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Genetic Variability, Heritability and Genetic Advances in the Garlic, *Allium sativum* Genotypes

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ABSTRACT

The present investigation was carried out to find out the Genetic variability, heritability and genetic advance in garlic in Central Uttar Pradesh during Rabi season. The experiment was laid out in randomized block design. All the treatments were randomly distributed among the plots and replicate three times. Most of the characters under study exhibited high estimates of heritability viz., plant height, and number of cloves per bulb, bulb weight, dry weight of bulb, weight of 10 uniform cloves and fresh weight of bulb. These characters would be effective in selection for garlic improvement.

KEY WORDS: GARLIC, GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE.

INTRODUCTION

Garlic (*Allium sativum L.*) is an important spice and condiment crop grown throughout the country as well as world. It is one of the most important bulb vegetable crop which have been used since ancient for its culinary, medicinal and health benefits (Narayan et al., 2019). Garlic is the second most important bulb crop after onion. It is an important spice crop belonging to family Alliaceae and botanically known as (*Allium sativum L.*). Growth of garlic mainly depends on the time of planting as the vegetative growth is stimulated under a short photoperiod and low temperature and bulb production is enhanced by a long photoperiod and high temperature (Atif et al,. 2020). The economic yield is obtained from its underground bulb, which is consisted of bulblets, popularly called as cloves. Garlic is used in flavoring foods, preparing chutneys, pickles, curry powder, tomato ketchup etc. It contains protein (6.3%), phosphorus (0.31%), potash (0.40%), calcium (0.03%), magnesium (0.025%), carbohydrates (29%) and a colourless as well as odourless water soluble amino acid called allicin. On crushing the blub clove, an enzyme *allinase* acts upon *allicin* and breaks down to produce *allicin*. Garlic contains volatile oil known as *diallel - disulphide* which is the major flavouring component in garlic. Beneficial use of garlic extract has been found against many fungi and bacteria (Pandey, 1997). Besides the nutritive value of garlic and its use in various forms, it is included in Indian system of medicines (Ayurvedic, Unani and Siddha) as carminative and gastric stimulant to help indigestion and absorption of food. Garlic is a scapigerous foeti 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 (Yadav et al, 2018).

Allicin present in aqueous extract of garlic reduce blood cholesterol concentration in human blood (Shankaracharya, 1974). Garlic oil or its juice is

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recommended to inhale in cases of pulmonary tuberculosis, rheumatism, sterility, impotency, cough and redness of eyes (Pruthi, 1979). India ranks second after China in area (171.45 thousand hectare) and second in production (923.250 thousand tonnes) of garlic with an average productivity of 4.38 tonnes per hectare (Anonymous, 2009). The major garlic producing states of India are Maharashtra, Madhya Pradesh, Orissa, Rajasthan, Karnataka, Uttar Pradesh and Gujarat. India is one of the most garlic exporting countries in the world. The export was 13008.78 tonnes (worth Rs 1962.66 lakh) in 2010- 11 In Uttar Pradesh, garlic is grown extensively in the districts, Kanpur, Bundel Khand, Mirjapur, Fathepur, Varanasi, Raebareli, Agra, Mathura, Lucknow, Jaunpur and Azamgarh. Despite the importance of crop, so far very limited breeding work has been done. The adequacy of germplasm collection is determined by the amount of genetic variability present in the germplasm. Assessment of variability present in these genotypes is helpful in selection of suitable genotype. Hence, to boost the economy of garlic growing farmers in Uttar Pradesh, there is urgent need to select/develop superior varieties for our zone i.e. Agro climatic zone nine.

MATERIALS AND METHODS

The twenty five genotypes of garlic used for the present investigation were collected from the different parts of India. The experiment was laid down in a randomized block design with three replications. Randomization of the genotype was done. The row to row spacing 15 cm and plant to plant 10 cm in double row of 5 meter length of each genotype were planted. All the standard package of practices and plant protection measures were timely adopted to raise the crop successfully. The Department of Applied Plant Science (Horticulture), BBAU, Lucknow. The twenty five germplasm/ genotypes lines of garlic were obtained from the "Department of Plant Breeding and Genetics, S.K.N. College Of Agriculture, Jobner, Sri Karan Narendra Agriculture University Jobner. Geographically, Lucknow is situated at an elevation of 111 meter above Mean Sea Level in the subtropical climate of Central Uttar Pradesh at 260 56" North latitude and 800 52' East longitudes. The climate of region is subtropical with maximum temperature ranging from 22 0 C to 45 0C in summer, minimum temperature ranging from 3.5 0C to 15 0C in winter and relative humidity ranging from 60-80% in different season of the year.

Ten randomly selected plants from each replication were utilized for recording observations and drawing sample for estimating variability, heritability and genetic advance in garlic. The observations were recorded on plant height (cm), number of leaves per plant, bulb weight (g), number of cloves per bulb, weight of ten uniform cloves (g), bulb yield (q/h-1), fresh weight of bulbs (g), dry weight of bulb (g), fresh weight of leaves (g), dry weight of leaves (g), neck thickness (cm), circumference of bulb (cm), volume of bulb, total soluble solids (%) (0 brix) and Vitamin 'C' (mg/100g). The critical differences for the treatments comparison were worked out, wherever the "F" test was found significant at 5 per cent level of significance. The mean values obtained from the data were used for estimating the analysis of variance. The data were analyzed to work out various components coefficient of variation and heritability in broad sense and expected genetic advance as percent of Mean were estimated as suggested by (Johnson et al, 1955 and Burton and Devane (1952). The data was statistically analyzed for variance and test the significance of variance using the standard procedure by (Panse and Sukhatme, 1961).

RESULTS AND DISCUSSION

The analysis of variance for the design of experiment indicated that the mean squares due to genotypes were highly significant for most of the characters indicating a wide genetic variability among the genotypes (Table 1). The analysis of variance revealed significant differences among the genotypes for different traits viz., plant height, number of leaves per plant, fresh weight of leaves, dry weight of leaves, number cloves per bulb, weight of 10 uniform cloves, fresh weight of bulb, dry weight of bulb, neck thickness, circumference of bulb, volume of bulb, total soluble solids, vitamin C, bulbs weight and bulb yield. The result of the present investigation revealed that there exists significant variations were observed for different characters. The range of 25 genotypes for all the twelve characters is presented in the (Table 2). The highest genotypic variance was observed for bulb yield (288.15) whereas moderate genotypic variance was obtained for number of cloves per bulb (29.63), plant height at 90 DAS (28.63) and bulb weight (27.55) and low genetic variance was obtained for volume of bulb (9.59), weight of 10 uniform cloves (9.38), dry weight of bulb (5.89), fresh weight of leaves (2.81), TSS (2.40), vitamin C (0.46), number of leaves per plant (0.09), neck thickness (0.003) and. Highest phenotypic variance was also observed for bulb yield (421.26) followed by number of cloves per bulb (31.88), bulb weight (29.88), plant height at 90 DAS (29.14) and fresh weight of bulb (26.38).

The highest genotypic coefficient of variation was recorded for weight of 10 uniform cloves (23.03) followed by dry weight of bulb (22.52), number of cloves per bulb (22.02) and bulb weight (21.52) whereas moderate genotypic coefficient of variance was obtained for fresh weight of bulb (19.44), dry weight of leaves (18.36), fresh weight of leaves (17.73), volume of bulb (17.10), bulb yield (14.28) and plant height at 90 days after sowing (10.11) and low genotypic coefficient of variation was recorded for circumference of bulb (8.01), vitamin C (6.38), TSS (3.80), neck thickness (3.48) and number of leaves per plant (3.12). The phenotypic coefficient of variation was also highest for weight of 10 uniform cloves (24.79) followed by dry weight of bulb (24.39), number of cloves per bulb (22.84), bulb weight (22.42), dry weight of leaves (21.98), fresh weight of bulb (21.41) and fresh weight of leaves (20.59) whereas moderate genotypic coefficient of variance was obtained for volume of bulb (19.53), bulb yield (17.27), circumference of bulb (10.49) and plant height at 90 days after sowing (10.20).

Table 1: Analysis of variance for fifteen characters in garlic germplasm

Source of variation	D.f	Plant height (cm)	No. of leaves /plant	Fresh weight of leaves (g)	Dry weight of leaves (g)	No. Of cloves/ bulb	Weight of 10 uniform cloves (g)	Fresh weight of bulb (g)	Dry weight of bulb (g)	Neck thickness (cm.)	Circumfe-rence of bulb (cm)	Volume of bulb (cc)	TSS (%)	Vitamin C (mg/ 100g)	Bulb weight (g)	Bulb yield (q/ha)
Replication	2	0.15	0.91	0.47	0.19	4.32	0.14	3.60	1.18	0.000004	0.52	0.38	4.42	0.02	6.35	110.79
Genotypes	24	86.40**	0.56*	9.40**	1.39**	91.13**	29.62**	69.90**	18.68**	0.0055**	3.63**	31.69**	10.17**	1.90**	84.98**	997.56**
Error	48	0.51	0.31	0.98	0.18	2.25	1.49	4.63	1.02	0.0026	0.70	2.92	2.98	0.52	2.33	133.11

*Significant at 5%
**Significant at 1%

Similar to genotypic coefficient of variation low genotypic coefficient of variation was recorded for vitamin C (9.32), TSS (5.70), neck thickness (6.69), number of leaves per plant (6.68). Heritability a wide range of heritability (21.81% to 98.23%) was observed for the characters under study. High values of heritability were observed for plant height (98.23%), number of cloves per bulb (92.94%), bulb weight (92.19), dry weight of bulb (85.22%), weight of 10 uniform cloves (86.29) and fresh weight of bulb (82.47%), whereas moderate heritability was obtained for volume of bulb (76.67%), fresh weight of leaves (74.17%), dry weight of leaves (69.78%), bulb yield (68.40%) and circumference of bulb (58.38%) and low value of heritability was recorded for vitamin C (46.44%), TSS (44.58), neck thickness (27.14%) and number of leaves per plant (21.81%).

The highest genetic advance was recorded for the character bulb yield (28.92) followed by plant height (10.92), number of cloves per bulb (10.81) and bulb weight (10.38) whereas, fresh weight of bulb (8.73), weight of 10 uniform cloves (5.86), volume of bulb (5.59), dry weight of bulb (4.61), fresh weight of leaves (2.97), TSS (2.13), circumference of bulb (1.56), dry weight of leaves (1.10), vitamin c (0.96 number of leaves per plant (0.28), neck thickness (0.03) and exhibited the low genetic advance. Genetic Advance as per cent of mean the high genetic gain was recorded for dry weight of leaves (30.17%), and dry weight of bulb (19.94%), neck thickness (20.46%) and fresh weight of leaves (18.25%). The genetic advance as per cent of mean were low for number of cloves per bulb (13.30%), bulb weight (13.21%), volume of bulb (13.05%), fresh weight of bulb (12.31%), circumference of bulb (10.11%), vitamin C (9.19%), plant height (6.25%), number of Experimental Results 56 leaves per plant (5.66%) and bulb yield (4.52%). The character TSS recorded the lowest (3.59%) genetic advance.

The range in mean values an indicator of variability revealed high variation for bulb yield, plant height at 90 days after sowing, bulb weight, number of cloves per bulb and fresh weight of bulb and low for other characters. Comparison of coefficient of variation indicated that the phenotypic coefficient of variation was higher than genotypic coefficients of variation for all the characters which indicated effect of environment on the character expression. Among all the characters high GCV and PCV were observed for weight of 10 uniform cloves (23.03) followed by dry weight of bulb (22.52), number of cloves per bulb (22.02) and bulb weight (21.52) in comparison of other characters, indicating the presence of high amount of genetic variability for these traits and selection for these characters would be effectives because the response to selection is directly proportional to the variability present in the experimental material. These results are in broad conformity to earlier researchers (Mohanty and Prusti, 2001) and (Gurjar and Singhania, 2006) in onion.

Estimates of PCV and GCV observed for vitamin C, TSS, neck thickness and number of leaves per plant indicated that the genotypes used had less genetic variability

for these characters. The heritability estimate of a quantitative character is very important as phenotypic expression of a genotype may be altered by environment at various stages of its development. Heritability indicates the effectiveness with which selection for genotypes can be done on the basis of its phenotypic variation. It expresses the extent to which individual phenotypes are determined by their genotypes. The heritability estimates serve as a useful guide to the breeder because selection would be fairly easy for the characters with high heritability. Thus, there would be a close correspondence between the genotypes and phenotype will be attributed to a relatively smaller contribution of the environment to phenotype. But for a character with low heritability, selection may not be effective due to the masking effect of the environment on genotypic effect. The response to selection depends upon the relative magnitude of heritable variation present in relation to the phenotypic variation. Therefore, it is desirable to partition observed variability into its heritable and non-heritable components. (Burton, 1952) suggested that genotypic coefficient of variation along with heritability would give a better idea about the efficiency of selection.

Thus, a character with high genotypic coefficient of variation and high heritability will be more valuable in selection programme. In present investigation, high heritability along with high genotypic coefficient of variance was recorded for number of cloves per bulb, bulb weight and dry weight of bulb, weight of 10 uniform cloves and fresh weight of bulb. This indicates good correspondence between genotypic and phenotypic values and thereby low environmental effect on the expression of these characters.

Thus phenotypic selection might be effective for number of cloves per bulb, bulb weight, and dry weight of bulb, weight of 10 uniform cloves and fresh weight of bulb. Moderate heritability was obtained for volume of bulb, fresh weight of leaves, dry weight of leaves, bulb yield and circumference of bulb and low value of heritability was recorded for vitamin C, TSS, neck thickness and number of leaves per plant.Similarly, high heritability for bulb weight in onion (Mohanty, 2001 and Atif et al., 2020), number of cloves per bulb in garlic (Singh and Chand, 2004), weight of 10 uniform cloves in garlic and fresh weight of bulb in onion (Hossain et al., 2008) and (Singh et al., 2004) in garlic have been reported by earlier researchers. Low heritability in number of leaves in garlic (Agarwal and Tiwari, 2004). Moderate heritability in onion is reported by (Mohanty, 2001 and Yadav et al., 2018). Heritability estimates alone do not provide reliable information about the gene action governing the expression of a particular character and also this does not provide the information of the amount of genetic progress that would result from the selection of best individuals.

Table 2. Estimates of range, general mean, genotypic and phenotypic coefficient of variation in percent of mean for fifteen characters in garlic.

Characters	Mean± S.Em	Range	Genotypic variance	Phenotypic variance	Coefficient of variance		Herita bility (%)	Genetic Advance	G.A. as % of mean
					Genotypic	Phenotypic			
Plant height (cm)	52.91±0.24	36.33-60.70	28.63	29.14	10.11	10.20	98.23	10.92	6.25
No. of leaves per plant	9.38±0.18	8.57-10.13	0.09	0.39	3.12	6.68	21.81	0.28	5.66
Fresh weight of leaves (g)	9.45±0.33	6.00-13.63	2.81	3.79	17.73	20.59	74.17	2.97	18.25
Dry Weight of leaves (g)	3.47±0.14	2.37-4.83	0.41	0.58	18.36	21.98	69.78	1.10	30.17
No. of cloves per bulb	24.72±0.50	16.03-38.27	29.63	31.88	22.02	22.84	92.94	10.81	13.30
Weight of 10 uniform cloves (g)	13.30±0.41	7.90-17.87	9.38	10.87	23.03	24.79	86.29	5.86	18.20
Fresh weight of bulb(g)	23.99±0.72	14.97-31.60	21.76	26.38	19.44	21.41	82.47	8.73	12.31
Dry weight of bulb(g)	10.77±0.34	6.05-16.50	5.89	6.91	22.52	24.39	85.22	4.61	19.94
Neck thickness (cm.)	0.89±0.02	0.81-0.95	0.002	0.004	3.48	6.69	27.14	0.03	20.46
Circumference of bulb (cm)	12.34±0.28	8.76-14.35	0.98	1.67	8.01	10.49	58.38	1.56	10.11
Volume of bulb (cc)	18.11±0.57	12.37-24.00	9.59	12.51	17.10	19.53	76.67	5.59	13.05
TSS (%)	40.69±0.58	36.50-43.17	2.40	5.38	3.80	5.70	44.58	2.13	3.59
Vitamin C (mg/100g)	10.64±0.24	9.24-11.56	0.46	0.98	6.38	9.32	46.84	0.96	9.19
Bulb weight (g)	24.39±0.51	12.50-32.13	27.55	29.88	21.52	22.42	92.19	10.38	13.21
Bulb yield (q/ha)	118.85±3.85	82.60-151.40	288.15	421.26	14.28	17.27	68.40	28.92	4.52

(Johanson et al., 1955) had pointed out that the heritability estimates along with genetic advance were more useful than heritability estimates alone in predicting the response to selection. In the present investigation, genetic advance as per cent of mean was also estimated in order to determine the relative merits of different characters that can be further utilized in the selection programme.

Relative comparison of heritability along with genetic advance as per cent of mean over the characters indicated that characters viz. weight of 10 uniform cloves and dry weight of bulb had high heritability estimates along with high genetic advance as per cent of mean. Earlier, Panse, (1961) had suggested that the genotypic variations for such characters is probably due to high additive gene effects and are least influenced by the environment. The phenotypic selection based on such a character is likely to be more effective for improvement and hence these characters offer good promise for further breeding programme using simple breeding methods. Similar results were also reported by (Singh and Chand, 2004 and Narayan et al., 2019) in garlic. Thus, high heritability along with high genetic advance as a percentage of mean was observed for other characters also like weight of 10 uniform cloves and dry weight of bulb. In this condition selection will be more effective for these characters. However, low heritability and low genetic gain was reported for vitamin C, TSS, neck thickness and number of leaves per plant, therefore, selection in these characters would not be much effective.

CONCLUSION

Based on the present results, it can be concluded that Analysis of variance revealed highly significant differences among the genotypes for all the characters showing thereby considerable amount of genetic variability for all the characters and were amenable to improvement. The estimates of phenotypic coefficient of variation (PCV) were higher than the genotypic co-efficient of variation (GCV) for all the characters. Most of the characters under study exhibited high estimates of heritability viz., plant height, and number of cloves per bulb, bulb weight, dry weight of bulb, weight of 10 uniform cloves and fresh weight of bulb. These characters would be effective in selection for garlic improvement. The number of cloves had positive and desirable association with bulb yield and selection of these traits would be effective for yield improvement in garlic.

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