Bulb Morphological Characteristics as Selection Indices to Improve Yield of Garlic (*Allium sativum* L.)

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ABSTRACT

During this study, 21 garlic genotypes consisted of ten clones of Egyptian cultivar, nine clones of Chinese cultivar, as well as their original populations were evaluated to estimate the extent of improvement in four yield component traits after six cycles of clonal selection. Also, simple phenotypic correlation among these traits and their relationship with yield. Besides estimating linear and quadratic responses (simple and multiple regression); to clarify the relationship between yield and the four studied characteristics. This research has been conducted at the Research farm of Faculty of Agriculture in "Abies" area of Alexandria University, Egypt, for 2020/2021 during the winter season, in a randomized complete block design with three replications. The studied traits were included bulb weight, cloves weight per bulb, average clove weight, cloves number per bulb, and yield per plot. T-test in group reflected a significant improvement in the four yield components traits, whether in the improved clones of Egyptian or Chinese cultivar. The results illustrated, also, that yield per plot showed a highly significant positive correlation with bulb weight, cloves weight per bulb, and average clove weight. Stepwise regression indicated that more than 98% of the variation in yield is explained by bulb weight, average clove weight, and cloves number per bulb. Thus, high yield of garlic plants can be obtained by selecting breeding materials with these aforementioned three variables.

Keywords: bulb traits, correlation, evaluation, garlic, regression

INTRODUCTION

Garlic, *Allium sativum* L., Alliaceae family, is considered one of the most important aromatic spices in this family. It is one of the important vegetables grown under Egyptian conditions, whether for local marketing or export. Garlic products have become popular in recent years, and a variety of culinary preparations and pharmaceuticals are now available in Egypt and many countries.

Evaluation and selection of local and foreign garlic cultivars is a work in progress because some cultivars have greater adaptability while others are a source of diversity for breeding improved cultivars. Several efforts have been made to introduce high-yielding garlic cultivars to Egypt to overcome the problem of low productivity of the local cultivar (Egyptian) (El-Mesirry and Radi, 2019). Accordingly, many new garlic cultivars and clones appeared, which were evaluated under local conditions and proved successful for several years (Omer and Abou Hadid, 1992, Osman and Moustafa, 2009 and Gadel-Hak et al., 2011), but some deterioration appeared on some cultivated genotypes over time (Mostafa et al., 2020). So, plant breeders began to improve those degraded traits and reach some new and distinct genotypes.

Selection of excellent and outstanding genotypes of productivity is not an easy task; since the yield characteristic is a complex genetic trait, it is the result of the integration of many genetic and environmental variants. Accordingly, in order to be properly studied and to reach the best results, it is necessary to know the extent of the effect and the relationship between the garlic yield and its components, which would raise the efficiency of breeding programs, by identifying the appropriate indices for selecting distinct garlic cultivars (Singh et al., 2011). Dubey et al. (2010) and Barad et al. (2012) showed that the production efficiency of garlic cloves number and bulb diameter positively improved the yield. Their studies reflected the importance of any of the variables, especially weight of bulb and number of cloves, in the breeding programs. Accordingly, various statistical techniques have been used in crop yield modeling including correlation, regression, path analysis, factor analysis, factor components, and cluster analysis. Simple correlation relationship measures associations between two characteristics that quantify the magnitude and direction of the influences of one characteristic on another. Regression is an important statistical procedure for examining the degree of contribution of return variables (Barad et al., 2012).

Therefore, this study was conducted as a practical experiment to clarify the relationship between garlic yield and its components. The aim was to provide a practical basis for guiding garlic breeders who are looking for the genetic association of key agricultural traits and their effect on garlic plant productivity. To

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achieve this goal, the relationship between garlic yield and its components was studied using regression procedure, and the reflection of that relationship on improving the yield characteristic as well as improving the bulb quality.

MATERIAL AND METHODS

Plant material and experimental design:

The evaluated genotypes comprised of 21 garlic genotypes, include ten improved clones of the local cultivar (Egyptian cultivar) and nine improved clones from the Chinese cultivar as well as the two original cultivars Egyptian and Chinese. These genotypes were evaluated in a randomized complete block design with three replications in the farm of the Faculty of Agriculture, Alexandria University, Egypt, during the 2020/2021 winter season in the first week of October. Garlic cloves of each genotype were planted in the experimental unit (8.4 m^2). It consisted of four rows 3.00 m long and 0.7 m wide, and garlic cloves were planted on both sides of the row with 7.0 cm between hills. Immediately after sowing and before irrigation, weeds were controlled with pre-emergence herbicides. All other agricultural practices were carried out as recommended for commercial production.

Harvesting and data logging

At harvesting time (185 days after planting), when older leaves turned yellowish-green and started withering. All plants of each plot were harvested, and bulbs were spread in single layers under room temperature conditions for the curing process for three weeks. The total yield per plot was calculated after curing by 7 days. In addition, 5 bulbs were randomly collected from each plot to determine bulb weight (g), cloves weight per bulb (g), cloves number per bulb, and average clove weight (g).

Statistical analysis

To test the significance of the studied traits of Egyptian garlic population versus its improved clones and the original Chinese population versus its improved clones, student test in groups was used. A matrix of simple correlation coefficients between studied traits and stepwise multiple regression were performed using SAS 9.3 software (SAS, 2007). Linear and quadratic responses (simple regression) between yield per plot and each of the four studied traits, were performed by Curve Expert, ver. 1.34 (Hyams, 2005).

RESULTS AND DISCUSSION

Estimating the degree of improvement in the two studied populations (Egyptian and Chinese cultivars)

The results of the t-test in groups for the studied traits reflected the presence of significant differences between the original populations of both cultivars, Egyptian and Chinese, and their improved clones for all the studied traits. The following illustrations of the normal distribution curves were used to show the extent of improvement obtained after six selection cycles in the Egyptian and Chinese garlic cultivars.

Bulb weight (g)

The illustration of the normal distribution curve, Fig. 1A showed a degree of improvement obtained for bulb weight trait of the original population of Egyptian cultivar and its improved clones. The results illustrated that the curve of the original population extended at its two ends from 10 to 60 g with a range of 50 g and a mean of 30 g. While the curve of the improved clones descended from it ranged from 30 to 81 g with a mean of 58 g and thus reflected an improvement of 93.3%. These results led to an increase in the height of the curve (the flatness decreased); where, the improved population recorded standard deviation 11.6, while it was 13.5 in the original population of Egyptian cultivar. That means the differences between clones were lower than the original population. As for the original population of Chinese cultivar, Fig. 1B illustrated that the minimum and maximum end of curve ranged from 10 to 70 g, with a mean of 30 g. As for the improved population clones, the values of the two sides were 59 and 90 g, with a mean of 70 g, and an improvement rate of 133.3% as well as the derived clones became more homogenous. Concerning the improved clones, the coefficient of variation value was 13.00%, while it was 44.0% in the original Chinese cultivar. From the obtained improvement percentage of bulb weight trait, the doubling of the crop can be observed, in the improved clones of Egyptian or Chinese cultivars, compared to the two original populations from which the improved clones descended. These results are confirmed with Dawood *et al*., 2011, Saker, 1996 and Anwar *et al*., 2017

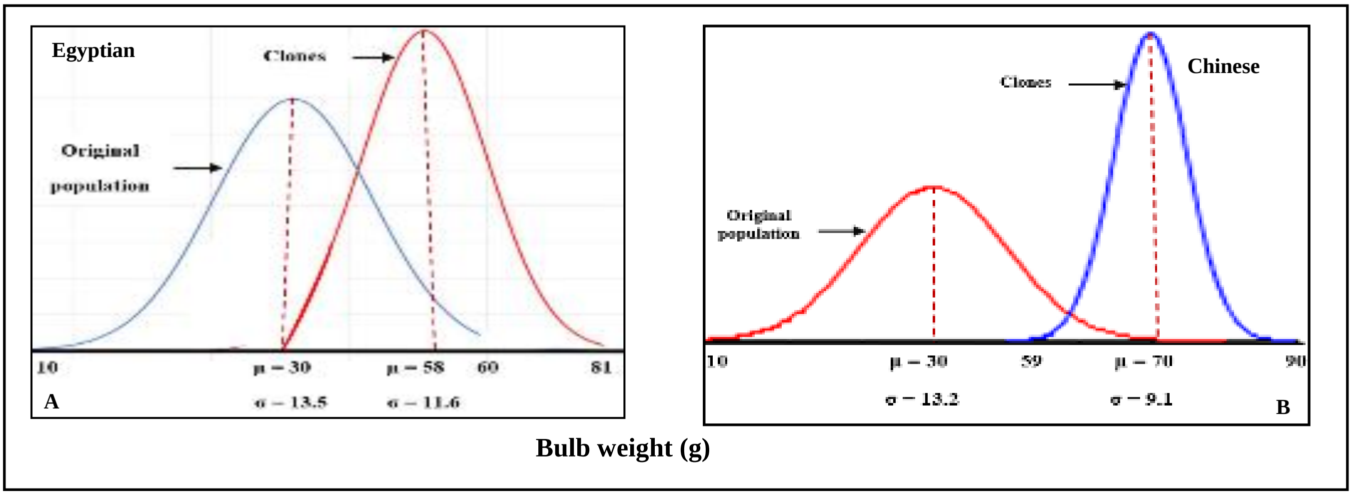
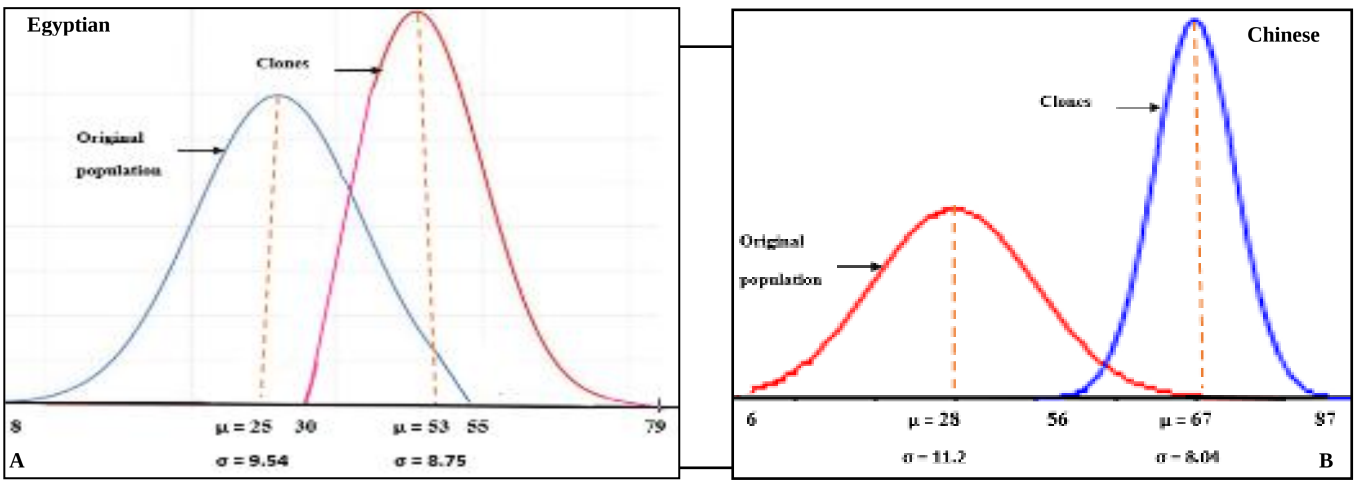


Fig. 1. Normal distribution of bulb weight trait for original and improved populations

Cloves weight per bulb (g)

As for the trait of cloves weight per bulb, the illustration of the normal distribution curve, Fig. 2A showed that mean of the studied trait of the original population (Egyptian cultivar) was estimated at 25 g, and the ends of the normal curve ranged from 8 to 55 g. The selection cycles led to obtaining a population of improved clones, which gave an average value of 53 g, with an improvement rate of 112% compared to the original population, with ranged values of 30 and 79 g, respectively. Concerning the Chinese cultivar population, Fig. 2B, the recorded data showed noticeable improvement of this trait as the curve of the improved clones varied with a range of 31 g, mean of 67 g, and standard deviation of 8.04. While the normal curve of the original population of Chinese cultivar was low (more widening), where its standard deviation was 11.2 with a mean of 28 g. Therefore, the improved clones outperformed by 133.3% compared to the original Chinese cultivar, with the curve range of 61 g.



Cloves weight per bulb (g)

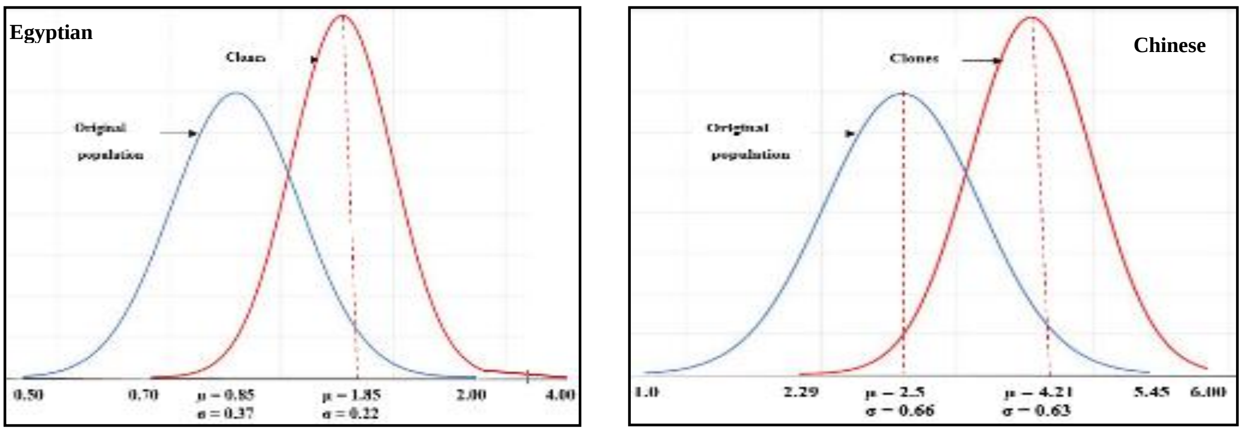
Fig. 2. Normal distribution of cloves weight per bulb trait for original and improved populations

Average clove weight (g)

The illustration of the normal distribution curve for average clove weight, Fig. 3A, showed that the mean value of the original population of Egyptian cultivar of 0.85 g, while the mean value of average clove weight of the improved clones was 1.85 g, with an improvement percentage 117.6%. The standard deviation of the improved clone's population was 0.22 while it was 0.37 for the original population of Egyptian cultivar. As for the original Chinese cultivar population and the improved clones descended from it, Fig. 3B, showed that the percentage of improvement reached 68.4%, where the average clove weight of the improved clones was 4.21 g compared to 2.50 g for the original Chinese cultivar. Lack of improvement of this trait in the improved Chinese clones compared to the improved Egyptian clones may be due to the heavy weight of the clove in the Chinese cultivar compared to the Egyptian cultivar.

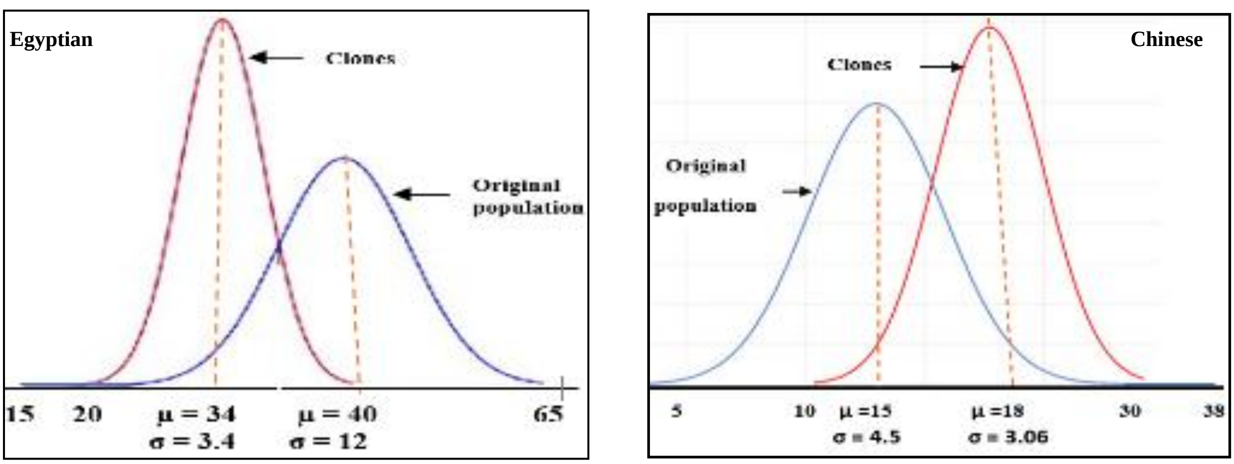
Cloves number per bulb

A shown in Fig. 4A, the original population of Egyptian cultivar recorded a minimum of 15 cloves per bulb and a maximum of 65 cloves per bulb, with average of 40 cloves per bulb. The trend of selection in multiple cycles aimed to decrease cloves number per bulb with an increase of average clove weight. Therefore, the curve of the improved clones moved to the left, which reflected the success of the selection program, where the improved clones gave mean values less than the original population of Egyptian cultivar.



A **Average clove weight (g)** B

Fig. 3. Normal distribution of average clove weight trait for original and improved populations



A **Cloves number per bulb** B

Fig. 4. Normal distribution of average clove weight trait for original and improved populations

The improved clones recorded 34 cloves per bulb as an average with a minimum of 15 cloves per bulb and a maximum of 40 cloves per bulb, which gave an improvement rate of 15%. It was also noted a few differences in the improved clones, with a standard deviation of 12.0 compared to the original population of Egyptian cultivar 3.4. On the other hand, Fig. 4B showed that improved clones curve had a mean value of 18 cloves per bulb with an increase of 20% over the mean value of the original population of Chinese cultivar (15 cloves per bulb), which extended between 10 to 30 cloves per bulb. While the curve edges of the original population were between 5 to 38 cloves per bulb; moreover, the standard deviation of the improved clones was lower than the original Chinese cultivar, (3.06 and 4.50), respectively. These results can be supported by Omar and Abou Hadid, 1992 and Zepeda, 1997.

Correlation coefficients estimates

Yield is a complex quantitative trait that is controlled by several genes interacting with the environment. Yield is the resultant of many attributes which are known as yield components. Accordingly, efficiency of selection in any breeding program depends mainly on the relationship between those characters. Knowing the associations between yield and its associated traits can significantly enhance the efficiency of yield improvement using appropriate selection indicators.

Correlation coefficient is one of the important tools that indicate the nature of the correlation between different traits. The traits that are correlated with yield are of great importance to plant breeders in the case of breeding by selection. In the current study (Table 1), the yield per plot showed a highly significant positive correlation with bulb weight (0.98), cloves weight per bulb (0.98) and average clove weight (0.67); while relationship between yield per plot and cloves number per bulb did not reach significant level. Finding are harmony with those illustrated by Dubey et al., 2010, Singh et al., 2011, Barad et al., 2012 and Sable et al., 2020.

The studied yield attributes also were positive and highly significant related with each others, except cloves number per bulb that negatively and significantly related with average clove weight (-0.73). However, relation between cloves number per bulb and each of bulb weight and cloves weight per bulb did not reach significance level (-0.23 and -0.23).

Thus, selection based on bulb weight, cloves weight per bulb, and average clove weight traits could help in improvement program of garlic.

Table 1. Simple phenotypic correlation coefficients between the studied characters of garlic

Characteristics	Cloves weight per bulb (g)	Cloves number per bulb	Average clove weight (g)	Yield per plot (kg)
Bulb weight	0.99**	-0.23	0.73**	0.98**
Cloves weight per bulb		-0.23	0.72**	0.98**
Cloves number per bulb			-0.73**	-0.11
Average clove weight				0.67**

**: Significant 0.01 level of probability.

Estimates of regression

Yield trait is controlled by many characteristics that are called yield components, as such traits affect the trait of yield negatively or positively. As each of these characteristics has its effect and the degree of its contribution to the manifestation of the characteristic of yield, whether on its own or if it overlaps with one or more other characteristics. To find out the extent to which each of the traits of the components of the studied yield individually affects the productivity trait, as well as the extent to which each trait contributes to reflect the best yield; the regression coefficient, either simple or multiple .Simple and multiple regression coefficients were estimated on three improved garlic populations, namely, ten improved clones of Egyptian cultivar, nine improved clones of Chinese cultivar, and whole improved clones of both Egyptian and Chinee cultivars.

Simple regression coefficient estimation

Bulb weight (X_1) and cloves weight per bulb (X_2)

The results of Fig. 5 describe simple regression relationship between the characteristic of bulb weight (g) and yield per plot reflected positive linear relationship. The coefficient of determination (r^2) values with 0.99, 0.97, 0.97 for the three studied improved clones derived from Egyptian cultivar, Chinese cultivar, and whole clones, respectively. The relationship between the two traits showed that the increase in bulb weight is accompanied by an increase in yield per plot. Also, the relationship between cloves weight per bulb and yield per plot showed the same direction, where increase cloves weight per bulb led to an increase in yield trait. The percentages of differences due to this relationship compared to the total differences (the coefficient of determination values) for the three improved populations derived from Egyptian cultivar, Chinese cultivar, and whole garlic clones were 0.98, 0.95, 0.96, respectively, as shown in Fig. 6.

Average clove weight (X_3)

As for average clove weight and its relationship to yield per plot, Fig. 7, reflected a second-order relationship with a coefficient of determination of 0.66 for improved clones of Egyptian cultivar, 0.17 for improved clones of Chinese cultivar, and 0.66 for garlic in general. The results illustrated that with an increase in the average clove weight, the yield increases until average clove weight 2.925 g in improved clones of Egyptian cultivar, 5.78 g in improved clones of Chinese cultivar, and 4.76 g in garlic in general, and then yield begins to decrease. The decrease in yield at this limit of average clove wight can be attributed in the different populations to the accompanying decrease in cloves number per bulb, as shown in Table (1).

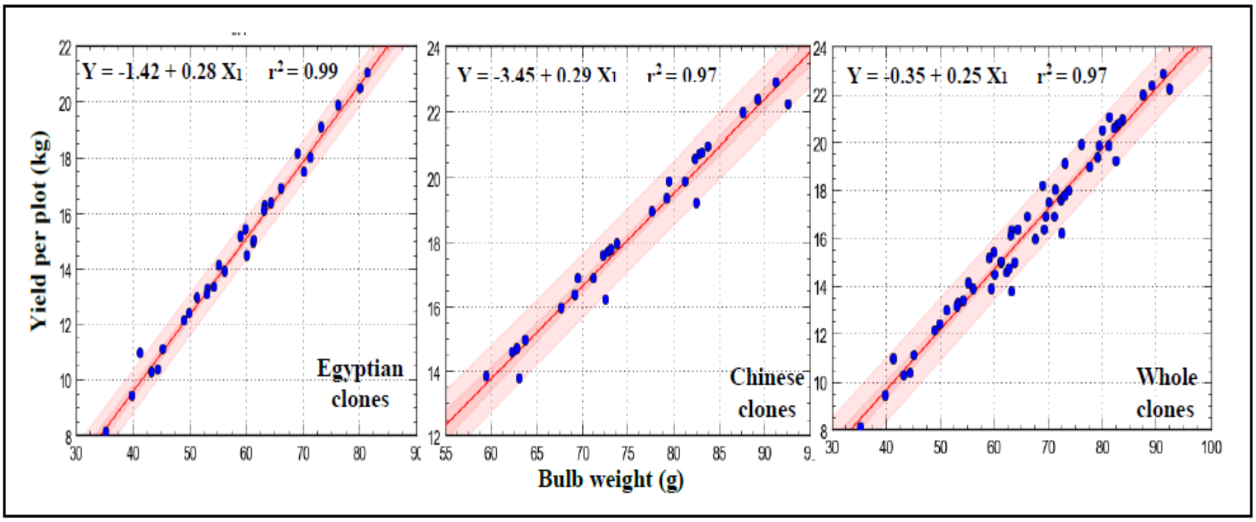


Fig. 5. Relationships between yield per plot and bulb weight of different populations

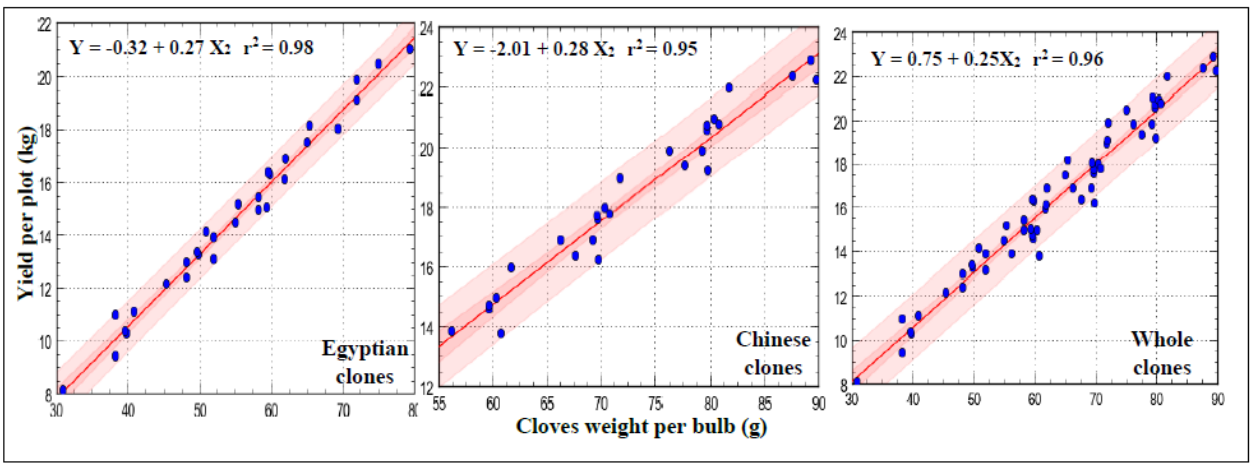


Fig. 6. Relationships between yield per plot and cloves weight per bulb of different populations

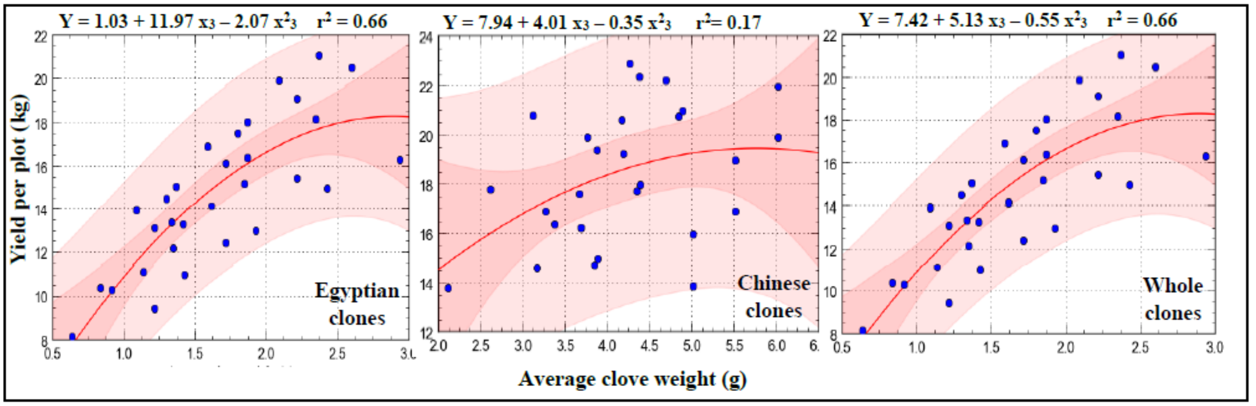


Fig. 7. Relationships between yield per plot and average clove weight of different populations

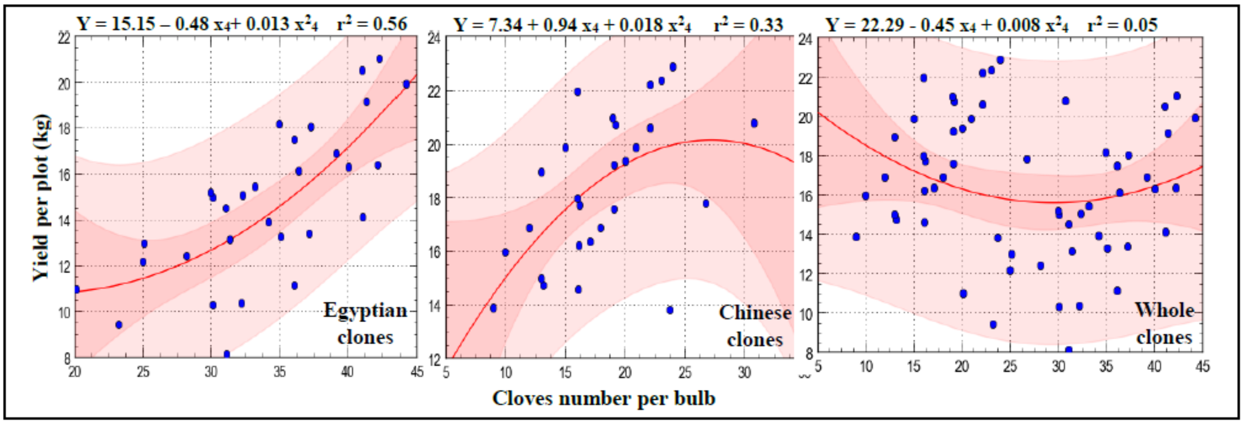


Fig. 8 Relationships between yield per plot and cloves number per bulb of different populations

Cloves number per bulb (X_4)

Regarding cloves number per bulb and its relationship with yield per plot; it recorded a second-degree (curve linear) relationship. Coefficient of determination values for the three improved populations; Egyptian cultivar, Chinese cultivar, and garlic in general; were estimated as 0.56, 0.33, 0.05, respectively. The data in Fig. 8 showed that with an increase in cloves number per bulb, the yield of improved clones of Egyptian cultivar increases. While in the improved clones derived from Chinese cultivar the data reflected an increase in yield per plot with increasing cloves number per bulb up to optimum point (27.499 cloves per bulb), which gave the maximum value of yield per plot. But as the number of cloves continues to increase, yield begins to decline; this may be due to the low average clove weight. As for garlic in general population, the results reflected a decrease in yield with increasing cloves number per bulb up to 36.2 cloves per bulb; while yield per plot seemed to increase after this limit. This may be due, as previously mentioned to the relationship between average clove weight and the yield per plot (Fig. 7). This result reflected that the increase in yield per plot depended on increasing in the average clove weight up 4.76 g despite the small number of cloves. While, higher increases in the average clove weight led to a decrease in yield per plot. Based on that result, it can be concluded that the most important trait for increasing yield is cloves number per bulb.

Multiple regression coefficient estimate

Improved clones of Egyptian cultivar

By studying the multiple regression relationship, of improved clones of Egyptian garlic population, it was found that the best equation could represent it

$$\hat{Y} = 1.56 + 0.25^{**}X_1 + 1.51^{*}X_3 - 0.21^{*}X_4 - 0.3^{*}X_3^2 + 0.004^{*}X_4^2$$

Where this equation describes 99.45% of the total differences that exist in yield per plot. Also, it is clear from the equation that an increase in bulb weight and a decrease in cloves number per bulb, as well as an increase in the average clove weight up to a certain limit; reflects an increase in the crop, but with the continued increase in average bulb weight accompanied by a decrease cloves number per bulb leads to a decrease in the yield, because the increase in the average clove weight is not compensated by the decrease in cloves number. And based on what has been achieved; it can be concluded that the limiting factor to increase yield per plot in this population is the characteristic of cloves number per bulb, as this result agreed with what was reached when estimating the simple regression of the same features (Fig. 5, 7 and 8). Moreover, these results, also, confirmed the negative correlation between the two traits when estimating the correlation coefficient (r = - 0.73**). Based on the foregoing, it can be increased yield per plot of the improved clones of Egyptian garlic by increasing the average head weight, accompanied with an increasing average clove weight up to a certain extent. This is because of the large increase in the average clove weight will decrease cloves number per bulb, which causes the decrease in yield.

Based on the previous equation; cloves weight per bulb and the square effect for both cloves number per bulb and cloves weight per bulb were excluded due to their insignificance effects as well as their partial coefficient of determination (0.0002, 0.0001, and 10.0002), respectively.

Improved clones of Chinese cultivar

For the improved clones of Chinese garlic population, the best equation describing the relationship is

$$\hat{Y} = -7.01 + 0.2^{**}X_1 + 0.25^{**}X_3 - 0.19^{**}X_4 - 0.18^{*}X_3^2$$

The data of this equation reflected that yield per plot depends on the components of the equation at a percentage of 98.5%, where the yield increases with the increase in bulb weight and the increase in cloves number per bulb, as well as the increase in average clove weight with the significance of the squared effect of this trait. These results mean that with a large increase in average clove weight, yield decreases due to the lack of cloves number per bulb. This confirms the importance of this trait when selecting to increase yield, and this was indicated in the description of the relationships of simple regression as illustrated from Fig. 5, 7 and 8.

The square effect of bulb weight and cloves number per bulb, as well as the linear and squared effect of average clove weight trait, were excluded due to their insignificant effects where their partial coefficient of determination values were (0.0000, 0.0000, 0.0014, and 0.0004).

Garlic in general

Concerning the garlic population in whole, the best multiple regression equation relationship is

$$\hat{Y} = -2.34 + 0.24^{**}X_1 + 0.35^{**}X_3 + 0.08^{**}X_4$$

As the value of the coefficient of determination (0.985) indicates the strength of the relationship and it is a linear relationship. Where, with an increase in bulb weight, cloves number per bulb, and average clove weight; yield per plot will increase. Based on this, it can be confirmed through the equation that these components are among the most important components of yield, where the trait of average clove weight was excluded because there was no significant effect for it, which was estimated at 0.0003.

Similar findings have been reported by Dubey et al., 2010, Singh et al., 2011, Barad et al., 2012, Al Gehani and Kanbar, 2013 and Sable et al., 2020, who illustrated that production efficiency of cloves number and bulb weight of garlic positively improved yield.

CONCLUSION

The multiple statistical procedures which have been used in this study showed that the bulb weight, average clove weight, and cloves number per bulb were the most important variables for improving garlic yield. This was clear with all used statistical procedures; thus, the high yield of garlic can possibly be obtained by selecting genotypes that have these three variables.

REFERENCES

Al Gehani, I and A. Kanbar. 2013. Multivariant statistical analysis of bulb yield and morphological characters in garlic (*Allium sativum* L.). Australian J. Basic Applied Sciences. 7: 353 – 358.

Anwar, G.M., A.M. Ata, M.A. Mahmoud, A.R. Tawfek and O.F. Dakhly. 2017. Morphological and biochemical assessment of sixteen garlic clones cultivated in Egypt. Egypt. J. Plant Breed. 21: 820 – 836.

Barad, Y.M., K.B. Kathiria and K.G. Modha. 2012. Correlation and path coefficient studies in garlic (*Allium sativum* L.) over different environments. Vegetable Sci. 39: 79-82.

Dawood A.R., S.A. AbdElaal, A.S. Badawey and S.Y. Attallah .2011. Testing of some garlic (*Allium sativum* L.) cultivars under Assiut conditions. Assiut J. Agric. Sci. 42: 378 – 390.

Dubey, B.K., R.K. Singh and S.R. Bhonde. 2010. Variability and selection parameters for yield and yield contributing traits in garlic (*Allium sativum* L.). Indian J. Agric. Sci. 80: 737-741.

El-Mesirry, D.S and H.M. Radi. 2019. Effect of Clove Diameter and Plant Growth Regulators on Growth and Yield of Balady Garlic (Allium sativum L.). Alex. Sci . Exch. J. 40: 599-603.

Gadel-Hak, S.H., Y.M. Moustafa, G.F. Abdel-Naem and I.A. Abdel-Wahab. 2011. Studying different quantitative traits of some white-and colored-bulb garlic genotypes grown under drip irrigation system. Australian J. Basic and Applied Sciences. 596: 1415 – 1427.

Hyams, D. 2005. Curve Expert Version 1.37. A comprehensive curve fitting package for Windows.

Mostafa, H.H., W. Haiping, S. Jiangping, Z. Xiaohui and L. Xixiang. 2020. Genetic diversity among Chinese and Egyptian garlic (*Allium sativum* L.) germplasm accessions based on 19 morphological traits and 16 new microsatellite markers. Middle East J. Agriculture Research.

Omer, E.A and A.F. Abou Hadid. 1992. Evaluation of some lines of Chinese garlic comparing with Balady cultivar. Egyptian J. Hort. 19: 161 – 169.

Osaman, A.M and M.M. Moustafa. 2009. Horticultural and cytogenetical characteristics of some Egyptian and foreign garlic cultivars. Afr. Crop Sci. 9: 459 – 465.

Sable, S.V., D.T. Deshmukh, S.M. Ghawade and S.S. Rawat. 2020. Genetic variability and correlation studies in Garlic (*Allium sativum* L.). Int. J. Curr. Microbiol. App. Sci. 9: 358-363.

Sakr, A.M. 1996. Efficiency of clonal selection in Egyptian and Chinese garlic cultivars. M.Sc. Thesis Faculty of Agriculture Alex, Univ. Egypt.

SAS. 2007. SAS Institute, Inc. SAS Technical Report SAS/STAT Software; Changes and Enhancements Users Guide. Volume 2, Version 9.1.3, Fourth Edition, Cary, NC: SAS Institute Inc.

Singh, R.K., B.K. Dubey, S.R. Bhonde and R.P. Gupta. 2011. Correlation and path coefficient studies in garlic (*Allium sativum* L.). Journal Spices and Aromatic Crops.20: 81-85.

Zepeda, A. 1997. Number of cloves per bulb; selection criteria for garlic improvement. I. results with “Chileno” type. Acta Hort. 433: 265 - 270

الملخص العربي

الخصائص المورفولوجية للبصلة كدلائل انتخاب لتحسين إنتاجية الثوم

انتصار ابراهيم مسعود راغب، منى محمد حميد

تم فى هذه الدراسة تقييم ٢١ تركيب وراثى من الثوم، عباره عن عشرة سالات من الصنف المصري وتسع سلالات من الصنف الصيني الى جانب العشائر الاصلية من الصنفين، وذلك بهدف تقدير مدى التحسن في أربع صفات من مكونات محصول الثوم بعد ست دورات من انتخاب السلالة الخضرية. الى جانب ذلك تم تقدير معامل الارتباط المظهري بين هذه الصفات وبعضها البعض، مع دراسة علاقتها بالمحصول. إلى جانب ذلك تم تقدير علاقة الانحدار البسيط والمتعدد لتوضيح العلاقة بين المحصول للوحدة التجريبية والصفات الأربعه المدروسة. اجريت تلك الدراسة في مزرعة كلية الزراعة بمنطقة "أبيس" بجامعة الإسكندرية بمصر خلال موسم الشتاء ٢٠٢٠/٢٠٢١ باستخدام تصميم القطاعات العشوائية الكاملة بثلاثة مكررات. تضمنت الصفات المدروسة وزن الرأس ، ووزن الفصوص للرأس ، ومتوسط وزن الفص ، وعدد الفصوص للرأس ، والمحصول للوحدة التجريبية. أظهر اختبار T في مجموعتين تحسنًا معنويا بالنسبة لسمات الاربعة لمكونات المحصول، في السلالات المحسنة سواء من الصنف المصري أو الصيني. وقد اظهرت صفة المحصول ارتباطًا إيجابيًا معنويًا عاليًا مع وزن الرأس ، ووزن الفصوص للراس، ومتوسط وزن الفص. كما أشارت نتائج الانحدار المتعدد إلى أن اكثر من ٩٨٪ من التباين في المحصول يعتمد على وزن الرأس، متوسط وزن الفص، عدد الفصوص للرأس. بناءا على نتائج تلك الدراسة ، يمكن الحصول على محصول عالى من نباتات الثوم عن طريق الانتخاب لهذه الصفات الثلاثة المذكورة أعلاه.

الكلمات المفتاحية: صفات الرأس ، الارتباط ، التقييم ، الثوم، الانحدار.