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Genetic variability studies in Indian garlic (*Allium sativum* L.) accessions using agro-morphological traits

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ABSTRACT

To assess the dispersion of genetic variation among Indian garlic accessions, twenty-five genotypically diverse accessions were studied through analysis of genetic variability, mean performance, heritability and genetic gain for 17 yield contributing agro-morphological traits.The study involving 25 Indian garlic accessions was undertaken at Vegetable Farm, CSK HPKV, Palampur during 2017-2018. Based on mean performance, Kanaid Local Selection and Chambi Local Selection were the top-ranking genotypes for bulb yield per plant which significantly out yielded all the genotypes with a significant increase of 28.7 % and 12.7 %, respectively over standard check, (GHC-1). In general, the magnitude of PCV was higher than their respective GCV for all the traits studied which reflected the considerable influence of environment on the manifestation of these traits.High estimates of phenotypic and genotypic coefficients of variation were obtained for bulbils per plant, clove weight and clove equatorial diameter indicating better scope for improvement through selection.The high heritability coupled with high genetic gain for bulbils per plant, clove weight, leaf width at middle portion, clove equatorial diameter, cloves per bulb and pseudo stem diameter showed active involvement of additive gene action in the inheritance of these traits and selection for these traits will directly increase bulb yield per plant.

Key words: Genetic gain, GCV, heritability, mean performance, NHRDF, PCV.

INTRODUCTION

Garlic (*Allium sativum* L.), an asexually propogated crop and member of family Amaryllidaceae, is an important spice crop and is the second most widely cultivated *Allium* after onion throughout the world. Garlic has been considered as 'Nectar of life' in Ayurveda as it is richest source of S reducing blood lipids cholesterol, having anticancerous and antiscorbutic effects. The chief constituents of oil are diallyl disulphide, diallyl trisulphide, allyl-propyl disulphide and a small quantity of diethyl disulphide and diallyl polysulphide. Diallyl disulphide is known to possess the true garlic odour. In India, it is mainly grown as short-day plant. However, long day varieties need photoperiod of more than 13 hrs. with 20-25 °C for bulbing. Hence temperate areas like Jammu and Kashmir, Himachal Pradesh and Uttarakhand are most suitable for long day garlic cultivars (Geetika *et al.* 2017). Early sowing, longer photoperiod and higher temperature plays key role in quality garlic production (Atif *et al.* 2020).The major constraints in garlic production are lack of availability of improved varieties for commercial cultivation, processing and export. Consequently, farmers are restricted to use garlic landraces inferior in yield, prone to most of the diseases and insects. Because of lack of systematic study to improve this crop, very little information is available on genetic diversity, and contribution of characters for bulb yield. This study was, therefore, conducted with the objective of assessing the genetic diversity using morpho-agronomic traits among 25 garlic accessions.

MATERIALS AND METHODS

The study involving 25 garlic accessions collected both within and outside the state was undertaken at Vegetable Farm, CSK HPKV, Palampur during 2018 at an elevation of 1290 m above mean sea level with 32^0 6' N latitude and 76^0 3' E longitude. Agroclimatically, the location represents mid hill zone of H.P with high rainfall of 2500 mm annually, of which 80 % is received during June to September. The soil was acidic in nature with pH ranging from 5.0 to 5.6 and soil texture was silty clay loam. Mean temperature during the crop season varied from 13.5 to 25.8 ^{0}C while relative humidity varied from 52 to 84.3 %. The experiment was laid out in randomized complete block design with three replications during *Rabi* 2017-2018. Sowing was done on

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10th Oct, 2017 with spacing of 20 x 10 cm. Each experimental plot consisted of 4 rows each of 0.6 m length, accomodating 6 plants per row. The standard agronomic practices and plant protection measures were followed for raising the healthy crop of garlic as per the "Package of Practices for Vegetable Crops" by CSKHPKV, Palampur. The observations were recorded on 10 randomly selected competitive plants from each entry per plot in each replication for 14 quantitative traits namely, plant height, leaves per plant, leaf length, bulb polar diameter, bulb equatorial diameter, cloves per bulb, clove weight, clove length, clove polar diameter, clove equatorial diameter, total soluble solids, bulbils per plant and bulb yield per plant. Data were analysed using procedures of statistical software XLSTAT.

RESULTS AND DISCUSSION

Analysis of variance

The analysis of variance revealed that mean squares due to genotypes were significant (Table 1) for all the traits studied indicated thereby the presence of sufficient genetic variability among the genotypes. The results were in confirmation with the findings of Dixit *et al.* (2021) who observed sufficient genetic diversity amongst the experimental material evaluated.

Table 1: Analysis of variance for experimental design

Source of variation/ Trait	Mean squares		
	Replication	Genotype	Error
df	2	24	48
Plant height	10.0	227.7*	3.5
Leaves per plant	0	1.5*	0.5
Leaf length	8.8	126.6*	1.9
Bulb polar diameter	9.6	50.8*	2.4
Bulb equatorial diameter	15.3	130.8*	1.8
Cloves per bulb	3.9	32.3*	1.3
Clove weight	0.1	2.4*	0.05
Clove length	0.5	0.9*	0.03
Clove polar diameter	8.5	107.0*	2.0
Clove equatorial diameter	5.1	61.8*	1.5
Bulb yield per plant	11.6	101.5*	3.0
Bulb yield per plot	0.006	0.06*	0.002
TSS	0.5	26.0*	3.7
Bulbils per plant	0.3	3.8*	0.03

**Significant at 5 % level of significance*

Mean performance

Based on mean performance (Table 2), Kanaid Local Selection and Chambi Local Selection were the top-ranking genotypes for bulb yield per plant which significantly out yielded all the genotypes with a significant increase of 28.7 % and 12.7 %, respectively over standard check (GHC-1).Overall, two genotypes viz., Kanaid Local Selection (38.0 g) and Chambi Local Selection (33.3 g) for bulb yield per plant; four genotypes for TSS viz., Kasharala Local Selection (46.4 ^{0}b), Agrifound White (44.7 ^{0}b), Ner Chowk Local Selection (44.6 ^{0}b) and Yamuna Safed-9 (44.4 ^{0}b); two genotypes viz., Kanaid Local Selection (0.9 kg), and Chambi Local Selection (0.8kg) for bulb yield per plot; one genotype namely, Kanaid Local Selection (29.9 mm) for clove equatorial diameter; two genotypes viz., Kanaid Local Selection (46.7 mm) and Bijni Local Selection (37.0 mm) for clove polar diameter; three genotypes viz., Kanaid Local Selection (5.5 cm), Leda Local Selection (4.8 cm) and Jhungi Local Selection (4.2 cm) for clove length; one genotype viz., Kanaid Local Selection (5.3 g) for clove weight; seven genotypes viz., Yamuna Safed-5 (20.8), Yamuna Safed-4 (17.6), Bijni Local Selection (16.0), Chakar Local Selection (14.9), Yamuna Safed-2 (12.4), Yamuna Safed-1 (12.0) and Pungh Local Selection (12.0) for number of cloves per bulb; two genotypes viz., Kanaid Local Selection (50.8 mm) and Chambi Local Selection (45.9 mm) for bulb equatorial diameter;

one genotype viz., Kanaid Local Selection (41.0 mm) for bulb polar diameter showed high performance potential than standard check variety. Findings of Panse *et al.*(2013), Sandhu *et al.*(2015), Khar *et al.* (2015),Bhatt *et al.*,(2017), Kumar *et al.*(2017)followed close proximity with our results.

Table 2: Mean performance of garlic accessions for 14 quantitative bulb yield and related traits

Genotype	Plant height (cm)	Leaves per plant	Leaf length (cm)	Bulb polar diameter (mm)	Bulb equatorial diameter (mm)	Cloves per bulb	Clove weight (g)	Clove length (cm)	Clove polar diameter (mm)	Clove equatorial diameter (mm)	Bulb yield per plant (g)	Bulb yield per plot (kg)	TSS (^{o}b)	Bulbils per plant
Yamuna Safed-9	54.2	8.4	39.5	34.4	36.4	7.5	3.0	4.1	32.2	18.5	23.2	0.5	44.4	4.1
Yamuna Safed-4	56.9	7.1	29.5	37.4	32.6	17.6	1.0	3.3	22.0	11.2	17.7	0.4	43.0	3.1
Leda Local Sel.	55.8	8.2	33.3	33.4	39.5	10.3	2.5	4.8	27.3	13.8	22.8	0.6	37.8	0
Yamuna Safed-5	54.7	7.6	38.6	27.1	31.3	20.8	1.0	3.3	26.5	10.9	22.5	0.5	40.5	3.7
Bijni Local Sel.	58.6	9.1	32.7	36.2	39.6	16.0	1.9	3.5	37.0	11.6	30.4	0.7	41.4	0
Agrifound White	41.6	7.8	28.2	29.3	28.3	10.6	1.4	3.6	31.4	11.7	15.6	0.3	44.7	4.0
Yamuna Safed-3	56.7	7.00	28.2	28.4	34.0	11.0	1.8	3.4	23.7	12.5	20.4	0.4	41.4	3.6
Yamuna Safed-1	50.9	8.3	29.7	30.5	36.6	12.0	1.5	3.4	21.8	10.9	18.4	0.4	42.3	2.8
Agrifound Parvati-2	53.8	9.8	37.3	35.3	40.8	9.8	3.1	3.6	23.2	16.5	30.6	0.7	37.1	3.9
Agrifound Parvati	56.2	8.3	35.5	35.5	40.6	9.2	2.6	3.9	26.3	15.1	24.3	0.5	37.5	3.8
Yamuna Safed-2	37.7	7.7	18.2	25.4	26.6	12.4	1.5	3.2	20.7	9.6	18.5	0.4	42.3	3.6
Yamuna Safed-8	45.0	7.4	24.3	25.6	31.7	11.0	1.7	3.1	18.7	10.4	19.5	0.4	37.4	3.6
Ner Chowk Local Sel.	33.4	7.7	28.3	29.6	26.4	9.7	1.8	3.8	26.3	10.4	17.2	0.4	44.6	3.5
Mahadev Local Sel.	40.4	7.8	28.7	30.7	29.4	7.8	2.3	3.5	24.7	11.5	18.6	0.4	39.1	0
Kangra Local Sel.	41.2	7.3	20.2	26.6	25.0	9.3	1.7	2.9	18.4	11.9	16.3	0.3	40.4	2.9
Kanaid Local Sel.	57.8	8.9	35.1	41.0	50.8	6.5	5.3	5.5	46.7	29.9	38.0	0.9	34.0	0
Gheru Local Sel.	41.5	7.6	35.9	29.6	27.7	8.6	2.0	3.4	24.7	11.1	17.4	0.4	38.7	3.4
Chambi Local Sel.	52.0	8.3	40.2	33.6	45.9	10.8	3.1	3.8	25.3	17.1	33.3	0.8	41.6	3.8
Biara Local Sel.	42.8	8.4	27.8	30.8	37.0	8.9	2.9	3.5	28.9	18.4	26.2	0.6	41.9	3.5
Kasharala Local Sel.	43.1	7.5	24.6	30.0	27.5	11.2	1.8	3.2	26.2	19.6	20.5	0.4	46.4	3.1
Jhungi Local Sel.	50.5	8.5	38.9	32.9	40.2	11.2	2.3	4.2	31.7	15.9	25.9	0.6	37.0	3.0
Chakar Local Sel.	49.1	9.1	30.7	35.6	39.0	14.9	1.5	3.6	29.7	13.9	23.5	0.5	40.0	0.00
Pungh Local Sel.	60.0	7.8	30.6	33.5	38.9	12.0	2.1	3.4	26.6	18.8	25.4	0.6	42.9	3.3
Badraina Local Sel.	57.5	7.7	31.8	37.3	38.6	7.7	2.5	3.6	26.5	16.5	19.3	0.4	42.6	3.6
GHC-1 (Check)	71.3	9.4	46.3	37.0	40.8	9.6	3.0	3.8	30.6	19.1	29.5	0.7	39.9	0
Mean	50.5	8.1	31.8	32.3	35.4	11.0	2.2	3.7	27.1	14.7	23.1	0.5	40.8	2.6
Range	33.4-71.3	7.0-9.8	18.2-46.3	25.4-41.0	25.0-50.8	6.5-20.8	1.0-5.3	2.9-5.5	18.4-46.7	9.6-29.9	15.6-38.0	0.3-0.9	34.0-46.4	0.-4.1
SE (m) ±	1.0	0.4	0.8	0.9	0.78	0.6	0.1	0.1	0.8	0.7	1.0	0.02	1.1	0.1
CD (5%)	3.0	1.2	2.3	2.5	2.2	1.9	0.3	0.3	2.3	2.0	2.8	0.07	3.1	0.3
CV (%)	3.7	9.3	4.4	4.8	3.8	10.4	10.2	4.9	5.3	8.4	7.5	7.6	4.7	6.9

Phenotypic and genotypic coefficient of variation

In general, the magnitude of phenotypic coefficients of variation (PCV) was higher than their respective genotypic coefficients of variation (GCV), indicating considerable influence of environment on the performance of genotypes. The phenotypic coefficients of variation ranged from 8.1 % for TSS to 42.2 % for bulbils per plant while the genotypic coefficients of variation varied from 6.6 % for TSS to 41.7 % for bulbils per plant**(Table 3)**. High estimates of phenotypic and genotypic coefficients of variation were obtained for bulbils per plant, clove weight and clove equatorial diameter, indicated better scope for improvement through selection. In general, the magnitude of PCV was higher than their respective GCV for all the traits studied which reflected the considerable influence of environment on the manifestation of these traits.The results are in line with the finding of Khar *et al.,*(2015) and Bhatt *et al.,* (2017).

Heritability

The heritability estimates were high for bulbils per plant, bulb equatorial diameter, plant height, leaf length, clove polar diameter, clove weight, clove equatorial diameter, bulb yield per plant, bulb yield per plot, clove length, cloves per bulb and bulb polar diameter However, moderate heritability estimates were recorded for TSS. Low heritability estimates were observed for leaves per plant. The results were in close proximity with the findings of Dixit *et al.*, 2021 who observed low to high heritability estimates for bulb yield and yield contributing traits in garlic.

Table 3: Estimates of phenotypic, genotypic coefficients of variation, heritability and genetic gain for 14 agro-morpho quantitative traits

Trait	Mean ± SE (m)	Range	PCV (%)	GCV (%)	Heritability (h^2bs)	Genetic gain
Plant height	50.5 ± 1.0	33.4-71.3	17.5	17.1	95.5	34.4
Leaves per plant	8.1 ± 0.4	7.0-9.8	11.6	7.0	36.4	8.7
Leaf length	31.8 ± 0.8	18.2-46.3	20.7	20.2	95.4	40.8
Bulb polar diameter	32.3 ± 0.9	25.4-41.0	13.3	12.4	86.9	23.8
Bulb equatorial diameter	35.4 ± 0.7	25.0-50.8	18.8	18.4	95.8	37.3
Cloves per bulb	11.0 ± 0.6	6.5-20.8	30.8	28.9	88.4	56.1
Clove weight	2.2 ± 0.1	1.0-5.3	41.0	39.7	93.8	79.2
Clove length	3.70± 0.1	2.9-5.5	15.3	14.5	89.4	28.2
Clove polar diameter	27.1 ± 0.8	18.4-46.7	22.4	21.8	94.4	43.6
Clove equatorial diameter	14.7 ± 0.7	9.6-29.9	31.6	30.4	92.8	60.5
Bulb yield per plant	23.1 ± 1.0	15.6-38.0	25.8	24.7	91.4	48.7
Bulb yield per plot	0.5 ± 0.02	0.3-0.9	25.9	24.7	91.2	48.6
TSS	40.8 ± 1.1	34.0-46.4	8.1	6.6	66.4	11.2
Bulbils per plant	2.69 ± 0.11	0.00-4.18	42.2	41.7	97.6	84.3

Genetic gain

The highest estimates of genetic advance as percentage of mean were recorded for bulbils per plant, clove weight, clove equatorial diameter and cloves per bulb, while bulb yield per plant, bulb yield per plot, clove polar diameter, leaf length, bulb equatorial diameter, plant height and clove length exhibited moderate values for genetic advance. However, the traits like bulb polar diameter, TSS and leaves per plant had the lowest estimates of genetic advance as percentage of mean (genetic gain).The high heritability coupled high genetic advance as percentage of mean was observed for bulbils per plant, clove weight, clove equatorial diameter and cloves per bulb. This indicated the presence of additive gene effects in the inheritance of these traits. High heritability with moderate genetic advance was observed for bulb yield per plant, bulb yield per plot, clove polar diameter, leaf length, bulb equatorial diameter, plant height and clove length. High heritability coupled with low genetic gain was observed for bulb polar diameter. However, TSS displayed moderate heritability estimates with low genetic gain. Low heritability coupled with low genetic gain was observed for leaves per plant indicated non-additive gene action and lateral selection in such a situation would be more effective in its improvement. The results of present investigation indicated presence of additive gene action in the inheritance of most of the traits studied, offering ample scope for improvement of these traits through selection. The results of the present study are in accordance with the findings of Pervin *et al.,*(2014) and Sandhu *et al.,*(2015) who observed high heritability estimates coupled with low to high genetic gain for bulb yield and yield related traits in garlic.

Garlic accessions namely Kanaid Local Selection, Chambi Local Selection, GHC-1, Yamuna Safed-9, Yamuna Safed-5 and Kasharala Local Selection were found promising for maximum number of bulb yield and related traits studied. On the other side, standard check variety GHC-1 was the only variety which was found promising for plant height, leaves per plant, leaf length and number of bulbils per plant. So, selection of these genotypes with high heritability and genetic gain is going to shorten the breeding cycle for planning future garlic

improvement program due to additive gene action. But care must be taken for traits with non-additive/epistatic gene action as delayed lateral selection must be done in such traits.

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