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Population Fluctuation of Gram Pod Borer in *Rabi* Pulses of West Bengal

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Abstract

During the *rabi* season of 2021-22, a field research has been carried out at BCKV [District Seed Farm (AB Block)] Kalyani, Nadia, West Bengal for studying the pattern of incidence of gram pod borer or tomato fruit borer (*Helicoverpa armigera* Hubn.) in relation with prevailing meteorological parameters and to record the population fluctuation in four *rabi* pulse crops, *viz*., chickpea (var. KWR 108 and JAKI 9218), fieldpea (var. Rachna and VL 42), lentil (var. IPL 220 and L 4727) and grasspea (var. Prateek and Ratan). During the vegetative stage of the fieldpea, the *Helicoverpa* population first emerged, then gradually increased and declined near maturity; in lentil and grasspea it was recorded from flowering stage and persisted until maturity; in chickpea it was noticed from pod formation stage and continued up to maturity. None of the weather variables were significantly correlated with the *Helicoverpa* larvae population recorded on fieldpea and lentil while, regression studies denote that maximum (Max. T) and minimum (Min. T) temperature exhibited the most impact on the occurrence of *Helicoverpa* in grasspea and chickpea, respectively. The comparative study revealed that, *Helicoverpa* first appeared on lentil and field pea during the first week of January; then population appeared on grasspea during the end of second fortnight of January. Occurrence of the pest was noticed on lentil, field pea and grasspea in January and February and after that the population shifted to grasspea, fieldpea and chickpea during February to March. Chickpea was the most preferred crop as the highest population observed on this crop coinciding with pod formation stage.

Keywords: Correlation, *Helicoverpa*, Population shifting, *Rabi* pulse, Regression, Weather parameters

Introduction

Pulse crops, generally considered as '*Dal*', belong to the botanical family Fabaceae (Leguminosae) which are rich source of vegetable protein that's why defined as 'Poor Man's Protein' (Ramamurthi *et al*., 2012). For Indian vegetarians, they are the chief protein source in their diet and can be produced with a minimum use of resources. Different regions with different agro-climatic conditions in India dominate different pulse crops, *e.g.*, pigeonpea, chickpea, grass pea, field pea and black gram occupies the states of central zone, lentil and grass pea covers eastern and some portion of central region and in southern states black gram and red gram are preferred locally over other pulses. Pulses are grown during all the three cropping seasons prevalent in our country, *viz*., *kharif* (covering black gram, green gram, red gram, horse gram and cowpea), *rabi* (including chickpea, lentil, grass pea, field pea, rajmash) and pre-*kharif* or summer (covering green gram, black gram and cowpea). Though pulses are grown in all three seasons but more than 60% of the total pulse production is contributed by *rabi* pulses only (Kaur *et al*., 2018). There are number of constraints in national pulse production including higher demand-supply gap, less productivity as well as socio-political problems. Again, the less productivity is mainly due to majority of its cultivation in less fertile, problematic soils and unpredictable environmental conditions, constrains of both biotic and abiotic stresses and other agronomic constraints as well. The main biotic stresses that hinder pulse productivity include

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various insect pests. Climate also has a significant impact on changing crop pest scenario including pests of pulses (Reddy *et al*., 2009). According to Lal (1996), infestation of insect pests can cause 75-90% yield reduction in pulse crops. The deadliest of them is the chickpea pod borer (*Helicoverpa armigera* Hub.) known for causing severe yield reduction in pulse crops and alone it is the key limiting factor of chickpea cultivation (Lateef *et al*., 1985; Reed *et al*., 1987). Diapause, mobility, extensive polyphagy and a rapid rate of reproduction contribute significantly to its status as a serious pest (Fitt, 1989; Priyanka *et al*., 2020). Reed (1983) reported that it can cause yield loss up to 85% in India. The yield reduction resulting from the pest feeding the pods was found to occur up to 21% (Kumar and Smithson, 1980) and 37-50% (Khan and Faizullah, 1999) respectively. In favorable weather condition, yield loss reached up to 90-95% when 30-40% pods are damaged (Rahman, 1990; Sachan and Katti, 1994). In total larval period a single larvae can consume 25-30 pods (Singh and Ali, 2005). Maurya *et al*. (2007) reported yield losses of up to 70-95% as a result of gram pod borer infestation. Monitoring of insect pests is a pre-requisite for taking suitable management decisions in right time for any crop. Therefore, the objective of the current research is to document the fluctuation of *Helicoverpa* populations across four significant *rabi* pulses, as well as the incidence pattern, time of occurrence and influence of prevailing weather parameters on population growth.

Materials and Methods

The present study has been carried out at the farm of Bidhan Chandra Krishi Viswavidyalaya [District Seed Farm (AB Block)] Kalyani, Nadia, West Bengal (Latitude: 22°87′ N, Longitude: 88°20′ E), during *rabi* season of 2021-22 using four *rabi* pulse crops, *viz*., chickpea [*Cicer arietinum* L.] (var. KWR 108 and JAKI 9218), field pea or mator [*Pisum sativum* var. *arvense* L.] (var. Rachna and VL 42), lentil [*Lens culinaris* Medik] (var. IPL 220 and L 4727) and grass pea or *lathyrus* [*Lathyrus sativus* L.] (var. Prateek and Ratan). General agronomic practices were followed in case of all the crops keeping the experimental plots completely pesticide free. *Helicoverpa* population data was collected weekly starting 21 days post-sowing and carried out upto the maturity of crop in order to investigate the seasonal incidence. Larval population was recorded from 5 randomly selected sample plants during early morning hours with least disturbance. For estimating the larval population visual counting method has been followed and counting has been done on a whole plant basis. Gram pod borer's mean larval population was worked out. The weekly average data of the eight meteorological variables that were considered - maximum and minimum temperature, temperature difference, morning and evening RH, differences among the relative humidity, speed of the wind and bright sunshine hours - was then correlated with the mean population to work out the correlation coefficient using Standard statistical formulae (Gomez and Gomez, 1984) and multiple-step wise linear regression has been followed using MS Excel, 2010. The cumulative rainfall over the preceding seven days was used when calculating rainfall.

Results and Discussion

Pattern of Incidence of larval population of Gram Pod Borer on Chickpea

Table 1 indicates the gram pod borer or tomato fruit borer population over the duration of study that was observed during *rabi* season of 2021-22. It was observed that the *Helicoverpa* population first appeared in chickpea on 24th February (8th SMW) in both the varieties and reached its peak on 17th March (3.2 plant^{-1} on 11th SMW) and 24th March (3.4 plant^{-1} on 12th SMW) in varieties KWR 108 and JAKI 9218, respectively, subsequently there was a gradual decrease in the population. The larval population was found to be prevalent from the pod formation stage until maturity. Yadav and Jat (2009) also recorded maximum infestation of *Helicoverpa* from pod formation to grain development stage. Kumar and Bisht (2013) reported highest larval population at pod formation stage and report of Meena and Bhatia (2014) in Rajasthan showed that peak incidence of *H. armigera* was generally occurred in flowering and pod formation stage which is comparable to the current findings. Again, according to Gautam *et al*. (2018), *Helicoverpa* infestation started during the vegetative stage and persisted until crop maturity. Reddy *et al.* (2009) noticed that the larval population of *H. armigera* started increasing with a peak in the fourth week of March which nearly supports the present study. Shinde *et al*. (2013) in their study, found maximum mean larval population in 12th and 11th SMW during 2009-10 and 2010-11, respectively and the study of Kumar and Singh (2014) revealed that *H. armigera* appeared on 10th SMW and during 13th SMW peak population was recorded. They also found that population become suppressed with increment of temperature and crop maturity which is similar with the present experiment.

Influence of Prevailing Weather Variables on the Occurrence of Gram Pod Borer population in Chickpea

Table 2 indicates the results of correlation between incidences of *Helicoverpa* in chickpea with different weather parameters (Figure 1). Effect of different meteorological parameters on *Helicoverpa* population in chickpea are evaluated by calculating simple correlation between the population and weather factors during the course of study using the pooled data of two varieties. It was found that maximum temperature (Max. T) (0.82), minimum temperature (Min. T) (0.69) and difference in relative humidity (RH) (0.64) exhibited significant positive correlation with larval population though, other factors were non-significantly correlated. Temperature difference (0.31), morning relative humidity (0.04), wind speed (0.29) and bright sunshine hours (0.41) exhibited positive correlation with the larval population, conversely, rainfall (-0.33) and evening relative humidity (-0.53) showed negative correlation.

The current observations are in tune with the reports of several researchers (Pandey *et al*., 2012; Kumar and Bisht, 2013; Kumar and Singh, 2014) who found that minimum and maximum temperature, wind speed and bright sun shine hours showed positive effects while, rainfall and morning and

Table 1: Seasonal incidence of *Helicoverpa armigera* on different pulse crops

Date	SMW	Chickpea Mean pest population (plant^{-1})		Date	SMW	Field pea Mean pest population (plant^{-1})	
		KWR 108	JAKI 9218			Rachna	VL 42
				23/12/21	51	0.0	0.0
				30/12/21	52	0.0	0.0
06/01/22	1	0.0	0.0	06/01/22	1	0.2	0.4
13/01/22	2	0.0	0.0	13/01/22	2	0.4	0.6
20/01/22	3	0.0	0.0	20/01/22	3	0.6	0.8
27/01/22	4	0.0	0.0	27/01/22	4	1.0	1.0
03/02/22	5	0.0	0.0	03/02/22	5	1.4	1.4
10/02/22	6	0.0	0.0	10/02/22	6	1.0	0.6
17/02/22	7	0.0	0.0	17/02/22	7	0.8	0.4
24/02/22	8	0.2	0.4	24/02/22	8	0.4	0.2
03/03/22	9	0.2	0.6	03/03/22	9	0.2	0.2
10/03/22	10	0.4	1.0	10/03/22	10	0.2	0.2
17/03/22	11	3.2	2.6	17/03/22	11	0.0	0.0
24/03/22	12	3.0	3.4				
31/03/22	13	0.6	0.6				

Table continue...

Date	SMW	Lentil Mean pest population (plant^{-1})		Date	SMW	Grass pea Mean pest population (plant^{-1})	
		IPL 220	L 4727			Prateek	Ratan
23/12/21	51	0.0	0.0	23/12/21	51	0.0	0.0
30/12/21	52	0.0	0.0	30/12/21	52	0.0	0.0
06/01/22	1	0.4	0.2	06/01/22	1	0.0	0.0
13/01/22	2	0.6	0.6	13/01/22	2	0.0	0.0
20/01/22	3	1.6	1.4	20/01/22	3	0.2	0.2
27/01/22	4	1.4	1.2	27/01/22	4	0.4	0.4
03/02/22	5	1.0	0.8	03/02/22	5	0.8	0.6
10/02/22	6	0.4	0.6	10/02/22	6	1.0	0.8
17/02/22	7	0.2	0.4	17/02/22	7	1.4	1.2
24/02/22	8	0.2	0.2	24/02/22	8	1.2	1.0
03/03/22	9	0.0	0.0	03/03/22	9	1.4	1.6
10/03/22	10	0.0	0.2	10/03/22	10	1.6	1.8
17/03/22	11	0.0	0.4	17/03/22	11	0.8	1.0
				24/03/22	12	0.6	0.6
				31/03/22	13	0.4	0.4

[SMW = Standard Meteorological Week]

evening RH had a negative impact on the incidence pattern of *H. armigera.* Findings reported by Yadav and Jat (2009) also proved that changes in population were not influenced by RH and rainfall, but a notable positive correlation existed between the population of gram pod borer and both maximum and minimum temperatures. Similarly, according to Solangi *et al.* (2016) temperature and RH had a positive effect on the larval count of *Helicoverpa*. On the contrary, Bhagat *et al.* (2020) observed that Max. T showed non-significant negative and Min. T exhibited a significant negative effect on the *Helicoverpa* larval inhabitants. Though, a significant positive influence was observed between larval population and RH, while other parameters such as rainfall, wind speed and period of bright sunshine displayed non-

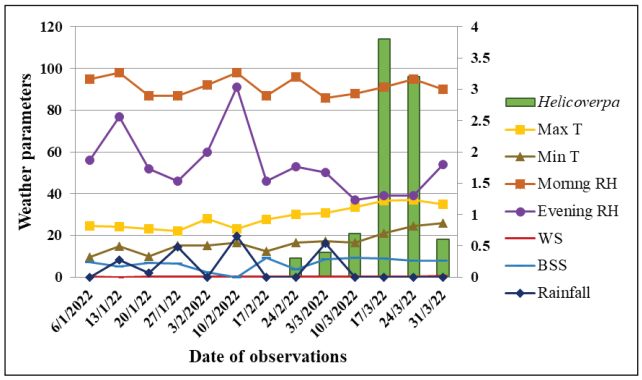

Figure 1: *Helicoverpa* population in chickpea along with prevailing weather parameters

significant positive effect. This type of dissimilarities might probably due to study in different climatic regions.

Regression Studies among Gram Pod Borer Population in Chickpea and Weather Variables

Multiple regression analysis was carried out to predict the equation,

Y = - 5.06 + 0.05 minimum temperature + 0.05 temperature difference + 0.04 evening RH + 0.04 RH difference + 0.24 wind speed + 0.01 bright sunshine hours + 0.02 rainfall

The multiple regression co-efficient (R^2) was 0.80, which means independent variables (weather parameters) caused 80% variation in the dependent variables that is the larval population of chickpea pod borer.

Multiple step wise linear regression shows that the weather parameters had a significant impact on the gram pod borer incidence. Current findings (in Table 3) indicated that the minimum temperature had the greatest impact on the gram pod borer population density among the various meteorological factors. The R^2 value was 0.48 that means minimum temperature described *Helicoverpa* population up to 48%. Ray (2021) found that influence of maximum RH was most on the population intensity of the pest which could describe pest population up to 82% during first year and maximum temperature alone could describe pest population up to 53% during second year, though the experiment was conducted on eight chickpea varieties together.

Table 2: Correlation of *H. armigera* population with weather parameters in different pulse crops

Crop	Correlation coefficient (r) values in respect of weather parameters								
	Max. T	Min. T	T def.	Morn. RH	Even. RH	RH def.	WS	BSS	Rainfall
Chickpea	0.82*	0.69*	0.31	0.04	-0.53	0.64*	0.29	0.41	-0.33
Field pea	-0.34	-0.15	-0.32	0.11	0.24	-0.25	-0.03	-0.32	0.32
Lentil	-0.52	-0.37	-0.36	-0.01	0.11	-0.14	0.11	-0.19	0.20
Grass pea	0.62*	0.45	0.43	-0.24	-0.39	0.37	0.21	0.34	0.16

[*Significance at 5% level in two tail]

Table 3: Multiple step-wise linear regression among *H. armigera* population and weather parameters in different pulse crops

Crop	Regression equation	R2 value	Variables	Remarks
Chickpea	Y = - 0.10 + 0.066 X	0.48	Y = *Helicoverpa* population X = Minimum temperature	Minimum temperature became the sole governing factor.
Grass pea	Y = 0.27 + 0.027 X	0.30	Y = *Helicoverpa* population X = Maximum temperature	Maximum temperature became the sole governing factor.

[*Significance at 5% level]

Pattern of Incidence of larval population of Gram Pod Borer on Field Pea

Incidence pattern of *Helicoverpa* recorded during the course of study in two different varieties is presented in table 1. The larval population first appeared on 6th January, 2022 (1st SMW) during vegetative stage then gradually increased and maximum population was noticed on 3rd February, 2022 (1.4 plant^{-1} on 5th SMW) in both the varieties, *e.g.*, Rachna and VL 42. After that, the population gradually declined. Presence of *Helicoverpa* was noticed throughout the crop growth period. Peak incidence of *H. armigera* on vegetable pea in Meerut was recorded during first week of February by Dhaka *et al.* (2011). Roy and Banerjee (2021) reported that the gram pod borer population in field pea reached peak at nine weeks after sowing (WAS) which supports the present finding. But, Shantibala and Singh (2003), in Manipur, reported that the first seven days of March, 2001 and the last seven days of February, 2000, respectively, marked the peaks of the pod borer population in their two years of experiment.

Influence of Prevailing Weather Variables on the Occurrence of Gram Pod Borer population on Field Pea

Table 2 indicates the correlation between the incidences of *Helicoverpa* in field pea with various weather parameters (Figure 2). A simple correlation in between the variables viz., larval population and weather attributes was calculated throughout the study, using the pooled data from the two varieties, for assessing the impact of various weather variables on the larval population of *Helicoverpa* on field

pea. It was found that none of the weather elements showed significant association with the larval population. The pest population was negatively associated with maximum temperature (-0.34), minimum temperature (-0.15), temperature difference (-0.32), relative humidity difference (-0.25), wind speed (-0.03) and bright sunshine hours (-0.32). In contrast, the morning (0.11) and evening (0.24) RH and rainfall (0.32) showed positive effect. Earlier, Dhaka *et al.* (2011) revealed that rainfall and the pest incidence were observed to be positively correlated, while the Max. T showed a negative correlation but, the correlations were significant. Again, Roy and Banerjee (2021) reported that the *Helicoverpa* population in field pea exhibited a non-significant correlation with all meteorological parameters, regardless of crop variety. However, during the first year only, the Rachna variety showed a significant positive correlation with wind speed which partially corroborates the present finding.

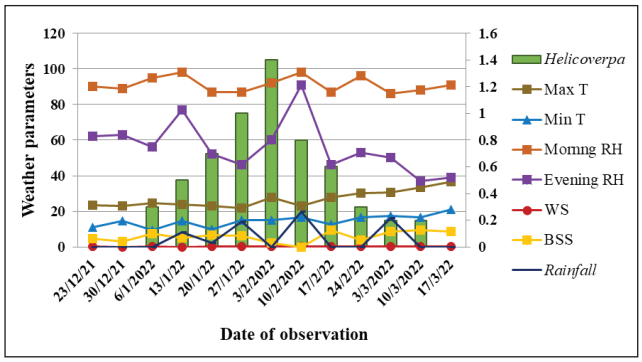

Figure 2: *Helicoverpa* population in field pea along with prevailing weather parameters

Pattern of Incidence of larval population of Gram Pod Borer on Lentil

During the research work, it was noted that pest population initially arrived in lentil on 1st SMW, 2022 in both varieties. On 20th January (3rd SMW), the peak population was noticed, with a mean population of 1.6 plant^{-1} in IPL 220 and 1.4 plant^{-1} in L 4727. After that, the population gradually declined (Table 1). Chickpea pod borer was observed to be prevalent starting from the flowering stage and continued up to maturity. Though, Kumar and Yadav (2018) reported peak population of *H. armigera* on 9th SMW, who conducted the study over the country in various regions.

Influence of Prevailing Weather Variables on the Occurrence of Gram Pod Borer population in Lentil

A simple correlation was computed between the population and weather variables to find out the impact of various weather elements on the gram pod borer population in lentil (Figure 3) using pooled data from two varieties. From table 2, it was found that none of the parameters exhibited significant correlation with the larval population of *Helicoverpa*. Among them, the pest population was positively associated with evening RH (0.11), rainfall (0.20) and wind speed (0.11) while, negatively correlated with maximum temperature (Max. T) (-0.52), minimum temperature (Min. T) (-0.37), temperature difference (-0.36), morning RH (-0.01), RH difference (-0.14) and bright sunshine hours (-0.19). Kumar and Yadav (2018) reported that *Helicoverpa* showed non-significant correlation with the abiotic factors which supports the present study.

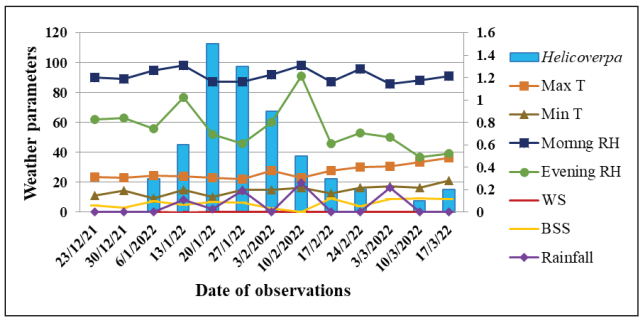

Figure 3: *Helicoverpa* population in lentil along with prevailing weather parameters

Pattern of incidence of larval population of Gram Pod Borer on Grass Pea

First appearance of gram pod borer was noticed on 20th January when the crop was at flowering stage and it continued up to crop maturity in both the varieties (Table 1). Maximum larval population was observed on 10th March, 2022 (10th SMW), in case of both the varieties causing huge infestation. Bera (2020) recorded maximum gram pod borer population at 13th and 11th WAS during 2018-19 and 12th WAS during 2019-20, which is at par with the current findings.

Influence of Prevailing Weather Variables on the Occurrence of Gram Pod Borer population in Grass Pea

Using the pooled data from two varieties, a simple correlation between the pest population and weather elements was calculated to find out the influence of various weather factors on the larval population of *H. armigera* on grass pea (Figure 4). Table 2 indicates that maximum temperature (0.62) was the only weather parameter which displayed significant positive correlation with the pest population whereas, other variables were non-significantly correlated. Minimum temperature (0.45), temperature difference (0.43), relative humidity difference (0.37), wind speed (0.21), bright sunshine hours (0.34) and rainfall (0.16) were positively correlated with population of *Helicoverpa*, while, morning (-0.24) and evening relative humidity (-0.39) exhibited negative correlation. In West Bengal Bera (2020) found that pest population showed significant positive as well as significant negative correlation with maximum temperature and afternoon relative humidity, respectively, which supports the current outcomes.

Regression Studies among Gram Pod Borer population in Grass Pea and Weather Variables

Multiple regression study was carried out to predict the equation,

Y = 2.52 + 0.06 maximum temperature (Max. T) - 0.02 minimum temperature (Min. T) - 0.03 morning RH + 0.01 evening RH - 0.40 wind speed - 0.01 bright sunshine hours.

The multiple regression co-efficient (R^2) was 0.46, which

means independent variables (weather parameters) caused 46% variation in the dependent variables that is the larval population of *Helicoverpa*.

The results (Table 3) of multiple step-wise linear regression denotes that the larval density of *H. armigera* recorded in grass pea was mostly influenced by maximum temperature. The R^2 value was 0.30 that means maximum temperature described population of *Helicoverpa* up to 30%.

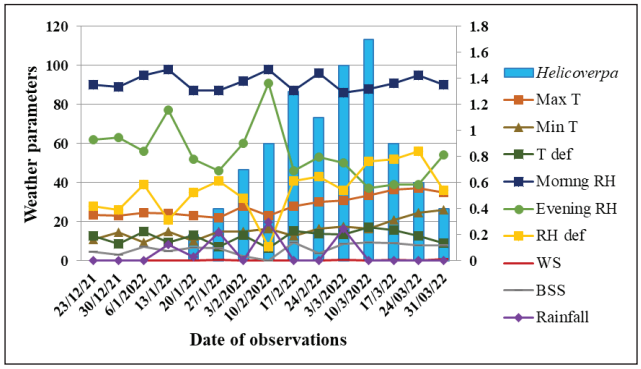

Figure 4: *Helicoverpa* population in grass pea along with prevailing weather parameters

Comparative Study on Occurrence Pattern of Gram Pod Borer larvae in Different Rabi Pulses

From the field data it was observed that *Helicoverpa armigera* (Table 4) was found on all of the studied crops though their pattern and timing of occurrence varied depending on the crop.

The larval population of *Helicoverpa* (Figure 5) was initially observed on lentil and field pea during the first week of January (06/01/2022). Subsequently, the populations of both crops increased, with the first peak population for lentil being recorded in the final week of January (20/01/2022), after that population on lentil decreased gradually while

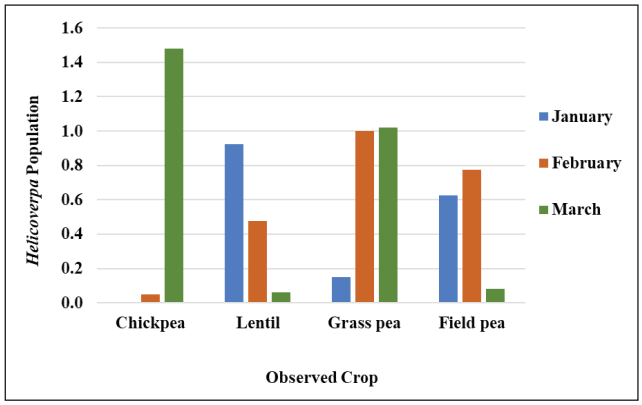

Figure 5: Population of *Helicoverpa armigera* in different *rabi* pulses

on field pea, the population grew gradually and peaked during the first week of February (03/02/2022). After that the population for the first time was recorded on grass pea during last week of January (20/01/22) and increased gradually and became highest on second week of March. Comparatively the population arrived lately on chickpea after damaging other pulse crops. The population persisted on grass pea and chickpea till March. Chickpea was proved as the most preferred crop as the highest population of *Helicoverpa* was observed on this crop coinciding with pod forming stage of the crop. It can be said that though the pest was observed on other pulse crops during the early period of *rabi* season but the population shifted at higher intensity on chickpea crop during late *rabi* season and highest mean population was recorded in this crop. It can be concluded that the pest may be appeared during January to February on lentil, field pea and grass pea and after that the population may be shifted to grass pea, field pea and chickpea during February to March when variety of pulse crops are available to act as host of the particular pest in close vicinity.

Table 4: Pattern of incidence of *Helicoverpa armigera* in different *rabi* pulses

Date of Observation	Mean *Helicoverpa armigera* population (plant^{-1})			
	Chickpea	Lentil	Grass pea	Field pea
06/01/22	0.0	0.3	0.0	0.3
13/01/22	0.0	0.6	0.0	0.5
20/01/22	0.0	1.5	0.2	0.7
27/01/22	0.0	1.3	0.4	1.0
03/02/22	0.0	0.9	0.7	1.4
10/02/22	0.0	0.5	0.9	0.8
17/02/22	0.0	0.3	1.3	0.6
24/02/22	0.2	0.2	1.1	0.3
03/03/22	0.2	0.0	1.5	0.2
10/03/22	0.4	0.1	1.7	0.2
17/03/22	3.2	0.2	0.9	0.0
24/03/22	3.0	0.0	0.6	0.0
31/03/22	0.6	0.0	0.4	0.0

Conclusion

The larval population of *Helicoverpa* on field pea first appeared during vegetative stage then gradually increased and declined near maturity; in lentil and grass pea it was recorded from flowering stage and persisted up to maturity; in chickpea it was noticed from pod formation stage and continued up to maturity. None of the weather elements displayed significant effect on the larval population of gram pod borer noted on field pea and lentil while, regression studies denote that maximum temperature (T Max.) and minimum temperature (T Min.) exhibited notable effect on the population density of *Helicoverpa* in grass pea and chickpea, respectively. From the comparative study it was found that the pest recorded during January to February on lentil, field pea and grass pea and after that the population shifted to grass pea, field pea and chickpea during February to March. Chickpea was the most preferred crop as the highest intensity of population observed on this crop coinciding with pod formation stage.

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