Journal homepage www.jzs.univsul.edu.iq
Journal of Zankoy Sulaimani
Part-A- (Pure and Applied Sciences)

Effect of tillage systems on yield and its components of seven cowpea (*Vigna unguiculata* L.) varieties and performing correlation, path and cluster analysis under Sulaimani condition

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Article info

Original: 21/11/2017
Revised: 12/12/2017
Accepted: 06/02/2018
Published online:

Key Words: *Cowpea Genotypes, Grain yield, Correlation Analysis, Path Coefficient Analysis and Cluster Analysis.*

Abstract

This study was conducted during 2015 season at The Qlyasan Agricultural Research Station / College of Agricultural Sciences / University of Sulaimani. Randomized Complete Block Design (RCBD) with three replicates was used to study the effect of two tillage systems using (Mould board plow and Disc plow) on seven cowpea varieties (*Vigna unguiculata* L.) in term of agro-morphological characters and yield assessment. Mean comparisons were performed by the least significant difference test (L.S.D) at 1% and 5% levels of significance. Correlation and path coefficient analyses were performed to determine the degree of association of characters with yield and also among themselves and to detect the relative importance of the characters contributing to grain yield. Cluster analysis based on (UPMAG) was implemented to identify the genetic diversity of the genotypes. The results of this study confirm that plowing with mould board recorded the maximum values for all of the studied characters which indicate the effectiveness of this system compared to disc plow. Tropicana variety achieved the best values for most of the studied characters, while Ramshorn using mould board plow gave the highest values for the character root length and number of branches per plant respectively. Grain yield per plant were recorded highly significant positive correlations with Pod yield/plant, number of pods per plant, pod length with 0.978, 0.766, and 0.755 respectively, while significant positive correlation was noticed between grain yield per plant and pod weight and 100-grain weight with 0.560 and 0.541 respectively. Maximum positive direct effect in grain yield recorded by pod yield per plant with 0.906, while maximum positive indirect effect in grain yield recorded by number of pods per plant *via* pod yield per plant with 0.771. Cluster analysis indicated three groups in both tillage systems depending on the agro-morphological data with a small differences because (American Cowpea) genotype was in first group in mould board plow and in second groups in disc plow tillage systems results indicated the presence of high variability between genotypes in both tillage systems.

Introduction

Cowpea (*Vigna unguiculata* L.) is the most important leguminous crop in the world and one of the most ancient crops known to human ***[1]*** and ***[2]***. Cowpeas seeds provide a rich source of proteins and calories, as well as minerals and vitamins and the seed can consist of 25% protein with low fat content ***[3]*** and ***[4]***.

Cowpea is gaining popularity in developing and under developed countries due to its nutritional value. It is a warm season, annual, herbaceous legume, like other legumes it fixes atmospheric nitrogen into the soil and increasing N-availability ***[5]***. The most widely grown varieties are the vegetable types whose immature pods are eaten by humans. The indigenous varieties are climbing and decumbent but in recent times, erect, bushy varieties have been developed with the objective of increasing yield ***[1]*** and ***[2]***. Because cowpea contains high protein level, it has been referred as "poor man's meat" ***[6]***.

Yield in Cowpea is the result of many plant processes, which are usually expressed in yield components and this approach have been extensively used to explain variation in the yield of several grain legumes and have been shown to be affected by tillage systems, genotype and environment and can be of great help in explaining yield reduction ***[7]*** and ***[8]***.

Kumar *et al.* (2001); Erkut and Cengiz (2004); Kumawat and Raje (2005) were evaluated some cowpea genotypes to estimate the relationship among some morphological traits through correlation and path coefficient analysis and they recorded different results concerning grain yield per plant with other character ***[9]***, ***[10]*** and ***[11]***.

Singh and Mehndirata (1970); Khan and Stoffella (1985); Fernandez and Miller (1985) were found that number of pods/plant was the components that have been associated with yield in vegetable cowpea, while Aggarwal *et al.*(1982); Braithwaite (1982) reported that pod weight was the components that have been associated with yield ***[12]***, ***[13]***, ***[14]***, ***[15]*** and ***[16]***.

The cowpea improvement is limited due to inadequate knowledge of the genetic diversity of the existing genotypes. Breeding program for cowpea has been a difficult mission for the breeder because the crop depends on many characters ***[17]***. The cluster analysis use a model-based clustering approach by assigning individuals to clusters based on their morphological data ***[18]***. A good tillage practices could lead to increase crop growth and yield. The selection of tillage practice for the production of cowpea depends on the soil type. This practice is different in our region where the farmer's uses mould board plow or disc plow. A good soil preparation keep the soil from water and wind erosion, give a good weed-free seedbed for planting, destroys hardpans or compacted layers that may limit root expansion. In addition it will let maintenance or even an increase of soil organic matter ***[19]*** and ***[20]***.

In Kurdistan Region, despite the importance and popularity of this nutritionally important vegetable legume, little information's have been achieved on its production under different tillage systems. This study is aims to evaluate the response of seven newly introduced varieties to different tillage systems under the privilege weather in our region as well as to finding the association among the yield related traits through correlation coefficient, path coefficient analysis. As well as dividing this varieties into groups through cluster analysis depending on the agro-morphological traits.

Materials and Methods:

This experiment was conducted at the experimental field of The Qlyasan Agricultural Research Station, College of Agricultural Sciences, University of Sulaimani (Latitude 35° 34′ 307″ ; N, Longitude 45° 21′ 992″ ; E, 765 MASL), located 2 km North West of Sulaimani city.

A Randomized Complete Block Design with three replicates was conducted, two tillage systems (Mould board Plow and Disc Plow) were used as the first factor and as the second factor were seven cowpea varieties (*Vigna unguiculata* L.) namely (Long Yard Bean, Standard, Ramshorn, California, American Cowpea, Tropicana and Pakistani) which introduced by The Sulaimani Agricultural Research Centre, Ministry of Agriculture and Water Resource, Kurdistan Regional Government, Iraq. The varieties were planted in 4th August 2015 and harvested in 4th November 2015. Trials were irrigated throughout the growing season and cultural operations, fertilization, and weed control were accomplished according to normal field practices. Each plot consists of 4 rows 4 m long, 0.75 m apart and 0.25 m between plants. Samples were harvested by hand, for agro-morphological characters and yield assessment. Soil samples were analyzed at

the laboratory of Soil and Water Sciences Department, College of Agricultural Sciences, University of Sulaimani as shown in Appendix (1).
The Metrological data obtained from Sulaimani Metrological Stations during the growing season 2015 from August to November as shown in Appendix (2).

Studied Characteristics:

The studied characters were Root length (cm), Number of branches per plant, Number of pods per plant, Pod length (cm), Pod weight (g), Number of grains per pod, 100 grain weight (g), Pod yield per plant (g), and Grain yield per plant (g).

Statistical Analysis:

The data were statistically analyzed according to the methods of analysis of variance as a general test; all possible comparisons among the means were carried out by using Least Significant Difference (L.S.D) test at significant levels of 5% and 1% after they show their significance in the general test ***[21]***.

Correlation Analysis:

The correlation coefficient was conducted to determine the degree of association of the characters with the yield and also among themselves. Phenotypic correlations were computed between characters in the growing season using the formula given by Singh and Chaudhary (1985) ***[22]***.

Path Coefficient Analysis:

The path coefficient analysis was carried out as suggested by Dewey and Lu (1959) ***[23]***. Seed yield was kept as resultant variable and other characters as causal through (Analysis of Moment Structures) AMOS Ver. 18 Software.

Cluster Analysis:

The Hierarchical Cluster Analysis based on Euclident Distance and Unweighted Pair-group Linkage (UPGMA) was also performed to classify the cowpea genotype relatedness based on agro-morphological traits using IBM SPSS program, Ver. 19 ***[24]***.

Results and Discussion:

Table (1) and Appendix (3) shows the effect of tillage systems on the studied characters, highly significant differences were observed among all of the studied characters with exception of number of branches/plant and 100-grain weight (g). Plowing with Mould board recorded the maximum values for root length (cm), number of pods/plant, pod length (cm), pod weight (g), number of grains/pod, pod yield/plant (g) and grain yield/plant (g) with 22.746 cm, 22.810, 14.303 cm, 2.706 g, 9.071, 63.233 g and 53.904 g, respectively (Table 1). These results indicate the effect of compaction of the disc plow on the soil as well as reduce the required nutrient and air around the root of the plant, while mould board plow was more effective system in cultivating cowpea in Qlyasan soil condition because it improves the size of the soil clods and give the roots good ventilation. The root system is crucial factor for optimum crop yields when soil is in good condition. Similar result was obtained in an investigation on the effect of tillage system on studied characters and root length ***[20]***.

Table 1: Effect of tillage system on the studied characters

Tillage Systems	*Root length (cm)*	*No. of branches/ plant*	*No. of pods/ plant*	*Pod length (cm)*	*Pod weight (g)*	*No. of grains/ pod*	*100-grain weight (g)*	*Pod yield/ Plant (g)*	*Grain yield/ plant (g)*
Mould board Plow	22.746	7.587	22.810	14.303	2.706	9.071	25.290	63.233	53.904
Disc Plow	18.984	7.349	19.317	13.078	2.441	8.522	24.097	45.241	37.985
$LSD_{(P\leq0.05)}$	**1.086**	**n.s**	**2.532**	**0.512**	**0.178**	**0.382**	**n.s**	**7.795**	**7.250**
$LSD_{(P\leq0.01)}$	**1.469**	**n.s**	**3.423**	**0.692**	**0.241**	**0. 517**	**n.s**	**10.537**	**9.801**

The analysis of variance were showed highly significant response of the varieties for the characters number of branches/plant, pod length, pod weight and 100-grain weight, while significant response were recorded for root length, number of grains/pod, pod yield/plant and grain yield/plant and no significant difference were noticed in term of number of pods/plant (Appendix 3). Varieties responses were recorded in Table (2). Tropicana gave the maximum values for pod length (15.727cm), pod weight (2.894g), number of grains/pod (9.467), 100-grain weight (26.881g), pod yield/plant (72.517g) and grain yield/plant (61.719g), while Ramshorn recorded the maximum value for root length (22.333cm) and American cowpea recorded the maximum number of branches with 8.833. These results indicated that genotypes differed significantly in respect to phonological, yield and some yield related characters were highly influenced by the environment.

Table 2: Response of varieties in term of the studied characters

Varieties	*Root length (cm)*	*No. of branches/ plant*	*No. of pods/ plant*	*Pod length (cm)*	*Pod weight (g)*	*No. of grains/ pod*	*100-grain weight (g)*	*Pod yield/ Plant (g)*	*Grain yield/ plant (g)*
Long Yard Bean	21.833	5.778	22.000	13.400	1.964	8.261	19.199	52.472	40.074
Standard	21.222	6.833	18.944	13.711	2.437	8.661	23.782	50.491	44.473
Ramshorn	22.333	7.833	20.722	13.178	2.426	9.100	23.536	49.335	42.716
California	19.389	6.889	19.833	13.522	2.398	8.900	23.868	48.194	40.045
American Cowpea	21.056	8.833	18.556	13.189	2.868	8.872	25.878	46.787	38.412
Tropicana	19.500	8.611	25.833	15.727	2.894	9.467	26.881	72.517	61.719
Pakistani	20.722	7.500	21.556	13.106	3.029	8.317	29.714	59.861	54.174
$LSD_{(P\leq0.05)}$	**2.032**	**0.861**	**n.s**	**0.958**	**0.334**	**0.715**	**2.385**	**14.583**	**13.564**
$LSD_{(P\leq0.01)}$	**n.s**	**1.164**	**n.s**	**1.295**	**0.451**	**n.s**	**3.224**	**n.s**	**n.s**

The interaction effects of tillage systems and varieties were significant for root length and number of branches/plants only (Appendix 3). The maximum root length was recorded by Ramshorn using mould board plow with 26.889cm, while Tropicana by using disc plow gave the maximum number of branches/plants with 9.333 branches (Table 3). High variations in yield and its component of the cowpea genotypes were observed in the current study, and this result is in accordance with the finding of Nwofia *et al.* (2007); Shimelis *et al.* (2010); and El-Shaieny *et al.* (2015) ***[26], [27]*** and ***[28].***

Table 3: The interaction effect of tillage system and varieties on the studied characters

Tillage Systems	Varieties	Root length (cm)	No. of branches/ plant	No. of pods/ plant	Pod length (cm)	Pod weight (g)	No. of grains/ pod	100-grain weight (g)	Pod yield/ Plant (g)	Grain yield/ plant (g)
Mould board Plow	Long Yard Bean	22.667	6.444	23.444	13.656	2.044	8.911	19.797	62.408	47.287
	Standard	22.444	6.889	21.778	14.800	2.469	9.256	23.546	60.818	54.620
	Ramshorn	26.889	9.000	25.111	14.000	2.484	9.111	24.243	59.364	50.444
	California	21.000	7.000	23.000	13.756	2.364	8.844	23.158	55.971	45.642
	American Cowpea	23.333	8.556	16.667	13.822	3.224	9.244	27.133	46.152	38.490
	Tropicana	21.000	7.889	27.111	17.021	3.112	9.778	28.384	87.838	75.976
	Pakistani	21.889	7.333	22.556	13.067	3.246	8.356	30.772	70.077	64.867
Disc Plow	Long Yard Bean	21.000	5.111	20.556	13.144	1.883	7.611	18.601	42.536	32.861
	Standard	20.000	6.778	16.111	12.622	2.406	8.067	24.019	40.164	34.326
	Ramshorn	17.778	6.667	16.333	12.356	2.367	9.089	22.828	39.306	34.987
	California	17.778	6.778	16.667	13.289	2.431	8.956	24.579	40.417	34.448
	American Cowpea	18.778	9.111	20.444	12.556	2.511	8.500	24.622	47.422	38.333
	Tropicana	18.000	9.333	24.556	14.433	2.676	9.156	25.378	57.196	47.462
	Pakistani	19.556	7.667	20.556	13.144	2.811	8.278	28.656	49.644	43.481
$LSD_{(P\leq0.05)}$		**2.874**	**1.218**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**
$LSD_{(P\leq0.01)}$		**n.s**	**1.647**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**

The correlation was performed among different characters of the evaluated interaction of tillage system and varieties as shown in Table (4). The analysis revealed significant positive correlation between number of branches/plants and pod weight (0.560*) and 100-grain weight (0.533*). Highly significant positive correlations were noticed between number of pods/plant and the characters pod length, pod yield/plant, and grain yield/plant with 0.692**, 0.851** and 0.775** respectively. Pod length recorded highly significant positive correlations with number of grain/pod (0.690**), pod yield/plant (0.804**) and grain yield/plant (0.766**). Pod weight recorded highly significant positive correlation with 100-grain weight (0.945**), while it gave significant positive correlation with grain yield/plant (0.560*). Significant positive correlation was noticed between 100-grain weight and grain yield/plant (0.541*). Pod yield/plant was correlated significantly with grain yield/plant (0.978**).

Table 4: Correlation coefficient analysis among the studied characters

Correlation Coefficients	Root length (cm)	No. of branches/ plant	No. of pods/ plant	Pod length (cm)	Pod weight (g)	No. of grains/ pod	100-grain weight (g)	Pod yield/ plant (g)
No. of branches/plant	0.123 n.s							
No. of pods/plant	0.393 n.s	0.304 n.s						
Pod length (cm)	0.278 n.s	0.229 n.s	0.692**					
Pod weight (g)	0.100 n.s	0.560*	0.126 n.s	0.355 n.s				
No. of grains/pod	0.158 n.s	0.458 n.s	0.347 n.s	0.690**	0.388 n.s			
100-grain weight (g)	-0.018 n.s	0.533*	0.129 n.s	0.245 n.s	0.945**	0.249 n.s		
Pod yield/plant (g)	0.375 n.s	0.237 n.s	0.851**	0.804**	0.456 n.s	0.506 n.s	0.415 n.s	
Grain yield/plant (g)	0.341 n.s	0.246 n.s	0.775**	0.766**	0.560*	0.500 n.s	0.541*	0.978**

*. Correlation is significant at the 0.05 level (2-tailed), $t_{0.05}(12) = 2.179$

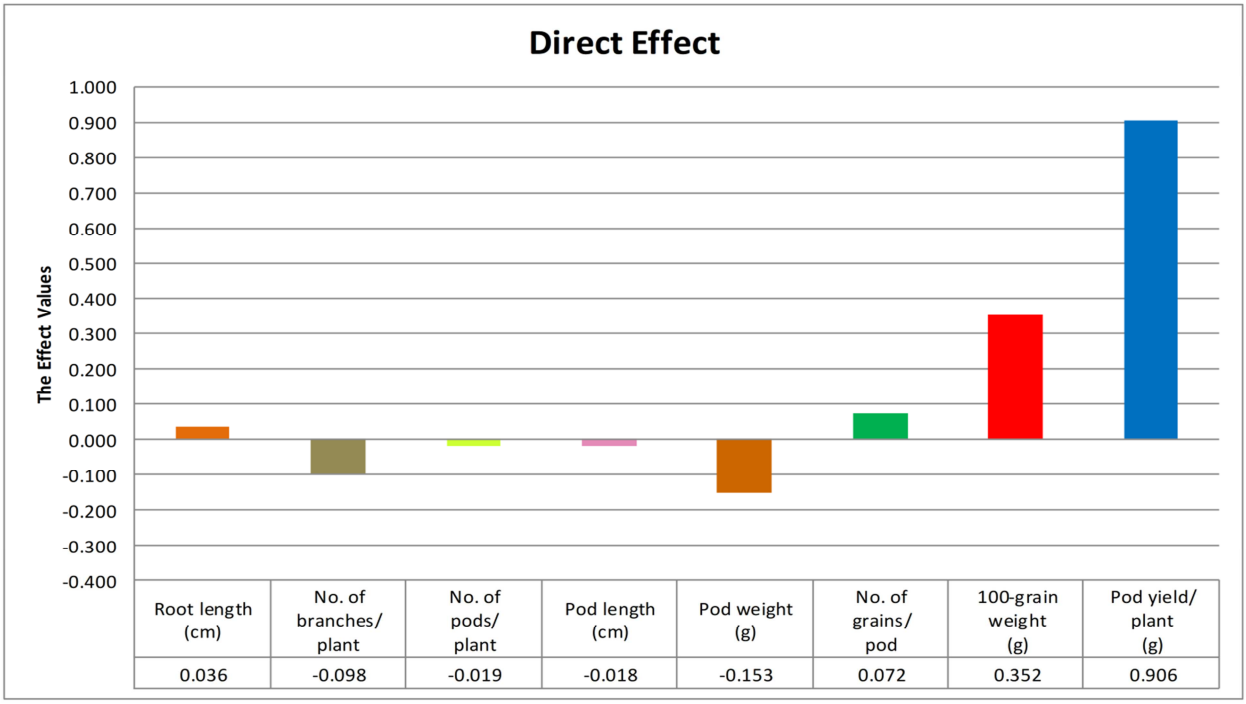
**. Correlation is significant at the 0.01 level (2-tailed), $t_{0.01}(12) = 3.055$

Table (5) and Figure (1) shows path coefficient among the studied characters, pod yield/plant recorded the maximum positive direct effect on grain yield/plant (0.906); followed by100-grain weight (0.352), while pod weight gave the maximum negative direct effect with (-0.153).

Regarding the indirect effects of the studied characters *via* themselves on grain yield/plant, the analysis revealed different values for these effects. The maximum positive indirect effect values recorded by number of pods per plant and pod length both *via* pod yield/plant with 0.771 and 0.728 respectively, while the maximum negative indirect effect value recorded by 100-grain weight *via* pod weight with -0.145. These results indicated that the characters number of pods/plant and pod length had great influence toward increasing grain yield of cowpea with respect of pod yield/plant and this fact must be consider when breeding cowpea for grain yield, on the other hand 100-grain weight may lead to decrease in grain yield if the pod weight increased (Table 5 and Figure 2).

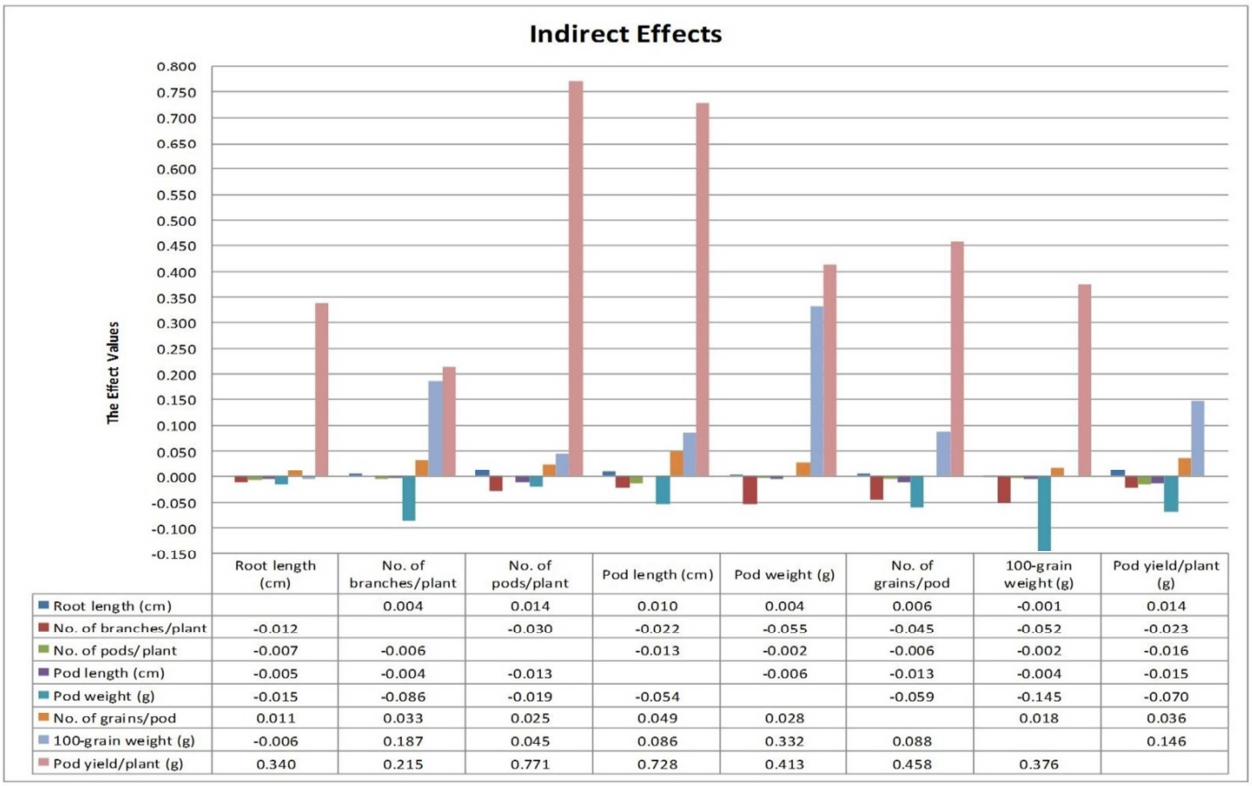
Table 5: Path coefficient analysis for the studied characters

Path Coefficients	Root length (cm)	No. of branches/ plant	No. of pods/ plant	Pod length (cm)	Pod weight (g)	No. of grains/ pod	100-grain weight (g)	Pod yield/ plant (g)
Root length (cm)	0.036	0.004	0.014	0.010	0.004	0.006	-0.001	0.014
No. of branches/plant	-0.012	-0.098	-0.030	-0.022	-0.055	-0.045	-0.052	-0.023
No. of pods/plant	-0.007	-0.006	-0.019	-0.013	-0.002	-0.006	-0.002	-0.016
Pod length (cm)	-0.005	-0.004	-0.013	-0.018	-0.006	-0.013	-0.004	-0.015
Pod weight (g)	-0.015	-0.086	-0.019	-0.054	-0.153	-0.059	-0.145	-0.070
No. of grains/pod	0.011	0.033	0.025	0.049	0.028	0.072	0.018	0.036
100-grain weight (g)	-0.006	0.187	0.045	0.086	0.332	0.088	0.352	0.146
Pod yield/plant (g)	0.340	0.215	0.771	0.728	0.413	0.458	0.376	0.906
Grain yield/plant (Correlations)	0.341 n.s	0.246 n.s	0.775**	0.766**	0.560*	0.500 n.s	0.541*	0.978**



Root length (cm)	No. of branches/ plant	No. of pods/ plant	Pod length (cm)	Pod weight (g)	No. of grains/ pod	100-grain weight (g)	Pod yield/ plant (g)
0.036	-0.098	-0.019	-0.018	-0.153	0.072	0.352	0.906

Figure 1: Path coefficient analysis shows direct effects of the studied characters on grain yield per plant



	Root length (cm)	No. of branches/plant	No. of pods/plant	Pod length (cm)	Pod weight (g)	No. of grains/pod	100-grain weight (g)	Pod yield/plant (g)
Root length (cm)		0.004	0.014	0.010	0.004	0.006	-0.001	0.014
No. of branches/plant	-0.012		-0.030	-0.022	-0.055	-0.045	-0.052	-0.023
No. of pods/ plant	-0.007	-0.006		-0.013	-0.002	-0.006	-0.002	-0.016
Pod length (cm)	-0.005	-0.004	-0.013		-0.006	-0.013	-0.004	-0.015
Pod weight (g)	-0.015	-0.086	-0.019	-0.054		-0.059	-0.145	-0.070
No. of grains/pod	0.011	0.033	0.025	0.049	0.028		0.018	0.036
100-grain weight (g)	-0.006	0.187	0.045	0.086	0.332	0.088		0.146
Pod yield/plant (g)	0.340	0.215	0.771	0.728	0.413	0.458	0.376	

Figure 2: Path coefficient analysis shows indirect effects of the studied characters on grain yield per plant

The dendrogram based on cluster analysis revealed three major groups for each treatment mould board plow on the left (A) and disc plow (B) on the write (Figure 3). The first group in Mould board Plow tillage systems comprised of four genotypes (Long Yard Bean, Standard, Ramshorn, California and American Cowpea), while the second groups (Pakistani) and the last group (Tropicana). Whereas the first group in disc plow tillage systems comprised of four genotypes (Long Yard Bean, Standard, Ramshorn and California), while the second groups (American Cowpea and Pakistani) and the last group (Tropicana). The result indicates the presence of high variability between genotypes used in this study and the genotypes in both tillage systems, because (American Cowpea) genotype was in first group in mould board plow and in second groups in disc plow tillage systems. The variability among the genotypes was high, and the improvement of this crop is possible through the breeding techniques. This agrees with some of the findings of Ajayi and Adesoye (2013); Selvi *et al.* (2003) ***[20]*** and ***[25]***.

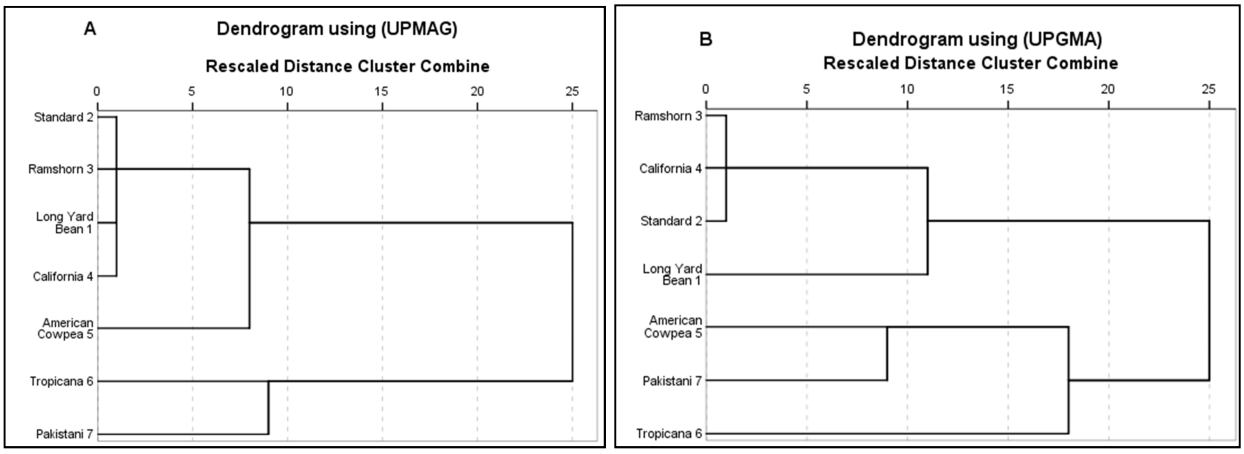


Figure- 3: Dendrogram of seven cowpea genotypes based on cluster analysis of agro-morphological data, A. Mould board Plow and B. Disc Plow tillage systems.

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Appendix 1: Soils physical and chemical properties at Sulaimani – Qlyasan environments in the date of sowing season 2015

Soil Properties	*Sulaimani – Qlyasan*
PSD	Silty clay
Sand %	5.83
Silt %	42.07
Clay %	52.10
pH	7.13
Organic Matter %	2.13
Total Nitrogen %	0.15
Available Phosphate (ppm)	4.49

Appendix 2: The Metrological data at Sulaimani – Qlyasan environments during the growing season 2015

Period	*Sulaimani – Qlyasan*		
	Temp. °C		*Rainfall mm*
	Max.	*Min.*	
August	46.5	22.0	0.0
September	41.5	16.2	14.1
October	38.2	11.0	132.6
November	25.0	4.0	194.1
Total	**—**	**—**	***340.8***

Appendix 3: Mean squares of variance analysis of the studied character

S.O.V	*d.f*	*Root length (cm)*	*No. of branches/ plant*	*No. of pods/ plant*	*Pod length (cm)*	*Pod weight (g)*	*No. of grains/ pod*	*100-grain weight (g)*	*Pod yield/ Plant (g)*	*Grain yield/ plant (g)*
Replicates	**2**	1.130	1.558	74.612	5.160	0.549	1.352	17.893	600.075	734.893
Tillage Systems	**1**	148.595 **	0.595 n.s	128.042 **	15.764 **	0.742 **	3.167 **	14.945 n.s	3398.941 **	2660.603 **
Varieties	**6**	7.320 *	6.900 **	36.280 n.s	5.119 **	0.839 **	1.093 *	64.435 **	498.967 *	455.158 *
Tillage Systems × Varieties	**6**	9.571 *	2.348 **	24.265 n.s	1.431 n.s	0.111 n.s	0.488 n.s	3.885 n.s	139.460 n.s	120.215 n.s
Experimental Error	**26**	**2.933**	**0.527**	**15.937**	**0.652**	**0.079**	**0.363**	**4.038**	**150.993**	**130.639**