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Variability and Correlation Studies in Garlic (*Allium sativum* L.) Germplasm Collected from Different Parts of Jammu

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Present investigations were carried out at Experimental Area-I, Division of Vegetable Science and Floriculture, SKUAST-Jammu, Chatha during *rabi* season of 2012-13. The analysis of variance revealed significant difference among the genotypes for all the traits studied except for number of leaves/plant, leaf length, dry matter content, total soluble solids and equatorial diameter indicating greater variability in the germplasm. In general, estimates of phenotypic coefficient of variance (PCV) were found higher in magnitude than corresponding genotypic coefficient of variance (GCV). PCV and GCV were high for pseudo stem diameter, plant height, average weight of cloves, average bulb weight, yield/ha and leaf length. High estimates of heritability were obtained for plant height, average weight of cloves, average bulb weight, number of leaves, equatorial diameter, leaf length and low for total soluble solids and dry matter content. High heritability coupled with high genetic advance as percent of mean was observed for plant height, average weight of cloves, average weight of bulb and yield/ha, suggesting additive gene action that can be improved through direct selection. Average bulb weight (g) showed positive and significant correlation with number of leaves/plant, leaf length (cm), average weight of cloves (g), equatorial diameter (cm), while it was negative and significantly correlated with total soluble solids (^{o}B) hence indicating genetic improvement of bulb yield in garlic by putting positive selection pressure on various characters like number of leaves/plant, leaf length, average weight of cloves and equatorial diameter of bulbs.

Key Words: *Allium sativum*, Correlation, Genetic gain, Genetic advance, Variability

Introduction

Common garlic (*Allium sativum* L.), a diploid species (2n=2x=16) is cultivated extensively throughout subtropical plains to intermediate higher reaches of Jammu, covering an area of 530 ha with a production of 7,070 MT and productivity of 13.33 MT/ha (Anonymous, 2014). Districts of Jammu region showing preponderance of garlic cultivation are Jammu, Rajouri and its adjoining areas like Nowshera, Jaba-Anjana, Dudasanwala and Mandi etc. Poonch district including Manjakot, Surankot, Mandi, Loran, Mendhar *etc*. Kathua and parts of Bani, Basoli. Udhampur (Basht, Chenani) and Doda (Baderwah).

Garlic displays considerable variability with respect to morphological features, yield, quality features as well as resistance to important insect pests and diseases. It also shows adaptation to wide range of soil types, temperatures, day length etc making its farming possible from tropics to temperate latitudes. It also showed greater climatic adaptability, some being heat tolerant and others being frost hardy (Maab and Klass, 1995). Given that the germplasm of *A. sativum* is highly variable for morpho-physiological traits (Avento *et al*.,1998; Maab and Klass, 1995), clones could be identified on the basis of canopy structure and yield related traits (Zepeda, 1997). It was, therefore, considered important to study genetic variation and estimates of the degree of heritability of traits of interest for vegetative growth, yield and quality related traits among populations of cultivated garlic under Jammu agro-climatic conditions so that potential and good performing germplasm can be identified and further utilized in *Allium* breeding programme.

Materials and Methods

A collection of garlic genotypes comprising of 14 hexaploids (*A. ampeloprasum* L.), ploidy level 2n=2x=32

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and 27 diploids (*A. sativum* L.), ploidy level 2n=2x=16, from different zones of Jammu division including four released varieties from NHRDF, Karnal, Haryana, were collected and evaluated against two checks *i.e.,* Agrifound Parvati (G-313) and Yamuna Safed (G-50) for 10 morphological, yield and quality traits (Table 1). All the genotypes were planted on October 24, 2012 in Randomized Block Design for evaluation with three replications in a plot size of 2.25 m x 2.0 m with spacing of 15 cm × 10 cm. All the recommended cultural practices were followed during the entire growth period of crop to raise a healthy crop. The Experimental Area-I is located in the subtropical zone of Jammu and Kashmir at 32°40′ North latitude and 74°58′ East longitude having an elevation of 332 m above msl. Its climate is subtropical with hot dry summer, warm humid rainy season and cold winters. The maximum temperature goes up to 47°C during summer (May to June) and minimum temperature falls below 10°C during winter (December-January). The mean annual rainfall during 2012 was 27.2 mm whereas it was 13.2 mm during 2013 (Source: *Agro meteorological Section, Division of Agronomy, SKUAST-Jammu*). The soil of the experimental area was near neutral in reaction (pH 6.3) with medium in nitrogen and phosphorus concentration but low in potassium level. All the observations were recorded as per standard procedures from five randomly selected plants of each genotype in all the three replications and their mean were worked out for statistical analysis as per Panse and Sukhatme (1967). Plant height was measured from base of the plant to the upper leaf at 80 days after sowing. Leaf length of the 4th leaf was measured from leaf axil up to its tip and leaf width was measured from the middle of the 4th leaf with the help of graduated scale whereas pseudo-stem length was measured from the soil level to inner leaf lamina notch of the plants and diameter was recorded below leaf level of the plant with the help of vernier caliper. The phenotypic and genotypic coefficient of variance were calculated according to formulae given by Burton and De-Vane (1953). Heritability (broad sense) and genetic advance was calculated as suggested by Allard (1960) and genetic gain expressed as per cent of population mean, was calculated by the method given by Johnson *et al*. (1955).

Results and Discussion

Forty one collections of garlic were assessed to know the magnitude of genetic variability and heritability of important economic characters. Considerable amount of variability was observed in all the genotypes of garlic as is evident from analysis of variance which showed significant differences among various traits like plant height, leaf length, pseudostem length, average weight of 10 cloves, equatorial diameter, average weight of bulb, yield /ha except total soluble solids, dry matter weight and number of leaves (Table 2).The results therefore clearly indicate that substantial amount of variability exists in the above mentioned traits and thus can be initialized for improvement of quantitative attributes of the crop under study. Similar results are observed by Mohanty (2001), Monpara *et al*. (2005), Gupta *et al*. (2007), Haydar *et al*. (2007), Hosamani *et al*. (2010) and Singh *et al*. (2012a).

The garlic (*A. sativum)* is being currently considered a species complex and it shows immense variability (Kamenetsky, 2007). Although belonging to a same group, the collections showed clear distinguishable features in many respects: leaf shape, colour and orientation, bulb shape and colour, days to harvest *etc*. Nine genotypes were broad leaved (leaf width >1.5cm) and spreading in orientation, 7 were narrow leaved (leaf width <1.5 cm) and erect including check Yamuna Safed (G-50), 13 were broad leaved and erect in orientation including check Agrifound Parvati (G-313), whereas 10 genotypes were broad leaved showing prostate orientation (Table 2). On the basis of clove colour, broadly two categories: white and pink white emerged among the collections. 20 genotypes showed whitish cloves where as 21 genotypes including both the checks showed pink-white cloves of the bulbs. On bulb shape basis, 30 genotypes showed ovate bulbs whereas 11 genotypes showed broadly ovate shape of the bulbs. Regarding foliage colour, four categories emerged, out of which, 6 genotypes showed green colour foliage, 11 genotypes showed dull green foliage, 14 genotypes showed light green and 10 genotypes were having bright dark green foliage. G-408 had dull dark green foliage colour. On the basis of crop duration, the genotypes were harvested in two lots *i.e.,* one at 190 days after sowing and second at 205 days after sowing, thereby showing a difference of 15 days with a mean value of (193.20 days). Eight genotypes including check Yamuna Safed (G-50) namely SJG-11-07, SJG-11-12, SJG-11-17, SJG-11-19, SJG-11-26, SJG-11-28, G-408 and Yamuna Safed (G-282) were harvested 15 days late *i.e.,*at 205 days after sowing as compared to rest of the genotypes which were harvested at 190 days after sowing. Variability with respect to the ability of formation of aerial bulbils (propagating

Table 1. List of garlic genotypes and their source of collection

S. No.	Genotype	Source	Ploidy level (2n)=16,32	S. No.	Genotype	Source	Ploidy level (2n)=16,32
1	SJG-11-01	Kanachak (Jammu, J&K)	Diploid	22	SJG-11-22	Surankote (Poonch, J&K)	Hexaploid
2	SJG-11-02	Kanachak (Jammu, J&K)	Diploid	23	SJG-11-23	Panjgran (Rajouri, J&K)	Hexaploid
3	SJG-11-03	Bhaderwah(Doda,J&K)	Diploid	24	SJG-11-24	Jaba-Anjana (Rajouri, J&K)	Diploid
4	SJG-11-04	Kathua, J&K	Diploid	25	SJG-11-25	Thanamandi (Rajouri, J&K)	Hexaploid
5	SJG-11-05	Kathua, J&K	Diploid	26	SJG-11-26	Lower Loren (Poonch, J&K)	Diploid
6	SJG-11-06	Chandak (Poonch, J&K)	Diploid	27	SJG-11-27	Surankote (Poonch, J&K)	Diploid
7	SJG-11-07	Rajouri, J&K	Hexaploid	28	SJG-11-28	Dudasanwala (Poonch, J&K)	Diploid
8	SJG-11-08	Nowshera (Rajouri, J&K)	Diploid	29	SJG-11-29	Rajouri, J&K	Diploid
9	SJG-11-09	Poonch, J&K	Hexaploid	30	SJG-11-30	Surankote (Poonch,J&K)	Hexaploid
10	SJG-11-10	Khaneter (Poonch, J&K)	Hexaploid	31	SJG-11-31	Dandidhar (Poonch,J&K)	Diploid
11	SJG-11-11	Surankote (Poonch, J&K)	Hexaploid	32	SJG-12-01	Karla Selection-1 (Udhampur, J&K)	Hexaploid
12	SJG-11-12	Surankote (Poonch, J&K)	Diploid	33	SJG-12-02	Karla Selection-2 (Udhampur, J&K)	Diploid
13	SJG-11-13	Poonch, J&K	Hexaploid	34	SJG-12-03	Marh, Jammu, J&K	Diploid
14	SJG-11-14	Poonch, J&K	Diploid	35	SJG-12-04	Marh, Jammu, J&K	Diploid
15	SJG-11-15	Manjakot (Rajouri, J&K)	Hexaploid	36	G-408	NHRDF, Karnal, Haryana	Diploid
16	SJG-11-16	Rajouri, J&K	Hexaploid	37	Yamuna Safed (G-282)	NHRDF, Karnal, Haryana	Diploid
17	SJG-11-17	Chandak (Poonch, J&K)	Diploid	38	Yamuna Safed (G-323)	NHRDF, Karnal, Haryana	Diploid
18	SJG-11-18	Mandi (Poonch, J&K)	Hexaploid	39	Yamuna Safed (G-1)	NHRDF, Karnal, Haryana	Diploid
19	SJG-11-19	Rajouri, J&K	Hexaploid	40	Yamuna Safed (G-50)*	NHRDF, Karnal, Haryana	Diploid
20	SJG-11-20	Upper Loren (Poonch, J&K)	Hexaploid	41	Agrifound Parvati(G-313)*	NHRDF, Karnal, Haryana	Diploid
21	SJG-11-21	Rajouri, J&K	Diploid				

*=check

Table 2. Mean performance of various morphological, yield and quality characters in garlic genotypes

S. No.	Genotype(s)	Average weight of 10 cloves (g)	Average weight of bulbs (g)	Bulbil formation	Bulb shape	Clove Colour	Days to harvest	Dry matter content (%)	Equatorial diameter (cm)	Foliage colour	Leaf length (cm)	Leaf type	Number of leaves/ plant	Plant height (cm)	Pseudostem length (cm)	Total soluble solids (°B)	Yield/ ha (q)
1	SJG - 11 – 01	13.26	26.23	Present	Ovate	White	190	44.6	3.63	Bright dark green	25.73	Spreading &Broad	7.60	37.50	2.40	24.50	71.73
2	SJG - 11 – 02	9.33	28.13	Present	Broadly-ovate	Pink-white	190	39.0	3.46	Bright dark green	27.20	Spreading &Broad	9.70	38.73	4.00	23.86	77.20
3	SJG - 11 – 03	15.56	27.00	Absent	Ovate	White	190	37.6	3.40	Green	37.00	Erect & Narrow	6.90	50.53	3.56	23.76	73.56
4	SJG - 11 – 04	16.16	30.30	Absent	Ovate	White	190	38.3	3.36	Green	32.50	Erect & Broad	7.60	39.30	3.30	24.26	83.86
5	SJG - 11 – 05	19.70	28.30	Absent	Ovate	Pink-white	190	39.0	4.03	Dull green	34.90	Prostate & Broad	10.00	47.03	2.70	25.40	88.00
6	SJG - 11 – 06	9.80	18.73	Absent	Broadly-ovate	White	190	28.6	2.46	Dull green	29.36	Prostate & Broad	6.80	45.36	3.33	23.93	58.20
7	SJG - 11 – 07	22.83	25.60	Absent	Ovate	White	205	39.6	3.80	Bright dark green	30.00	Prostate & Broad	8.10	46.43	4.56	24.76	79.60
8	SJG - 11 – 08	20.96	29.13	Absent	Ovate	White	190	28.0	3.70	Bright dark green	28.86	Prostate & Broad	5.80	39.33	2.93	22.80	90.63
9	SJG - 11 – 09	19.40	30.90	Absent	Ovate	White	190	38.6	3.50	Dull green	25.13	Erect & Broad	8.30	34.03	2.66	23.90	90.80
10	SJG - 11 – 10	23.50	43.40	Absent	Ovate	White	190	41.0	4.16	Light green	29.50	Erect & Broad	7.90	36.80	2.50	24.10	134.96
11	SJG - 11 – 11	15.96	21.63	Absent	Ovate	White	190	40.3	3.66	Dull green	28.26	Erect & Broad	8.40	33.16	2.13	24.80	68.23
12	SJG - 11 – 12	17.63	27.30	Absent	Ovate	White	205	36.0	3.63	Light green	25.93	Prostate & Broad	8.20	35.50	3.16	23.60	84.86
13	SJG - 11 – 13	13.13	22.83	Absent	Broadly-ovate	White	190	42.6	3.30	Bright dark green	32.73	Prostate & Broad	7.70	47.60	2.53	23.96	60.66
14	SJG - 11 – 14	16.66	16.30	Absent	Broadly-ovate	Pink-white	190	26.0	2.30	Light green	31.20	Erect & Broad	7.86	38.60	3.70	26.10	50.63
15	SJG - 11 – 15	17.50	17.16	Absent	Ovate	White	190	51.0	3.70	Light green	35.80	Erect & Broad	7.76	52.10	3.20	25.10	53.33
16	SJG - 11 – 16	7.80	8.56	Absent	Ovate	White	190	43.3	2.76	Light green	30.20	Erect & Broad	6.10	39.70	4.00	24.40	37.10
17	SJG - 11 – 17	8.00	9.30	Absent	Ovate	Pink-white	205	36.6	2.23	Bright dark green	15.40	Prostate & Broad	5.50	22.00	1.86	24.16	36.23
18	SJG - 11 – 18	9.90	17.96	Present	Ovate	Pink-white	190	27.0	2.86	Light green	31.80	Prostate & Broad	8.40	38.30	2.10	22.80	55.86
19	SJG - 11 – 19	9.33	26.83	Absent	Broadly-ovate	Pink-white	205	39.3	2.70	Bright dark green	22.83	Erect & Narrow	5.30	33.40	2.53	24.66	83.50
20	SJG - 11 – 20	30.56	38.40	Present	Ovate	White	190	34.3	4.33	Dull green	21.30	Spreading &Broad	5.50	31.50	4.50	23.53	119.53
21	SJG - 11 – 21	17.96	21.76	Absent	Ovate	Pink-white	190	23.6	2.23	Light green	19.23	Erect & Broad	4.80	27.13	3.00	26.40	57.26
22	SJG - 11 – 22	17.20	20.13	Present	Ovate	White	190	42.3	3.90	Light green	22.86	Erect & Broad	8.10	32.06	3.46	24.56	62.70
23	SJG - 11 – 23	8.26	28.73	Present	Ovate	White	190	35.3	2.73	Light green	21.56	Erect & Narrow	5.70	28.50	3.66	23.60	79.00
24	SJG - 11 – 24	12.66	28.20	Absent	Broadly-ovate	White	190	42.3	3.40	Dull green	29.66	Spreading &Broad	7.03	40.13	4.80	23.20	77.30
25	SJG - 11 – 25	9.30	25.66	Absent	Ovate	Pink-white	190	35.6	3.66	Light green	22.80	Erect & Broad	6.50	34.96	4.16	23.60	79.86
26	SJG - 11 – 26	22.76	40.86	Present	Ovate	Pink-white	205	43.0	4.40	Light green	22.66	Erect & Narrow	5.90	32.20	3.50	24.30	127.00
27	SJG - 11 – 27	7.26	32.86	Absent	Broadly-ovate	Pink-white	190	35.0	2.60	Light green	25.86	Erect & Broad	6.56	38.26	3.43	23.23	102.33

Table 2 Contd.

S. No.	Genotype(s)	Average weight of 10 cloves (g)	Average weight of bulbs (g)	Bulbil formation	Bulb shape	Clove Colour	Days to harvest	Dry matter content (%)	Equatorial diameter (cm)	Foliage colour	Leaf length (cm)	Leaf type	Number of leaves/ plant	Plant height (cm)	Pseudostem length (cm)	Total soluble solids (°B)	Yield/ ha (q)
28	SJG - 11 – 28	10.13	30.76	Absent	Ovate	Pink-white	205	39.0	2.86	Light green	21.60	Erect & Broad	8.20	25.83	2.73	23.90	95.63
29	SJG - 11 – 29	20.40	15.20	Absent	Broadly-ovate	Pink-white	190	37.3	3.56	Light green	21.66	Erect & Narrow	6.60	30.47	3.46	24.56	47.36
30	SJG - 11 – 30	18.10	34.00	Absent	Ovate	White	190	43.0	4.10	Dark green	22.03	Erect & Narrow	6.30	30.76	3.33	24.33	116.60
31	SJG - 11 – 31	14.60	20.20	Absent	Ovate	White	190	37.0	2.66	Green	25.53	Erect & Broad	7.60	33.10	3.16	23.00	73.30
32	SJG - 12 – 01	17.30	18.63	Present	Ovate	Pink-white	190	43.0	3.80	Green	25.60	Spreading &Broad	6.70	38.26	2.26	22.23	128.90
33	SJG - 12 – 02	13.53	15.20	Present	Broadly-ovate	Pink-white	190	41.6	2.83	Dull green	24.73	Erect & Narrow	5.80	36.73	3.40	24.20	49.33
34	SJG - 12 – 03	24.96	21.23	Absent	Ovate	Pink-white	190	37.0	2.66	Dull green	29.90	Spreading &Broad	7.90	40.63	2.43	27.70	100.83
35	SJG - 12 – 04	31.16	39.56	Present	Ovate	Pink-white	190	34.3	4.13	Green	32.50	Erect & Broad	9.30	41.60	2.70	29.86	88.53
36	Yamuna Safed (G-1)	21.26	38.06	Present	Broadly-ovate	Pink-white	205	37.0	4.20	Dull green	34.50	Erect & Narrow	6.53	49.76	1.76	23.73	59.16
37	Yamuna Safed (G-282)	22.90	29.10	Absent	Ovate	Pink-white	190	45.0	3.93	Bright dark green	35.66	Spreading &Broad	8.00	48.16	1.83	23.70	58.00
38	Yamuna Safed (G-323)	20.86	28.50	Absent	Ovate	Pink-white	205	44.0	3.83	Dull green	31.30	Erect & Broad	7.50	38.73	3.06	25.20	47.30
39	G – 408	21.10	25.96	Absent	Ovate	White	190	41.0	3.60	Dull dark green	25.30	Prostate & Broad	5.90	31.10	3.10	24.33	123.06
40	Yamuna Safed (G-50) (check)	6.46	19.50	Absent	Broadly-ovate	Pink-white	190	48.6	2.83	Bright dark green	28.00	Prostate & Broad	6.10	45.66	4.70	24.90	70.73
41	Agri found Parvati (G-313) (check)	30.46	15.56	Present	Ovate	Pink-white	205	44.0	2.73	Green	20.93	Erect & Broad	6.16	26.60	3.36	24.10	78.46
	Mean	16.72	25.45	–	–	–	193.20	38.5	3.35	–	27.30	–	7.13	37.50	3.14	24.36	78.56
	S.E. ±	2.48	2.59	–	–	–	–	8.5	0.40	–	3.10	–	1.07	2.59	0.61	1.41	11.76
	C.D.(5%)	6.99	7.30	–	–	–	–	23.8	1.12	–	8.74	–	N.S	7.31	1.73	N.S	33.52
	C.V.	25.73	17.66	–	–	–	–	38.32	20.63	–	19.71	–	26.07	11.99	33.87	10.03	26.25

material) is concerned, 12 genotypes including check Agrifound Parvati (G-313) and Yamuna Safed (G-50) showed the ability to produce aerial bulbils (Table 2).

An insight into the magnitude of variability present in a crop species is of utmost importance as it provides basis for effective selection. More the variability in germplasm, more is the chance for selecting desirable genotypes (Vavilov,1951). According to Fisher (1918), most of the economic traits are quantitative in nature, exhibit continuous variation under the control of both heritable and non-heritable factors and effective selection would therefore depend upon the relative heritable portion. In the present investigation, PCV was observed to be higher than the corresponding GCV for all the characters studied (Table 3). High estimates of PCV were observed for average weight of cloves (44.35%), average weight of bulbs (35.19%), yield /ha (38.81%), dry matter content (34.75%), plant height (21.62%) and leaf length (24.64%). However, the differences were narrow which implied their relative resistance to environmental variations. It also described that genetic factors were predominantly responsible for expression of these attributes and selection could be made effective on the basis of phenotypic performance. The traits which showed high phenotypic and genotypic coefficient of variation are of economic importance and there is scope for improvement of these traits through selection. The findings of Yadav *et al.* (2012), Golani *et al.* (2006) and Gashua *et al.* (2013) are similar to that of present findings.

Heritability in broad sense ranged from (4.00% to 74.80%)**.** High estimates of heritability in broad sense (Table 3) were recorded for characters like plant height (69.23%), average weight of cloves (66.3%), yield/ hectare (54.00%), leaf length (36.04%), equatorial diameter (32.20%) and average weight of bulbs (74.8%) indicating that selection for such characters be fairly easy because traits would be least influenced by environmental modifications and selections based on phenotypic performance would be reliable. Similar results were obtained by Gupta *et al.* (2007), Haydar *et al*. (2007), Singh *et al*. (2012b) and Yadav *et al.* (2012). Low heritability was obtained for characters like Stemphylium blight intensity and total soluble solids.The findings of Yadav *et al.* (2012), Agrawal *et al.* (2003), Gashua *et al.* (2013) and Degewione *et al.*(2011) are in line with the present findings.

Genetic advance is the improvement over the base population that can potentially be made from selection for a characteristic. It is the function of the heritability of the traits, the amount of phenotypic variation and the selection differential(s) that the breeder uses. The estimates of heritability and genetic advance should always be considered simultaneously as high heritability is not always associated with high genetic gain (Johnson *et al*., 1955). Burton (1952) suggested that GCV along with heritability give the best picture of the genetic advance to be expected from selection. The estimates of genetic advance as percent of mean ranged from 0.81% to 60.60 % for total soluble solids and average weight of 10 cloves, respectively (Table 3). This indicates that selection from top 5% of the base population could result in an advantage of 0.81 to 60.60% over base population mean. High genetic advance coupled with high heritability was obtained for average weight of cloves, average weight of bulb, plant height and yield/ha. Hence due to additive gene action selection for these characters is likely to be more effective (Panse *et al.,* 2013). The present study is supported by Agrawal *et al.* (2003), Trivedi *et al*. (2006), Dhotre *et al.* (2010), Singh *et al.* (2012b) and Yadav *et al.* (2012). The characters like number of leaves/plant, leaf length, pseudo stem length, dry matter content, total soluble solids and equatorial diameter had

Table 3. Estimates of various genetic parameters for various characters in garlic genotypes

Character	Mean±S.E.	Range	PCV (%)	GCV (%)	h^2 (%) Broad sense	GA (%)	GA (% of mean)
Average weight of bulb (g)	25.45 ± 2.59	8.56 – 43.40	35.19	30.44	74.80	13.80	54.23
Average weight of 10 cloves (g)	16.72 ± 2.48	6.46 – 31.16	44.35	36.12	66.30	10.13	60.60
Dry matter content (%)	3.85 ± 0.85	2.36 – 5.10	34.75	16.15	21.60	0.59	15.46
Equatorial diameter (cm)	3.35± 0.40	2.23 – 4.40	25.06	14.22	32.20	0.55	16.62
Leaf length (cm)	27.30 ± 3.10	15.4 – 37.0	24.64	14.79	36.04	4.99	18.29
Number of leaves/plant	7.13 ± 1.07	4.80 – 10.00	27.38	8.37	9.30	0.37	5.27
Pseudostem length (cm)	3.14 ± 0.61	1.76 – 4.80	37.06	15.05	16.59	0.39	12.59
Plant height (cm)	37.50 ± 2.59	22.00 – 52.10	21.62	17.99	69.23	11.56	30.83
Total soluble solids (°B)	24.36 ± 1.41	22.23 – 29.86	9.84	1.97	4.00	0.19	0.81
Yield/ha (q)	78.56 ± 11.76	36.23–134.90	38.81	28.59	54.00	34.08	43.37

low heritability coupled with high to low genetic gain and GCV depicting that these characters were governed by non-additive genes and would not be effective as it did not corroborate with the conclusion of Burton (1952) and Johnson *et al*.(1955). Similar findings were reported by Tsega *et al.* (2011) and Singh *et al.* (2010).

The phenotypic and genotypic correlation studies revealed that average weight of bulb in garlic showed significant and positive association with number of leaves/plant, leaf length and equatorial diameter at both phenotypic and genotypic levels (Table 4). These results are in conformity with the results of Agarwal and Tiwari (2009), Dhotre *et al.* (2010), Panse *et al.* (2013) and Trivedi *et al.* (2006). Negative and significant correlation with average weight of bulb was shown by total soluble solids at genotypic levels and these results are in agreement with Trivedi *et al.* (2006) and Agarwal and Tiwari (2009). Significant and positive correlation of plant height was observed with number of leaves, leaf length and equatorial diameter at both genotypic and phenotypic levels and results are supported by Figliuolo *et al.* (2001) and Panse *et al.* (2013).Significantly positive correlation of number of leaves/plant with equatorial diameter and average weight of cloves was observed at genotypic level and with leaf length at phenotypic level. The present finding was supported from the work of Panse *et al.* (2013) and Naruka and Dhaka (2004). Similarly, significant but negative correlation of number of leaves/plant was observed with pseudostem length, total soluble solids and dry matter weight at genotypic levels. The findings of Marey *et al.* (2012) and Hosamani *et al.* (2010) are in line with the present results. Leaf length showed positive and significant correlation with equatorial diameter and negative but significant correlation with total soluble solids at genotypic levels. The results are in accordance with the results reported earlier by Singh *et al.* (2006). Pseudostem length was significantly and positively correlated with total soluble solids but negatively with average weight of cloves. Average weight of cloves/bulb showed positive and significant correlation with equatorial diameter, whereas negative and significantly correlated with dry matter content and total soluble solids. Significant positive correlation was observed of equatorial diameter with total soluble solids but significant negative correlation with dry matter content. On the other hand, dry matter showed positive significant correlation with total soluble solids. The findings are in line with Morsey *et al.* (2011), Singh *et al.* (2006) and Singh *et al*.(2012a).

The present investigations indicated that there is a good scope for garlic improvement through selection of suitable genotypes for desirable traits in this region of Jammu and Kashmir state. Also, as the present study was conducted on single location using limited number of local accessions, the results need further confirmation across locations with more cultivars/genotypes including exotic accessions.

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Table 4. Estimates of genotypic (G) and phenotypic (P) correlation coefficients among various characters in garlic genotypes

Character		Average weight of 10 cloves (g)	Dry matter content (%)	Equatorial diameter (cm)	Leaf length (cm)	Number of leaves/ plant	Plant height (cm)	Pseudostem length(cm)	Total soluble solids (°B)
Average weight	(G)	–							
of 10 cloves (g)	(P)	–							
Dry matter	(G)	-0.178*	–						
content (%)	(P)	-0.030	–						
Equatorial	(G)	0.748**	–0.528**	–					
diameter (cm)	(P)	0.389**	0.073	–					
Leaf length (cm)	(G)	0.173	–0.048	0.480**	–				
	(P)	0.093	0.035	0.127	–				
Number of	(G)	0.405**	–0.276**	0.690**	0.150	–			
leaves/ plant	(P)	0.016	–0.038	0.170	0.337**	–			
Plant height (cm)	(G)	0.045	–0.172	0.356**	0.222*	0.859**	–		
	(P)	0.018	0.002	0.181*	0.618**	0.202*	–		
Pseudostem	(G)	–0.252**	–0.146	–0.171	–0.190*	–0.599**	0.046	–	
length (cm)	(P)	–0.045	0.000	0.031	–0.091	–0.085	0.002	–	
Total soluble	(G)	–0.282**	–0.334**	0.187*	–0.299**	–0.269**	–0.060	0.842**	–
solids (°B)	(P)	0.221*	0.005	0.010	0.079	0.073	0.048	0.016	–
Average weight	(G)	0.478**	0.103	0.898**	0.211*	0.256**	0.114	–0.026	–0.220*
of bulb (g)	(P)	–0.278**	0.074	0.409**	0.054	0.128	0.049	–0.041	–0.004

*, ** Significant at 5 % and 1% level respectively

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