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Correlation and Path Coefficient Analysis in Some Varieties of Phaseolus (*Phaseolus vulgaris* L.)

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Abstract: ***The experiment was carried out at vegetable research farm, horticulture and landscape design, college of agriculture and forestry, Mosul university, during growing season spring 2019, the goal of this study was to determine the correlation and path coefficient analysis in 12 genotypes of common bean, The genotypes were planting in a randomized complete block design with three replications. The results indicated highly significant (P < 0.05) difference between 12 genotypes for all traits which were plant height, number of branches per plant, green pod length, green diameter pod, pod weight, number of seeds per pod, seed length, seed diamete, weight of 1000 seeds, seeds yield per plot, seed yield per plant and total seeds kg per hectare. The result recorded higher positive significant genotypic and phenotypic correlation between the number of pods per plant and the seeds yield per plant, pod length, number of seed per pod, also the result showed that the weight of pod was higher positive significant with the number of seed per plant and pod length, the total dry weight seeds yield gave a higher correlation positive significant with the number of pod per plant, seeds yield per plant, seeds weight per plant and the number of seeds per pod. In the other side there was a positive path coefficient analysis within the total seed yield per donum and number of pods per plant, seeds weight per plant, 1000 seeds weight, and number of seeds per pod, while the result recorded a positive path coefficient analysis among total seeds yield per donum among green diameter pod, pod weight, seed diameter, weight of 1000 seeds and seeds yield per pod, and indirect effects trough number of pods per plant and number of seeds per pod***

Keywords: Correlation, Path Analysis, Phaseolus, yield, Dry seed

1. Introduction

The common bean (*Phaseolus vulgaris* L.) is a diploid (2n= 2x = 22) and predominantly self-crossing species although 3% or more out crossing rate has also been observed (Ibarra –Perez *et al*., 1997). It is an herbaceous plant that grown around the world for food as fresh (green pods) and dry seeds. Over a period of 7000 years common bean evolved from a wild plant into one of the main crops legumes, the domestrication of wild bean occurred the regions of Middle America and the Andes of South America independently (Kapland and Lynch, 1999). It is the most important food fabacea in the world (Ciat, 2001), dry common bean also called field bean, French bean, kidney bean common bean etc. is one of the most important fabacea crops in the world. The phaseolus plant given that most protein consumed by the poor is from plant sources, being protein rich, it play an especially significant role in the human diet (Yoseph *et al*., 2014). It has high levels of minerals mainly iron and zinc (Carvslho, *et al*., 2012). Use of genetic resources as old as the history of agriculture, hundreds of plants have been bred over many hundreds of years and thousands varieties have been developed by natural and artificial selection (Sari *et al*. 2008, Zarei *et al*. 2012). The large spectrum genetic variability in segregating populations depends on the level of genetic diversity among genotypes offer better scope for selection, A successful breeding programmed in common bean would need information on the nature and degree of genetic divergence in the available stock for choosing the right and best parents for further improvement. Genetic diversity can be evaluated with morphological traits, seed protein, isozymes and DNA markers conventionally (Vidyakar, *et al*., 2017).

Seed yield is affected by genotype and environmental factors because it is a quantative traits, therefore, generally, seed yield has a low heritability. Using as selection criteria of traits direct relationship with seed yield increase the success of selection in plant breeding. Correlation analysis describes merely the mutual relationship among different pairs of traits without providing the nature of cause and effect relationship of each trait. Hence, the path analysis was also performed to determine the direct and indirect contribution of each trait to seed yield (Berhe et al., 1998). Breeder who needs to specify the basics of selection should determine the impact factors and the degree of relationships among yield components (Torun and Koycu, 1999). Many previous researches indicated that the seed yield was positively associated with number of pods per plant, number of seeds per pod, and seed yield per plant (Halvecioglu and Sehirali, 2001; Peksen and Gulumser, 2005; Karasu and Oz, 2010; Lobato *et al*., 2014 ; Alemu *et al*. 2017 and Bagheri *et al*. 2017). Esho (2019) indicated that there were higher positive significant genotypic and phenotypic correlation coefficients between total dry seeds yield with the plant height, seeds weight per plot seed diameter and 100-seeds weight.

The aim of this study was to study the correlation among seed yield and its components and to determine direct and indirect effects of certain yield components on seed yield.

2. Materials and Methods

This experiment was carried out during spring season 2019 at the field vegetable experiments of department of horticulture and landscape design, college of agriculture and forestry, Mosul University to study the Correlation And Path coefficient analysis in Common Bean (*Phaseolus vulgaris* L.). The experiments materials consisted of 12 genotypes of common bean (table 1).

Table 1: List of phaseolus genotypes used in the experiment

S.No.	Genotype	Source
1	Iranian	From local marker (Sulaimania), Kurdistan Iraq
2	Iranian	From local marker (Sulaimania), Kurdistan Iraq
3	Brinco	From local marker Mosul, (Turkish)
4	Strick	From local marker Mosul, (Netherlands)
5	line 3 K.M. Ph -22	Esho 2019
6	Bar-245	From local marker Erbil Kurdistan Iraq .(French)
7	American	From local marker (Erbil), Kurdistan Iraq
8	Brs- Pitango	From local marker (Erbil), Kurdistan Iraq (Iranian)
9	Line 5 K.M. Ph. 28	Esho 2019 . College of Agri. & Fors. Mosul University
10	Line 6 K,M Ph. 33	Esho 2019, College of Agri. & Fors. Mosul University
11	Line 8 K.MPh 31	Esho 2019, College of Agri. & Fors. Mosul University
12	Line 4 K.M Ph. 35	Esho 2019, College of Agri. & Fors. Mosul University

The seeds of the genotypes were sowing at 15/ 3/ 2019 in rows of 1.5 m length and 30 cm with an approximate plant to plant distance of 15 cm (20 plants per plot). Using randomized complete block design (R.C.B.D.) with three replicate for each genotype possesses 12 plots. All other necessary cultural such as fertilizing, weeding and cultivation were applied to all plots uniformly. The data were recorded for the traits. Vais: plant height (cm), number of branches per plant, number of pods per plant, length and diameter of pod (cm) number of seeds per pod, length and diameter of seed (cm), 1000 seeds weight (gm), seeds weight per plats (gm), seeds yield per plant (gm) and total seeds yield per hectares.(ton). All the agronomic data were recorded and being subjected to analysis using the SAS statistical software (SAS, 2007). Phenotypic and genotypic correlation between seeds yield and yield related traits were estimated using the method described by Miller *et al.* (1958). For the analysis of direct and indirect effects over seeds yield it was carried out path analysis among traits, with estimates obtained by means of regression equations, where triats are previously standardized, by using the method described by Crus (2013).

$$\text{Phenotypic correlation (rp)} = \frac{\text{Phenotypic covariance of traits x and y}}{\sqrt{(\text{Б}^2 \text{ ph x}) \times \text{Б}^2 \text{ ph y})}}$$

$$\text{Genotypic correlation (rg)} = \frac{\text{Genotypic covariance of traits x and y}}{\sqrt{(\text{Б}^2 \text{ g x}) \times \text{Б}^2 \text{ g y})}}$$

where, σ2phY = phenotypic variance for character Y, σ2ph X = phenotypic variance for character X, σ2g X = genotypic variance for character X and σ2g Y = genotypic variance for character Y.

Based on genotypic correlation, path coefficient which refers to the direct and indirect effects of the yield attributing traits (independent character) on green pod yield (dependent character) was calculated following the method given by (Dewey and Lu 1959) as follows:

rij = Pij + Σ rikpkj, where, rij = mutual association between the independent character (i) and dependent character (j) as measured by the genotypic correlation coefficients, Pij = direct effects of the independent character (i) on the dependent variable (j) as measured by the genotypic path coefficients, and Σrikpkj = summation of components of indirect effects of a given independent character (i) on a given dependent character (j) via all other independent traits (k). The residual effect, which determines how best the causal factors account for the variability of the dependent factor, yield, was obtained using the formula:

1=p2R + Σ pijrij, where, p2R is the residual effect and Σ pijrij is summation of the product of direct effect of any variable and its correlation coefficient with yield.

3. Results and Discussion

Table (2) showed the analysis of variance for 13 characters in genotypes of phaseolus during growing spring season 2019. indicated highly significant (P < 0.05) difference between 12 genotypes for all traits which were plant height, number of branches per plant, green pod length, green diameter pod, pod weight, number of seeds per pod, seed length, seed diameter, weight of 1000 seeds, seeds yield per plot, seed yield per plant and total seeds kg per hectare . Many research reported in there studied, there was significant differences between genotypes of phaseolus in vegetative growth trait and for yield and yield components. (Santalla *et al.*, 2004 ; Yoseph *et al.*, 2014 ; Darkwa *et al.*, 2016 ; Alemu *et al.*, 2017 ; Bagheri *et al.*, 2017; Esho, 2019) .

Table (3) showed the phenotype coefficient correlation among the 12 traits in common bean genotypes . plant height had negative and highly significant (P < 0.01) correlation with seeds yield plant, 1000 seeds weight, seed diameter, pod weight, green diameter pod and number of pod per plant. The number of branches per plant had negative and highly significant (P< 0.05) correlation with seeds yield per plot, weight of 1000 seeds; seed diameter and seed length. The number of pod per plant had positive significant correlation with seeds yield plant and was negative significant correlation among seeds yield per plant, number of seeds per pod and with green pod length. In table 3 there was a positive high significant correlation between green pod length and number of seeds per pod, and it has a negative coefficient correlation with most characters. Green diameter pod had positive significant coefficient correlation with total dry seeds yield per donum, seeds yield per plot, weight of 1000 seeds, seed diameter, and pod weight, and it has negative correlation with number of seeds per pod . The pod weight had a positive coefficient correlation with total seeds yield per donum . Also the table showed a positive high coefficient correlation between seed diameter and total dry seeds yield per donum, seeds yield per plant and with weight 1000 seeds . Weight of 1000 seeds had negative and highly coefficient correlation with total dry seeds yield per donum, seeds yield per plant and seeds yield per plot.

Table (4) showed the genotypic correlation between the yield and yield component in common bean, from the table the plant height had had positive and highly significant correlation with most traits excepted with green pod length which was a negative coefficient correlation. Number of branches per plant gave a negative high significant correlation with most traits. The same result for the number of pods per plant and green length of pod. The trait green diameter of pod had a positive significant correlation with total dry seeds yield per donum, seeds yield per plant, seeds yield per plot, weight of 1000 seeds, seed diameter and with pod weight. Pod weight gave a high positive significant coefficient correlation with total dry yield per donum, weight of 1000 seeds and seed diameter. The number of seed per pod exhibited a negative significant correlation with all traits under the study. Seed length was correlation with seed diameter significantly and positive. Seed diameter had a positive high significant correlation with most traits. Weight of 1000 seeds had positive high significant correlation with total dry seed yield per donum, seeds yield per plant and seeds yield per plot. A lot of genotypic correlation coefficient characters were significant than corresponding phenotypic correlation (table 3) values, this indicates that the traits are inherited. The importance of genotypic and phenotypic correlation and its use has been selection by a number of researchers Cabral *et al.*, 2011 ; Onder *et al.*, 2013; Negahi *et al.*, 2014 ; Ejara *et al.*, 2017; Bagheri et al., 2017; Alemu *et al.*, 2017 and Esho, 2019), recorded the same result for the phenotype coefficient correlation between the traits yield and it's component of phaseolus.

Table 2: ANOVA analysis for traits in phaseolus genotypes during growing spring season 2019

S,O. V.	d.f	Mean square												
		Plant height (cm)	No. of branches/ plant	No. of pods /plant	Green Pod length (cm	Green diameter pod (cm)	Pod weight (g)	No. of seeds/ pod	Seed length (cm)	Seed diameter (cm)	Weight of 1000 seeds (g)	Seeds yield /plot (g)	Seeds yield /plant (g)	Total dry seeds (kg/donum)
Block	2	49.568	0.031	3.420	0.173	0.001	0.001	0.083	0.002	0.001	1020.528	5385.028	3.070	6875.33
Genotypes	11	720.835**	0.924**	22.819**	5.209**	0.035**	0.019**	2.242**	0.005**	0.035**	10428.331**	19292.998**	48.152**	26577.443**
Error	22	15.898	0.132	1.987	0.109	0.002	0.001	0.144	0.001	0.001	465.740	810.119	1.986	997.801
Total	53													

Table 3: The genotypic correlation between the traits in phaseolus genotypes during growing spring season 2019

No. of branch/ plant	No. of pods /plant	Green Pod length (cm	Green diameter pod (cm)	Pod weight (g)	No. of seeds/ pod	Seed length (cm)	Seed diameter (cm)	Weight of 1000 seeds (g)	Seeds yield / plot (g)	Seeds yield / plant (g)	Total dry seeds (kg/ donum)	The traits	
-0.023	0.281*	-0.775**	0.784**	0.638**	-0.783**	-0.190	0.685**	0.447**	-0.070	0.584**	0.078	Plant height (cm)	rg
	0.086	0.173	0.231*	-0.124	-0.094	-0.794**	-0.345**	-0.239*	-0.218*	-0.007	-0.413 **	No. of branches/plant	rg
		-0.272**	-0.108	-0.053	-0.007	0.063	-0.020	0.011	-0.509**	0.372**	-0.462**	No. of pods /plant	rg
			-0.556**	-0.193	0.747**	0.088	-0.904**	-0.749**	-0.022	-0.785**	-0.258*	Green Pod length (cm	rg
				0.655**	-0.561**	-0.196	0.524**	0.508**	0.285*	0.254*	0.300*	Green diameter pod (cm)	rg
					-0.463**	-0.146	0.349**	0.338*	0.068	0.163**	0.614**	Pod weight (g)	rg
						0.208*	-0.801**	-0.718**	-0.032	-0.771	-0.407**	No. of seeds/pod	rg
							0.204*	0.012	-0.092	0.130	-0.051	Seed length (cm)	rg
								0.788**	-0.045	0.745**	0.552**	Seed diameter (cm)	rg
									0.277*	0.589*	0.818**	Weight of 1000 seeds (g)	rg
										-0.202*	0.435**	Seeds yield /plot (g)	rg
											0.205*	Seeds yield /plant (g)	rg

Table 4: The phenotypic correlation between the traits in phaseolus genotypes during growing spring season 2019

No.of branches/ plant	No. of pods /plant	Green Pod length (cm	Green diameter pod (cm)	Pod weight (g)	No. of seeds/ pod	Seed length (cm)	Seed diameter (cm)	Weight of 1000 seeds (g)	Seeds yield /plot (g)	Seeds yield/ plant (g)	Total dry seeds (kg/ donum)	The traits	
-0.030	0.242*	-0.732**	0.716**	0.606**	-0.706**	-0.096	0.672**	0.434**	-0.079	0.541**	0.090	Plant height (cm)	rp
	0.093	0.177	0.067	-0.112	0.000	-0.444**	-0.258*	-0.213*	-0.244*	0.028	-0.183	No. of branches/plant	rp
		-0.201*	0.014	-0.070	-0.056	-0.046	0.016	0.054	-0.462**	0.268*	-0.156	No. of pods /plant	rp
			-0.521**	-0.206*	0.660**	-0.036	-0.828**	-0.706**	-0.039	-0.725**	-0.219*	Green Pod length (cm	rp
				0.594**	-0.514**	-0.125	0.481**	0.492**	0.252*	0.188	0.227*	Green diameter pod (cm)	rp
					-0.414**	-0.019	0.310*	0.308**	0.080	0.175	0.384**	Pod weight (g)	rp
						0.175	-0.692**	-0.618**	0.007	-0.617**	-0.304**	No. of seeds/pod	rp
							0.107	0.033	0.025	0.065	0.014	Seed length (cm)	rp

0.745**	-0.074	0.662**	0.379**	Seed diameter (cm)	rp
	0.230*	0.529**	0.574**	Weight of 1000 seeds (g)	rp
		-0.202*	0.159	Seeds yield /plot (g)	rp
			0.112	Seeds yield /plant (g)	rp

Table (5) showed the path coefficient analysis for the traits in phaseolus genotypes during growing season 2019, total dry seed yield per donum had exerted the highest positive direct effect on green diameter pod, pod weight, seed diameter, weight of 1000 seeds, seeds yield per pod and seeds yield per plant . According to the result for the study total dry seeds per donum was mostly affected by this traits and negatively affected by number of branches per plant, number of pods per plant, green pod length, number of seeds per pod, and seed length . Similarly, the most effective factors in common bean were determined as plant height, green diameter, pod weight, seed diameter, weight of 1000 seeds and seeds yield per pod and per plant .For the plant height and green pod length and number of seeds per pod it was observed higher values in the direct effect (0.3683 and 0.3722 respectively . Positive direct effects were observed for number of pods per plant and seeds yield per plot (0.4282) . Green pod length had a direct effects for plant height (0.4894), green diameter pod (0.3513), seed diameter (0.5713), weight of 1000 seeds (0.4729) and seeds yield per plant (0.4957) . For the pod weight, it was observed direct effects of the plant height (0.6158), green diameter pod (0.6323), pod weight (0.9649), seed diameter (0.3364) and weight 1000 seeds (0.3261) . Berhe et al., 1998 ; Onder *et al.*, 2013 ; Doner et al ., 2013 ; Alemu *et al.*, 2017, Studying the direct effects of components traits over seeds yield in phaseolus . Evidencing that direct effects for this crop are expressive predictors of genetic and phonetic correlation, enabling selection for the dry seeds yield among its primary components, and this result allowed inferring that genotypes with high seeds yield may be obtained from the direct selection of genotypes with high number of pods per plant, seeds yield per plot and plant and 1000 seeds weight . In a similar research, Peksen and Gulumser (2005) ; Karasu and Oz (2010) ; indicated that seed weight had highest direct effect on seed yield among number of seeds per pod, seeds per plant and plot .

Table 5: The path coefficient analysis for trait in phaseolus genotypes during growing spring season 2019

Seeds yield/ plant (g)	Seeds yield / plot (g)	Weight of 1000 seeds (g)	Seed diameter (cm)	Seed length (cm)	No. of seeds/ pod	Pod weight (g)	Green diameter pod (cm)	Green Pod length (cm)	No. of pods /plant	No. of branches/ plant	Plant height (cm)	The traits
-0.2777	0.0335	-0.2127	-0.3255	0.0904	0.3722	-0.3034	-0.3726	0.3683	-0.1334	0.0111	-0.4754	Plant height (cm)
0.0018	0.0552	0.0605	0.0873	0.2010	0.0239	0.0314	-0.0584	-0.0438	-0.0218	-0.2532	0.0059	No. of branches/plant
-0.3128	0.4282	-0.0091	0.0166	-0.0534	0.0060	0.0443	0.0910	0.2291	-0.8419	-0.0724	-0.2362	No. of pods /plant
0.4957	0.0137	0.4729	0.5713	-0.0556	-0.4720	0.1221	0.3513	-0.6318	0.1719	-0.1094	0.4894	Green Pod length (cm
-0.0641	-0.0720	-0.1282	-0.1323	0.0494	0.1415	-0.1654	-0.2523	0.1403	0.0273	-0.0582	-0.1977	Green diameter pod (cm)
0.1572	0.0652	0.3261	0.3364	-0.1406	-0.4471	0.9649	0.6323	-0.1864	-0.0507	-0.1196	0.6158	Pod weight (g)
-0.5016	-0.0210	-0.4671	-0.5212	0.1350	0.6503	-0.3014	-0.3647	0.4859	-0.0046	-0.0614	-0.5091	No. of seeds/pod
-0.0310	0.0218	-0.0029	-0.0486	-0.2380	-0.0494	0.0347	0.0466	-0.0210	-0.0151	0.1890	0.0453	Seed length (cm)
-0.5774	0.0349	-0.6105	-0.7745	-0.1582	0.6207	-0.2700	-0.4062	0.7003	0.0152	0.2670	-0.5303	Seed diameter (cm)
0.6685	0.3138	1.1347	0.8944	0.0136	-0.8151	0.3835	0.5766	-0.8495	0.0123	-0.2712	0.5077	Weight of 1000 seeds (g)
0.0648	-0.3208	-0.0887	0.0144	0.0294	0.0104	-0.0217	-0.0916	0.0069	0.1632	0.0699	0.0226	Seeds yield /plot (g)
0.5817	-0.1174	0.3427	0.4336	0.0758	-0.4486	0.0948	0.1478	-0.4564	0.2161	-0.0041	0.3398	Seeds yield /plant (g)
0.2051	0.4349	0.8176	0.5518	-0.0512	-0.4073	0.6137	0.2998	-0.2580	-0.4615	-0.4125	0.0776	Total dry seeds (kg/donum)

4. Conclusion

From the our resulted we conclusion that all genotypes were significant for all traits, the genotype, phenotype were significant positive correlation coefficient of the total yield per unite area with the yield component, the path coefficient analysis was positive direct effect observed for plant height with weight of 1000 seeds, seeds yield per plant, pod weight.

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