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# Genetic variability in the garlic (*Allium sativum*) genotypes for growth, yield and yield attributing traits

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## ABSTRACT

*A field investigation was carried out at Agriculture Research Station, Mandor, Agriculture University, Jodhpur, Rajasthan, India during rabi season of 2015-16. The study comprised 13 garlic genotypes evaluated to assess the mean performance and to determine variability and correlation among growth, yield and yield attributing traits. Results revealed that the mean squares due to genotypes were highly significant for all the traits. Genotypes Yamuna Safed-9 recorded maximum plant height in (58.2 cm), leaves/plant (9.8), neck thickness (10.3 mm), bulb diameter (4.6 cm), cloves/bulb (25.3), average bulb weight (23.0 g) and bulb yield (9.46 t ha$^{-1}$) among the genotypes evaluated; whereas, Yamuna Safed-2 noted the highest TSS (43.9%) and dry matter of bulb (40.7%). While lowest bulb yield (6.09 t ha$^{-1}$) was observed in Kota Local which also recorded lowest plant height, leaves/plant, days to maturity, bulb diameter, cloves/bulb. The higher magnitude of phenotypic coefficient of variations (PCV) than genotypic coefficient of variations (GCV) for all the traits indicates environmental factor influencing their expression and high magnitude of PCV and GCV for all the characters under study indicates scope for improvement of these traits through selection. High values of heritability combined with medium genotypic coefficient of variation and high genetic advance as percent of mean were observed for cloves/bulbs and bulb diameter suggesting additive gene action and scope for improvement of the genotypes through selection for these traits. Maximum significant positive correlation of bulb yield with bulb diameter (r=0.925**) and cloves/bulb (r=0.908**) indicated that improvement of these traits may directly contributes the bulb yield.*

**Key words:** Phenotypic coefficient of variation, genotypic coefficient of variation, heritability, genetic advance, garlic

## INTRODUCTION

Garlic (*Allium sativum* L.) is considered as one of the most important species in the family Alliaceae and as an important bulb crop next to onion. The cloves of garlic bulb are used in flavoring of various vegetarian and non-vegetarian dishes. The significance of this spice is increasing owing to its wide range of medicinal properties (Chanchan *et al.,* 2014). India, besides being a major garlic exporting countries of the world ranks second after China in area (247.52 thousand ha) and production (1259.27 thousand tonnes) of garlic with an average productivity of 5.09 tonnes/ha. In Rajasthan, garlic is grown extensively in the districts of Chittorgarh, Baran, Jodhpur, Jhunjhunu, Jhalawar, Udaipur, Kota, Dungarpur, Bundi, Jaipur and Sikar with an area of 59.45 thousand ha with an annual production of 235.98 thousand tones and 3.97 tonnes/ha productivity in Rajasthan (Gupta, 2014).The constraints of garlic production are lack of availability of improved varieties for local consumption, export and processing. Since, production and productivity does not depend only on area and cultural practices but also on the genotypes of the crop and environmental conditions (Lawande *et al.,* 2009). Garlic is generally not fertile and thus propagated by cloves. A wide range of adaptability to soil types, temperatures and day length, makes its farming possible from tropics to temperate region. Clones of garlic are variable for morphophysiologic traits (Avato *et. al*., 1998), genotypes may also differ in pungency, length of storage, colour, size, number of cloves per bulb, hardiness, and suitability for cooking. Despite the importance of crop, so far very limited breeding work has been done on garlic. The basic pre-requisite for yield improvement is the presence of genetic variability in genetic stock and knowledge of inheritance and inter-relationship of the yield components, along with their relative influence on each other (Sharma and Saini**,** 2010). Information on the variability and correlation between agronomic characters of different genotypes with yield are important for supporting breeding program of the plant

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(Hakim, 2008). In addition, knowledge of the nature of association of bulb yield with yield contributing characters is necessary for yield improvement through selection of better varieties (Haydar *et al.,* 2007). Hence, to boost the economy of garlic growing farmers in western Rajasthan, the present investigation was carried out with the objectives to assess the mean performance and to determine variability and correlation among growth, yield and yield attributing traits.

## MATERIALS AND METHODS

Field evaluation of 13 cultivars obtained from different parts of India (Table 1) was carried out at the experimental farm of Agriculture Research Station, Mandor, Jodhpur, Rajasthan during the *rabi* season of 2015-16. The different cultivars were grown in randomized block design with three replications. The crop was planted in the second week of October at a spacing of 15 × 10 cm. Fertilizer 100:50:100 kg NPK $ha^{-1}$ in the form of urea, diammonium phosphate and muriate of potash, respectively was applied. Total P and K and half of the N was applied before planting and remaining amount of N was top dressed in two equal splits at 30 and 45 days after planting during weeding. All other agricultural practices were performed as recommended. A random sample of 10 plants of each cultivar was collected from each plot to measure the plant height (cm) and number of leaves/plant at 90 days after planting. However, days to maturity, pseudostem diameter, pseudostem length, neck thickness, bulb diameter, number of cloves/bulb, TSS content and mean bulb weight were recorded from randomly selected 10 plant at the time of harvesting. The total bulb yield was recorded in kg from net plot area and then converted in to q $ha^{-1}$. The data were analyzed as per the standard statistical procedures.

Table 1: List of genotypes and their source of collection

| S. No. | Name of genotype | Notification year | Source |
|---|---|---|---|
| 1 | Agrifound white (G-41) | 1989 | NHRDF, Karnal |
| 2 | Yamuna Safed-2 (G-50) | 1996 | NHRDF, Karnal |
| 3 | Yamuna Safed-3 (G-282) | 1999 | NHRDF, Karnal |
| 4 | Yamuna Safed-4 (G-323) | 2006 | NHRDF, (Karnal |
| 5 | Yamuna Safed-5 (G-189) | 2011 | NHRDF, Karnal |
| 6 | Yamuna Safed-8 (G-384) | 2015 | NHRDF, Karnal |
| 7 | Yamuna Safed-9 (G-386) | 2015 | NHRDF, Karnal |
| 8 | Bhima omkar | 2015 | DOGR, Pune |
| 9 | Bhima Purple | 2009 | DOGR, Pune |
| 10 | Jodhpur Local | - | Jodhpur |
| 11 | Chittor Local | - | Chittorgarh |
| 12 | Kota Local | - | Kota |
| 13 | Bara Local | - | Baran |

## RESULTS AND DISCUSSION

The ANOVA for the characters under study revealed that the mean square estimates due to genotypes were highly significant for all the characters studied (Table 2). In other words, the performance of the genotypes with respect of these characters was statistically different; suggesting that, there exists ample scope for selection in different traits for garlic improvement.

On the basis of *per se* performance the mean data (Table 3) indicated that, plant height was recorded maximum in Yamuna Safed-9 (58.2 cm) followed by Yamuna Safed-2 (53.6 cm) and Yamuna Safed-4 (53.2 cm). Maximum number of leaves/plant (9.8) was noted in Yamuna Safed-9 which was at par with Yamuna Safed-4 (9.3) which also took maximum duration to mature (135 days) closely followed by Yamuna Safed-2 and Yamuna Safed-5 (133 days). Contrarily, genotype Kota Local recorded smallest plant (44.1 cm), minimum number of leaves/plant (7.5) and was earliest to mature (125 days). The highest pseudostem diameter was recorded in Yamuna Safed-4 (9.3 mm) followed by Yamuna Safed-9 (9.2 mm), while the longest pseudostem was recorded in Chittor

Local (21.3 mm) followed by Bara Local (19.7 mm). The minimum pseudostem diameter (5.9 mm) and pseudostem length (12.3 mm) was noted in Bhima Omkar. The highest neck thickness (10.3 mm) and bulb diameter (4.6 cm) were recorded in Yamuna Safed-9; whereas Yamuna Safed-2 (7.4 mm) and Kotal Local (2.5 cm) registered lowest neck thickness and bulb diameter, respectively. The highest average bulb weight (23.0 g) and bulb yield (9.46 t/ha) was observed in Yamuna Safed-9 followed by Bhima Purple (21.5 g and 9.28 t $ha^{-1}$, respectively). Genotype Yamuna Safed-2 closely followed by Yamuna Safed-5 noted the highest TSS (43.9%) and dry matter of bulb (40.7%).

Table 2: Analysis of variance (MSS) for different characters in garlic

| S. No. | Character | MSS |
|---|---|---|
| 1 | Plant height (cm) at 90 DAS | 45.9** |
| 2 | Leaves/plant at 90 DAS | 1.37** |
| 3 | Days to maturity | 21.9** |
| 4 | Pseudostem diameter (mm) | 3.02** |
| 5 | pseudostem length (cm) | 19.0** |
| 6 | Neck thickness (mm) | 1.95** |
| 7 | bulb diameter (mm) | 1.0** |
| 8 | No. of cloves/bulb | 37.5** |
| 9 | Av. Bulb weight (g) | 28.9** |
| 10 | Bulb yield (t/ha) | 3.5** |
| 11 | TSS (%) | 19.6** |
| 12 | Dry matter (%) | 18.7** |
| **Significant at 1% | | |

Estimates of different basic statistical and genotypic parameters like mean, range, coefficient of variation, genotypic and phenotypic coefficients of variability, heritability and genetic advance as well as percentage of mean for the traits under study are presented in Table 4. All the characters exhibited considerable variations, indicating sufficient diversity among the genotypes. A wide range of variability was recorded for plant height (44.1 to 58.2 cm), cloves/bulb (14.6 to 25.3), average bulb weight (13.2 to 23.0 g), bulb diameter (2.5 to 4.6 cm) and bulb yield (6.1 to 9.5 t $ha^{-1}$). The high ranges of variation among different genotypes bears breeding potential for further improvement of desired traits.

In the present investigation phenotypic coefficient of variations (PCV) was higher than the genotypic coefficient of variations (GCV) for all the traits indicating that environmental factor influencing their expression and their susceptibility to environmental fluctuations (Table 4 & 5). The PCV and GCV for all the yield attributing traits and yield were medium, while these parameters were low for growth and quality traits studied. Similar results for some important traits are reported by Dhar (2002).The traits exhibiting higher PCV and GCV are of economic importance and there is scope for improvement of these traits through selection. The heritability values of different traits ranged from (41.4 to 87.7%). High value of heritability was recorded for cloves/bulb (87.7%) followed by bulb diameter (85.8%) and pseudostem length (82.1%). High heritability for above traits clarified that, they were least effected by environmental modifications and selection based on phenotypic performance would be reliable. The findings are in consonance with observations of Tsega *et al.* (2010). The heritability estimates along with genetic advance are more useful than the heritability values alone for selecting the best individual. From the present investigation, high estimates of genetic advance was showed by cloves/bulbs (31.3%) followed by bulb diameter (29.6%), average bulb weight (26.8%) and pseudostem length (26.4%), while rest of the traits showed moderate to low genetic advance. High values of heritability combined with medium GCV and high genetic advance as percent of mean were observed for cloves/bulbs and bulb diameter (Table 5), suggesting that these traits are genetically controlled by additive gene action and can be improved through selection. High estimates of heritability, genetic advance as percent of mean and moderate estimates of GCV were observed for cloves/bulbs, bulb diameter, whereas moderate heritability coupled with low genetic advance and low GCV and PCV were observed for TSS and dry matter and moderate heritability coupled with high genetic advance is observed for average bulb weight and bulb yield. However, plant height, leaves/plant and maturity duration showed low heritability and low genetic advance, as also reported by Agarwal and Tiwari (2004).

Table 3: Mean performance of different garlic genotype for different traits

| Genotype | Plant height (cm) at 90 DAP | Leaves /Plant at 90 DAP | Days to maturity | Pseudo-stem diameter (mm) | Pseudo-stem length (mm) | Neck thickness (mm) | Bulb diameter (cm) | Cloves /bulb | Av. Bulb weight (g) | Bulb yield (t/ha) | TSS (%) | Dry matter (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agrifound white | 50.7 | 8.9 | 131 | 7.6 | 16.9 | 8.3 | 4.0 | 22.6 | 20.0 | 8.41 | 42.5 | 39.3 |
| Yamuna Safed-2 | 53.6 | 9.0 | 133 | 7.9 | 16.3 | 7.4 | 3.9 | 24.8 | 19.4 | 8.28 | 43.9 | 40.7 |
| Yamuna Safed-3 | 52.6 | 8.7 | 130 | 8.9 | 18.2 | 10.1 | 3.9 | 22.5 | 20.5 | 8.42 | 39.0 | 35.9 |
| Yamuna Safed-4 | 53.2 | 9.3 | 135 | 9.3 | 16.9 | 8.9 | 4.0 | 24.8 | 21.3 | 8.90 | 42.5 | 39.1 |
| Yamuna Safed-5 | 47.3 | 8.5 | 133 | 8.2 | 16.4 | 8.4 | 3.5 | 21.5 | 18.0 | 8.39 | 43.0 | 39.8 |
| Yamuna Safed-8 | 48.0 | 9.4 | 132 | 8.7 | 14.9 | 10.0 | 3.5 | 22.0 | 20.0 | 8.19 | 42.7 | 39.3 |
| Yamuna Safed-9 | 58.2 | 9.8 | 131 | 9.2 | 18.8 | 10.3 | 4.6 | 25.3 | 23.0 | 9.46 | 40.3 | 37.4 |
| Bhima Purple | 50.5 | 9.2 | 129 | 6.4 | 13.7 | 8.6 | 4.4 | 24.3 | 21.5 | 9.28 | 35.6 | 32.6 |
| Bhima Omkar | 45.1 | 9.2 | 127 | 5.9 | 12.3 | 8.7 | 3.5 | 21.8 | 16.8 | 8.49 | 41.4 | 38.5 |
| Jodhpur Local | 48.1 | 8.0 | 132 | 8.7 | 19.2 | 8.6 | 3.1 | 17.4 | 14.7 | 6.80 | 38.6 | 35.6 |
| Chittor Local | 46.5 | 7.7 | 128 | 7.6 | 21.3 | 9.1 | 2.9 | 15.7 | 13.2 | 6.17 | 38.1 | 34.9 |
| Kota Local | 44.1 | 7.5 | 125 | 8.0 | 18.9 | 9.1 | 2.5 | 14.6 | 13.9 | 6.09 | 39.1 | 35.9 |
| Bara Local | 50.7 | 8.4 | 129 | 8.0 | 19.7 | 9.4 | 3.6 | 19.1 | 16.9 | 8.63 | 37.4 | 34.1 |
| SEm± | 2.08 | 0.36 | 2 | 0.38 | 0.65 | 0.46 | 0.13 | 0.75 | 1.13 | 0.405 | 1.08 | 1.09 |
| CD at 5% | 6.1 | 1.0 | 5 | 1.1 | 1.9 | 1.3 | 0.4 | 2.2 | 3.3 | 1.18 | 3.2 | 3.2 |

Table 4: Genetic parameter of variation for different traits in garlic

| Traits | Range | | Grand Mean | CV (%) | PCV (%) | GCV (%) | Heritability (%) | Genetic Advance (GA) | GA (%) of Mean |
|---|---|---|---|---|---|---|---|---|---|
| | Minimum | Maximum | | | | | | | |
| Plant height (cm) at 90 DAS | 44.1 | 58.2 | 49.9 | 7.2 | 9.8 | 6.6 | 45.7 | 4.61 | 9.2 |
| Leaves/plant at 90 DAS | 7.5 | 9.8 | 8.74 | 7.1 | 9.7 | 6.6 | 46.2 | 0.81 | 9.2 |
| Days to maturity | 125.3 | 134.7 | 130 | 2.1 | 2.7 | 1.7 | 40.8 | 2.92 | 2.2 |
| Pseudostem diameter (mm) | 5.9 | 9.3 | 8.0 | 8.3 | 14.3 | 11.6 | 65.6 | 1.55 | 19.3 |
| Pseudostem length (mm) | 12.3 | 21.3 | 17.2 | 6.6 | 15.6 | 14.1 | 82.1 | 4.53 | 26.4 |
| Neck thickness (mm) | 7.4 | 10.3 | 9.0 | 8.8 | 11.5 | 7.5 | 41.7 | 0.89 | 9.9 |
| Bulb diameter (cm) | 2.5 | 4.6 | 3.7 | 6.3 | 16.6 | 15.4 | 85.8 | 1.07 | 29.3 |
| Cloves/bulb | 14.6 | 25.3 | 21.3 | 6.1 | 17.3 | 16.2 | 87.7 | 6.67 | 31.3 |
| Av. Bulb weight (g) | 13.2 | 23.0 | 18.4 | 10.6 | 19.0 | 15.7 | 68.7 | 4.93 | 26.8 |
| Bulb yield (t/ha) | 6.1 | 9.5 | 8.1 | 8.6 | 15.1 | 12.3 | 66.7 | 1.69 | 20.7 |
| TSS (%) | 35.6 | 43.9 | 40.3 | 4.7 | 7.4 | 5.7 | 60.3 | 3.70 | 9.2 |
| Dry matter (%) | 32.6 | 40.7 | 37.2 | 5.09 | 7.9 | 6.03 | 58.4 | 3.53 | 9.49 |

Table 5: Summary of GCV, PCV, heritability, genetic advance as per cent of mean for different traits in garlic

| Traits | PCV (%) | GCV (%) | Heritability (%) | GA (%) Mean |
|---|---|---|---|---|
| Plant height (cm) at 90 DAS | L | L | L | L |
| No. of leaves/plant at 90 DAS | L | L | L | L |
| Days to maturity | L | L | L | L |
| Pseudostem diameter (mm) | M | M | M | M |
| Pseudostem length (cm) | M | M | H | H |
| Neck thickness (mm) | M | L | L | L |
| bulb diameter (mm) | M | M | H | H |
| cloves/bulb | M | M | H | H |
| Av. Bulb weight (g) | M | M | M | H |
| Bulb yield (t/ha) | M | M | M | H |
| TSS (%) | L | L | M | L |
| Dry matter (%) | L | L | M | L |

Table 6: Phenotypic correlation coefficients of yield and its components in garlic

| Characters | Plant height (cm) at 90 DAS | Leaves/ plant at 90 DAS | Days to maturity | Pseudo-stem length (cm) | Bulb diameter (mm) | Cloves/ bulb | Av. Bulb weight (g) | TSS (%) |
|---|---|---|---|---|---|---|---|---|
| Leaves/plant at 90 DAS | 0.642* | | | | | | | |
| Days to maturity | 0.543 | 0.469 | | | | | | |
| Pseudostem diameter (mm) | 0.492 | 0.058 | 0.567* | | | | | |
| Pseudostem length (cm) | 0.117 | -0.605* | -0.082 | | | | | |
| Neck thickness (mm) | 0.208 | 0.173 | -0.189 | 0.272 | | | | |
| bulb diameter (mm) | 0.835** | 0.858** | 0.465 | -0.358 | | | | |
| No. of cloves/bulb | 0.739** | 0.924** | 0.600* | -0.554* | 0.923** | | | |
| Av. Bulb weight (g) | 0.789** | 0.894** | 0.530 | -0.417 | 0.933** | 0.936** | | |
| Bulb yield (t/ha) | 0.679* | 0.887** | 0.436 | -0.520 | 0.925** | 0.908** | 0.894** | |
| TSS (%) | 0.119 | 0.372 | 0.570* | -0.312 | 0.099 | 0.403 | 0.259 | |
| Dry matter (%) | 0.128 | 0.388 | 0.558* | -0.331 | 0.117 | 0.418 | 0.267 | 0.998** |

The phenotypic correlations of different traits are presented in Table 6. Association of plant height (r=0.679*), leaves/plant (r=0.887**), bulb diameter (r=0.925**), cloves/bulb (r=0.908**) and average bulb weight (r=0.894**) with bulb yield was positive and significant indicated that improvement of these traits may directly contributes the bulb yield. Whereas, pseudostem length exhibited significant negative association with cloves/bulb (r=-0.554**). The maximum positive correlation (r=0.998**) was found between dry matter and TSS followed by average bulb weight and cloves/bulb (r=0.936**). In support to this study bulb yield showed positive and significant correlation with average bulb weight (r=0.894**) and bulb diameter (r=0.925**). Dubey *et al.* (2010) also reported similar correlation between bulb yield with bulb weight and bulb size. The existence of considerable variation in the tested garlic genotypes for growth, yield and yield attributing traits shows breeding potential for further improvement in desirable traits. Traits like cloves/bulbs and bulb diameter exhibited high estimates of heritability and genetic advance as percent of mean, besides showing maximum positive correlation with bulb yield and can be improved through selection. Considering yield potential and other desirable traits the superior genotypes like Yamuna Safed-9, Bhima Purple and Yamuna Safed-4 can be selected preliminarily and may be used for further crop improvement with a view to develop new varieties.

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