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Morphological characterization of chickpea genotypes and their influence on *Helicoverpa armigera* (Hubner) population and its natural enemies

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Abstract
Helicoverpa armigera is an important pest in Indian subcontinent causing huge crop losses in chickpea. Exploiting plants resistance against pests could be handier in controlling the pest which is compatible with other methods of pest management. Hence the present study was undertaken to morphologically characterize various chickpea genotypes for the pest management. Larval population and number of pupal cases differed significantly among the genotypes with BGD 111-01 having lowest larval population (0.62 larvae plant^{-1}) and pupal cases (1.39 pupal cases plant^{-1}). Highest larval load was recorded in KAK-2 (1.11 larvae plant^{-1}) whereas the highest number of pupal cases was recorded in A-1 (1.95 pupal cases plant^{-1}). Trichome density on leaves, calyx and pod differed significantly among the genotypes. Significant variation in leaf thickness was observed among the genotypes and it ranged from 0.17 mm (BGD-103 and A-1) to 0.36 mm (BGD 111-01). Pod husk thickness differed significantly among the genotypes with highest in BGD 111-01 (0.41 mm) and lowest in A-1 (0.23 mm).

Keywords: Chickpea, *Helicoverpa*, trichomes, resistance

1. Introduction
Chickpea (*Cicer aretinum* L.) is the most important legume and often called as "King of pulses" as it is the cheapest source of highly nutritious food with greater protein content, energy, soluble and insoluble fiber [1]. Despite the most important crop its yields remained stagnant since past two decades. Chickpea has a global average yield potential of 6 t ha^{-1} which is significantly higher than the current national average of 0.8 t ha^{-1} [2]. Among several biotic and abiotic constraints limiting its yield potential, gram pod borer is the most important pest. *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is an important old world species that inflicts serious damage to several crops. It is polyphagous, multivoltine, persistent and cosmopolitan pest feeding on 182 species of host plants spread across 47 families in India [3] causing an yield loss of 70-95 percent [4]. High polyphagy, high fecundity, mobility, diapause, migratory behavior, high adaptations to various climatic conditions are the attributes that favour the pest [5]. Chemical measures of control seem to be harmful and not feasible with increasing reports of pest resistance. Exploring plant resistance to insects seems to be a better approach yielding favorable results. Developing tolerant/resistant cultivars to the pest is sustainable, cheaper, easy to handle, providing durable resistance and also compatible with other methods. Though the research to develop the resistant cultivars is going on since last two decades, the progress remains limited due to the low level of resistance available in the cultivated species.
Several studies done on mechanism of plant resistance indicate that many morphological structures like spinescence, pubescence, sclerophylly and raphides formed a basis of resistance against the pest [6]. Trichomes play a crucial role in the plants defense mechanism by impaling the pest and also contribute to the chemical defense of a plant. Several field trials conducted to assess the impact of morphological characters of chickpea genotypes against pod borer revealed that larval population and pod damage showed a negative correlation with trichome density [7, 8]. Various breeding programmes are evaluating the germplasms for both quality and quantity aspects. It is a continuous process to identify resistant traits. Hence the present study was conducted with fifteen chickpea genotypes to know the influence of their morphological characters on *H. armigera* population and its natural enemies.

2. Material and Methods

Field experiments were laid out during *rab*i, 2017 to study the influence of various chickpea genotypes on *H. armigera* population and its natural enemies. Crop protection measures were taken at 65 DAS as it was a testing material and to ensure the sufficient production of seeds for the next generation. Fifteen genotypes (BGD 133, BGD 1501, BGD 1536, BGD 103, BGD 111-01, JAKI 9218, JG 11, DBGV 204, DBGV 209, DBGV 206, DBGV 215, DBGV 213, DBGV 212 and KAK - 2) with Annigeri-1 as a susceptible check were sown in randomized block design replicated thrice. All the genotypes were *desi* ones except KAK-2. There were four rows, each of four-meter length. Spacing was 30 cm × 10 cm for *Desi* genotypes while it was 45 cm × 10 cm for *Kabuli* ones and plot size was 4 m × 1.2 m for *Desi* and 4 m × 1.8 m for *Kabuli* ones. Observations on no. of larvae ten plants^{-1} were recorded at weekly interval.

At physiological maturity, no. of damaged pods/plant stage, percent pod damage, and yield /plot were recorded.

$$\text{Per cent pod damage} = \frac{\text{No.of damaged pods}}{\text{Total no.of pods}} \times 100$$

For all above observations, ten plants were taken at random and observations were recorded at weekly intervals. Data on larval population, pupal cases count was subjected to angular transformation while data on percent pod damage was subjected arc sine transformation respectively and used for further statistical analysis by following DMRT as suggested by [9]. As the larval population was very less, to make a note of parasitism in the field, number of pupal cases of *C. chlorideae* in the field was recorded.

2.1 Morphological characterization

2.1.1 Trichome density

The methodology devised by [10] was used to measure trichome density. Uniformly grown up leaves were cut into bits of 9 mm^2 **(**3 x 3 mm**)** and number of trichomes present on the epidermis of the leaf bits were counted under a binocular microscope at 100x magnification. Further trichome density on calyx and pods were also recorded.

2.1.2 Leaf and pod husk thickness

Uniformly developed three leaves and pods were taken from each treatment at 45 DAS in all the three replications and were measured for leaf and pod husk thickness by using vernier caliper represented in millimeter (mm).

Observations recorded on all morphological and biochemical characters were analyzed by following analysis of variance and treatments means were compared by following DMRT as suggested by [9].

3. Results and Discussion

3.1 Influence of chickpea genotypes on *Helicoverpa armigera* (Hubner) population

The results of observations on larval population is mentioned below and given in table 1.

30 DAS: Significant differences in larval population were recorded among the genotypes which ranged from 0.28 to 0.61 larvae plant^{-1}. BGD 111-01 recorded lowest larval density and was on par with all the remaining genotypes except A-1, DBGV 204, DBGV 209, DBGV 206, DBGV 213 and KAK-2 whereas highest larval population was recorded in KAK-2 which differed significantly from others.

37 DAS: Larval density though varied significantly among the genotypes ranging from 0.31 to 0.59 larvae plant^{-1}, it was not sufficiently high to discriminate the difference among the genotypes. Lowest larval population was recorded in DBGV 212 which was on par with DBGV 213 whereas highest larval population was recorded on DBGV 204 which was on par with BGD-103, A-1, JAKI 9218, JG 11, DBGV 209, DBGV 206 and KAK-2.

44 DAS: Larval population varied significantly among the genotypes and it ranged from 0.49 to 1.12 larvae plant^{-1}. A slight increase in larval population from the previous week was evident in this week. BGD 111-01 recorded lowest larval density which was significantly different from other genotypes whereas KAK-2 recorded highest larval population which was on par with A-1.

51 DAS: Significant differences in larval population were recorded among the genotypes and it ranged from 0.72 to 1.48 larvae plant^{-1}. BGD 111-01 recorded lowest larval density which was on par with BGD-133, BGD-1501, BGD-1536, DBGV 204, DBGV 215, DBGV 213 and DBGV 212. A-1 recorded highest larval population which was on par with BGD-103, JAKI 9218, JG-11, DBGV 209, DBGV 206 and KAK-2.

57 DAS: Highly significant variation in larval density was recorded among the genotypes and it ranged from 1 to 1.90 larvae plant^{-1}. Lowest larval population was recorded in DBGV 215 which was on par with BGD-1501, BGD-1536, BGD 111-01, JAKI 9218, DBGV 204, DBGV 213 and DBGV 212. Highest larval population was recorded in BGD-103 which was on par with BGD-133 and A-1.

The pooled data of pest population indicated significant differences in the larval populations among the genotypes. BGD 111-01 recorded lowest pest population (0.62 larvae plant^{-1}) which was on par with remaining genotypes except BGD-103, A-1, DBGV 209, DBGV.

Table 1: Response of chickpea genotypes to pod borer, *Helicoverpa armigera* at weekly intervals (*rabi* crop) (October-February)

Sl. No.	Genotypes	No. of larvae/ten plants						Percent pod damage*	Yield (q/ha)
		30 DAS #	37 DAS#	44 DAS#	51 DAS#	57 DAS#	Pooled data#		
1	BGD 133	0.37 (0.93)^{bcd}	0.43 (0.96)^{cd}	0.67 (1.08)^{e}	0.92 (1.19)^{bcd}	1.62 (1.45)^{abc}	0.80 (1.14)^{cdef}	1.80 (7.52)^{bc}	26.90^{a}
2	BGD 1501	0.33 (0.91)^{cd}	0.44 (0.97)^{bcd}	0.66 (1.08)^{e}	0.88 (1.17)^{cd}	1.18 (1.30)^{def}	0.70 (1.09)^{def}	1.73 (7.33)^{bc}	21.41^{abcd}
3	BGD 1536	0.32 (0.91)^{cd}	0.43 (0.96)^{cd}	0.63 (1.06)^{e}	0.83 (1.15)^{d}	1.27 (1.33)^{cdef}	0.70 (1.09)^{def}	1.50 (7.03)^{bc}	21.01^{abcd}
4	BGD 103	0.39 (0.94)^{bcd}	0.55 (1.02)^{abc}	0.88 (1.18)^{bc}	1.17 (1.29)^{abc}	1.90 (1.55)^{a}	0.98 (1.22)^{abc}	2.83 (9.5)^{abc}	20.75^{abcd}

5	A-1	0.46 (0.98)^{b}	0.56 (1.03)^{ab}	1.00 (1.22)^{ab}	1.48 (1.41)^{a}	1.85 (1.53)^{ab}	1.07 (1.25)^{ab}	4.58 (12.36)^{a}	20.26^{bcd}
6	BGD 111-01	0.28 (0.88)^{d}	0.44 (0.97)^{bcd}	0.49 (0.99)^{f}	0.72 (1.10)^{d}	1.17 (1.29)^{def}	0.62 (1.06)^{f}	1.40 (6.72)^{c}	21.89^{abcd}
7	JAKI 9218	0.30 (0.90)^{cd}	0.50 (1.00)^{abcd}	0.71 (1.10)^{e}	1.22 (1.31)^{ab}	1.33 (1.35)^{cdef}	0.81 (1.15)^{bcdef}	4.16 (11.76)^{ab}	19.90^{bcd}
8	JG 11	0.35 (0.92)^{bcd}	0.49 (1.00)^{abcd}	0.71 (1.1)^{e}	1.25 (1.32)^{ab}	1.38 (1.37)^{cde}	0.84 (1.16)^{bcdef}	3.40 (10.61)^{abc}	16.78^{cd}
9	DBGV 204	0.42 (0.96)^{bc}	0.59 (1.04)^{a}	0.84 (1.16)^{cd}	0.83 (1.15)^{d}	1.18 (1.30)^{def}	0.77 (1.13)^{cdef}	2.90 (9.73)^{abc}	19.43^{bcd}
10	DBGV 209	0.43 (0.96)^{bc}	0.55 (1.02)^{abc}	0.86 (1.16)^{cd}	1.20 (1.30)^{abc}	1.37 (1.36)^{cde}	0.88 (1.17)^{abcde}	1.73 (7.55)^{bc}	23.58^{ab}
11	DBGV 206	0.41 (0.96)^{bc}	0.50 (1.00)^{abcd}	0.88 (1.17)^{bc}	1.20 (1.30)^{abc}	1.55 (1.42)^{bcd}	0.91 (1.19)^{abcd}	1.77 (7.63)^{bc}	19.10^{bcd}
12	DBGV 215	0.36 (0.92)^{bcd}	0.41 (0.96)^{cd}	0.62 (1.06)^{e}	0.85 (1.16)^{cd}	1.00 (1.22)^{f}	0.66 (1.08)^{ef}	1.67 (7.33)^{bc}	16.32^{d}
13	DBGV 213	0.41 (0.95)^{bc}	0.41 (0.95)^{de}	0.72 (1.11)^{de}	0.88 (1.17)^{cd}	1.30 (1.34)^{cdf}	0.75 (1.12)^{cdef}	2.13 (8.33)^{abc}	17.56^{bcd}
14	DBGV 212	0.37 (0.93)^{bcd}	0.31 (0.90)^{e}	0.68 (1.09)^{e}	0.82 (1.14)^{d}	1.12 (1.27)^{ef}	0.66 (1.08)^{ef}	1.48 (6.97)^{c}	23.01^{abc}
15	KAK - 2	0.61 (1.05)^{a}	0.55 (1.02)^{abc}	1.12 (1.27)^{a}	1.33 (1.35)^{a}	1.92 (1.56)^{a}	1.11 (1.27)^{a}	4.77 (12.59)^{a}	21.85^{abcd}
	S.Em.±	0.02	0.02	0.02	0.04	0.04	0.01	1.40	1.88
	C.D. at 5%	0.06	0.06	0.06	0.12	0.12	0.03	4.15	5.45
	C.V. (%)	9.74	11.75	12.8	12.00	10.90	11.25	13.39	15.80

DAS: Days after sowing; #: Values in the parentheses are √(x+0.5) transformed values used for statistical analysis; *: Values in the parentheses are arc sine transformation used for statistical analysis. Means followed by same alphabet in a column do not differ significantly by DMRT.

206 and KAK-2 while the highest larval load was recorded on KAK-2 (1.11 larvae plant^{-1}) which was on par with BGD-103, A-1, DBGV 209 and DBGV 206.

The larval population was below the ETL to draw any useful conclusions. This might be explained by the fact that the gram pod borer, *H. armigera* requires high temperatures and low relative humidity for its higher incidence in the field conditions. Similar reports indicating the influence of weather parameters on the incidence of the pest were given by several authors. Significant positive correlation between temperature and larval population was given by [11] whereas significantly negative correlation of larval population and relative humidity was reported by [13]. The other possible reasons for the low incidence of pest might be the success of Bt-cotton hybrids in controlling the pest and presence of the herbivore induced plant volatiles in several hosts. Many previous studies reporting the effect of plant volatiles on pest population also support the reason behind low population [12].

Differential responses to test genotypes were noticed as evident by varying population loads at different weekly intervals. However, the pooled data indicates significant differences in larval population. Since the larval population was below ETL, the results of only pooled data are discussed here under. The pooled data (Table 1) indicates that BGD 111-01 recorded lowest larval population (0.62 larvae plant^{-1}) while KAK-2 recorded the highest (1.11 larvae plant^{-1}). This might be due to the fact that more number of glandular trichomes in BGD 111-01 might have repelled the adult from oviposting on it. This view is supported by the non-significant negative correlation of glandular trichomes with larval population (r= -0.167). Previous studies [14] stating that glandular trichomes could impart resistance to the plants also supports the above.

3.2 Influence of various chickpea genotypes on natural enemies of *Helicoverpa armigera* (Hubner)

The data on the number of pupal cases of *Campoleites chlorideae* (Uchida) (per ten plants) in *rabi* crop (table 2) is given below

30 DAS: Significant variations in the number of pupal cases were recorded among the genotypes. Number of pupal cases ranged from 1.17 to 1.85. A-1 recorded the highest number of pupal cases which was on par with all the genotypes except BGD 111-01. BGD 111-01 recorded the lowest number of pupal cases which was on par with BGD-1501, BGD-1536, JAKI 9218, JG 11, DBGV 215, DBGV 213 and DBGV 212.

Table 2: No. of *Campoleites chlorideae* pupal cases recorded on chickpea genotypes (*rabi* crop) (October-February)

Sl. No.	Genotypes	No. of pupal cases/ten plants					
		30 DAS #	37 DAS#	44 DAS#	51 DAS#	57 DAS#	Pooled data#
1	BGD 133	1.65 (1.47)^{a}	1.88 (1.54)^{a}	1.93 (1.56)^{a}	1.89 (1.55)^{a}	1.95 (1.56)^{abc}	1.86 (1.54)^{ab}
2	BGD 1501	1.43 (1.39)^{ab}	1.85 (1.53)^{a}	1.97 (1.57)^{a}	1.85 (1.52)^{a}	1.83 (1.52)^{bc}	1.79 (1.51)^{ab}
3	BGD 1536	1.45 (1.39)^{ab}	1.62 (1.45)^{a}	0.95 (1.20)^{b}	1.53 (1.42)^{ab}	1.88 (1.54)^{abc}	1.49 (1.41)^{c}
4	BGD 103	1.73 (1.49)^{a}	1.94 (1.56)^{a}	1.98 (1.57)^{a}	1.78 (1.51)^{a}	2.13 (1.62)^{a}	1.91 (1.55)^{ab}
5	A-1	1.85 (1.53)^{a}	1.95 (1.56)^{a}	1.98 (1.57)^{a}	1.97 (1.57)^{a}	1.98 (1.57)^{abc}	1.95 (1.56)^{a}
6	BGD 111-01	1.17	1.17	1.62	1.23	1.78	1.39

		(1.28)[b]	(1.29)[b]	(1.45)[a]	(1.31)[b]	(1.51)[bc]	(1.37)[c]
7	JAKI 9218	1.48 (1.41)[ab]	1.69 (1.48)[a]	1.75 (1.50)[a]	1.93 (1.56)[a]	1.80 (1.52)[bc]	1.73 (1.49)[b]
8	JG 11	1.60 (1.45)[ab]	1.78 (1.51)[a]	1.86 (1.54)[a]	1.92 (1.55)[a]	1.85 (1.53)[bc]	1.80 (1.52)[ab]
9	DBGV 204	1.77 (1.51)[a]	1.93 (1.56)[a]	1.97 (1.57)[a]	1.70 (1.48)[a]	1.82 (1.52)[bc]	1.84 (1.53)[ab]
10	DBGV 209	1.69 (1.48)[a]	1.84 (1.53)[a]	1.83 (1.53)[a]	1.91 (1.55)[a]	1.93 (1.56)[abc]	1.84 (1.53)[ab]
11	DBGV 206	1.65 (1.47)[a]	1.87 (1.54)[a]	1.69 (1.48)[a]	1.83 (1.53)[a]	1.94 (1.56)[abc]	1.80 (1.52)[ab]
12	DBGV 215	1.60 (1.45)[ab]	1.92 (1.56)[a]	1.58 (1.44)[a]	1.75 (1.50)[a]	1.75 (1.50)[c]	1.72 (1.49)[b]
13	DBGV 213	1.52 (1.41)[ab]	1.85 (1.53)[a]	1.95 (1.57)[a]	1.73 (1.49)[a]	2.02 (1.59)[ab]	1.81 (1.52)[ab]
14	DBGV 212	1.57 (1.44)[ab]	0.93 (1.18)[b]	1.70 (1.48)[a]	1.67 (1.47)[a]	1.06 (1.25)[d]	1.39 (1.37)[c]
15	KAK - 2	1.82 (1.52)[a]	1.92 (1.55)[a]	1.97 (1.57)[a]	1.92 (1.55)[a]	2.02 (1.59)[ab]	1.93 (1.56)[a]
	S.Em.±	0.14	0.06	0.05	0.05	0.03	0.02
	C.D. at 5%	0.40	0.18	0.15	0.16	0.10	0.06
	C.V. (%)	10.50	11.20	12.90	12.60	11.40	10.50

DAS: Days after sowing; #: Values in the parentheses are √(x+0.5) transformed values used for statistical analysis. Means followed by same alphabet in a column do not differ significantly by DMRT.

37 DAS: Significant differences in number of pupal cases were recorded among the genotypes and it ranged from 0.93 to 1.95 plant^{-1}. Highest number of cases was recorded in A-1 which was on par with all the genotyes except BGD 111-01 and DBGV 212 whereas the lowest number of pupae were recorded in DBGV 212 which was on par with BGD 111-01.

44 DAS: Number of pupal cases differed significantly among the genotypes and it ranged from 0.95 to 1.98 plant^{-1}. Highest parasitism was recorded in A-1 which was on par with all remaining genotypes except BGD-1536 whereas the lowest number was recorded on BGD-1536 which differed significantly.

51 DAS: Significant differences in parasitism levels were recorded among the genotypes and it ranged from 1.23 to 1.97. A-1 recorded highest number of pupal cases which was on par with with all the genotyes except BGD 111-01 which recorded the lowest number of pupal cases (1.23).

57 DAS: Number of pupal cases varied significantly among the genotypes and it ranged from 1.06 to 2.13. BGD-103 recorded highest number of pupal cases respectively which was on par with BGD-133, BGD-1536, A-1, DBGV 209, DBGV 206, DBGV 213 and KAK-2 whereas lowest number of cases was recorded in DBGV 212 which differed significantly from others.

The pooled data pertaining to number of *C. chlorideae* pupal cases revealed significant differences among the genotypes. A-1 recorded highest number of pupa (1.95 pupal cases plant^{-1}) which was on par with all the genotypes except BGD-1536, BGD 111-01, JAKI 9218, DBGV 215 and DBGV 212 whereas BGD 111-01 and DBGV 212 recorded lowest number of pupa (1.39 pupal cases plant^{-1}) which was on par BGD-1536.

This could be explained by the Lotka-volterra model *i.e.* concept of pest-predator relation [14]. Generally in an ecosystem the populations of prey and predator are mutually dependent on each other. The natural enemies will be in a continuous search for the prey to feed on. Hence, it is obvious that the natural enemies would try to localize on that hosts where pest or prey population is abundant in numbers. The present research also supports the above concept of prey-natural enemy concept. Natural enemies were abundantly available on A-1 which harboured highest larval population and were least abundant in BGD 111-01 and DBGV 212 where there is low pest load. Further, previous studies by [13] also supported our results.

3.3 Percent pod damage

Percent pod damage differed significantly among the genotypes during cropping period. Pod damage ranged from 1.40 to 4.77 percent. Lowest pod damage was recorded on BGD 111-01 which was on par with all the remaining genotypes except A-1, JAKI 9218 and KAK-2. Highest pod damage was recorded in KAK-2 which was on par with BGD-103, A-1, JAKI 9218, JG 11, DBGV 204 and DBGV 213 (Table 1). This might be due to the fact that BGD 111-01 recorded lowest larval population throughout the cropping period whereas KAK-2 recorded highest larval population which resulted in highest pod damage. Such low levels of pod damage might be due to low larval incidence.

3.4 Yield

Yield (q ha^{-1}) differed significantly among the genotypes and it ranged from 16.32 to 26.9 q ha^{-1}. Highest yield was recorded in BGD-133 (26.9 q ha^{-1}) which was on par with all remaining genotypes except A-1, JAKI 9218, JG 11, DBGV 204, DBGV 206, DBGV 213 and DBGV 215 whereas lowest yield was recorded in DBGV 215 (16.32 q ha^{-1}) which was on par with remaining genotypes except BGD-133, DBGV 209 and DBGV 212 (Table 1). It might be due to lower larval population and lesser pod damage that resulted in higher yields in BGD-133.

Lowest yield in DBGV 215 is supported by the view that a resistant genotype need not always give highest yields as yield is governed by the inherent genetic characteristics of genotype and hence yield parameters cannot be alone considered for evaluating the resistance potential of a genotype. A low yielding variety may carry the gene for resistance, while a high yielding variety may be highly susceptible to the pest. The resistant variety in the process of

interaction with the pest spends its entire energy derived from metabolism in conferring resistance to the pest leading to considerable lower yields. This view is also supported by the findings of [15] who reported lowest yield loss in susceptible variety KPG 59 in spite of the high larval population and high percent pod damage.

3.5 Morphological characterization

3.5.1 Trichome density: Trichomes observed on leaf surface, calyx and pod were recorded and the results obtained were given in Table 3. In the present investigation, two different types of trichomes *viz.*, glandular and non-glandular trichomes were recorded on leaf and calyx whereas only non-glandular trichomes were present on the pods of chickpea.

3.5.1.1 Trichome density on leaves

3.5.1.1.1 Glandular trichomes: Genotypes differed significantly among themselves in number of glandular trichomes and they ranged from 1.33 to 8.67. Highest number of glandular trichomes were recorded in DBGV 204 which was on par with BGD-133, BGD-1501, A-1, BGD 111-01, JAKI 9218, JG 11, DBGV 212 and KAK-2. Lowest number of glandular trichomes was recorded in DBGV 206, DBGV 215 and DBGV 213 which were on par with BGD 1536, BGD-103, JAKI 9218, DBGV 209 and DBGV 212.

3.5.1.1.2 Non-glandular trichomes: The number of non-glandular trichomes ranged from 25 to 55. Significant difference in number of non-glandular trichomes was recorded in between the genotypes. BGD-1536 recorded highest non-glandular trichomes which was on par with BGD-103, A-1, BGD 111-01, JAKI 9218 and DBGV 206 whereas DBGV 212 recorded lowest number of non-glandular trichomes which was on par with BGD-133, JG-11, DBGV 209, DGBV 215, DBGV 213 and KAK-2.

3.5.1.2 Trichome density on calyx: There was a significant difference in number of glandular and non-glandular trichomes among the genotypes.

3.5.1.2.1 Glandular trichomes: Variations in number of the glandular trichomes were observed among the genotypes and they ranged from 21 to 48.30. Highest number of glandular trichomes was recorded in JG-11 which was on par with BGD-1536 and DBGV 212 whereas KAK-2 recorded lowest number of glandular trichomes which was on par BGD-103, JAKI 9218 and DBGV 213.

3.5.1.2.2 Non-glandular trichomes: Significant disparities in number of the non-glandular trichomes were observed among the genotypes and it ranged from 32.7 to 65.7. BGD-133 recorded the highest number of non-glandular trichomes which was on par with BGD-1536 and DBGV 204. DBGV 212 recorded the lowest non-glandular trichomes which was on par with DBGV 206.

The correlation studies revealing non-significant negative correlation (r=-0.477) between trichome density on calyx and larval population and previous findings of [8] who revealed that number of trichomes on calyx exhibited significant negative association (-0.596), with percent pod damage in chickpea.

Table 3: Morphological characterization of chickpea genotypes

Sl. No.	Genotypes	Trichome density on leaves		Trichome density on calyx		Trichome density on pod	Leaf thickness (mm)	Pod husk thickness (mm)
		G	NG	G	NG			
1	BGD 133	6.33^{ab}	26.30^{gh}	39.30^{b}	65.70^{a}	51.30^{bcd}	0.26^{cde}	0.30^{cd}
2	BGD 1501	7.33^{a}	40.00^{bcdef}	30.70^{cd}	54.30^{b}	57.70^{b}	0.25^{cde}	0.31^{bc}
3	BGD 1536	2.00^{bc}	55.00^{a}	44.30^{a}	65.30^{a}	44.00^{d}	0.25^{cde}	0.30^{cd}
4	BGD 103	1.33^{c}	51.00^{abc}	25.30^{ef}	44.30^{c}	48.30^{cd}	0.17^{f}	0.26^{cde}
5	A-1	6.00^{ab}	54.00^{a}	28.30^{de}	40.70^{c}	30.30^{efg}	0.17^{f}	0.23^{e}
6	BGD 111-01	6.67^{a}	46.30^{abcde}	38.70^{b}	50.70^{b}	36.30^{e}	0.36^{a}	0.41^{a}
7	JAKI 9218	4.67^{abc}	52.00^{ab}	21.70^{f}	52.30^{b}	33.30^{ef}	0.33^{ab}	0.26^{cde}
8	JG 11	8.33^{a}	30.30^{fgh}	48.30^{a}	51.30^{b}	54.00^{bc}	0.30^{bc}	0.26^{cde}
9	DBGV 204	8.67^{a}	39.00^{cdefg}	39.00^{b}	61.00^{a}	22.70^{gh}	0.29^{bcd}	0.36^{ab}
10	DBGV 209	2.00^{bc}	37.30^{defgh}	33.30^{c}	41.30^{c}	32.70^{ef}	0.25^{cde}	0.28^{cde}
11	DBGV 206	1.33^{c}	49.70^{abcd}	26.70^{de}	34.70^{d}	33.00^{ef}	0.29^{bcd}	0.27^{cde}
12	DBGV 215	1.33^{c}	31.70^{fgh}	24.70^{ef}	41.30^{c}	28.30^{fgh}	0.23^{de}	0.25^{cde}
13	DBGV 213	1.33^{c}	36.70^{efgh}	27.70^{de}	40.70^{c}	69.30^{a}	0.22^{ef}	0.27^{cde}
14	DBGV 212	5.00^{abc}	25.00^{h}	47.30^{a}	32.70^{d}	22.30^{h}	0.25^{cde}	0.30^{cd}
15	KAK - 2	8.00^{a}	31.30^{fgh}	21.00^{f}	49.70^{b}	26.00^{fgh}	0.21^{ef}	0.24^{de}
	S.Em.±	1.43	3.88	1.52	1.82	2.45	0.02	0.02
	C.D. at 5%	4.14	11.22	4.38	5.28	7.08	0.05	0.06
	C.V. (%)	12.02	11.66	7.93	6.55	10.81	12.32	11.98

Means followed by same alphabet in a column do not differ significantly by DMRT. **G**-Glandular, **NG**- Non glandular

3.5.1.3 Trichome density on pods: Genotypes differed significantly among themselves in number of trichomes on pod and it ranged from 22.3 to 69.3. DBGV 213 recorded highest number of trichomes which was significantly different from other genotypes. DBGV 212 recorded lowest number of trichomes which was on par with DBGV 204, DBGV 215 and KAK-2. Longer trichomes on pods might provide a physical barrier to feeding by pod borer. Similar results were presented by [17] who reported that number of trichomes on leaves and pods showed a significant negative effect on pod damage.

3.5.2 Leaf thickness: There was a significant variation in leaf thickness among the genotypes and it ranged from 0.17 to 0.36 mm. BGD 111-01 recorded highest leaf thickness which was on par with JAKI 9218 whereas BGD-103 and A-1 recorded lowest which were on par with DBGV 213 and KAK-2 (Table 3).

3.5.3 Pod husk thickness: Pod husk thickness differed significantly among the genotypes and it ranged from 0.23 to 0.41 mm. Highest pod thickness was recorded in BGD 111-01 which was on par with DBGV 204 whereas A-1 recorded lowest (Table 3). The correlation data (Table 4) revealed the presence of significant negative correlation between pod husk thickness and larval load (r=-0.585). The present results were in accordance with findings of [8] wherein, leaf thickness and pod husk thickness exhibited significant negative association (-0.668) with percent pod damage in chickpea.

4. Conclusions

The present results show us that trichomes form a basis of resistance against the pod borer along with other mechanisms. The genotypes BGD-133, BGD 111-01 and BGD-1501 which had higher number of glandular trichomes harbored lower larval population with lower pod damage and higher yields. Hence they can be used further in the resistance breeding programmes and field trials.

Table 4: Correlation coefficients of various morphological and biochemical parameters with larval population (*rabi crop*) (October-February)

	LP	PC	GTL	NGTL	GTC	NGTC	TPOD	LTH	PHTH	PD	Y
LP	1	.721**	-.167	.237	-.477	-.161	-.150	-.476	-.585*	.754**	-.225
PC		1	.053	.005	-.555*	.009	.170	-.516*	-.585*	.575*	.039
GTL			1	.085	-.048	.329	-.193	-.002	.441	.223	-.121
NGTL				1	-.319	.055	-.009	.020	-.021	.175	-.289
GTC					1	.295	-.001	.338	.485	-.429	.137
NGTC						1	.227	.261	.373	.023	.116
TPOD							1	-.103	-.053	-.205	.003
LTH								1	.646**	-.223	-.152
PHTH									1	-.528*	-.024
PD										1	-.472*
Y											1

LP: Larval population; PC: Pupal cases; GTL: Glandular trichomes on leaves; NGTL: Non-glandular trichomes on leaves; GTC: Glandular trichomes on calyx; NGTC: Non-glandular trichomes on calyx; TPOD: Trichome son pod; LTH: leaf thickness: PHTH: Podhusk thickness; PD: Pod damage; Y: Yield; **: Correlation is significant at the 0.01 level (2- tailed); *: Correlation is significant at the 0.05 level (2- tailed).

5. References

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