

**“Studies on succession of insect pest complex associated with pea (*Pisum sativum* L.) and screening of pea genotypes against major pests”**



**THESIS**

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**Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya**

In partial fulfilment of the requirements for the Degree of

**MASTER OF SCIENCE**

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**AGRICULTURE**

**(ENTOMOLOGY)**

**By**

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**2021**

## **CERTIFICATE - I**

This is to certify that the thesis entitled, “**Studies on succession of insect pest complex associated with pea (Pisum sativum L.) and screening of pea genotypes against major pests**” submitted in partial fulfillment of the requirements for the Degree of **MASTER OF SCIENCE in Agriculture Entomology of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalyaya, Gwalior**, is a record of the bona-fide research work carried out by **Ms. SHRADDHA TARE ID No 19131908** under my guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and the Director of Instruction.

No part of the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of this investigations has been acknowledged by the scholar.

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### List of Abbreviations and Symbols

Symbol	Abbreviation	Stand for
@		At the rate of
%		Per cent
±		Plus or minus
°C		Degree centigrade
	C.V.	Coefficient of variation
	C.D.	Critical difference
	d.f.	Degrees of freedom
	<i>et al.,</i>	Co- workers
	Fig.	Figure
	R.H.	Relative Humidity
	NS	Non-significant
	<i>spp.</i>	species
	<i>viz.</i>	For instance
	<i>i.e.</i>	That is
	etc.	X sectra
	kg.	kilogram
	gm	gram
	cm	centimeter
	mg	Milligram
	hrs.	hours
	q	quintal
	r	Correlation coefficient
	<i>viz.,</i>	Namely

# CHAPTER I

## INTRODUCTION

Pea, *Pisum sativum* L. is an important leguminous vegetable crop, also called as *matar* in hindi, is the prime vegetable crop of Indian sub-continent and an important winter season crop in the family fabaceae largely confined to cooler temperate zone. It is grown for its fresh delicious green seeds, soft green pods, dried seeds, and leaves (Duke 1981). It is cultivated commercially all over the world and is used as a vegetable and a pulse crop (Dhar *et al.*, 2001). In addition to chickpea and lentil, pea is the third most popular rabi pulse in India, after chickpea and lentil.

Pea is an inseparable ingredient of vegetarian diet, highly nutritive and is the cheapest source of digestible protein, carbohydrate, fat, vitamins and minerals (Tiwari *et al.*, 2019). It contains 62.1g (19.2%) carbs, 22.5g (7.2%) protein contents, 1.8g lipids and fat, 64mg calcium, 4.8mg (1.8%) iron, 0.15 mg riboflavin (vitamin B<sub>2</sub>), 0.72 mg thiamine (vitamin B<sub>1</sub>), 2.4 mg niacin (vitamin B<sub>3</sub>), 80 per cent phosphorus, Vitamin, Vitamin C and 0.8 per cent mineral matters, in a hundred gram of dried edible portion of pea seed (Gueguen and Barbot, 1988; Swiątecka *et al.*, 2010; Dahl *et al.*, 2012). Hence, it is grown in almost all the states of the country during rabi season and is harboured throughout the world because of its taste, nutritive value, fast growth and high yield. Tender seeds are also used in food starters and soups. Canned, frozen and dehydrated peas are very common for use during off-season. Like any legume crop, it is also cultivated as a cattle forage and is an integral component of sustainable agriculture due to its soil enriching and conditioning properties. It can be grown around the year under variable conditions, but the crop prefers well drained, loose and friable loamy soil for early crop and clayey soil for high yield with ideal pH 6.0-7.5.

It is cultivated on 528.71 thousand hectares of area throughout the world and ranks fourth in addition to soybean, groundnut, and beans, in terms of production (441.53 thousand tonnes). India occupy 4<sup>th</sup> position in area (10.53%) and 5<sup>th</sup> position in production (5.36%) (Annual Report, DPD 2016-17). Field pea is cultivated on 5.97 lakh hectares in India, with a yield of around 8.60 lakh tonnes and a productivity of 1440 kg/ha. [Anonymous (b),

2019-20]. It is estimated that early varieties produce 2.5-4.0 t/ha, mid-season varieties 6.00-7.5 and late types 8.0-10.0 t/ha of green pods. The seed yield ranges from 2.0 to 2.5 tonnes per hectare. Out of it, Madhya Pradesh produces 48000 metric tonnes contributing 55.81% of total production [Anonymous (a), 2019-20]. Uttar Pradesh ranked first both in area and production followed by Madhya Pradesh and Jharkhand. Maharashtra had the lowest yield (390 kg/ha), followed by C.G. (437 kg/ha) and Assam (817 kg/ha). (Annual report, DPD 2016-17). The state of Uttar Pradesh is the largest producer of field peas. About 65.77 percent of India's pea production comes from this region alone. Additionally, Uttar Pradesh, Jharkhand, and Madhya Pradesh are the top pea producing states (DES, 2019). Garden pea is also grown in Punjab, Himachal Pradesh, Haryana, Rajasthan, Jammu and Kashmir, West Bengal, Bihar, Uttarakhand and parts of Orissa and Maharashtra. In south, pea is cultivated in many parts of Karnataka and the hilly regions of Kerala and Tamil Nadu.

However, various abiotic factors (weather parameters) and biotic factors (living organisms) affect the production and productivity of the pea crop. Of the biotic factors, insect-pest losses are one of the more important limiting factors in achieving maximum yields of the vegetable pea crop. All the parts of the plant at various crop stages from seedling to harvest are known to be devastated by various insect pests. As many as 24 insect species have been reported infesting the pea crop at different stages (Bijur and Verma 1995). Of them, the insect pests like gram pod borer, *Helicoverpa armigera* (Hubner), blue butterfly, *Lampides boeticus* (L.), pea pod borer, *Etiella zinckenella* (Treitschke), pea aphid, *Acyrtosiphon pisum* (Harris), pea leaf miner, *Phytomyza horticola* (Goureau), pod fly, *Melanogromyza obtuse* (Malloch), pea stem fly, *Melanogromyza phaseoli* (Tryon) and thrips *Caliothrips indicus* (Bagnall) causes serious and significant losses in crop productivity (Mittal and Ujagir (2007; Yadav *et al.*, 2015). These pests attack field pea during the blooming and pod formation stages and are believed to be the major cause of low productivity, affecting not only the yield but also the grain quality.

Its production is severely limited because of insect pest damage. At first, the larvae of *Etiella zincknella* (Treitschke) feed on the floral parts before

boring into the pods to feed and develop further. This is caused by the tiny green caterpillars, which eat the immature seeds, causing the seed pod to open and spill out the seeds. After feeding on the leaves and flowers for a little while, *Helicoverpa armigera* larvae drills into the mature seeds, leaving their bodies exposed. While still a larva, it has the potential to injure several pods.

Kushwaha (2002) conducted the experiments in Jabalpur, M.P. and concluded that there were nine insect pests found to damage pea crop viz. *Aphis craccivora*, *Melanogromy zaphaseoli*, *Phytomyza atriconis*, *Caliothrips indicus*, *Helicoverpa armigera*, *Etiella zinckenella*, and *Spodoptera litura* and 13 to 17 percent loss was calculated.

Pod damage due to pea pod borer, *Etiella zinckenella* was 3.5 to 30.8 alone in Uttar Pradesh. It is widely dispersed throughout the country with special reference to Uttar Pradesh, Bihar, Madhya Pradesh and Punjab (Yadav and Chauhan 2000). Pea grain yield loss was found to be 20 percent caused by pea leaf miner (Mehta *et al.*, 1994). This crop known to have a large number of insects-pests feeding on it, resulting in low productivity. Due to a significant population of insects and pests that feed on it, this crop's yield was found to be low. *H. armigera* and *L. boeticus* caused 7.50 and 6.38 per cent pod damage in pea, respectively. Khan *et al.*, (2015) also reported 5.5 to 12.5 per cent pod damage caused by the pod borers of Lepidoptera.

For the new pea varieties to reach their maximum output potential, it is important to avoid crop losses due to insect infestations. Physiomorphic characteristics of vegetation can have an impact on insect herbivore population growth, reproduction, and survival (Kareiva and Sahakian, 1990; Soroka and MacKay, 1990). Herbivore performance may be affected by plant shape in a variety of ways. Reduced mobility and greater crowding of herbivores may be caused by plant design, affecting the effective per capita access to nutrients (Dixon, 1973).

On the other hand, Soroka and MacKay (1990) found that pea architecture has a substantial impact on aphid population increase. By creating resistant cultivars, host plant resistance can be an effective means of crop protection against important pests such as the gram pod borer (*Helicoverpa armigera* Hub.) and the pulse aphid (*Aphis craccivora* Koch.) that attack peas.

In other words, gathering knowledge about the most common pests infesting the field pea crop will aid in developing effective and efficient management solutions and all these facts and previous studies signify that there are ample opportunities to study the seasonal incidence of major insect pests on pea crops, as the application of chemical insecticides is most common approach to adopt to cope with these insect pests. As a result of their negative consequences such as pest resurgence, health ill effects and contamination of the environment, pesticide usage should be critically avoided. Thus in accordance to environmental safety and compatibility with other pest management techniques, the cultivation of resistant genotypes is a major component of integrated pest control.

With all these facts in mind, investigations were undertaken to discover what pests of pea crop appear to be the most prevalent and the varietal screening of the genotypes was done for their relative susceptibility towards pod borer complex at Sehore district of Madhya Pradesh and the present study was proposed to be undertaken with the following objectives:-

**Objectives:-**

1. Seasonal incidence of major insect pests on pea crop.
2. Screening of field pea genotypes for their relative susceptibility towards pest complex.

## CHAPTER II

### REVIEWS OF LITERATURE

Successful crop production greatly depends on the least possible damage caused by several major and minor insect pests. This results in the higher economic and biological yield. Knowledge about the incidence of insect pests and their prompt and efficient management strategies greatly plays an important role in increasing the flowering and pod setting, that ultimately results in increased yields. Several studies have been conducted earlier related to all these aspects of succession of insect pests in the field pea crop and screening of various genotypes for pod borer complex. The available literature on the succession of the major insect pests and screening of different genotypes is reviewed in this Chapter under the following heads:

#### **2.1 Seasonal incidence of major insect pests on pea crop.**

#### **2.2 Screening of field pea genotypes for their relative susceptibility to pest complex.**

#### **2.1 Seasonal incidence of major insect pests on pea crop.**

There are several possible mechanisms through which plant morphology could affect herbivore performance. Plant architecture may cause reduced movements and increased crowding of herbivores therefore may alter the effective per capita access to resources (Dixon, 1973).

Vaishampayan and Veda (1980) reported that the peak population of gram pod borer occurred in December and January and the temperature and relative humidity showed positive correlation with pest population while rainfall was negatively correlated on gram.

Honda (1989) studied on the biology of *Acyrtosiphon pisum* on peas in the field in Japan during May-September, crop sown in late April, *Apterous virginoparae* were found from the end of May and the population density peaked in early July, and crop sown in early September, apterae occurred from late September and the population peaked in early October. *Alate virginoparae* began to emerge, when the population density exceeded 20 individuals /plant. While sexual morphs did not emerge under conditions of low temperature (11.2°C) and short-day length (LD 12: 12). It was concluded that the life cycle of this aphid was holocyclic.

Blue butterfly, *P. boeticus* is regular and serious pest in Haryana also for the last few years and average 8 percent damage on pod and locule basis has been reported (Kaushik *et al.*, 1982).

In India, the extent of losses due to *H. armigera* in chickpea is up to 27.9 per cent in northwest plain zone, 13.2 per cent in north east plain zone, 24.3 per cent in central zone and 36.4 per cent in south zone (Lateef *et al.*, 1983). The crop has been noted to suffer an avoidable loss of 9 to 60 per cent (Tahhan *et al.*, 1982). The problem of this pest is magnified due to its direct attack on fruiting structures, voracious feeding habits, high mobility, fecundity and multivoltine overlapping generations (Sigsgaard *et al.*, 2002) and (Sithanantham *et al.*, 1983).

Prasad *et al.* (1983) studied the succession of the insect-pests in pea variety 'Arkel' and noted 19 insect -pests in succession at different stages from seedling to maturity stage of the crop under the agro climatic condition of Delhi and concluded that, *Aphis craccivora* (Koch) and *Plusia orichalcea* (Fab.) *Phytophthora horticola* were the major pests.

Shaw *et al.* (1989) found that out of the 10 host plants, soybean and pea, were most suitable for multiplication and development of pea thrips.

The prevention of crop losses from pest attack is necessary for resulting massive production of higher yielding potential of the new pea varieties. The physiomorphic characters of plants can affect the population growth, reproduction and survival of insect herbivore (Kareiva and Sahakian, 1990; Soroka and MacKay, 1990).

Soroka and MacKay (1990) reported that there is a strong influence of pea architecture on aphid population growth. Therefore, host plant resistance is an efficient method of crop protection and may provide a viable tactic for managing the major pests *viz.* gram pod borer (*Helicoverpa armigera* Hub.) and pulse aphid (*Aphis craccivora* Koch.) occurring on peas by developing resistance cultivars. Keeping in view the significance of pea the present research work was directed to explore the role of morphological characters of pea cultivars against major insect pests.

Martinovich *et al.* (1991) studied the population dynamic of *H. armigera* in pea seed production unit of Matra Basin in Northern Hungary during 1978-88 and found that the degree of infestation was related to time of occurrence

of spring, temperature precipitation and relative humidity, late sown varieties were generally more heavily infested than early and medium sown varieties.

Dubey *et al.* (1993) reported that *H. armigera* feed on vegetable pea during crop season. The pest showed peak activity in February to March.

Dubey *et al.* (1993) studied the population dynamics of *H. armigera* on various crops including pea in Jabalpur condition over two years. The peak activity was observed in February and March and he found that environmental factors (Temp., R.H., and rainfall) had an impact on the development of pest population.

Bijur and Verma (1995) reported that pea variety 'Arkel' was infested by 24 insect's pests at Delhi.

Singh *et al.* (1995) studied the population dynamics of pea pod borer *Etiella zinckenella* on pea in Ludhiana, two peak periods were observed firsts in the mid of March and second in mid of April.

Bijur and Verma (1995) reported 57 species of insect pests which attack pea crop, with an annual monetary loss of 540 million Indian rupees.

Bijur and Verma (1996) concluded the population build-up of any insects is very immediately associated with weather parameters prevailing during preceding and corresponding periods. As the pests status of pea crop can change rapidly because of their dynamics nature and also gets affected in general by wind speed, light rainfall etc. So, it is necessary to know the factors affecting the insect pests and natural enemies positively or negatively.

Sood *et al.* (1997) concluded the population build-up of immature stages of *Chromatomyia horticola* revealed that this pest was found to appear and establish on pea in mid-February. The leaf miner population was at its peak in March-April. Maximum numbers of larvae and pupae were recorded on April 5, 1991 and March 21, 1992. Environmental factors played an important role in leaf miner infestation. The ambient maximum (19-26 °C) and minimum (10-14°C) temperature in March appeared to be the most important for leaf miner multiplication. Relative humidity and rainfall had no significant impact on leaf miner population fluctuations.

Prasad *et al.* (1997) reported host range and seasonal incidence of *H. armigera* was maximum adult catches obtain in late week of March.

Prasad *et al.* (1982) reported significant negative correlation with minimum temperature and with rainfall.

Bhadoria *et al.* (1998) studied on biology of *Etiella zinckenella* on pea crop and he found that the pea crop is suitable host for *Etiella zinckenella* with more egg production, more hatching, shorter larval period, lower larval and pupal mortality and higher frequency of adult emergence.

Mehta *et al.* (1998) found that majority of pea varieties were highly infested with leaf miner *Chromatomyia horticola* including Arkel, Cincan, and Bonneville.

Chakarborty and Dutta (1999) the population build-up of *Megalurothrips distalis* was studied on pea crop in Assam Agricultural University, Jorhat, India during Rabi season of 1996 - 97 and 1997 - 98. The incidence of *M. distalis* (number /plant) was recorded at the flowering stage of the crop. The infestation remained from 15 Jan. to 12 March 1997 with a peak of 1.40 thrips per plant on 29 Jan.1996. While in 1997-98 the period of activity was from 12 Jan. to 16 Feb. with a peak of 0.54 thrips/plant on 12 Jan.1998. Correlation studies involving meteorological parameters and thrips population revealed a positive significance impact of morning relative humidity in both the years.

Sixty cultivated and sixty-seven wild host plants attacked by *H. armigera* have been recorded from India (Karim, 2000).

Dixon and Harrington (2000) studied that the variations in aphids' population was closely associated with temperature from Jan. to July. Cold weather in Jan. and Feb. results in large number of aphids. This explain population crashes of the pea aphid observed at early growth stage of the crop on vinning and combining peas, late sowing of peas a probable effect of cold winters, resulted, in higher aphid densities at flowering. The probable explanation for this was that late sown crop was colonized of an earlier growth stage, so that the aphid population has a longer period of time in which to develop.

*H. armigera* is also highly polyphagous and also a serious pest of pea crop. Blue butterfly, *P. boeticus* (Lycaenidae: Lepidoptera) is considered as one of the major borers of pulses (Ganapathy *et al.*, 2000).

Kushwaha (2002) studied the succession of insect pests on pea at Jabalpur. He recorded nine insect-pests on pea crop. out of which four insect-pest i.e. *Phytomyza atricornis*, *Caliothrips indicus*, *H. armigera*, and *Etiella zinckenella* were identified as the major pest and two i.e. *Plusia orichalcea*, and *Spodoptera litura* were treated a minor pest while the rest of the pests i.e. *B. halaris* and *H. banian* were of a little importance.

Ashalata (2002) recorded that leaf infestation by leaf miner and pest population on leaf miner was correlated with meteorological parameters; she found that both positively correlated with maximum temperature and sunshine hours and negatively correlated with relative humidity and minimum temperature on tomato crop.

Wale Melaku (2002) found pea aphid population increased and decreased with delay in planting at Adet and Zema, respectively. At Adet peaks of weekly counts of aphid numbers were observed in August and seasonal totals of aphid on individuals planting dates increased as planting was delayed. At zema peaks of weekly counts of aphid numbers were observed in mid-July (1996), late August and early September (1995) and mid-September, peas planted on June 16 gave the lowest seasonal totals of aphids. For most planting dates and years weekly aphid population showed positive correlation with maximum temperature and negative correlated with minimum temperature and relative humidity.

Kushwah *et al.* (2002) worked on the succession of insect pests of pea ,gram pod borer (*Helicoverpa armigera*) and pea leaf miner (*Phytomayza atricornis* )were recorded throughout the crop season while maximum pea thrips and pea pod borer were recorded during the flowering and the pod formation stage of the crop. The period from the 2<sup>nd</sup> week of January to 2nd week of February was the most favourable for the activity of the almost all the pest.

Kushwaha (2002) recorded 9 insect pests on pea crop at different stages of its growth and estimated losses ranged from 13 to 17 percent in Jabalpur, Madhya Pradesh and these were *Aphis craccivora*, *Melanogromyza zaphaseoli*, *Phytomyza atriconis*, *Caliothrips indicus*, *Plusia orichalcea*, *Helicoverpa armigera*, *Etiella zinckenella*, *Melanagromyza obtusa*, *Spodoptera litura*.

Pandey *et al.*, (2002) worked conducted on the effect of I.P.M. technology on yield of field pea in eastern parts of Uttar Pradesh and observed that the population of insect -pests (pea stem fly, pod borer and leaf miner) was less in I.P.M technology in comparison to the farmer's practice.

The overall mean population of *C. indicus* has been recorded on garden pea 10.47 per leaf per plant (Khan, 2003).

Shantibala and Singh (2003) reported that the seasonal activity of *L. boeticus* started from the flowering stages and remained up to crop harvest. The pod borer damage commenced during the flowering stage with 12.50 and 8.33% in the third and fourth week of January 2000 and 2001, respectively. The infestation continued up to the last picking of pods with 20.20 per cent and 18.52 per cent in the first and third week of March during the two consecutive seasons, respectively. The peak populations of 25.52 per cent and 23.08 per cent were attained in the fourth week of February 2000 and in first week of March 2001, respectively. No rainfall was observed during the period and maximum pod infestation was recorded in both the cropping seasons. Among the abiotic factors, mean temperature exhibited significant positive association.

Maximum leaf damage (40 percent) by Pea leaf miner, *C. horticola* has been recorded in early maturing variety HFP-8909 (Singh *et al.*, 2004).

Mittal and Ujagir (2007) showed that various abiotic and biotic factors cause losses in the pea crop so that the yield of it is reduced. Among the biotic constraints, the losses caused by insect-pests are a major limiting factor in realization of optimum yield of the vegetable pea crop. It is known to be ravaged by several insect pests during its various crop stages. Insect pests like pea pod borer, *Etiella zinckenella*, pod borer, *Helicoverpa armigera*, blue butterfly, *Lampedes boeticus*, pea stem fly, *Ophiomyia phaseoli*, cotton jassid, *Emrasca devastans*, pea leaf miner, *Phytomyza atricornis*, aphid, *Myzus persicae* and mite, *Tetranychus telarius*, pod fly, *Melanogromyza obtusa* and tobacco caterpillar, *Spodoptera litura* are serious pests and causes substantial loss to the crop.

Mittal and Ujagir (2007) studied on the major insect pests infesting pea in Pantnagar, Uttaranchal, India during the rabi season of 2001-02 and 2002-03. A total of 32 pests were found, among them *Etiella zinckenella*,

*Helicoverpa armigera*, *Lampides boeticus* and *Euchrysops cnejus* were major pests.

Singh and Saravanan (2008) reported the pea leaf miner (*Phytomyza atricornis*) commenced from 2<sup>nd</sup> week of Feb. with an average population of 7.3 leaf miner/plant leaf miner population gradually increased and reached its peak level of 9.25 leaf miner per pant during 4th week of Feb. (9<sup>th</sup> standard Week).

In western Uttar Pradesh, in addition to other insect pests, the pod borers *Etiella zinckenella* (Treitschke) and *Helicoverpa armigera* (Hübner) are most serious insect pests of vegetable pea appearing during the flowering and pod stage which seriously damage the crop and are considered to be a major limiting factor for the production of vegetable pea (Singh *et al.*, 2010).

Dhaka *et al.* (2011) reported that on vegetable pea, *H. armigera* was negatively correlated with minimum and maximum temperature and positively correlated with minimum and maximum relative humidity and rainfall.

Dhaka *et al.* (2011) reported that peak incidence of *E. zinckenella* as well as *H. armigera* larvae was recorded during February first week during both the years. During study period *E. zinckenella* ranged from 0.00 to 18.67 whereas, *H. armigera* ranged from 0.00 to 17.67 larvae per ten plants. Maximum temperature ( $r = -0.543$  &  $-0.568$ ) for *E. zinckenella* and  $r = -0.497$  &  $-0.522$  for *H. armigera* showed the negative significant correlation with incidence of larvae during 2008-09 and 2009-10, respectively. Rainfall ( $r = 0.374$  &  $0.388$ ) showed the positive non-significant correlation with incidence of larvae *E. zinckenella* during 2008-09 and 2009-10 and also found positively correlated with the incidence of larvae of *H. armigera* with  $r = 0.382$  and  $0.396$  during 2008-09 and 2009-10, respectively. Whereas, maximum relative humidity indicated positive significant relation with incidence of *E. zinckenella* larvae ( $r = 0.012$ ) during 2008-09 and was negatively correlated with incidence of same pest during 2009-10 with  $r = -0.672$ . Relation between field incidence of *E. zinckenella* larvae was found to be positively correlated during 2008-09 and negatively correlated during 2009-10 with minimum humidity. However, relation between incidence of larvae of *H. armigera* with minimum relative humidity ( $r = 0.183$  &  $-0.388$ ) was positive during 2008-09 and negative during 2009-10.

Large numbers of insect-pests are found feeding on this crop, resulting in low productivity of this crop. Pod damage in field pea by pod borer complex has been reported to be 13.45 to 40.38 per cent (Dahiya *et al.*, 1993). Similarly, pod damage in pigeon pea by *H. armigera* and *L. boeticus* was found to be 7.50 and 6.38 per cent respectively (Sandip *et al.*, 2016). Pod damage (5.5 to 12.5 per cent) by lepidopterous pod borer has also been reported by Khan *et al.*, (2014).

Abel Tesom *et al.* (2014) a total of 602 pea accessions from Ethiopia were screened for pea weevil resistance at three field sites in Ethiopia. From this trial, accessions with relatively low mean percent seed damage (PSD) were selected and evaluated during June-October 2012 in replicated trials. The gene bank accessions 32454 and 235002 had consistently 40 per cent PSD. These accessions had 17 and 33 per cent PSD, respectively at a site where the highest and overall mean PSD were 92 and 75 per cent, respectively. Also, promising genotypes with consistently low levels of seed damage were identified in accessions 226037 and 32410.

Among the insect pest, pea stem fly (*Melanogromyza phaseoli* Tryon), pea leaf miner (*Chromatomyia horticola* Goureau), pea aphid (*Acyrtosiphon pisum* Harris), and pod borer complex [*Helicoverpa armigera* (Hub.), *Lampides boeticus* (L.) and *Etiella zinckenella* (Tr.)] and thrips (*Caliothrips indicus* Bagnall) often cause substantial loss to the crop (Yadav, *et al.*, 2015).

As many as 24 insect species have been reported infesting the pea crop at different stages (Bijur and Verma 1995). Of them, the insect pests like pea pod borer, *Etiella zinckenella* (Treitsshke), gram pod borer, *Helicoverpa armigera* (Hubner), blue butterfly, *Lampides boeticus* (L.), pea leaf miner, *Chromatomyia horticola* (Goureau), pea stem fly, *Melanogromyza phaseoli* (Tryon), pea aphid, *Acyrtosiphon pisum* (Harris), pod fly, *Melanogromyza obtuse* (Malloch) and thrips, *Caliothrips indicus* (Bagnall) are serious pests and causes substantial loss to the crop. These are important pests that infest field pea at flowering and pod formation stages and are considered as main reason of low productivity, besides reduction in yield, the quality of the grains is also affected (Mittal and Ujagir, 2007; Yadav *et al.*, 2015).

Yadav *et al.* (2015) observed a pest complex of about 5 insect pest belonging to 3 orders and 3 families were recorded at Pantnagar infesting the

pea variety 'Pant P-13' at different stages of crop growth in an overlapping manner, out of 5 species, 2 recorded as foliage feeders, one as sap suckers, one as pod feeders and one as a stem feeder one leaf miner, *Chromatomyia horticola* (Goureau) was observed as the major pest on pea. During this course of investigation, 3 species of natural enemies were found to be associated with insect pest of pea of which *Diglypus* sp. was recorded as a major one.

Pea leaf miner caused more than 20 per cent loss in pea grain yield (Mehta *et al.*, 1994). Large numbers of insects-pests are found feeding on this crop, resulting in low productivity of this crop. Pod damage in pea by *H. armigera* and *L. boeticus* were found to be 7.50 and 6.38 per cent, respectively. Pod damage (5.5 to 12.5 per cent) by Lepidoptera pod borer has also been reported by Khan *et al.* (2015).

Yadav and Patel (2015) studied that pea pod borer (*Etiella zinckenella*) and gram pod borer (*Helicoverpa armigera*) are the major pests of field pea causing as high as 50.9 per cent pod infestation with 77.64 per cent seed damage resulting in 23.9 per cent loss in the seed yield.

An overall 10-15 per-cent reduction in yield of field pea was reported due to insect pest. The percent pod damage by pod borer, *E. zinckenella* in field pea ranged from 1.0 to 4.0 percent (Anonymous 2015 b).

Fernandez *et al.* (2017) studied for the sources of resistance to pea weevil in a pisum species germplasm and found that Accessions P669 (*P. sativum*) and P656 (*P. fulvum*) showed a stable reduction in seed infestation across environments. Meanwhile, accessions P314 (*P. sativum* spp.) and P1 (*P. abyssinicum*) showed a stable reduction in larval development. The most promising accession was P665 (*P. sativum* ssp.) which showed resistance at both pod and seed levels.

Manisha *et al.* (2018) observed the seasonal incidence of insect-pests viz. *Etiella zinckenella*, *Helicoverpa armigera*, *Polyommatus boeticus*, *Chromatomyia horticola* and *Caliothrips indicus* on field pea was studied under field conditions during rabi 2015-16. Peak population of *H. armigera* (1.22 larvae/ plants), *E. zinckenella* (5.94 larvae/plant), *P. boeticus* (1.55 larvae/plant), *C. horticola* (3.4 larvae/leaf) and *C. indicus* (3.05 /plant) was recorded on 8<sup>th</sup>, 10<sup>th</sup>, 12<sup>th</sup>, 8<sup>th</sup> and 7<sup>th</sup> Standard meteorological weeks (SMW),

respectively. *Etiella zinckenella* population showed significant positive correlation with temperature (max. and min.) i.e.  $r = 0.715$  and  $0.821$ . However *C. indicus* and *C. horticola* population had significant negative correlation with temperature maximum ( $r = -0.508$  and  $r = -0.712$ ) and minimum ( $r = -0.659$  and  $r = -0.680$ ), respectively; whereas positive and significant correlation was found between *C. horticola* population and morning relative humidity ( $r = 0.731$ ).

Vaibhav *et al.* (2018) studied that the population of *E. zinckenella* larval reached its peak (12.66 larvae/10 plants) in the all control plots on 26th February (8<sup>th</sup> standard weeks) when the maximum and minimum temperature  $22.07^{\circ}\text{C}$  and  $12.55^{\circ}\text{C}$ , respectively, relative humidity 81.07% and rainfall 11.72 mm was recorded. The larval population of *E. zinckenella* showed negative correlation with maximum temperature ( $r = -0.007$ ) while positively correlated with minimum temperature ( $r = 0.378$ ) and the correlation between larval population and relative humidity was found positive ( $r = 0.313$ ) and also positive with rainfall ( $r = 0.393$ ). The observation on the population of *H. armigera* larval reached its peak (10.33 larvae/10 plants) in all control plots on 26<sup>th</sup> February (8<sup>th</sup> standard weeks) when the maximum and minimum temperature  $22.07^{\circ}\text{C}$  and  $12.55^{\circ}\text{C}$ , respectively, relative humidity 81.07% and rainfall 11.72 mm was recorded. The larval population of *H. armigera* showed negative correlation with maximum temperature ( $r = -0.034$ ) while minimum temperature ( $r = 0.364$ ), relative humidity ( $r = 0.351$ ) and rainfall ( $r = 0.384$ ) were positively correlated during crop season i.e. rabi 2014-15.

Kumar *et al.* (2018) noted that six insect-pests were found during the crop season attacking on the crop at different growth stages. Among them, pea pod borer (*Etiella zinckenella*) and gram pod borer (*Helicoverpa armigera*) were recorded as major pests. The pea leaf miner (*Chromatomyia horticola*), pea aphid (*Acyrtosiphon pisum*), blue butter fly (*Lampides boeticus*) and stem fly (*Ophiomyia phaseoli*) were recorded as 'minor' pests. The population of pea pod borer was recorded during, first week of December and reached the peak in the first week of March. The pea pod borer population was negatively correlated with maximum temperature and positively correlated with minimum temperature, relative humidity and rain fall. Gram pod borer population was recorded during second week of December

and reached to its peaked level in last week of February. Its population showed the significant negative correlation with maximum temperature while positive correlations with minimum temperature, relative humidity and rain fall. The initial incidence of pea leaf miner, pea aphid, and stem fly was observed during last week of November to first week of December and subsequently reaching to while to peak level on first and second week of February.

Insect pests are probably the main factor limiting the legume production. Gram pod borer, *H. armigera* Hubner, (Lepidoptera: Noctuidae) is one of the most devastating crop pest worldwide (Singh *et al.*, 2019).

Singh *et al.*, (2020) studied on biology and effective management of gram pod borer, *Helicoverpa armigera* on field pea in rabi 2018-2019 and result showed that the population of *H. armigera* appeared on 4th week of November (1.15 larvae/ 5plant) i.e. 47<sup>th</sup> Standard Meteorological Week (SMW) & reach its peak (15.10 larvae/ 5plant) during 52<sup>nd</sup> SMW i.e. last week of December. The pest population gradually decreased (0.8 larvae/ 5plant) in the 3<sup>rd</sup> week of February i.e. 7<sup>th</sup> SMW due to the reason of crop maturity. Regarding efficacy of treatments cow urine + neem leaf proved most effective which was closely followed by cow urine + tobacco leaf and cow urine + lantana leaf. Maximum yield i.e. 21.40q/ha was given by cow urine + neem leaf which was closely followed by cow urine + tobacco leaf and cow urine + lantana leaf.

Yadav *et al.* (2020) studied the succession of insect pest complex associated with pea was conducted at Instructional farm, College of Agriculture, SKRAU, Bikaner during rabi 2016-17. As many as 7 species of insect pests have been recorded in all stages of the pea. Among them stem fly and leaf miner had appeared in the vegetative stage with peak infestation during 2<sup>nd</sup> week of January and 1<sup>st</sup> week of February, respectively. Whereas, sucking pests like whitefly and aphid appeared during the vegetative stage and continues up to young podding stage of the crop. Gram pod borer, pea pod borer and blue butterfly were appeared from flowering to maturity stage i.e. 3<sup>rd</sup> week of December to 1<sup>st</sup> week of March. The overall observations recorded during the crop period reported that stem fly, gram pod borer and pea pod borer has attained the status of major pest.

Pal *et al.* (2020) observed that aphid population varied from 0.26 per plant to 2.08 per plant in first year and the range was 1.23 to 3.99 per plant during second year, while the larval population of gram pod borer varied from 0.24 to 1.57 per plant in first year and from 0.01 to 0.38 per plant in second year. Pod damaged ranged from 7.20 to 31.17 per cent in first year and the range was 0.29 to 21.87 per cent in second year. Gram pod borer population showed significant and positive correlation with plant height and number of seeds per pod among different plant morphological parameters during both seasons.

Patidar *et al.* (2020) showed that the beginning of *Helicoverpa armigera* infestation was recorded in the 48<sup>th</sup> SMW (26 Nov to 02 Dec) and reached a peak level 4.80 larvae/mrl in the 9<sup>th</sup> standard meteorological week (26 Feb to 04 March). Correlation studies revealed that maximum temperature, Minimum temperature and evaporation exhibited significantly positive correlation ( $r = 0.54, 0.61$  and  $0.61$  respectively), with *H. armigera* larval population. A negative but very weak correlation between *Helicoverpa* larval population and morning and evening relative humidity ( $r = -0.22$ , and  $-0.29$  respectively), was observed to non-significantly level. Whereas positive correlation between *Helicoverpa* larval population rainfall ( $r = 0.14$ ), was also found to be non-significant.

## **2.2 Screening of field pea genotypes for their relative susceptibility towards pest complex.**

Afzal *et al.* (2001) reported that out of the screened eight lines of chickpea against *H. armigera*, they found that two cultivar lines (Pb-2000 and 96051) were highly resistant, three advanced lines (9075, 96052 and BC-6-5) were resistant, two advanced lines (90395-K and 97047) were moderately resistant and only advanced line (88194) was susceptible.

Mandal (2003) also reported that two genotypes (PS83149 and Bhawanipatna) were resistant, 6 were moderately resistant, 7 were moderately susceptible and 3 were in susceptible to the pest *H. armigera*.

Singh *et al.* (2004) evaluated 19 early maturing field pea genotypes (dwarf) and 13 late maturing genotypes (tall) against pea leaf miner, *Chromatomyia horticola* and pod borer, *Etiella zinckenella*, the observed per cent pod damage done by pod borer in early 7 maturing genotypes was

minimum (1%) in Pant P-11 HUDP-15, LFP-283, KPMR-526 and KPMR-593 and maximum in HUDP 17 (4.0%).

Vishal and Ram (2005) screened 165 germplasm of pea for resistance and found out of 18 dwarf germplasm, two germplasm viz., P4039 and P-4107 were resistant for *H. armigera*. Eleven genotypes (HFP-1137, HFP 1120, HFP- 530B, HFP-715, HFP-529, HFP-1107, HFP- 9426, HFP-4, HFP-9907B, HFP-8909 and HFP- 1140 were categorised as moderately resistant (PSR: 3-5), six genotypes (HFP-1132, HFP- 1129, HFP-1010, HFP-914, HFP-1125 and HFP- 8712) were observed as highly susceptible (PSR: 8-9) to *P. boeticus* on the basis of PSR.

Chandraker *et al.* (2006) screened fourteen chickpea genotypes against *H. armigera*, and found BG-1047, BGD-74, BGD-330, FG-344, FG-451, H-92-67, H-97-71, H-92-106, IG-443, KW-109, RG-9210, RG-9213, RSG-798 and JG-74. BGD74 had the minimum pod damage of 6.64% and the highest yield of 1433 kg per hectare.

Kooner and Cheema (2006) who evaluated the resistance of pigeon pea genotypes against pod borer complex and reported three genotypes (AL 1498, AL 1502 and AL 1340: PSR 3.0-3.5) as promising on the basis of PSR compared with check varieties (AL 15, AL 201 and T 21: PSR 4.0 to 5.5) and infestor (PSR 6.0).

Singh *et al.* (2013) reported minimum (1.91%: in Pant P-183, Pant P-184, RFP-61, KPMR-913 and VL-54) and maximum pod damage (12.0%: HFP-716).

Abhilasha and Shekharappa (2017) reported that three varieties Arka Karthika, Arka Ajit and Arka Sampurna were observed as resistant against pod borers (*Helicoverpa armigera*, *Lampides boeticus* and *Cydia nigricana*) with the per cent pod damage of 19.58, 17.08 and 16.56 respectively whereas, two varieties GS-10 and DS-10 as moderately resistant with the per cent pod damage of 30.37 and 36.35. The five varieties observed as intermediate and five as susceptible based on percent pod damage.

Krishna *et al.* (2019) conducted study on 50 field pea germplasm screening against leaf miner, aphid and pod borer. The population of leaf miner and aphid were observed 20 DAS while pod borer at 50% flowering till harvesting of the crop which ranged in leaf miner, aphid and pod borer from

12.0 to 22.80, 19.33 to 20.80 and 0.17 to 4.47 respectively. Forty eight out of 50 germplasm screened against leaf miner fell under resistant category while two germplasm were found moderately resistant. All the 50 germplasm screened against aphid fell under moderately resistant category. Maximum pod borer population of 4.47/5 plants was found in the germplasm VL 58 and Pant P 195. Lowest population of 0.17 pod borer/ 5 plants was recorded in the germplasm IPFD 12-2 and RG 3.

Manisha *et al.* (2019) evaluated eighteen field pea genotypes to know their reaction to pod borer complex (*Helicoverpa armigera*, *Etiella zinckenella* and *Lampides boeticus*). Sixteen genotypes (HFP1140, HFP-914, HFP-1120 and HFP-530B, HFP-1129, HFP-1010, HFP-1125, HFP-715, HFP-4, HFP-9907B, HFP-1132, HFP-1107, HFP-1137, HFP-8712, HFP-8909 and HFP-529) were categorized as moderately resistant to *E. zinckenella*. However, three genotypes (HFP-1137, HFP530B and HFP-529) were examined as resistant (PSR 2), thirteen genotypes as moderately resistant (PSR 3-5) and one genotype (HFP-8712) as highly susceptible (PSR-8) against *H. armigera*. On the consequences of Pest Susceptibility Rating (PSR) six genotypes (HFP-1132, HFP-1129, HFP-1010, HFP-914, HFP-1125 and HFP-8712) were observed as highly susceptible (PSR: 8-9) *P. boeticus*.

## **CHAPTER III**

### **MATERIALS AND METHODS**

This chapter deals with a brief description of the location of study area, experimental details, observation recorded, methodology and techniques employed for analysis of observations during the course of investigation. In accordance with the objectives, the study was divided into sections as detailed below:

1. Seasonal incidence of major insect pests on pea crop.
2. Screening of field pea genotypes for their relative susceptibility towards pest complex.

#### **3.1 Location:**

The experiments were laid out at the Research farm of R.A.K. College of Agriculture, Sehore, Madhya Pradesh, during *rabi* season of 2020-21.

#### **3.2 Climate, season and geography:**

Sehore is situated in sub-tropical zone at the latitude of 23°12" North and longitude of 77°05" East. The altitude of the place is 498.77 meters from mean sea level (MSL) in western part of Vindhya plateau of Madhya Pradesh. The average annual precipitation of Sehore is 1000 to 1200 mm. Most of the rains are received from July to September. The mean annual maximum and minimum temperatures are 31.41°C and 16.98°C, respectively. May is the hottest month, having maximum average temperature of 40.50°C, winter months are mild cool with average minimum temperature of 9.02°C and maximum of 27.2°C.

#### **3.3 Soil:**

The soil of the experimental area was medium black having clay loam texture (vertisol) consisting clay (58.9%), silt (10.6%) and sand (30.7%). The pH of the soil was 7.5 and it was rich in phosphorus & organic matter, medium in potash content and with medium nitrogen content.

#### **3.4 Field preparation:**

The field was ploughed during October, 2020 with the help of tractor followed by harrowing twice with blade harrow (*Desi Bakher*). Stubbles of the previous crop were picked and removed from the site.

#### **3.5 Method of sowing**

The seeds were sown manually. A pre-sowing irrigation was given for proper germination. The distance between rows was maintained uniformly at 30 cm.

### **3.6 Harvesting, threshing and yield:**

Harvesting of the crop was done with the help of simple sickles, manually and threshing was done with the help of wooden sticks. After threshing, the seeds were dried under sunlight for two days and finally grain yield of each net plot was recorded and converted to kg/ha.

#### **Experiment 1: Seasonal incidence of major insect pests on pea crop.**

##### **Experimental details:**

A non-replicated trial was laid out in the field for seasonal incidence of major insect pests of crop. The details of the experiment are as follows:

- |                            |   |                   |
|----------------------------|---|-------------------|
| 1. Crop                    | : | Pea               |
| 2. Variety                 | : | 'Arkel'           |
| 3. Plot Size               | : | 50 m <sup>2</sup> |
| 4. Row to row distance     | : | 30 cm             |
| 5. Plant to plant distance | : | 30 cm             |
| 6. Number of plots         | : | 1 (untreated)     |
| 7. Date of sowing          | : | 18/11/2020        |
| 8. Date of germination     | : | 25/11/2020        |

The crop was sown following standard agronomical practices and maintained without insecticidal application to study the succession of insect pests associated with pea crop. The incidence of insect pests was recorded right from germination till the harvest of the crop at weekly intervals. The immature stages of the pests were collected and brought to the laboratory for rearing and for the purpose of their identification. The collected adult insects were killed in a killing bottle, mounted on card depending on its size and labelled properly. The specimens were identified with the help of already identified collections and the taxonomist in the department.

##### **Observations recorded**

Observations were recorded weekly on the population of major insect pests of pea from 10 randomly selected tagged plants throughout the crop season commencing from the germination till maturity. The methods used for recording the population of these pests have been described below:

**For pod borer complex-** Number of larvae of pea pod borer, gram pod borer and blue butterfly were recorded by counting their number on ten randomly selected plants from the plot (visual count technique).

**For pea leaf minor-** Numbers of larvae of leaf miner were recorded from 3 leaves (1- each from upper, middle and lower canopy) from each of the ten randomly selected plants at weekly intervals starting from appearance.

**For pea aphid-** The populations of pea aphid, *Acyrtosiphon pisum* was recorded by counting their number from the tender parts of ten randomly selected plants from the plot.

## **Experiment 2: Screening of field pea genotypes for their relative susceptibility towards pest complex**

### **Experimental details:-**

- |  |   |                                   |
|--|---|-----------------------------------|
| 1. Design                              | : | Randomized Block Design           |
| 2. Number of replications              | : | 3                                 |
| 3. Plot Size                           | : | 1.8 x 4.0 m (7.2 m <sup>2</sup> ) |
| 4. Number of rows per plot             | : | 06                                |
| 5. Row to row distance                 | : | 30 cm                             |
| 6. Plant to plant distance             | : | 10 cm                             |
| 7. Replication to replication distance | : | 1.0 m                             |
| 8. Number of treatment                 | : | 13 field pea genotypes            |
| 9. Row length                          | : | 4.0 m                             |

### **Treatments (entry codes):**

<b>T1</b>	Pant P 479	<b>T8</b>	IPFD 10-12
<b>T2</b>	KPMR 942	<b>T9</b>	IPFD 20-03
<b>T3</b>	HFP 17-11	<b>T10</b>	Pant P 480
<b>T4</b>	RNCP 14-13	<b>T11</b>	IPFD 11-05
<b>T5</b>	IPFD 12-02	<b>T12</b>	Pant P 484
<b>T6</b>	HFP 16-02	<b>T13</b>	IPFD 20-02
<b>T7</b>	IPFD 20-09		

The entries were kept unprotected for natural infestation by the pest complex.

### **Method of observation:**

The borers' attack was compared on the basis of infestation of pods. The larval population of each borer was recorded at weekly intervals starting with pod initiation till harvest and overall mean population was calculated. From each treatment, randomly three plants were selected as sample plants and tagged with the help of paper card.

1. The larval population of *H. armigera* was counted by ground sheet method. In ground sheet method we put a sheet on the ground and by shaking the plant collected larvae were counted.
2. Population of *P. boeticus* was counted by ground sheet as well as by visual count method (by opening 3 pods from randomly selected 3

plants of each replication).

The genotypes were screened for susceptibility of pod borer complex under natural insect infestation in the field. For this, pod damage and pod yield was recorded from the sampled plants after maturity. The damage of pod borer complex was differentiated as, in *H. armigera*: pods with round holes and *P. boeticus*: buds, flowers and young pods with boreholes, presence of slug like caterpillar. The pod damage was recorded at harvesting stage from 3 plants selected at random. Total pods and damaged pods were counted to calculate the per cent pod damage of each insect and the data was analysed statistically.

$$\text{Pod damage \%} = \frac{\text{No. of damaged pods per plant}}{\text{Total no. of pods per plant}} \times 100$$

Pest Susceptibility Rating (PSR) was calculated on the basis of total pod damage by pod borer complex, by taking Pant P 479 as check. Based on pod damage the pest susceptibility rating (PSR) was counted as suggested by using a formula derived by Abott (1925) as given below:

$$\text{Pest susceptibility percent} = \frac{\text{P. D. of check} - \text{P. D. of test of entry}}{\text{P. D. of check}} \times 100$$

where, P. D. = Mean of per cent pods damaged.

Susceptibility for pod borer complex damage in field pea genotypes was rated using a scale of 1-9 as reported by Vishal *et al.*, 2005. The per cent pest susceptibility will be further converted into 1 to 9 rating scale as follows:

<b>Pest Susceptibility Rating (PSR)</b>	<b>Pest susceptibility (%)/ resistance (%)</b>	<b>Remarks</b>
1	100%	Highly resistant
2	75 to 99.9%	
3	50 to 74.9%	
4	25 to 49.9%	Least susceptible
5	10 to 24.9%	
6	-10 to 9.9%	Moderately susceptible
7	-25 to -9.9%	
8	-50 to -24.9%	Highly susceptible
9	-50% or less	

Yield - The grain yield (g) per plant will be recorded at harvest and converted into kg/ha and calculated under different treatments as given below:

$$\text{Yield /ha} = \text{Factor grain yield / plot}$$

where, Factor = (10,000/Net plot size) in sq. m.

## Statistical analysis

For analysis of data simple randomized block design was used. The following formulae were used for various estimations.

1. Standard error of treatment mean:

$$\text{S.E. (m)} = \frac{\text{MSS(e)}}{r \times t}$$

where,

S.E. (m) = Error mean sum of square

r = Number of replications

t = 't' value at 5% probability level

2. Critical Difference:

$$\text{C.D.} = \sqrt{\frac{\text{error variance}}{n}} \times \sqrt{2} \times t$$

where, n = the number of observations averaged

error variance = mean sum of squares due to error

't' = value from t-table at 5% level of significance and at error d.f.



**Infestation of larvae of Gram pod borer, *Helicoverpa armigera* (Hubner)**



**Infestation of larvae of Blue butterfly , *L.boeticus***



**Infestation of Pea Aphid, *Acyrtosiphon pisum***

**Plate :1 Major insect pests of pea crop**

## CHAPTER IV

### RESULTS

The results of the present investigation entitled “**Studies on succession of insect pest complex associated with Pea (*Pisum sativum* L.) and screening of pea genotypes against major pests.**” are presented in this Chapter.

#### **4.1 Seasonal incidence of major insect pests of pea crop.**

During Rabi season of 2020-21, four major insect pests were observed in pea crop at different stages of crop growth. The pests were gram pod borer, *Helicoverpa armigera* (Hubner), blue butterfly, *Lampides boeticus* (L.), pea leaf miner, *Chromatomyia horticola* Goureau and pea aphid, *Acyrtosiphon pisum* (Harris).

##### **4.1.1 Gram pod borer, *Helicoverpa armigera* (Hubner).**

During the course of this investigation, the larvae of *Helicoverpa armigera* feed on leaves, inflorescence, pods and seeds of the crop to a great extent. This degree of damage to the crop resulted as an economic threat and recognized as the status of major pest during the crop period. In 48<sup>th</sup> Standard Meteorological Week (29<sup>th</sup> Nov to 05<sup>th</sup> Dec) *H. armigera* started appearing with 0.4 larvae/ plant as represented in Fig. 1. Further it continued to increase from 2<sup>nd</sup> week of December to 3<sup>rd</sup> week of February (49<sup>th</sup> to 7<sup>th</sup> SMW), which varied from 1.00 to 7.20 larvae/plants. In 8<sup>th</sup> SMW (24<sup>th</sup> February) *H. armigera* activity was 7.80 larvae/plants) on (8<sup>th</sup> SMW) which was at its maximum throughout the study. During this stage, the maximum and minimum temperatures were 34.22°C and 11.55°C, respectively, relative humidity was 63.89 per cent and no rainfall was observed. The incidence then continued till the maturity of the crop 6.00 larvae/plants in the 11<sup>th</sup> SMW (14<sup>th</sup> to 20<sup>th</sup> March).

##### **4.1.2 Blue butterfly, *Lampides boeticus***

The crop was observed to be affected by the insect larvae, where they bore into the floral buds, pea pods causing internal feeding resulted in considerable damage to pea pods. *L. boeticus* started appearing at flower and pod formation stage that continued up to the full maturity of the crop.

The data presented in Table 1 show that the first appearance of *L. boeticus* was recorded in the 52<sup>nd</sup> Standard Meteorological Week (27<sup>th</sup> Dec to 02<sup>nd</sup> Jan) to 0.9 larvae/ plant. The larval population then continues to increase from 1<sup>st</sup> week of January to 4<sup>th</sup> week of February (1<sup>st</sup> to 8<sup>th</sup> SMW) which then varies from 1.70 to 8.10 larvae/ plants. In 9<sup>th</sup> SMW (4<sup>th</sup> March) *L. boeticus* activity was recorded to be highest at 8.60 larvae/ plants. During this stage, the maximum and minimum temperature were 34.94°C and 13.24°C, respectively, relative humidity was 64.50 per cent and no rainfall was observed. Further, this incidence then continued till the maturity of the crop *i.e.* 7.70 larvae/ plants in the 11<sup>th</sup> SMW (14<sup>th</sup> to 20<sup>th</sup> March).

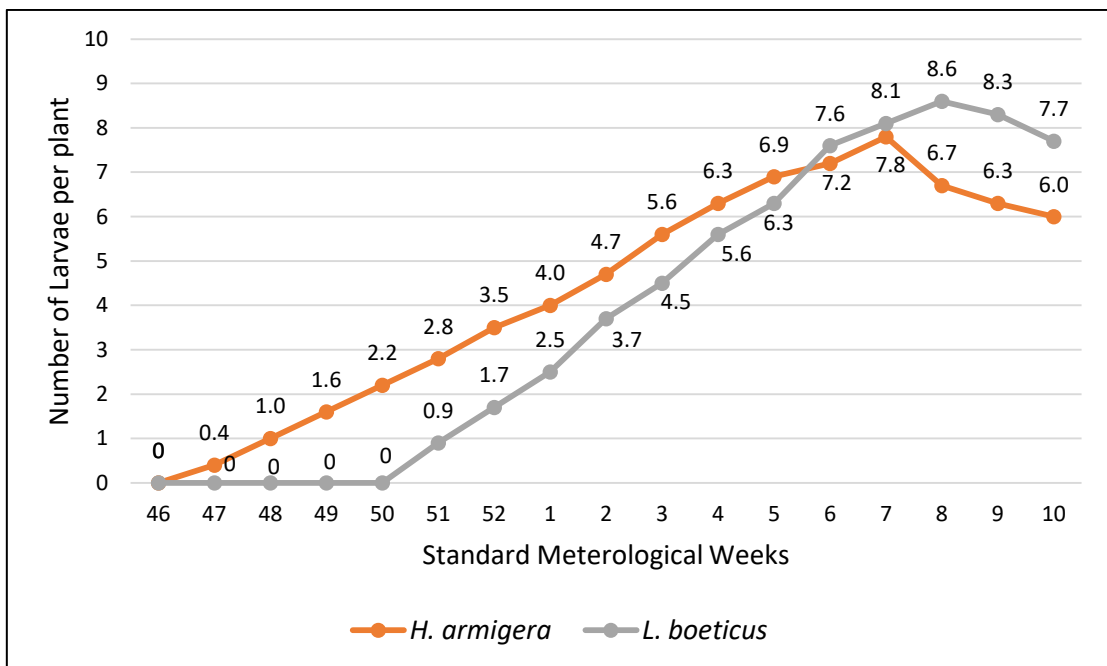
#### **4.1.3 Pea leaf miner, *Phytomyza (Chromatomyia) horticola* Goureau**

During the study period, the larvae of pea leaf miner *Chromatomyia horticola* were found to infest pea leaves. Since the larvae feed within the plant's leaves or needles, they produce either large blotches or tunnels and wander under the surface of the leaf. Larvae eat the green tissue inside the leaf and leave a meandering trail that is covered by a thin case or cover and gives the appearance of large blemishes or spots. The data of *C. horticola* population is presented in table 1, fig. 2 shows that the larvae of *C. horticola* appeared in 4<sup>th</sup> week of December (51<sup>st</sup> SMW) to 3.4 larvae/leaf. The larval population then continues to increase from 52<sup>nd</sup> SMW to 4<sup>th</sup> SMW (27<sup>th</sup> Dec to 30<sup>th</sup> Jan) which ranged from 3.6 to 5.1 larvae/ leaf. In 5<sup>th</sup> SMW (4<sup>th</sup> Feb) *C. horticola* activity was recorded with 5.50 larvae/leaf which was highest throughout the study period. During this stage, the maximum and minimum temperature were 25.91°C and 10.01°C respectively; the relative humidity was 66.24 per cent and no rainfall was observed. However, this incidence continued till the maturity of the crop (3.1 larvae/leaf) in the 11<sup>th</sup> SMW (14<sup>th</sup> to 20<sup>th</sup> March).

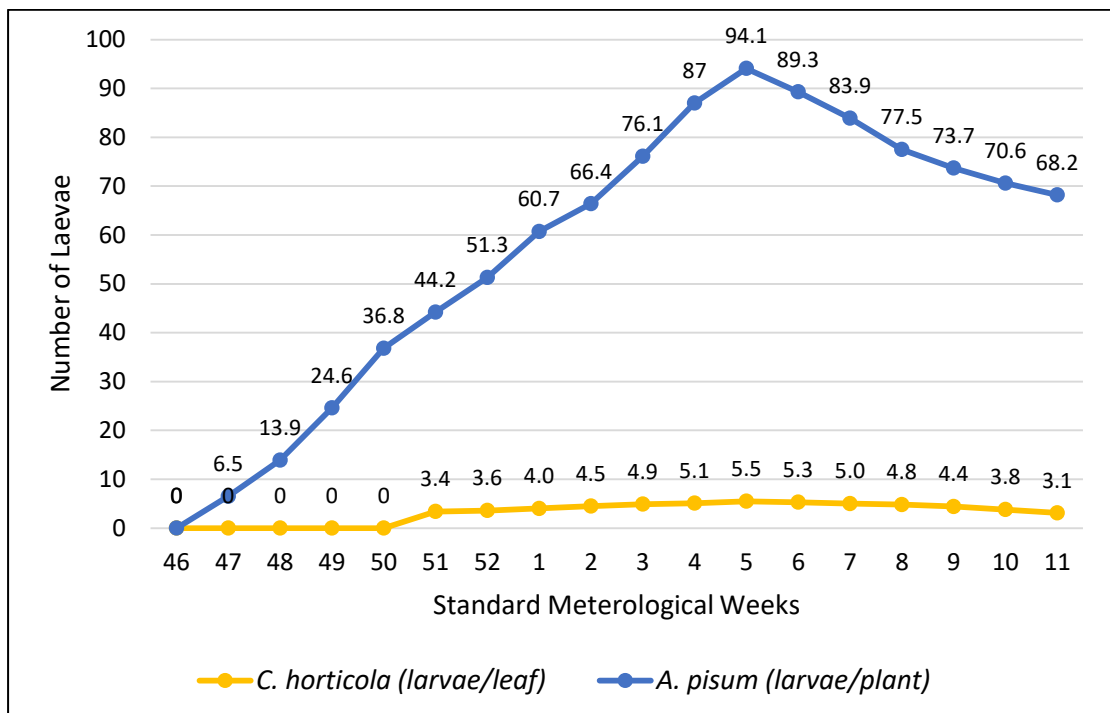
**Table 1: Seasonal incidence of major insect pests of pea during *Rabi* 2020-21.**

SMW	<i>H. armigera</i> (larvae/plant)	<i>L. boeticus</i> (larvae/plant)	<i>C. horticola</i> (larvae/leaf)	<i>A. pisum</i> (larvae/plant)	Temperature		Rainfall (mm)	Relative Humidity (%)
					Maximum (°C)	Minimum (°C)		
46	-	-	-	-	29.62	16.70	0.40	64.26
47	-	-	-	06.5	29.87	15.39	0.00	63.83
48	0.4	-	-	13.9	27.05	14.60	0.00	69.22
49	1.0	-	-	24.6	29.10	14.70	1.28	65.44
50	1.6	-	-	36.8	31.01	14.20	0.61	64.50
51	2.2	-	3.4	44.2	21.58	13.96	0.00	66.00
52	2.8	0.9	3.6	51.3	25.94	13.20	0.00	66.45
1	3.5	1.7	4.0	60.7	23.48	9.50	0.00	67.30
2	4.0	2.5	4.5	66.4	25.54	9.70	0.21	66.80
3	4.7	3.7	4.9	76.1	27.24	9.40	0.00	64.78
4	5.6	4.5	5.1	87.0	24.18	10.20	0.00	66.55
5	6.3	5.6	5.5	94.1	25.91	10.01	0.00	66.24
6	6.9	6.3	5.3	89.3	28.30	9.25	0.00	64.05
7	7.2	7.6	5.0	83.9	31.58	10.85	0.00	64.32
8	7.8	8.1	4.8	77.5	34.22	11.55	0.00	63.89
9	6.7	8.6	4.4	73.7	34.94	13.29	0.00	64.50
10	6.3	8.3	3.8	70.6	34.90	13.90	0.00	64.20
11	6.0	7.7	3.1	68.2	35.01	14.43	0.00	66.27

**Fig 1: Population of *H. armigera* and *L. boeticus* in pea during Rabi, 2020-21.**



**Fig 2: Population of *C. horticola* and *A. pisum* in pea during Rabi, 2020-21.**



#### **4.1.4 Pea Aphid, *Acyrtosiphon pisum*.**

During the study period, the larvae of pea Aphid, *Acyrtosiphon pisum* was found to infest the pea plant.

The data of *A. pisum* population is presented in Table 1, Fig. 2, which shows that the larvae of *A. pisum* appeared in 4<sup>th</sup> week of November (47<sup>th</sup> SMW) to 6.5 larvae/plant. Further, the larval population remained continued to increase from 48<sup>th</sup> SMW to 4<sup>th</sup> SMW (29<sup>th</sup> Nov to 30<sup>th</sup> Jan) which ranged from 13.9 to 87.0 larvae/ leaf. In 4<sup>th</sup> Feb (5<sup>th</sup> SMW) the activity of pea aphid (*A. pisum*) was highest with 94.1 larvae/leaf. During this stage, maximum and minimum temperature were 25.91°C and 10.01°C respectively, relative humidity was 66.24 per cent and no rainfall was observed. This incidence then continued till the maturity of the crop *i.e.* 68.2 larvae/leaf in the 11<sup>th</sup> SMW (14<sup>th</sup> to 20<sup>th</sup> March).

#### **4.1.5 Correlation between pest incidence and weather parameters**

The study revealed that weather parameters played a significant role in the incidence of larval population. The correlation studies of the present findings in table 2 revealed that the larval population of *H. armigera* per plant was found to have positive and non-significant effect with maximum temperature ( $r= 0.357$ ) and significant negative with minimum temperature ( $r= -0.628$ ). While it was negatively correlated with relative humidity ( $r= -0.260$ ) and rainfall ( $r= -0.465$ ), being non-significant. The population in number of larvae per plant of *L. boeticus* was found positively correlated with maximum temperature ( $r= 0.604$ ) being statistically significant. Further, it was observed to be negatively correlated with minimum temperature ( $r= -0.382$ ), being non-significant, during the study period. While, it was negatively correlated with relative humidity ( $r= -0.345$ ) and rainfall ( $r= -0.441$ ), being non-significant.

Further, the larval population per leaf of *C. horticola* was found significantly negative with minimum temperature and rainfall ( $r= -0.826$  and  $r= -0.584$ , respectively) and negative with maximum temperature ( $r= -0.097$ ) and relative humidity ( $r= -0.055$ ), being non-significant.

**Table 2: Correlation between weather parameters and major insect pests of pea during Rabi 2020-21.**

Insect pests	Weather parameters						
	Maximum Temperature		Minimum Temperature		Rainfall		Relative Humidity
	r	b <sub>yx</sub>	r	b <sub>yx</sub>	r	b <sub>yx</sub>	r
<i>H. armigera</i>	0.357	-	-0.628*	-0.70	-0.465	-	-0.260
<i>L. boeticus</i>	0.604*	0.50	-0.382	-	-0.441	-	-0.345
<i>C. horticola</i>	-0.097	-	-0.826*	-0.73	-0.584*	-3.76	-0.055
<i>A. pisum</i>	0.061	-	-0.806*	-9.85	-0.447	-	-0.092

\*significant at 5% level of significance

The larval population per plant of *A. pisum* had a significantly negative correlation with minimum temperature ( $r = -0.806$ ), but positive non-significant correlation with maximum temperature ( $r = 0.061$ ); while it was negatively correlated with relative humidity ( $r = -0.092$ ) and rainfall ( $r = -0.447$ ), being non-significant.

#### **4.2 Screening of field pea genotypes for their relative susceptibility to the pest complex.**

During the study period, the varietal screening of 13 pea varieties including a check was carried out under natural field conditions for the relative susceptibility towards pod borer complex. Performance of pea varieties against the pod borer complex was estimated on the basis of mean per cent of pod damage and yield (kg/ha).

##### **4.2.1 Gram pod borer, *Helicoverpa armigera* (Hübner).**

Larval Population of pod borer complex is represented in Table 2 revealed that none of the studied genotype was found free from *H. armigera*. Larval population of *H. armigera* was the minimum in Pant P 484 being 1.21 larvae/ plant and maximum in KPMR 942 being 2.01 larvae/ plant. All the genotypes had significant infestation of *H. armigera*. The larval population in various genotypes was 1.29 larvae/ plant (IPFD 12-02), 1.35 larvae/ plant (IPFD 20-03), 1.40 larvae/ plant (IPFD 11-05), 1.47 larvae/ plant (Pant P 480), 1.53 larvae/ plant (IPFD 20-09) 1.59 larvae/ plant (Pant P 479), 1.66 larvae/ plant (IPFD 20-02), 1.69 larvae/ plant (RNCP 14-13), 1.77 larvae/ plant (HFP 17-11), 1.83 larvae/ plant (IPFD 10-12) and 1.91 larvae/ plant (HFP 16-02).

Further, the percent damage of pods caused by the destructive larvae of *H. armigera* was recorded and it was found to be highest with 12.82% in KPMR 942 variety of pea which was found statistically same as in HFP 16-02 with 12.37 per cent pod damage. IPFD 12-02 (2.86%) and IPFD 20-03 (3.57%). The percent pod damage in various genotypes was IPFD 11-05 (4.78%), Pant P 480 (5.56%), IPFD 20-09 (7.41%), Pant P 479 (7.90%), IPFD 20-02 (8.21%), RNCP 14-13 (9.15%), HFP 17-11 (10.05%) and IPFD 10-12 (11.64%).

Pest susceptibility rating (PSR) ranged from 2 to 9 for *H. armigera*. Three varieties (Pant P 484, IPFD 20-03 and IPFD 12-02) were considered as highly resistant (PSR 2-3), two varieties (Pant P 480 and IPFD 11-05) were considered as least susceptible (PSR 4-5), four varieties (Pant P 479, RNCP 14-13, IPFD 20-09 and IPFD 20-02) were considered as moderately susceptible (PSR 6-7) and four varieties (KPMR 942, HFP 17-11, HFP 16-02 and IPFD 10-12) were considered as highly susceptible (PSR 8-9) against *H. armigera*.

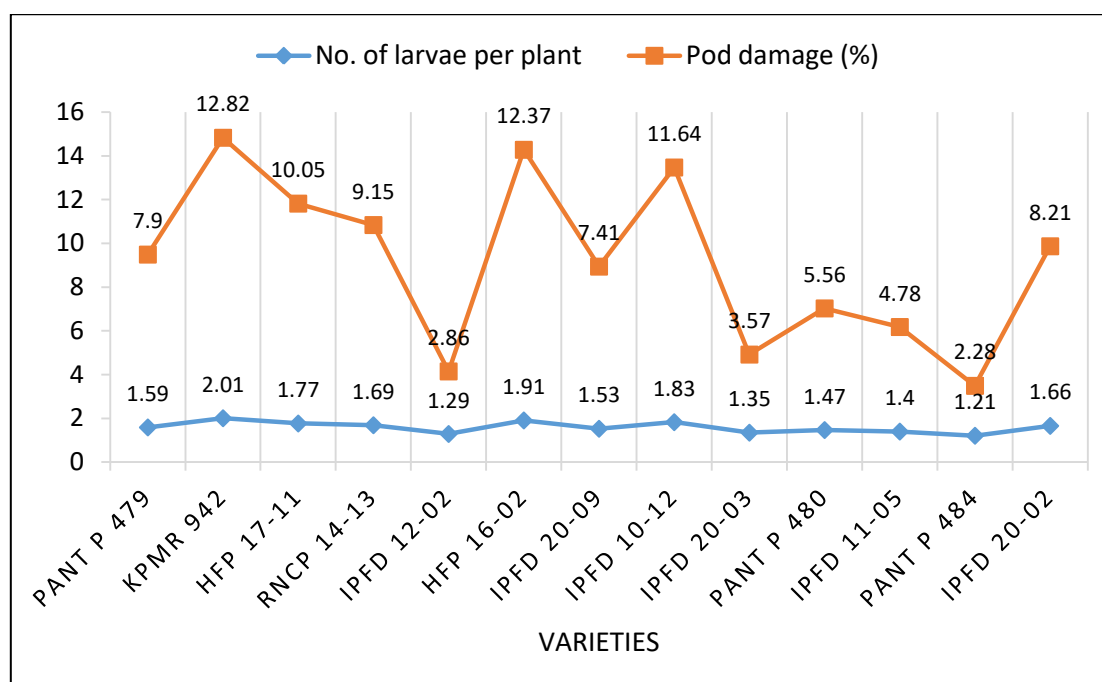
**Table 3. Larval population, Pod damage (%) and Pest Susceptibility Rating (PSR) for *H. armigera* in pea during 2020-21.**

Sr. No.	Varieties	No. of larvae per plant	Pod damage (%)	Pest Susceptibility Rating (PSR)
1	Pant P 479	1.59(1.61)*	7.90(16.21)**	6
2	KPMR 942	2.01(1.74)	12.82(20.81)	9
3	HFP 17-11	1.77(1.66)	10.05(18.26)	8
4	RNCP 14-13	1.69(1.64)	9.15(17.44)	7
5	IPFD 12-02	1.29(1.51)	2.86(9.63)	3
6	HFP 16-02	1.91(1.71)	12.37(20.4)	9
7	IPFD 20-09	1.53(1.59)	7.41(15.71)	6
8	IPFD 10-12	1.83(1.68)	11.64(19.8)	8
9	IPFD 20-03	1.35(1.53)	3.57(10.65)	3
10	Pant P 480	1.47(1.57)	5.56(13.51)	4
11	IPFD 11-05	1.40(1.55)	4.78(12.56)	4
12	Pant P 484	1.21(1.49)	2.28(8.57)	2
13	IPFD 20-02	1.66(1.63)	8.21(16.53)	6
S.E.(m) ±		0.01	0.55	-
C.D. (p = 0.05)		0.04	1.63	-

\*Figures in the parentheses are  $\sqrt{(x + 1)}$  transformed value

\*\*Figures in the parentheses are Arc sine transformed value.

**Fig 3: Larval population and pod damage for *H. armigera* in pea during Rabi, 2020-21.**



#### 4.2.2 Blue Butterfly, *Lampides boeticus* (Linnaeus)

Maximum population of *L. boeticus* was recorded on KPMR 942 (2.22 larvae/ plant), while it was minimum in Pant P 484 (1.36 larvae/ plant). All the genotypes were found significant for the infestation of *L. boeticus*. The larval population in various genotypes was 1.43 larvae/ plant (IPFD 12-02), 1.49 larvae/ plant (IPFD 20-03), 1.54 larvae/ plant (IPFD 11-05), 1.60 larvae/ plant (Pant P 480), 1.66 larvae/ plant (IPFD 20-09), 1.72 larvae/ plant (Pant P 479), 1.78 larvae/ plant (IPFD 20-02), 1.81 larvae/ plant (RNCP 14-13), 1.89 larvae/ plant (HFP 17-11), 1.94 larvae/ plant (IPFD 10-12) and 2.02 larvae/ plant (HFP 16-02).

Pod damage by *L. boeticus* was the maximum in genotype KPMR 942 (15.00%) followed by HFP 16-02 (13.40%) which was found to be statistically same with 12.34 per cent pod damage in IPFD 10-12. The percent damage of pods caused by the destructive larvae of *L. boeticus* was recorded and it was found to be minimum with 2.83 per cent in Pant P 484 variety of pea followed by IPFD 12-02 (3.51%) which was found at par with IPFD 20-03 (3.57%). The percent pod damage in various genotypes was IPFD 11-05 (4.78%), Pant P 480 (5.67%), IPFD 20-09 (7.41%), Pant P 479 (7.90%), IPFD 20-02 (8.86%),

RNCP 14-13 (9.80%) and HFP 17-11 (10.74%).

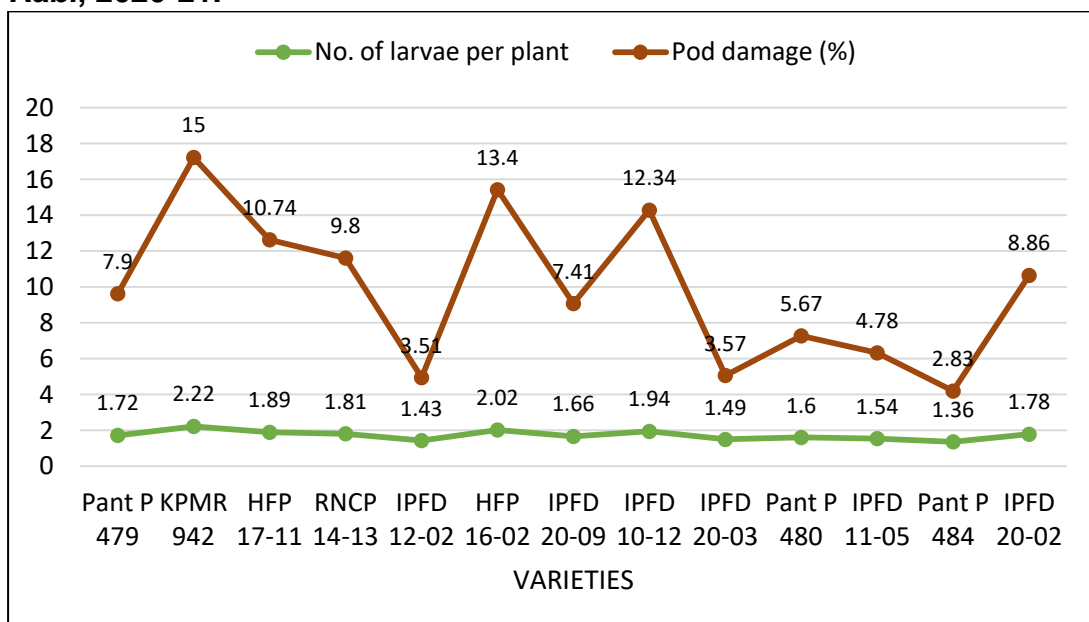
**Table 4. Larval population, Pod damage (%) and Pest Susceptibility Rating (PSR) for *L. boeticus* in pea during 2020-21.**

Sr. No.	Varieties	No. of larvae per plant	Pod damage (%)	Pest Susceptibility Rating (PSR)
1	Pant P 479	1.72(1.65)*	7.90(16.21)**	6
2	KPMR 942	2.22(1.79)	15.00(22.47)	9
3	HFP 17-11	1.89(1.70)	10.74(18.84)	8
4	RNCP 14-13	1.81(1.68)	9.80(18)	7
5	IPFD 12-02	1.43(1.56)	3.51(10.55)	3
6	HFP 16-02	2.02(1.74)	13.40(21.21)	9
7	IPFD 20-09	1.66(1.63)	7.41(15.71)	6
8	IPFD 10-12	1.94(1.72)	12.34(20.35)	9
9	IPFD 20-03	1.49(1.58)	3.57(10.65)	3
10	Pant P 480	1.60(1.61)	5.67(13.64)	4
11	IPFD 11-05	1.54(1.59)	4.78(12.56)	4
12	Pant P 484	1.36(1.54)	2.83(9.37)	3
13	IPFD 20-02	1.78(1.67)	8.86(17.13)	7
S.E.(m) ±		0.01	0.72	-
C.D. (p = 0.05)		0.03	2.11	-

\*Figures in the parentheses are  $\sqrt{+1}$  transformed value

\*\*Figures in the parentheses are Arc sine transformed value.

**Fig 4: Larval population and pod damage for *L. boeticus* in pea during Rabi, 2020-21.**



Pest susceptibility rating (PSR) ranged from 3 to 9 for *L. boeticus*. Three varieties (IPFD 12-02, IPFD 20-03 and Pant P 484) were considered as highly resistant (PSR 3), two varieties (Pant P 480 and IPFD 11-05) were considered as least susceptible (PSR 4), four varieties (Pant P 479, RNCP 14-13, IPFD 20-09 and IPFD 20-02) were considered as moderately susceptible (PSR 6-7) and four varieties (KPMR 942, HFP 17-11, HFP 16-02 and IPFD 10-12) were considered as highly susceptible (PSR 8-9) against *H. armigera*.

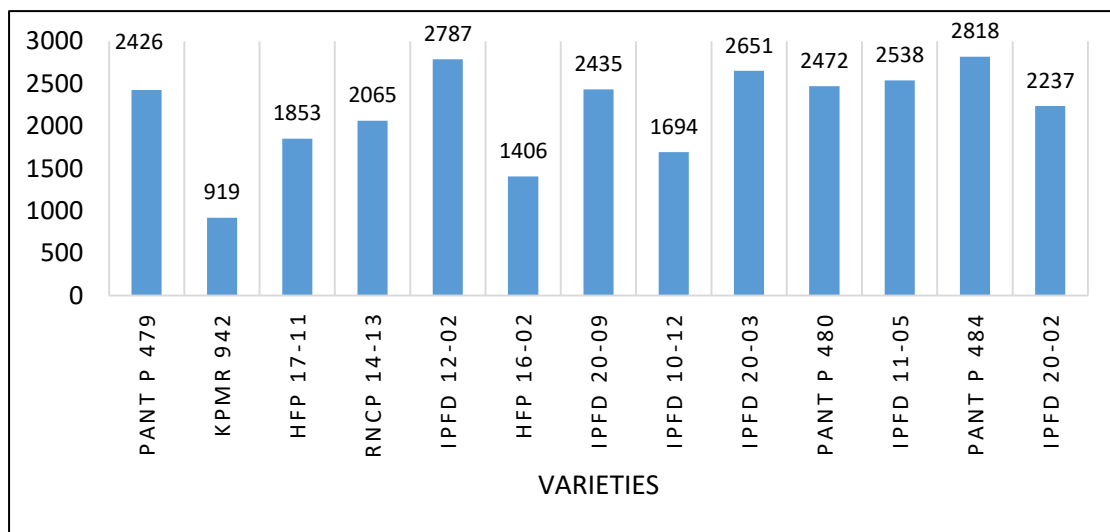
#### 4.2.3 Yield of pea varieties screened for the relative susceptibility towards pod borer complex.

The pea varieties were grown under natural conditions. The yield data in the table 5 revealed that the maximum yield was recorded from Pant P 484 (2818 kg/ha) which was at par with IPFD 12-02 (2787 kg/ha) followed by IPFD 20-03 (2651 kg/ha), however it was found at par with IPFD 11-05 (2538 kg/ha). Further, yield of Pant P 480 was 2472 kg/ha which was found at par with IPFD 20-09 (2435 kg/ha) and Pant P 479 (2426 kg/ha). The minimum yield was recorded from HFP 16-02 (1406 kg/ha), however it was at par with KPMR 942 (919 kg/ha) during the crop period.

**Table 5. Yield of field pea varieties screened for the relative susceptibility to pod borer complex during *Rabi*, 2020-21.**

Sr. No.	Varieties	Yield (Kg/ha)
1	Pant P 479	2426
2	KPMR 942	919
3	HFP 17-11	1853
4	RNCP 14-13	2065
5	IPFD 12-02	2787
6	HFP 16-02	1406
7	IPFD 20-09	2435
8	IPFD 10-12	1694
9	IPFD 20-03	2651
10	Pant P 480	2472
11	IPFD 11-05	2538
12	Pant P 484	2818
13	IPFD 20-02	2237
S.E.(m) ±		156.8
C.D. (p = 0.05)		469.2

**Fig 5: Yield of field pea varieties during *Rabi*, 2020-21.**



## CHAPTER V

### DISCUSSION

The discussion of the present investigation entitled “**Studies on succession of insect pest complex associated with Pea (*Pisum sativum*) and screening of pea genotypes against major pests**” are presented in this Chapter.

#### **5.1 Seasonal incidence of major insect pests of pea crop.**

During *Rabi* season of 2020-21, four major insect pests were observed in pea crop at different stages of crop growth. The pests were, gram pod borer, *Helicoverpa armigera* (Hubner), blue butterfly, *Lampides boeticus* (L.), pea leaf miner, *Phytomyza* (= *Chromatomyia*) *horticola* Goureau and pea aphid, *Acyrtosiphon pisum* (Harris).

##### **5.1.1 Gram pod borer, *Helicoverpa armigera* (Hubner).**

In 48<sup>th</sup> Standard Meteorological Week (29<sup>th</sup> Nov to 05<sup>th</sup> Dec) *H. armigera* started appearing with 0.4 larvae/ plant as represented in Fig. 1. Further it continued to increase in numbers from 2<sup>nd</sup> week of December to 3<sup>rd</sup> week of February (49<sup>th</sup> to 7<sup>th</sup> SMW) which varied from 1.00 to 7.20 larvae/plant. In 8<sup>th</sup> SMW (24<sup>th</sup> February) *H. armigera* activity was 7.80 larvae/plant) on (8<sup>th</sup> SMW) which was at its maximum throughout the study. This incidence then continued till the maturity of the crop *i.e.* 6.00 larvae/plant in the 11<sup>th</sup> SMW (14<sup>th</sup> to 20<sup>th</sup> March).

Dubey *et al.* (1993) concluded that during the crop season of vegetable pea, *H. armigera* was found to feed with its peak activity starting from February and it continued to March. These results support the present findings. During late March, Prasad *et al.* (1997) concluded that adult of *H. armigera* was observed to catch maximum population during studying the host range and seasonal incidence. Dhaka *et al.* (2011) found that the number of larvae per ten plant ranged from 0.00 to 17.67. *H. armigera* started appearing from 4<sup>th</sup> week of November as concluded by Chatar *et al.* (2010). This is in conformity with the present findings. The peak activity (4.80 larvae/Meter row length) of the pest was observed during 9<sup>th</sup> SMW (26<sup>th</sup> Feb to 04 Mar) and declined steadily as the crop matures. During this period maximum and minimum temperatures were 33.29°C and 13.00°C, respectively with morning

and evening relative humidity of 80 and 25 per cent, respectively. During the first week of March, Ramteke *et al.* (2013) noticed a gradual rise in the larval population of *H. armigera* with its peak at 4.71 larvae/ plant. From the second week of March onwards, a declining trend was observed, with an average population of 4.30 larvae/plant.

The study was also conducted to see if the incidence of *H. armigera* correlated with meteorological factors. According to these studies, the larval population was negatively correlated with minimum temperature ( $r = -0.628$ ), being statistically significant and positively correlated with maximum temperature ( $r = 0.357$ ). Negative correlations with relative humidity ( $r = -0.260$ ) and rainfall ( $r = -0.465$ ) were found, although they were not statistically significant. Prasad *et al.* (1997) pointed out that some of their conclusions are in line with the present studies, while others are quite different such that minimum temperature and rainfall were significantly negatively correlated. Dhaka *et al.* (2011) conducted the correlation studies and found that morning and evening relative humidity ( $r = -0.22$ , and  $-0.29$  respectively), was observed to non-significantly level. Whereas positive correlation between *Helicoverpa* larval population rainfall ( $r = +0.14$ ), was also found to be non-significant. Pandey *et al.* (2002) concluded that correlation between populations of gram pod borer shows significant positive linear relationship with maximum temperature (0.64), minimum temperature (0.62) and evaporation (0.60).

### **5.1.2 Blue butterfly, *Lampides boeticus* Linnaeus**

The data presented in Table 1 shows that the first appearance of *L. boeticus* was recorded in the 52<sup>nd</sup> Standard Meteorological Week (27<sup>th</sup> Dec to 02<sup>nd</sup> Jan) to 0.9 larvae/ plant. The larval population then continued to increase from 1<sup>st</sup> week of January to 4<sup>th</sup> week of February (1<sup>st</sup> to 8<sup>th</sup> SMW) which then varies from 1.70 to 8.10 larvae/plants. In 9<sup>th</sup> SMW (4<sup>th</sup> March) *L. boeticus* activity was recorded to be highest at 8.60 larvae/plant. Further, this incidence then continued till the maturity of the crop *i.e.* 7.70 larvae/plants in the 11<sup>th</sup> SMW (14<sup>th</sup> to 20<sup>th</sup> March). According to Kaushik and Singh (1982), the pod damage of the crop occurred in the early stages of forming pods, with a peak in the last week of March. Kunte (1997) observed similar results in four

tropical environments with varying levels of disturbance. Most butterfly species also demonstrated a surge in abundance during similar seasons.

The correlation studies of the present findings revealed that the larval population of *L. boeticus* showed statistically significant relationship with maximum temperature ( $r= 0.604$ ). However, the larval population was not found to exhibit significant results with minimum temperature ( $r= -0.382$ ), relative humidity ( $r= -0.345$ ) and rainfall ( $r= -0.441$ ). The feeding of the blue pea butterfly larvae inside pods may cause an accumulation of larval waste and fungal infection which the marketing value of the crop (Ajeigbe and Singh, 2006).

### **5.1.3 Leaf miner *Phytomyza (=Chromatomyia) horticola* Goureau**

The data of *C. horticola* population is presented in Table 1, Fig. 2 shows that the larvae of *C. horticola* appeared in 4<sup>th</sup> week of December (51<sup>st</sup> SMW) to 3.4 larvae/leaf. The larval population then continues to increase from 52<sup>nd</sup> SMW to 4<sup>th</sup> SMW (27<sup>th</sup> Dec to 30<sup>th</sup> Jan) which ranged from 3.6 to 5.1 larvae/ leaf. In 5<sup>th</sup> SMW (4<sup>th</sup> Feb) *C. horticola* activity was recorded with 5.50 larvae/leaf which was highest throughout the study period. However, this incidence remained continued till the maturity of the crop *i.e.* 3.1 larvae/leaf in the 11<sup>th</sup> SMW (14<sup>th</sup> March to 20<sup>th</sup> March).

The correlation studies of the present findings revealed that the larval population per leaf of *C. horticola* had significantly negative with minimum temperature and rainfall ( $r= -0.826$  and  $r= -0.584$ , respectively) and also negative with maximum temperature ( $r= -0.097$ ) and relative humidity ( $r= -0.055$ ), being non-significant. Singh *et al.*, (2013) under field conditions, studied the incidence of *C. horticola* and found that the pest emerges firstly in 1<sup>st</sup> week of January. During the fourth week of February, the leaf miner population peaked at 3.74 leaf miners per plant. They found that there exists significant, positive correlation between the pea leaf miner population and maximum temperature ( $r = 0.790$ ) and minimum temperatures ( $r = 0.862$ ), as well as a strong significant negative correlation with relative humidity ( $r = -0.737$ ) and wind velocity ( $r= -0.367$ ). Venkateswarlu *et al.* (2011) studied that the infestation continued till the harvesting of the crop. These findings were also somewhat similar with the previous results which stated that maximum infestation was observed during the last week of February and second week

of March, when the maximum temperature was 17.7°C, mean temperature 6.5° C and total rainfall 2.5mm. Similarly, Singh and Saravanan (2008) observed that the pea leaf miner population started in the second week of February, with 7.3 leaf miners per plant. After a steady increase, the number of leaf miners per plant peaked in the 4<sup>th</sup> week of February at 9.25 leaf miners per plant (9<sup>th</sup> SMW). Thus, pea leaf miner was found to be positively correlated with maximum temperature, rainfall, and morning relative humidity, and negatively correlated with minimum temperature, evening relative humidity, wind speed, and sunshine hours. According to Keval *et al.* (2019) pea pests were found from the 50<sup>th</sup> to the 11<sup>th</sup> SMW. From 1<sup>st</sup> to 11<sup>th</sup> SMW, *P. horticola* was observed, with the peak population (71 percent leaf infestation) occurring in the 7<sup>th</sup> SMW.

#### **5.1.4 Pea Aphid, *Acyrtosiphon pisum* (Harris)**

The data of *A. pisum* population is presented in Table 1, Fig. 2 shows that the larvae of *A. pisum* appeared in 4<sup>th</sup> week of November (47<sup>th</sup> SMW) to 6.5 larvae/plant. Further, the larval population remained continued to increase from 48<sup>th</sup> SMW to 4<sup>th</sup> SMW (29<sup>th</sup> Nov to 30<sup>th</sup> Jan) which ranged from 13.9 to 87.0 larvae/ leaf. In 4<sup>th</sup> Feb (5<sup>th</sup> SMW) the activity of pea aphid (*A. pisum*) was highest with 94.1 larvae/leaf. This incidence then continued till the maturity of the crop *i.e.* 68.2 larvae/leaf in the 11<sup>th</sup> SMW (14<sup>th</sup> march to 20<sup>th</sup> March).

The larval population per plant of *A. pisum* had significant negative correlation with minimum temperature ( $r = -0.806$ ), but positive correlation with maximum temperature ( $r = 0.061$ ) though non-significant. It was negatively correlated with relative humidity ( $r = -0.092$ ) and rainfall ( $r = -0.447$ ), being non-significant.

In a general way, Melesse and Singh observed similar results (2012). There was an increase in aphid population when rainfall decreased and temperatures rose. Aphid infestations (more than 100 aphids per plant) caused all plants to die at 5-10 percent pod formation before reaching grain filling stage, making early and mid-planting dates ineffective.

#### **5.2 Screening of field pea genotypes for their relative susceptibility to pest complex.**

During the study period, varietal screening of 13 pea varieties including a check was carried out under natural field conditions for the relative

susceptibility towards pod borer complex. Performance of pea varieties against the pod borer complex was estimated on the basis of mean per cent of pod damage and yield (kg/ha).

### 5.2.1 Gram pod borer, *Helicoverpa armigera* (Hubner)

Larval population of pod borer complex represented in Table 2 revealed that none of the studied genotypes was found free from *H. armigera*. Larval population of *H. armigera* the minimum in Pant P 484 being 1.21 larvae/ plant and the maximum in KPMR 942 being 2.01 larvae/ plant. All the genotypes were found significant for the infestation of *H. armigera*. The larval population in various genotypes was 1.29 larvae/ plant (IPFD 12-02), 1.35 larvae/ plant (IPFD 20-03), 1.40 larvae/ plant (IPFD 11-05), 1.47 larvae/ plant (Pant P 480), 1.53 larvae/ plant (IPFD 20-09) 1.59 larvae/ plant (Pant P 479), 1.66 larvae/ plant (IPFD 20-02), 1.69 larvae/ plant (RNCP 14-13), 1.77 larvae/ plant (HFP 17-11), 1.83 larvae/ plant (IPFD 10-12) and 1.91 larvae/ plant (HFP 16-02).

Further, the percent damage of pods caused by the larvae of *H. armigera* was recorded and it was found to be highest with 12.82 per cent in KPMR 942 variety of pea which was found statistically same as in HFP 16-02 with 12.37 per cent pod damage IPFD 12-02 (2.86%) and IPFD 20-03 (3.57%). The percent pod damage in various genotypes was IPFD 11-05 (4.78%), Pant P 480 (5.56%), IPFD 20-09 (7.41%), Pant P 479 (7.90%), IPFD 20-02 (8.21%), RNCP 14-13 (9.15%), HFP 17-11 (10.05%) and IPFD 10-12 (11.64%).

The concluded results are supported by the work of Abhilasha and Shekharappa (2017), who reported that two varieties (GS-10 and DS-10) of pea were rated as moderately resistant to pod borers (*Helicoverpa armigera*, *Lampides boeticus*, and *Cydia nigricana*); whereas, Arka Karthika, Arka Ajit, and Arka Sampurna were rated as resistant. According to percent pod damage, five genotypes were classified as intermediate and five as susceptible. The results are in line with the findings of Singh *et al.* (2013), who reported maximum pod damage in HFP-716 pea variety with 12.00 per cent and the minimum 1.91 per cent pod damage was observed in Pant P-183, Pant P-184, RFP-61, KPMR-913 and VL-54.

Further, the pest susceptibility rating (PSR) for *H. armigera* varies from 2 to 9. Three varieties (Pant P 484, IPFD 20-03 and IPFD 12-02) were concluded as highly resistant (PSR 2-3), two varieties (Pant P 480 and IPFD 11-05) were considered as least susceptible (PSR 4-5), four varieties (Pant P 479, RNCP 14-13, IPFD 20-09 and IPFD 20-02) were considered as moderately susceptible (PSR 6-7) and four varieties (KPMR 942, HFP 17-11, HFP 16-02 and IPFD 10-12) were considered as highly susceptible (PSR 8-9) to *H. armigera*.

The present findings are in line with Chandraker *et al.* (2006) who reported that of the screened fourteen chickpea genotypes against *H. armigera*, they found BG-1047, BGD-74, BGD-330, FG-344, FG-451, H-92-67, H-97-71, H-92-106, IG-443, KW-109, RG-9210, RG-9213, RSG-798 and JG-74. BGD74 had the minimum pod damage of 6.64 per cent and the highest yield of 1433 kg per hectare. Mandal (2003) also reported that he found two genotypes (PS83149 and Bhawanipatna) to be resistant, 6 moderately resistant, 7 moderately susceptible and 3 were in susceptible to the pest *H. armigera*.

After screening eight chickpea cultivar lines against *H. armigera*, Afzal *et al.* (2001) found that Pb-2000 and 96051 were found to have high degree of resistance, three of them 9075, 96052 and BC-6-5 were found to be simply resistant, 90395-K and 97047 were two cultivars found to moderate level of resistant, while only one cultivar line (88194) was susceptible.

Vishal and Ram (2005) found that 18 germplasms of pea were having dwarf characters and out of them, only two germplasms were found to be resistant against *H. armigera* (P4039 and P-4107) when 165 germplasm of pea were studied for resistance.

### **5.2.2 Blue Butterfly, *Lampides boeticus* Linnaeus.**

Maximum population of *L. boeticus* was recorded on KPMR 942 (2.22 larvae/ plant), while it was minimum in Pant P 484 (1.36 larvae/ plant). All the genotypes were found significant for the infestation of *L. boeticus*. The larval population in various genotypes was 1.43 larvae/ plant (IPFD 12-02), 1.49 larvae/ plant (IPFD 20-03), 1.54 larvae/ plant (IPFD 11-05), 1.60 larvae/ plant (Pant P 480), 1.66 larvae/ plant (IPFD 20-09), 1.72 larvae/ plant (Pant P 479), 1.78 larvae/ plant (IPFD 20-02), 1.81 larvae/ plant (RNCP 14-13), 1.89

larvae/ plant (HFP 17-11), 1.94 larvae/ plant (IPFD 10-12) and 2.02 larvae/ plant (HFP 16-02).

Percent pod damage by *L. boeticus* was found maximum in genotype KPMR 942 (15.00%) followed by HFP 16-02 (13.40%) which was found to be statistically same with 12.34 per cent pod damage in IPFD 10-12. The percent damage of pods caused by the destructive larvae of *L. boeticus* was recorded and it was found to be minimum with 2.83 per cent in Pant P 484 variety of pea followed by IPFD 12-02 (3.51%) which was found at par with IPFD 20-03 (3.57%). The percent pod damage in various genotypes was IPFD 11-05 (4.78%), Pant P 480 (5.67%), IPFD 20-09 (7.41%), Pant P 479 (7.90%), IPFD 20-02 (8.86%), RNCP 14-13 (9.80%) and HFP 17-11 (10.74%). There are some differences in the findings of Singh *et al.* (2004), who observed that minimum (1%) pod damage was found in 7 early maturing (Pant P-11 HUDP-15, LFP-283, KPMR-526 and KPMR-593) and 4 per cent pod damage in HUDP 17 genotype and concluded that 19 dwarf genotypes were early maturing type and 13 tall genotypes were late maturing.

Pest susceptibility rating (PSR) ranged from 3 to 9 for *L. boeticus*. Three varieties (IPFD 12-02, IPFD 20-03 and Pant P 484) were considered as highly resistant to *L. boeticus* (PSR 3), two varieties (Pant P 480 and IPFD 11-05) were considered as least susceptible (PSR 4), four varieties (Pant P 479, RNCP 14-13, IPFD 20-09 and IPFD 20-02) were considered as moderately susceptible (PSR 6-7) and four varieties (KPMR 942, HFP 17-11, HFP 16-02 and IPFD 10-12) were found highly susceptible (PSR 8-9).

Three different pea genotypes (AL 1498, AL 1502, and AL 1340) were found to be resistant on the basis of Pest Susceptibility Rating and declared them as encouraging on comparing them to check varieties (AL 15, AL 201, and T 21) as well as the infestor, as reported by Kooner and Cheema (2006). Vishal and Ram (2005) on the basis of PSR studied the level of resistance against *P. boeticus* and identified eleven genotypes as moderately resistant (PSR: 3-5) and six genotypes as highly susceptible (PSR: 8-9).

### **5.2.3 Yield of pea varieties screened for the relative susceptibility to pod borer complex.**

The pea varieties were grown under natural conditions. The yield data in the Table 5 revealed that Pant P 484 (2818 kg/ha) recorded the maximum

highest yield which was at par with IPFD 12-02 (2787 kg/ha) followed by IPFD 20-03 (2651 kg/ha); however it was found at par with IPFD 11-05 (2538 kg/ha). Further, yield of Pant P 480 was 2472 kg/ha which was found at par with IPFD 20-09 (2435 kg/ha) and Pant P 479 (2426 kg/ha). The minimum yield was recorded from HFP 16-02 (1406 kg/ha), however it was at par with KPMR 942 (919 kg/ha).

## CHAPTER VI

### SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

The present investigations entitled, “**Studies on succession of insect pests complex associated with Pea (*Pisum sativum*) and screening of pea genotypes against major pests**” was carried out at the Research farm of R.A.K. College of Agriculture, Sehore, Madhya Pradesh, during *Rabi* season of 2020-21. In this Chapter the salient findings of the investigations are summarized and meaningful conclusions have been drawn.

#### **6.1 Seasonal incidence of major insect pests of pea crop.**

During *Rabi* season of 2020-21, four major insect pests were observed in pea crop at different stages of crop growth, which comprised gram pod borer, *Helicoverpa armigera* (Hubner), blue butterfly, *Lampides boeticus* (L.), pea leaf miner, *Chromatomyia horticola* Goureau and pea aphid, *Acyrtosiphon pisum*.

##### **6.1.1 Gram pod borer, *Helicoverpa armigera*.**

*Helicoverpa armigera* was observed to appear initially in the 48<sup>th</sup> Standard Meteorological Week (SMW) (November 29<sup>th</sup> to December 5<sup>th</sup>) with 0.4 larvae/plant. On February 24<sup>th</sup>, *i.e.* in 8<sup>th</sup> SMW the larval population of *H. armigera* reached its peak (7.80 larvae/plant). This incidence activity then persisted till the crop maturity, *i.e.* 11<sup>th</sup> SMW (14<sup>th</sup> to 20<sup>th</sup> March) with 6.00 larvae/plant.

##### **6.1.2 Population fluctuation of blue butterfly, *Lampides boeticus***

*Lampides boeticus* was observed to appear initially in the 52<sup>nd</sup> Standard Meteorological Week (SMW) (27<sup>th</sup> Dec to 02<sup>nd</sup> Jan) with 0.9 larvae/plant. On March 4<sup>th</sup>, *i.e.* in 9<sup>th</sup> SMW the larval population of *L. boeticus* reached its peak (8.60 larvae/plant). This incidence activity then persisted till the crop maturity, *i.e.* 11<sup>th</sup> SMW (14<sup>th</sup> march to 20<sup>th</sup> March) with 7.70 larvae/plant.

##### **6.1.3 Population fluctuation of pea leaf miner, *P. horticola***

The leaf miner was observed to appear initially in the 51<sup>st</sup> Standard Meteorological Week (SMW) (4<sup>th</sup> week of December) with 3.4 larvae/leaf. On February 4<sup>th</sup>, *i.e.* in 5<sup>th</sup> SMW the larval population reached its peak (5.50

larvae/leaf). This incidence activity then persisted till the crop maturity, *i.e.* 11<sup>th</sup> SMW (14<sup>th</sup> to 20<sup>th</sup> March) with 3.1 larvae/leaf.

#### **6.1.4 Population fluctuation of pea Aphid, *Acyrtosiphon pisum*.**

*Acyrtosiphon pisum* was observed to appear initially in the 47<sup>th</sup> Standard Meteorological Week (SMW) (4<sup>th</sup> week of November) with 6.5 larvae/plant. On February 4<sup>th</sup>, *i.e.* in 5<sup>th</sup> SMW the larval population of *A. pisum* reached its peak (94.1 larvae/plant). This incidence activity then persisted till the crop maturity, *i.e.* 11<sup>th</sup> SMW (14<sup>th</sup> to 20<sup>th</sup> March) with 68.2 larvae/plant.

#### **6.1.5 Correlation between pest incidence and weather parameters**

The correlation studies of the larval population of *H. armigera* per plant was found to have negative effect with minimum temperature ( $r = -0.628$ ) being significant and positive effect with maximum temperature was not significant. Also, it was not found to be significant with relative humidity and rainfall. The correlation studies of the larval population of *L. boeticus* per plant was found to have statistically significant positive effect with maximum temperature ( $r = 0.604$ ) and non-significant negative effect with minimum temperature. However, it was not found to be significant with relative humidity and rainfall. Further, the larval population per leaf of *C. horticola* was found significantly negative with minimum temperature and rainfall ( $r = -0.826$  and  $r = -0.584$ , respectively) and negative with maximum temperature and relative humidity, being non-significant. The larval population per plant of *A. pisum* was found significantly negative with minimum temperature ( $r = -0.806$ ) and also positive with maximum temperature, being non-significant; while it was negatively correlated with relative humidity and rainfall, being non-significant.

### **6.2 Screening of field pea genotypes for their relative susceptibility to pest complex**

During the study period, the varietal screening of 13 pea varieties including a check was carried out under natural field conditions for the relative susceptibility towards pod borer complex. Performance of pea varieties against the pod borer complex was estimated on the basis of mean per cent of pod damage and yield (kg/ha).

#### **6.2.1 Gram pod borer, *Helicoverpa armigera*.**

Larval population of *H. armigera* was the minimum in Pant P 484 being 1.21 larvae/ plant and maximum in KPMR 942 being 2.01 larvae/ plant. All the

genotypes were found significant for the infestation of *H. armigera*. Further, the percent damage of pods caused by the destructive larvae of *H. armigera* was recorded and it was found to be highest with 12.82% in KPMR 942 variety of pea which was found statistically same as in HFP 16-02 with 12.37% pod damage. IPFD 12-02 (2.86%) and IPFD 20-03 (3.57%). Pest susceptibility rating (PSR) ranged from 2 to 9 for *H. armigera*. Three varieties (Pant P 484, IPFD 20-03 and IPFD 12-02) were considered as highly resistant (PSR 2-3), two varieties (Pant P 480 and IPFD 11-05) were considered as least susceptible (PSR 4-5), four varieties (Pant P 479, RNCP 14-13, IPFD 20-09 and IPFD 20-02) were considered as moderately susceptible (PSR 6-7) and four varieties (KPMR 942, HFP 17-11, HFP 16-02 and IPFD 10-12) were considered as highly susceptible (PSR 8-9) against *H. armigera*.

### **6.2.2 Blue butterfly, *L. boeticus*.**

Maximum population of *L. boeticus* was recorded on KPMR 942 (2.22 larvae/ plant), while it was minimum in Pant P 484 (1.36 larvae/ plant). All the genotypes were found significant for the infestation of *L. boeticus*. Percent pod damage by *L. boeticus* was found maximum in genotype KPMR 942 (15.00%) followed by HFP 16-02 (13.40%) which was found to be statistically same with 12.34 per cent pod damage in IPFD 10-12. The percent damage of pods caused by the destructive larvae of *L. boeticus* was recorded and it was found to be minimum with 2.83 per cent in Pant P 484 variety of pea followed by IPFD 12-02 (3.51%) which was found at par with IPFD 20-03 (3.57%). Pest susceptibility rating (PSR) ranged from 3 to 9 for *L. boeticus*. Three varieties (IPFD 12-02, IPFD 20-03 and Pant P 484) were considered as highly resistant (PSR 3), two varieties (Pant P 480 and IPFD 11-05) were considered as least susceptible (PSR 4), four varieties (Pant P 479, RNCP 14-13, IPFD 20-09 and IPFD 20-02) were considered as moderately susceptible (PSR 6-7) and four varieties (KPMR 942, HFP 17-11, HFP 16-02 and IPFD 10-12) were considered as highly susceptible (PSR 8-9) against *H. armigera*.

### **6.2.3 Yield of pea varieties screened for the relative susceptibility towards pod borer complex.**

The pea varieties were grown under natural conditions. The yield data in the Table 4 reveal that the maximum yield was recorded from Pant P 484 (2818 kg/ha), which was at par with IPFD 12-02 (2787 kg/ha) followed by

IPFD 20-03 (2651 kg/ha); however, it was at par with IPFD 11-05 (2538 kg/ha). The minimum yield was recorded from HFP 16-02 (1406 kg/ha); however, it was at par with KPMR 942 (919 kg/ha) during the crop period.

### **Conclusion:**

During the study period, the key results arrived were of the significant importance to farmers who are involved in the production of Egyptian clover for the purpose of forage cut or for the purpose of seed production. These key results are discussed here under:

- Pea crop with Arkel variety was found to be infested by four major insect pests at different stages of crop growth. Of them, gram pod borer, *Helicoverpa armigera* (Hubner), blue butterfly, *Lampedes boeticus* (L.), pea leaf miner, *Chromatomyia horticola* Goureau and pea aphid, *Acyrtosiphon pisum*.
- During the investigation, blue butterfly larvae were observed to cause highest damage followed by gram pod borer, pea leaf miner, and pea aphid. These pests remained active till the harvest of the crop with one peak coincided with the pod formation stage of the crop, thus, may reduce the yield considerably.
- The study revealed that weather parameters played a key role in the incidence of larval population to some extent.
- During the screening of pea varieties, KPMR 942 had the highest mean larval population and the highest percent pod damage, while Pant P 484 had the lowest mean larval population and the lowest percent pod damage.
- Further, it can be concluded that, out of total 13 varieties screened for the infestation by pod borer complex, three varieties were considered as highly resistant, two varieties were considered as least susceptible, four varieties were considered as moderately susceptible and four varieties were considered as highly susceptible.
- Relatively highest yield was obtained in Pant P 484, while it was lowest in KPMR 942.

**Suggestion for further work:**

During the whole study, there are some areas that have ample scope for further studies related to crop pollination ecology in the region. Some of the points are mentioned below:-

- Further studies can also be conducted for the efficient management of the potential insect pests by using different types of bio pesticides, newer insecticides at different levels of concentration so as to discover and explore more alternatives for farmers.
- To promote the use of the effective chemicals for efficient management, their economics and spraying schedule must be studied.
- Pest succession and population dynamics of insect pests complex on pea should be monitored regularly for two or three years so as to evaluate the pest's status and the best time to adopt the most feasible control measures.
- Large scale trials should be conducted to compare the efficacy of the different chemicals against major insect pests on pea.

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## APPENDIX I

Analysis of Variance (ANOVA) for larval population and pod damage for *H. armigera* in pea during *Rabi*, 2020-21 (Table 3)

<b>LARVAL POPULATION</b>			
Source of variation	Degrees of freedom	Sum of Squares	Mean sum of squares
Replications	2	0.001	-
Treatments	12	0.213	0.018
Error	24	0.011	0.000
<b>Total</b>	<b>38</b>	<b>0.224</b>	<b>-</b>

<b>POD DAMAGE (%)</b>			
Source of variation	Degrees of freedom	Sum of Squares	Mean sum of squares
Replications	2	172.118	-
Treatments	12	606.184	50.515
Error	24	22.114	0.921
<b>Total</b>	<b>38</b>	<b>800.417</b>	<b>-</b>

## APPENDIX II

Analysis of Variance (ANOVA) for larval population and pod damage for *L. boeticus* in pea during *Rabi*, 2020-21 (Table 4)

<b>LARVAL POPULATION</b>			
Source of variation	Degrees of freedom	Sum of Squares	Mean sum of squares
Replications	2	0.000	-
Treatments	12	0.204	0.017
Error	24	0.008	0.000
<b>Total</b>	<b>38</b>	<b>0.212</b>	<b>-</b>

<b>POD DAMAGE (%)</b>			
Source of variation	Degrees of freedom	Sum of Squares	Mean sum of squares
Replications	2	260.431	-
Treatments	12	662.589	55.216
Error	24	37.114	1.546
<b>Total</b>	<b>38</b>	<b>960.134</b>	<b>-</b>

## VITA

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