NTU Journal of Agricultural and Veterinary Sciences (2025) 5 (2) : 157-163
DOI: https://doi.org/10.56286/fer1v321

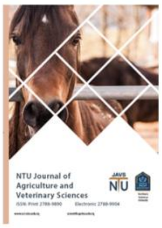
IRAQI Academic Scientific Journals

JAVS NTU

P-ISSN: 2788-9890 E-ISSN: 2788-9904

NTU Journal of Agricultural and Veterinary Sciences

Available online at: https://journals.ntu.edu.iq/index.php/NTU-JAVS/index



Study of Genotypic and Phenotypic Correlation and Path Coefficient for Several Entries of Spring Chickpea (*Cicer arietinum L.*)

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Article Information

Received: 30-09- 2024,
Accepted: 28-01-2025,
Published online: 28-06-2025

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Keywords:
genetic advance,
genetic variability,
heritability,
seed yield,
tillers,
Mosul

A B S T R A C T

The experiment was carried out using 20 genotypes obtained from the International Research Center (ICARDA) in addition to a local cultivar available in the local market, where the cultivation process took place in the research center of the Science College/ Mosul university during spring season 2019-2020 using random complete block design (R.C.B.D) To evaluate genetic variability, correlations, direct and indirect impacts between yield and yield components, path analysis, genetic variability, and correlations. Through studying the following characteristics: number of days until 50% of the plants flower, secondary branching branches/plant, height of first pod in cm, pods number per plant, number of seeds per pod, harvesting index, 100-grain weight (gm), biological yield gm, and grain yield per plant gm. The results showed that number of days for plants flowering at 50% and the number of main branches in a plant, as well as the secondary branches/plant, pods per plant, and 100-grain weight (gm), were found to have the highest genotypic and phenotypic coefficients of variation. Certain traits, including the number of seeds per pod, biological yield per plant, and harvest index, had a strong phenotypic and genetic link while others, like plant height, the secondary branches/plant, and the height of the first pod, did not approach the significant limit. Analysis of path coefficients (seed yield as a dependent variable) concluded that the number of seeds per plant, biomass yield, biological yield, number of tillers, and number of secondary branches in the plant had a beneficial direct impact on seed yield. When choosing the highest-yielding genotypes in chickpeas, it is crucial to consider factors like grain yield and seed weight in the pod where the phenotypic path coefficient was significant for certain traits and in the desired direction.

How to cite: Mohemmed, I. M., & Al-Mamary, H. A. (2025). *Study of genotypic and phenotypic correlation and path coefficient for several entries of spring chickpea (Cicer arietinum L.).* **NTU Journal of Agricultural and Veterinary Sciences, 5**(2),

Key findings: To assess relationships, genetic variability as well as the consequences of yield and yield components, both direct and indirect, a study on path analysis, genetic variability, and correlations was conducted. There are both direct and indirect effects from the link between yield and yield components. . Maximum coefficient of variation for both genotype and phenotype. Certain traits, such the number of seeds per pod, biological yield per plant, and harvest index, exhibit a strong phenotypic and genetic correlation. Other traits, like plant height, the secondary branches/plant, and the height of the first pod, did not reach the significant limit. For several variables, the phenotypic path coefficient was significant, and in the desired direction, grain yield and seed weight in the pod are crucial factors to consider when choosing genotypes with the highest yields in chickpeas.

INTRODUCTION

After dried beans and peas, chickpea (*Cicer arietinum* L.) is the second most important legume crop in the world. It is a significant source of food for humans and animals, but it also contribute to increased soil fertility and the provision of essential nutrients, particularly in drylands. [1]. Adding chickpeas to a grain-based rotation scheme can increase the productivity of the entire cycle, which is especially popular in developing nations [2]. This breaks the cycle of disease and gets rid of pests[3]. The global production of coarse grains in 2022 amounted to 1.462 million tons After reducing forecasts by about 5 million tones, as of current present, a 3.1% drop from the level observed in 2021 is anticipated.

Chickpea is the third-most important pulse crop produced in the world, with a global production of 11.67 million tons annually 12. The main producer countries are India, Turkey, the Russian Federation, Myanmar, Pakistan, Ethiopia, the United States, Australia, Canada, and Mexico[4] Chickpea, mostly grown in underdeveloped countries, can be added to the cereal crop rotation to break the pest and disease cycle and increase the overall productivity of the rotation[3]. India remains the world's top producer of chickpeas, accounting for 70% of the crop's area and 67% of its production worldwide. Thus, it comes in third place among pulses and its product, accounting for 12% of global production. The crop known as chickpea (*Cicer arietinum L.*) self-pollinates. In every region of India, chickpeas are primarily grown as a rainfed crop (68 percent of the total area) [5].Chickpeas were grown on 10.76 million hectares of land in 2017–18, yielding 11.20 million tons of product and 1032 kg/ha of productivity. The degree of genetic diversity present in the breeding material and the heritability of the yield component traits over generations determine how much crop production may be improved. Therefore, genetic variability can be used to choose appropriate parents. However, because quantitative features are susceptible to environmental influences, effective breeding programs require the division of overall variations into heritable and non-heritable components [6]. Character variability cannot be used as a deciding element to determine which character demonstrates the greatest degree of variability. Though since the estimates of heritability, expected genetic advance, and genotypic and phenotypic coefficient of variation are useful for improving yield, the relative values of these variables provide insight into the amount of variability found in a population. The aforementioned values were estimated to determine the extent of improvement in chickpea genotype yield. Direct selection based solely on yield may not be profitable because yield is a complex trait that is impacted by numerous environmental conditions. Consequently, it's critical to have a fundamental grasp of the type and strength of the link between yield-related component features. Identifying the critical characteristics that influence the dependent trait—such as seed yield—as well as the selection criteria needed to simultaneously increase a variety of attributes and provide an economic yield[7]. Chickpeas are grown on about 655,700 hectares in Turkey. According to SIS (2002), 650,000 tons of chickpeas are produced annually with a yield of 991 kg. Due to the mild temperatures and winter rainfall in the Mediterranean region, chickpeas are typically a spring crop. This causes the crop to suffer from heat and drought stress as it matures, resulting in poor and inconsistent yields.

Researches implemented by scientists who relied in their research on the use of hybrid chickpea plants that are not genetically modified contains good quantities of materials that cosmetic companies can use to manufacture materials that prevent wrinkles i.e Korean DumiDang Chickpea Essence Toner, and Chickpea DIY Mask and some of baby creams, because it is less allergenic than soybeans as a milk substitute [3].The results of [8]. showed that there are relationships between the seed yield, the number of seeds, and the number of pods/plant, and it is discovered that the most crucial characteristics for the quantitative calculation of chickpea seed output per hectare were grain and plant biological yield [9,10]. stated that the biological yield and harvest index were the main direct factors in seed yield, as demonstrated by correlation and path coefficient analysis, the correlation analysis revealed a negative relationship between plant height and harvest index. In additionally, there was a positive correlation between the total number of pods and 100-grains weight[11].According to [12], progress has been noted in the primary and secondary numbers of branches, respectively, and the percentage is linked to varying heredity between low and medium, they also mentioned that the environment had a big impact on these characteristics. Days to flowering, number of secondary branches, and weight of 100 seeds were discovered by[13]. The weight of 100 seeds showed a high genetic and phenotypic correlation and path analysis also indicated that the number of pods for each plant and the weight of 100 seeds had an effective role in the grain yield of the plant, the harvest index and the biological yield were the most important contributors to the seed weight, either directly or indirectly. Verma *et al* [14],reported that the 100-grains weight, and grain yield of a plant. The plant and the number of primary and secondary branches had a significant impact on plant production. In addition, the weight of seeds per plant and the quantity of pods per plant showed a strong association. According to Güler *et al.*[8] relationship between seed yield for each plant were shown to have a significant and positive association. The quantity of seeds and pods produced by each plant. The authors discovered that the most frequently reported correlation was between the plant's seeds and biological yield, and a path coefficient analysis revealed a relationship between harvest index and biological yield. These two factors have the greatest direct effects on seed output. However, this is following the correlation analysis's findings. [15]. Plant height and the yield index exhibited a negative association, but some pods displayed a positive correlation with whole seeds [14]. The objective of this study was to estimate the overall genetic variance and correlations, along with performing pathway analysis, which are crucial selection factors for enhancing production in chickpeas.

MATERIALS AND METHODS

The study was conducted at the College of Science /Mosul University in Iraq: During the growing season 2019-2020, twenty genotypes provided by ICARDA (International Center for Dry Agriculture) ,plus a local cultivars (Table 1) were used as plant materials. Seeds of each genotype were planted in three rows of four meters each, with a fifty centimeters between each row and twenty centimeters inside it, using a randomized complete block design (R.C. B. D). All agricultural procedures were followed as advised for the production of chickpeas. For the sole purpose of recording data on the following qualities, five plants were chosen for each phenotype: The number of days until 50% of the plant flowering, number of secondary branches /plant, the first pod height (cm), the number of pods per plant, and the number of seeds per pod Grain yield per plant (gram), selection index, biological yield (gm), and 100-grain weight (gm). To find the phenotypic, genotypic, and environmental variance as well as the coefficient of variation, the samples were processed to an analysis of variance using the formula proposed by [16, 17]. This study set out to assess the effectiveness of 20 novel inputs obtained from ICARD, as Table 1 illustrates as compared with the local variety. where the soil was mowed using disc harrows and the ground was tilled using a ploughing disc plow where the twenty- Between the dates of 23 and 12 of 2014, in the context of a demographic experiment, two lines measuring 4 meters in length, with 50 centimeters separating each line from the next and 20 centimeters separating hole in the soil from the other, were used as the experimental unit in three replicates of the random segments full RCBD design. Luria (N percent 46) was applied as fertilizer at an average rate of (120 kg / e) in the first two stages following germination and the second at the start of the flower-holding stage. Five randomly selected plants from the experimental unit were used for the experiments, which were conducted at the end of the growth season. After the experimental unit plants were harvested, the yield was calculated by counting the number of days needed for 50% of the plants to flower, measuring the plant height in centimetres, the total number of plants, the Qurna length in kilograms per hectare, the dry seed yield in kilograms per hectare, the harvest index in percentage, and the weight of 100 seeds (g). Utilizing the SIS [18] program, the data were statistically analyzed in accordance with the design of the full random sectors (R.C.B.D.). Genetic, phenotypic, and environmental variables were evaluated based on their explanations [19].

Table 1. Numbers, Names, and Pedigrees genotypes of chickpea

Pedigree	Genotypes	S.NO.
X03TH-29/(S99858XFLIP97-26) XS00432	FLIP07-180C	1
X02TH 61/S99520XL.Mt-1	FLIP07-193C	2
X05TH7/X04TH-126XFLIP01-18	FLIP09-63C	3
X05TH64/X04TH-202XFLIP00-17	FLIP09-88C	4
X05TH64/X04TH-202XFLIP00-18	FLIP09-97C	5
X05TH64/X04TH-202XFLIP00-19	FLIP09-113C	6
X05TH64/X04TH-202XFLIP00-20	FLIP09-114C	7
X05TH64/X04TH-202XFLIP00-21	FLIP09-122C	8
X05TH64/X04TH-202XFLIP00-22	FLIP09-220C	9
X05TH64/X04TH-202XFLIP00-23	FLIP09-221C	10

X05TH64/X04TH-202XFLIP00-24	FLIP09-222C	11
X05TH64/X04TH-202XFLIP00-25	FLIP09-223C	12
X05TH64/X04TH-202XFLIP00-26	FLIP09-224C	13
X05TH64/X04TH-202XFLIP00-27	FLIP09-225C	14
X05TH64/X04TH-202XFLIP00-28	FLIP09-226C	15
X05TH64/X04TH-202XFLIP00-29	FLIP09-227C	16
X05TH64/X04TH-202XFLIP00-30	FLIP09-228C	17
X05TH64/X04TH-202XFLIP00-31	FLIP09-230C	18
X05TH64/X04TH-202XFLIP00-32	FLIP09-231C	19
X05TH64/X04TH-202XFLIP00-33	FLIP09-232C	20
Local check variety	Duhok variety	21

Statistical analysis

Using a randomized complete block design (R.C.B.D), an analysis of variance was performed for the qualities under study and according to what was reported by[20]. The correlation coefficients, genetic (rG), environmental (rE), and phenotypic (rP) between the studied traits were estimated in the manner explained by [21], according to the following equations:

rG= ، rP = *rE*=

As indicated in Table 1, the study was conducted to assess the effectiveness of 20 novel inputs obtained from the International Center for Dry Agriculture (ICARD).

RESULTS AND DISCUSSION

The findings of the analysis of variance for the genotypes of the investigated traits are shown in Table 2. Except for the number of pods per plant, the harvest index, and the weight of one hundred grains, which did not reach the level of significance, the table demonstrated significant differences between the genotypes at the 1 percent significance level for most of the traits. This leads us to the conclusion that genetic behavior needs to be investigated to genotype the subjects. The number of pods in each plant was positively and significantly correlated with both genotype and phenotypic traits.

Table 2. Mean square of variance analysis for studied traits in chickpea.

S.O. V	d.f	Days to 50% flowering	Plant height (cm)	No. of primary branches per plant	No. of second branches per plant	First height pod (cm)	No. pods per plant	No. seed per pod	Biology yield of Per plant	Grain yield of Per plant	Harvest index %	100-grain weight (gm)
Replication	2	5.762	1.714	0.008	87.246	1.440	2407.284	0.146	953.581	1184.736	3314.336	5.168
Genotype	20	** 197.071	** 48.537	** 1.024	** 230.100	** 45.276	n.s. 614.419	** 0.205	** 2213.293	** 470.206	n.s. 655.777	n.s. 174.356
Error	40	76.662	8.575	0.211	42.430	6.197	474.265	0.052	640.596	88.550	311.030	86.546

**Significance at 0.01probability levels respectively.

Table 3. shows the values of the genetic correlation equations (upper part) for the traits studied in the spring chickpea, where the characteristic of the days number for 50% flowering showed a positive correlation with the grain yield trait and the number of secondary and main branches of the plant, but it did not reach the significant limit, while the correlation was negative for this trait In each of the grain yield per plant, the weight of 100 grains, the biological yield, the number of seeds per pod, the number of pods per plant, the height of the first pod, and the height of the plant. As for the characteristic of plant height, the correlation of this trait was positive and significant at the level of 1% for the characteristic of the height of the first pod, and it was positive, but it did not reach the limit of significance in the rest of the traits, except for the biological yield's characteristic, where it had a negative and non-significant correlation.

Table 3. Estimates of genotypic (g) and phenotypic (p) correlation coefficient for 10 quantitative characters in 21 genotypes of chickpea.

Characters	r	Grain yield of a plant	100-grain weight (gm)	Harvest index %	Biology yield of a plant	No. seed per pod	No. pods per plant	Pod first height	No. of second branches per plant	No. of primary branches per plant	Plant height (cm)
Days to flowering 50%	G	-0.082	-0.006	0.123	-0.195	-0.043	-0.105	-0.015	0.006	0.039	-0.014
	P	*-0.268	-0.048	0.184	-0.515	-0.123	*-0.235	-0.103	0.011	0.077	-0.015
Plant height (cm)	G	0.066	0.079	0.078	-0.070	0.116	0.075	**0.328	0.142	0.077	
	P	0.062	0.126	0.048	-0.065	**0.424	*0.240	**0.739	**0.530	**0.334	
No. of primary branches per	G	0.040	0.065	0.045	-0.047	0.010	0.102	0.126	0.138		
	P	0.057	0.112	0.013	-0.081	0.093	0.230	*0.284	**0.525		

plant								
No. of second branches per plant	G	0.049	0.034	0.038	-0.064	0.084	0.165	0.178
	P	0.171	0.044	0.076	-0.070	*0.304	**0.579	**0.391
Pod first height	G	-0.012	0.019	-0.051	-0.002	-0.012	0.087	
	P	0.032	0.069	0.002	-0.070	0.032	0.047	
No. pods per plant	G	0.097	0.045	0.086	-0.022	0.054		
	P	0.217	0.239	-0.093	0.197	0.233		
No. seed per pod	G	0.158	-0.110	0.114	0.022			
	P	**0.430	-0.090	0.155	0.153			
Biology yield of plant	G	0.156	-0.124	-0.072				
	P	**0.376	-0.061	**-0.487				
Harvest index %	G	0.113	-0.025					
	P	**0.561	0.072					
100-grain weight (gm)	G	-0.025						
	P	0.072						

The main branching number exhibits a positive and insignificant correlation for all traits except for the biological crop trait, which had a negative correlation with the trait. And for the number of secondary branches, where showed a positive non-significant correlation with all purebreds, except for the biological yield's characteristic with a negative correlation. And the characteristic of the first pod height, as this characteristic was associated with a positive and insignificant correlation for several characteristics such as the weight of 100 grains and the number of pods per plant, and negative for the rest characteristics. As for the pods number, there was a positive and insignificant correlation for all traits except for the biological yield's characteristic, which had a negative correlation. As for the number of seeds per pod, it had a positive and insignificant correlation for all traits except for the 100 seeds weight, which had a negative correlation. The characteristic of the biological yield was positively and non-significantly correlated with the grain yield trait, and negatively and insignificantly with the weight of 100 grains [22]. And as for the harvest index, it was associated with a positive non-significant correlation with the grain yield of the plant, and a negative one with the weight of 100 grains [14]. As for the weight of 100 grains, there was a negative correlation with grain yield only. Table 3. shows the values of the phenotypic correlation coefficients in the lower part of the traits studied in the spring chickpea, in which a positive phenotypic correlation was noted for the the number of days for 50% flowering, harvest index, the number of secondary and primary branches in the plant, while the correlation of this trait was negative and significant for grain yield per plant and the pods number. The plant height characteristic, showed a positive and significant correlation at the probability level of 1% for each of the number of grains in the pod, the first pod height, and the number of secondary and primary branches in the plant. The number of pods in the plant was positive and significant at 5%, and some traits showed a wave correlation, but did not reach the significant limit for each of the grain yield, the weight of 100 grains, and the harvest index, while it showed a negative and insignificant correlation for the plant biological yield. As for the main and secondary branches number of the plant a positive and significant correlation was shown at the probability level of 1%, and the primary pod high at the level of probability 5%. As for the number of secondary branches in the plant, showed a positive and significant correlation with the number of pods in the plant and the length of the primary pod, at the level of probability 1% and significant at the level of probability 5% for the characteristic of the number of seeds in the pod [23], and it did not reach the limit of significance for the rest of the traits, except for the biological yield's characteristic, which was associated with a negative correlation with this trait but it did not reach the significant limit. For the characteristic of the first pod height, all the characteristics were positively and non-significantly associated, except for the biological yield's, which had a negative correlation. For the number of pods per plant, the biological yield, the weight of 100 grains, and the number of pod grains showed a positive correlation, while a negative correlation was associated with the characteristic of the harvest index. The characteristic of the number of grains in the pod was associated positively and significant correlation at the level of probability of 1% with the characteristic of grain yield per plant, and the significant limit did not reach the characteristic of the harvest index and the biological yield of the plant, while a negative correlation was associated with the weight of 100 grains. As for the characteristic of the biological yield of the plant, a positive and significant correlation was associated at the level of 1% with the characteristic of the grain yield of the plant, and the other was negative with the characteristic of the harvest index, while a negative and insignificant correlation was associated with the characteristic of the weight of 100. For the characteristic of the harvest index, as was associated with the two traits, the grain yield of the plant and the weight of 100 grains, one of which was significant at the probability level of 1%, and the other was not significant. Two traits mean that the genetic improvement of one trait will be associated with the genetic improvement of the other trait and vice versa. The results of this study are mostly agree with some studies in some of their findings [24, 25, 26, 27]

The number of tillers directly affected grain yield (Table 4), although it had less of an impact on the plant's secondary branches, the number of seeds per pod, the number of pods per plant, and the weight of one hundred grains, according to the phenotypic and genetic path coefficient analysis. The number of spikes and number of grains per spike have a direct, positive, and significant impact on grain yield, according to an analysis of the coefficient of the genetic route of five genotypes of coarse wheat. Arshad *et al* [12] shown that the length of the spike has a direct and higher correlation with phenotypic and genetic path analysis during their investigation of thirty genotypes of bread wheat.

Table 4. Direct (Diagonal) and indirect effects of component traits attributing to seed yield in 21 genotypes of chickpea.

Traits	No. of primary branches per plant	No. of second branches per plant	No. pods per plant	No. seed per pod	100-grain weight (gm)
No. of primary branches per plant	0.028	0.004	0.0003	0.003	0.002
No. of second branches per plant	0.003	0.019	0.002	0.003	0.001
No. pods per plant	0.008	0.014	0.005	0.084	0.004
No. seed per pod	0.002	0.013	0.150	0.008	-0.017
100seed weight (gm)	-0.001	-0.001	0.002	-0.001	-0.015
Rg	0.040	0.049	0.158	0.097	-0.025

The phenotypic correlation's direct and indirect effects are also shown in Table 5, The limits of direct and indirect pathway coefficient effects as mentioned by [28], are as follows: 0-0.09 neglected, 0.1-0.19 low, 0.20-0.29 medium, 0.30-0.99 high, more (than 1 very high), where the trait of the number of seeds per pod exhibited a direct and positive correlation with the number of pods per plant, while the other traits showed a less direct effect that varied between the group of traits' positive and negative indirect effects. This information can be utilized in breeding programs. choosing varieties that yield a lot of springtime chickpea seeds [29].

Table 5. Direct (Diagonal) and indirect effects of component characters attributing to seed yield in 21 genotypes chickpea.

Traits	No. of primary branches per plant	No. of second branches per plant	No. pods per plant	No. seed per pod	100-grain weight (gm)
No. of primary branches per plant	**-0.005**	-0.003	-0.001	-0.001	-0.001
No. of second branches per plant	-0.012	**-0.023**	-0.007	-0.013	-0.001
No. pods per plant	0.026	0.066	0.027	**0.114**	0.027
No. seed per pod	0.039	0.127	**0.419**	0.097	-0.038
100-grain weight (gm)	0.009	0.004	-0.008	0.020	**0.084**
Rp	**0.057**	**0.171**	**0.430**	**0.217**	**0.072**

Conclusions

The study shows a significant and positive relationship among some of studied traits. These traits contribute significantly to obtaining a high seed yield, increasing the number of pods and 100 seeds weight per plant. These standards are considered essential in improving genotypes synthesis. Consequently, it assists in getting high-quality products.

Competing Interests

The authors declare that there are no competing interests

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