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Research Article

Correlation and Path Coefficient Analysis in Garlic (*Allium sativum* L.) Under Mosul Conduction

Kamal Benyamin Esho*

Department of Horticulture and Landscape Design, College of Agriculture and Forestry, Mosul University, Iraq

***Corresponding Author:** Kamal Benyamin Esho, Department of Horticulture and Landscape Design, College of Agriculture and Forestry, Mosul University, Iraq.

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Abstract

The presented work is conducted at research farm for the vegetable plant, Department of Horticulture and Landscape Design, Agriculture and Forestry college, University. of Mosul, Throughout the autumn growing season 2018/2019, the major aim of this work is to determining the correlation as well as the path coefficient analysis in seven genotypes of garlic which were (Sinjari, Mankyshi, Iranian, Bakistani, lacal va., Kristal and Nader) collected from different origin and local market. The resulted indicated that the trait's mean squares have been highly considerable with regard to all traits indicating wide genetic variability between genotypes. The genotype local va. was best in leaf length, head diameter of height and head weight, also the number of leaves for each one of the plant while genotype Kristal gave a higher value in total yield ha-1 and biological yield. The result indicated significant and positive genotypic and phenotypic association between leaf length and the total yield, biological yield, T.S.S (Total soluble solid), weight, length and clove diameter showed negative correlation genotypic and phenotypic significantly with head length and number of cloves/head, while leaf's length through number of leaves plant-1, head diameter, clove's weight, and total yield showed maximum positive direct effects on total bulb yield. Clove diameter viz leaf length, biological yield, head weight, T.S.S, head diameter, number of cloves/head, clove weight, as well as clove length showed maximum indirect effect on the total yield per hectare.

Keywords: Correlation Coefficient; Clove Traits; Garlic; Path Analysis; Total Yield

Introduction

The garlic plant (*Allium sativum* L.) can be classified within class monocotyledon 2n = 16 and belongs to the Alliaceae family. The plant is rich in protein, phosphorus, potassium, calcium and carbohydrates and also considered as "Nectar of Life" in Ayurveda. A compound bulb contains the edible product of this crop. Cloves were utilized to flavor different non-vegetarian dishes. The importance of such species was increased due to its various medicinal properties [1]. In addition, the garlic plant shows high agronomic variations in size, colors for the bulb, height plant, size, and the number of the cloves [2,3]. The plant is vegetative propagated by cloves, and cultivars still bolt, garlic thus present and interesting problem as to origin of many varieties were, the difference in maturity, size of bulb, clove size, and number. The breeding works was very limited garlic. Yet, the yield is considered as one of the complicated traits and it was a complex direct improvement. The program breeding in garlic aims to increase the plant productivity, the yield, and yield components which have indirect or direct effects on the yield. Also, the path coefficient analysis provides a critical examination related to certain force actions for producing correlation and measuring the relative significance regarding all factors.

A study conducted by [4], throughout the path coefficient analysis specified direct impacts related to bulb diameter, bulb weight and indirect effects regarding plant's height, polar bulb diameter, the number of leaves for each one of the plants, equatorial bulb diameter, the amount of coves for each one of the bulbs and 50 cloves weight must be simultaneously considered with regard to the total yield's amenability. A lot of studies indicated that such factors have been impacting the bulb yield in garlic plants, also they were significant to improve bulb yield. The was positive correlation between bulb yield and the plant's height, number of leaves for each plant, diameter, and bulb weight [5-12]. A study conducted by [13] observed positive and significant correlation between to-

tal bulb yield ha^{-1}. Yet, with regard to combined analysis, there was no positive correlation regarding the number of cloves with bulb yield. A study carried out viz [14] specified that there were positive and significant correlations of the bulb yield per plant with the number of cloves for each bulbs (head) and showing that the selection regarding such traits might be efficient to enhance the yield regarding bulb $plant^{-1}$. A study carried out by [15] recorded that there have been significant and positive correlation of leaf's length with plant's weight, number of leaves per plant, and bulb diameter indicating that the selection regarding such traits might be efficient to improve the bulb yield for each plants. During path analysis bulb, the yield has been taken as the dependent variable, while the remaining traits are specified as independent variable. Also, the phenotypic path coefficient analysis specified that positive, as well as maximum direct effect on the bulb yield exerting number of cloves per bulb succeeded via the bulb weight, the amount of leaves for plant, total T.S.S (Total Soluble Solid), the height of plant and weight of clove, such traits are specified as the main components regarding the bulb yield [7]. Research conducted by [16] identified the genotypic and phenotypic, bulb yield has been positively and considerably correlation to the amount of cloves bulb and weight of ten uniform cloves, During the level of genotypes, there was a maximum direct effect as well as positive effect on the bulb yield which is exerted by the number of cloves per plant, succeeded via ascorbic acid. Also, the highest negative direct on the bulb yield succeeded via bulb's volume, the height of the plant at 90 days following sowing, T.S.S and weight of ten uniform cloves. Furthermore, significant amounts of indirect effect through the weight of bulb are identified for the diameter of bulb polar, clove's length, weight and the number of cloves for bulb [17].

The aim of this paper was to estimate the correlation and path coefficient analysis in garlic (*Allium sativum* L.) which was grown in the environment in Mosul city, Iraq.

Materials and Methods

This research is performed at a vegetable research farm, Horticulture and Landscape Design, Agriculture and Forestry College, University. of Mosul, throughout the autumn growing season 2018/2019, for studying the path coefficient analysis and correlation in (*Allium sativum* L.) The study contained seven genotypes from different sours (Table 1).

The cloves of each genotype was sowing at 24/9/2018, three lines were for each genotype, the length of line 1.5 (m), the distance between the line was 30 cm and between cloves in the line was 10 cm under drip irrigation system. utilizing design Randomized Complete Block Design (R.C.B.D.) along with total of 3 replicates for each genotype, while the recorded data were: leaf long(cm), number of leaves per plant, leaf area (cm^2), the biological yield per plant (gm), head weight (gm), head length (cm), head diameter (cm), number of cloves per each head, clove weight (gm), diameter and length of clove (cm), total soluble solid (T.S.S.) and total yield (ton/hectare). All data traits have been recorded as well as subjected using SAS statistical [18]. Correlation phenotypic and genotypic between bulbs, yield and yield components associated traits have been evaluated with the use of technique indicated via [19,20].

No.	Genotype	Sours
1	Sinjari	Sinjar, Ninevah, Iraq
2	Mankyshi	Duhok, Mankeash, kordustan region, Iraq
3	Iranian	Local market, Mosul, Iraq
4	Bakistani	Local market, Erbil, kordustan region, Iraq
5	Local va.	From private farm, Bashiqa, Ninevah, Iraq
6	Kristal	Local market Erbil, kordustan region, Iraq
7	Nader	Local market, Sulaymania, kordustan region, Iraq

Table 1: The sours for the garlic genotypes.

Figure 1: The garlic genotypes use in the study (1=Sinjari, 2= Mankyshi, 3=Iranian, 4= Bakistani, 5= Local va., 6= Kristal, 7= Nader).

Figure 2: The clove for the garlic genotypes.

Indirect and direct analysis effect over the total yield, the path coefficient analysis conducted among the traits, on the basis of genotypic correlation, path coefficient that indicates to indirect and direct effect regarding the yield attributing traits on the total yield (dependent characters) is evaluated based on a technique indicated via [21].

Results and Discussion

The aim of the plant breeding program regarding all crops was enhancing the current types of evolving a new type that is superior to existing ones. Collection of genotypes from different geographical origin and evaluation for assessing the extent of variability are the first step in any crop improvement program, as this offers a new broad genetic base population to make further selections.

Mean squares have been very considerable with regard to all the traits specifying various genetic variabilities between the genotypes (Table 2). Also the genotypes' performance in terms of such scope for selection indifferent traits for garlic yield and yield components improvement. The same results reported by [7,15,22-25].

Mean value of genotypes

Large amount of variability noted the mean values related to growth as well as yield parameters with regard to garlic leaf length (cm), leaves number plant^{-1}, biological yield (gm/plant), weight of the head (bulb), length of the head(cm), the diameter of head (cm), total soluble solid (T.S.S), number of cloves per each plant, diameter and length of clove (gm), and total yield (ton/hectare) related to seven garlic genotypes colleted from many areas northern part of Iraq. In this work, an evaluation of leaf length and number exhibited a wide range of variation between the genotypes which was 106.00 (cm) in Nadir genotype and 83.67(cm) in Mankyshi genotype. The genotypes exhibited considerable variation for the leaves per plant and it range between (8.33) to (13.33). The maximum leaves per plant was recorded in Local va. genotypes followed by Kristal and Iranian, Nader (11.33), while the minimum value in Mankyshi genotype (8.33). The biological yield exhibited sufficient variability ranged from 457.47 (gm) to 189.33 (gm). The maximum was recorded in Kristal (457.47 gm) and the minimum in Mankyshi genotype (189.33 gm). The genotype Local had the maximum value for head weight (79.73 gm), while the genotype Sinjari gave a minimum value (36.70 gm). the genotype Bakistani and Local va. had largest clove length (3.17) compared with the genotype Mankyshi which was a lowest clove length (2.57 cm). On the other hand the genotype Local va. had a largest value for head weight (79.73 gm), head length (4.93 cm), head diameter (7.10 cm), clove weight (6.67 gm) and clove length (3.17cm) compared with the genotype Mankyshi which gave a lowest value for head diameter, and clove length. The higher T.S.S value was in genotype Nadir (39.27%) followed by genotype Sinjari (32.70%), Kristal (31.07), Iranian (28.97), the lowest was in Bakistani (24.03%). The genotype Kristal gave a maximum total yield per hectare (3.02 ton/hectare) compared with the genotypes under the study, followed by Bakistani genotype (2.99), Iranian genotype (2.77) and Nader genotype (2.04) ton/hectare. The result of the present study are agreeing with [2,7-9,11,13,26-28], and these study reported significant variation between sexually derived families with regard to clove and bulb weight, number of leaves/plant, leave's length, number of clove head^{-1}, T.S.S, head traits as well as yield per area among garlic genotypes.

S.O. V	D. F	Mean square											
		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
Block	2	79.476	1.000	483.084	4.066	15.240	0.266	0.038	3.000	0.023	0.004	0.015	0.038
Genotypes	6	183.429**	8.206 **	30493.460 **	654.179**	74.143**	0.690*	1.298**	200.540**	7.215**	0.154*	0.581*	1.10**
Error	12	37.976	1.444	194.544	13.705	6.138	0.128	0.049	2.611	0.063	0.017	0.005	0.012
Total	20	300.9881	10.65	31171.088	671.95	95.521	1.084	1.385	206.151	7.301	0.175	0.601	1.150

Table 2: Anova table for the traits garlic genotypes at growing season 2018/2019.

X1 = leaf length(cm), x2 = number of leaves/plants, x3 = biological yield(gm/plant), x4 = head weight (g), x5 = T.S.S, X6 = head length (cm), x7 = head diameter (cm), x8 = number of cloves/head, x9 = clove weight (gm), x10 = clove length (cm), x11 = clove diameter (cm), x12 = total yield (ton/hectare). *, ** at 0.01%, and 0.05% for Duncan test.

Genotypes	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
Sinjari (local va.)	101.00 a	9.67bc	201.37e	36.70d	32.30b	3.77d	5.73c	36.00a	2.03e	2.87b	1.27e	1.91c
Mankyshi	83.67b	8.33c	189.33e	61.20b	25.63cd	4.93a	5.17d	16.33b	4.23d	2.57c	1.83d	1.98c
Iranian	101.33a	11.33ab	252.33d	74.00a	28.97bc	4.23b-d	6.50b	12.67c	5.77bc	3.00ab	1.83d	2.77b
Bakistani	100.67 a	10.00bc	325.00c	50.07c	24.03d	3.87cd	5.57cd	12.33c	6.20b	3.17a	2.73a	2.99ab
Local va.	107.00a	13.33a	303.09c	79.73a	29.43bc	4.93a	7.10a	16.33b	6.67a	3.17a	1.87cd	1.71d
Kristal	103.67a	12.00ab	457.47a	58.03b	31.07b	4.70ab	5.57cd	16.00b	5.33c	2.90b	1.97c	3.02a
Nader	106.00a	11.33ab	407.20b	50.53c	39.27a	4.50a-c	5.80c	15.33bc	5.43c	3.2a	2.17b	2.04b

Table 3: Averaged performance value in garlic genotypes at growing season 2018/2019.

X1 = leaf length(cm), x2 = number of leaves/plant, x3 = biological yield(gm/plant), x4 = head weight (g), x5 = T.S.S, X6 = head length (cm), x7 = head diameter (cm), x8 = number of cloves/head, x9 = clove weight (gm), x10 = clove length (cm), x11 = clove diameter (cm), x12 = total yield (ton/hectare).

Estimates of phenotypic and genotypic correlation variability

The correlation between total yield as well as the yield component and other quantitative characteristics allow to understand the traits' interdependence (Table 4). Leaf length shows significant and positive phenotypic relations with clove's length, the clove's weight, the diameter related to head (bulb), T.S.S, Biological yield, and with number of leaves/plant shows considerable and positive genotypic correlation with total yield, clove's length, clove's weight, diameter of the head, T.S.S, and biological yield, while amount of leaves/plant. In addition, the number of leaves for each plant has been an indication of the significant and positive phenotypic and genotypic correlation to clove's length, clove's weight, diameter of head, T.S.S, biological yield. and shows negative correlation and significant with number of cloves/head (bulb). Biological yield (gm/plant) indicated positive and considerable genotypic as well as phenotypic association to total yield, clove's diameter, the length of clove and T.S.S.

At the same time biological yield showing significant and negative correlation with number of cloves/head (bulb). There is positive and significant genotypic and phenotypic correlation between the clove's weight, diameter of the bulb(head), the length of the head while showing negative and significant correlation of phenotypic and genotypic correlation to the amount of cloves/bulbs as well as the genotypic correlation with T.S.S. In addition, T.S.S showed significant and positive genotypic correlation to total yield, length of clove, the number of cloves for each plant and showed a significant and positive correlation with the diameter of clove. The bulb's length indicated a significant and positively genotypic correlation with the clove's weight and exhibited significant and negative genotypic correlation with the total yield as well as the number of cloves for each plant. while the number of cloves/plants indicated negative as well as significant phenotypic and genotypic correlation with total yield, the diameter clove, the weight of clove, also the clove weight indicated significant and positive phenotypic and genotypic relation to the total yield, clove diameter and clove length. Furthermore, the length of clove shows considerable and positive phenotypic and genotypic correlation to the clove's diameter and total yield. The diameter of the clove shows significant and positive phenotypic and genotypic relation to total yield. This result recorded these attributes were high influencing improvement in yield of bulb in garlic. Selection of the yield might not be efficient as there might be the number of genes in terms of the bulb (head) yield, this might result in interactions between different components, the knowledge regarding relations between head yield as well as its components was vital and selection for components might indicate simultaneous changes in the other. Generally, the correlation value is between (-1.0 to 1.0), thus, in the case when the correlation coefficient value is more than 1.0 ; it might be due to fact in the case when covariance was overestimated, while variance was underestimated [29]. When the values are more negative such positive correlation among head yield and leaf length, biological yield, T.S.S head length, the diameter of head, number of cloves for each one of the plant, clove's weight, clove's length and diameter of clove, was reported earlier [5-17,24].

Analysis of path coefficient

Path coefficient analysis can be defined as one of the significant tools to partition the correlation coefficient into indirect and di-

Traits	Cor. Coef.	X12	X11	X10	X9	X8	X7	X6	X5	X4	X3	X2
x1	rp	0.246*	0.094	0.628**	0.304**	0.005	0.406**	-0.236	0.491**	0.022	0.512**	0.563**
	rg	0.652**	0.129	1.039**	0.412**	-0.004	0.765**	-0.173	0.561**	0.102	0.686**	1.061**
x2	rp	0.092	0.047	0.451**	0.498**	-0.253*	0.647**	0.184	0.404**	0.491**	0.482**	1.000
	rg	0.416**	0.082	0.832**	0.703**	-0.298*	0.895**	0.423**	0.308**	0.610**	0.668**	1.000
x3	rp	0.654**	0.477**	0.472**	0.496**	-0.404**	0.012	0.176	0.382**	0.009	1.000	
	rg	0.902**	0.499**	0.560**	0.506**	- 0.429**	-0.004	0.212	0.468**	0.001	1.000	
x4	rp	-0.173	0.057	0.064	0.661**	-0.587**	0.650**	0.573**	-0.255*	1.000		
	rg	0.075	0.074	0.148	0.719**	-0.628**	0.711**	0.705**	-0.262*	1.000		
x5	rp	0.230*	-0.240	0.253*	-0.169	0.228	0.080	-0.065	1.000			
	rg	0.634*	-0.288*	0.387**	-0.178	0.271*	0.133	0.108	1.000			
x6	rp	-0.234*	-0.027	-0.251*	0.315**	-0.384**	0.143	1.000				
	rg	0.473**	-0.043	-0.226	0.437**	-0.466**	0.188	1.000				
x7	rp	-0.220	-0.147	0.501**	0.470**	-0.114	1.000					
	rg	-0.362**	-0.151	0.596**	0.489**	-0.136	1.000					
x8	rp	-0.511**	-0.748**	-0.261	-0.868**	1.000						
	rg	0.747**	-0.765**	-0.312**	-0.898**	1.000						
x9	rp	0.379**	0.706**	0.548**	1.000							
	rg	0.876**	0.719**	0.637**	1.000							
x10	rp	0.361**	0.462**	1.000								
	rg	0.456**	0.527**	1.000								
x11	rp	0.619**	1.000									
	rg	0.994**	1.000									

Table 4: Coefficients of genotypic, phenotypic correlation between various pairs of the studied traits in garlic genotypes growing season 2018/2019.

X1 = leaf length(cm), x2 = number of leaves/plants, x3 = biological yield(gm/plant), x4 = head weight (g), x5 = T.S.S, X6 = head length (cm), x7 = head diameter (cm), x8 = number of cloves/head, x9 = clove weight (gm), x10 = clove length (cm), x11 = clove diameter (cm), x12 = total yield (ton/hectare)., *, ** at 0.01 and 0.05 Dunacn test.

Traits	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	genotypic correlation for the yield
X1	0.132	0.104	0.343	- 0.136	0.099	- 0.177	0.332	- 0.234	0.134	-0.056	0.068	0.443	0.652**
X2	-0.109	- 0.156	0.364	0.179	-0.112	0.332	-0.168	0.099	-0.214	0.135	-0057	0.123	0.416**
X3	0.333	0.353	0.343	0.245	-0.321	0.354	-0.332	0.368	-0.345	-0.321	-0.231	0.456	0.902**
X4	0.123	0.354	0.357	-0.289	-0.290	0.454	-0.321	-0.332	0.346	-0.203	0.43	-0.467	0.075
X5	-0.056	0.033	-0.104	-0.109	0.103	-0.068	-0.055	0.302	-0.043	0.110	0.222	0.299	0.634**
X6	0.124	-0.166	0.232	0.444	-0.111	-0.332	0.344	0.364	-0.301	-0.232	-0.103	0.210	0.473**
X7	0.221	0.135	0.333	-0.333	0.123	-0.143	-0.443	-0.133	0.032	-0.125	0.221	0.350	-0.274*
X8	0.100	0.054	0.210	0.234	-0.102	0.154	-0.099	-0.321	0.110	0.321	0.332	-0.246	0.747**
X9	0.057	0.045	0.443	-0.068	0.111	0.065	0.143	0.345	-0.143	-0.032	-0.124	0.134	0.876**
X0	0.011	0.035	0.216	-0.106	0.012	-0.231	-0.321	0.443	-0.068	0.110	0.055	0.300	0.456**
X11	0.134	0.022	0.359	0.432	0.130	-0.321	0.212	0.343	0.332	0.231	- 0.654	0.236	0.994**

Table 5: Path coefficient analysis for the traits on total yield for garlic genotypes at growing season 2018/2019.

X1 = leaf length(cm), x2 = number of leaves/plants, x3 = biological yield(gm/plant), x4 = head weight (g), x5 = T.S. S, X6 = head length (cm), x7 = head diameter (cm), x8 = number of cloves/heads, x9 = clove weight (gm), x10 = clove length (cm), x11 = clove diameter (cm), x12 = total yield (ton/hectare).

rect effect regarding independent variables on a dependent variable with inclusions regarding further variables in the correlation research in the case when their indirect relation become extra complicated, throughout such analysis total heads yield is taken as dependent variable traits have been specified as independent, path coefficient analysis is splitting the genotypic correlation coefficient regarding various characteristics for indirect and direct effects on the total bulb [4].

When two or more variables are included in the correlation studies, it becomes difficult to determine which traits enhance the yield. The technique of path coefficient analysis overcomes this situation which partitions the forces of association and examines, the relative contribution of direct and indirect effects of the independent variable on the dependent variable. The leaf length among the number of leaves/plant (0.104), the diameter of the head (0.332), clove weight (0.134), and total yield (0.443) had exerted maximum positive direct impacts on total bulb yield. In addition, the number of the leaves for each one of plants through biological yield (0.364), head weight (0.179), head length 90.332), clove length (0.135) had exerted maximum positive direct effects upon total bulb yield, head diameter via leaf length (0.221), biological yield (0.210), T.S.S (0.123), clove diameter (0.221) showed negative indirect impact on total yield. The diameter of clove through leaf length (0.134), biological yield (0,359), head weight (0.432), T.S.S (0.130), head diameter (0.212), amount of cloves/head (0.343), clove's weight (0.332), clove's length (0.231) had a maximum indirect effect on the total yield per hectare. Similar results were reported [4,5,9-14,17,24].

Conclusion

This research that all genotypes were significantly differ for all traits. The genotype local variety was best in leaf length, leaves number per plant, head diameter and weight, while the genotype Kristal gave a higher value in biological yield and total yield per hectare. The length of leaf via number of leaves/plant, the weight of clove, the diameter of the head, and total yield showed maximal positive direct effects upon total bulb yield.

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