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Biometric Indicators of Semi-Erect Chickpea (Cicer Arietinum L.) Collection Samples Grown Under Weakly Saline Soil Conditions of Sirdarya Region

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Abstract: This article presents the results of studying semi-erect chickpea collection accessions under mildly saline soil conditions. The study object comprised semi-erect chickpea accessions introduced from the ICARDA international organization. Among them, the FLIP 97-21c and FLIP 97-95c collection accessions were identified as promising in terms of yield, with their productivity recorded at 22–22.08 c/ha. Additionally, the FLIP 97-95c, FLIP 98-211c, and FLIP 97-23c collection accessions exhibited 1000-seed weights of 429–433.4 g, surpassing the control, and were recommended as primary sources for initiating breeding programs.

Keywords: Chickpea, germplasm, correlation, yield, yield components, factor analysis.

Introduction: Leguminous grain crops are regarded as crop species of biological, ecological, and socio-economic importance. This, in turn, is associated with the high protein content of its seeds, their value as quality feed for livestock, and their potential to enhance soil fertility. Among leguminous seed crops, chickpea ranks after common bean and soybean, with a seed protein content of 14–32%, and has been traditionally consumed by the population. The primary center of origin of chickpea has been recorded as Southwest Asia and the Mediterranean region, whereas its secondary center is noted to be Ethiopia. Moreover, chickpea diversity has been documented across the Mediterranean, Central Asia, the Near East, and India [1; 18-20; 10; 26-33].

The key biological characteristics of chickpea, as noted above, include its high-quality protein content as well as its tolerance to drought and cold. These specific traits enable the cultivation of chickpea across diverse regions of the world. The plant gene bank established for studying, conserving, and utilizing the biodiversity of chickpea species in scientific research holds significant importance not only in breeding and genetics but also in plant science. The plant gene bank serves as a primary resource for both analytical and synthetic breeding, and developing cultivars adapted to the soil and climatic conditions of each region holds critical importance. It has been determined that currently, the All-Union Institute of Plant Science maintains 3,380 chickpea accessions introduced from 60 countries worldwide. The study of the biological, morphological, and economic traits of these accessions revealed that those introduced from Ethiopia exhibited stability and dominance in quantitative traits, whereas accessions introduced from Turkey demonstrated high

variability in their characteristics. The chickpea accessions from Turkey and Ethiopia have been recognized as having significant value for breeding [2; 5-12, 3; 170-179].

As noted above, chickpea's tolerance to drought and cold enables its cultivation on fallow lands and during early spring. Additionally, it has been established that chickpea can be cultivated under irrigated conditions and in soils prone to salinization [7; 122, 8;71-75]. However, the biological and economic values of chickpea accessions have not been comprehensively studied under irrigated soils prone to salinization. In particular, evaluating the breeding value of chickpea accessions and recommending them as initial sources for breeding holds significant importance. For this purpose, modern statistical software has been recommended [4 23-25, 5; 243-245; 7; 122, 9; 262-264, 11; 7-13].

The main objective of this study was to investigate the biometric traits of semi-erect chickpea accessions under mildly saline soil conditions and to select the most promising ones.

METHODS

The study object consisted of semi-erect chickpea accessions introduced by ICARDA (International Center for Agricultural Research in the Dry Areas). The acclimatized chickpea variety Uzbekistan-32 was used as the control. All phenological observations and measurements were conducted following the guidelines issued by the Scientific Research Institute of Cotton Growing of the Republic of Uzbekistan [12; 175], and primary data analysis was performed using specialized statistical software [6; 120, 14; 65-107]. To determine the structure of correlation relationships, the formula d=1−rd = 1 - rd=1−r was used, where ddd represents the distance between traits and rrr is the correlation coefficient between them [13; 306].

RESULTS AND DISCUSSION

Table 1 presents the studied traits and their quantitative indicators of the semi-erect chickpea accessions used as the research object. According to the table, the average weight of pods per plant was 20.03 g, ranging from a minimum of 10.40 g to a maximum of 30.80 g. These values indicate that the pod weight per plant exhibited considerable variation across the genotypes. The number of pods per plant was 38.89 or 39, the seed weight per plant was 15.36 g, and the number of seeds per plant was 42.49 or 43. The number of seeds per pod was 1.09, the seed proportion in the pod was 77.32%, the weight of 1000 seeds was 363.6 g, and the yield was 15.51 c/ha.

Based on the primary data, it can be observed that there are pronounced differences among genotypes in terms of yield components formed per individual plant, including the number of pods, seed number, and seed weight. In such cases, in order to compare genotypes, it is primarily necessary to obtain data on traits and their quantitative indicators. This can also be observed from the data presented in Figure 1. The figure provides information on the degree and structure of correlation relationships between traits and their quantitative indicators in semi-erect genotypes. The figure shows that there is a strong correlation (r = 0.95–0.96) between pod weight per plant (trait 1), seed weight per plant (trait 3), and yield (trait 8).

It should be noted that the distance between the figures represents the magnitude of the correlation coefficient and was calculated using the formula d = 1 − r. Here, d denotes the distance between traits, while r represents the correlation coefficient between them.

Table 1

Biometric parameters of semi-erect pea genotypes

№	Genotype	On one plant							Grain yield, q/ha
		Bean		grain		Seeds per pod, pcs	Grain share, %	Weight of a 1000 grain, g	
		weight, g	quantity, pcs.	weight, g	quantity, pcs.				
		1	2	3	4	**5**	**6**	**7**	**8**
1	Uzbekistan-32 (control)	29,4	72,3	22,6	88.0	1,2	77,3	258,8	22,8
2	FLIP 97-190c	16,5	33.0	12,5	36,2	1,1	75,6	339,5	13,5
3	FLIP 98-109c	22,2	47.0	17,3	58,5	1,1	79,6	301	19.0
4	FLIP 97-21c	29,2	53,6	20,9	55,5	1.0	71.0	368,9	22.0
5	FLIP 97-51c	10,4	20,9	8,4	20,7	1,1	79,3	363,7	9.0

6	FLIP 97-104c	17,6	33,3	13	33,2	1.0	74,8	366,7	12.0
7	FLIP 97-95c	30,8	45,9	24,4	57,2	1,3	78,7	423,3	22,8
8	FLIP 95-46c	20,3	45.0	15,4	45.0	1.0	75.0	336,4	17,2
9	FLIP 97-220c	15,5	28,3	11,7	33,9	1,2	77,1	338,4	12,6
10	**FLIP 98-211c**	21,2	38,5	16,6	36,2	1.0	80.0	433,4	18,7
11	FLIP 97-102c	17,2	35.0	13,6	35,7	1,1	82,5	375,8	12.0
12	FLIP 97-141c	13,9	29,5	10,9	32,1	1.0	78,3	341,9	12.0
13	**FLIP 97-23c**	24,5	37,7	18,7	44,2	1,2	76,4	429,4	17.0
14	ILC-3832	17,5	37,3	14,3	35,3	1.0	82,5	399,6	12,5
15	ILC-3279 (105)	13,8	25,8	10,7	28,4	1,1	77,6	373,5	10.0
16	ILC-3279 (100)	20,5	34,4	14,7	39,7	1,1	71,4	368,1	15.0
Average		**20.03 ±1,50**	**38.59 ±3.08**	**15.36 ±1,12**	**42.49 ±4.0**	**1,09 ±0,02**	**77.32 ±0,83**	**363.6 ±11,4**	**15.51 ±1,13**
Minimum		10,40	20,90	8,40	20,70	1,00	71,00	258,8	9,00
Maximum		30,80	72,30	24,4	88,00	1,30	82,50	433,4	22,80

The higher the correlation coefficient, the shorter the distance between the traits.

Based on these findings, pod weight per plant (trait 1) and seed weight per plant (trait 3) were identified as major factors strongly influencing yield (trait 8), and, due to their strong interrelationships, they formed the core of the correlation group. This correlation group was designated as "yield." In turn, yield was also influenced by the number of pods per plant (trait 2) and the number of seeds per plant (trait 4). Consequently, an increase in the number of pods per plant (trait 2) also affected the increase in the number of seeds per plant (trait 4). A strong correlation (r = 0.96) was observed between these traits.

A negative correlation (r = −0.405) was observed between the seed proportion per pod (trait 7) and the number of pods formed per plant (trait 2). This indicated that an increase in the number of pods led to a decrease in seed weight. A weak correlation (r = 0.303) was observed between the number of seeds per pod (trait 5) and yield (trait 8). This can also be inferred from the distances between these traits. A weak negative correlation (r = −0.284) was observed between seed proportion per pod (trait 6), yield (trait 8), and pod weight per plant (trait 1). Thus, an increase in pod weight led to a reduction in seed output.

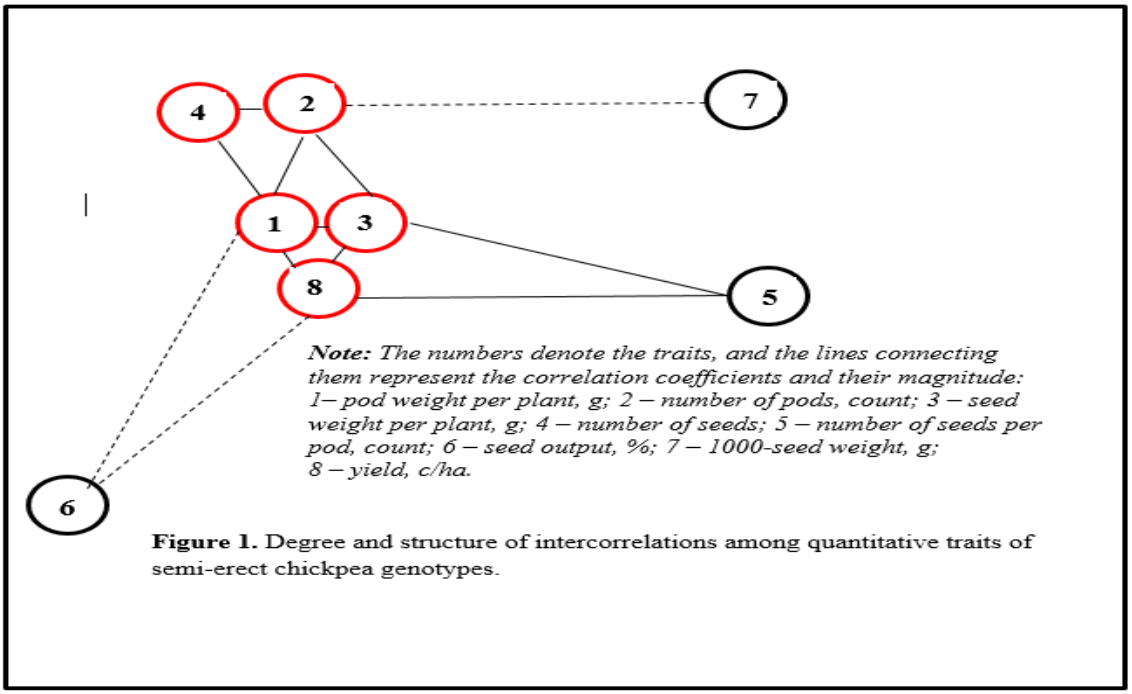

Figure 1. Degree and structure of intercorrelations among quantitative traits of semi-erect chickpea genotypes.

As noted above, the degree of correlation among the quantitative indicators of traits in semi-erect chickpea collection accessions varied, which served as the basis for their classification into distinct correlation groups. This can also be observed from the data presented in Table 2. Table 2 shows the results of factor analysis of quantitative traits in semi-erect chickpea genotypes. According to the first factor, pod weight per plant (0.963), number of pods per plant (0.938), seed weight per plant (0.958), number of seeds per plant (0.956), and yield (0.959) exhibited relatively high factor loadings. Based on the nature of these traits, the first factor can be defined as the "productivity" factor. This is because these traits had a strong influence on productivity. This was also clearly demonstrated by the data presented in Figure 1.

For the second factor, 1000-seed weight (0.864) exhibited the highest factor loading. This factor was designated as the "seed weight" factor. For the third factor, traits such as the number of seeds per pod (0.487) and seed proportion per pod (0.721) differed in their factor loadings. It should be noted that the number of seeds per pod exhibited relatively high factor loadings in both the first factor (0.409) and the second factor (0.413). However, for the third factor, its loading was higher compared to the first and second factors. The fourth factor did not provide any significant information, as all studied traits were adequately represented in the first three factors.

Table 2.

Factor loadings of quantitative traits in semi-erect chickpea genotypes.

Traits	Factor loadings of chickpea traits			
	1	**2**	**3**	**4**
Pod weight per plant, g	**0,963**	0,193	-0,174	0,019
Number of pods per plant, count	**0,938**	-0,220	0,070	0,223
Seed weight per plant, g	**0,958**	0,260	-0,080	0,066
Number of seeds per plant, count	**0,956**	-0,194	0,200	0,036
Number of seeds per pod, count	0,409	0,413	**0,487**	-0,652
Seed output, %	-0,255	0,402	**0,721**	0,502
1000-seed weight, g	-0,231	**0,864**	-0,428	0,108
Yield, c/ha	**0,959**	0,095	-0,132	0,099

The distribution of quantitative trait indicators of semi-erect chickpea collection accessions across factors is also illustrated in Figure 2. Based on the data presented in the figure, pod weight per plant (1), seed weight per plant (3), and yield (8) were found to be similar in terms of the degree of their correlation relationships. Under these conditions, yield was more strongly associated with pod weight and seed weight. A similar result was also observed between the number of pods per plant (2) and the number of seeds per plant (4). Although the number of seeds per pod (5) had a weak effect on yield, a positive correlation with yield was recorded. The proportion of seeds per pod (6) and the 1000-seed weight were negatively correlated with the first factor.

These data indicated that a strong correlation group was formed among the traits of semi-erect chickpea, based on the degree and structure of their interrelationships. Pod weight per plant, seed weight per plant, number of seeds per plant, and number of pods per plant were identified as major factors influencing yield.

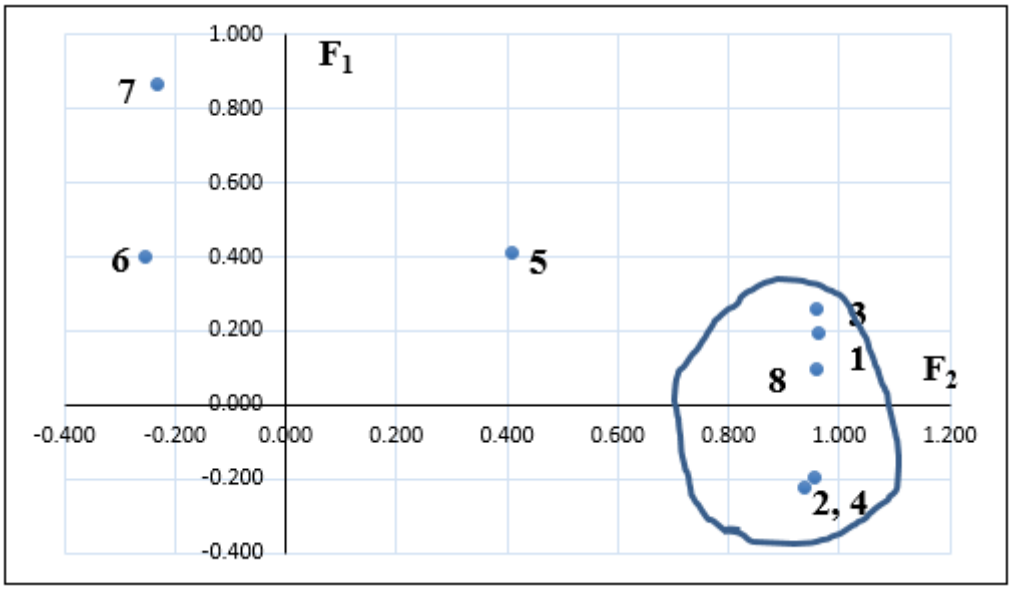

Figure 2. Factor structure of quantitative trait indicators in semi-erect chickpea collection accessions

Here, F1 represents the similarity of traits across factors; while F2 represents the specificity of traits across factors.

Note: Numbers correspond to traits: 1 – pod weight per plant, g; 2 – number of pods, count; 3 – seed weight per plant, g; 4 – number of seeds; 5 – number of seeds per pod, count; 6 – seed output, %; 7 – 1000-seed weight, g; 8 – yield, c/ha.

Based on the analysis results, it became possible to select semi-erect chickpea collection accessions. This can be clearly observed from the following Table 3 and figures. Based on the table data, collection accessions with serial numbers №1 (Uzbekistan-32), №4 (FLIP 97-21c), and №7 (FLIP 97-95c) were identified as high-yielding. Their factor loadings on the first factor (note: the first factor represents yield, the second factor — 1000-seed weight, and the third factor — proportion of seeds per pod) were 2.224, 1.238, and 1.474, respectively. This can also be observed from Table 1. The yield of these varieties and collection accessions ranged from 22.0 to 22.8 c/ha.

Regarding the second factor, i.e., 1000-seed weight, collection accessions №7 (FLIP 97-95c) (2.228), №10 (FLIP 98-211c) (1.153), and №13 (FLIP 97-23c) (1.532) exhibited higher values compared to others, ranging from 429.4 to 433.4 g, whereas the control variety Uzbekistan-32 had a value of 258.8 g.

Table 3

Factor loadings of semi-erect chickpea genotypes

№	Factor loadings of the genotypes				№	Factor loadings of the genotypes			
	1	**2**	**3**	**4**		**1**	**2**	**3**	**4**
1	**2,244**	-1,391	1,611	0,015	**9**	-0,58	-0,124	0,827	-1,557
2	-0,438	-0,610	-0,015	-0,761	**10**	-0,04	**1,153**	-0,754	1,730
3	0,674	-0,750	**1,118**	0,604	**11**	-0,55	0,600	*1,117*	0,771
4	**1,238**	-0,595	-2,143	0,346	**12**	-0,90	-0,740	0,100	0,540
5	-1,483	0,0001	0,660	-0,510	**13**	0,41	**1,532**	-0,455	-0,85
6	-0,583	-0,584	-0,963	0,062	**14**	-0,57	0,621	0,373	1,859
7	**1,474**	**2,284**	0,351	-0,804	**15**	-1,03	0,047	0,171	-0,595
8	0,197	-1,024	-0,706	0,531	**16**	-0,04	-0,41	-1,29	-1,37

For the third factor, related to the proportion of seeds per pod, collection accessions №3 (FLIP 98-109c) and №11 (FLIP 97-102c) exhibited relatively high values, ranging from 79.6 to 82.5%.

Based on the data in Figure 3, accessions №7, №1, and №4 were identified as promising, whereas №5, №15, №12, №11, and №14 were observed to be low-yielding genotypes.

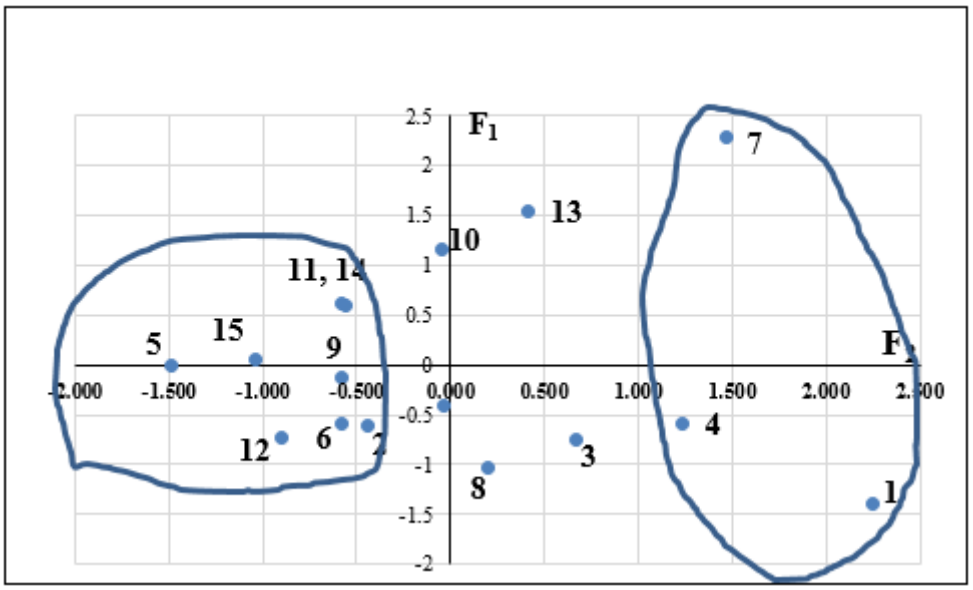

Figure 3. Distribution of semi-erect chickpea collection accessions across factors

Here, F1 represents the loadings of chickpea genotypes on the first factor;

F2 represents the loadings of chickpea genotypes on the second factor.

The numbers correspond to the genotypes; see Table 1.

Overall, among the semi-erect chickpea collection accessions, FLIP 97-21c and FLIP 97-95c were identified as high-yielding. The yield of these genotypes ranged from 22.0 to 22.8 c/ha.

Based on the obtained results, the following conclusions were drawn.

1. In the semi-erect chickpea collection accessions, the average pod weight per plant was 20.0 g, the number of pods per plant was 38.59 or 39, the seed weight per plant was 15.36 g, and the number of seeds per plant was 42.49 (43). The number of seeds per pod was 1.09, the proportion of seeds per pod was 77.32%, the 1000-seed weight was 363.6 g, and the average yield was 15.51 c/ha.

2. The degree of correlation among chickpea traits was found to be weak, moderate, or strong. Yield was observed to be strongly correlated with the number of pods, pod weight, the number of seeds, and seed weight.

3. Under mildly saline soil and climatic conditions, among the studied semi-erect chickpea collection accessions, FLIP 97-21c and FLIP 97-95c were identified as promising and recommended for use in breeding programs.

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