Research Article

Genetic variability among chickpea genotypes evaluated under two different environmental conditions

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Citation

Lubna Naz, Sumayya Inayat, Amna Shafi and Rozina Hamayoon. Genetic variability among chickpea genotypes evaluated under two different environmental conditions. Pure and Applied Biology. Vol. 10, Issue 4, pp1230-1239. <http://dx.doi.org/10.19045/bspab.2021.100129>

Received: 19/11/2020

Revised: 22/01/2021

Accepted: 02/02/2021

Online First: 08/02/2021

Abstract

Genetic variability among diverse chickpea genotypes were studied at two different environmental conditions evaluated at The University of Agriculture, Peshawar and Agricultural Research Station, Ahmad Wala Karak, during 2007-2008. The experiment was carried out in randomized complete block design with three replications. Data was recorded on yield, yield components and other agronomic parameters to estimate genetic variability, heritability and genotype x environment interaction. Result revealed significant differences among genotypes for all traits under study. Genotype by environment interaction was also found highly significant for all the characters except for number of seeds per pod⁻¹ suggesting this trait is stable across both the environments.. The genotypes at Karak showed significantly greater seed yield than at Peshawar. Based on yield performance, chickpea genotype SL-03-14 produced higher yield at both the environmental conditions. High heritability estimates were observed for days to flowering, plant height, number of nodules plant⁻¹, 100-seed weight, seed yield (kg ha⁻¹) both at Peshawar and Karak. High heritability estimates showed the presence of genetic variability. Thus, these traits can be effectively utilized in future breeding program for genetic improvement of chickpea genotypes.

Keywords: Genetic variability; Genotype X environment interaction; Heritability

Introduction

Chickpea (*Cicer arietinum* L.) is an important food legume after dry beans and peas [1] and one of the leading pulses grown in Pakistan. It is thought to be originated in the Southern Caucasus and Northern Persia [2] and mostly cultivated in the arid and semi- arid region of the world. Chickpea is of vital importance as it restores soil fertility by adding significant amount of nitrogen and organic matter to the soil and there by benefits other cereals.

Chickpea was cultivated on an area of 0.94 million hectare with the production of 0.39million tons in Pakistan, whereas, in Khyber Pakhtunkhwa it was cultivated on an area of 0.04 million hectare with the production of 0.02 million tons during 2014 [3]. In Khyber Pakhtunkhwa about 75% of the chickpea is cultivated in southern districts including DI Khan, Tank, Lakki Marwat, Bannu and Karak. Irrespective of its economic and nutritional significance, the yield of chickpea is very limited in Pakistan mainly due to its narrow genetic base, lack of high yielding varieties and

vulnerability to various biotic and abiotic stresses. In order to improve the performance of chickpea, germplasm diversification is highly essential [4].

Pakistan is basically a protein-deficient country and major protein requirement is met through pulses. Chickpea is rich and cheapest source of nutritive elements, containing 23% protein, 64% total carbohydrates, 5% fat, 6% crude fiber and 3% ash (ICRISIT). Chickpea also contain 21% starch suitable for textile industry and give a light finish to silk, wool and cotton clothes [5]. With increase in population, the need for protein is increasing day by day which enhanced the production of pulses because animal protein is scarce and expensive and beyond the purchase power of poor masses [6]. Therefore, plant breeders are using different scientific approaches to increase the genetic potential of the crop to enhance its productivity and yield [4,7] in order to meet the demand of the overly increasing population. For this purpose, it is prerequisite for plant breeders to know about the nature and magnitude of variation among chickpea genotypes in varying environments [8].

Agriculture productivity across the globe is severely threatened by the changes in climate which leads to occurrence of extreme events such as drought and flood. The vulnerability of climate necessitates the production of stable and consistent genotypes across various environmental conditions. In this regard, interaction between genotype and environment is an important factor to consider in any plant breeding program as it indicates the adaptability of genotype in different environments. Thus, selecting superior genotypes for particular climatic condition is hard to achieve as this interaction is very complex to unwind. Therefore, plant breeders include genetic variability in their breeding program as an opportunity to select desirable genotypes with higher yield. In addition, estimation of heritability is another important factor to consider as it

reflects the differences in phenotype contributed either by genetic or environmental variations. High heritability for any trait indicates less environmental influence and therefore can be effectively considered in crop improvement program [9]. It is therefore, mandatory to evaluate the performance of genotypes in several environments to examine their genetic potential. Keeping in view the utmost importance of genetic variability and introducing best adopted genotypes for various environmental conditions, the present study was conducted with the objective to determine and compare the estimation of heritability across locations and to assess genotype x environment interaction for yield and yield related components.

Material and Methods

To determine genetic variability among twenty chickpea genotypes, an experiment was conducted at two different locations (The University of Agriculture, Peshawar and Agricultural Research Station, Ahmad Wala Karak) of Khyber-Pakhtunkhwa during 2007-08. The crop was sown in October 2007 at both the locations using randomized complete block design with three replications. The detail of the experimental material is given in (Table 1).

Plant to plant and row to row distance was 10 and 40 cm, respectively. Each replication consisted of 20 plots and each plot comprised of 3 rows with 4-meter row length. Data were recorded on the following parameters.

1. Days to 50% flowering

The number of days to 50% flowering was calculated as the total number of days from the date of sowing to the time when 50% plants of an entry showed the appearance of first flower and then average was calculated.

2. Plant height (cm)

Height of randomly selected plants was measured from ground to the tip of the plant at maturity and averaged was calculated.

3. Number of nodules plant⁻¹

Number of nodules was counted on randomly selected plants when flowering started.

4. Number of productive branches plant⁻¹

Number of branches bearing pods was counted on randomly selected plants and then averaged.

5. Number of pods plant⁻¹

Pods were taken from randomly selected plants and counted after harvesting and then average was calculated.

6. Number of seeds pod⁻¹

The total number of seeds in a pod was counted for randomly selected pods from randomly selected plants and their average value was calculated.

7. 100-grain weight

The 100-seeds from randomly selected plants were weight in grams and average was calculated.

8. Seed yield (kg ha⁻¹)

Average seed yield per plot was calculated and then converted to kg/ha using the following relationship:

$$\text{Yield (kg/ha)} = \frac{\text{Yield (g)} \times 10,000}{3 \times 0.4 \times 4.0 \times 1000}$$

Table 1. Details of the experimental material

Genotype	Origin	Genotype	Origin
NDC-727	NIFA, Pakistan	NKC-5-S16	ICARDA, Syria
NDC-15-4	NIFA, Pakistan	NKC-5-S17	ICARDA, Syria
NDC-4-15-3	NIFA, Pakistan	NKC-5-S23	ICARDA, Syria
NDC-4-20-1	NIFA, Pakistan	NKC-5-S24	ICARDA, Syria
NDC-4-20-3	NIFA, Pakistan	SL-05-42	Karak
NDC-4-20-7	NIFA, Pakistan	SL-05-53	Karak
NDC-5-S11	ICRISAT, India	SL-03-14	Karak
NKC-5-S12	ICARDA, Syria	SL-03-15	Karak
NKC-5-S14	ICARDA, Syria	SL-03-29	Karak
NKC-5-S15	ICARDA, Syria	SL-03-64	Karak

Statistical analysis

The data from both Peshawar and Karak was analyzed using Statistical software SAS (Statistical analysis system). Least significant difference (LSD) test was also applied on the data. The estimation of heritability was calculated by using following formula [10].

$$\text{Heritability} = V^2_g / V^2_p$$

Results and Discussion

Data collected from different morphological and agronomic traits were analyzed and interpreted to determine the variation among the genotypes across two different locations. Analysis of variance revealed significant differences among genotypes for all the parameters studied.

Locations/environment also differed significantly for all the traits except for plant height. Genotype by environment interaction was also found highly significant for all the characters studied except for number of seeds per pod⁻¹, indicating this parameter is stable and thus not affected by change in environments (Table 2)

1. Days to 50% flowering

Among locations/environments, minimum number of 104 days to flowering was recorded at Karak, while maximum (144days) at Peshawar (Table 3). For genotypes, the mean value indicated that the genotype NKC-5-S23 emerged 50% flowers earlier with the mean value of 115

days while, genotype NDC-4-20-7 showed more days to flowering with mean value of 137 days. The performance of genotype across environment showed that NDC-5-S11 produced earliest flowering (92 days) at Karak condition. Farmer needs short duration genotype because they reduce the incidence of insect, pest and disease attack. Singh and Bejiga [11], Shaukat Ali *et al.* [12], Hakim *et al.* [13] Atta *et al.* [14] and Saleem *et al.* [15] also reported significant results for days to flowering. Significant genotype x environment interaction for days to flowering showed genetic diversity in chickpea genotypes, which responded differently. The findings of Singh and Bejiga [11], Vijay [16], and Rao [17] also support the result of the present study.

2. Plant height (cm)

Data revealed, maximum mean value of plant height (41.0 cm) for Peshawar, while minimum mean value (40.9 cm) for Karak location (Table 3). For tested genotypes, NDC-15-4 showed maximum plant height of 47.2 cm, while SL-03-29 showed minimum plant height of 32.3 cm. Regarding performance of genotype across environment, both maximum and minimum plant height was observed for genotype NKC-5-S15 (52.9cm) and SL-03-29 (30.5cm) at Peshawar location... The result suggested sufficient variability among tested genotypes for plant height. Raza and Mehdi [18], Nawab [19], Arshad *et al.* [20], Hakim *et al.* [13] and Atta *et al.* [14] reported sufficient variability among genotypes for plant height. Genotype x environment interaction were also found significant in the present study which is in line with the findings of Singh and Bejiga [11], Vijay [16] and Mishra and Jian [21].

3. No. of nodules plant⁻¹

Among tested locations, highest number of nodules plant⁻¹ was recorded for Karak (9.0) while, lowest for Peshawar (7.0) (Table 4). Results indicated that among genotypes, maximum nodules of 20.0 were observed for genotype NKC-5-S17 and minimum nodules of 2.0 were recorded for genotype NKC-5-S16. Regarding

performance of genotype across environments, NKC-5-S14 produced more no. of nodules plant⁻¹ (23.0 no. of nodules plant⁻¹) at Karak condition. Significant differences among chickpea genotypes for number of nodules plant⁻¹ were also reported by Gul *et al.* [22] and Hussain *et al.* [23].

4. No. of productive branches plant⁻¹

Peshawar showed the highest number of productive branches (10.0 branches plant⁻¹) while, lower number of branches was recorded for Karak (4.0 branches plant⁻¹) (Table 4). Regarding tested genotypes, maximum productive branches of 11.0 was recorded for genotype SL-05-53 and minimum branches of 5.0 was recorded for genotype NDC-727, NDC-15-4, NDC-4-15-3, NDC-4-20-1 and NDC-4-20-3. Concerning genotype and environment interaction, genotype SL-05-53 performed better by producing more no. of productive branches (17.0 branches plant⁻¹) at Peshawar location. Significant differences among genotypes for branches per plant were also reported by Raza & Mehdi [18] and Saleem *et al.* [15] and similarly, significant genotype by environment interactions were also reported by Vijay [16] and Mishra & Jain [21].

5. Number of pods plant⁻¹

Among locations/environments, maximum number of pods plant⁻¹ was recorded for Peshawar (35.0), whereas, minimum was recorded for Karak (24.0) (Table 5). On the other hand, among tested genotypes SL-03-14 gave maximum mean value of 45.0 while, lowest value of 21.0 was observed for NDC-4-20-1. In case of performance of genotype across environments, maximum pods plant⁻¹ (64.0 pods plant⁻¹) was produced by SL-03-14 at Peshawar location. Significant differences among chickpea genotypes for number of pods plant⁻¹ were also observed by Raza and Mehdi [18], Nawab [19], Arshad *et al.* [20] Hakim *et al.* [13] and Atta *et al.* [14]. Furthermore, significant genotype by environment interaction was also reported by Vijay [16], Rao [17], and Mishra and

Jain [21] which supports our results of significant genotype by environment interaction..

6. Number of seeds pod⁻¹

Results revealed that among locations, Peshawar showed higher number of seeds pod⁻¹(1.3) whereas, Karak showed minimum seeds pod⁻¹ (1.1 seeds pod⁻¹) (Table 5). Among various genotypes, NDC-4-20-3 exhibited highest mean value of 1.5, whereas, minimum mean value of 1.0 was recorded for SL-05-53. In case of interaction effect, genotypes NDC-4-20-1, NDC-727, NDC-4-20-3 produced more number of seeds pod⁻¹with mean value of 1.7 at Peshawar location.. Our results indicated significant differences among genotypes while, non-significant differences for genotype by environment interaction indicating that this trait is stable across locations. Significant differences among genotypes were also reported by Shahzad *et al.* [24] and Pattnaik *et al.* [25] in chickpea genotypes.

7. 100-grain weight (g)

It was observed from the data that mean value for 100-grain weight was higher for Karak as compared to Peshawar (Table 6). In case of genotypes, NKC-5-S17 showed the highest mean value of 33.6 whereas, minimum mean value of 14.8 was observed for SL-03-29. The performance of genotype across environment showed that genotype NKC-5-S17 produced maximum 100-grain weight of 37.3 g at Karak location. .Raza and Mehdi [18], Nawab [19], Arshad *et al.* [20] Hakim *et al.* [13] and Atta *et al.* [14] also reported significant differences among chickpea genotypes for 100 grain weight which are in line with the findings of our experiment. Our results also showed significant GXE interaction which was supported by the work of Vijay [16] and Rao [17] who also reported significant GXE interaction.

8. Seed yield (kg/ha)

According to the data, maximum seed yield was recorded at Karak (830.4 kg/ha) followed by Peshawar (316.0 kg/ha) (Table 6). Among tested genotypes, SL-03-14

produced maximum seed yield of 1126.5 kg /ha whereas lowest seed yield of 100.2 kg/ha was produced by NKC-5-S24. Regarding performance of genotype across environment, SL-03-14 produced maximum seed yield of 1541 kg/ha in Karak location.). . Whereas, NKC-5-S24 produced minimum seed yield at both the locations. The findings from our study are in agreement with those of Vijay [16], Shaukat *et al.* [12] and Hakim *et al.* [13] who also reported significant differences for genotype by environment interaction.

Heritability

Genotypic and phenotypic variance provides basic information about the variability only, whereas, heritability determines the heritable portion of this variability. At Peshawar location, high heritability estimates were observed for days to 50% flowering (85%), number of nodules plant⁻¹(90%) and 100-seed weight (70%), while, moderate heritability was recorded for plant height (64%), no. of pods plant⁻¹ (64%), no. of productive branches plant⁻¹ (50%) and seed yield (kg/ha) (52%) (Table 7). However, no. of seeds pod⁻¹ showed low heritability estimate of 28%.

In case of Karak, traits such as days to 50% flowering (90%), number of nodules plant⁻¹(89%) and 100-seed weight (90%) and seed yield (82%) exhibit high heritability, whereas, plant height and no. of seed pods⁻¹ showed moderate heritability of 60% and 46% (Table 7). Low heritability was observed for traits such as no. of productive branches plant⁻¹ (2.12) and no. of pods plant⁻¹ (26%). Characters with high heritability value are least influenced by environmental variation and therefore can be effectively used in crop improvement program when selecting for stable genotypes Maniee*et al.*[9].High heritability in these characters in chickpea genotypes were also reported by Raz and Mehdi [18], Arrora *et al.* [26] Sable *et al.* [27] Zubair *et al.* [28] Noor *et al.* [29] Ghafoor *et al.* [30] Hakim *et al.* [13] Durga *et al.* [31] and Saleem *et al.* [15]. Moderate to low heritability estimates were recorded for

number of seeds pod⁻¹ (28%, 46%), number of productive branches plant⁻¹ (50%, 2.12%) at Peshawar and Karak locations, respectively. Similar results were also identified by Shahzad *et al.* [24]. Low heritability value indicated that the main proportion of variability is due to

environmental effects. Number of pods plant⁻¹ showed moderate heritability value of 64% in Peshawar region while low in Karak region (26%). High heritability for number of pods plant⁻¹ was also reported by Pattnaik *et al.* [25] Jeena *et al.* [32] and Durga *et al.* [31].

Table 2. Analysis of variance for different parameters of 20 chickpea genotypes evaluated at Agricultural University Peshawar and Ahmad Wala Research Station, Karak during 2007-08

Parameters	Environment	Genotypes	GXE	Error
Days to 50% flowering	48320.5**	184.2**	42.5**	4.49
Plant height	0.16 ^{NS}	107.1**	63.8**	14.4
No. of nodules plant ⁻¹	146.9**	110.0**	55.6**	2.92
Number of productive branches plant ⁻¹	1200.2**	15.7**	11.7**	3.7
Number of pods plant ⁻¹	3583.9**	232.9**	184.5**	50.7
Number of seeds pod ⁻¹	1.30**	0.12**	0.05 ^{NS}	0.04
100-grain weight	649.6**	109.3**	7.53**	3.99
Seed yield (kg ha ⁻¹)	7940278**	503328**	167170**	29772

** = Significant at 1% probability level. NS = Non-significant

Table 3. Mean values for days to 50% flowering and plant height

Days to 50% flowering				Plant height		
Genotype	Peshawar	Karak	Mean	Peshawar	Karak	Mean
NDC-727	150	110	130	32.7	46.3	39.5
NDC-15-4	150	108	129	44.6	49.7	47.2
NDC-4-15-3	148	104	126	38.7	35.9	37.3
NDC-4-20-1	149	109	129	42.1	39.4	40.8
NDC-4-20-3	152	109	131	40.4	37.4	38.9
NDC-4-20-7	152	121	137	48.3	33.3	40.8
NDC-5-S11	140	92	116	47.7	42.6	45.2
NKC-5-S12	142	104	123	37.9	40.7	39.3
NKC-5-S14	141	106	124	37.4	40.1	38.8
NKC-5-S15	139	105	122	52.9	40.8	46.9
NKC-5-S16	137	94	115	35.4	38.3	36.9
NKC-5-S17	136	98	117	40.3	41.4	40.9
NKC-5-S23	131	99	115	39.4	36.4	37.9
NKC-5-S24	143	106	125	38.4	45.3	41.9
SL-05-42	143	104	124	43.3	42.4	42.9
SL-05-53	147	102	124	42.8	50.9	46.9
SL-03-14	140	101	121	44.1	46.1	45.1
SL-03-15	152	102	127	46.2	44.2	45.2
SL-03-29	149	100	125	30.5	34.0	32.3
SL-03-64	141	104	123	36.0	32.5	34.3
Total	144	104	124	41.0	40.9	40.9

Table 4. Mean values for No. of nodules plant⁻¹ and No. of productive branches plant⁻¹

No. of nodules plant ⁻¹				No. of productive branches plant ⁻¹		
Genotype	Peshawar	Karak	Mean	Peshawar	Karak	Mean
NDC-727	12	3.0	7.0	7.0	3.0	5.0
NDC-15-4	5.0	6.0	5.0	7.0	3.0	5.0
NDC-4-15-3	6.0	7.0	7.0	7.0	3.0	5.0
NDC-4-20-1	8.0	9.0	9.0	8.0	3.0	5.0
NDC-4-20-3	6.0	4.0	5.0	7.0	3.0	5.0
NDC-4-20-7	11	7.0	9.0	9.0	3.0	6.0
NDC-5-S11	5.0	19	12	11	4.0	7.0
NKC-5-S12	4.0	7.0	5.0	10	3.0	7.0
NKC-5-S14	12	23	18	12	4.0	8.0
NKC-5-S15	3.0	2.0	3.0	10	4.0	7.0
NKC-5-S16	2.0	3.0	2.0	9.0	4.0	6.0
NKC-5-S17	21	18	20	9.0	4.0	7.0
NKC-5-S23	6.0	9.0	7.0	8.0	4.0	6.0
NKC-5-S24	11	7.0	9.0	8.0	4.0	6.0
SL-05-42	7.0	5.0	6.0	12	4.0	8.0
SL-05-53	5.0	9.0	7.0	17	5.0	11
SL-03-14	9.0	10	10	14	5.0	10
SL-03-15	1.0	13	7.0	11	4.0	8.0
SL-03-29	4.0	7.0	5.0	8.0	4.0	6.0
SL-03-64	2.0	14	8.0	15	3.0	9.0
Total	7.0	9.0	8.0	10	4.0	7.0

Table 5. Mean values for No. of pods plant⁻¹ and No. of seeds pod⁻¹

No. of pods plant ⁻¹				No. of seeds pod ⁻¹		
Genotype	Peshawar	Karak	Mean	Peshawar	Karak	Mean
NDC-727	28	29	29	1.7	1.1	1.4
NDC-15-4	28	20	24	1.5	1.4	1.4
NDC-4-15-3	27	25	26	1.5	1.3	1.4
NDC-4-20-1	30	11	21	1.7	1.1	1.4
NDC-4-20-3	27	20	23	1.7	1.2	1.5
NDC-4-20-7	32	17	24	1.5	1.1	1.3
NDC-5-S11	45	20	32	1.1	1.0	1.1
NKC-5-S12	29	19	24	1.1	1.1	1.1
NKC-5-S14	36	29	33	1.4	1.1	1.2
NKC-5-S15	43	21	32	1.3	1.0	1.2
NKC-5-S16	36	24	30	1.1	1.0	1.1
NKC-5-S17	30	28	29	1.3	1.1	1.2
NKC-5-S23	32	34	33	1.3	1.1	1.2
NKC-5-S24	32	34	33	1.1	1.1	1.1
SL-05-42	40	30	35	1.1	1.0	1.1
SL-05-53	54	29	41	1.0	1.1	1.0
SL-03-14	64	25	45	1.5	1.1	1.3
SL-03-15	38	22	30	1.2	1.1	1.2
SL-03-29	24	26	25	1.1	1.2	1.2
SL-03-64	27	18	22	1.3	1.1	1.2
Total	35	24	29	1.3	1.1	1.2

Table 6. Mean value 100-grain weight (g) and Seed yield (kg/ha)

100-grain weight (g)				Seed yield (kg/ha)		
Genotype	Peshawar	Karak	Mean	Peshawar	Karak	Mean
NDC-727	22.9	25.3	24.1	181.3	159.3	170.3
NDC-15-4	25.5	31.7	28.6	498.0	1430.0	964.0
NDC-4-15-3	23.2	27.3	25.3	454.3	1132.0	793.2
NDC-4-20-1	25.7	32.0	28.9	360.7	895.7	628.2
NDC-4-20-3	24.2	30.7	27.5	176.0	472.3	324.2
NDC-4-20-7	24.5	29.0	26.8	260.3	430.3	345.3
NDC-5-S11	26.1	29.7	27.9	476.3	861.0	668.7
NKC-5-S12	20.9	28.0	24.5	288.3	625.0	456.7
NKC-5-S14	24.3	31.0	27.7	168.3	725.7	447.0
NKC-5-S15	29.3	35.7	32.5	235.7	618.7	427.2
NKC-5-S16	21.7	28.7	25.2	74.7	483.3	279.0
NKC-5-S17	29.8	37.3	33.6	226.0	354.0	290.0
NKC-5-S23	26.7	27.7	27.2	339.7	472.3	406.0
NKC-5-S24	25.4	30.3	27.9	54.3	146.0	100.2
SL-05-42	25.1	32.3	28.7	336.3	1152.0	744.2
SL-05-53	27.1	27.7	27.4	544.0	1375.0	959.5
SL-03-14	28.1	31.7	29.9	712.0	1541.0	1126.5
SL-03-15	27.5	30.7	29.1	317.3	1486.0	901.7
SL-03-29	13.3	16.3	14.8	356.3	1111.0	733.7
SL-03-64	17.3	18.7	18.0	260.7	1138.0	699.4
Total	24.4	29.1	26.8	316.0	830.4	573.2

Table 7. Estimates of variances and heritability of various traits of 20 chickpea genotypes

Traits	Peshawar			Karak		
	V ² _g	V ² _e	h ²	V ² _g	V ² _e	h ²
Days to 50% flowering	35.1	6.1	85	37.1	3.7	90
Plant height (cm)	25.3	14	64	22	14.8	60
No. of nodules plant ⁻¹	21.4	2.2	90	31.9	3.5	89
No. of productive branches plant ⁻¹	6.64	6.6	50	0.01	0.8	2.12
No. of pods plant ⁻¹	86.8	48.5	64	18.5	52.9	26
No. of seed pods ⁻¹	0.02	0.07	28	0.006	0.007	46
100-seed weight (g)	13.5	5.73	70	22.8	2.2	90
Seed yield (kg/ha)	20102	18495	52	183548	41049	82

V²_g = Genotypic variance, V²_e = Environmental variance, h² = Heritability

Conclusion

The current investigation showed the presence of greater genetic variability for yield and yield related traits in the studied genotypes. Most of the traits showed high heritability estimates which indicates the presence of greater genetic influence on these characters and therefore can be effectively used in future breeding program for genetic improvement of existing chickpea genotypes. Moreover, chickpea

genotype SL-03-14 produced higher yield at both the environmental conditions. So, this genotype could be considered at both the locations when breeding for stable genotype.

Authors' contributions

Conceived and designed the experiments: L Naz & S Inayat, Performed the experiment: L Naz, Analyzed the data: L Naz, A Shafi & R Hamayoon, Contributed reagents/

materials/ analysis tools: S Inayat & A Shafi, Wrote the paper: L Naz.

References

1. FAO (2008). Land and plant nutrition management service.
2. Maesen (1987). Origin, history and taxonomy of chickpea. pp. 11-34. In: MC Sexena & KB Singh (Eds.). The chickpea. CAB International, UK.
3. Agricultural Statistics of Pakistan (2014-2015). Ministry of Food, Agriculture and Livestock. Govt. Pak., Islamabad.
4. Robertson LD, OcampoB & Singh KB (1997). Morphological variation in wild annual Cicer species in comparison to the cultigen. *Euphytica* 95: 309-319.
5. Duke JA (1981). Handbook of legumes of world economic importance. 2nd Ed. Plenum Press, New York. pp. 52-57.
6. Sattar A, Atta S, and Akhtar MA (1990). Effect of irradiation and germination on trypsin inhibitor and protein content of chickpea (*Cicer arietinum* L.). *Int J Vitamin and Nutr Res* 60(4): 402-406.
7. CollardBCY, Pang ECK, Ades PK & Taylor PWJ (2003). Preliminary investigation of QTLs for seedling resistance to ascochyta blight from *Cicer echinospermum*, a wild relative of chickpea. *Theoretical Appl Genet* 107: 719–729.
8. Arshad M, Bakhsh A, Zubair M & GhafoorA (2003). Genetic variability and correlation studies in chickpea (*Cicer arietinum* L.). *Pak J Bot* 35(4): 605-611.
9. ManieeM, Kahrizi D & Mohammadi R (2009). Genetic variability of some morpho-physiological traits in durum wheat (*Triticum durum* Desf.). *J of Appl Sci* 9: 1383-1387.
10. Singh RK & Chaudry BD (1979). Biometrical methods in quantitative genetic analysis. 2nd Ed. pp. 303. Kalyani Pub. Ludhiana and New Delhi India.
11. Singh KB & Bejiga G (1990). Analysis of stability for some characters in kabuli chickpea Springer Netherland Publisher. *Euphytica* 49(3): 223-227.
12. Shaukat A, Baksh A, Wahid M, Rashid A, and Zahid MA (2003). Evaluation of chickpea germplasm for semi-arid zones of Balochistan. *Sarhad J Agric* 36(2): 113-116.
13. HakimK, Ahmad SQ, Ahmad F, Khan MS & Iqbal N (2006). Genetic Variability and correlation among quantitative traits in gram. *Sarhad J Agric* 22(1): 55-59.
14. Atta BM, Haq MA & Shah TM (2008). Variation and inter-relationship of quantitative traits in Chickpea (*Cicer arietinum* L.). *Pak J Bot* 40(2): 637-647.
15. Saleem M, Arshad M & Ahsan M (2008). Genetic variability and interrelationship for grain yield and its various components in Chickpea (*Cicer arietinum* L.). *J Agric Res* 46(2): 109-116.
16. Vijay P (2001). Stability analysis for grain yield and contributing traits in chickpea. *Indian J Genetics and Plant Breeding* 24(1): 75-80.
17. RaoSM (2003). Stability analysis in chickpea. *Legume Res* 34(1): 22-27.
18. Raza SM & Mehdi SS (1992). Genetic variation of yield and yield components of chickpea (*Cicer arietinum* L.) grown in two diverse environments. *Pak Agric Sci* 2(1): 47-48.
19. Nawab NB (2002). Estimation of variability parameters and correlation for quantitative traits in *Cicer arietinum* L. *Sarhad J Agric* 27(1): 30-39.
20. Arshad M, Qureshi AS, Shaukat A, Baksh A & Ghafoor A (2004). An assessment of variability for economically important traits in Chickpea (*Cicer arietinum* L.). *Pak J Bot* 36(4): 779-785.
21. Mishra DK & Jain PK (2003). Testing and evaluation of stable chickpea

- genotypes under pulse-based cropping system. *JNKVV Res J* 37(1): 43-46.
22. Gul R, Khan H, Khan NU & Khan FU (2014). Characterization of chickpea germplasm for nodulation and effect of rhizobium inoculation on nodules number and seed yield. *The J Anim Plant Sci* 24(5): 1421-1429.
 23. Hussain Q, Ahmad N, Khan R, Asim M, Adnan M, Aziz T & Muhammad A (2017). Assessment of genetic variability and heritability for quantitative traits between desi and kabuli chickpea genotypes. *Pure Appl Biol* 6(4): 1111-1118.
 24. Shahzad K, Saleem M, Javid M & Shahzad AR (2002). Heritability estimates for grain yield and quality character in chickpea (*Cicer arietinum* L.). *Int J Agric and Biol* 4(2): 275-276.
 25. Pattnaik RK, Mishra PK & Sial P (2003). Studies on genetic variability, heritability and genetic advance in chickpea (*Cicer arietinum* L.). *Environ and Ecol* 21(1): 210-213.
 26. Arora PP & Jeena AS (2001). Role of variability for improvement in chickpea. *Legume Res* 24(2): 50-51.
 27. Sable NH, Narkhede, MN, Wakode MM & Lande GK (2003). Genetic parameters and selection indices in chickpea. *Indian J Pulses Res* 16(1): 10-11.
 28. Zubair M, Arshad M, Bakhsh A & Ghafoor A (2003). Genetic variability and correlation studies in chickpea (*Cicer arietinum* L.). *Pak J Bot* 35(4): 605-611.
 29. Noor F, Arshad M & Ghafoor A (2003). Path analysis and relationship among quantitative traits in chickpea (*Cicer arietinum* L.). *Pak J Biol Sci* 6(6): 551-555.
 30. Ghafoor A, Arshad M, and Bakhsh A. (2004). Path coefficient analysis in chickpea (*Cicer arietinum* L.) under rainfed conditions. *Pak J Bot* 36 (1): 75-81.
 31. Durga KK, Muthy SSN, Rao YK, and Reddy MV (2007). Genetic studies on yield and yield components of chickpea. *Indian J Agric* 27(3): 61-79.
 32. Jeena AS, Arora PP, and Ojha OP (2005). Variability and correlation studies for yield and its components in chickpea. *Legume Res* 28(2): 146-148.