

**FIELD SCREENING OF CERTAIN CHICKPEA  
(*Cicer arietinum* L.) GENOTYPES AGAINST GRAM  
POD BORER (*Helicoverpa armigera* Hubner)**



**THESIS**  
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**Master of Science (Agriculture)**  
in  
**Entomology & Agricultural Zoology**

Supervisor  
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*Dedicated  
to  
My Mother*



डा० पी.एस. सिंह, प्रोफेसर  
कीट एवं कृषि जन्तु विज्ञान विभाग,  
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### CERTIFICATE

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The Registrar (Academic)  
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**Through:** The Head, Department of Entomology & Agricultural Zoology, Institute of Agricultural Sciences, B.H.U., Varanasi.

Dear Sir,

I have great pleasure in forwarding the thesis entitled “**Field screening of certain chickpea (*Cicer arietinum* L.) genotypes against gram pod borer (*Helicoverpa armigera* Hubner)**” submitted by **Mr. Pavan Kumar, ID. No. 19412EAZ010**, in partial fulfilment of the requirements for the degree of **Master of Science (Agriculture) in Entomology & Agricultural Zoology**, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi and placing on record that he has completed the requisite residential requirements as contained in the statutes of the university.

I certify that the entire scheme of investigation presented herein was planned and carried out solely by the candidate under my guidance and supervision. The data presented in the thesis, to the best of my knowledge and belief, are genuine and original.

Thanking you.

Yours faithfully,

Forwarded by

**(P. S. Singh)**  
**Supervisor**

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(*Helicoverpa armigera* Hubner)**



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2021

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**Date:**

**Place:** Varanasi

**(Pavan Kumar**

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## INTRODUCTION

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Pulses cover 70.6 million hectares and contribute 61.5 million tonnes of produce to the world's overall food grain production, with an average yield of 871 kg/ha. It has important nutritional and health benefits, and it has been shown to lower the risk of noncommunicable diseases including colon cancer and cardiovascular disease (Jukanti *et al.* 2012).

India is a premier pulse-growing country. The pulses are an integral part of the cropping system of farmers all over the country because these crops fit in well in the crop rotation and crop mixtures. Pulses are an important part of the Indian diet and provide a significant amount of protein.

Pulses are an important protein source for vegetarians in India, containing proteins, amino acids, vitamins, and minerals to supplement their diets of staple cereals. They have 20-25% protein, which is almost twice as much as wheat and three times as much as rice. They are known as "soil fertility restorers" because they improve physical, chemical and biological properties of soil through their unique ability to fix atmospheric nitrogen (up to 30 kg ha<sup>-1</sup>), dense foliage, deep root system and ability to mobilize insoluble soil nutrients.

In India, Pulses cover 28.34 million hectares and contribute 23.15 million tonnes of produce to overall food grain production, with an average yield of 817 kg/ha. Rajasthan contributes largest area (22.36% area with production of 19.41%) followed by Maharashtra (15.48% area with production of 17.40%) and Madhya Pradesh (16.70% area with and 16.41% production) of total pulse area and production. (Directorate of Economics & Statistics, DAC&FW 2019-2020).

The availability of pulses per capita per day has been proportionately declined from 54.7 gm in the year 2017 to 51.3 gm in the year 2018 and 47.9 gm per capita per day 2019 (Statista 2021).

Among the pulses, Chickpea (*Cicer arietinum L.*) is one of the major important pulse crops in the world. Chickpea (*Cicer arietinum L.*), commonly known as Bengal gram, gram or chana, originated from South-Western Asia, is an important *Rabi* pulse crop of India which has been considered as 'King of Pulses' (Bhatt and Patel, 2001).

Chickpea has been known in this country for a long time. It is said to be one of the oldest pulses known and cultivated from ancient times both in Asia and in Europe. Its probable place of origin lies in south-western Asia, that is, in the countries lying to the north-west of India such as Afghanistan and Persia. According to Aykroid and Doughty (1964) the centre of origin of chick-pea is eastern Mediterranean. According to De Candolle, the fact that gram has a Sanskrit name would indicate that the crop has been under cultivation in India longer than in any other country.

Gram commonly known as 'Chickpea' or Bengal gram is the most important pulse crop of India. India alone has nearly 52.5 per cent of the world acreage and production of gram. Chickpea occupies about 38 per cent of area under pulses and contributes about 50 per cent of the total pulse production of India. It is used for human consumption as well as for feeding to animals. It is eaten both whole fried or boiled and salted, or more generally the form of the split pulse which cooked and eaten. Both husks and bits of the 'dal' are valuable cattle feed. Fresh green leaves are used as a vegetable (sag). The straw of chickpea is excellent fodder for cattle. The grains are also used as a vegetable (chhole). Chickpea flour (besan) is used in the preparation of various types of sweets. Chickpea is considered to have medicinal effects and it is used for blood purification. Chickpea contains 21.1 per cent protein, 61.5 per cent carbohydrate, 4.5 per cent fat. It is also rich in calcium, iron, Phosphorus and niacin Calorific value 396 Kcal/100g.

Chickpea is a diploid ( $2n=16$ ) highly autogamous crop with natural cross pollination ranging between (zero to one per cent) in Desi or Brown Gram (*Cicer arietinum L.*): In this group, the colour of the seed ranges from yellow to dark brown. Seed size is usually small. It is the most widely grown group. Plants are small with good branching ability. Chromosome number is  $2n = 14, 16$ .

Kabuli or White Gram (*Cicer kabulium*): In this group, the colour of the seed is usually white. Seeds are bold and attractive. The yield potential of this group is

poor as compared to desi or brown gram. Plants are generally taller as compared to desi gram and stand more or less erect. The chromosome number is  $2n = 16$ .

Chickpea belongs to the family Leguminosae. It is a small, much-branched herbaceous plant rarely exceeding 60-centimeter height. The botanical chickpea has a well-developed root system. The roots usually include a central strong taproot, with numerous lateral branches that spread out in all directions in the upper layer of soils. There are numerous nodules on roots. The rhizobium bacteria present in these nodules fix up atmospheric nitrogen. The stem is generally greyish in appearance. The stem is branched with granular hairs on it. The main branch in gram usually produces not more than one secondary shoot, but in some types, the main branches may produce numerous lateral branches. The leaves are pinnately compound, usually with one terminal leaflet. The number as well as the size of the leaflet, however, vary in different types. There are 9 to 15 pairs of leaflets. The leaflets of the pinnate leaves are small and have serrated edges. The leaves are covered with glandular hairs. The colour of the leaves also varies, some being light green while others are green or dark green. Certain types possess leaflets with red margins. The flowers are typical papilionaceous consisting of five sepals, five petals comprised of one standard, two wings and two keels, ten stamens, nine fused to form one staminal column and one free, and a carpel with the style borne laterally on the ovary. The flowers are usually solitary and are present in the axils of the leaves. They are of various colours from white to shades of pink or blue. Anthesis starts between 9 a.m. and 10 a.m. and may continue up to 3 p.m. The flowers remain open for two days, the flowering process being over early on the second day. Self-pollination is the rule, but cross pollination may occur to the extent of about 5-10% due to agency of insects. The pod is about 2 cm long and usually contain two seeds. A single plant produces about 50 to 150 pods. The seeds are spherical in shape, wrinkled and with a pointed beak. They vary a great deal in size as well as in colour. The colour of seed may vary from white, light fawn, yellowish-orange, brown, dark brownish and with a little bluish tinge. The seed coat may be smooth or puckered and wrinkled. The cotyledons are thick and yellowish in colour.

India is the world's largest producer of chickpea (followed by Turkey and Pakistan) with (10.17 m ha) of the global area and approximately (11.35 MT) of the global production (Directorate of Economics & Statistics, DAC&FW 2019-2020).

Chickpea covers almost 31% of the country's total pulse area and produces more than 37% of the country's pulse production. It is mostly cultivated in Rajasthan, Maharashtra, Madhya Pradesh, Uttar Pradesh, Bihar, Haryana, and Punjab in India during the *Rabi* season. Chickpeas are grown on 2.46 million hectares in Rajasthan, with an annual production of 2.66 million and productivity of 1080 kg ha<sup>-1</sup> (2019-2020 Directorate of Economics and Statistics, DAC&FW). Chickpea is an essential component of dry, rainfed cropping systems because it can fix 80 to 120 kg nitrogen per hectare through symbiotic nitrogen fixation (Papastylanou 1987).

Chickpea crop suffers due to the losses caused by various insect pests and diseases. It is infested by eleven different insect pests. In most chickpea-growing locations around the world, the pod borer *Helicoverpa armigera* (Lepidoptera Noctuidae) is one of the most important insect pests.

*Helicoverpa armigera* damages the chickpea plants at all stages from seedling to crop maturity stage. *Helicoverpa armigera* is a polyphagous pest that attacks over 181 different types of plants species such as Maize, Sorghum, Pearl millet in cereals, Sunflower, Groundnut in oilseeds, Okra, Tomato in vegetables including Chickpea, Pigeon pea, Cotton, Tobacco, etc. This pest feeds on leaves, flowers, flower buds and pods. The chickpea pods are damaged by this insect to the extent of 50 to 60%. (Khare and Ujagir, 1977). This pest infests host plants a few weeks after crop emergence and continues to feed before harvesting.

With advancements in crop production and protection technologies, as well as changes in farming practices, the severity of the pod borer problem has also changed. Because of changes in technology and climate, insect pest problems have changed dramatically in the first decade of the twenty-first century, with an overall drop in the severity of *Helicoverpa armigera*. The introduction of *Bt* Cotton resulted in reduction in the population of this insect pest (Dhaliwal *et al.*, 2010), and this pest subsequently moves from cotton to pigeon pea and then to chickpea (Bambawale *et al.*, 2009).

Early instars of *H. armigera* larvae are different foliar feeders but subsequently change to growing roots and fruits, resulting in a severe loss in output (Reed and Pawar, 1982). The most destructive pest to the chickpea crop is *H. armigera*, which brings severe economic losses (Singh and Yadav, 2006, Sarwar *et al.* 2009).

In India, losses caused by *H. armigera* on chickpea and pigeon pea fields exceeded 12,000 million Rs. per year as per a survey carried out by ICRISAT (Anonymous. 1996). The pest could cause 3.6-72.8 per cent pod damage in chickpea in Orissa, India (Patnaik et.al., 1991).

In its lifetime, a single *H. armigera* larva can destroy 30-40 pods (Atwal and Dhaliwal, 2005). Excessive chemical use not only puts a strain on farmers' finances, but it also has a significant negative impact to the environment and human health.

The identification and adaptation of host plant resistance as a key concept for the management of *H. armigera* (gram pod borer) has improved motivation to the identification and use of chickpea genotype against pod borer resistance. Plant mechanisms such as antixenosis and antibiosis can help reduce insect size, weight, survival length, reproduction, and development time (Sharma *et al.*, 2003). Keeping the aforesaid fact in view, the current research was carried out to screen chickpea genotypes against the pod borer *H. armigera* in natural conditions, which can help in finding acceptable genotypes for long-term production.

Thus, the present investigation is an effort in this direction to facilitate the development of resistant genotypes of chickpea against gram pod borer (*Helicoverpa armigera*) by the screening of different chickpea genotypes. Therefore, keeping above points in view present study was carried out with the following objectives.

**Objective:**

1. Screening of certain chickpea genotypes against gram pod borer (*Helicoverpa armigera*)
2. Study on seasonal incidence of *Helicoverpa armigera* on chickpea
3. To find out the correlation between *Helicoverpa armigera* population and abiotic factors.



## **REVIEW OF LITERATURE**

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Previous work done by scientists on screening of chickpea genotypes for resistance and related aspects has been presented here chronologically.

### **2.1 Screening of certain chickpea genotypes against gram pod borer (*Helicoverpa armigera*)**

Shrivastava *et al.* (1975) investigated 20 varieties of chickpea (*Cicer arietinum* L) in Kanpur and found that F 378 was the least susceptible to *Helicoverpa armigera* with 4.6 per cent pod damage, followed by C 235 with (6.1 per cent) pod damage. Genotype Annigeri and 850-3/27, had recorded the highest pod damage (13.5 and 15 per cent) respectively.

Lateef *et al.* (1981) studied the susceptibility of seven chickpea cultivars to *H. armigera*, and found that the Annigeri 1 (the standard) had recorded the highest pod damage while ICC 506 had the least.

Odak *et al.* (1982) studied 11 chickpeas (*Cicer arietinum* L.) genotypes against *H. armigera*. They revealed that Kabuli variety L 550 was more sensitive to pod damage (10%) than variety JG-315 (3.4%), and that bold seeded varieties were favoured over small-seeded varieties.

Patnaik *et al.* (1985) observed the lowest pod and seed damage as 11.7 per cent and 7.8 per cent in RSG-130 and highest (68.7 per cent and 54.5 %) in BG-264, respectively due to *H. armigera*.

Bhalani *et al.* ((1987) screened 16 genotypes of chickpea in Gujarat for resistance to *H. armigera* and observed that ICC 4 recorded the lowest pod damage, by pod borer and highest mean yield (1929 kg/ha).

Chhabra *et al.* (1990) recorded seven genotypes viz GL 645, Dulia 6-28, GGP Chaffa, P 1324-11, P 1697, P 6292 and selection 418 with less than 5% pod damage,

by *H. armigera*, for consecutive 3 years, as against standard varieties (16.1 per cent and 36.0 per cent infester) respectively. They, further observed that GL-645 (Kabuli type) had the lowest pod borer incidence, which is due to contents of a high per cent age of crude fiber and non-reducing sugars, as well as a low per cent age of starch in its.

Singla *et al.* (1991) found that variety GL 769 had lower (9.8%) pod damage by *H. armigera* than variety L 550 (19.8%) at the normal plant spacing. with increased plant spacing, the larvae population and per cent age of pod damage decreased.

Miah *et al.* (1992) reported that Pabna local was highly susceptible, while least infestation was recorded on S-1 among the tested seven varieties of chickpea in the field at Bangladesh.

Chauhan and Dahiya (1994) screened 39 chickpeas (*C. arietinum*) genotypes for tolerance to *H. armigera* during 1989-90 and 1990-91, and that they observed the larval population range from 6.5 (PDE 2-1) to 32.08 (H 86- 18) with the highest pod damage in Hooda (24.49%) and lowest in GNG 469 (7.3%).

Ogenga *et al.* (1994) recorded the highest numbers of larvae on cultivar Annageri (1.34/plant) and the lowest on ICC-506 (0.22/plant). On average, the most susceptible cultivars were Annageri and K-850 while, ICC X-790197-25, PLB-12, PLB-3, PLB-PBLB and ICC-506 were the least infested.

Screening of forty desi (local) early maturity chickpea genotypes for resistance against *H. armigera* under natural field conditions in Akola (Maharashtra) was done by Bhagwat *et al.*, (1995). ICC-506 with 8% pod damage harboured 10 larvae on 10 plants, was designated as the least susceptible, whereas ICC-14665 with 41.8% pod damage and 26 larvae on 10 plants was categorized as most susceptible. A low amount of acidity in leaf exudates (24.1 and 41.9 meq/100 gm) of the genotype (ICC-14665) was associated with susceptibility in larvae of *H. armigera*, 60 and 75 days after sowing respectively.

Reddy *et al.* (1996), reported the chickpea genotype Pusa-261, BG-374, and BG-386 were the least susceptible, while larvae of *H. armigera* prefer Kabuli varieties BG-356, L-550, and Pusa-267 over Desi variants.

Amjed *et al.* (1996) tested 20 test lines of chickpea test against pod borer, *H. armigera*. The pest was moderately resistant to four cultivars (620, 662, C-727, and 905), whereas the rest of the cultivars are moderately susceptible. However, while one cultivar, 801, was moderately susceptible, but it produced the largest yield.

Reddy *et al.* (1996) tested 14 chickpea genotypes against *H. armigera*. Genotype Pusa 261, BG 374, and BG 386 were the least susceptible ones. The most preferred cultivar by larvae is BG-356, L 550, and Pusa 267. The highest yield was obtained from genotype Pusa-261, while the lowest yield was obtained from genotype BG-356, the least and most susceptible genotype, respectively

Hafeez and Kotwal (1996) conducted a field trial in Jammu and Kashmir, India, in 1994-95, 11 genotypes or varieties of chickpea were tested for resistance to *H. armigera*. GMS-968, H-91-51, KPG-223 and C-235 were found to be resistant, 12 genotypes were moderately resistant and Pusa-256 and BG 387 were susceptible to the pest.

Parvez *et al.* (1996) screened varietal resistance of 20 test lines of chickpea against gram pod borer, *H. armigera* showed that only one cultivar *i.e.* 1230 was resistant to *H. armigera*. The pest assault was moderately resistant to three cultivars: 932, 1084, and 4001. The rest of the cultivars were determined to be moderately susceptible. C-44, although being a cultivar, was found to be moderately susceptible, however, it produced the highest mean yield despite significant pod loss. This was probably due to its high potential for yield.

Yelshetty *et al.* (1996) reported genotype BJ-256 to have the lowest (3.0) pest susceptibility rating in both seasons, whereas highest pest susceptibility rating was found in PDG-90-3 E, PDG-90-1 E and PDG-90-2E.

Bhatnagar and Rao (1997) recorded pod damage ranging from 7.5 per cent (JG-897) to 21.1 per cent (JG-935). The genotypes JG-897, JG-322 and JG-394 had good resistance to pod damage and recorded the highest yields under rain-fed conditions.

Banchhor (1998) worked on 67 genotypes of chickpea against pod borer *H. armigera* at Raipur. The highest grain yield (15.74 Q/ha.) was obtained from RG-995 followed by Jaki9226 (15.20 Q/ha), Jaki 9218, Phule G-41 (14.08 Q/ha), GCP-101 (13.64 Q/ha), CSG-90019 (13.26 Q/ha), BKG-5020 (12.14 Q/ha), all being at par with each other PBG-5 had the highest pod damage (27.93%) and lowest grain yield (2.98 Q/ha).

Das and Katariya (1999) screened chickpea genotypes and reported pod damage ranging from 2.7 per cent (JG-74) to 11.4% (JG-89-G). The other genotypes showed pod damage below 5% (RWG-2, JG-315 and JG- 322).

Singh and Yadav (1999) evaluated seventy desi chickpea genotypes by using an open field screening technique under field conditions in Bihar. The parameters used for evaluating these genotypes were relative pest pressure index, the relative intensity of damage index and relative productivity index. None of the genotypes could exhibit complete resistance to *Helicoverpa armigera*.

Olla and Saini (1999) screened 8 genotypes of chickpea (H 86-18, H 91-47, H 92-67, H 93-106, C 235, HK 89-96, HK 89-131 and L 550) in the laboratory for feeding preference of fifth- instar larvae of *H. armigera*. Feeding preference for leaves (damaged or eaten) was greatest in H 86-18 (4 per cent), H 89-131 (3.75 per cent) and HK 89-96 (3.50 per cent), H 92-67 and H 91- 47, and least prefer for feeding with respect to all the plant parts. *H. armigera* during 1996-1997 incidence on these genotypes exhibited that pod damage was lowest in H 92-67, followed by H 91-47 and C 235 (14.5, 19.09 and 22.5 per cent respectively).

Bhagwat and Sharma (2000) screened 21 chickpea genotypes for resistance to *H. armigera* that reported genotypes ICC-506, ICCV-10, ICCL-86102 and ICCV-

95992 had low pod damage (by *H. armigera*) rating of 3 (on a 1-less susceptible to 9 - highly susceptible scale).

Gumber *et al.* (2000) screened 62 chickpea germplasm accessions and six approved cultivars in the field against *H. armigera* and recorded the number of pods per plant, number of pods damaged by pod borer, pod length, pod width, and seed yield per plant, indicating that accessions ICC 93512, ICC 93515, and ICC 93212 were the most promising, with higher seed yield and low pod borer damage.

Afzal *et al.* (2001) tested eight chickpea test lines against *H. armigera* that recorded two genotypes (Pb-2000 and 96051) to be highly resistant, three advanced lines (9075, 96052, and BC-6-5) to be resistant, two advanced lines (90395-K and 97047) to be moderately resistant, and only one advanced line (88194) to be susceptible.

Bhatt and Patel (2001) conducted field trials of some chickpea genotypes in Gujarat and observed Chaffa (14.32) and ICCV-10 (17.31) had lower larval populations, whereas Phule G-5, PG-81-1-1 (24.90), GNG-465 (23.61), and BG-391 had greater larval populations (23.31). Chaffa received the lowest pod damage rate (9.55%) had the lowest yield (772 kg/ha) due to its smaller grain size and lower yield potential, whereas ICCV-4 had the highest grain yield (1250 kg/ha).

Khattak *et al.* (2002) screened 8 chickpea cultivar CMN 729-2, SCMN 335-3, CMN 667-4, NIFA 95 (Desi), PB 9, CMNK 440-9 (Kabuli) CMNK 287-3 and CMNK -281- 7 against *Helicoverpa* in the laboratory. CMNK-440-9 had the highest larval survival, pupal recovery, and adult emergence rates (100,100, and 90%, respectively), while NIFA-95 had the lowest (60 50 and 30 per cent respectively). NIFA-95 was the most resistant genotype, while CMNK-440-9 was the most susceptible among all genotypes.

Mandal (2003) evaluated 18 chickpea (*C. arietinum L.*) genotypes against *H. armigera* in the field experiment conducted in Umerkote, Orissa, India. Pod damage varied from 9.43 to 24.80%. Two genotypes (DS-83149 and Bhawanipatna) were

resistant, six were moderately resistant, seven were moderately susceptible, and three were susceptible to the pest.

Shrivastava (2003) observed that the larvae population was 5.86 to 10.16 per plant, pod damage was 12 to 67.30 per cent, and yield losses ranged from 27.52 to 42.16 per cent. Genotype KPG 42-1 was shown to be the least preferable genotype among the studied genotypes based on larval population and per cent pod damage. Genotype Sadabahar harboured highest larval population resulting in maximum per cent pod damage, despite the high larval population and high per cent pod damage, genotype KPG-59 had the lowest yield loss.

Rajput *et al.* (2003) evaluated eight chickpea genotypes against the infestation of *Helicoverpa* species under the field condition at NIA, Tandojam. The data on larval population, percentage damage and yield components were highly variable, showing the percentage larval attack severity 1.00 to 50.00, pods damage 8.50 to 90.90% and 23.33 to 1920.00 gm grain yield of the sampling unit. Data revealed that genotype C-727 was relatively resistant against pod borer infestation as compared to other genotypes.

Rashid *et al.* (2003) screened 11 improved chickpea strains and observed that pod damage was 9.38 and 21.49 per cent, respectively, with grain yields of 0.333 and 0.137 kg/plot on the most promising strain BRC-4 and the least susceptible strain BRC-1.

Shahzad *et al.* (2005) carried out a field trial to screen chickpea cultivar against *H. armigera*. The data was recorded based on the number of trichomes, plants height, pod borer larval population and per cent pod damage at different phenological stages of genotypes. A minimum larval population of 20 numbers was observed on Hassan-2k (40krad) while the maximum was recorded on NIFA-95 (10krad). Per cent damage was highest in Hassan-2k (10krad) and lowest in Pb-91 (20krad). Maximum yield was recorded on Hassan-2k (30krad). Trichomes and height were negatively correlated with *H. armigera* infestation. Pb-91 (20krad) is recommended as tolerant to the infestation of *H. armigera*.

Wakil *et al.* (2005) reported genotype CM-2000 to be high yielding (1059.40 g plot'), while, CM-93127 gave the minimum yield (39.57g plot'). The grain yield was affected significantly in an inverse proportion to both pod-infestation and larval population.

Maurya and Ujagir (2005) studied the larval survival as well as growth and development of *H. armigera* on 12 least susceptible chickpea (*C. arietinum L.*) genotypes at room temperature in the laboratory. On genotypes, ICC-12968 and L-550, the highest larval survival (4.2 larvae per plant) was recorded and the minimum survival (0.2 larvae/plant) was observed in genotype-ICC 10998, There was a significant difference in the weight of individual larvae fed on the different genotypes. Rai and Ujagir (2005) screened promising 10 desi and 1 Kabuli, early maturing chickpea genotypes. 4 genotypes (ICCV 93929, ICCV 90029, ICCV 96030 and ICCV 2) showed resistance to gram pod borer, *H. armigera* with a pest damage score of 3 on a scale of 1-9 On the other hand ICCV 10, ICCV 97115, ICCV 97119 and ICCV 16381 showed tolerant, as they produced greater seed yield than the others.

Patel *et al.* (2005) tested certain promising chickpea genotypes against *H. armigera* and found that 4 genotypes, B 105, B 106, BG 1088, and ICCV 2, were not infested. However, MP JGK-2 and JGK-923 genotypes, on the other hand, showed much greater larval populations (4.66 and 6.00 larvae per plot). The remaining genotypes had a medium larval population (ranging from 0.33 to 2.66 larvae per plot). Genotype LBEG-7 and ICCV-2 reported no pod damage.

Shafique *et al.* (2008) compared resistance among recombinants against pod borer in a field trial at the Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, and found that none were fully resistant to this insect. However, recombinants CH-70/02, CH-75/02, CH- 83/02 and CH-86/02 were found highly resistant. Recombinants CH-62/02, CH-64/02 and CH-66/02 possessed intermediate resistance. While, recombinants CH-60/02, CH-63/02, CH- 67/02 and CH-68/02 were found least resistant. CH-75/02 was identified as highly resistant with 13.3% pod damage which decreased damage up to 31.1% with an increased in yield up to 100% when compared with check, whereas CH-63/02 were found to be the least resistant as

22.7% pod damage, damage increased up to 17.6% with decreased yield 31.4% over the check.

Sarwar *et al.* (2009) reported genotypes C-727 to have the least population and damage by *H. armigera*, while CM-88 proved susceptible and least productive. The larval population during both the years ranged from 0.71 to 1.0 on C-727, while it was 2.52 to 6.33 in CM-88. Pod damage ranged from 26.01% to 40.08% in CM-88, while it was 9.20% to 16.06% in C-727. Genotype CM-88 registered yields of 68.33 to 165.0 gm per 3 m<sup>2</sup>, while genotype C-727 was the highest yielding (300 to 530 gm per 3 m).

Nadeem *et al.* (2010) conducted a field trial to compare varietal resistance in 13 improved desi chickpea genotypes against the gram pod borer, *H. armigera* during 2007-08. From the first week of March to the third week of April, weekly observations showed that the mean larval population of pod borer in different genotypes ranged from 0.33 to 4.33 per meter row, with pod damage ranging from 7.4 to 14.2 per cent. The results show that B-8/02, along with B-8/03, CH-4/02, and CH-9/02, were the most resistant to pod borer, with the least larval population per plant, the least pod damage, and the best grain production, with an increase of 256.8 to 285.7 per cent above with respect to check genotype. It is concluded that these genotypes can be used in crossing/evolving new elite chickpea varieties.

Kumar *et al.* (2013) conducted an experiment to screen fifty genotypes of chickpea against gram pod borer, *H. armigera* under field condition. Each genotype was sown in two rows of 2 m length in Augmented Design. Susceptible (H-82-2) and resistant (C-235) genotypes as checks were sown after every 10 genotypes. The population of gram pod borer larvae was recorded on each test genotype at 50% pod filling stage. On the basis of pod damage caused by the pod borer, was classified into three categories (Tolerant, Moderate resistant, Susceptible). DGP 15, GIG 0312, ICCL 87315, ICCV 7, RIL 115, ICC 29, ICC 12470, ICCV 10, and PG 23 were among the nine genotypes identified as rating scale 1, graded as tolerance because their pod damage (5.50-8.50%). Seven genotypes (DGP-15, GIG-0312, ICCL-87315, ICCV-7, RIL-115, ICC-29, ICC-12470, ICCV-10, and PG-23) reported pod damage

ranging from 20.00-23 per cent and rating scale 3 placed them in the susceptible category because they were comparable to the susceptible check (H82-2), while the remaining 34 genotypes showed pod damage ranging from 10.50-1900% and rating scale 2 placed them in the moderately resistant category.

Jeewesh Kumar *et al.* (2013) conducted studies on screening of 50 genotypes of chickpea against *H. armigera* under field conditions. The maximum number of larvae (3.0/10 plants) and highest of pod damage (23%) was recorded in susceptible genotype H-82-2 and the lowest larvae population (0.5/10 plants), and lowest pod damage (5.5%) was recorded in resistant genotype C-235.

Sai Reddy and Meena (2018) conducted an experiment to screen eleven genotypes of chickpea against *Helicoverpa armigera*. They observed the highest larval population was found in JG 11 (3.60 larvae/plant) and lowest mean larval population in ICCV 92944 (1.68 larvae/plant). Per cent age pod damage varied significantly from the highest in ICCV 92944 (19.94 %) to the lowest in JG 11 (35.67%). On the basis of the per cent pod damage of genotypes ICCV 09103, HC 1, NBEG 1004, GLW 48, GL 25016 and ICCV 92944 were found to be least preferred and can be used as source of resistance against *H. armigera*.

Kumar *et al.* (2018) screened fifteen chickpea varieties/genotypes (JG 11, ICCV 2, KAK 2, Pusa 391, JGK 1, GJG 3, JG 315, JG 228, JG 63, ICCV 10, Vishal, RSG 888, RSG 44, JAKI 9218 and KPG 59) against *H. armigera* in T.C.A., Dholi Muzaffarpur (Bihar). They recorded lowest mean larval population in genotype Pusa 391 followed by RSG 888 and the highest mean larval population was recorded in genotype JGK 1 (4.46 larvae/5 plants) which was at par with GJG 3, JAKI 9218, JG 315, JG 63 and JG 218.

Sameer *et al.* (2018) conducted a field trail during *Rabi* 2016- 17 at Agriculture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. Twenty chickpea genotypes along with susceptible and resistant check, Annageri-1 and C-235 was screened against pod borer *Helicoverpa armigera*. The mean larval population of *H. armigera* on different genotypes was ranged from

1.54 larvae/mr-1 to 6.54 larvae/ mr-1. The genotypes BG-372 (1.54 larvae/mr-1) and KWR 108 (2.79 larvae/mr-1) recorded lowest larval population density which was at par with resistant check C-235.BG 256 recorded significantly highest number of larvae population which was at par with BG 1053 (6.53 larvae/mr-1), Annigeri-1 (6.33 larvae/mr-1), PUSA 128 (5.94 larvae/mr-1), PHULE G0027 (5.59 larvae/ mr-1), GNG 469 (5.58 larvae/mr-1), GLK 26155 (4.97 larvae/ mr-1) and AVRODHI (4.85 larvae/mr-1), respectively.

## 2.2 Seasonal incidence of gram pod borer (*Helicoverpa armigera*)

Thakur *et al.* (1981) observed the dynamics of the larval pest population. The minimum daily temperature below 10 °C tended to reduce larval population, whereas the minimum temperature between 11°C to 20 °C and RH between 50-80% proved to be favourable for the build-up of the population. *C. Chloridae Uchida* was the dominant larval parasite on the gram, which parasitized on early larval instars. Its activity was more at a daily minimum temperature range between 9°C to 15°C. It parasitized from 15 to 61% during 1978-79 and from 11.75 to 55% during 1979-80.

Chaudhary and Sharma (1982) studied the nature of damage and intensity of the population of the pest at the different growth stages of chickpea. The first and second instars feed by making scratches on leaves and pods. The third instar feeds on leaves, leaf, buds, and flowers. They prefer to feed on pod during podding. Third and fourth instars larvae can hide inside the pod and fifth instar larvae remain half body out.

Lal *et al.* (1985) assessed the damage in Uttar Pradesh and on an average the crop suffered 5.5% damage in that state and only 4.4% farmers were using insecticide to control the pest. Later Lal *et al.* (1984) reported that on an average chickpea in Uttar Pradesh suffered a loss of 15.3% from *H. armigera* on a pod basis causing a monetary loss of about Rs. 450 million per annum. Pupal diapauses resulted in heavy population build-up during post-winter months with a peak between 15 March and 30 April. Delayed sowing and high plant density resulted in more pod damage and low grain yield. Mixed cropping had significantly less pod damage than the sole cropping.

Mehto *et al.* (1985) described larvae-infested tender leaves, shoot, flower buds and pods. The population gradually built up in the first week of January and peaked during February and March. The larval population suddenly declined at pod maturity by the end of March.

Qadeer and Singh (1989) reported an outbreak with a population of up to 10 larvae/meter row of *H. armigera* on chickpea in Haryana during Rabi 1987-88. The population increased from the first week of March resulting in heavy crop losses in the first week of April.

Singh *et al.* (1990) reported larvae peaked of *H. armigera* in early April (16-32 larvae/M<sup>2</sup>) and damage to pods and seeds varied from 13.6 to 84.3 and 3.15 to 37.22%. The Ichneumonid (*Campoletis chloridae*), house sparrow (*Paser domesticus*) and black myna were important natural enemies of the pest.

Prashad *et al.* (1991) studied the population dynamics on various dates in Bihar in 1984-85. They observed a fairly low larval population during December when the average minimum temperature was 7.5°C.

Yadava *et al.* (1991) studied the influence of reported that *H. armigera* formed 62.5 per cent of the larvae infesting chickpeas abiotic factors on the relative abundance of pod borers of chickpea (*C. arietinum*) and was abundant during 47-51th and 10-17th standard weeks.

Dubey *et al.* (1993) studied the population dynamics of *H. armigera* in Madhya Pradesh during (1983-84 and 1984-85). They observed that larvae fed on chickpea, pigeon pea, pea, lentil and tomato in cropping season and tomato, berseem, bhindi, fodder and grains sorghum, soybean, hollyhock, Datura, rose and 10 Bougainvillea during the off-season (April-August). During both years, the pest was most active in February and March. The most preferred hosts were chickpea and pigeon pea. The development of the pest population. *C. chloride* a larval parasitoid was influenced by environmental conditions such as temperature, relative humidity, and rainfall.

Sekhar *et al.* (1995) reported that inter-cropping system in chickpea for regulating *H. armigera* population through alteration in habitat, the results indicated that none of intercrops.

Patnaik *et al.* (1996) reported 3.6 to 26.4% pod damage in chickpea by *H. armigera* between 1982 and 1988 in Orissa with peak larval activity in the last week of December.

In a study on the role played by the larval parasitoid of *H. armigera* infesting gram, Kaur *et al.* (2000) reported that parasitism due to *C. chloridae* ranged from 0.98 to 68.50 per cent throughout the crop season, with the maximum parasitism occurring in the third week of February 1999, when the minimum mean temperature was 11.9°C and the relative humidity was 95 per cent.

Devi *et al.* (2002) recorded 5 parasitoids associated with gram pod borer *H. armigera*, among these, *Campoletis chloridae* Uchida was identified as the most important natural enemy of this pest, with parasitism ranging from 0.18 to 23.81% from March to May. The maximum incidence of the parasitoids was observed during the 1st and 2<sup>nd</sup> week of April from 1998 to 2000, and there was a strong positive relationship between the pest and the parasitoid.

Awasthi *et al.* (2003) studied the seasonal incidence of the pod borer, *H. armigera*, and yield losses in the chickpea crop in Chhattisgarh, reporting that the pod borer first emerged on the crop in the third week of December when it was still in the vegetative stage. The larval population of the pest was recorded to be in increasing order and attained peak (5.37 larvae/m. row length) during the 2<sup>nd</sup> week of January which coincided with the flowering stage of the crop. A reduction in larval population (2.92 larval/m. row lengths) was observed during 1<sup>st</sup> week of February at the pod stage of the crop, which subsequently decreases towards the maturity stage of the crop and disappeared in the third week of March.

Suganthi *et al.* (2003) studied the seasonal incidence of the gram pod borer in rain-fed chickpeas. They reported Pest activity peaked in the mid of December to January, and February when the crop was at its peak podding stage.

Metange *et al.* (2004) noticed the effects of temperature on the incidence of gram pod borer, *H. armigera* infesting chickpea cv. Vijay during the *Rabi* seasons of 1997-98. Within the 15 weeks of the experiment, the minimum temperature ranged from 10.4 to 22.1 degrees centigrade, whereas the maximum temperature ranged from 26.2 to 41.4 degrees centigrade. The pest did not lay eggs during the first, ninth and fifteenth week when temperature ranges were 14.7-30.1, 12.3-26.7 and 22.1-41.4 degrees centigrade. No larvae were recorded during the first and second weeks of the experiment when the temperature was 14.7-30.1 and 16.4-29 degrees centigrade respectively. Adult catches were nil during the first, eighth, fourteenth and fifteenth week of experiment when temperature was 14.7-30.1, 13.4-26.2, 17.2-35.6 and 22.1-41.4 degrees centigrade.

Kaur *et al.* (2004) reported a variation in the natural parasitization of *H. armigera* by the parasitoid, *C. chloridae* on different chickpea cultivars. The parasitoid population varied from 0.02-1.50 cocoons per meter row length and the larval population ranged between 0.86 and 14.50 larvae per meter row length. The highest number of cocoons were recorded on PBG- 5 (0.88) followed by L-550 (0.74). The *H. armigera* population was also high on PBG-5 (9.38 larvae/m row length) followed by L-550 (6.75 larvae/m row length).

Patel *et al.* (2005) evaluated the promising chickpea genotypes and found that four of them, B 1105, B 1106, BG 1088, and ICCV 2, were not attacked by *H. armigera*. However, genotypes such as MP JGK 2 and JGK 92337 had much greater larval populations (4.66 and 6.00 per plot). The remaining genotypes had a moderate larval population, ranging from 0.33 to 2.66 larvae per plot.

Shah and Shahzad (2005) studied the seasonal changes of *H. armigera* pod borer pest on chickpea. They found that the pest population was low from the 49th to the 6th standard weeks, it increased from the seventh standard week onwards and declined again in the fourteenth standard week. The eggs, larval instars, and overall density insect all had a positive connection with average maximum and minimum temperatures. The eggs, larval instars, and overall density, on the other hand, had a

negative connection with the average morning per cent relative humidity. The evening per cent relative humidity did not effect on the eggs, larval instar and overall density.

Singh and Ali (2006) used pheromone traps to study the seasonal activity of the gram pod borer, *H. armigera*, and its parasitoid, *Campoletis chloridae*, on chickpea cv. K-850 during *Rabi* (2000-2001 and 2001-2002) in Faizabad, Uttar Pradesh. The larval activity of *H. armigera* was sustained throughout the crop season with two peaks in both years, 1st from 45 and 49 standard weeks and the 2nd from 5 and 13 standard weeks. In 45 and 12 standard weeks, respectively, the highest mean larval populations of 6.3 and 6.4 larvae/m<sup>2</sup> were observed. *Campoletis chloridae* parasitization reached its peak in four standard weeks. From 44 to 50 standard weeks, there was a decrease in parasitization. Minimum and maximum temperatures showed a negative correlation and relative humidity a positive correlation, with parasitisation.

Kulhari and Singh, (2008) also reported that the temperature, rainfall and wind speed had a positive significant correlation with larval population, during their studies on the seasonal incidence of *H. armigera* on chickpea (*C. arietinum* (L.)). Larvae appeared 37 days after sowing and their peak activity during the beginning of March and occurred on the crop throughout the growth phase being low at vegetative and flowering stage and high at the grain development stage.

Hossain *et al.* (2008) studied the incidence, population changes and level of damage by pod borer, *H. armigera* on chickpea during *Rabi* crop seasons of 2003-04 and 2004-05 at Regional Agricultural Research Station, Ishurdi, Pabna, Bangladesh. Depending on sowing dates, the outbreak occurred in the second to fourth weeks of January. The borer population varies according to the sowing dates. Pod borer populations were significantly higher in early sown crops (October 15 to November 01), and with delayed the dates of sowing from November 01 to 30 population was declined and then increased again. It was observed in Early (October 15 to November 01) and late-planted (December and onward) crops both received greater pod borer damage and gives lower yields, while mid sown (November 08 to 30) crops received less pod borer damage and gave better yields. Hence, for ensuring better yield with less pod borer infestation, chickpea should be sown between November 08<sup>th</sup> to 30<sup>th</sup> and the best date of sowing to be November 15.

Reddy *et al.* (2009) revealed that the larval population of *H. armigera* in chickpea started to increase from the 2nd week of February and reached its maximum population of 12.97 larvae/ plant and then the population declined rapidly with the maturation of pods.

Khan *et al.* (2009) conducted an experiment to find out the most tolerant variety of chickpea against gram pod borer at the Research Farms of Agriculture Research Institute Ratta Kulachi and found that the chickpea variety CM 72 was significantly higher tolerant to the attack of *H. armigera* followed by KK-1. The variety CM-88 recorded Maximum pod borer infestation.

Chatar *et al.* (2010) studied the population dynamics of gram pod borer on chickpea they observed that the pest appeared in the second week of December and peaked (3.12 larvae/plant) in the second week of January. The pest was active from the end of December to the third week of January. After that, as the crop matured, the insect population gradually decreased.

Verma *et al.* (2014) observed the larval population of *H. armigera* throughout the crop season during *Rabi* seasons of 2009-2010 and 2010-2011. In 2009-2010, the larval population peaked twice, the first from 17 November to 10 December (47th to 50th standard weeks) and the second from 12 March to 5 April (10th to 14th standard weeks), during 2010- 11 first from 22 November to 13 December (47th to 50th standard weeks) and second from 13 March to 4 April (10th to 14th standard weeks). The highest mean larval populations of 6.80 larvae per meter row length were seen in the first year during the 12<sup>th</sup> standard week, while 7.1 larvae per meter row length were found in the second year during the 11th standard week. However, the lowest mean larval population of 0.5 larvae per meter row length in the first year was seen during the second standard week and in the 2nd year it was 0.6 larvae/meter row length seen during 1st standard week.

Brar and Singh (2015) compared the 9 chickpea genotypes against *H. armigera*. The population of *H. armigera* eggs and larvae on different genotypes ranged from 2.30 to 15.74 eggs and 0.27 to 13.28 larvae, respectively, per five plants. Genotype 5282 was recorded 5.28 eggs and 3.56 larvae/five plants, respectively,

which had significantly the lowest oviposition and larval population. Genotype 5282 had the least pod damage, with 11.02 per cent and a PRSR score of 3. Genotype GL 25016 recorded the significantly highest grain yield (1388 kg/ha).

Gautam *et al.* (2018) studies population dynamics *H. armigera* on chickpea. The population of *H. armigera* were notice for the first time during the 46<sup>th</sup> SW of 2016 and respective mean population were 0.33 larvae/plants. The lowest mean population of *H. armigera* is 0.33 larvae/plant was recorded during 46<sup>th</sup> and 47<sup>th</sup> SW at the minimum temperature of 11.8 °C, maximum temperature of 29 °C, relative humidity 67.4 and were no rainfall. Whereas maximum mean population of *H. armigera* population of 5.67 larvae/plants was recorded during the 8<sup>th</sup> SW of 2017 at the minimum temperature of 11.1 °C, maximum temperature of 27.9 °C, relative humidity 63.9 r and there was no rainfall.

### **2.3 Correlation between *Helicoverpa armigera* population and abiotic factors**

Yadava *et al.* (1991) reported that larval population of *H. armigera* was significantly positively correlated with Maximum and minimum temperatures, while relative humidity was significantly negatively correlated.

Chavan *et al.* (2003) observed larval activities throughout the crop growth period and the peak incidence was noticed during the 2nd fortnight of December and January. Maximum temperature of 25.3 to 31.7 °C, morning and evening relative humidity of 86% and 21 to 40%, respectively were the congenial weather parameter for the larval development. The correlation between pheromone trap catches and egg counts was correlated positively (0.89 and 0.94).

Singh and Ali (2006) found that both larval and adult populations of *H. armigera* showed a positive association with minimum and maximum temperatures, while relative humidity showed a negative correlation.

Kant *et al.* (2007) found that the that larval population of *H. armigera* had a significant positive correlation with mean atmospheric temperature.

Reddy *et al.* (2009) found that the larval population of *H. armigera* significant positive correlation between both minimum and maximum temperature and the pest incidence with the correlation coefficient being  $r$  (0.71 and 0.82), respectively. The morning and afternoon relative humidity correlation coefficients were both  $r$  (-0.66). The correlation coefficient ( $r=0.03$ ) indicated a positive relationship between larval population and rainfall but, it was non-significant.

Chatar *et al.* (2010) study the Population dynamics of pod borer (*H. armigera*) infesting chickpea they reported the larval population of *H. armigera* exhibited a highly significant negative correlation with maximum temperature ( $r= -0.7514$ ), whereas, minimum temperature and mean temperature showed significantly negative correlation with larval population of *H. armigera* i.e.  $r=-0.5771$  and  $r=-0.6836$ , respectively. While, the pest population showed highly significant positive correlation with morning relative humidity ( $r=0.7098$ ), evening relative humidity ( $r=0.7293$ ) and mean relative humidity ( $r= 0.8063$ ). Mean bright sunshine hours ( $r=-0.2365$ ) and wind speed ( $r=-0.1485$ ) exhibited negative correlation with larval population of *H. armiger*.

Pandey *et al.* (2012) reported that population of *H. armigera* on chickpea showed significant positive correlation with both minimum and maximum temperatures and the correlation coefficient was 0.62 and 0.64, respectively.

Mallik *et al.* (2016) reported that population of *H. armigera* on chickpea showed positive correlation with mean temperature. While, in the present investigation the population of *H. armigera* showed negative non-significant correlation with relative humidity ( $r=-0.46$  and  $r=-0.20$ ) during 2013-14 and 2014-15, respectively.

Kachhawa *et al.* (2016) Studies on the seasonal incidence of *H. armigera* in chickpea ecosystem in corelation with weather parameter they reported the population of gram pod borer had a significant positive correlation with the mean atmospheric temperature ( $r=0.60$  and  $r= 0.65$ ) during 2013-14 and 2014-15, respectively.

Bahadur *et al.* (2018) found that the larval population of *H. armigera* was positive significant association with maximum temperature ( $r = 0.636^*$ ), and positive non-significant association with minimum temperature ( $r = 0.580$ ), sunshine ( $r = 0.595$ ), wind velocity ( $r = 0.480$ ) and evaporation ( $r = 0.630$ ). Whereas, negative significant relationship was found with the morning relative humidity ( $r = -0.706^*$ ) and negative non-significant correlation with evening relative humidity ( $r = -0.320$ ), and rainfall ( $r = -0.148$ ). However. During the year 2017-18 there was positive non-significant association with maximum temperature ( $r = 0.463$ ), and minimum temperature ( $r = 0.562$ ), while negative non-significant relationship was found with the morning relative humidity ( $r = -0.399$ ). and negative significant correlation with evening relative humidity ( $r = -0.761^*$ ). positive non-significant correlation was observed with rainfall ( $r = 0.000$ ). sunshine ( $r = 0.449$ ) and wind velocity ( $r = 0.166$ ) whereas, positive significant correlation with evaporation and evaporation ( $r = 0.834^{**}$ ).



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## **MATERIAL AND METHODS**

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The present investigation entitled, “**Field screening of certain chickpea, (*Cicer arietinum* L.) genotypes against gram pod borer (*Helicoverpa armigera* Hubner)**” was carried out during *Rabi* 2020-2021 at agriculture farm, Institute of Agriculture Sciences, Banaras Hindu University, Varanasi. The details of materials used and the methodology adopted have been mentioned below:

### **3.1 Experimental site**

The geographical position of Varanasi is at the longitude of 83.30 east, latitude of 25.18 north and the altitude of 141.3 meters from mean sea level (SL), almost in centre of Indo-Gangetic belt on the Ganga River of Uttar Pradesh.

#### **3.1.1 Climate and weather conditions of the locality**

The climate of the Varanasi region is a semi-arid zone which is characterized by extremes of the temperature during the hot summer, which goes as high as 48°C and as low as 3°C during peak winter. The average rainfall is 750-1000 mm which is mostly received from mid-July to September. This area provides for the majority of crops with a healthy long growing season.

#### **3.1.2 Soil and meteorological information**

The soil condition of this region is alluvial, well-drained, and moderately fertile as it is situated on the bank of river Ganges which is less in available nitrogen and medium in available phosphorus and potash. The land surface is almost flat. The normal soil pH varies from 7.3 to 8.4 making it slightly alkaline. The climate of Varanasi city is moist, subtropical, monsoonal with a high range of variations between the seasons of summer and winter. Summers are long, from early April till October with the normal temperature between 32°C to 46°C (90°F to 115°F) and between 5°C to 15°C (41°F to 59°F) in the winter season. May is the hottest and January is the

coldest month of the year. The average annual temperature is 26.1 °C. The monsoon season is in between both the seasons with the average rate of annual rainfall around 998 mm and the difference in precipitation between the driest and wettest months, is 296 mm.

### **3.1.3 Field preparation and manuring**

The experimental plot was ploughed two times with the help of tractor-mounted disc harrow. Each ploughing was followed by levelling with the help of leveller. Being a leguminous crop, chickpea needs a small amount of nitrogen for the time of early growth. Added 10-12 t / ha of well-rotted FYM and fertilizers were added in the soil at a rate of 20 kg of nitrogen, 40 kg of phosphorus and 10 kg of Potash for one hectare before sowing.

### **3.1.4 Weeding**

The first weeding was done at 15 days after germination with the help of manual-weeder/motorised-weeder and the second weeding is done when the crop was 35 days old.

### **3.1.5 Harvesting, threshing and yield**

Harvesting of the crop was done with the help of a single sickle by manual-labourers and threshing was done with the help of wooden sticks. After threshing, the seeds were dried under sunlight for three days and finally, the grain yield of each net plot was recorded and converted to kg/ha.

### **3.1.6 Seed yield**

Dried seeds from each plant of every plot were assessed for their weight measurement. The total yield per plot was calculated which includes the yield of sample grains and it was then converted on a kg/ha basis.

### **3.2 Genotypes and sowing methods**

Sixteen chickpea genotypes were being sown manually with a row to row spacing of 30 cm and plant to plant spacing of 10cm on the prepared ridges. Here is the list of all the sixteen genotypes that were examined as per the desired parameters.

**Table 3.1: Genotypes**

<b>S.No.</b>	<b>Name</b>
1	KWR 108 (DESI TYPE)
2	PDE 9802 E (DESI TYPE)
3	L 550 (KABULI TYPE)
4	IPCK 2002-29 (KABULI TYPE)
5	IPCK 2004-29 (KABULI TYPE)
6	K 850 (DESI TYPE)
7	GG 2 (DESI TYPE)
8	JG 315 (DESI TYPE)
9	BG 212 (DESI TYPE)
10	JG 130 (DESI TYPE)
11	KPG 59 (DESI TYPE)
12	RVG 203 (DESI TYPE)
13	JG 16 (DESI TYPE)
14	DCP 92-3 (DESI TYPE)
15	NBEG 47 (DESI TYPE)
16	BG362 (CHECK)

### **3.2.1 Meteorological data**

The weekly minimum and maximum temperatures, relative humidity, rainfall, wind velocity and sunshine hours were recorded during the period of experimentation from December 2020 to April 2021 according to the University Meteorological observation of the Institute of agricultural sciences, BHU.

### **3.2.2 Specific details of the experiments**

#### **Layout**

The experiment was laid out in the field. The details of experiment are as follows: Experiment: Studies on certain chickpea genotypes against *Helicoverpa armigera*.

#### **Experimental details:**

- |    |                    |   |                     |
|----|--------------------|---|---------------------|
| 1. | Design             | : | R.B.D.              |
| 2. | Replications       | : | Three               |
| 3. | Treatment          | : | 15+ (1 check entry) |
| 4. | Plot size          | : | 3.0 m x 0.9 m       |
| 5. | Spacing            | : | 30 x10 cm           |
| 6. | Date of Sowing     | : | 07-12-2020          |
| 7. | Date of harvesting | : | 08-04-2021          |

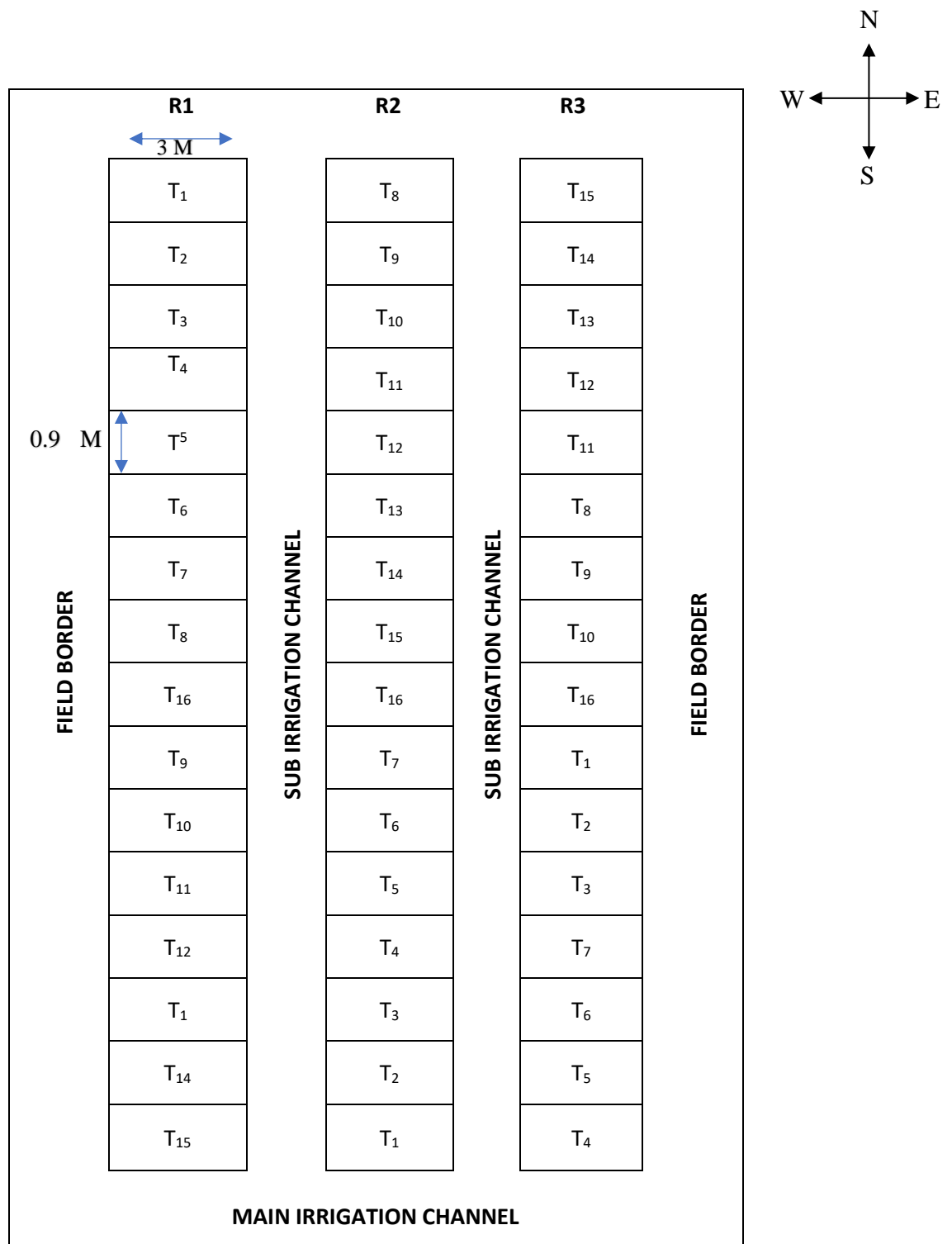


Fig. 3.1: Layout plan of the experimental field for the screening of chickpea genotypes.



**Plate 3.1: Layout of the experimental field of Chickpea**

### 3.2.3 Observation

- a) The observations of the larval population were recorded on five randomly selected plants on each test genotypes and from each replication at the weekly interval after 45 days after sowing.
- b) Pod damage on 5 plants/treatment/ replication was recorded at the time of maturity of the pod.
- c) Seed yield from each plot was recorded at harvest. Genotypes was rated as resistant/ tolerant and susceptible depending on pest population and damage.

### 3.3 Per cent pod damage

For recording observations on screening against *Helicoverpa armigera*, five plants were randomly selected from each plot and the pods of these plants were plucked separately at the time of maturity of the crop. Pod damage was recorded at harvest by observing randomly plucked 100 pods from those five plants of each genotypes. The number of damaged pods by *H. armigera* were recorded separately from each sample and converted into per cent pod damage as indicated below:

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

#### 3.3.1 Grain damage

The damaged seeds were identified based on the number of affected seeds in pods which were taken for observation. The per cent pod damage was carried out by the following formula.

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

### 3.3.2 Pest Susceptibility rating

Pest susceptibility rating (PSR) for each genotypes was worked out using a formula derived from Abott (1925) as given below.

$$\text{Pest Susceptibility\%} = \frac{\text{P.D.of chick entry} - \text{P.D. of test entry}}{\text{P.D. of chick entry}} \times 100$$

Where, P.D. = Mean of % pods damaged

**Table 3.2 Pest Susceptibility Rating (Resistant/ tolerant, Susceptible)**

<b>Pest susceptibility</b>	<b>Grade</b>	<b>Category</b>
100%	1	Highly resistant
75 to 90%	2	Resistant
50 to 75%	3	Least susceptible
25 to 50%	4	Least susceptible
10 to 25%	5	Least susceptible
-10 to 10%	6	Moderately susceptible
-10 to -25%	7	Moderately susceptible
-25 to -50%	8	Highly susceptible
<-50%	9	Highly susceptible

### Analysis of variance

All the data recorded were subjected to statistical analysis as per the Randomized Block Design method. The per cent pod damage and grain damage so calculated were subjected to angular transformation while morphological and biochemical data were transformed by square root  $\sqrt{(X+0.5)}$  transformation prior to statistical analysis. The data so obtained were analyzed by using the analysis of variance techniques as given below.

**Table 3.3: The skeleton of “Analysis of Variance” is given below**

Sources of variance	D.F.	S.S.	M.S.S.	F. Cal	F. Table
Replications	(R-1) = r				
Treatments	(T-1) = t				F at 5%
Error	(r-1) (t-1)				
Total	rt-1				

**Standard error of mean** =  $SE_{m\pm} = \sqrt{\frac{E.ms}{r}}$

The significance among different treatment means was judged by critical difference (C.D) at a 5% level of significance for comparison among the treatments, for which the marginal mean of each treatment was considered. The following formula was used for various estimations.

**Critical difference (C.D.)** =  $SE_m \times \sqrt{2 \times t \text{ at } 0.05}$

**Where**

Ems = error mean sum of square

t = t value at 5 % level at error d.f.

r = number of replications

$SE_{m\pm}$  = standard error of any treatment means

C = Critical Difference

### **3.4 Seasonal incidence of *Helicoverpa armigera* in chickpea**

In order to study the seasonal incidence of *H. armigera* a bulk plot of 200 m<sup>2</sup> of genotype BG-362 was sown and maintained without any insecticide application.

### 3.4.1 Observation

Larval population of *H. armigera* was recorded at weekly interval on five randomly selected plants from five different locations of the plot.

### 3.5 Correlation studies

In relation to study the impact at different weather parameters on pest incidence. A simple correlation between larval population of gram pod borer and weather parameters was calculated using the following formula:

$$r_{xy} = \frac{\sum xy - \frac{(\sum x)(\sum y)}{n}}{\sqrt{\left[\sum x^2 - \frac{(\sum x)^2}{n}\right] \left[\sum y^2 - \frac{(\sum y)^2}{n}\right]}}$$

Where,

- $r_{xy}$  = Co-efficient of correlation
- $n$  = Number of observations
- $x$  = Mean population of *H. armigera*
- $y$  = Independent variable

Then the correlation co-efficient (r) was tested for significance or non-significance by Fisher's  $t$  which is defined as follows.

$$t = \frac{r}{\sqrt{1-r^2}} \sqrt{n-2} \text{ with } (n-2) \text{ d.f}$$

For correlation studies, weekly average values of the environmental factors were taken into consideration to know their influence on the gram pod borer population.





**Plate 3.2: Observation of the population of *Helicoverpa armigera* on chickpea**



**Plate 3.3: Early instar larva of *Helicoverpa armigera* (Hubner) on Chickpea**



**Plate 3.4: Larva of *Helicoverpa armigera* feed inside the Chickpea pod**



**Plate 3.5: Chickpea pods damage by *Helicoverpa armigera* (Hubner)**



**Plate 3.6: Larva of *Helicoverpa armigera* feed on the surface of Chickpea pod**

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## RESULTS

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Performance of different Chickpea genotypes, as observed in screening against *H. armigera* is presented in this chapter.

### **4.1 Screening of certain chickpea genotypes against pod borer *Helicoverpa armigera* (Hubner).**

#### **4.1.1 Mean larval population of *Helicoverpa armigera* /5 pants (Table-4.1and Fig. 4.1, 4.2).**

##### **A. Fifty-two days after sowing**

Chickpea genotypes namely IPCK-2002-29, BG-212, JG-130, KPG-59 and RVG-203 each registered (zero larvae/5 plants) larval mean population of *H. armigera* followed by genotypes PDE-9802, L-550, IPCK-2004-29, K-850, JG-315, JG-16, NBEG-47 and BG-362 each registered mean population of 0.33 larva/5 plants. The highest mean population was recorded in genotypes namely KWR-108, GG-2 and DCP-92-3 each registered (0.66 larvae/5 plants each).

##### **B. Fifty-nine days after sowing**

Chickpea genotypes namely IPCK-2002-29, JG-130, KPG-59 and RVG-203 registered (0.33 larvae/5 plants) larval mean population of *H. armigera* followed by genotypes PDE-9802, IPCK-2004-29, BG-212 and BG-362 that registered 0.66 larvae/5 plants. The highest mean population was recorded in genotype JG-315 and JG-16 each reregistered 1.66 larvae/5 plants. However, mean population of the remaining 6 genotypes was registered as 1 to 1.33 larvae/5 plants.

##### **C. Sixty-six days after sowing**

Chickpea genotype namely RVG-203 registered (0.33 larvae/5 plants) larval mean population of *H. armigera* followed by genotype KPG-59 and BG-212 that registered mean population of 0.66 and 1.33 larvae/5 plants respectively. The highest mean population was recorded in genotype L-550, IPCK2004-29 and K-850 each registered 2.66 larvae/5 plants. However, mean population of the remaining 10 genotypes registered as 1.66 to 2.33 larvae/5 plants.

**D. Seventy-three days after sowing**

Chickpea genotype namely KPG-59 and RVG-203 that registered (0.66 and 1 larvae/5 plants respectively) larval mean population of *H. armigera* followed by genotype NBEG-47, PDE-9802, and BG-212 that registered mean population of (1.66, 2, and 2 larvae/5 plants respectively). The highest mean population was recorded in genotype IPCK-2004-29, GG-2 and BG-362 each registered 3.66 larvae/5 plants. However, mean population of remaining 8 genotypes was registered as 2.33 to 3.33 larvae/5 plants.

**E. Eighty days after sowing**

Chickpea genotype namely RVG-203 and KPG-59 registered (1.33 and 1.66 larvae/5 plants) larval mean population of *H. armigera* followed by genotype K-850 and JG-130 that registered mean population of 2 larvae/5 plants. The highest mean population was recorded in genotypes L-550, IPCK-2004-29, GG-2 and BG-262 that registered 4.33 larvae/5 plants. However, mean population of remaining 8 genotypes was registered as 2.33 to 3.66 larvae/5 plants.

**F. Eighty-seven days after sowing**

Chickpea genotype namely KPG-59 and RVG-203 registered (1.33 larvae/5 plants) mean population of *H. armigera* followed by BG-212 and NBEG-47 that registered (2.33 larvae/5 plants) mean population. The highest mean population was recorded in genotype L-550 that registered 5.66 larvae/5 plants. However, mean population of remaining 11 genotypes was registered as 2.66 to 4.66 larvae/5 plants.

**G. Ninety-four days after sowing**

Chickpea genotype namely BG-212 and KPG-59 that registered (1.33 larvae/5 plants) mean population of *H. armigera* followed by genotype RVG-203, IPCK-2002-29 and JG-130 that registered (1.66, 2.33 and 2.33 larvae/5 plants respectively) mean population. The highest mean population was recorded in genotype L-550 and BG-362 that registered (5.66 and 5.33 larvae/5 plants). However, mean population of remaining 9 genotypes was registered as 2.66 to 3.66 larvae/5 plants.

#### **H. One hundred one days after sowing**

Chickpea genotype namely KPG-59 registered mean population of *H. armigera* 0.66 larvae/5 plants followed by genotypes BG-212, RVG-203, JG-16 and DCP-92-3 that registered (1.33 larvae/5 plants) mean population. The highest mean population was recorded in genotype L-550 and BG-362 that registered 4.66 larvae/5 plants. However, mean population of remaining 9 genotypes was registered as 1.66 to 3.33 larvae/5 plants.

#### **I. One hundred eight days after sowing**

Chickpea genotype namely KPG-59 registered (0.33 larvae/5 plants) mean population of *H. armigera* followed by genotype IPCK-2002-29, BG-212 and RVG-203 that registered (1 larvae/5 plants) mean population. The highest mean population was recorded in genotypes KWR-108, PDE-9802, L-550, GG-2, JG-315 and BG-362 that registered 2.66 larvae/5 plants. However, remaining 6 genotypes was registered as 1.33 to 2.33 larvae/5 plants.

#### **J. One hundred fifteen days after sowing**

Chickpea genotype namely KPG-59, BG-212 and RVG-203 registered (0.00, 0.33 and 0.33 larvae/5 plants respectively) mean population of *H. armigera* followed by genotype IPCK-2002-29 that registered (0.66 larvae/5 plants) mean population. The highest mean population was recorded in genotype PDE-9802, L-550 and GG-2 that registered 1.66 larvae/5 plants. However, remaining 9 genotypes was registered as 1 to 1.33 larvae/5 plants.

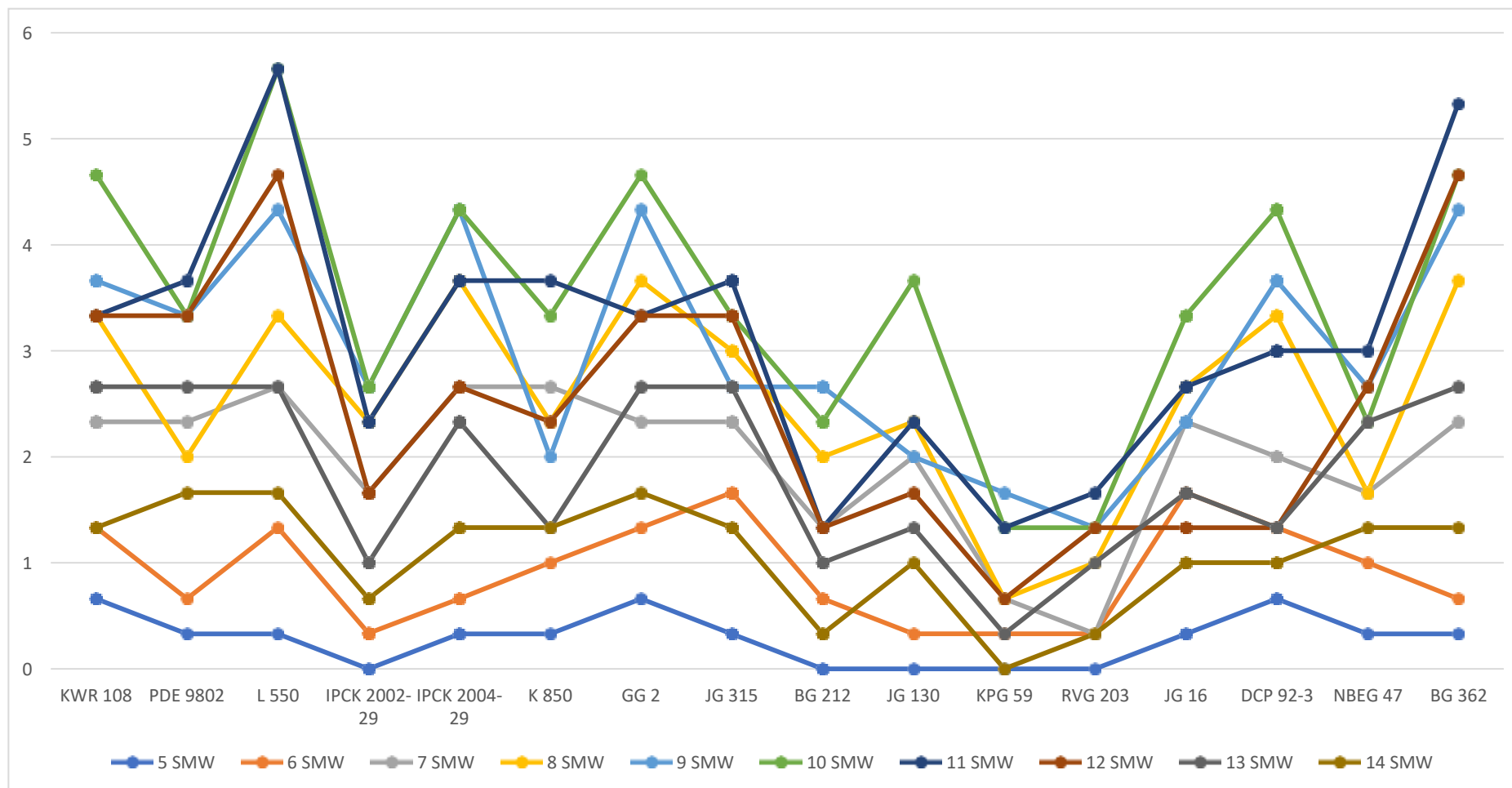
#### **4.1.2 Overall mean larval population of *Helicoverpa armigera* per 5 plants per treatments during the crop season 2020-2021**

Chickpea genotype namely KPG-59 and RVG-203 registered lowest (0.69 and 0.86 larvae/5 5 plants) mean larval population of *H. armigera* followed by genotypes BG-212, IPCK-2002-29, JG-130, NBEG-47 and JG-16 that registered (1.29, 1.52, 1.66, 1.89 and 1.929 larvae/5 plants respectively) mean larval population. The highest mean larval population was recorded in genotypes L-550, BG-362, GG-2, KWR-108 and IPCK-2004-29 that registered (3.22, 2.99, 2.79, 2.66 and 2.59 larvae/5 plants respectively).

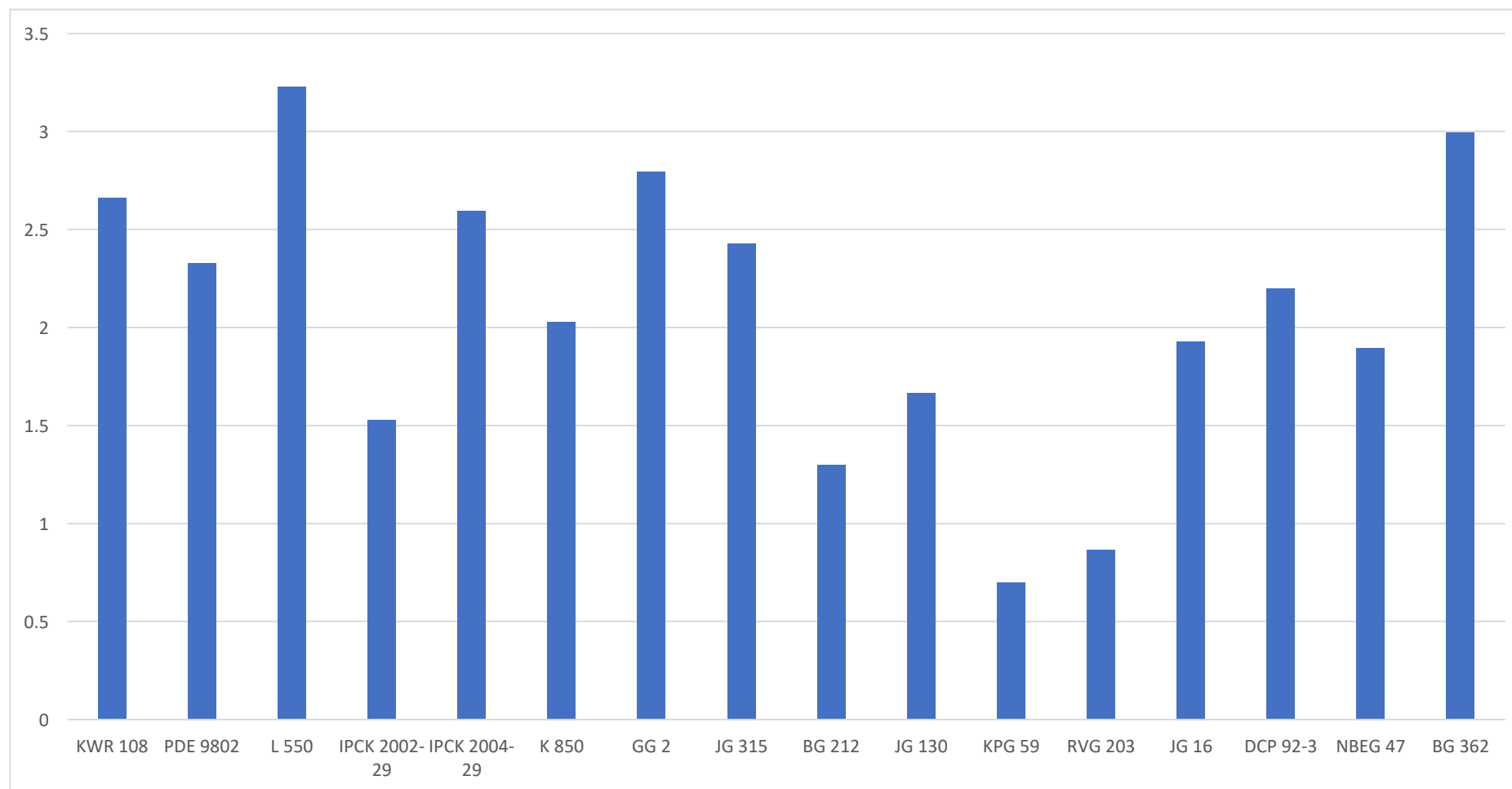
**Table 4.1: Mean larval population of *H. armigera* / 5 plants in different SMW on different chickpea genotypes during Rabi 2020-2021.**

S.No.	GENOTYPES	5 SMW	6 SMW	7 SMW	8 SMW	9 SMW	10 SMW	11 SMW	12 SMW	13 SMW	14 SMW	Overall mean
1	KWR 108	0.66 (1.276)*	1.33 (1.520)	2.33 (1.821)	3.33 (2.079)	3.66 (2.157)	4.66 (2.378)	3.33 (2.079)	3.33 (2.079)	2.66 (1.911)	1.33 (1.520)	2.66 (1.886)
2	PDE 9802	0.33 (1.138)	0.66 (1.276)	2.33 (1.821)	2.00 (1.732)	3.33 (2.079)	3.33 (2.079)	3.66 (2.157)	3.33 (2.157)	2.66 (1.911)	1.66 (1.626)	2.32 (1.794)
3	L 550	0.33 (1.138)	1.33 (1.520)	2.66 (1.911)	3.33 (2.079)	4.33 (2.307)	5.66 (2.580)	5.66 (2.580)	4.66 (2.378)	2.66 (1.911)	1.66 (1.626)	3.22 (2.007)
4	IPCK 2002-29	0 (1.00)	0.333 (1.138)	1.66 (1.626)	2.33 (1.821)	2.66 (1.911)	2.66 (1.911)	2.33 (1.821)	1.66 (1.626)	1.00 (1.382)	0.66 (1.276)	1.52 (1.559)
5	IPCK 2004-29	0.33 (1.138)	0.66 (1.276)	2.66 (1.911)	3.66 (2.157)	4.33 (2.307)	4.33 (2.307)	3.66 (2.157)	2.66 (1.911)	2.33 (1.794)	1.33 (1.520)	2.59 (1.855)
6	K 850	0.33 (1.138)	1.00 (1.414)	2.66 (1.911)	2.33 (1.821)	2.00 (1.732)	3.33 (2.079)	3.66 (2.157)	2.33 (1.821)	1.33 (1.520)	1.33 (1.520)	2.03 (1.715)
7	GG 2	0.66 (1.276)	1.33 (1.520)	2.33 (1.821)	3.66 (2.157)	4.33 (2.307)	4.66 (2.378)	3.33 (2.079)	3.33 (2.079)	2.66 (1.911)	1.66 (1.626)	2.79 (1.919)
8	JG 315	0.33 (1.138)	1.66 (1.626)	2.33 (1.821)	3.00 (2.00)	2.66 (1.911)	3.33 (2.079)	3.66 (2.157)	3.33 (2.079)	2.66 (1.911)	1.33 (1.520)	2.42 (1.828)
9	BG 212	0.00 (1.00)	0.66 (1.276)	1.33 (1.520)	2.00 (1.732)	2.66 (1.911)	2.33 (1.821)	1.33 (1.520)	1.33 (1.520)	1.00 (1.382)	0.33 (1.138)	1.29 (1.491)
10	JG 130	0.00 (1.00)	0.33 (1.138)	2.00 (1.732)	2.33 (1.821)	2.00 (1.732)	3.66 (2.157)	2.33 (1.821)	1.66 (1.626)	1.33 (1.520)	1.00 (1.414)	1.66 (1.600)
11	KPG 59	0.00 (1.00)	0.33 (1.138)	0.66 (1.276)	0.66 (1.276)	1.66 (1.626)	1.33 (1.520)	1.33 (1.520)	0.66 (1.276)	0.33 (1.138)	0.00 (1.00)	0.69 (1.286)
12	RVG 203	0.00 (1.00)	0.33 (1.138)	0.33 (1.138)	1.00 (1.414)	1.33 (1.520)	1.33 (1.520)	1.66 (1.626)	1.33 (1.520)	1.00 (1.414)	0.33 (1.138)	0.86 (1.350)
13	JG 16	0.33 (1.138)	1.66 (1.626)	2.33 (1.821)	2.66 (1.911)	2.33 (1.821)	3.33 (2.079)	2.66 (1.911)	1.33 (1.520)	1.66 (1.626)	1.00 (1.414)	1.92 (1.691)
14	DCP 92-3	0.66 (1.138)	1.33 (1.520)	2.00 (1.732)	3.33 (2.079)	3.66 (2.157)	4.33 (2.307)	3.00 (2.000)	1.33 (1.520)	1.33 (1.520)	1.00 (1.414)	2.19 (1.756)
15	NBEG 47	0.33 (1.138)	1.00 (1.414)	1.66 (1.626)	1.66 (1.626)	2.66 (1.911)	2.33 (1.821)	3.00 (1.989)	2.66 (1.911)	2.33 (1.821)	1.33 (1.520)	1.89 (1.683)
16	BG 362 (CHECK)	0.33 (1.138)	0.66 (1.276)	2.33 (1.821)	3.66 (2.157)	4.33 (2.307)	4.66 (2.515)	5.33 (2.515)	4.66 (2.378)	2.66 (1.911)	1.33 (1.520)	2.99 (1.945)
	<b>SE(m) +</b>	<b>0.118</b>	<b>1.121</b>	<b>0.96</b>	<b>0.081</b>	<b>0.08</b>	<b>0.083</b>	<b>0.089</b>	<b>0.094</b>	<b>0.423</b>	<b>0.102</b>	<b>0.045</b>
	<b>CD @ 5%</b>	<b>0.340</b>	<b>0.351</b>	<b>0.28</b>	<b>0.236</b>	<b>0.233</b>	<b>0.242</b>	<b>0.258</b>	<b>0.271</b>	<b>0.381</b>	<b>0.297</b>	<b>0.125</b>

\*Figures in parentheses are square root transformed values.  
SMW= Standard Meteorological Weeks.



**Fig 4.1: Weekly mean larval population of *H. armigera* on different Chickpea genotypes during *Rabi* 2020-2021.**



**Fig. 4.2: Overall mean larval population of *H. armigera* on different Chickpea genotypes during *Rabi* 2020-2021.**

#### 4.1.3 Per cent Pod Damage

The harvested pods of different accessions were assessed for the damage caused by gram pod borer, *Helicoverpa armigera*. Data on per cent pod damage and per cent grain damage was computed in all the sixteen genotypes of chickpea are presented (Table 4.2 and Fig. 4.3).

The pod damage showed a substantial variation amongst the genotypes studied, ranging from 5.33 to 31.33 per cent. The genotypes RVG-203 and KPG-59 was recorded lowest pod damage, with per cent ages of 5.33 and 6.03, respectively followed by genotype BG-212, IPCK-2002-29, K-850 and JG-130 that recorded (9.66, 11.66, 14.33 and 14.66 per cent pod damage respectively). The highest per cent pod damage was recorded in genotype L-550 and BG-362 that recorded (31.33 and 24.33) per cent respectively. However, remaining 8 genotypes pod damage recorded (16.66 to 23.33) per cent.

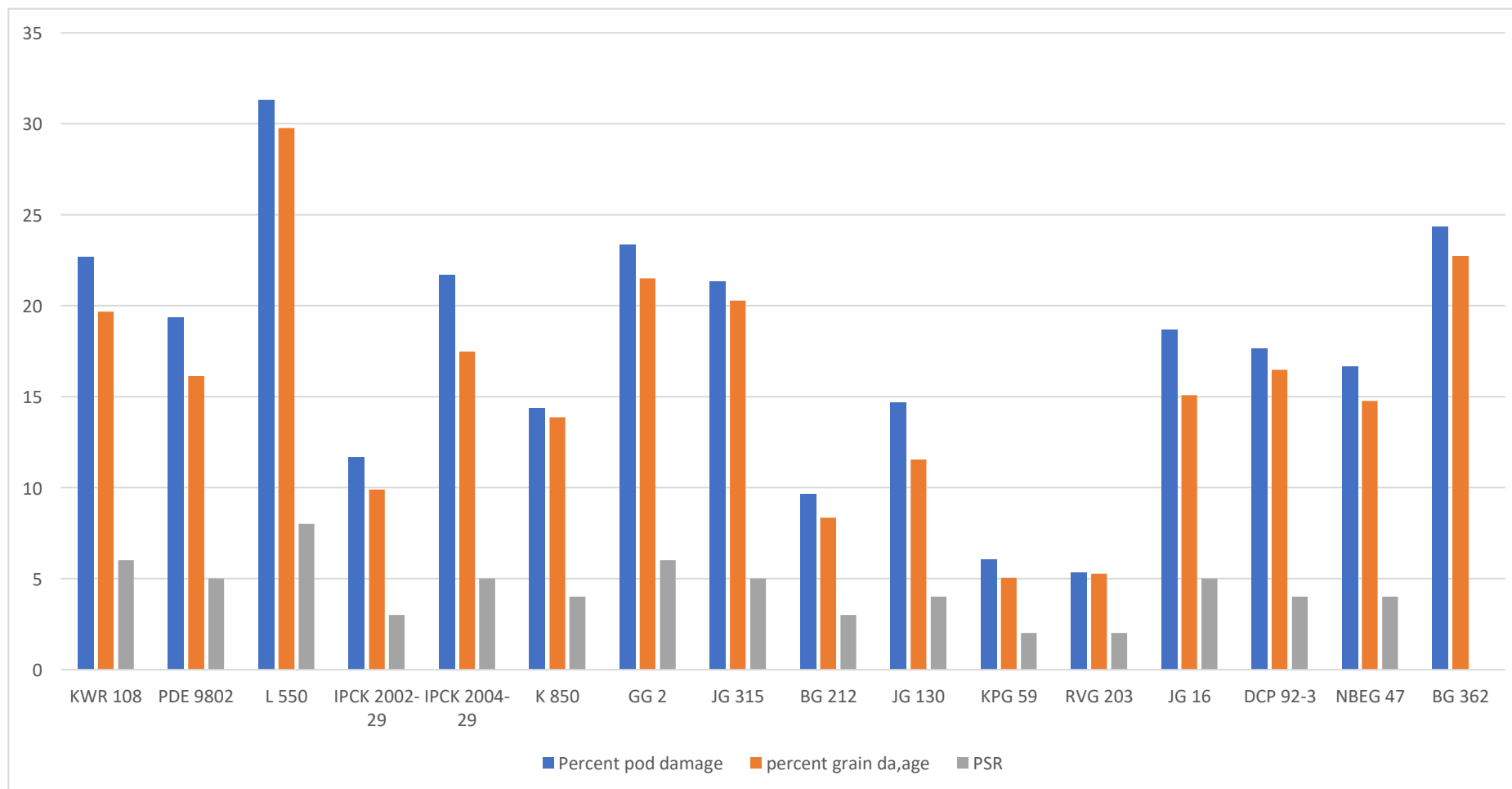
#### 4.1.4 Per cent Grain Damage

The significant grain damage was recorded by the *H. armigera* in the year 2020-2021, varying from 5.03 per cent in genotype KPG-59 to 29.76 per cent in genotype L-550 (Table 4.2 and Fig. 4.3). The maximum per cent of grain damage was recorded in the genotype L-550 (29.76) followed by genotype BG-362 (22.70), GG-2 (21.50) and JG-315 (20.28). The genotype KPG-59 showed lowest per cent of grain damage 5.03 per cent followed by genotype RVG-203 (5.27), BG-212 (8.34) and IPCK-2002-29 (9.88) per cent grain damage computed in all the sixteen genotypes of chickpea are presented.

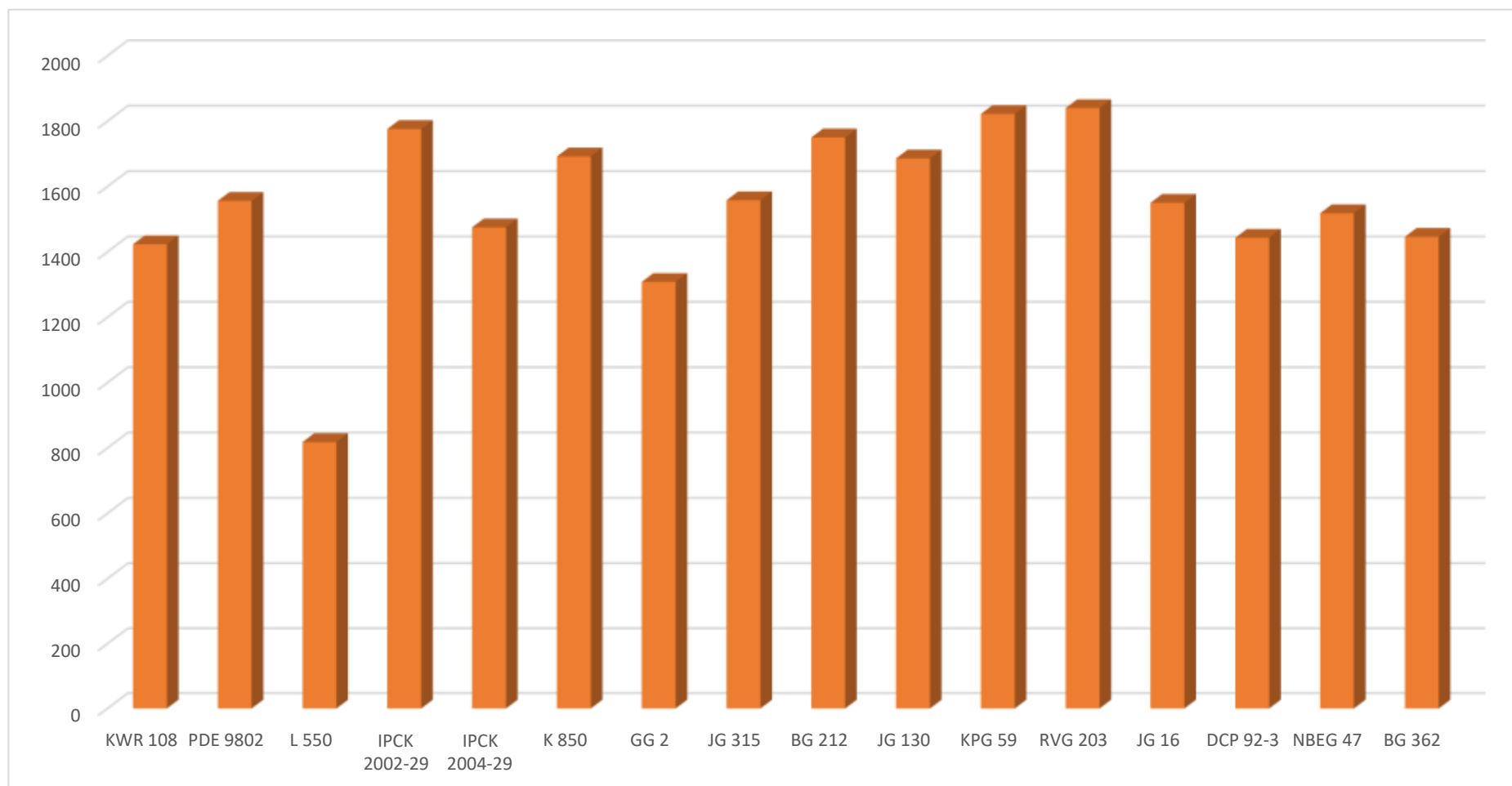
**Table 4.2: Extent of pod damage, Grain damage by *Helicoverpa armigera*, Susceptibility, PSR and Yield (kg/ha) of different Chickpea genotypes.**

S.No.	Genotypes	Pod damage %	Grain damage (%)	Pest Susceptibility (%)	PSR	Yield (kg/ha)
1	KWR 108	22.66 (28.415) *	19.67 (26.313) *	6.84	6	1423
2	PDE 9802	19.33 (26.071)	16.13 (23.665)	20.54	5	1556
3	L 550	31.33 (34.024)	29.76 (33.047)	-28.76	8	818
4	IPCK 2002-29	11.66 (19.958)	9.88 (18.312)	52.05	3	1776
5	IPCK 2004-29	21.66 (27.725)	17.47 (24.697)	10.95	5	1475
6	K 850	14.33 (22.234)	13.86 (21.848)	41.09	4	1692
7	GG 2	23.33 (28.871)	21.50 (27.613)	4.10	6	1308
8	JG 315	21.33 (27.495)	20.28 (26.750)	12.32	5	1558
9	BG 212	9.66 (18.100)	8.34 (16.777)	60.27	3	1750
10	JG 130	14.66 (22.503)	11.54 (19.851)	39.72	4	1686
11	KPG 59	6.03 (14.209)	5.03 (12.955)	75.20	2	1822
12	RVG 203	5.33 (13.343)	5.27 (13.660)	78.08	2	1840
13	JG 16	18.66 (25.582)	15.08 (22.841)	23.28	5	1550
14	DCP 92-3	17.66 (24.840)	16.47 (23.933)	27.39	4	1443
15	NBEG 47	16.66 (24.080)	14.77 (22.952)	31.50	4	1518
16	BG 362 (check)	24.33 (29.542)	22.70 (28.442)	0.00	-	1446
	<b>CD @ 5 %</b>	<b>0.222</b>	<b>0.586</b>			
	<b>SE (m) ±</b>	<b>0.076</b>	<b>0.202</b>			

\* Figures in parentheses are angular transformed values  
PSR = Pest susceptibility rating



**Fig.4.3:** Per cent pod damage, gain damage by (*H. armigera*) and pest susceptibility rating on different Chickpea genotypes during Rabi 2020-2021.



**Fig 4.4: Yield of different Chickpea genotypes in kg/hac. during *Rabi* 2020-2021**

#### 4.1.5 Categorization of different chickpea genotypes in response to pod damage by gram pod borer *Helicoverpa armigera*

Out of the 16 Genotypes of the chickpea which were assessed in the year 2020-2021 it was found that none of the genotypes were found to be highly resistant with regard to pod damage (Table 4.1) The pest susceptibility rating was recorded in the genotypes ranged from 2 to 8. While to genotype KPG-59 and RVG-203 reported resistant with pest susceptible rating of 2. Two genotypes (IPCK-2002-29 and BG-212) with a rating of 3, four genotypes (K-850, JG-130, DCP-92-3 and NBEG-47) with a rating of 4 and four genotypes (PDE-9802, IPCK-2004-29, JG-315 and JG-16) with rating of 5, all of these genotypes rating 3 to 5 are moderate susceptible to *Helicoverpa armigera*. Three genotypes (KWR-108, GG-2 and BG-362) with susceptible rating is 6 are moderate susceptible. Genotype L-550 are highly susceptible to *H. armigera* with rating 8 computed in all the sixteen genotypes of chickpea are presented. (Table 4.3).

**Table 4.3: Categorization of different chickpea genotypes**

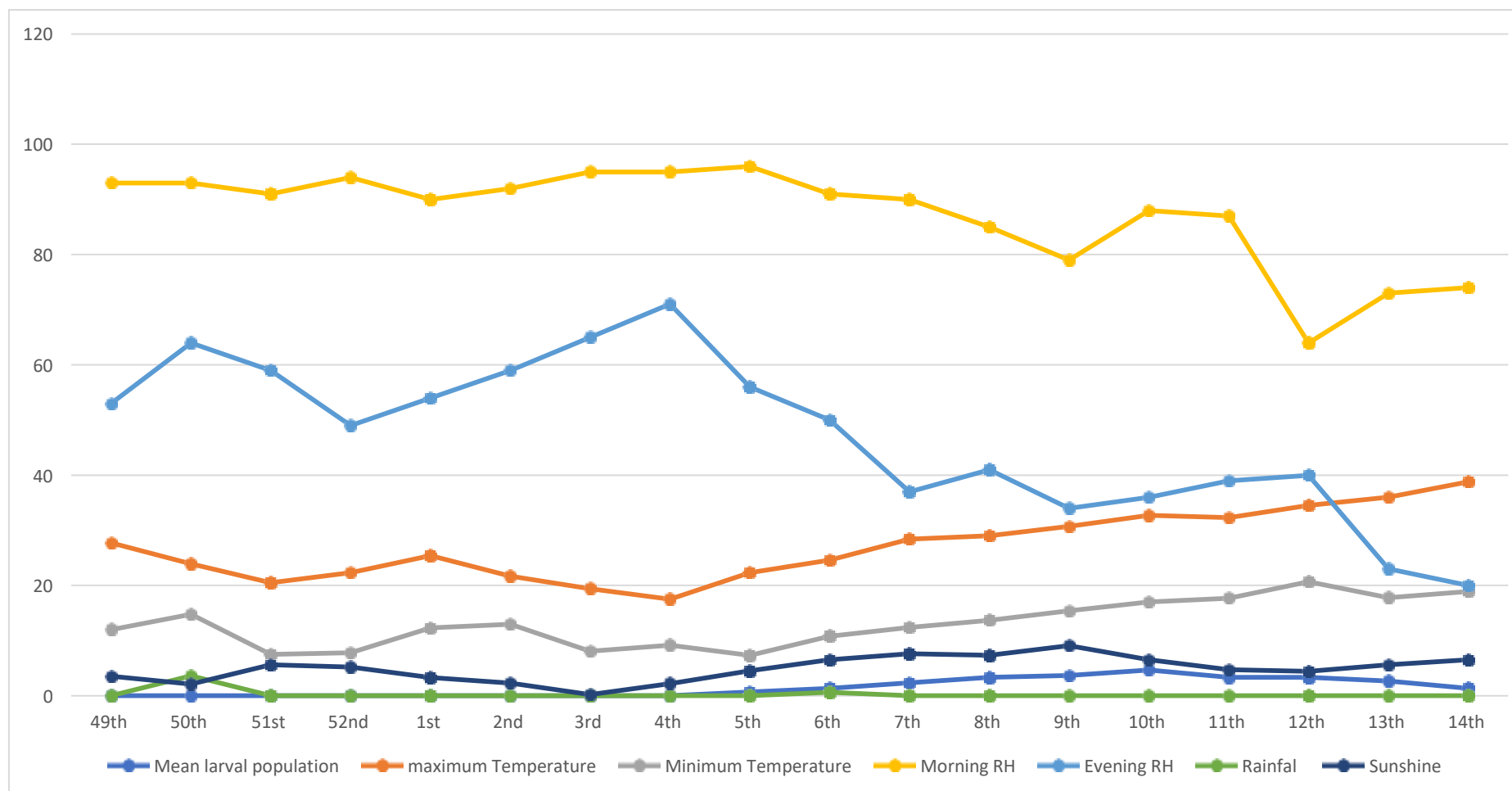
Rating scale	Reaction group	Varieties/ Genotypes
1	Highly resistant	-
2	Resistant	KPG 59 and RVG 203
3 -5	Least susceptible	IPCK 2002-29, BG 212, K 850, JG 130, DCP 92-3, NBEG 47, PDE 9802, IPCK 2004-29, JG 315, JG 16
6 -7	Moderately Susceptible	KWR 108 and GG,2
8-9	Highly Susceptible	L-550

#### 4.2 Seasonal incidence of gram pod borer (*Helicoverpa armigera*) on chickpea genotype BG 362

The data of seasonal incidence of *H. armigera* infesting chickpea during the year 2020-2021 was represented in Table 4.4 and graphically depicted in Fig. 4.5 The data showed that during 2020-2021, the larval mean population of *H. armigera* was in the range between 0.66 to 4.66 larvae/5 plants. The incidence of the pod borer (*H. armigera*) larva was appeared at the 5<sup>th</sup> standard week (Jan. 2021) i.e., 0.66 larvae/5 plants and continues till 14<sup>th</sup> standard week (2021) i.e., 0.1.33 larvae/5 plants. The pod borer (*H. armigera*) larval population was attained its peak (4.66 larvae/5 plants) in the 10<sup>th</sup> standard week of 2021.

**Table 4.4: Seasonal incidence of *Helicoverpa armigera* on chickpea genotype BG 362 during Rabi 2020-2021.**

S.no	SMW	Mean larval Population/5 plants	Temperature (°C)		Relative Humidity (%)		Total Rainfall (mm)	Sunshine (hours)
			Maximum	Minimum	Morning	Evening		
1	49	0	27.7	12	93	53	0	3.5
2	50	0	23.9	14.8	93	64	3.6	2.1
3	51	0	20.5	7.5	91	59	0	5.6
4	52	0	22.3	7.8	94	49	0	5.2
5	1	0	25.4	12.3	90	54	0	3.3
6	2	0	21.7	13	92	59	0	2.3
7	3	0	19.4	8.1	95	65	0	0.2
8	4	0	17.5	9.2	95	71	0	2.2
9	5	0.66	22.3	7.3	96	56	0	4.5
10	6	1.33	24.6	10.8	91	50	0.6	6.5
11	7	2.33	28.4	12.4	90	37	0	7.6
12	8	3.33	29	13.7	85	41	0	7.3
13	9	3.66	30.7	15.4	79	34	0	9.1
14	10	4.66	32.7	17	88	36	0	6.5
15	11	3.33	32.3	17.7	87	39	0	4.7
16	12	3.33	34.5	20.7	64	40	0	4.4
17	13	2.66	36	17.8	73	23	0	5.6
18	14	1.33	38.8	18.9	74	20	0	6.5



**Fig 4.5:** Relation of mean larval population of *Helicoverpa armigera* (different Standard meteorological weeks) with weather factor on chickpea genotype BG 362 during Rabi 2020-2021.

### 4.3 Correlation between larval population of *Helicoverpa armigera* with weather parameter and abiotic parameter during Rabi, 2020-2021.

To know the effect of abiotic variable on the larval population of *H. armigera* simple correlation analysis was carried out. The result of the analysis has been presented in (Table- 4.4) and detail have been given here as below.

Significant negative correlation was observed with respect to *H. armigera* with morning relative humidity ( $r = -0.602^*$ ) and evening relative humidity ( $r = -0.721^*$ ) and significance positive correlation with maximum temperature ( $r = 0.725^*$ ), minimum temperature ( $r = 0.685^*$ ) and sunshine ( $r = 0.666^*$ ). The Non-significant negative correlation was observed with respect of total rainfall ( $r = -0.226^{**}$ ) observed on chickpea are presented. (Table 4.5).

**Table 4.5: Correlation between larval population of *Helicoverpa armigera* and abiotic parameters during Rabi, 2020-2021.**

Insect	Temperature (°C)		Relative Humidity (%)		Sunshine (hours)	Rainfall (mm)
	Maximum	Minimum	Morning	Evening		
Gram Pod Borer	0.725*	0.685*	-0.602*	-0.721*	0.666*	-0.226**

\* Correlation is significant at 0.05 level

\*\*Correlation is non-significant at 0.05 level



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## DISCUSSION

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In the light of the available relevant literature, the results of the present investigation are being discussed in this chapter. Present experiment entitled “**Field screening of certain chickpea, (*Cicer arietinum* L.) genotypes against gram pod borer (*Helicoverpa armigera* Hubner)**” was conducted during *Rabi* 2020-2021.

### **5.1 Screening of chickpea genotypes against *Helicoverpa armigera* during *Rabi* 2020-2021**

#### **5.1.1 Mean Larval Population of *Helicoverpa armigera* during *Rabi* 2020-2021.**

The mean larval population of *H. armigera* per 5 plants during crop period was ranged from between 0.69 larvae/5 plants (KPG-59) to 3.22 larvae/5 plants (L-550).

When seasonal mean larval population of *H. armigera* was considered in the present experiment, chickpea genotypes namely KPG-59, RVG-203, BG-212 and IPCK-2002-29 registered lowest mean population (0.69, 0.86, 1.29 and 1.52 larvae/5 plants respective) followed by genotype JG-130, NBEG-47 and JG-16 that registered mean population (1.66, 1.89 and 1.92 larvae/5 plants respective). Highest mean population was recorded in genotypes L-550, BG-362, GG-2 and KWR-108 that registered (3.22, 2.99, 2.79 and 2.66 larvae/5 plants, respective). However, mean population of remaining 5 genotypes was registered (2.02 to 2.59 larvae/5 plants).

Similar results have been reported by kumar *et al.* (2018). They were absorbed the mean larval population of *H. armigera* is varies from 2.16 to 4.46 larvae/5 plants. The genotype KPG 59 recorded 2.16 larvae/ 5 plants and the genotype JG 315 recorded 3.99 larvae/5 plant. Shinde *et al.* (2014) reported the larval population of *H. armigera* in genotype JG 130 range between 0.5 to 6.8 larvae/meter row length. Patel *et al.* (2015) reported mean larval population was rage between 1.70 larvae/5 plants to 7.36 larvae/5 plants in different genotypes/ cultivars they absorbed genotypes/cultivar

Chaffa (3.56 larvae/5 plants), GG 2 (6.32 larvae/5 plants), Phule-G-5 (2.77 larvae/5 plants) and BJD 72 (1.70 larvae/5 plants).

The present findings are also showing similar result by kumar *et al.* (2019) recorded mean larval population of certain chickpea genotypes JG 11 (3.23 larvae/5 plants), Pusa 391 (2.60 larvae/5 plants), JG 315 (3.99 larvae/ 5 plants), JG 218 (3.72 larvae/5 plants) and KPG 59 (2.16 larvae/5 plants). Ogenga *et al.* (1994) reported lowest larval population of *H. armigera* on chickpea cultivars ICC- 506 (0.22/plant), while Reddy *et al.* (1996) reported chickpea varieties Pusa 261, BG 374, BG 386 as the least susceptible. Yelshetty *et al.* (1996) reported genotypes BJ 256 to have lowest pest density under field condition. Bhatnager and Rao (1997) reported chickpea genotypes JG-897, JG-322 and JG-394 to exhibit good resistance against *H. armigera* under rainfed conditions. Das and Katariya (1999) reported lowest pod damage (2.7%) in variety JG-74. Singh and Yadav (1999) evaluated 70 desi genotypes against *H. armigera* and reported that none of the genotypes could exhibit complete resistance against the pest.

### **5.1.2 Per cent pod damage during Rabi 2020-2021.**

The pod damage showed a significant variation amongst the genotypes under investigation ranging from 5.33 to 31.33 per cent. The genotype RVG-203 and KPG-59 recorded significant lowest pod damage 5.33 and 6.03 respectively. Highest per cent pod damage was recorded in genotype L-550, BG-362 and GG-2 that recorded 31.33, 24.33 and 23.33 per cent respective. However, remaining 11 genotypes pod damage recorded in the range between (9.66 to 22.66) per cent.

The present findings show a close association with findings of Odak *et al.* (1982) reported pod damage as 3.4% to 10.00% with minimum on JG-315 and maximum on *kabuli* variety L-550. Variation in pod damage has been reported from minimum of 17.91 % to maximum of 29.26 % in different genotypes at Sehore (Anonymous, 1984). Patel *et al.* (2015) they recorded lowest (4.67%) pod damage in variety BJD-72, which was at par with Dahod yellow, in which pod damage was 6.50%. Higher (23.00%) pod damage was found in genotype 8802-2. The

descending order of pod damage of gram pod borer in different genotypes / cultivars of chickpea were 8802-2 (23.00%), GG-1 (19.17%), GG-2 (18.17%), PKV-2 (17.33%), Vishal (16.17%), Dahod yellow (6.50%) and BJD-72 (4.67%).

The present finding is also showing a close association with finding Kumar *et al.* (2019) reported pod damage by *H. armigerar* ranging from 2.77 to 15.52 per cent. The minimum pod damage was observed in genotype Pusa 391 (2.77%) and KPG-59 (6.73%) whereas maximum pod damage was in genotype JGK 1 (15.52%) closely followed by GJG 3 (13.25%), JG 315 (12.44%) and JG 63 (12.10%). Jagdish *et al.* (2017) reported pod damage by *H. armigera* in certain genotypes. The genotype L-550 recorded (77.88 %), PG-186 (58.4%), ICCV 97105 (53.56%) pod damage. Odak *et al.* (1982) reported that the bold seeded varieties are more preferred by pod borer than the small seeded. On the contrary Deshmukh *et al.* (2010) the reported that Dahod yellow and BG 256 had the highest pod damage (22.81 and 20.49%, respectively), but gave good grain yield.

### 5.1.3 Per cent grain damage during *Rabi* 2020-2021

The grain damage of chick pea genotypes accounted by *H. armigera* varied from 5.03 to 29.76 per cent. The genotype KPG-59 recorded significant lowest grain damage 5.03. Genotypes L-550, BG-362, JG-315 and KWR-108 was recorded Highest (29.76, 22.70, 20.28 and 19.67) per cent grain damage.

### 5.1.4 Grain yield

During present study significant differences were observed in the grain yield of different genotypes. Genotype RVG-203 and KPG-59 recorded the highest grain yield of 1840 and 1822 kg/ha followed by genotype IPCK-2002-29, BG-212 and K-850 was recorded grain yield (1776, 1750 and 1692 kg/hac respective) as against the lowest grain yield of 818 kg/ha genotype L 550. In present findings, direct correlation of grain yield could not be established with the trend of larval population and pod damage.

The yield potential of genotypes may be varied due to the resistance and susceptibility against the pest. Sameer *et al.* (2018) reported the yield was ranged from 6.18q/ha to 16.37q/ha. The significantly highest yield was recorded in RSG 888 (16.37 q/ha) which was on par with CSG 8962 (14.73 q/ha), VISHWAS (14.55 q/ha), KWR 108 (14.34 q/ha) and GNG 2144 (13.64 q/ha), respectively. The significantly lowest yield was recorded in the genotype PUSA 128 (6.18 q/ha) which was on par with GLK 26155 (7.64 q/ha) and BG 1053 (8.00 q/ha) yield.

Close association of the result of present finding was reported by Agnihotri *et al.* (2017) reported genotype L-550 recorded 736.11 kg/hac grain yield. Deshmukh, *et al.* (2010) recorded low pod damage and higher yield in some varieties. Jagdish *et al.* (2017) reported the genotype L550 recorded 736.11 kg/ha grain yield. Singh and Yadav (2006) concluded that varieties BG-256 and JG-130 were tolerant against *H. armigera* by virtue of their genetic potentiality. In present investigations genotype JG-16 fetched the highest yielding with larval population (0.66 larvae/plant) and pod damage (2.66%) followed by KPG-59 fetching 1806 kg/ha yield with lowest larval population 0.59 larvae/plant and 1.97% pod damage, respectively. The genotypes BG-362, K-850, JG-130 also proved good with yield point.

### 5.1.5 Pest Susceptibility Rating (PSR)

The PSR in the genotypes under investigation was lesser and ranged from 2 to 8. The genotype KPG-59 and RVG-203 proved excellent with lest PSR of two followed by genotypes BG-212, IPCK-2002-29 both recorded 3 PSR and K-850, JG-130, DCP-92-3, NBEG-47 each recorded PSR is 4. Genotype L-850 recorded highest pest susceptibility rating is 8. Genotypes KWR-108 and GG-2 recorded PSR 6. All the genotypes have PSR is 3 to 5 are least susceptible to *Helicoverpa armigera*. Genotype have PSR rating is 6 are moderate susceptible and genotype have PSR 8 are highly susceptible to *Helicoverpa armigera*. The genotype has PSR 2 are resistant to *H. armigera* are less susceptible and genotype have PSR rating is 6 are susceptible to pod borer.

Amjed *et al.*, (1996), Khattak *et al.* (2002), Mandal (2003), Waqas *et al.* (2005) and Deshmukh *et al.* (2010). Rai and Ujagir (2005) and Kooner and Cheema (2008) have evaluated the chickpea cultivars on the basis of pest susceptibility rating. Rai and Ujagir reported four genotypes (ICCV 93929, ICCV 96029, ICCV 96030 and ICCV2) with 3 rating whereas, Kooner Cheema reported entry ICC 12493 as the best and resistant with PSR of three during four years of testing.

## **5.2 Seasonal incidence of gram pod borer (*Helicoverpa armigera*) on chickpea during Rabi 2020-2021**

The data from the present investigation on the mean larval population of *H. armigera* revealed that the pest population ranged between 0.66 (5th SMW) to 1.33 (14th SMW) larvae per 5 plants and reached peak 4.66 mean larval population per 5 plants during the 10<sup>th</sup> standard meteorological week. The minimum mean larval population of 0.66 per 5 plants was recorded during 5th standard meteorological week.

The present findings consonance with Chhabra and Kooner (1980) reported that the pest *H. armigera* attained peak during March to April in Punjab. Singh *et al.* (1990) reported that in Punjab the larval population peaked in early April. The results are similar with Pandey *et al.* (2012) They were recorded highest larval population in the 4th week of March 2012 (12th standard week) with 15.3 mean larval population/plant.

The present findings show a close association with findings of Sabbithi (2016) who reported that the mean larval population of *H. armigera* ranged from (0.77 larvae per mrl) to (7.33 larvae per mrl) and 0.99 to 7.30 larvae per mrl during the 2013 and 2014 respectively. The minimum larval population was recorded during the 5th standard meteorological week of 2013 and 2014, which gradually increased and attain a peak during the 14th standard meteorological week and further gradual decline towards the complete maturity of the crop at the 15th standard meteorological week of 2013 and 2014 respectively.

Nitharwal *et al.* (2016) reported that the population of pod borer appeared on chickpea in the 6<sup>th</sup> standard week with an average 0.25 larvae per plant and increased up to the 6.25 larvae per plant at the 13<sup>th</sup> standard week and showed gradual decline till the crop maturity during the last week of April.

The present investigation show consonance with the findings of Ramteke *et al.* (2014) They reported that larval population of the *H. armigera* commenced from the standard week (SW), with an average population of 0.34 larva/plant, which was further showed a gradual increasing trend and reached the peak level of 9.97 larvae plant on the 10th SW (2nd week of March). Thereafter, the population declined from the 11th SW (3d week of March), with an average population of 5.44 larvae plant, which gradually decreased with 2.32, 0.79 and 0.43 larvae/plant in the 12 SW (4th week of March), 13th and 14th SW (1st and 2nd week of April) respectively.

### **5.3 Correlation between larval population of *Helicoverpa armigera* with weather parameter and abiotic parameter during Rabi. 2020-2021.**

The present investigation a simple correlation worked out between mean larval population of *H armigera* and weather parameters exhibited following results i.e., a significant positive correlation with maximum temperature ( $r= 0.725$ ), minimum temperature ( $r= 0.685$ ) and Sunshine ( $r= -0.666$ ), whereas a significant negative correlation was observed in morning relative humidity ( $r= -0.602$ ) and evening relative humidity ( $-0.721$ ). A non-significant negative correlation observed with rainfall ( $r= -0.226$ ).

The present finding are similar with Sabbithi (2016) who reported that the mean larval population of *H. armigera* Correlation coefficient with different weather parameters during 2013 and 2014 indicated that the larval population exhibited a highly significant positive correlation with maximum temperature, minimum temperature, wind speed, and pan evaporation, a highly non-significant positive correlation with sunshine hours, while, ground minimum, morning relative humidity and evening relative humidity and highly significant negative correlation with rainfall.

The results are similar with the earlier workers such as Pandey *et al.* (2012) The population has shown a significantly positive correlation with both the minimum and maximum temperature and the correlation coefficient was 0.62 and 0.64 respectively. The correlation coefficient of morning and afternoon relative humidity showed a negative correlation with larval population (-0.76 and -0.73). Similarly, the rainfall and larval population also showed negative correlation coefficient (-0.09) which was not significant.

The present finding also closely related to Nitharwal *et al.* (2016) They reported that the weather parameters maximum and minimum temperatures showed significantly positive correlation whereas, the both relative humidity and rainfall showed negative significant correlation with pod borer population. The wind velocity and the sunshine hour showed significantly positive correlation with pod borer population on chickpea.



## **SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK**

The current study ongoing, “Field screening of certain chickpea, (*Cicer arietinum* L.) genotypes against gram pod borer (*Helicoverpa armigera* Hubner)” was carried out during the *Rabi* season of 2020-2021 at Agriculture Research Farm, Institute of Agricultural Sciences BHU, Varanasi Uttar Pradesh.

The experiment was conducted in Randomized Block Design with 3 replications and 16 genotypes. Recommended agronomical practices were adopted, to raise good crop. Larval population of *Helicoverpa armigera* on different genotypes was recorded once in every standard meteorological week (SMW) sample unit was 5plants/treatment/replications. Pod damage observations are recorded at the time of harvesting such samples were observed in each treatment and replication. Observations on total number of pods (healthy and damaged) were recorded on 5 randomly selected plants in every plot. Seed yield from each plot was recorded at harvest. The larval population observed in different genotypes was subjected to analysis of variance at 5% level of significance.

The first instar larvae of *H. armigera* were observed on chickpea in 5th SMW at vegetative stage. Pest activity continued till 14th SMW (crop maturity).

The larval mean population of *H. armigera* per five plants was ranged between 0.33 larvae per five plants to 3.22 larvae per five plants. The genotype L-550 and KPG-59 showed highest (3.22 larvae per five plants) and lowest (0.69 larvae per five plants) larval population /5 plants respectively. The overall mean larval population per five plants during the crop periods was 2.06.

The per cent pod damage at harvest ranged from 5.33 per cent to 31.33 per cent during the crop period. The genotype RVG-203 (5.33 per cent) and L-550 (31.33

per cent) recorded lowest and highest per cent pod damage. The overall mean per cent pod damage during the crop period was 17.41 per cent.

The per cent grain damage at harvest ranged from 5.03 per cent to 29.76 per cent during the crop period. The genotype KPG-59 (5.03 per cent) and L-550 (29.76 per cent) recorded lowest and highest per cent grain damage. The overall mean per cent grain damage during the crop period was 15.48 per cent.

The pest susceptible rating ranged from 2 to 8. The genotype L-550 recorded highest pest susceptible rating of 8 and the Genotype KPG-59 and RVG-203 both recorded lowest pest susceptible rating of 2. The 2-genotype recorded pest susceptible rating of 3, 4-genotypes recorded pest susceptible rating of 4, 4-genotypes recorded pest susceptible rating of 5 and 2-genotype recorded pest susceptible rating of 6.

The yield was ranged from 818 kg/ha to 1840 kg/ha during the crop period 2020-2021. The lowest and highest yield of 818 kg/ha and 1840 kg/ha was recorded on the genotype L-550 and RVG-203 respectively. The overall mean grain yield during the crop period was 1541.31 kg/ha.

The seasonal incidence of mean larval population of *H. armigera* on chickpea ranged from 0.66 (5<sup>th</sup> SMW) to 1.33 (14<sup>th</sup> SMW) larvae per five plants. The incidence of *H. armigera* larvae occur during the 5<sup>th</sup> standard meteorological week with 0.66 mean larval population per five plants and reached a peak with 4.66 larvae per five plants during the 10<sup>th</sup> standard meteorological week.

The correlation between mean larval population of *H. armigera* and weather parameter exhibited on chickpea results i.e., a significant positive correlation with maximum temperature ( $r= 0.725$ ), minimum temperature ( $r= 0.685$ ) and Sunshine ( $r=-0.666$ ), whereas a significant negative correlation was observed in morning relative humidity ( $r= 0.602$ ) and evening relative humidity ( $-0.721$ ). A non-significant negative correlation observed with rainfall ( $r= -0.226$ ).

## **Conclusion**

On the basis of overall mean larval infestation, per cent pod damage, yield\ha, the genotype KPG-59 and JG-16 performed well recording the lesser infestation (0.59 and 0.79), pod damage (1.97 and 2.68%), and yield (1806 and 1833 kg/hac) respectively.

On the basis of PSR rating two genotype (NBEG-47 and K-850) PSR rating is six are susceptible to *H. armigera*, one genotype (GG-2) PSR rating 5 are less susceptible and rest of all genotypes PSR rating 3 to 4 are tolerant to *H. armigera*.

The correlation between mean larval population and weather factor significant positive correlation with maximum temperature, minimum temperature and sunshine whereas a significant negative correlation with morning relative humidity and evening humidity. A non-significant negative correlation with rainfall.

## **Suggestions for further work**

As it is evident from the present studies that the *H. armigera* is prominent and potential insect pest of chickpea, it is necessary to determine the extent of damage in various larval stages of the pest continuously for 3-4 y ears, and to further identify the cultivars having multiple resistance with better grain yield. Tested genotypes may be screened further for the confirmation of present results.



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## APPENDIX

**Weekly Meteorological Data: Varanasi, Year- 2020-2021 Department of Agronomy IAS,  
BHU (Varanasi).**

Week No.	Month & Date	Rainfall (mm)	Temperature °C		R.H. (%)		Wind Speed (km/hr)	Sunshine (Hours)	Evaporations (mm)
			Max	Min	Morn.	Even.			
49	Dec 03-09	0.0	27.7	12	93	53	0.9	3.5	1.2
50	10-16	3.6	23.9	14.8	93	64	1.8	2.1	1.4
51	17-23	0.0	20.5	7.5	91	59		5.6	1.3
52	24-31	0.0	22.3	7.8	94	49		5.2	1.2
1	Jan 01-07	0.0	25.4	12.3	90	54		3.3	1.1
2	08-14	0.0	21.7	13.0	92	59		2.3	1.6
3	15-21	0.0	19.4	8.1	95	65		0.2	1.0
4	22-28	0.0	17.5	9.2	95	71		2.2	1.0
5	29-04	0.0	22.3	7.3	96	56		4.5	1.25
6	Feb 05-11	0.6	24.6	10.8	91	50		6.5	1.7
7	12-18	0.0	28.4	12.4	90	37		7.6	1.9
8	19-25	0.0	29.0	13.7	85	41		7.3	2.6
9	26-04	0.0	30.7	15.4	79	34		9.1	3.8
10	Mar 05-11	0.0	32.7	17.0	88	36		6.5	4.5
11	12-18	0.0	32.3	17.7	87	39		4.7	6.3
12	19-25	0.0	34.5	20.7	64	40		4.4	5.1
13	26-01	0.0	36.0	17.8	73	23		5.6	5.6
14	Apr 02-08	0.0	38.8	18.9	74	20		6.5	6.3

