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# Correlation and path coefficient studies in garlic (*Allium sativum* L.)

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## Abstract

Correlation and path coefficient analysis were studied in 32 promising germplasm lines of garlic (*Allium sativum*) at Karnal (Haryana). Marketable yield was positively and significantly correlated with leaves plant$^{-1}$, bulb diameter, bulb size index, weight of 20 bulbs and cloves bulb$^{-1}$ at genotypic and phenotypic levels and negatively correlated with weight of 50 cloves at both levels. Gross yield was positively and significantly correlated with plant height, neck thickness and negatively correlated with clove diameter and clove size index at genotypic and phenotypic levels, indicating that selection based on these traits will help in increasing the yield. At genotypic level, traits such as leaves plant$^{-1}$, clove diameter, cloves bulb$^{-1}$ and weight of 50 cloves showed a positive direct effect on yield. Clove diameter had maximum positive direct effect (0.744) followed by weight of 50 cloves (0.547), cloves bulb$^{-1}$ (0.313) and leaves plant$^{-1}$ (0.288). The highest negative direct effect was noted for clove size index (-0.874), followed by neck thickness (-0.341), weight of 20 bulbs (-0.264) and plant height (-0.057). The estimates of direct and indirect effect on yield were more pronounced in genotypic path than phenotypic path coefficient. The study thus indicated that weight of 20 bulbs, bulb size index, weight of 50 cloves and cloves bulb$^{-1}$ produced higher positive direct effect on yield and should be given emphasis during selection for improvement of garlic.

**Keywords:** *Allium sativum*, correlation, garlic, genotype, path coefficient.

The productivity of garlic (*Allium sativum* L.) in India is 5.75 t$^{-1}$ ha (Anonymous 2011), which is quite low when compared to other garlic growing countries. Knowledge regarding association and path coefficient analysis between yield and its components traits are important in determining the component characters that could be used as selection parameters for effective improvement of the crop. The present study was conducted to assess the relationship among germplasm collections of garlic based on morphological and physiological variations and to identify clones having high bulb yield with other desirable traits.

The experiment was carried out at National Horticultural Research and Development Foundation, Salaru, Karnal (Haryana) during 2006-08. Thirty two promising diverse genotypes along with 5 checks (released varieties) (G-1, G-41, G-50, G-282 and G-323) selected among 300 germplasm lines were laid out in a randomized block design with three replications. Cloves with uniform size were selected and planted in first fortnight of October in beds of 3.0 m x 1.5 m size with spacing of 15.0 cm x 7.5 cm. The climate of Karnal is subtropical with minimum and maximum temperatures ranging between $2^0$ to $45^0$C and favorable for garlic cultivation during r*abi* season. Recommended cultural operations were carried out to ensure a healthy crop. Observations were recorded on 10 randomly selected plants in each replication for the characters plant height (cm), leaves plant$^{-1}$, neck thickness (cm), bulb diameter (cm), bulb size index (cm$^2$), weight of 20 bulbs (g), clove diameter (cm), clove size index (cm$^2$), cloves bulb$^{-1}$, weight of 50 cloves (g), gross yield (t ha$^{-1}$) and marketable yield (t ha$^{-1}$). The pooled data of both years were analyzed to work out correlation and path coefficient analysis by the method suggested by Al-Jibouri *et al*. (1958) and Dewey & Lu (1959), respectively.

The correlation studies revealed that, marketable yield was positively and significantly correlated with leaves plant$^{-1}$, bulb diameter, bulb size index, weight of 20 bulbs and cloves bulb$^{-1}$ at genotypic and phenotypic levels and negatively correlated with weight of 50 cloves bulb$^{-1}$ at both levels. Gross yield was positively and significantly correlated with plant height, neck thickness and negatively correlated with clove diameter, clove size index at genotypic and phenotypic levels, indicating that selection based on these traits will help in increasing the yield (Table 1). Godhani & Singh (2000), Naruka & Dhaka (2004) and Dubey *et al.* (2010) have also reported similar significant positive correlation between bulb yield with bulb weight and bulb size.

Bulb diameter was significantly and positively correlated with bulb size index and weight of 20 bulbs at phenotypic and genotypic levels whereas, leaves plant$^{-1}$ at genotypic level. Weight of 20 bulbs had positive correlation with bulb diameter and bulb size index and negatively correlated with neck thickness. Clove size index was positively and significantly correlated with clove diameter. Cloves bulb$^{-1}$ was negatively and significantly correlated with clove diameter and clove size index. It is suggested that, if number of cloves bulb$^{-1}$ increased then clove diameter will be reduced. The trait, weight of 50 cloves was significantly and positively correlated with clove diameter and clove size index and negatively correlated with cloves bulb$^{-1}$ at both genotypic and phenotypic levels. It may be concluded from the correlations that, the traits, plant height, bulb diameter, bulb size index, weigh of 20 bulbs, clove diameter, clove size index and cloves bulb$^{-1}$ are correlated to each other and helpful in increasing in the bulb yield as reported earlier by Dhar (2002) and Tsega *et al.* (2010).

The genotypic and phenotypic path coefficient analysis is presented in Tables 2 and 3. At genotypic level, traits such as leaves plant$^{-1}$, clove diameter, cloves bulbs$^{-1}$, weight of 50 cloves showed a positive direct effect on yield. Clove diameter had maximum positive direct effect (0.744) followed by weight of 50 cloves (0.547), cloves bulb$^{-1}$ (0.313) and leaves plant$^{-1}$ (0.288). The highest negative direct effect was noted for clove size index (-0.874) followed by neck thickness (-0.341), weight of 20 bulbs (-0.264) and plant height (-0.057). The traits, clove diameter showed direct positive effect on yield and indirect effect was mainly by bulb size index, weight of 20 bulbs, clove size index and weight of 50 cloves. The direct effect of weight of 50 cloves was positive and indirect effect via clove diameter and clove size index was positive.

At phenotypic level, highest positive direct effect was shown by leaves plant$^{-1}$ (0.211) followed by weight of 50 cloves (0.168), and clove diameter (0.096). The traits, plant height, neck thickness, bulb size index, weight of 20 bulbs, clove size index and gross yield showed negative effect on yield. It was interesting to note that the residual effect on genotypic and phenotypic levels was only -0.0374 and 0.1389, respectively. The estimates of direct and indirect effect on yield were more pronounced in genotypic path than phenotypic path coefficient. It is concluded from the study that weight of 20 bulbs, bulb size index, weight of 50 cloves and cloves bulb$^{-1}$ produced higher positive direct effect on yield and should be given more emphasis in improvement of garlic.

**Table 1.** Correlation studies in promising garlic germplasm lines

| Character | | Plant height | Leaves plant$^{-1}$ | Neck thick-ness | Bulb diameter | Bulb size index | Weight of 20 bulbs | Clove diameter | Clove size index | Cloves bulb$^{-1}$ | Weight of 50 cloves | Gross yield | Marketable yield |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plant height | G | 1.00 | 0.248 | 0.587** | 0.066 | 0.026 | -0.006 | -0.321 | -0.329* | 0.255 | -0.259 | 0.652** | 0.201 |
| | P | 1.00 | 0.256 | 0.550** | 0.031 | 0.017 | -0.006 | -0.289 | -0.303* | 0.240 | -0.239 | 0.593** | 0.186 |
| Leaves plant$^{-1}$ | G | | 1.00 | 0.148 | 0.414* | 0.302* | 0.154 | -0.415** | -0.322* | 0.214 | -0.218 | 0.232 | 0.415** |
| | P | | 1.00 | 0.190 | 0.279 | 0.260 | 0.153 | -0.344* | -0.261 | 0.197 | -0.209 | 0.206 | 0.368* |
| Neck thickness | G | | | 1.00 | 0.066 | -0.122 | -0.428** | -0.449** | -0.496** | 0.010 | 0.004 | 0.856** | -0.129 |
| | P | | | 1.00 | -0.007 | -0.087 | -0.349* | -0.383* | -0.406** | 0.020 | 0.002 | 0.695** | -0.088 |
| Bulb diameter | G | | | | 1.00 | 0.946** | 0.473** | -0.004 | 0.078 | 0.227 | 0.073 | 0.178 | 0.563** |
| | P | | | | 1.00 | 0.740** | 0.446** | 0.048 | 0.107 | 0.111 | 0.034 | 0.127 | 0.515** |
| Bulb size index | G | | | | | 1.00 | 0.603** | 0.085 | 0.200 | 0.214 | 0.088 | 0.057 | 0.639** |
| | P | | | | | 1.00 | 0.603** | 0.129 | 0.206 | 0.129 | 0.102 | 0.075 | 0.624** |
| Weight of 20 bulbs | G | | | | | | 1.00 | 0.271 | 0.265 | 0.405** | -0.209 | -0.344* | 0.813** |
| | P | | | | | | 1.00 | 0.263 | 0.250 | 0.337* | -0.183 | -0.288 | 0.781** |
| Clove diameter | G | | | | | | | 1.00 | 0.916** | -0.464** | 0.561** | -0.588** | -0.130 |
| | P | | | | | | | 1.00 | 0.857** | -0.434** | 0.491** | -0.448** | -0.027 |
| Clove size index | G | | | | | | | | 1.00 | -0.424** | 0.604** | -0.551** | -0.045 |
| | P | | | | | | | | 1.00 | -0.359 | 0.553** | -0.421** | 0.021 |
| Cloves bulb$^{-1}$ | G | | | | | | | | | 1.00 | -0.822** | 0.189 | 0.628** |
| | P | | | | | | | | | 1.00 | -0.776** | 0.136 | 0.492** |
| Wt. of 50 cloves | G | | | | | | | | | | 1.00 | -0.122 | -0.404** |
| | P | | | | | | | | | | 1.00 | -0.077 | -0.306* |
| Gross yield | G | | | | | | | | | | | 1.00 | 0.115 |
| | P | | | | | | | | | | | 1.00 | 0.368* |

*, ** Significant at 5% and 1% levels, respectively; G=Genotypic; P=Phenotypic

**Table 2.** Estimates of phenotypic direct (diagonal) and indirect effect of traits in promising garlic germplasm lines

| Character | V1 | V2 | V3 | V4 | V5 | V6 | V7 | V8 | V9 | V10 | V11 | Marketable yield |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plant height (cm) V1 | **-0.042** | 0.054 | -0.070 | 0.001 | -0.002 | 0.002 | -0.028 | 0.033 | 0.016 | -0.040 | -0.231 | 0.186 |
| Leaves plant$^{-1}$ V2 | -0.011 | **0.211** | -0.024 | 0.002 | -0.027 | -0.007 | -0.033 | 0.028 | 0.013 | -0.035 | -0.081 | 0.368* |
| Neck thickness (cm) V3 | -0.023 | 0.040 | **-0.127** | 0.003 | 0.009 | 0.017 | -0.037 | 0.044 | 0.001 | 0.001 | -0.271 | -0.088 |
| Bulb diameter (cm) V4 | -0.001 | 0.059 | 0.001 | **0.001** | -0.076 | -0.022 | 0.005 | -0.012 | 0.008 | 0.006 | -0.049 | 0.515** |
| Bulb size index (cm$^2$) V5 | -0.001 | 0.055 | 0.011 | 0.001 | **-0.103** | -0.029 | 0.012 | -0.022 | 0.009 | 0.017 | -0.029 | 0.624** |
| Wt. of 20 bulbs (kg) V6 | 0.003 | 0.032 | 0.044 | 0.002 | -0.062 | **-0.048** | 0.025 | -0.027 | 0.023 | -0.031 | 0.112 | 0.781** |
| Clove diameter (cm) V7 | 0.012 | -0.073 | 0.048 | 0.004 | -0.013 | -0.013 | **0.096** | -0.093 | -0.030 | 0.082 | 0.175 | -0.027 |
| Clove size index (cm$^2$) V8 | 0.013 | -0.055 | 0.051 | 0.006 | -0.021 | -0.012 | 0.082 | **-0.109** | -0.025 | 0.093 | 0.164 | 0.021 |
| Cloves bulb$^{-1}$ V9 | -0.010 | 0.042 | -0.003 | 0.003 | -0.013 | -0.016 | -0.041 | 0.039 | **0.068** | -0.130 | -0.053 | 0.492** |
| Wt. of 50 cloves (g) V10 | 0.010 | -0.044 | 0.003 | 0.002 | -0.010 | 0.009 | 0.047 | -0.060 | -0.053 | **0.168** | 0.030 | -0.306* |
| Gross yield (t ha$^{-1}$) V11 | -.025 | 0.044 | -0.088 | 0.006 | -0.008 | 0.014 | -0.043 | 0.046 | 0.009 | -0.013 | **-0.390** | 0.368* |

*, **=Significant at 5% and 1% levels, respectively; Residual effect=0.1389; Bold values indicate direct effect

**Table 3.** Estimates of genotypic direct (diagonal) and indirect effect of traits in promising garlic germplasm lines

| Character | V1 | V2 | V3 | V4 | V5 | V6 | V7 | V8 | V9 | V10 | V11 | Marketable yield |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plant height (cm) V1 | **-0.059** | 0.072 | -0.200 | -0.007 | -0.001 | 0.002 | -0.239 | 0.288 | 0.080 | -0.142 | -0.003 | 0.201 |
| Leaves plant$^{-1}$ V2 | -0.015 | **0.288** | -0.050 | -0.044 | -0.017 | -0.041 | -0.309 | 0.281 | 0.067 | -0.119 | -0.001 | 0.415** |
| Neck thickness (cm) V3 | -0.035 | 0.042 | **-0.341** | -0.007 | 0.007 | 0.113 | -0.334 | 0.434 | 0.003 | 0.002 | -0.004 | -0.129 |
| Bulb diameter (cm) V4 | -0.004 | 0.119 | -0.023 | **-0.106** | -0.054 | -0.125 | -0.003 | -0.68 | 0.071 | 0.040 | -0.001 | 0.563** |
| Bulb size index (cm$^2$) V5 | -0.002 | 0.087 | 0.042 | -0.100 | **-0.057** | -0.159 | 0.063 | -0.175 | 0.067 | 0.046 | 0.003 | 0.639** |
| Wt. of 20 bulbs (kg) V6 | 0.023 | 0.044 | 0.146 | -0.050 | -0.034 | **-0.264** | 0.201 | -0.232 | 0.127 | -0.114 | 0.019 | 0.813** |
| Clove diameter (cm) V7 | 0.019 | -0.120 | 0.153 | 0.002 | -0.005 | -0.071 | **0.744** | -0.801 | -0.145 | 0.307 | 0.003 | -0.130 |
| Clove size index (cm$^2$) V8 | 0.019 | -0.093 | 0.169 | -0.008 | -0.011 | -0.070 | 0.681 | **-0.874** | -0.132 | 0.330 | 0.002 | -0.045 |
| Cloves bulb$^{-1}$ V9 | -0.015 | 0.062 | -0.003 | -0.24 | -0.012 | -0.107 | -0.345 | 0.371 | **0.313** | -0.449 | -0.001 | 0.628** |
| Wt. of 50 cloves (g) V10 | 0.015 | -0.063 | -0.001 | -0.008 | -0.005 | 0.055 | 0.417 | -0.528 | -0.257 | **0.547** | 0.001 | -0.404** |
| Gross yield (t ha$^{-1}$) V11 | -0.038 | 0.067 | -0.292 | -0.018 | -0.003 | 0.091 | -0.437 | 0.482 | 0.059 | -0.067 | **-0.004** | 0.115 |

*, **=Significant at 5% and 1% levels, respectively; Residual effect=-0.0374; Bold values indicate direct effect

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