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Characterization of Seven Chickpea Genotypes Using Correlation, Path and Cluster Analysis

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Abstract

Selecting genotype and sowing strategies vary with environment and consider as an important cultural practice for chickpea production. This research was carried out during 2015-2016 season at Qlyasan Agricultural Research Station/College of Agricultural Sciences/University of Sulaimani. Randomized Completely Block Design (RCBD) with three replicates was used to study the effect of sowing dates (winter 12th December 2015 and spring 17th February 2016) on seven chickpea genotypes received from ICARDA for some agronomic characteristics including the yield. The results confirm the effectiveness of winter sowing date for all of the studied characters compared to their planting in spring. FLIP 05-150C genotype gave the best values for most of the studied characters. Seed yield/plant was positively and high significantly $p < 0.01$ affected by plant height (0.834), plant weight (0.968), number of branches/plant (0.889) and number of pod/plant (0/931). Number of pods/plant recorded the maximum positive direct effect on seed yield/plant (0.711); followed by plant weight (0.416) In contrast, number of branches/plant recorded the maximum negative direct effect with (-0.302). Whereas the maximum positive indirect effect was recorded by plant weight and number of branches/plant via a number of pod/plant with 0.646 and 0.648 respectively, while the maximum negative indirect effect values were recorded by plant height (-0.242), plant weight (-0.281) and number of branches/plant (-0.302) via a number of branches/plant. Cluster analysis indicated three groups in both sowing dates depending on the studied traits. Finally the result demonstrated that winter sowing is very promising for this region.

Introduction

Chickpea (*Cicer arietinum* L.) 2x=2n=16, having a genome size of approximately 740 Mbp is one of the oldest Pulses farmed by modern humans in the Fertile Crescent. Archaeological evidence said that chickpeas domesticated around 8000 BC in the Fertile Crescent, the region where start from western Iran, northern Iraq, Turkey, and Syria through Israel) is the primary centre of diversity of chickpea **[1]**. Ample studies have been conducted on this aspect in these countries except Iraq. World Chickpea productions have been increased in the last half century from 7 million tonnes to 13 million tonnes **[2]**. Canada, Mexico and Australia have obtained an average yield of more than 1200 kg/hectare for many years, whereas the global average yield is around 745 kg/hectare. Similar gain in chickpea yield is possible in other countries with improved crop management. The seeds (dry or green) are used for human consumption (flour, frozen, boiled or roasted). Fresh plant, dried grain and the plant residuals are used as to feed animals, in addition is used as green manure. The World Health Organization (WHO) recommends the consumption of pulses of 80 g/day per capita **[3]**. Chickpea became widely cultivated in the Mediterranean, North Africa, the Middle East and

India, whereas today about two-thirds of the global chickpea crop are grown in these area. Similar gain in chickpea yield is possible in other countries with improved crop management and superior varieties.
The chickpea is a winter crop, however it is sown in spring in many parts of the world. Its evolutionary path has spread to a broad range of habitats characterized by different climates. In Mediterranean region rainfall is in winter, and some of the farmers start to plant chickpea in December, while other farmers start to plant it in spring due to susceptibility to low temperatures and ascochyta blight in colder area, whereas in spring the crop grows under receding residual soil moisture, which results in low yields. In contrast with the lack of these problems the winter-planted chickpeas are easier to mechanical harvest due to sufficient plant height as compared with traditional spring-sown crops **[4].** In some part of Mediterranean environments, the yield advantage of winter sowing over spring sowing has been documented long time ago **[5, 6]**. Sowing chickpea in winter in the Mediterranean regions possesses a good yield over spring culture **[7]**. Many studies have been carried out regarding the advantages of winter and autumn culture of chickpea growing in the eastern part of Iran **[8]**. In the investigation of 42 genotypes of chickpea grown under two different dates of sowing **[9]**, results indicate sufficient variability for most of the characters.
For identifying the relationships among study characters and the degree of linear relation between them most of the scientists use correlation coefficients while others use path analysis to determine the effect size (direct and indirect) of the causal components which is more reliable and agronomically accessible **[10]**. Ozdemir **[11]** noted that the number of branches were among the important yield components, which has significant direct effect. Borate and Dalvi **[12]** found that number of pods per plant and number of branches had highest direct positive effect on yield of chickpea.
Genetic characterization can be made for selecting genotypes for future breeding program based on different methods, ranging from conventional methods like the use of descriptor lists of morphological characters, as well as biochemical and molecular methods **[13]**. The cluster analysis uses a model-based clustering approach by assigning individuals to clusters based on their morphological data **[14].**
In Kurdistan region farmers use unknown source of chickpea genotypes consequently. Farmers in this region have no access to the reliable germplasm with unsatisfied system for chickpea crop management such as sowing dates. The objective of this study is to evaluate the response of seven newly introduced varieties of chickpea from ICARDA to different sowing dates in Sulaimani.

Materials and Methods:

The experiment was conducted in a Randomized Complete Block Design with three replicates. Two sowing dates (winter and spring) were used as the first factor and the second factor was included seven chickpea varieties (*Cicer arietinum* L.) namely; FLIP 97-706C, FLIP 03-87C, FLIP 05-74C, FLIP 05-87C, FLIP 05-110C, FLIP 05-142C and FLIP 05-150C, which introduced by the Sulaimani Agricultural Research Centre, Ministry of Agriculture and Water Resource, Kurdistan Regional Government, Iraq. The chickpea genotypes were planted at the Qliasan Research Station, College of Agricultural Sciences, University of Sulaimani, (Lat. 35^{o} 34' 307" N, Long 45^{o} 21' 992" E, 765 MASL) on 12th December 2015 and 17th February 2016. During the growing seasons cultural operations, fertilization, and weed control was accomplished according to normal field practices. Each plot consisted of 3 rows of 3 m long, 30 m apart and 0.20 m between plants. Samples were harvested manually, for agro-morphological characters and yield assessments. Soil samples were analysed 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 from December 2015 to June 2016 were shown in Appendix (2).

Studied Characteristics:

At harvesting time five plants were selected randomly from each plot and tagged for recording the following characteristics: plant height (cm), plant weight (g), number of branches/plant, number of pods/plant, number of seed/pod, 100-grain weight (g), seed yield/plant (g).

Statistical Analysis:

The data were statistically analysed 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 using IBM SPSS program, version 19 **[15]**. The correlation coefficient was conducted to determine the degree of association of characters with yield and also among themselves. Phenotypic correlations were computed between characters in the growing season using a formula given by Singh and Chaudhary **[16]**. The path coefficient analysis was performed using R version 3.2.3 **[17]**. Seed yield was recorded as resultant variable and other characters as causal through. The Hierarchical Cluster Analysis based on Euclidean distance and Unweighted Pair-Group linkage (UPGMA) was also performed to classify the chickpea genotype relatedness based on agro-morphological traits using an IBM SPSS program, version 19 **[15]**.

Results and Discussion:

Data in Table 1 and Appendix 3 present the results of sowing dates on the studied characters. Highly significant differences were observed among all the studied characters except number of seed/pod, 100-seed weight (g). Winter sowing recorded the maximum values for all the studied characters; plant height (73.791 cm), plant weight (173.407 g), number of branches/plant (2.833), number of pods/plant (49.543), number of seed/pod (1.060), 100-seed weight (29.757 g), Seed yield/plant (15.049 g).

Table 1. Effect of sowing dates on the studied characters

Sowing date	Plant height (cm)	Plant weight (g)	No. of branches/plant	No. of pods/plant	No. of seed/pod	100-grain weight (g)	Seed yield/plant (g)
Winter	73.791	173.407	2.833	49.543	1.060	29.757	15.049
Spring	53.806	76.363	2.148	22.648	1.030	28.959	6.812
LSD(P≤0.05)	2.111	24.010	0.209	4.136	n.s	n.s	1.824
LSD(P≤0.01)	2.853	32.458	0.282	5.592	n.s	n.s	2.466

The mean squares due to varieties were highly significant for the characters plant height, number of pods/plant and 100-seed weight, whereas no significant difference was noticed for other characters (Appendix 3). Data in Table 2 explain the varieties responses. Maximum value due to the number of branches/plant was produced by FLIP 97-706C (2.700), and for 100-grain weight 32.758 gm was produced by FLIP 03-87C. While for the character plant height, FLIP 05-87C recorded the highest value (67.905 cm). In addition, FLIP 05-150C gave the maximum values for plant weight (142.938 g), number of pods/plant (55.650), number of seed/pod (1.108) and seed yield/plant (13.771 g). The results indicated that these ICARDA genotypes are differ in their respect to agro-morphological and some yield related characters were highly influenced by the environment.

Table 2.Response of genotypes in term of the studied characters

Varieties	Plant height (cm)	Plant weight (g)	No. of branches/plant	No. of pods/plant	No. of seed/pod	100-grain weight (g)	Seed yield/plant (g)
FLIP 97-706C	63.372	128.977	2.700	40.600	1.037	29.388	11.580
FLIP 03-87C	65.533	129.005	2.450	30.500	0.978	32.758	11.128
FLIP 05-74C	63.133	124.580	2.467	33.800	1.067	28.635	9.836
FLIP 05-87C	67.905	124.238	2.433	33.283	1.012	26.995	10.064
FLIP 05-110C	63.533	117.178	2.300	29.533	1.057	31.612	10.712
FLIP 05-142C	64.250	107.817	2.400	29.300	1.057	32.663	9.425
FLIP 05-150C	58.865	142.398	2.683	55.650	1.108	23.455	13.771
LSD(P≤0.05)	3.949	n.s	n.s	7.738	n.s	2.269	n.s
LSD(P≤0.01)	5.338	n.s	n.s	10.461	n.s	3.067	n.s

Data in Table 3 illustrates the interaction effects of sowing date and varieties, being significant only for number of pods/plant (Appendix 1). FLIP 05-150C recorded the maximum number of pods/plant only with 77.800 and 33.500 for winter and spring sowing, respectively. Using different sowing dates and varieties showed that to be a good strategy for selecting good genotypes for future program by showing a good respond of the genotype during each sowing date. The variations in yield and its component were observed among other ICARDA genotypes in the current study.

Table 3: Interaction effect of sowing dates and genotypes on the studied characters

Sowing date	Varieties	Plant height (cm)	Plant weight (g)	No. of branches/plant	No. of pods/plant	No. of seed/pod	100-seed weight (g)	Seed yield/plant (g)
Winter	**FLIP 97-706C**	74.833	171.773	3.000	56.867	1.050	30.750	16.397
	FLIP 03-87C	77.333	179.973	2.667	42.167	1.063	34.217	16.579
	FLIP 05-74C	74.000	167.930	2.933	44.600	1.047	30.070	12.463
	FLIP 05-87C	77.010	161.223	2.800	43.067	1.040	26.150	13.047
	FLIP 05-110C	73.800	156.733	2.600	38.767	1.057	30.990	14.076
	FLIP 05-142C	72.900	161.333	2.667	43.533	1.103	32.277	13.831
	FLIP 05-150C	66.663	214.880	3.167	77.800	1.057	23.847	18.952
Spring	**FLIP 97-706C**	51.910	86.180	2.400	24.333	1.023	28.027	6.762
	FLIP 03-87C	53.733	78.037	2.233	18.833	0.893	31.300	5.677
	FLIP 05-74C	52.267	81.230	2.000	23.000	1.087	27.200	7.208
	FLIP 05-87C	58.800	87.253	2.067	23.500	0.983	27.840	7.080
	FLIP 05-110C	53.267	77.623	2.000	20.300	1.057	32.233	7.349
	FLIP 05-142C	55.600	54.300	2.133	15.067	1.010	33.050	5.020
	FLIP 05-150C	51.067	69.917	2.200	33.500	1.160	23.063	8.590
LSD(P≤0.05)		n.s	n.s	n.s	10.944	n.s	n.s	n.s
LSD(P≤0.01)		n.s	n.s	n.s	n.s	n.s	n.s	n.s

The correlation coefficients of the studied characters are shown in Table 4. Plant height was positively and high significantly $p < 0.01$ affected by plant weight, number of branches/plant, number of pods/plant and seed yield/plant. Their correlation coefficients (r) were 0.877, 0.802, 0.663, and 0.834, respectively. Plant weight recorded highly significant and positive correlations with the number of branches/plant (0.931), number of pods/plant (0.909) and seed yield/plant (0.968), number of branches/plant recorded highly significant and positive correlations when plotted against number of pods/plant (0.912) and seed yield/plant (0.889). In addition number of pods/plant was positively and highly significant $p < 0.01$ affected by Seed yield/plant (0.931). Our result is in agreement with **[18]** and **[19]** who found a positive and significant association between seed yield and each of pod weight/plant and number of pods/plant.

Table 4. Correlation coefficient between the studied traits of chickpea varieties.

	Plant height (cm)	Plant weight (g)	No. of branches/ plant	No. of pods/plant	No. of seed/pod	100-seed weight (g)	Seed yield/plant (g)
Plant height (cm)	1						
Plant weight (g)	0.877**	1					
No. of branches/plant	0.802**	0.931**	1				
No. of pods/plant	0.663**	0.909**	0.912**	1			
No. of seed/pod	0.146 n.s	0.210 n.s	0.142 n.s	0.332 n.s	1		
100-seed weight (g)	0.253 n.s	-0.012 n.s	-0.098 n.s	-0.312 n.s	-0.313 n.s	1	
Seed yield/plant (g)	0.834**	0.968**	0.889**	0.931**	0.353 n.s	-0.046 n.s	1

n.s . Not significant

*. 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 show path coefficient analysis of the studied characters. Number of pods/plant recorded the maximum positive direct effect on seed yield/plant (0.711); followed by plant weight (0.416), in contrast number of branches/plant gave the maximum negative direct effect (-0.302).
Concerning the indirect effects of the studied characters *via* themselves on the seed yield/plant, the analysis showed different values (Figure 2). The maximum positive indirect effect was recorded by plant weight and number of branches/plant *via* a number of pod/plant with 0.646 and 0.648 respectively, while the maximum negative value of indirect effect was recorded by plant height (-0.242), plant weight (-0.281) and number of branches/plant (-0.302) via a number of branches/plant. In addition of direct contribution, negative indirect effect value was recorded by plant height (-0.222) via number of pods/plant. Borate and Dalvi **[12]** revealed that number of pods per plant had the highest direct positive effect on seed yield in chickpea. While Ozdemir **[11]** pointed that number of branches is among the important yield components, which have significant direct effects and indirect effects.

Table 5: Path coefficient analysis of the studied characteristics of chickpea genotypes

Characters	Plant height (cm)	Plant weight (g)	No. of branches/plant	No. of pods/plant	No. of seed/pod	100-seed weight (g)
Plant height (cm)	**0.195**	0.171	0.157	0.130	0.029	0.049
Plant weight (g)	0.365	**0.416**	0.387	0.378	0.087	-0.005
No. of branches/plant	-0.242	-0.281	**-0.302**	-0.275	-0.043	0.030
No. of pods/plant	0.472	0.646	0.648	**0.711**	0.236	-0.222
No. of seed/pod	0.012	0.018	0.012	0.028	**0.085**	-0.027
100-seed weight (g)	0.033	-0.002	-0.013	-0.040	-0.040	**0.129**
Seed yield/plant (Correlation)	**0.834**	**0.968**	**0.889**	**0.931**	**0.353**	**-0.046**

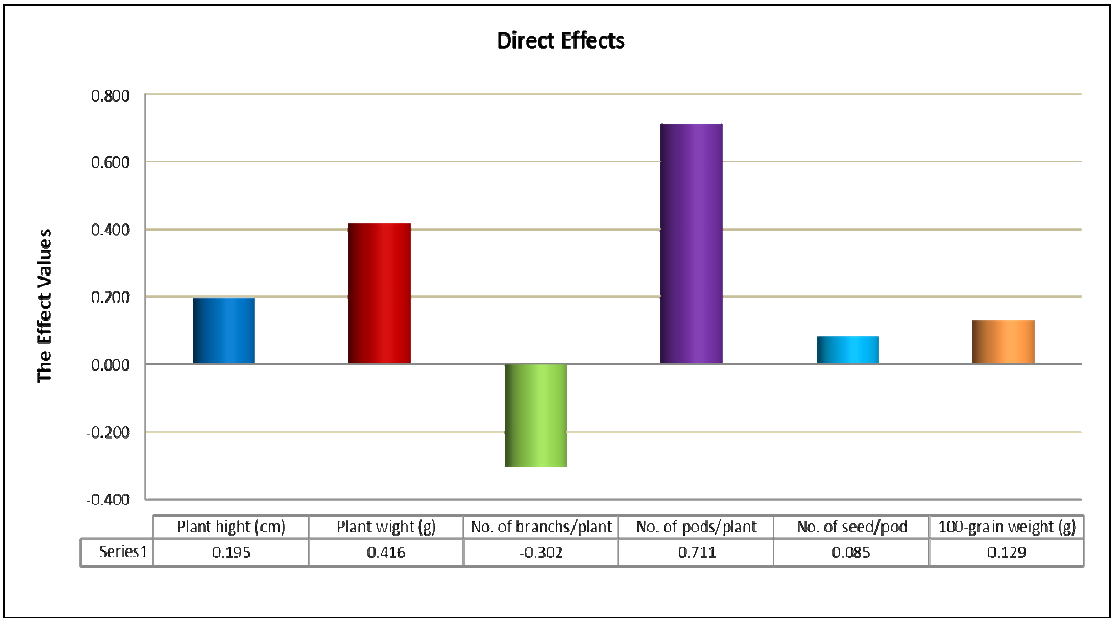
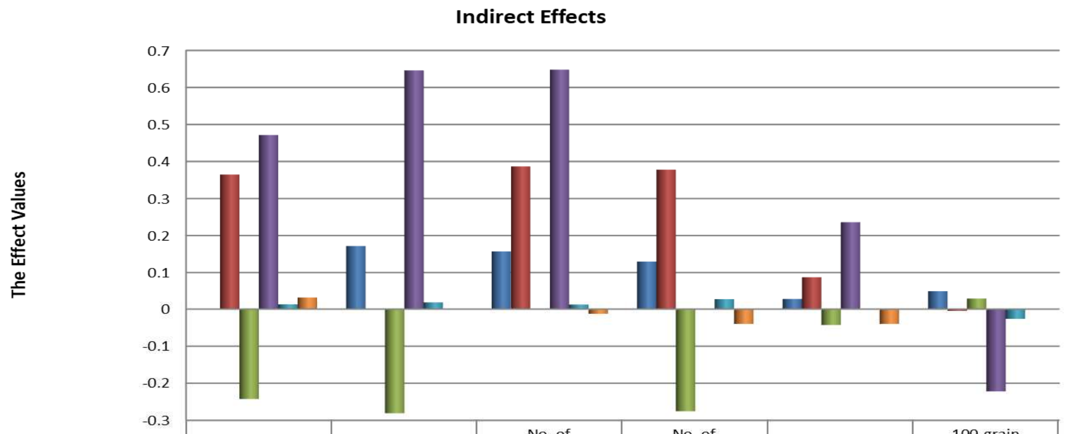


Figure 1. Path coefficient analysis of the chickpea genotypes shows direct effects of the studied characters on seed yield per plant



	Plant hight (cm)	Plant wight (g)	No. of branchs/plant	No. of pods/plant	No. of seed/pod	100-grain weight (g)
Plant hight (cm)		0.171	0.157	0.130	0.029	0.049
Plant wight (g)	0.365		0.387	0.378	0.087	-0.005
No. of branchs/plant	-0.242	-0.281		-0.275	-0.043	0.030
No. of pods/plant	0.472	0.646	0.648		0.236	-0.222
No. of seed/pod	0.012	0.018	0.012	0.028		-0.027
100-grain weight (g)	0.033	-0.002	-0.013	-0.040	-0.040	

Figure 2: Path coefficient analysis shows indirect effects of six characteristics on grain yield per plant.

A cluster of all ICARDA genotypes was conducted to identify a cluster membership of the studied genotype based on agro-morphological data. The results indicate three major (K=3) groups for each sowing dates (winter and spring), Table 6 and Figure 3. The first group in winter sowing date comprised of one genotype (FLIP 97-706C), while the second groups comprised of five genotypes (FLIP 03-87C, FLIP 05-74C, FLIP 05-87C, FLIP 05-110C and FLIP 05-142C) and the last group (FLIP 05-150C). Whereas the first group in winter sowing date comprised of five genotypes (FLIP 97-706C, FLIP 03-87C, FLIP 05-74C, FLIP 05-87C and FLIP 05-110C), FLIP 05-142C was in the second group and the last group was FLIP 05-150C. The result indicates the presence of high variability between genotypes used in this study and low variability in both sowing dates, because genotypes in the second group in winter and in first groups in spring were similar. The variability among the genotypes was high, and the improvement of this crop is possible through the breeding techniques. This result agrees with some of the findings of **[14]** and **[20].**

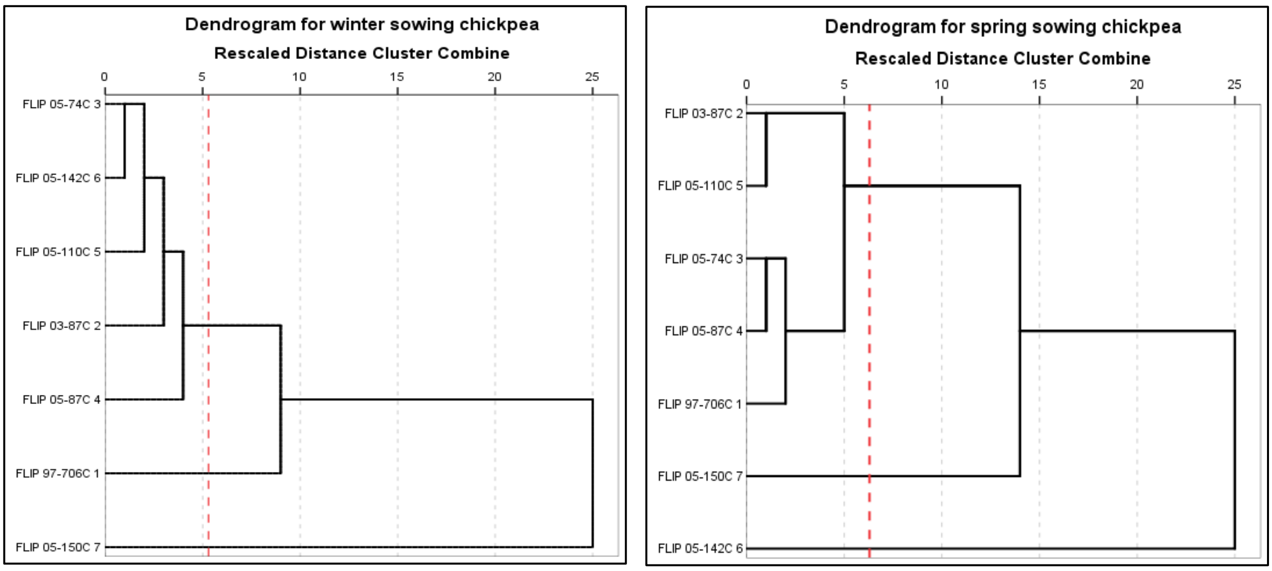


Figure 3. Dendrogram of seven chickpea genotypes based on cluster analysis of agro-morphological (winter and spring) dates

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Appendix 1: Physical and chemical properties of the study soil in Sulaimani-Qlyasan.

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. Metrological data at Sulaimani-Qlyasan during (2015-2016).

Period	*Sulaimani – Qlyasan*		
	Temp. C°		*Rainfall (mm)*
	Min.	*Max.*	
December	7.4	12.45	52.7
January	5.7	10.6	72.5
February	9.88	15.7	64.8
March	12.4	18.4	122.6
April	17.1	23.9	55.2
May	22.4	29.8	6
June	30.6	37.6	0
Total	**—**	**—**	***373.6***

Appendix 3. Mean squares of variance analysis of the studied characters.

S.O.V	d.f	Plant height (cm)	Plant weight (g)	No. of branches/plant	No. of pods/plant	No. of seed/pod	100-grain weight (g)	Seed yield/plant (g)
Replicates	**2**	27.895	3097.391	0.545	0.662	0.010	13.552	0.630
Sowing date	**1**	4193.802**	98883.760**	4.937**	7595.215**	0.009 n.s	6.688 n.s	712.430**
Varieties	**6**	45.111**	691.665 n.s	0.131 n.s	536.397**	0.010 n.s	68.519**	12.791 n.s
Sowing date × Varieties	**6**	13.669 n.s	878.035 n.s	0.061 n.s	125.665*	0.012 n.s	6.329 n.s	7.555 n.s
Experimental Error	**26**	**11.072**	**1432.631**	**0.108**	**42.519**	**0.033**	**3.655**	**8.272**