of variation was observed for most of the characters like marketable bulb yield (56.54 to100.49 q/ha), total bulb yield (73.05 to116.99 q/ha), plant height (58.58 to 83.70 cm), number of cloves per bulb (17.48 to 39.34), days to harvest (154.67 to 174.33), average weight of bulb (17.55 to 37.01 g), leaf length (34.81 to 49.12 cm), dry matter content (30.23 to 42.47 %), total soluble solids (35.84 to 45.78 %), pseudostem length (18.26 to 27.88 cm) and average weight of cloves (7.70 to 15.43 g). Presence of such high variability for these parameters will form the basis for effective selection of superior genotypes in garlic. Such wide variability in this crop has also been reported for different characters by [9], [10] and [11]. The estimates of variance, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in a broad sense and genetic advance as percent of mean for eighteen different characters studied are presented in Table 2. The magnitude of phenotypic and genotypic variances was highest for the total bulb yield (156.59 and 123.64, respectively) followed by marketable bulb yield (128.80 and 111.00), plant height (50.22 and 39.35), days to harvest (33.66 and 26.01), average weight of bulbs (32.95 and 30.36), number of cloves per bulb (27.85 and 23.91), leaf length (15.72 and 14.59) and dry matter content (14.84 and 10.46). A high magnitude of PCV and GCV were registered for average weight of the bulb (22.13 and 21.24) and average weight of cloves per bulb (21.49 and 20.19). This conformed to the findings of [12] who reported higher PCV and GCV in garlic for average weight of cloves and average bulb weight. The moderate values of PCV and GCV were recorded for number of cloves per bulb (19.80 and 18.35), marketable bulb yield (14.59 and 13.54), days to harvest (14.37 and 13.26), total bulb yield (13.40 and 11.91) and pseudostem length (12.85 and 11.14). The findings are in close harmony with the result for number of cloves per bulb by [13] and pseudostem length by [14]. Three traits *viz.* dry matter content, leaf width and number of leaves per plant were observed having moderate magnitude of PCV along with low GCV. The rest of the traits showed a low magnitude of PCV and GCV. In the present investigation, the value of PCV was found to be slightly higher than their respective GCV for all the characters which might be the result of the influence of the environment in the expression of characters.

Table 1: Analysis of variance for 18 different characters for 34 genotypes in garlic

Sr. No.	Characters	Mean sum of squares			SE(d)	CV (%)
		Replications	Genotypes	Error		
Degree of freedom		2	33	66		
1	Plant height (cm)	2.18	128.92**	10.87	2.69	4.57
2	Number of leaves per plant	0.11	1.56**	0.10	0.26	4.23
3	Leaf length (cm)	3.60	44.91**	1.13	0.87	2.48
4	Leaf width (cm)	0.0089	0.08**	0.0099	0.081	5.67
5	Pseudostem length (cm)	10.164	22.09**	2.203	1.21	6.42
6	Pseudostem diameter (cm)	0.0035	0.021**	0.0020	0.036	3.32
7	Days to harvest	23.12	85.68**	7.65	2.25	1.66
8	Polar diameter (cm)	0.024	0.34**	0.010	0.082	2.54
9	Equatorial diameter (cm)	0.0065	0.19**	0.0017	0.033	0.99
10	Number of cloves per bulb	3.19	75.69**	3.94	1.62	7.44
11	Average weight of bulb (g)	5.12	93.67**	2.59	1.31	6.21
12	Average weight of cloves (g)	0.54	15.03**	0.63	0.65	7.35
13	Length of cloves (cm)	0.0021	0.11**	0.0025	0.041	2.13
14	Width of cloves (cm)	0.026	0.045**	0.0025	0.040	5.53
15	Marketable bulb yield (q/ha)	1.15	350.81**	17.80	3.44	5.42
16	Total bulb yield (q/ha)	5.50	403.87**	32.95	4.68	6.14
17	Total soluble solids (%)	0.85	20.87**	2.48	1.28	3.89
18	Dry matter content (%)	2.30	35.76**	4.38	1.71	5.66

* * significant at 0.01 probability level

Table 2: Genetic parameters of bulb yield and yield developmental characters in garlic

Sr. No.	Characters	General mean	Range		σ2p	σ2g	PCV	GCV	h^2_b	GA	GAM
			Min.	Max.							
1	Plant height (cm)	72.08	58.58	83.70	50.22	39.35	9.83	8.70	78.3	23.56	32.68
2	Number of leaves per plant	7.66	6.73	9.47	0.58	0.48	10.05	9.12	82.3	2.69	35.11
3	Leaf length (cm)	42.83	34.81	49.12	15.72	14.59	9.26	8.92	92.8	15.61	36.44
4	Leaf width (cm)	1.76	1.51	2.25	0.032	0.023	10.38	8.70	70.2	0.53	30.11
5	Pseudostem length (cm)	23.12	18.26	27.88	8.83	6.63	12.85	11.14	75.1	9.47	40.96
6	Pseudostem diameter (cm)	1.34	1.20	1.45	0.008	0.006	6.83	5.97	76.3	0.28	20.89
7	Days to harvest	165.65	154.67	174.33	33.66	26.01	14.37	13.26	77.3	19.03	11.48
8	Polar diameter (cm)	3.96	3.25	4.49	0.12	0.11	8.83	8.45	91.7	1.35	34.09
9	Equatorial diameter (cm)	4.16	3.64	4.68	0.06	0.06	6.18	6.10	97.4	1.07	25.72
10	Number of cloves per bulb	26.65	17.48	39.34	27.85	23.91	19.80	18.35	85.8	19.21	72.08
11	Avg. weight of bulb (g)	25.94	17.55	37.01	32.95	30.36	22.13	21.24	92.1	22.43	86.46
12	Avg. weight of cloves per bulb (g)	10.85	7.70	15.43	5.43	4.80	21.49	20.19	88.3	8.73	80.46
13	Length of cloves (cm)	2.38	1.80	2.68	0.03	0.03	3.87	3.49	93.5	0.78	32.77
14	Width of cloves (cm)	0.90	0.68	1.12	0.016	0.014	3.50	3.08	85.2	0.47	52.22
15	Marketable bulb yield (q/ha)	77.80	56.54	100.49	128.80	111.00	14.59	13.54	86.2	41.50	53.34
16	Total bulb yield (q/ha)	93.39	73.05	116.99	156.59	123.64	13.40	11.91	79.0	41.92	44.88
17	Total soluble solids (%)	40.47	35.84	45.78	8.61	6.13	7.25	6.12	71.1	8.85	21.86
18	Dry matter content (%)	36.95	30.23	42.47	14.84	10.46	10.43	8.75	70.4	11.51	31.15

σ2p = phenotypic variance; **σ2g** = genotypic variance, **PCV** = phenotypic coefficient of variation, **GCV** = genotypic coefficient of variation, $\mathbf{h^2_b}$= heritability (in broad sense) **GA** = genetic advance, **GAM** = genetic advance as percent of mean

The heritability in the broad sense ranged from 70.02 (leaf width) to 97.4 (equatorial diameter). High values of heritability were observed for all the characters like length of cloves (93.5 %), leaf length (92.8 %), average weight of bulb (92.1), polar diameter (91.7 %), average weight of cloves per bulb (88.3 %), marketable bulb yield (86.2 %), number of cloves per bulb (85.8 %), width of cloves (85.2 %) and number of leaves per plant (82.3 %). These results are similar with the results obtained by [15] for marketable bulb yield in onion and average weight of bulb, number of cloves per bulb and average weight of cloves per bulb reported by [16] in garlic. Out of eighteen characters studied in the present investigation, high genetic gain over mean coupled with high heritability were observed in the characters namely average weight of bulb (86.46), average weight of cloves per bulb (80.46), number of cloves per bulb (72.08), marketable bulb yield (53.34) and width of cloves (52.22). These findings are in agreement for weight of cloves and number of cloves per bulb by [17] and average weight of bulb by [12]. Higher heritability estimates were accompanied by a moderate genetic advance over the mean for leaf length (36.44), number of leaves per plant (35.11), polar diameter (34.09), length of cloves (32.77) and equatorial diameter (25.72).

CONCLUSION

The present study on garlic revealed that the highest phenotypic as well as genotypic coefficient of variations were exhibited by average weight of bulb and average weight of cloves per bulb indicating that the genotype posses a considerable range of variation for these traits. The high heritability associated with high genetic advance as percent of mean were observed in average weight of bulb, average weight of cloves per bulb, number of cloves per bulb, marketable bulb yield and width of cloves. These characters are governed by additive gene effects. It was also concluded that selection based on these characters will be more useful for the improvement of this crop towards attaining higher yield.

Conflicts of interest

The authors declare no conflict of interest.

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