Research Article

Evaluation of Advanced Chickpea (*Cicer arietinum* L.) Genotypes for Yield and Resistance to Pod Borer (*Helicoverpa armigera* L.)

Hamid Ullah Khan[1]*, Muhammad Anas[1]*, Rozina Gul[1], Waseem Ullah Shah[1], Abdul Haleem[2], Muneeb Ahamd Khan[1], Muhammad Taimur[1], Tahreem Shah[1], Sajjad Ur Rahman[1], Noman Anjum[1] and Muhammad Saqib[3]

[1]Department of Plant Breeding and Genetics, University of Agriculture, Peshawar, Khyber Pakhtunkhwa, Pakistan; [2]Research Officer, Directorate of Agriculture Research, District Kila Safullah, Balochistan, Pakistan; [3]Department of Agriculture, University of Swabi (KP), Pakistan.

Abstract | Evaluation of genotypes for morphological and yield-promoting traits over different years is a key component in cultivar development. The main goals of the current research studies were to identify pod worm-resistant/tolerant and high-yielding genotypes over two years along with other desirable traits that could be manipulated in future chickpea breeding programs. The experimental material consisted of 45 chickpea genotypes tested over two years in the Randomize Complete Block Design (RCBD) with three replications at the University of Agriculture, Peshawar. Data was documented in terms of days of emergence, days to flower, plant height, pods per plant, seed per pod, 100 seed weight, grain yield, larval infestation, pod damage percentage and biological yield. The pooled analysis of variance showed highly significant differences (P<0.01) between years and between genotypes and genotype-year interaction (GYI) for all traits examined, except plant height. On average over two years, a minimum of (126) days to flowering were recorded over two years for genotypes D-15015 and D-13011, while a maximum of (136) days to flowering were recorded for genotype K-01209. For plant height over two years, the lowest and highest data were recorded for genotypes NKC-10-99 (72 cm) and FLIP82-150 (104 cm), respectively. The highest (25g) 100-seed weight across two years was shown by genotypes K-88168 followed by KARAK-2. The lowest (5662 kg ha-1) biological yield was recorded for genotype K-08003, whereas the highest (13022kg ha-1) biological yield was observed in D-13011. A lower percentage of damaged pods (17.0%) was observed for NIFA-2005, followed by both genotypes K-01153 (18%) and K-70009 (21%). The lowest grain yield was recorded for genotype D-15012 (328 kg h-1), while the highest grain yield (988 kg ha-1) was from genotypes D-14005, K-60058 (914 kg h-1) and D- 15036 was achieved (910 kg ha-1). GYI genotypes K88170, D-14014, D-14005, K-60058, D-15036, KARAK-2, K-CH47/04, and NIFA-2005 showed the highest grain yield and a lower percentage of pod damage. The genotypes K88170, D-14014, K-60069, K-01153, K-70009, KARAK-2, K-CH47/04, D-15036 and NIFA-2005 performed very well and were registered with less larval infestation and pod damage Percentage and maximum yield over two years, therefore recommended for developing pod worm resistant/tolerant and high yielding chickpea varieties.

Received | October 10, 2022; **Accepted** | February 19, 2024; **Published** | July 10, 2024
***Correspondence** | Hamid Ullah Khan and Muhammad Anas, Department of Plant Breeding and Genetics, The University of Agriculture, Peshawar, Khyber Pakhtunkhwa, Pakistan; **Email:** m.anas@aup.edu.pk
Citation | Khan, H.U., M. Anas, R. Gul, W.U. Shah, A. Haleem, M.A. Khan, M. Taimur, T. Shah, S. Rahman, N. Anjum, M. Saqib. 2024. Evaluation of advanced chickpea (*Cicer arietinum* L.) genotypes for yield and resistance to pod borer (*Helicoverpa armigera* L). *Sarhad Journal of Agriculture,* 40(3): 726-739.
DOI | https://dx.doi.org/10.17582/journal.sja/2024/40.3.726.739
Keywords | Chickpea, Pod borer attack, Morphological traits, Pooled analysis, Larval count and LSD count

Introduction

Globally, it is cultivated on about 13.2 million hectares in more than fifty developing countries with a 95% contribution to the total world production. In Pakistan during 2018-19, the total area under chickpea cultivation was 1050 thousand hectares with a total production of 350 thousand tons and an average yield of 345.9 kg ha^{-1}, while in Khyber Pakhtunkhwa the total cultivated area and production of chickpeas were reported as 33387 hectares and 16940 tons, respectively. Among the major chickpea-producing countries, Pakistan ranks fourth after India and Australia, which share 5.73% of the total global production (FAO, 2017).

Chickpeas are mainly divided into two groups based on phenotypic characteristics, like seed size, seed colour, seed shape and flower colour as Desi and Kabuli. Desi chickpea gives an output of 15-25 mounds per acre. Kabuli chickpea has a relatively large seed size and whitish creamy coloured seed with a thinner seed coat. Kabuli-type plant height is larger as compared to Desi type. The deep tap-rooted chickpea system boosts its ability to adapt to stress conditions. Chickpea performs well in low agriculture inputs and is drought tolerant because of their deep tap root system.

Grams are generally grown in moderate-heavy soils, light soils, mostly sandy loams are preferred. The best type of soil for chickpeas is one that is well-drained and not too heavy. The plants remain short in dry and light soils, while heavy soils have high water retention capacity. There is no side effect of chickpea proteins on human health as compared to animal protein, the digestibility rate of chickpea protein is high as compared to animal protein. Apart from providing these nutritional requirements to humans, chickpea is also useful in soil fertility management due to their nitrogen fixation.

Correlation analysis provides information on the associated response of plant characters and therefore, leads to a directional model for yield production in chickpeas (Khan and Qureshi, 2001). Being rich in protein, the chickpea plant is susceptible to several biotic and abiotic stresses which attack roots, foliage and pods. Gram Pod borer (*Helicoverpa armigera* L) is one of the major biotic stresses which causes a reduction in yield and quality in chickpeas (Kumar *et al*., 2019). This pest is the major constraint in chickpea production causing severe losses of up to 100% despite several rounds of insecticidal applications. Due to its polyphagous nature, pod borer infests many hosts including chickpeas and causes severe damage to the crop during pod development (Sarwar, 2013). The pod borer, (*Helicoverpa armigera* L.), is the most serious pest in causing economic loss to the chickpea crop (Yadav *et al*., 2006). Damage caused by pod borer in the form of losses in seed yield may reach up to 75% to 90% in severe cases (Sarwar, 2013). Therefore, adopting an environmentally friendly and cost-effective approach, as the development of host-resistant cultivars to pod borer is necessary (Jadhav and Gawande, 2016).

Objectives of the study

- Identify pod worm-resistant/tolerant and high-yielding genotypes for future chickpea breeding programs.
- Evaluate genotypes for morphological and yield-promoting traits over two years.
- Assess traits such as days to emergence, days to flower, plant height, pods per plant, seed per pod, 100 seed weight, grain yield, larval infestation, pod damage percentage, and biological yield.
- Determine significant differences between years, genotypes, and genotype-year interaction for the examined traits.
- Recommend genotypes with high grain yield, a lower percentage of pod damage, and less larval infestation for developing pod worm-resistant/tolerant and high-yielding chickpea varieties.
- Use pooled analysis as a powerful tool for identifying resistance levels of genotypes to the chickpea pod borer.
- Access line identification and check vs. test line performance through pooled analysis.
- Evaluate the performance of chickpea genotypes for yield and pod borer resistance/tolerance across two years.
- Identify genotypes with high resistance potential, tolerance to the chickpea pod borer, and high yield for future breeding programs.

Materials and Methods

The experiment was conducted to Evaluate the performance of chickpea genotypes for yield and pod borer resistance/tolerance across two years. This study was carried out during the chickpea growing seasons 2018-19 and 2019-20 at The University of Agriculture, Peshawar. The experimental materials consisted of 45 chickpea genotypes out of which 41 lines were collected from Ayub Agriculture Research Institute, Faisalabad (AARI), Pakistan and four were checked cultivars (Karak-1, Karak-2, Karak-3 and NIFA-2005).

The check cultivars were collected from Agriculture Research Station Ahmadwala Karak and Nuclear Institute for Food and Agriculture Peshawar (NIFA) (Table 1). The experiments were planted during the last week of October 2018 and mid-October 2019 in 1st and 2nd years, respectively in a randomized complete block design (RCBD) with three replications. Each genotype was grown in three rows with a four-meter row length by keeping row-to-row plant-to-plant and plot-to-plot distances as 30, 10 and 60 cm, respectively. All the cultural practices essential for crop management were uniformly carried out in all the treatments including hoeing and weeding applicable for chickpea crops from sowing to harvesting.

The advanced chickpea genotypes for evaluation in the study were selected based on the following criteria

- Yield and resistance to pod borer (*Helicoverpa armigera* L.)
- Morphological and yield-promoting traits
- Potential for manipulation in future chickpea breeding programs
- The evaluation focused on genotypes that exhibited desirable traits for future chickpea breeding programs.

These criteria were used to identify genotypes with desirable traits for the improvement of chickpea cultivars.

Results and Discussion

Days to emergence

The pooled analysis of variance over two years revealed highly significant differences ($P < 0.01$) between the years. Genotypes and genotype-year interaction (GY) also showed highly significant differences ($P<0.01$) for days up to 50% emergence (Table 2). The higher contribution of genotypes to the total sum of squares indicated that the observed variation was due to genetic differences in the material tested. Similar results were observed by Singh and Singh (2013) in chickpea genotypes for days to 50% emergence over years and genotype-to-year interaction. Early emergence was recorded in year 1, while late emergence was recorded in year 2 for the same genotypes due to different weather conditions (Figures 1, 2).

Table 1: *List of 45 chickpea genotypes evaluated across two years during 2018-19 and 2019-20.*

Source	Genotypes	Source	Genotypes	Source	Genotypes
AARI	D-15012	AARI	D-14005	AARI	K-08021
AARI	D-15019	AARI	D-15005	AARI	K-01153
AARI	D-10008	AARI	D-10039	AARI	K-01155
AARI	D-97086	AARI	D-93127	AARI	K-01210
AARI	D-14014	AARI	D-15036	AARI	K-70009
AARI	D-11030	AARI	K-08003	AARI	K-60058
AARI	D-13036	AARI	K-01158	AARI	K-88168
AARI	D-08025	AARI	K-60075	AARI	K-CH 47/04
AARI	D-15020	AARI	K-01208	AARI	FLIP82-150
AARI	D-13031	AARI	K-01151	AARI	NKC-10-99
AARI	D-13012	AARI	K-60066	AARI	NKC-5-5-20
AARI	D-12011	AARI	K-01213	ARSAK	KARAK-1Check-1
AARI	D-09027	AARI	K-01209	ARSAK	KARAK-2Check-2
AARI	D-13011	AARI	K-60069	ARSAK	KARAK-3Check-3
AARI	D-15015	AARI	K-88170	NIFA	NIFA-2005Check-4

Table 2: *Mean squares of days to 50% emergence, days to 50% flowering, plant height, pod damage% and larval count of 45 chickpea genotypes were evaluated across two years 2018-19 and 2019-20.*

SOV	Df	DTE50%	DTF50%	pH	LC	PD%
Year	1	4035.25**	4629.35**	58138.7^{NS}	4826.01**	113414**
Year*REP	4	1.02	0.10	3657.5	0.40	24
Genotypes	44	6.25**	25.86**	4670.6^{NS}	34.65**	1194**
G × Y	44	6.21**	16.31**	3651.8^{NS}	42.24**	1188**
Error	176	0.85	2.34	3722.6	0.86	7
CV (%)		7.50%	1.18%	11.08%	10.26%	6.12%

***= significant at 1%; *= significant at 5%; NS= non-significant. DTE50%= Days to 50% emergence, DTF50%= Days to 50% flowering, PH= plant height, PBA = Pod borer attack, PD = pod damage %.*

Table 3: *Mean squares of pods per plant, seeds per pod, 100 grain, weight biological yield and grain yield kg hac-1 of 45 chickpea genotypes were evaluated across two years during 2018-19. and 2019-20.*

Sov	Df	PPP	SPPOD	100GW	BY	GY
Year	1	22041.3**	14.7000**	360.533**	5698081.2**	425717**
Year*Rep	4	18.5	0.2556	3.363	148470	38436
Genotypes	44	177.0**	0.3364**	30.545**	290007**	252069**
G × Y	44	185.5**	0.3667**	58.329**	176885**	171370**
Error	176	15.8	0.1154	1.545	102130	47044
CV (%)		16.27%	20.25	6.00%	32.54%	14.94%

PPP= Pods per plant; SPPOD= Seeds per pod; 100GW= 100 Grain weight; BY= Biological yield; kg ha-1 = grain yield kg ha-1.

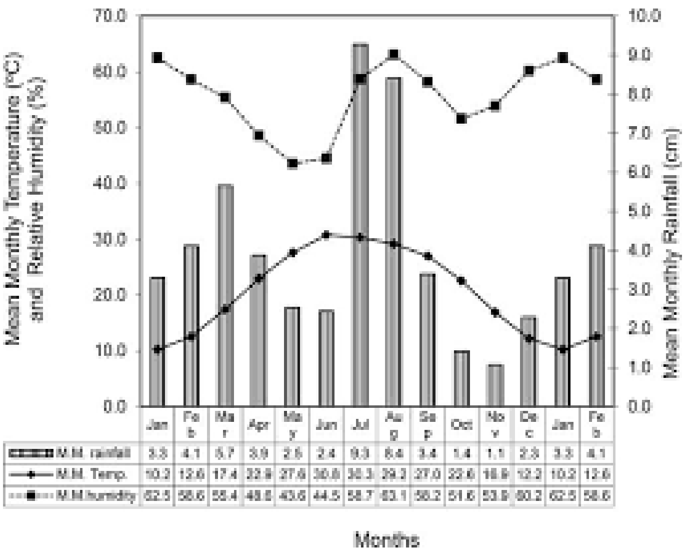

Figure 1: *Graph for 2019 weather conditions in Peshawar.*

The average days to emergence ranged from 10 to 14 days over two years. The K-01213 and K-08003 genotypes emerged early, followed by the D-15012 genotypes, while the K-01151 and Karak-3 genotypes emerged late. In GYI, the minimum (7) days to hatch D-15012 was noted, while the maximum (20) was recorded for genotype K-CH 47/04 (Table 4).

In year 1, days to emergence ranged from 7 to 10 days, while in year 2 they ranged from 11 to 20 days. In year 1, a minimum of (10) days to hatch was observed for D-15012, while a maximum of (14) days to hatch was observed for genotype D-13012. At year 2, genotype K-01213 emerged early, followed by genotype D-15012, while genotype K-CH47/04 emerged late (Table 4).

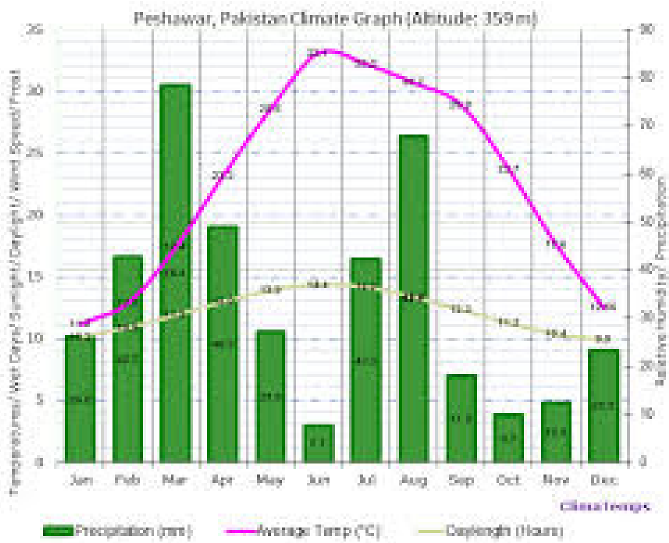

Figure 2: *Graph for 2020 weather conditions in Peshawar.*

Days to 50% flowering

Combined analyses of variance for days up to 50% flowering showed highly significant differences

Table 4: *Means and percentage difference for days to 50% emergence of 45 chickpea genotypes evaluated across two years during 2018-19 and 2019-20.*

Genotypes	Days to 50% emergence				Days to 50% flowering						
	1st Year	2nd Year	Mean	% Difference	1st Year	2nd Year	Mean	% Difference	1st Year	2nd Year	% Difference
D-15012	7	16	11	56	123	132	128	6	64	96	33
D-15019	8	17	13	52	125	132	128	5	74	81	8
D-10008	8	16	12	50	126	135	131	6	73	98	25
D-97086	8	14	11	42	126	132	129	4	80	105	23
D-14014	8	14	11	42	127	131	129	3	78	93	16
D-11030	8	15	12	46	125	132	128	5	69	109	36
D-13036	8	14	11	42	125	133	129	6	63	103	38
D-08025	9	15	12	40	122	131	127	6	75	81	7
D-15020	9	17	13	47	126	135	130	6	74	104	28
D-13031	9	18	13	50	127	131	129	3	76	84	9
D-13012	10	15	13	33	127	137	132	7	68	111	38
D-12011	10	17	14	41	125	131	128	4	67	79	15
D-09027	9	18	14	50	125	132	128	5	73	102	28
D-13011	8	17	13	52	122	130	126	6	74	89	16
D-15015	9	13	11	30	124	128	126	3	67	108	37
D-14005	9	14	12	35	127	133	130	4	73	106	31
D-15005	7	16	12	56	127	131	129	3	67	101	33
D-10039	9	17	13	47	126	136	131	7	67	84	20
D-93127	8	17	13	52	124	132	128	6	74	88	15
D-15036	8	18	13	55	125	132	128	5	72	86	16
K-08003	6	14	10	57	128	133	131	3	68	89	23
K-01158	8	14	11	42	126	137	132	8	78	94	17
K-60075	8	16	12	50	127	140	133	9	74	92	19
K-01208	10	16	13	37	124	133	128	6	69	97	28
K-01151	9	19	14	52	124	132	128	6	75	84	10
K-60066	10	16	13	37	122	133	127	8	91	84	-8
K-01213	9	11	10	18	125	130	128	3	73	82	10
K-01209	9	14	12	35	127	144	136	11	55	94	41
K-60069	7	13	10	46	127	134	131	5	61	85	28
K-88170	8	15	12	46	125	134	130	6	71	87	18
K-08021	8	17	12	52	126	138	132	8	65	86	24
K-01153	8	17	13	52	124	133	128	6	63	86	26
K-01155	9	16	12	43	125	133	129	6	64	100	36
K-01210	8	15	12	46	125	129	127	3	72	103	30
K-70009	7	19	13	63	126	133	130	5	93	103	9
K-60058	7	18	13	61	124	131	128	5	65	103	36
K-88168	8	16	12	50	124	133	129	6	53	96	44
K-CH 47/04	9	20	14	55	127	134	130	5	70	83	15
FLIP82-150	8	19	13	57	127	134	131	5	92	116	20
NKC-10-99	9	17	13	47	126	131	129	3	54	91	40
NKC-5-5-20	10	16	13	37	124	142	133	12	79	98	19
KARAK-1	7	18	12	61	127	143	135	11	73	82	10
KARAK-2	9	18	13	50	125	131	128	4	93	107	13
KARAK-3	10	18	14	44	126	133	129	5	80	95	15
NIFA-2005	9	16	13	43	124	132	128	6	85	86	1
Year mean	8	16	12		125	133	129		72	94	
LSD (5%)	Genotypes 2.9053		Year 1.5039		Genotypes 4.655		Years 2.4388			Genotypes 17.578	

(P 0.01) between years. Genotypes and genotype-year interaction (GY) also showed highly significant differences (P<0.01) for days up to 50% flowering (Table 2). Jul *et al*. (2013) and Akhtar *et al*. (2011) also reported highly significant differences between chickpea genotypes for days up to 50% flowering. In some cases, earlier flowering leads to lower grain yield due to the effects of frost and pod borer attacks on chickpea genotypes (Jenkins and Brill, 2011). However due to climate change in recent years, the month of February (flowering start month in chickpeas) has unexpectedly increased, favoring early flowering and leading to early ripening. Due to frost in the area, late blooms were observed in the 2nd year compared to the 1st year.

Over two years, the average days to flowering varied between 126 and 136 days. The minimum (126) days to flower over two years was shown by genotypes D-15015 and D-13011, while genotype K-01209 had a maximum (136) days to flower of 50%. In GYI, a minimum (123) was observed for genotype D-15012, while K-01209 showed a maximum (144) (Table 4).

During the first year, days to flowering they were ranged from 123 to 128 days. In year 1, genotypes D-15012 had a minimum (of 123) days to flower while genotypes K-08003 and K-01209 had a maximum (of 128) days to flower. In GYI, a minimum of (128) days to flower was observed for genotype D-15015, while genotype K-01209 required a maximum of (144) days to flower (Table 4).

Plant height (cm)

Pooled analysis of variance revealed non-significant differences between years, genotypes and genotype-year interaction (GY) also revealed non-significant differences (Table 2). Usually, growers prefer a short plant height to prevent storage. However, there should be a threshold for plant height. Reducing plant height beyond this level will prevent plants from becoming established but will negatively impact yield as they will bear fewer branches and pods (Desai *et al*., 2016). For plant height, the combined analysis of variance showed highly non-significant differences Tilahu *et al*. (2015), also reported non-significant differences between genotypes and years and the interaction between genotypes and years (GY) for plant height.

The two-year mean plant heights of 45 chickpea genotypes ranged from 72 to 104 cm. Over two years,

Table 5: *Means and percentage difference for days to 50% flowering of 45 chickpea genotypes evaluated across two years during 2018-19 and 2019-20.*

Genotype	1st Year	2nd Year	Mean	Percentage difference
D-15012	123	132	128	6
D-15019	125	132	128	5
D-10008	126	135	131	6
D-97086	126	132	129	4
D-14014	127	131	129	3
D-11030	125	132	128	5
D-13036	125	133	129	6
D-08025	122	131	127	6
D-15020	126	135	130	6
D-13031	127	131	129	3
D-13012	127	137	132	7
D-12011	125	131	128	4
D-09027	125	132	128	5
D-13011	122	130	126	6
D-15015	124	128	126	3
D-14005	127	133	130	4
D-15005	127	131	129	3
D-10039	126	136	131	7
D-93127	124	132	128	6
D-15036	125	132	128	5
K-08003	128	133	131	3
K-01158	126	137	132	8
K-60075	127	140	133	9
K-01208	124	133	128	6
K-01151	124	132	128	6
K-60066	122	133	127	8
K-01213	125	130	128	3
K-01209	127	144	136	11
K-60069	127	134	131	5
K-88170	125	134	130	6
K-08021	126	138	132	8
K-01153	124	133	128	6
K-01155	125	133	129	6
K-01210	125	129	127	3
K-70009	126	133	130	5
K-60058	124	131	128	5
K-88168	124	133	129	6
K-CH 47/04	127	134	130	5
FLIP82-150	127	134	131	5
NKC-10-99	126	131	129	3
NKC-5-5-20	124	142	133	12
KARAK-1	127	143	135	11
KARAK-2	125	131	128	4
KARAK-3	126	133	129	5
NIFA-2005	124	132	128	6
Year mean	125	133	129	

LSD (5%) for Genotypes 4.655; LSD for Years 2.4388

genotype NKC-10-99 was the shortest (72), while the largest (104) genotype was FLIP82-150. In GYI, the lowest (72) was recorded for genotype NKC-10-99, while the highest plant height was observed in FLIP82-150 (116) (Table 4).

In the 1st year, the plant height ranged from 53 to 93 cm, while in the 2nd year it ranged from 79 to 107 cm. The lowest (53) plant height was observed for genotype K-88168, K-01209 (55 cm), while the highest (93) plant height was taken from genotype K-70009, FLIP82-150 (92 cm) in 1st year. While in the 2nd year ranged from 79 to 107 cm. The lowest (79) plant height was observed for genotype D-12011, while the highest (107) plant height was taken from genotype Karak-2 (Table 4).

Pods plant^{-1}

Pods plant^{-1} is an important yield trait of the chickpea crop that has a direct positive impact on the final grain yield. Pooled analysis of variance for pod plant^{-1} showed highly significant differences (P< 0.01) over years. The interaction between genotypes and genotype years also showed significant differences (Table 3). The main component for the variable performance of the genotypes for Plant^{-1} pods was environmental factors, which made a high contribution to the overall variation. The pod of the chickpea crop is a major photosynthetic region that fixes carbon at the pericarp in the form of hydrocarbons that are eventually transferred to the seed (Frette *et al*., 2004). Our results for pod Plant^{-1} agree with Balkhsh *et al*. (2006) who reported highly significant differences between genotype years and their interaction (GY) for pod plant^{-1}.

The average of Plant^{-1} pods over two years ranged from 14 to 34. A minimum (14) of Plant^{-1} pods was observed for genotypes K-60069, NKC-10-99 and K-01209. While a maximum (of 34) pods of Plant^{-1} were noted in genotypes K-60058, D-15012, and D-15036. In GYI, a minimum (9) pods were counted from Plant^{-1} by genotype D-15019, while a maximum (54) was found in K-60058 (Table 7).

During the 1st year, the number of Plant^{-1} pods ranged from 9 to 25, while in the 2nd year it ranged from 17 to 54 Plant^{-1} pods. In year 1, a maximum (of 25) pods of plant^{-1} were observed for genotypes K-01153, K-08021, NKC-5-5-20, and K-01155, while minimal (9) pods of plant^{-1} were recorded in genotypes D-15019, K-60069, KARAK-2 and K-88168.

Table 6: *Means and percentage differences for a larval count of 45 chickpea genotypes were evaluated across two years during 2018-19. and 2019-20.*

Genotype	1st Year	2nd Year	Mean	Percentage difference
D-15012	6	13	10	53
D-15019	3	7	5	57
D-10008	3	12	8	75
D-97086	5	11	8	54
D-14014	6	10	8	58
D-11030	4	14	9	71
D-13036	6	13	9	53
D-08025	2	9	6	77
D-15020	4	12	8	66
D-13031	4	16	10	75
D-13012	6	10	8	72
D-12011	4	8	6	88
D-09027	4	14	9	71
D-13011	4	17	11	76
D-15015	5	19	12	73
D-14005	2	18	10	88
D-15005	4	12	8	66
D-10039	3	13	8	76
D-93127	3	11	7	72
D-15036	3	9	6	66
K-08003	6	7	6	8
K-01158	4	15	9	73
K-60075	3	21	12	85
K-01208	3	9	6	66
K-01151	4	9	7	55
K-60066	7	12	9	67
K-01213	3	15	9	80
K-01209	7	15	11	53
K-60069	9	7	8	-26
K-88170	7	10	8	36
K-08021	4	17	10	76
K-01153	3	28	15	81
K-01155	5	29	17	82
K-01210	6	12	9	94
K-70009	5	18	12	72
K-60058	4	11	8	63
K-88168	9	11	10	17
K-CH 47/04	6	11	8	81
FLIP82-150	6	10	8	72
NKC-10-99	7	15	11	53
NKC-5-5-20	6	19	13	68
KARAK-1	7	11	9	52
KARAK-2	4	10	7	60
KARAK-3	6	13	9	53
Nifa-2005	5	14	10	64
Year mean	5	13	9	

LSD (5%) for Genotypes 7.5582; LSD for Years 1.0556

Table 7: *Means and percentage differences for Pods per plant of 45 chickpea genotypes were evaluated across two years during 2018-19 and 2019-20.*

Genotype	1st Year	2nd Year	Mean	Percentage difference
D-15012	18	48	33	62
D-15019	9	25	17	64
D-10008	13	28	21	53
D-97086	18	33	25	45
D-14014	20	34	27	41
D-11030	17	51	34	66
D-13036	14	32	23	56
D-08025	16	51	34	68
D-15020	16	35	25	54
D-13031	17	30	23	43
D-13012	13	32	23	59
D-12011	10	34	22	70
D-09027	16	47	32	65
D-13011	17	44	30	61
D-15015	20	23	21	13
D-14005	19	40	30	52
D-15005	14	35	24	60
D-10039	17	24	20	29
D-93127	14	48	31	70
D-15036	12	53	32	77
K-08003	17	28	23	39
K-01158	14	46	30	69
K-60075	16	40	28	60
K-01208	12	46	29	73
K-01151	12	29	21	58
K-60066	20	36	28	44
K-01213	14	27	20	48
K-01209	14	20	17	30
K-60069	10	18	14	44
K-88170	13	18	16	27
K-08021	22	20	21	-10
K-01153	25	17	21	-47
K-01155	19	21	20	9
K-01210	17	41	29	58
K-70009	14	28	21	50
K-60058	14	54	34	74
K-88168	12	21	16	42
K-CH 47/04	13	31	22	58
FLIP82-150	15	41	28	63
NKC-10-99	13	18	16	27
NKC-5-5-20	20	39	29	48
Karak-1	10	32	21	68
Karak-2	11	31	21	64
Karak-3	18	26	22	30
NIFA-2005	13	33	23	60
Year mean	15	33	24	

LSD (5%) for genotypes 15.824; LSD for Years 2.324

While for genotypes K-60058, D-15036, D-11030, D-15012, and D-09027, a maximum (54) pods of plant^{-1} were observed in year 2, while a minimum (17) pods of plant^{-1} were observed for K- 01153, NKC-10-99, K-01209 and K-01155 (Table 7).

Seeds pod^{-1}

A larger number of seeds pod-1 means a larger number of kernels plant^{-1}, making it an important yield-promoting trait. Combined analyzes of variance for Seeds pod^{-1} showed highly significant differences (P<0.01) across years. Genotypes and genotype-year interaction (GY) showed significant differences for Seeds pod^{-1} (Table 3). Desaï *et al.* (2016) obtained similar results of highly significant differences between years, genotypes and GY from the combined analysis of variance. Averaged over two years, boll-1 of 45 chickpea genotypes ranged from 1.0 to 2.0. Genotypes D-15012, D-11030, D-13036, K-01209, and K-60058 produced a minimum (1.0) boll-1 while a maximum (2.0) boll-1 for genotypes D-15019, D-10039, K-60066 and NIFA-2005. A minimum (1.0) of Pod-1 of D-93127 and Karak-3 was observed in GYI seeds, while a maximum (2.0) was observed in genotypes NIFA-2005, Karak-2 and D-15019 (Table 8).

During Year 1, Seeds pod-1 ranged from 1.0 to 2.0. While in year 2 seed Pod-1 ranged from 1.0 to 2.0. At year 1, a maximum (2.0) seed pod-1 was observed for genotypes D-09027, Karak-2, NIFA-2005, and D-15019, while a minimum (1,0) Seed Pod-1 were recorded at -97086, Karak-3 and K01209. During year 2, for genotypes NIFA-2005, D-14014, D15005 and Karak-1, the maximum (2.0) of seed pod-1 was observed while the minimum (1.0) of seed pod- 1 for D-08025 and genotype K-01158 (Table 8).

100- seed weight (g)

Higher seed yield is directly related to large seed size, heavy seed weight and a larger number of seed plants^{-1}. In combination with other yield-attributing traits, seed weight plays an important role in increasing final grain yield. The combined analysis of variance for the 100 seed weight revealed highly significant differences (P <0.01) over years. The interaction of genotypes and genotype years (GY) also showed significant differences (Table 3). A higher contribution of the genotype year to the total variation suggested that the mean performance and ranking of the genotypes were inconsistent across years. Similar to our results Desai *et al.* (2016) and Tilahun *et al.* (2015) also reported highly significant differences between years, genotypes, and genotype-year interaction for 100 seed weights in chickpea genotypes.

Table 8: *Means and percentage difference for Seeds per Pod of 45 chickpea genotypes evaluated across two years during 2018-19 and 2019-20.*

Genotype	1st Year	2nd Year	Mean	Percentage difference (%)
D-15012	1	2	2	50
D-15019	2	2	2	0
D-10008	2	2	2	0
D-97086	1	2	2	50
D-14014	1	2	1	50
D-11030	1	2	2	50
D-13036	1	2	1	50
D-08025	2	1	2	-100
D-15020	2	2	2	0
D-13031	2	2	2	0
D-13012	1	2	1	50
D-12011	2	2	2	0
D-09027	2	1	2	-100
D-13011	1	2	1	50
D-15015	1	2	1	50
D-14005	1	2	1	50
D-15005	1	2	1	50
D-10039	2	2	2	0
D-93127	1	2	1	50
D-15036	1	2	1	50
K-08003	1	2	1	50
K-01158	2	1	2	-100
K-60075	1	2	1	50
K-01208	2	2	2	0
K-01151	1	2	1	50
K-60066	2	2	2	0
K-01213	1	2	1	50
K-01209	1	2	1	50
K-60069	1	2	1	50
K-88170	1	2	1	50
K-08021	1	2	1	50
K-01153	1	2	1	50
K-01155	1	2	1	50
K-01210	2	2	2	0
K-70009	2	2	2	0
K-60058	1	2	1	50
K-88168	1	2	1	50
K-CH 47/04	2	2	2	0
FLIP82-150	2	2	2	0
NKC-10-99	1	2	1	50
NKC-5-5-20	1	2	1	50
KARAK-1	1	2	1	50
KARAK-2	2	2	2	0
KARAK-3	1	2	1	50
NIFA-2005	2	2	2	0
Year mean	1	2	2	

LSD (5%) for Genotypes 0.7046; LSD for Years 0.1708

Table 9: *Means and percentage differences for Plant height of 45 chickpea genotypes were evaluated across two years 2018-19 and 2019-20.*

Genotype	1st Year	2nd Year	Mean	% Difference
D-15012	64	96	80	33
D-15019	74	81	77	8
D-10008	73	98	85	25
D-97086	80	105	92	23
D-14014	78	93	86	16
D-11030	69	109	89	36
D-13036	63	103	83	38
D-08025	75	81	78	7
D-15020	74	104	89	28
D-13031	76	84	80	9
D-13012	68	111	89	38
D-12011	67	79	73	15
D-09027	73	102	87	28
D-13011	74	89	81	16
D-15015	67	108	88	37
D-14005	73	106	89	31
D-15005	67	101	84	33
D-10039	67	84	76	20
D-93127	74	88	81	15
D-15036	72	86	79	16
K-08003	68	89	78	23
K-01158	78	94	86	17
K-60075	74	92	83	19
K-01208	69	97	83	28
K-01151	75	84	79	10
K-60066	91	84	87	-8
K-01213	73	82	77	10
K-01209	55	94	75	41
K-60069	61	85	73	28
K-88170	71	87	79	18
K-08021	65	86	75	24
K-01153	63	86	74	26
K-01155	64	100	82	36
K-01210	72	103	87	30
K-70009	93	103	98	9
K-60058	65	103	84	36
K-88168	53	96	75	44
K-CH 47/04	70	83	76	15
FLIP82-150	92	116	104	20
NKC-10-99	54	91	72	40
NKC-5-5-20	79	98	88	19
KARAK-1	73	82	78	10
KARAK-2	93	107	100	13
KARAK-3	80	95	87	15
NIFA-2005	85	86	86	1
Year mean	72	94	83	

LSD (5%) for Genotypes 17.578; LSD for Years 7.3610

Table 10: *Means and percentage difference for 100 Grain weight of 45 chickpea genotypes evaluated across two years during 2018-19 and 2019-20.*

Genotype	1st Year	2nd Year	Mean	Percentage difference
D-15012	19	22	21	13
D-15019	13	23	18	43
D-10008	19	27	23	29
D-97086	17	22	20	22
D-14014	13	21	17	38
D-11030	23	19	21	-21
D-13036	15	23	19	34
D-08025	20	20	20	0
D-15020	19	24	21	20
D-13031	17	18	17	5
D-13012	14	24	19	41
D-12011	19	21	20	9
D-09027	22	25	24	12
D-13011	16	25	20	36
D-15015	22	24	23	8
D-14005	17	21	19	19
D-15005	21	25	23	16
D-10039	19	24	22	20
D-93127	18	20	19	10
D-15036	20	23	22	13
K-08003	17	18	17	5
K-01158	22	24	23	8
K-60075	20	22	21	9
K-01208	23	22	23	-4
K-01151	18	21	20	14
K-60066	20	25	22	20
K-01213	18	25	22	28
K-01209	25	16	20	-36
K-60069	19	16	18	-18
K-88170	21	17	19	-23
K-08021	24	20	22	-20
K-01153	29	16	23	-81
K-01155	23	15	19	-53
K-01210	20	26	23	23
K-70009	17	27	22	37
K-60058	13	21	17	38
K-88168	35	16	25	-11
K-CH 47/04	12	23	17	47
FLIP82-150	20	24	22	16
NKC-10-99	18	16	17	-12
NKC-5-5-20	19	26	22	26
KARAK-1	22	25	23	12
KARAK-2	20	28	24	28
KARAK-3	18	16	17	-12
NIFA-2005	20	25	23	20
Year mean	19	22	21	

LSD (5%) for Genotypes 8.858; LSD for Years 0.7877

The mean values of 45 chickpea genotypes for the weight of 100 seeds ranged from 17 to 25 g over two years. The lowest (17) 100-seed weight over two years was exhibited by genotypes D-13031, K-08003, K-60058, NKC-10-99, and Karak-3, while the highest (25) 100-seed Weight over two years was exhibited by genotypes K-88168, Karak-2, Karak-1 (Table 11). In GYI, the lowest (13) 100-seed weight of genotype D-14014 was observed, whereas the highest (35) was observed in K-88168 (Table 10).

The lowest 100-seed weight was between 12 and 35 g in the first year, while it was between 16 and 27 g in the second year. The lowest (12) 100-seed weight was observed at year 1 in genotypes K-CH 47/04, D-15019, D-13036, D-13011, K-700009, and D-14005, while the highest (35) 100-seed weight observed was observed in genotypes K-88168, K-01209 and K-08021 at year 1. The lowest (16) 100 grain weight was observed in the 2nd year in genotypes Karak-3, NKC-10-99 and K-88168, while the highest (27) 100 seed weight was observed in the 2nd year in genotypes K-70009, NIFA-2005, D-13011, K-60066 and K-01210 (26g) (Table 10).

Biological yield (kg ha^{-1})

Pooled analysis of variance for biological yield showed highly significant differences (P 0.01) over years. Genotypes and genotype-year interaction (GY) also showed significant differences in biological yield (Table 3). Our results are similar to those of Jeena and Arora (2000), and Padmavathi *et al*. (2013) who also reported highly significant differences (P <0.01) between genotypes, years and genotype-year interaction (GxY) for biological yield.

The mean production of the two-year average biological yield ranged from 4511 to 8788 kg ha^{-1}. The minimum (4511) biological yield over two years was shown by genotype K-01213. while the maximum (8788 kg) biological yield over two years was shown by genotype D-15015. In GYI, the minimum (3335) kg biological yield was observed in genotype K-1213, while the maximum (9400) was observed in D-15019 (Table 11).

In the 2nd year, it ranged from 5267 to 9400 kg ha^{-1}. The minimum (3335 kg) biological yield was observed in the 1st year in the genotypes K-1213, while the maximum (8803 kg) biological yield was observed in the D-13011, while the minimum (5267 kg) biological yield in the 2nd year in the genotypes KARAK-3 was observed while the maximum (9400 kg) biological yield in year 2 was counted from D-15019 (Table 11).

Table 11: *Means and percentage difference for biological yield of 45 chickpea genotypes evaluated across two years during 2018-19 and 2019-20.*

Genotype	1st Year	2nd Year	Mean	Percentage difference
D-15012	5258	6347	5802	17
D-15019	6720	9400	8060	28
D-10008	8474	7440	7957	-13
D-97086	8498	9040	8769	-49
D-14014	6398	5320	5859	-34
D-11030	7556	6760	7158	-10
D-13036	7812	8706	8259	27
D-08025	7760	8395	8077	-51
D-15020	7153	6205	6679	-93
D-13031	8132	7480	7806	-62
D-13012	5198	9227	7212	43
D-12011	8026	8000	8013	-28
D-09027	8275	7427	7851	-10
D-13011	8803	7240	8022	-15
D-15015	8643	8933	8788	2
D-14005	7677	7267	7472	-14
D-15005	7267	8333	7800	-72
D-10039	6159	8109	7134	24
D-93127	6043	5800	5922	-17
D-15036	7404	7077	7241	-14
K-08003	5455	5869	5662	4
K-01158	6039	6867	6453	-13
K-60075	3612	5200	4406	-16
K-01208	5467	4733	5100	-15
K-01151	8507	4733	6620	-79
K-60066	5538	6333	5936	12
K-01213	3355	5667	4511	-13
K-01209	6109	7733	6921	21
K-60069	6372	6333	6353	1
K-88170	6076	7200	6638	15
K-08021	5464	6733	6099	19
K-01153	6072	8000	7036	24
K-01155	5721	6867	6294	16
K-01210	7071	5867	6469	-20
K-70009	7123	6200	6662	-93
K-60058	7752	6800	7276	-10
K-88168	7172	5600	6386	-20
K-CH 47/04	6422	8200	7311	-63
FLIP82-150	7064	6267	6665	-57
NKC-10-99	5545	7243	6394	23
NKC-5-5-20	7007	8267	7637	15
KARAK-1	4920	7333	6126	32
KARAK-2	6417	8800	7609	-86
KARAK-3	8732	5267	6999	-65
NIFA-2005	8713	7132	7922	-22
Year mean	6777	7061		

LSD (5%) for genotypes102.99; LSD for years 124.

Grain yield kg ha^{-1}

Yield improvement is one of the main goals of any plant breeding program and is a complex quantitative trait driven by genetic potential and also heavily influenced by environmental factors. The pooled analysis of variance for grain yield in kg ha^{-1} showed highly significant differences (P<0.01) over years. Genotypes and genotype-year interaction (G×Y) also showed significant differences in seed yield in kg ha^{-1} (Table 3). Previously, Yucele *et al.* (2005), Jeena *et al.* (2000) and Saxena (2003) also found highly significant differences between years, genotypes, and genotype-year interaction from a pooled analysis of variance for grain yield in chickpea genotypes.

The mean production of the two-year average grain yield ranged from 328 to 914 kg ha^{-1}. The lowest grain yield (328 kg) over two years was in genotype D-15012, while the highest grain yield (914 kg) over two years was in genotype K-60058. In GYI, the lowest (301 kg) grain yield was observed in genotype K-60069, while the highest (988 kg) grain yield was observed in D-14005 (Table 12).

The lowest (301) 1st year grain yield kg ha^{-1} was observed in genotype K-60069, while the highest (942) 1st-year grain yield kg ha^{-1} was observed in genotype K-60058. Whereas the lowest (339) grain yield kg ha^{-1} in year 2 was observed in genotype D-15012, while the highest (988) grain yield kg ha^{-1} in year 2 was observed in genotype D-14005 (Table 12).

Larval count

Among the insects, the pest Gram pod worm (*Helicoverpa armigera* L.) is a major constraint that severely reduces the yield of the chickpea crop (Sarwar, 2013). Data for larval counts were collected to screen for tolerant lugworm genotypes. For the number of larvae, the analysis of variance over two years showed a highly significant difference (P <0.01) between the years, genotypes and genotypes after year interaction (GY) also showed a highly significant difference (Table 2). The significance of the interaction (GY) indicates that the genotype response to the larval attack was variable over the years studied. The high contribution of environmental factors to the overall variation suggested a greater variety of years for the existence of pod borers to attack chickpea genotypes. Sarwar (2013) also reported the same results and reviewed the resistance susceptibility of chickpea genotypes to *Helicoverpa* species at NIAB Faisalabad.

Table 12: *Means and percentage differences for grain yield kg/h of 45 chickpea genotypes were evaluated across two years during 2018-19 and 2019-20.*

Genotypes	1st Year	2nd Year	Mean	Percentage difference
D-15012	317	339	328	9.88
D-15019	337	358	348	0.13
D-10008	791	576	683	2.48
D-97086	701	624	662	-0.22
D-14014	600	745	672	0.48
D-11030	873	654	764	6.58
D-13036	384	446	415	98.91
D-08025	715	869	792	13.74
D-15020	853	635	744	1.01
D-13031	897	777	837	-0.14
D-13012	327	395	361	4.24
D-12011	936	658	797	1.30
D-09027	865	933	899	2.56
D-13011	768	675	722	0.59
D-15015	505	530	518	7.47
D-14005	884	988	936	-0.05
D-15005	778	644	711	1.11
D-10039	412	433	423	3.67
D-93127	912	710	811	-0.29
D-15036	892	928	910	-0.24
K-08003	365	414	389	4.00
K-01158	876	651	764	6.25
K-60075	619	522	570	5.99
K-01208	416	444	430	4.03
K-01151	409	630	520	3.21
K-60066	320	373	347	19.41
K-01213	704	824	764	4.36
K-01209	308	386	347	5.61
K-60069	301	345	323	28.90
K-88170	314	342	328	154.06
K-08021	312	448	380	36.41
K-01153	303	355	329	38.02
K-01155	315	403	359	13.30
K-01210	551	489	520	4.39
K-70009	584	523	554	5.11
K-60058	942	887	914	5.47
K-88168	311	382	346	14.17
K-CH 47/04	663	549	606	17.83
FLIP82-150	539	468	504	3.45
NKC-10-99	323	365	344	14.49
NKC-5-5-20	359	383	371	27.11
Check-1	335	371	353	65.97
Check-2	828	627	727	13.36
Check-3	448	441	445	28.08
Check-4	515	480	497	11.98
Year mean	571	556		

LSD (5%) for genotypes 2.77; LSD for year 2.0153

Over two years, the number of Plant^{-1} larvae ranged from 5 to 17. Minimal Plant^{-1} larvae were observed for genotypes D-15019 and D-08025. Whereas for genotypes K-01155 and K-01153, maximum numbers of plant^{-1} larvae were observed. In GYI, the minimum (2) larval number was recorded from genotype D-14005, whereas the maximum (29) was shown from K-01155 (Table 6).

A low larval population density was observed in the 1st year. In the first year, the number of Plant^{-1} larvae ranged from 2 to 9. The minimum (2) of Plant^{-1} larvae was observed in genotypes D-08025, D-15019, D-10008, and D-14005, while the maximum (9) larvae plant^{-1} was recorded for the genotypes K-60069, K-88168, and NKC-10-99 and K-88170. In year 2, Plant^{-1} larvae ranged from 7 to 29. At least (7) Plant^{-1} larvae were observed in genotypes D-15019, D-12011, K-08003, and K-60069. A maximum (29) number of larvae Plant^{-1} was observed for genotypes K-01155, K-01153 and K-60075 (Table 6).

Pod damage percentage

The percentage of pod damage was caused by feeding larvae the developing seeds after making a hole and poking their heads in the pod. Combined analyzes of variance for the percentage of damaged pods revealed highly significant differences (P 0.01) over the years. The interaction between genotypes and genotype years also showed highly significant differences (Table 2). The importance of GxY implies that the response of the genotypes to the borer larvae for causing pod damage was different at the sites studied. Sarwar (2013) also reported that variations in pod damage could be due to different regional climatic conditions.

The average percentage of pod damage ranged from 17 to 57% on average over two years. The lowest (17) percentage of pod damage over two years was shown by genotype NIFA-2005. while the highest (57) percentage of pod damage over two years occurred in genotype D-13031. In GYI, the lowest (12) percentage of pod damage was observed in genotype D-15036, while the highest (95) percentage was observed in NKC-5-520 (Table 13).

The lowest (12) percentage of pod damage at year 1 was observed in genotype D-15036. In contrast, the highest (46) cent pod damage per year was observed in the Karak-1 genotype. While in year 2 the lowest (14) percentage of pod damage was observed in K-60069,

Links Researchers

the highest (95) percentage of pod damage in year 2 was observed in genotype NKC-5-520 (Table 13).

Table 13: *Means and percentage differences for pod damage% of 45 chickpea genotypes were evaluated across two years during 2018-19 and 2019-20.*

Genotypes	1st year	2nd year	Mean	Percentage difference
D-15012	37	74	56	74
D-15019	23	82	52	82
D-10008	15	93	54	93
D-97086	25	63	44	63
D-14014	27	47	37	47
D-11030	21	85	53	85
D-13036	39	91	65	90
D-08025	14	59	37	59
D-15020	19	73	46	73
D-13031	20	93	57	93
D-13012	42	79	61	78
D-12011	16	78	47	78
D-09027	16	86	51	86
D-13011	18	30	48	40
D-15015	31	93	62	92
D-14005	15	94	54	94
D-15005	26	87	57	87
D-10039	20	74	47	74
D-93127	19	76	48	76
D-15036	12	76	44	76
K-08003	28	37	32	36
K-01158	27	33	60	18
K-60075	15	42	29	42
K-01208	13	77	45	77
K-01151	17	74	46	73
K-60066	37	62	49	61
K-01213	14	26	20	25
K-01209	30	36	33	35
K-60069	36	14	25	11
K-88170	17	70	44	70
K-08021	15	74	45	74
K-01153	17	20	18	19
K-01155	22	26	24	25
K-01210	27	15	21	13
K-70009	20	22	21	21
K-60058	14	77	46	77
K-88168	39	91	65	91
K-CH 47/04	17	84	51	84
K-FLIP82-150	29	67	48	67
NKC-10-99	33	15	24	13
NKC-5-5-20	40	95	68	95
Karak-1	46	15	31	12
Karak-2	15	91	53	91
Karak-3	26	72	49	71
NIFA-2005	19	14	17	13
Year mean	24	65		

LSD (5%) for genotypes = 4.3666%; LSD for years = 3.0876%

Conclusions and Recommendations

It is concluded that the traits such as days to 50% emergence, days to 50% flowering, pods per plant, seeds per pod, 100 seed weight, biological yield and pod borer infestation showed significant differences and are directly related to the identification of Genotypes of resistance/tolerance to the chickpea pod borer (*Helicoverpa armigera* L.). The pooled analysis also proved to be a powerful tool for identifying the resistance level of genotypes to the chickpea pod borer (*Helicoverpa armigera* L.). Line identification and check vs. test line performance can also be easily accessed via pooled analysis.

The present study recommends that the genotypes K88170, D-14014, K-60069, K-01153, K-70009, KARAK-2, K-CH47/04, D-15036 and NIFA-2005 have a high resistance potential. tolerant of the chickpea pod borer and high yielding. These genotypes can be used in future breeding programs to develop pod borer (*Helicoverpa armigera* L.) resistant cultivars. Some of the genotypes like D-15012, D-13011, K-01210 and D-08025 showed early maturity and some genotypes like K-01213, D-15005, K-60069 and 15012 were early in formation and these genotypes can be recorded be used in future breeding programs.

Novelty Statement

This research recommends specific genotypes that performed well in terms of grain yield, pod damage percentage, and larval infestation, suggesting their potential for developing pod worm-resistant/tolerant and high-yielding chickpea varieties. The study also highlights the importance of plant height, as reducing it beyond a certain threshold negatively impacts yield

Author's Contribution

Hamid Ullah Khan: Conceptualization, methodology.
Muhammad Anas: Conceptualization, methodology, writing, data analysis.
Rozina Gul: Conceptualization, supervision.
Waseem Ullah Shah: Data analysis.
Abdul Haleem: Methodology.
Muneeb Ahamd Khan, Muhammad Taimur, Tahreem Shah, Sajjad Ur Rahman, Noman Anjum and Muhammad Saqib: Funding acquisition.

Conflict of interest

The authors have declared no conflict of interest.

References

After, S.Q., A. Shaukat, A. Bakhsh, M. Arshad and A. Ghafoor. 2004. An assessment of variability for economically important traits in chickpea (*Cicer arietinum* L.). Pak. J. Bot., 36(4): 779-785.

Akhtar, L.H., M.A. Pervez and M. Nasim. 2011. Genetic divergence and inter-relationships in chickpea (*Cicer arietinum* L.). Pak. J. Agric. Sci., 48(1): 35-39.

Azar, M.R., A. Javanmard, F. Shekari, A. Pourmohammad and E. Esfandyari. 2013. Evaluation of chickpea yield components (*Cicer arietinum* L.) in incorporating spring barley (*Cicer arietinum* L.). Indian J. Genet. Plant Breed., 51(2): 240-245.

Bakhsh, A., M. Arshad and A.M. Haqqani. 2006. Effect of genotypes x environment interaction on the relationship between grain yield and its component in chickpea (*Cicer argentina* L.). Pak. J. Bot., 38: 638-690.

Desai, K., C.J. Tank, R.A. Gami and A.M. Patel. 2016. G × E interaction and stability analysis chickpea (*Cicer argentina* L.). Int. J. Agric. Environ. Biotechnol., 9(4): 479-484. https://doi.org/10.5958/2230-732X.2016.00063.2

FAO, 2017. Production yearbook. Food and Agriculture Organization, Rome, Italy.

Frette, R.T., R. White, J.A. Palta and N.C. Turner. 2004. Internal recycling of respiratory CO_2 in pods ofchickpea (*Cicer argentina* L.) the role pod wall, seed coat and embryo. J. Exp. Bot., 55: 1687-1696. https://doi.org/10.1093/jxb/erh190

Jadhav, S.D. and V.L. Gawande. 2016. Genetics of traits associated with pod borer resistance and seed yield in chickpea (*Cicer arientinum* L.). Iran. J. Genet. Plant Breed., 4(1): 09-16.

Jeena, A.S. and P.P. Arora. 2000. Genetic variation in chickpea evaluated at Pantnagar India. Agric. Sci. Digest, 20(1).

Jenkins, D.W., and F.M. Brill. 2011. Genetic variability and resistance mechanisms in chickpea (*Cicer arietinum* L.) genotypes against pod borer (*Helicoverpa armigera* L.). Plant Breed. Genet. J., 8(2): 87-94.

Jul, R., H. Khan, M. Bibi, Q.U. Ain and B. Imran. 2013. Genetic analysis and inter-relationship of yield attributing traits in chickpea (*Cicer arietinum* L.). J. Anim. Plant Sci., 23(2): 521-526.

Khan, M.R. and A.S. Qureshi. 2001. Quantitative variations induced by gamma irradiation and gibberellic acid in M1 generation of chickpea. Sarhad J. Agric., 17(3): 367-371.

Kumar, P., M.A. Ahmad, R. Kumar and S. Moses. 2019. Varietalchickpea (*Cicer arientinum* L.) screening against pod borer (Helicoverpaarmigera). J. Ent. Zool. Stud., 7(1): 33-35.

Padmavathi, P.V., S.S. Murthy, V.S. Rao and M.A. Lal. 2013. Correlation and path coefficient analysis in Kabuli chickpea (*Cicer arietinum* L.). Int. J. Appl. Biol. Pharma. Technol., (4): 107-110.

Sarwar, 2013. Exploration of resources of resistance in chickpea (*Cicer arientinum* L.) genotypes to gram pod borer (Helicoverpaarmigera). Afr. J. Agric. Res., 8(26): 3431-3435. https://doi.org/10.5897/AJAR11.2452

Saxena, N.P., 2003. Management of drought in a chickpea-a holistic approach. Manage. Agric. Drought: Agron. Genet. Options, pp. 103-122.

Singh, A.K. and A.P. Singh. 2013. Study of genetic variability and interaction of some quantitative traits in chickpea (*Cicer arietinum* L.). J. Multidiscip. Adv. Res., 2(1): 87-94.

Singh, R.P., A.K. Singh, S.P. Upadhyay and R.K. Singh. 2020. An approach for site-specific assessment of pod borer management in chickpea, J. Entom. Zool. Stud., 8(2): 726-728.

Yadav, S.S., J. Kumar, S.K. Yadav, S. Singh, V.S. Yadav, N.C. Turner and R. Redden. 2006. Evaluation of Helicoverpa and drought resistance in desi and Kabuli chickpea. Plant Genet. Resour., 4(3): 198-203. https://doi.org/10.1079/PGR2006123

Yadav, B.S., S. Singh, S. Srivastava, N.K. Singh and A. Mani. 2019. Whole transcriptome expression profiling and biological network analysis of chickpea during heavy metal stress. J. Plant Biochem. Biotechnol., 28(3): 345-352. https://doi.org/10.1007/s13562-019-00486-3