

**SEASONAL DYNAMICS OF INSECT PESTS &  
NATURAL ENEMIES IN RELATION TO  
METEOROLOGICAL PARAMETERS ON MUSTARD**

**M.Sc. (Ag.) Entomology Thesis**

**by**

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FACULTY OF ENTOMOLOGY  
INDIRA GANDHI KRISHI VISHWAVIDYALAYA  
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**SEASONAL DYNAMICS OF INSECT PESTS &  
NATURAL ENEMIES IN RELATION TO  
METEOROLOGICAL PARAMETERS ON MUSTARD**

**Thesis**

**Submitted to the**

**Indira Gandhi Krishi Vishwavidyalaya, Raipur**

**by**

**Suraj Kumar Yadav**

**IN PARTIAL FULFILMENT OF THE REQUIREMENTS**

**FOR THE DEGREE OF**

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**in**

**Agriculture (Entomology)**

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**August, 2021**

## CERTIFICATE – I





This is to certify that the thesis entitled “Seasonal dynamics of insect pests & natural enemies in relation to meteorological parameters on mustard” submitted in partial fulfilment of the requirements for the degree of “Master of Science in Agriculture” of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Suraj Kumar Yadav** under my guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted by any other degree or diploma or has been published/ published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

  
Chairman


Date: 18/08/2021

### THESIS APPROVED BY THE STUDENT’S ADVISORY COMMITTEE

Chairman	Dr. V. K. Soni	
Member	Dr. Sanjay Sharma	
Member	Dr. C. R. Netam	
Member	Dr. (Smt.) Gayatri Chandrakar	

## CETIFICATE - II


This is to certify that the thesis entitled "Seasonal dynamics of insect pests & natural enemies in relation to meteorological parameters on mustard" submitted by Suraj Kumar Yadav to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfilments of the requirements for the degree of Master of Science in Agriculture in the Department of Entomology has been approved by the external examiner and Student's Advisory Committee after oral examination.

  
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Approved/ Not approved

Director of Instructions

\_\_\_\_\_

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**Suraj Kumar Yadav**

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## LIST OF NOTATIONS AND ABBREVIATION

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Sr. no.	Symbols	Meaning
1.	%	per cent
2.	&	And
3.	(r)	Correlation coefficient
4.	*	Asterisk
5.	/	Per
6.	@	at the rate
7.	±	Plus or minus
8.	<	Less than
9.	>	More than
10.	µm	Micro metre
11.	°C	Degree Celsius

---

## LIST OF ABBREVIATIONS

Sr. no.	Abbreviation	Meaning
1.	A	Searching efficiency
2.	BSS	Bright sunshine hours
3.	CI	Confidence interval
4.	cv.	Cultivar
5.	DAS	Days after sowing
6.	Df	Degrees of freedom
7.	Dia	Diameter
8.	<i>et al.</i>	et alii (and others)
9.	etc.	Etcetera
10.	Fig.	Figure
11.	GDD	Growing degree days
12.	Ha	Hectare
13.	Hrs	Hours
14.	i.e.	Id est (that is)
15.	Kg	kilogram
16.	LSD	Least significant difference
17.	M	Metre
18.	Max.	Maximum
19.	Min.	Minimum
20.	Mm	Millimetre
21.	°C	Degree celsius
22.	P	Page
23.	P	Probability level of significance
24.	Pp	Pages
25.	RF	Rainfall
26.	RH	Relative humidity
27.	SE	Standard Error
28.	SMW	Standard meteorological week

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29.	sp.	Species (singular)
30.	spp.	Species (plural)
31.	Temp.	Temperature
32.	O	Handling time
33.	<i>viz.</i>	Vi delictet (namely)
34	Mor.	Morning
35	Eve.	Evening

---

## THESIS ABSTRACT

- a) Title of the Thesis : "Seasonal dynamics of insect pest & natural enemies in relation to meteorological parameters on mustard"
- b) Full Name of the Student : Suraj Kumar Yadav
- c) Major Subject : Entomology
- d) Name and Address of the Major Advisor : Dr. V. K. Soni  
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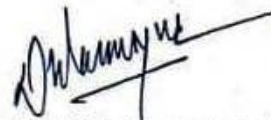


Signature of Major Advisor



Signature of the Student

Date: 18/08/2021



Signature of Head of the Department

## ABSTRACT

Studies on "Seasonal dynamics of insect pests and natural enemies in relation to meteorological parameters on mustards" was carried out in the Research cum Instructional Farm of Sant Vinoba Bhave College of Agriculture and Research Station, Marra (Patan), Durg (Chhattisgarh), during *rabi* season from November 2020 to February 2021.

During the study period, six insect pests were observed infesting mustard crop. Among these, the mustard aphid has been active on a regular basis throughout the crop period with the causing noticeable damage from flowering to maturity, however, flea beetle, saw fly, painted bug, diamond back moth, and leaf webber have been found infrequently and in low abundance on mustard crop.

Aphid and Flea beetle populations commenced at initial stage of the mustard crop with 1.21 aphids per plant per 10 cm apical twigs and 1.2 beetle/plant from last week of November (48<sup>th</sup> SMW), respectively. The peak infestation of aphids occurred in the 3<sup>rd</sup> week of January (3<sup>rd</sup> SMW) with 143.86 aphid per plant per 10 cm apical twigs which was favoured by minimum temperature of 11.7 °C, maximum temperature of 30.0 °C, mor. RH of 83% and eve. RH of 24%. Flea beetle was recorded its peak level of 11.5 beetle/plant in 3<sup>rd</sup> week of January (3<sup>rd</sup> SMW).

The populations of Painted bug, *Bagrada hilaris* and Saw fly, *Athalia lugens proxima* were commenced on the crop in the 4<sup>th</sup> week of December (52<sup>nd</sup> SMW) and 3<sup>rd</sup> week of December (51<sup>st</sup> SMW), respectively. The population of Painted bug gradually increased and reached to its peak (2.5 bug per plant) in 4<sup>th</sup> week of January (4<sup>th</sup> SMW) and pest population of saw fly reached to its peak with 1.02 adult per plant in 3<sup>rd</sup> week of January (3<sup>rd</sup> SMW).

The populations of diamond back moth and Leaf webber were commenced on crop in the 2<sup>nd</sup> week of December (50<sup>th</sup> SMW). Initially the population was observed with 0.10 larvae and 0.24 bug per plant, respectively. The population of diamond back moth and leaf webber, gradually increased and reached to its peak with 1.03 larvae per plant in 2<sup>nd</sup> week of January (2<sup>nd</sup> SMW) and 4.1 bug /plant in 3<sup>rd</sup> week of January (3<sup>rd</sup> SMW), respectively.

The population of lady bird beetle, *Cheilomenes sexmaculata* occurred in the 3<sup>rd</sup> week of December (51<sup>st</sup> SMW) and continue till last week of January (5<sup>th</sup> SMW) and attained highest level of 1.29 per plant in 3<sup>rd</sup> SMW on mustard crop.

Study on monitoring of alate mustard aphid revealed that initial appearance of the alate aphid was noticed during 48<sup>th</sup> SMW (last week of November) and its population gradually increased with slight fluctuation and finally declined after 5<sup>th</sup> SMW (last week of January). Maximum 106.34 alate aphid per trap was trapped in the sticky trap in 4<sup>th</sup> SMW, which, was favoured by max. temperature of 31.0 °C, min. temperature of 14.2 °C, mor. RH of 80% and eve. RH of 36%, rainfall of 0.00mm and 3.3 hrs of sunshine period. The correlation between alate aphid population with max. temperature and rainfall showed positive correlation whereas

min. temperature, morning RH, evening RH and sunshine hrs. showed negatively correlation.

The results of correlation studies indicated that mustard aphid population was significantly negative correlation with morning RH. Mustard aphid and flea beetle both were negative effect with sunshine hours and relative humidity (morning and evening) and positively correlated with maximum temperature and rainfall.

The correlation studies for painted bug and saw fly indicated that both were positively and non significantly correlated with maximum and minimum temperature. They were negative and non significant correlated with sunshine hours, mor. and eve. RH where only painted bug was found significantly correlated with morning relative humidity.

The correlation studies for Diamond back moth and leaf webber indicated that both pests showed positive and non significant correlation with max. and min. temperature. They were negative non significant correlated with mor. and eve. RH and sunshine hour. The rainfall showed positive correlation for leaf webber and negative for diamond back moth.

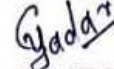
The correlation studies for a predator lady bird beetle *C.sexmaculata* showed positive non significant correlation with max. and min. temperature and rainfall while negative correlation with morning and evening relative humidity and sunshine hours.

## शोध सारांश

- अ) शोध का शीर्षक : "सरसो की फसल पर मौसम संबंधी मापदण्डों के संबंध में कीटों और प्राकृतिक शत्रुओं के मौसमी गतिशीलता पर अध्ययन"
- ब) छात्र का पूरा नाम : शूरज कुमार यादव
- स) प्रमुख विषय : कृषि कीटविज्ञान
- द) प्रमुख सलाहकार का नाम व पता : डॉ. व्ही.के.सोनी (सह प्राध्यापक)  
कृषि महाविद्यालय एवं अनुसंधान केन्द्र,  
मर्रा, पाटन (दुर्ग), (छ.ग.)
- ई) सम्मानित की जानी वाली उपधि : कृषि स्नातकोत्तर (कृषि कीटविज्ञान)




मुख्य सलाहकार का हस्ताक्षर



छात्र का हस्ताक्षर

दिनांक 18/08/2021



विभाग के प्रमुख का हस्ताक्षर

## सारांश

यह अध्ययन संत विनोबा भावे कृषि महाविद्यालय एवं अनुसंधान केंद्र, मर्रा (पाटन), दुर्ग, छत्तीसगढ़ के अनुसंधान सह निदेशक प्रक्षेत्र में नवम्बर 2020 से फरवरी 2021 तक "सरसो की फसल पर मौसम संबंधी मापदण्डों के संबंध में कीटों और प्राकृतिक शत्रुओं के मौसमी गतिशीलता पर अध्ययन" के लिए आयोजित किया गया।

अध्ययन अवधि के दौरान, सरसो की फसल को प्रभावित करने वाले छह कीट देखे गए। इनमें से सरसो का माँहू (एल. एरिसिमी) फसल काल में नियमित रूप से सक्रिय रहा है सरसो के माँहू की आबादी के कारण फूल आने से लेकर परिपक्वता तक ध्यान देने योग्य क्षति हुई, जबकि चित्रित बग (बी. हिलेरिस), आरा मक्खी (ए. लूगेंस प्रॉक्सिमा), पृष्ठ शलम (पी. जाइलोस्टेला) और लीफ वेबर (सी. विनोटालिस) कीट भी फसल अवधि के दौरान पाये गये पर इनसे नुकसान बहुत कम हुआ है।

सरसों के माँहू और पिस्सू भृंग की आबादी नवम्बर के अंतिम सप्ताह (48 वें, मानक मौसम सप्ताह) पर सरसों की फसल के प्रारम्भिक अवस्था में 1.21 माँहू प्रति पौधा प्रति 10 से.मी. ऊपरी टहनी तथा पिस्सू भृंग 1.2 भृंग प्रति पौधा के साथ शुरुआत हुई और सरसों माँहू जनवरी के तीसरे सप्ताह (तीसरे, मानक मौसम सप्ताह) में यह अपने चरम सीमा पर 143.86 माँहू प्रति

पौधा प्रति 10 से.मी. ऊपरी टहनी पर दर्ज किया गया। उस समय न्यूनतम तापमान 11.5 डिग्री सेल्सियस और अधिकतम तापमान 30 डिग्री सेल्सियस, सापेक्ष आर्द्रता सुबह 83 प्रतिशत और शाम 24 प्रतिशत सापेक्ष अनुकूल रहा। पिस्सू भृंग को जनवरी के तीसरे सप्ताह (तीसरे, मानक मौसम सप्ताह) में 11.5 भृंग प्रति पौधा पर अपने चरम स्तर पर दर्ज किया गया था।

चित्रित बग और आरा मक्खी की आबादी क्रमशः दिसंबर के चौथे सप्ताह (52 वे, मानक मौसम सप्ताह) और दिसम्बर के तीसरे सप्ताह (51 वे, मानक मौसम सप्ताह) में फसल पर शुरू हुई थी। इस अवधि के दौरान चित्रित बग की आबादी धीरे-धीरे बढ़ी और जनवरी के चौथे सप्ताह (चौथे, मानक मौसम सप्ताह) में अपने चरम स्तर 2.5 बग प्रति पौधा तक पहुँच गई और आरा मक्खी कीट की आबादी जनवरी के तीसरे सप्ताह (तीसरे, मानक मौसम सप्ताह) में अपने चरम स्तर 1.02 वयस्क प्रति पौधा पर पहुँच गई।

पृष्ठ शलभ और लीफ वेबर की आबादी दिसंबर के दूसरे सप्ताह (50 वं, मानक मौसम सप्ताह) में फसल पर शुरू हुई थी। प्रारंभ में पृष्ठ शलभ प्रति पौधा 0.10 लार्वा प्रति पौधा और लीफ वेबर 0.24 बग प्रति पौधा देखा गया। इस अवधि के दौरान पृष्ठ शलभ और लीफ वेबर की आबादी धीरे-धीरे बढ़ी और पृष्ठ शलभ जनवरी के दूसरे सप्ताह (दूसरे, मानक मौसम सप्ताह) पर 1.03 लार्वा प्रति पौधे और लीफ वेबर जनवरी के तीसरे सप्ताह (तीसरे, मानक मौसम सप्ताह) पर 4.1 बग प्रति पौधे के साथ अपने चरम स्तर पर पहुँच गये थे। इसके बाद, पृष्ठ शलभ की न्यूनतम आबादी 0.19 वयस्क प्रति पौधा जनवरी के चौथे सप्ताह (चौथे, मानक मौसम सप्ताह) में और लीफ वेबर के 2.1 बग प्रति पौधा जनवरी के अंतिम सप्ताह (5 वे, मानक मौसम सप्ताह) में देखा गया।

लेडी बर्ड बीटल (*सी. सेक्समाकुलाटा*) की आबादी दिसंबर के तीसरे सप्ताह (51 वे, मानक मौसम सप्ताह) से शुरू हुई और जनवरी के अंतिम सप्ताह (5 वे, मानक मौसम सप्ताह) तक जारी रही और जनवरी के तीसरे सप्ताह (तीसरे, मानक मौसम सप्ताह) में 1.29 वयस्क प्रति पौधा *सी. सेक्समाकुलाटा* आबादी की उच्चतम स्तर दर्ज किया गया।

उड़ने वाले सरसो के माहू की निगरानी पर अध्ययन से पता चला है, कि 48 वे मानक मौसम सप्ताह (नवंबर के अंतिम सप्ताह) के दौरान उनकी प्रारम्भिक उपस्थिति देखी गई फिर धीरे-धीरे मामूली उतार-चढ़ाव के साथ बढ़ो और अंत में 5 वे मानक मौसम सप्ताह (जनवरी के अंतिम सप्ताह) के बाद प्रयोग की अवधि के दौरान गिरावट आई। अधिकतम उड़ने वाले माहू चौथे मानक मौसम सप्ताह (जनवरी का चौथा सप्ताह) में 106.34 उड़ने वाले माहू प्रति टप दर्ज किया गया था। जिस समय मौसम संबंधी मापदण्ड जिसमें क्रमशः अधिकतम तापमान (डिग्री सेल्सियस) 31 और न्यूनतम तापमान 14.2 सापेक्ष आर्द्रता (प्रतिशत) सुबह 80 और शाम 36, वर्षा (मिमी) 0.00 और धूप (घंट में) 3.3 अनुकूल रहा। अधिकतम तापमान और वर्षा का उड़ने वाले माहू की आबादी के साथ सकारात्मक सहसंबंध और न्यूनतम तापमान, सापेक्ष आर्द्रता सुबह और शाम और धूप (घंट में) के साथ नकारात्मक सहसंबंध रहा।

सहसंबंध अध्ययनों के परिणाम से संकेत मिलता है, कि सरसो माहू और पिस्सू भृंग धूप (घण्टे) और सापेक्ष आर्द्रता सुबह और शाम के साथ नकारात्मक रूप से सहसंबंधित थे, लेकिन

सरसों माँहू का सुबह सापेक्ष आर्द्रता के साथ नकारात्मक महत्वपूर्ण सहसंबंध आया। सरसों माँहू और पिस्सू भृंग का अधिकतम तापमान और वर्षा के साथ सकारात्मक सहसंबंध थे, लेकिन माँहू का न्यूनतम तापमान के साथ सकारात्मक रूप से तथा पिस्सू भृंग के साथ नकारात्मक रूप से सहसंबंध थे। सरसों माँहू तथा पिस्सू भृंग का सभी मौसम मापदण्डों के साथ गैर महत्वपूर्ण सहसंबंध रहा। चित्रित बग एवं आरा मक्खी के सहसंबंध अध्ययनों से पता चला, कि दोनों नकारात्मक और गैर महत्वपूर्ण रूप से धूप के घण्टों, सापेक्ष आर्द्रता सुबह और शाम साथ सहसंबंध थे, जहां कवल चित्रित बग सुबह की सापेक्ष आर्द्रता के साथ महत्वपूर्ण रूप से सहसंबंध पाए गए थे। वर्षा के साथ चित्रित बग ने सकारात्मक सहसंबंध दिखाया, जबकि आरा मक्खी ने नकारात्मक सहसंबंध प्रदर्शित किया। चित्रित बग और आरा मक्खी ने अधिकतम और न्यूनतम तापमान के साथ सकारात्मक संबंध दिखाया।

पृष्ठ शलभ और लीफ वेबर के सहसंबंध अध्ययन में यह देखा गया, कि दोनों ने अधिकतम और न्यूनतम तापमान के साथ सकारात्मक और गैर महत्वपूर्ण सहसंबंध दिखाया। वे सापेक्ष आर्द्रता सुबह और शाम और धूप (घण्ट) के साथ नकारात्मक और गैर महत्वपूर्ण रूप से सहसंबंध थे। वर्षा न लीफ वेबर के लिए सकारात्मक सहसंबंध और पृष्ठ शलभ के लिए नकारात्मक सहसंबंध दिखाया।

सी. सेक्समाकुलाटा के सहसंबंध अध्ययनों से पता चला है कि यह अधिकतम और न्यूनतम तापमान और वर्षा के साथ सकारात्मक और गैर महत्वपूर्ण रूप से सहसंबंध था, जबकि सुबह और शाम की सापेक्ष आर्द्रता और धूप (घण्टे) के साथ नकारात्मक रूप से सहसंबंध था।

## CHEPTAR - I

# INTRODUCTION

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In India's agricultural economy, oil crops are the most important. Mustard, *Brassica juncea* L., is one of the first domesticated oil crops among the cruciferous plants, and it grows in the *Rabi* season. The term "mustard" comes from the Latin word "mustum," which means "must of old wine combined with crushed seed." It is one of the world's most important spices (Hemingway, 1976).

Mustard crop is an major source of edible oil. Edible oils are a high-energy food that is rightfully regarded as a necessary component of the human diet. Mustard is a condiment that originated in China and was later brought to North Eastern India and then spread all parts of country. rapeseed and mustard, several species are grown in India, mainly three cruciferous members of *Brassica* species are cultivated; *B. juncea* (Indian mustard or commonly called *rai*) being the chief oil-yielding crop, while three ecotypes of *B. rapa* sp. *oleifera*, viz. brown *sarson*, yellow *sarson*, *toria* and *B. napus* are grown to a limited extent (Bhatia *et al.*, 2011).from the nutritional point of view, it contains edible oil ranging from 38 to 46 per-cent, erucic acid 38 to 57 per-cent, linolenic acid 4.7 to 13 per-cent and oleic acid 27 per-cent which are of high nutritive value required for human body. Mustard oil is also widely used in cooking, frying and as a raw material for agro-based industries engaged in manufacturing of soaps, varnishes, paints, hair oils, medicines, lubricants, animal feeds *etc* (Downey 1983).

Globally, mustard is mainly cultivated in India, Canada, China, Pakistan, Poland, Bangladesh, Sweden and France. About 33.8 percent of the total cultivated area of world is in India with 16 per cent shares in production.

Indian rapeseed and mustard (*Brassica spp.*) crops are grown in a variety of agro-climatic conditions, from northest and northwest hilly areas to the south, under irrigation and rain irrigations, timely and late sowing, saline soil and mixed planting In 2018-19, the area of the area was 6.23 million hectares, the yield was

9.34 million tonnes and the productivity was 1494 kg ha<sup>-1</sup> (Anonymous, 2019).

In Chhattisgarh, Mustard is cultivated over 41.43 thousand hectares area with a production of 18.35 thousand tonnes and productivity of 443 kg ha<sup>-1</sup> (Anonymous, 2017-18). It is grown in Durg district over an area of about 0.98 thousand hectares with the production of 0.36 thousand tonnes and productivity of 367 kg ha<sup>-1</sup> (Anonymous, 2017-18).

It is reported that more than 43 species of pests infect mustard crop in India (Singh et al., 2009). Based on their economic importance, the pests of mustard crops can be divided into the following main pests: aphid, *L. erysimi* (Kalt), major pests: sawfly, *A. lugens proxima* (Klug), painted bug, *B. cruciferarum* (Kirkaldy) and leaf miner, *C. horticola* (Goureau) minor pests: bihar hairy caterpillar, *S. obliqua* (Walker), cabbage butterfly, *P. brassicae* (Linnaeus), flea beetle, *P. cruciferae* (Goeze) and green aphid, *M. persicae* (Sulzer), new pests: leaf webber, *C. binotalis* (Zeller), borer, *H. undalis* (Fabricius) and whitefly, *B. tabaci* (Gennadius) (Pal et al. 2020).

Mustard aphid is a potentially dangerous key pest of mustard crop has still been taking away of heavy loss of production. (Bakhetia and Sidhu, 1983). This noxious pest is responsible to 26 to 96% loss in seed yield and loss in oil content up to 15% in India. A large number of insecticides have been recommended for the management of this pest in different parts of the country. These insecticides cause serious problems such as environmental pollution, insect resistance and pest resurgence besides adversely affecting beneficial organisms. The use of natural enemies for the management of aphids has been emphasized. *Coccinella septempunctata* L., *Menochilus sexmaculatus* (Fabricius), *Chrysoperla carnea* (Stephens) and *Verticillium lecanii* (Zimmerman) have been reported for their potentiality against different aphid species (Honek, 1985).

Due to the huge changes in the date of aphid infestation and its reproduction, abiotic factors play a key role in affecting the aphid infestation. Under proper climatic conditions, because growers need to use pesticides repeatedly, mustard aphids will spread rapidly and cross the ETL boundary and reach EIL frequently. Several research have been conducted to establish relationships between meteorological factors and aphids populations. Aphids

activity on *B. juncea* peaked from the end of January to the first week of March, according to the researchers. Based on a simple linear regression study of the aphid population vs the three-year weather (Bihnoi *et al.* 1992)

Mustard sawfly, *A. lugens proxima* attacks the crop when the seedlings are 3-4 weeks old, during the early stages of development. The assault of *A. proxima* can result in a total loss in yield in rare cases, although on average, the reduction is around 25%.

Painted bug, *Bagrada hilaris* Burmeister (Hemiptera: Pentatomidae) is one of the most noxious pests of cruciferous crops in almost all parts of the country. It also attack the harvested mustard crop and on an average 30.09% reduction in seed weight, 2.75% in oil, 3.56% in protein and 1.11% in sugar contents has been reported due to the infestation of bug (Pradhan *et al.* 2019).

Mustard aphids and several biological factors in ladybirds are important predators, because most of them, *Coccinella septempunctata* and syrphid flies, are early predators on several insect pests, including aphids, coccidia, nematodes and Acyclics nematodes. 90% of the 4,200 known species of the genus *Chlorella* are precocious (Iperti and Paoletti, 1999), and the diversity of the Indian coccidioides includes 119 precocious species (Omkar and Pervez, 2000c). Among them, the discoloured Indian locust (Fabricius) is native to India (Agarwala and Ghosh, 1988; Gautam, 1994). Beetles have obvious sexual dimorphism (Omkar and Pervez, 2000b), and a large number of predators of aphids can effectively control certain aphids, such as cotton aphids (*Aphids gossypii* Glover) and *Aphids craccivora* Koch. (Agarwala, 1987; Omkar and Pervez, 2000b; Hemchandra *et al.*, 2010).

The alate reproductive forms of mustard aphid migrate from the hills to plains during the onset of winter and settle on the mustard crop in plains for their survival, growth and development. aphids are mostly attracted towards yellow colour of mustard flowers (Dilwari and Atwal, 1989). Generally, Insect traps are important tools for determining the need for control or the timing of control measures by monitoring insect populations and for assessing their effects (Gillespie and Quiring, 1987). In general, sticky trap catches can be used to

monitor the arrival of alate aphid which may prove useful in decision making for execution of pest management strategies.

Therefore, the present study was carried out to study on insect pest incidence of mustard and monitoring of the alate form of mustard with the following objectives:-

1. To study the seasonal incidence of insect pests of mustard and their natural enemies.
2. Monitoring of the alate form of mustard aphid through yellow sticky trap in relation to meteorological parameters.
3. Correlation studies of insect pests of mustard with the meteorological parameters.

## CHAPTER II

### REVIEW OF LITERATURE

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This chapter briefly introduces the research work carried out on the investigated pest. Related aspects by various workers from the abroad, India and Chhattisgarh are included during investigation. The writing relating to the current research entitled “**Seasonal dynamics of insect pests and natural enemies in relation to meteorological parameters on mustards**” are collected and explained below:

- 2.1: To study the seasonal incidence of insect pests of mustard and their natural enemies.
- 2.2: Monitoring of the alate form of mustard aphid through yellow sticky trap in relation to meteorological parameters.
- 2.3: Correlation studies of insect pests of mustard with the meteorological parameters.

#### **2.1: To study the seasonal incidence of insect pests of mustard and their natural enemies.**

##### **2.1.1. Aphid, *Lipaphis erysimi* (Kalt.)**

Begum and Begum (1974) studied the population fluctuations of the mustard aphid, *L. erysimi* on various sowing dates of mustard crop and observed that crops sown in the third week of September had a lower incidence of *L. erysimi* and produced higher yields without any chemical control.

Charoenridhi *et al.* (1976) studied the frequency and population fluctuation of aphid on mustard from Fang Northern Thailand and found that peak incidence of *Lipaphis* occurred between Decembar and March.

Prasad and Phadke (1980) concluded that aphid multiplication was favoured by temperatures ranging from 18 to 24°C and 7.6°C, respectively, with a prolonged dry spell.

Bakhetia and Sidhu (1983) reported that the highest time of aphid occurrence was from January 1 to March 6, when high temperatures exceeded 30°C and sub-zero winter temperatures had a negative impact on the aphid population.

Chandra and Kushwaha (1986) recorded that, from the second week of January to the last week of February was the most susceptible time of the infestation of aphid, *Lipaphis erysimi* (Kalt.) and *M. persicae* on mustard, cauliflower and cabbage.

Ahuja (1990) reported that the *Lipaphis erysimi* appeared on mustard in late December and reached a peak at the last week of January at Rajasthan. Aphid populations are negatively correlated with average maximum and minimum temperatures and sunshine time while, It is positively correlated with humidity.

Sandhya (1995) studied the population dynamics of mustard pests especially mustard aphids, *Lipaphis erysimi* (Kalt.) at Raipur, Chhattisgarh. She observed the activity of aphids from October to March and reached a peak in the second fortnight of December.

Panda *et al.* (2000) found that the aphid, infested the crop from the 52nd to 14th SMW, with a peak of 302.10 aphid/plant during the 7th SMW, when the crop was 70 days old. Minimum temperatures (7.1 to 15.1°C), maximum temperatures (24.9 to 29°C) and mean relative humidity (61-65.5 percent) were found to be most congenial for the proper development of aphid population.

Choudhari *et al.* (2002) reported from West Bengal, that the population of mustard aphid, *L. erysimi* was maximum during 3rd, 4th week of February and 1<sup>st</sup>, 2<sup>nd</sup> week of March.

Ansari *et al.*, (2007) investigated the arrival of mustard aphids on 11<sup>th</sup> January and their disappearance on 2<sup>nd</sup> March, when crop was 60 and 100 days old, respectively. Aphid peaks were found at the highest, lowest and average temperatures of 23.37°C, 6.87°C, and 15.76°C, respectively. Maximum and average temperatures had a positively non-significant, while low temperatures had a negatively non-significant impact on the aphid population.

Choudhary and Pal (2009) investigated mustard aphid population dynamics on seven common rapeseed-mustard cultivars and reported the occurrence of aphid starts from the 52nd SMW to 2nd SMW, with very low population levels on all cultivars, however, peaked between the 7th and 9th SMW.

Khedkar *et al.* (2012) recorded that the *L. erysimi* population started in the fifth week of December (52nd SMW), and the aphid index was 0.31 on variety Gujarat mustard-2. In the second week of February (6th SMW), pest activity increased steadily and reached a peak with 3.88 aphid index. The population steadily decreased as the crop matured, eventually disappearing at the 9 SMW. Overall, insect behaviour ranged from 0.312 to 3.88 aphid index from the fifth week of December to the first week of March (starting from flowering stage to crop maturity).

Yadav and Singh (2016) first observed the incidence of mustard aphid in the fourth week of January, when the plants were in flowering stage and peaked in the last week of February (82.5 aphids/plant).

Mandawi *et al.* (2017) recorded the appearance of mustard aphids on January 2nd & 5th during 2013-14 and 14-15, respectively and disappeared after mid March. The peak period of aphid population was found at 5th to 9th SMW with 114.41 to 318.01 aphid/plant during *rabi* 2013-14 and 113.92 to 314.52 aphid /plant during *rabi* 2014-15. The correlation coefficient showed a non-significant negative effect with maximum and minimum temperature whereas relative humidity showed non-significant positive effect.

Kashyap *et al.* (2018) recorded that the appearance of mustard aphids on 1st week of December with 1.32 aphid/ plant at 5 cm apical twig. Aphid infestation peaked in the 7th SMW, with a minimum temperature of 11.6°C and a maximum temperature of 24.30°C, as well as morning humidity of 91 percent and evening humidity of 44 percent.

Pradhan *et al.* (2019) recorded that the aphid, *L. erysimi* population on mustard crop were first appeared during 51<sup>st</sup> SMW *i.e.* 3rd week of December. However, correlation studies between different weather parameters and population of aphid revealed that maximum temperature recorded positive correlation.

Pradhan *et al.* (2020) conducted field experiments at Instructional-Cum-Research (ICR) farm, Assam Agricultural University, Jorhat during *rabi* 2018 & 2019 and investigated that the insect pest, mustard aphid, *Lipaphis erysimi* (Kalt.) were abundantly at different developing stages of the crop.

### **2.1.2. Mustard saw fly, *Athalia lugens proxima***

Choudhary and Bhamburkar (1970) reported that August had the highest population of *A. lugens proxima*. from Nagpur, Maharashtra.

Nair (1975) reported that, the mustard sawfly, *A. lugens prxima* appears throughout the year, and generally there are 3-4 generations in a year at northern India, However, there are as many as 10 overlapping generation in a year during severe winter at southern India.

Ghosh and Ghosh (1981) conducted an experiment to see how various sowing dates affects the population of mustard sawfly *A. lugens proxima* at West Bengal, India, The mustard crop sown in October had a significantly lower pest load and produced significantly better growth and seed yield than the crop sown in November.

Hassan *et al.* (1994) studied the seasonal abundance of *A. lugens proxima* on mustard at Bangladesh and recorded that when mustard was sown on 22<sup>rd</sup> September, 7<sup>th</sup> October and 22<sup>nd</sup> October, infestations of the pests were least while highest yields were recorded when mustard was sown on 22<sup>nd</sup> September.

Patel and Patel (1997) reported that the mustard sawfly populations were slightly lower and yields were higher, when crop was sown on third week of September and the first week of October as compare to the crop sown in the third week of November.

Ansari and Naqshbandi (2004) observed that mustard saw fly infestation was considerably higher, early in the crop cycle than later. The most severe damage was seen 50-60 days after sowing.

Singh *et al.* (2012) observed that the population of grubs of mustard saw fly were 0.17 to 0.55 and 0.62 to 1.78 grubs per plant during *Rabi* 2005-06 and *Rabi* 2006-07, respectively and during both seasons, the mustard saw fly was found attacking the crop at the seedling stage.

Singh *et al.* (2018) recorded that the mustard sawfly *Athalia lugens proxima* (Klug) emerged first from 51st SW with 0.75 larvae/plant and reached to peak at 2nd SW with 2.5 larvae/plant. The population declined further as the crop matured, eventually disappearing after the 7th SW, when the temperature was 25.4°C (maxi.) and 4.3°C (min.) with a RH of 69.00 percent and 0.0 mm rainfall.

Pradhan *et al.* (2019) reported mustard sawfly was first seen during the 51st SMW, or the third week of December, 2018 and remained involved until the 9th SMW, or the first week of March, 2019. The highest population (1.01/plant) was measured during the 4th SMW, which occurred during the last week of January 2019, when the maximum and minimum temperatures were 25.9°C and 10.3°C, respectively, with 93 percent and 61 percent morning and evening relative humidity and zero rainfall.

Pal *et al.* (2020) conducted research at Oilseed Farm Kalyanpur, Kanpur during *rabi*, 2018-19 and find out that the occurrence of Mustard sawfly *Athalia lugens proxima* Klug was observed at seedling stage, The cloudy weather condition and temperature from 8-32°C favoured the insect pests multiplication.

### **2.1.3. Painted bug, *Bagrada hilaris***

Batra (1958) recorded 4.5 per cent reduction in oil content when the rapeseed-mustard dry seeds were fed to painted bug under laboratory conditions for two months continuously.

Dhaliwal and Goma (1979) reported that the painted bug feeding on leaves, buds, bulbs, and growing seed pods caused 30 to 72 percent damage to a cauliflower seed crop, During the crop season, the pest density ranged from 2.08 to 4.95 (nymphs and adults) per 100 plants.

Joshi *et al.* (1989) reported that the painted bug infestations during seedling stage in rapeseed-mustard crops losses the seed yield were estimated to be 26.84 to 70.43 per cent.

Singh and Malik (1993) recorded two peak periods of painted bug population, the first in October-November and the second in March-April. The painted bug population revealed that a mean temperature of 22-25°C and a relative humidity of 54 percent were ideal for the pest's growth.

Sekhon (2003) observed the prevalence of occasional pests has an effect on the rapeseed-mustard. He observed over the last 20 years and suggested that two minor crop pests become major pests in several years and cause significant losses. Both *Bagrada hilaris* Burmeister and *Cornifrons ulceratalis* Lederer emerge during very dry years, when rainfall is scarce and the soil is dry and loose, optimal conditions for these insects. *B. hilaris* is so bad in dry weather that it totally wipes out germinating seeds, forcing farmers to re-sown the grain.

Jat *et al.* (2006) recorded seasonal occurrence of painted bug on mustard and found that the infestation starting at the time of germination (first to fourth week) and that the average population of painted bugs per plant was 2 to 5. Eventually, the population grew until it peaked in the third week of November. Climate conditions have a non-significant impact on painted bug population with a negative association between high temperature ( $=0.3051$ ) and minimum temperature ( $=0.164$ ).

Nagar *et al.* (2011) reported the painted bug infestation in the 46th SMW with (0.5 bug/m row length), which gradually increased and peaked (6.5 bug/m row length) in the 49th SMW, then diminished and vanished from the 1st to 4th SMW. It was seen again in the 5th SMW (0.2 bug/plant) and peaked at 9.7 bug/plant in the 12th SMW.

Divya *et al.* (2015) observed the incidence of painted bug on mustard, starting in the third week of December and reached two peaks, the first occurring during the first week of January with 6.75 bugs/plant and the second peak during the third week of January with 7.05 bugs/plant during 2012-13, and the population of painted bug reached, first peak during the second week of January with 6.95 bugs/plant in 2013-14.

Patel *et al.* (2017) conducted a research on seasonal incidence of painted bug, *Bagrada hilaris* at G.B. Pant University of Agriculture and Technology, Pantnagar (India) during *Rabi* 2015-16. *Brassica spp.*, including *Brassica campestris* var. *brown sarson*, *Brassica campestris*, *Brassica alba*, *Brassica carinata*, *Brassica nigra*, *Brassica juncea*, *Brassica napus*, and *Eruca sativa*, were sown at fifteen-days intervals on five dates between October 3 and December 3, 2015. The findings reveal that the pest infestation on the crop occurs in two phases,

one during seedling development and the other during crop maturity. *Bagrada hilaris* populations were lowest in *B. napus* and highest in *B. alba*. Regarding sowing date, the bug population was lowest in the crop sown on October 18 (second sowing), and highest on October 3 (first sowing). Maximum yield were found up to the third sowing date (Nov 3).

Kashyap *et al.* (2018) revealed that the painted bug infestation, *Bagrada hilaris*, began in the fourth week of December (52nd SMW) with 0.26 bug per plant. The population gradually increased and reached peak in the second week of February (7th SMW) with 3.8 bugs per plant. Thereafter, the population slowly declined until the second week of March.

Pal *et al.* (2018) studied the population dynamics of painted bug two times during the season. The first population was recorded from the 45th SW to 52nd SW, and second population observed from 6th SW to 12th SW. In the first population, there were  $0.3 \pm 0.2$ - $7.5 \pm 0.5$  larvae/plant, and in the second population, there were  $1.9 \pm 0.2$ - $8.9 \pm 0.5$  larvae/plant. The peak population of the first population at the 50th SW was  $7.5 \pm 0.5$  larvae/plant and the peak population of the second population at the 11th SW was  $8.9 \pm 0.5$  larvae/plant in season.

Pal *et al.* (2020) found that the painted bug emerged on *Brassica* crops at two distinct stages of growth: first, at the seedling stage, and then at the pod bearing to maturity stage, missing the flowering stage. The insect was observed from the 45th to the 48th SMW on a regular basis during the first phase, and from the 8th to the 12th SMW during the second phase.

#### **2.1.4. Diamondback moth, *Plutella xylostella***

Bana *et al.* (2012) observed the infestation of diamondback moth, started from the 3<sup>rd</sup> week of November and reached peak population in 1<sup>st</sup> week of January. Correlation studies revealed the population of diamondback moth with maximum and minimum temperatures showed significant negative correlation whereas, relative humidity and sunshine hours showed non-significant correlation.

Bhagat *et al.* (2018) recorded the activity of diamondback moth in cabbage started from the last week of December in 2015-2016 (0.075/20 plants) and first week of January in 2016-2017 (0.125/20 plants) and reached peak populations

(6.85/ 20 plants and 5.25/20 plants) in March during both the years. The maximum temperature had a non-significant negative correlation with larval population in the year 2016-17, but a positive correlation during 2015-16. In both years, the minimum temperature had a positive association with  $r = 0.24$  and  $r = 0.21$ , respectively. Though, the relative humidity had negative and positive relation with the larval population of diamondback moth in both years with the  $r = -0.26$  and  $r = 0.11$ , respectively. In 2015-16, sunshine hours had a negative but non-significant ( $r = -0.31$ ) effect, while in 2016-2017, it had a positive ( $r = 0.38$ ) effect. However, rainfall had a favourable non-significant relationship with  $r = -0.05$  and  $r = -0.08$ , respectively during both the years.

Sahu *et al.* (2020) recorded the activity of Diamondback moth *Plutella xylostella* (Lepidoptera: Plutellidae) on cabbage crop (*Brassica oleracea* var. *capitata* L.), in Jabalpur, Madhya Pradesh during the *Rabi* season 2017-2018. *P. xylostella* first appeared when the crop was around 82 days old, *i.e.* the first week of December (49th SW). The pest was present on the crop during the vegetative stage and remained active until the 11th standard week, when the crop was harvested. Maximum, minimum and average temperature showed significantly positive correlations with larval population, while morning and average relative humidity showed significant negative correlations with the pest.

#### **2.1.5. Flea beetle, *Phyllotreta striolata***

Nath *et al.* (2002) recorded the flea beetle, *Phyllotreta striolata* population on mustard crops began to rise in the last two weeks of December and peaked in February.

Choudhury and Pal (2005) observed the populations of flea beetle, *Phyllotreta striolata* at weekly intervals during *rabi* 2002-2003. The flea beetle population first observed on 18<sup>th</sup> December *i.e.* 3<sup>rd</sup> week after sowing on *Brassica*.

Nayak (2010) observed the occurrence of flea beetle, *Phyllotreta cruciferae* at 45<sup>th</sup> SMW. Correlation studies revealed the population of flea beetle was positive correlation with maximum and minimum temperature while negative correlation with relative humidity.

Patel *et al.* (2017) observed the population of flea beetle on *Brassica species* at different sowing dates. Eight *Brassica species*, including *B. rapa*, *B. alba*, *B. carinata*, *B. nigra*, *E. sativa*, *B. juncea*, and *B. napus* were sown at fifteen-days intervals on five different dates between October 3 and December 3, during *Rabi* 2015-16 and 2016-17. The findings revealed that *E. sativa* had the highest population of *P. cruciferae* (5.79 and 19.2 beetles/m<sup>2</sup>), while *B. carinata* had the lowest population (2.08 and 6.1 beetles/m<sup>2</sup>) for two years in a row, 2015-16 and 2016-17. The population of flea beetles observed on various *brassica species* differed significantly with respect to different sowing dates in both years. During 2015-16, the average mean population of *P. cruciferae* was observed to be highest in the first, second, and third sowing dates, and lowest in the fourth and fifth sowing dates. During 2016-2017, however, the flea beetle population was observed to be higher in the fourth and fifth sowing dates during 2016-17.

Kashyap *et al.* (2018) recorded the flea beetle population commenced at initial stage of the mustard crop from 1<sup>st</sup> week of December (49<sup>th</sup> SMW) with 2.4 beetle/plant. The peak infestation of flea beetle was 15.8 beetle/plant in 1<sup>st</sup> week of February (6<sup>th</sup> SMW). Correlation studies, revealed that the population of flea beetle was positive correlated with maximum temperature, minimum temperature and rainfall while negative correlation with morning relative humidity and evening relative humidity but all the correlation was non-significant.

Lal *at el.* (2018) determine the seasonal dynamics of insect pests of mustard. The flea beetle infestation started during the 47th SMW and peaked during the 52nd SMW. The flea beetle population had a significant positive correlation ( $r = 0.35$ ) with maximum temperature and a negative correlation ( $r = 0.35$ ) with morning and evening relative humidity.

Pradhan *et al.* (2019) reported the seasonal incidence of flea beetle, *P. cruciferae* and find out that the flea beetle, *P. cruciferae* appeared during 51st SMW *i.e.* 3rd week of December, 2018. The correlation studies between different weather parameters and population of flea beetle revealed that maximum temperature recorded positive correlation with correlation coefficient  $r = 0.510$ . Minimum temperature had non-significant positive correlation ( $r = 0.120$ )

population. Morning and evening relative humidity had non-significant negative correlation. Rainfall had negative and non-significant correlation ( $r = -0.206$ ).

#### **2.1.6. Natural enemies, *Cheilomenes sexmaculata***

Bakhetia and Sekhon (1989) reported the natural enemies play an important part in insect population control. Six species of *coccinellids*, sixteen species of syrphids, four species of hymenopterous parasitoids, four species of entomogenous fungi, and one parasitic bird were found to be synonymous with mustard aphid in India.

Panda (1999) observed the occurrence of mustard aphid beginning in the middle of December and reached peak in the middle of February, with a gradual decrease, as the temperature and relative humidity rise. In the months of January and February, natural enemies such as the ladybird beetle and the syrphid fly were found in close proximity.

Kulkarni and Patel (2001) reported that the *Diaeretella rapae* found in the first week of February with a parasitism rate of 11.27 percent, and then steadily increased until the fourth week of February with a parasitism rate of 43.68 percent.

Dogra *et al.* (2003) recorded the parasitization of *L. erysimi* by *Diaeretella rapae*, which appeared in the second week of January. Maximum parasitization (5-10 %) was recorded in the second week of March, when maximum, minimum, mean temperature and relative humidity were 22.5, 10.3 °C and 36%, respectively.

Dhiman (2007) found that the population density of both adult and mummified aphids was lowest in December-January and highest in February-April on mustard. During 2006-07 and 2007-08, the percentage of *Diaeretella rapae* parasitizing aphid, *L. erysimi* on mustard was 75.46 percent and 68.96 percent, respectively.

Singh *et al.* (2009) tested four bio-agents, including *C. septempunctata* L., *M. sexmaculatus* (F.), *C. carnea* (Stephens), and *V. lecanii* (Zimmerman), against the mustard aphid, *Lipaphis erysimi* (Kaltenbach), on single plants covered with muslin cloth in the mustard field. *C. septempunctata* @ two adults/plant was found to be the most successful, decreasing 96.19 percent of the aphid population in ten

days, followed by *C. septempunctata* @ two larvae per plant (93.42 percent ), *V. lecanii* @ 108 spores-ml (84.90 percent ), *M. sexmaculatus* @ two adults (84.62 percent ), and *C. carnea* @ four larvae (82.98 percent ). The aphid population was reduced by 77.49 percent when *C. septempunctata* was used as one adult per herb and *M. sexmaculatus* was reduced by 69.08 percent.

Ishwarbhai (2015) noticed the *Coccinellid* activity (grub and adult) began in the third week of January and continued until the first week of March, with a peak (0.80 grub and adult/plant) in the fourteenth week after sowing. *Diaeretella rapae* parasitization began in the 10th week after sowing (0.90 percent parasitism), *i.e.* the 4th week of January, and peaked in the 17th week after sowing, *i.e.* the 2nd week of March.

Varshney *et al.* (2017) studied the population dynamics of potential bio-agents of mustard aphids. At weekly intervals, the aphid population and natural enemies were counted. The findings revealed that *coccinellids* and syrphids first appeared during the 4th standard week, steadily increasing in population and peaking during the 9th (pooled mean 1.42 coccinellids/plant and 0.122 syrphid larva/plant) and 8th (pooled mean 3.96 coccinellids/plant and 0.228 syrphid larva/plant) standard weeks in 2008-09 and 2009-10, respectively.

Kashyap *et al.* (2018) worked on insect-pest succession in mustard crop with different weather parameters during *rabi* season. The activities of predators (lady bird beetle, syrphid fly) and parasitoid (*Diaeretella rapae*) were also recorded from December to 3<sup>rd</sup> week of March on mustard.

Pradhan *et al.* (2019) studied the natural enemies on mustard and revealed that the natural enemies *viz.*, ladybird beetle (*C. transversalis*) and *Diaeretella rapae* appeared during 4th SMW *i.e.* (last week of January, 2019).

Soni (2020) observed the three natural enemies: *coccinellids*, *syrphids*, and one parasitoid, *Diaeretiella rapae*, were found to be associated with the aphid species. They emerged late in the season, and their peak population did not coincide with aphid population levels, leaving them unable to control the aphid population.

## **2.2: Monitoring of the alate form of mustard aphid through yellow sticky trap in relation to meteorological parameters**

Diraviam and Uthamasamy (1992) demonstrated that the yellow sticky traps were used to track the behaviour of seven different species of thrips infesting cotton, sunflower, groundnut, and soybean in the garden land ecosystem, as well as brinjal, okra, tomato, chillies, onion, and sweet potato. The castor oil-smearred cylindrical aluminium traps (length 17.5 cm; diameter 15.5 cm; surface area 1030 sq. cm.) were erected at a height of 30 cm and painted with light highways yellow colour. Observations began 20 days after sowing/transplanting and lasted until the Crop reached senescence. The highest mean number of catches of thrips/trap/week on sunflower (915.34), followed by onion (638.98) and soybean (638.98), next in order was brinjal (452.05), okra (417.83), cotton (407.17), groundnut (374.44) and tomato (374.44). Sweet potato (253.21) > chillies (240.21) had the lowest catches, which were comparable to cotton, groundnut, and tomato.

Nandihalli *et al.* (1993) used yellow sticky traps at Regional Research Station, Raichur during 1986-88 and observed that the population dynamics of cotton whitefly, *Bemesia tabaci* (Genn.) showed greater presence of the pests from November to January. In the absence of cotton, the whitefly found alternative hosts in small numbers. When opposed to traps set at 60 cm and 90 cm heights, the trap set at 30 cm height from ground level caught more whitefly. It was noticed that the significantly negative relationship between whitefly capture and maximum and minimum temperature, as well as a significant positive relationship with mean morning relative humidity. The whitefly population was affected by all of the weather variables, which ranged from 42.9 to 70.6 percent.

Singh and Sharma (2009) noticed over the four-year sample, the alate mustard aphids appeared at different times. In the 51st SMW (2000-01), 50th SMW (2001-02), 4th SMW (2002-03) and 2nd SMW (2002-03), the aphid population began to grow (2003-04). The original populations were 0.93, 2.16, 1.0, and 19.4 aphids per traps, respectively. Similarly, the peak alate aphid population was registered during the 12th SMW (2000-01) with 86.14 aphids per trap; 9th SMW (2001-02) with 405.6 aphids per trap; 10th SMW (2002-03) with 99.71

aphids per trap; and 9th SMW (2003-04) with 847.25 aphids per trap. Any other year, the population record showed a strong improvement.

Krishnan (2012) prepared locally innovated yellow sticky traps and installed in cotton fields. When he tested various coloured sticky traps, he observed that yellow sticky traps attracted the most sucking pests such as jassids (2640), whiteflies (1166), and thrips (352) @ yellow sticky traps 50 per hectare.

Singh and Lal (2012) recorded the catches of aphid (*Lipaphis erysimi*) population through the yellow sticky trap installed all around mustard growing field, during *Rabi* 2009-10 and 2010-11. The catches of alate aphids were maximum 186.00/trap and 280.00/trap during the 8<sup>th</sup> standard week in both the years. The catches of alate aphid (*L. erysimi*) showed non-significant positive correlation with temperature (%), rainfall and sunshine (hrs). However, humidity showed non-significant negative correlation with alate catches.

Bantewad (2015) found that the treatments of yellow sticky trap along the crop canopy with azadirachtin 10,000 ppm @ 2 ml/lit. and yellow sticky trap at 15 cm height below crop canopy with azadirachtin were significantly effective treatments in order of merit for trapping 1930.33 and 1521.50 aphids/trap/week, respectively, and minimising aphid infestation on plants at 7 days (3.53 /L and 3.82/L) and 14 days (6.16/L and 6.46/ L) after spray, respectively.

Sundar *et al.* (2018) recorded that the population of aphids fluctuated throughout the season. The first observation noticed in the 45th SW of the season, with  $0.10 \pm 0.1$  aphid/plant attracted towards a yellow sticky trap. The population continued to grow, reaching 52nd SW with  $13.7 \pm 0.9$  aphids per plant. After that, the population of 1st SW decreased, and the population was  $9.7 \pm 0.4$  aphids/plant. This population continued to grow until it reached the 7th SW, after which it began to decline. The 52nd SW ( $13.7 \pm 0.9$  aphids/plant) and 7th SW ( $35.4 \pm 2.9$  aphids/plant) reported the two highest aphid populations.

Sahoo and Saha (2018) observed the alate aphid first appeared during the 50th Standard Meteorological Week (first fortnight of December), then steadily increased with minor fluctuations before eventually declining during the 10th Standard Meteorological Week (5th March–11th March). The highest alate mustard aphid trapping ( $305 - 457$  alate aphid trap<sup>-1</sup>) was reported at the end of February

(8th and 9th Standard Meteorological Week). This may be due to crop maturity and rising temperatures at that time, which affected alate aphid development for migration. Temperature (maximum and minimum), relative humidity (maximum and minimum), and wind speed were all found to be significantly correlated with alate aphid occurrence, with maximum temperature having the highest positive correlation ( $r = 0.698$ ). In general, higher populations of alate aphid were found during the experiment when the maximum temperature was 30°C and the minimum temperature was 16°C.

### **2.3: Correlation studies of insect pests of mustard with the meteorological parameters**

Achinty and Debjani (2012) reported that maximum and minimum temperature, average wind speed, and bright sunshine duration are significantly related to the numbers of *Lipaphis erysimi* and individuals/sampling unit.

Kashyap *et al.* (2018) worked on insect-pest succession in mustard crop during *rabi* season with different weather parameters. The activities of predators (lady bird beetle, syrphid fly) and parasitoid (*Diaeretella rapae*) were also recorded from December to 3<sup>rd</sup> week of March on mustard. They found that the correlation between natural enemies and weather parameters was positive and non-significant during rainfall and maximum, minimum temperature however, negative and non-significant correlation during morning and evening relative humidity.

Lal *et al.* (2018) recorded that the aphid population was positively correlated with morning ( $r = 0.49$ ) and evening relative humidity ( $r = 0.44$ ) and negatively correlated with maximum and minimum temperature, while painted bug population was found to be significantly and positively correlated with maximum and minimum temperature ( $r = 0.48$  and  $0.61$ ). The flea beetle population, on the other hand, showed a significant positive correlation ( $r = 0.35$ ) with mean temperature and a significant negative correlation ( $r = 0.35$ ) with morning and evening relative humidity. Natural enemies and weather parameters correlation revealed that the maximum temperature was significantly positive correlated ( $r = 0.76$ ,) with *Coccinella* beetle population while morning and evening relative humidity were found to be negatively correlated ( $r = -0.92$ ,  $-0.90$ , respectively).

The *Diaeretiella rapae* population showed significant positive correlation with maximum, minimum temperature and rainfall ( $r = 0.42, 0.40, \text{ and } 0.26$ , respectively), while morning and evening relative humidity were found to be negatively correlated ( $r = -0.11, -0.28$ , respectively)

Mandal *et al.* (2018) reported that the population of the aphid *Lipaphis erysimi* (Homoptera: Aphididae) in the mustard area fluctuated and peaked at 289 per plant on December 22. In comparison to individual siliqua and leaf, the inflorescence had a considerably higher degree of infestation. The prevalence of aphid had a strong negative correlation with the daily mean temperature, negligible negative correlation with light intensity, and insignificant positive correlation with relative humidity. The multiple linear regression study revealed that weather variables such as temperature, light intensity, and relative humidity, both individually and collectively, influenced aphid abundance, but the temperature had greater effect than other factors.

Pradhan *et al.* (2019) observed the correlation between different weather parameters and population of natural enemies in mustard field, maximum temperature had a positive impact on *C. transversalis* ( $r = 0.195$ ) and *D. rapae* population ( $r = 0.194$ ). Minimum temperature had significant positive correlation on ladybird beetle ( $r = 0.669$ ) and *D. rapae* population ( $r = 0.682$ ). Morning relative humidity had non-significant negative correlation with both natural enemies and evening relative humidity *C. transversalis* ( $r = -0.058$ ) and *D. rapae* ( $r = -0.047$ ) also it was found to be negatively correlated. Rainfall had positive and non-significant correlation with *C. transversalis* ( $r = 0.066$ ) and *D. rapae* ( $r = 0.080$ ) population.

Soni (2020) reported that the three natural enemies, *coccinellids*, *syrphids*, and one parasitoid, *Diaeretiella rapae* were found to be associated with the aphid species. Correlation coefficients indicated that the temperature favoured the growth of aphid populations and their natural enemies, while rainfall had a negative effect. The coccinellid population was negatively associated with the populations of *L. erysimi* and *M. persicae*, but there was a positive association with *B. brassicae*. The population of syrphids, was found to be positively correlated with the population of aphids. Regression analysis studies indicate that none of the weather

variables were liable on the population build-up of aphids and associated natural enemies.

## CHAPTER – III

# METHODS AND MATERIALS

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This chapter provides a brief overview of the soil, meteorological parameters, materials and procedures used during the investigation. The present investigation entitled “**Seasonal dynamics of insect pests and natural enemies in relation to meteorological parameters on mustard**” was carried out in the Research cum Instructional Farm at Sant Vinoba Bhave College of Agriculture and Research Station, Marra (Patan), Durg (Chhattisgarh), during *Rabi* 2020-21. This chapter goes into the specifics of the tools used and the methods used in the investigation.

### **3.1 Experimental site**

The experiment was conducted under the Chhattisgarh plains agro-climatic zone of Chhattisgarh. The site was located at Research cum Instructional Farm of Sant Vinoba Bhave College of Agriculture and Research Station, Marra (Patan), Durg (Chhattisgarh), during *Rabi* 2020-21.

### **3.2 Geographical Situation**

Durg district is situated in the southern part of the rich Chhattisgarh plains zone at 20°54' and 21°32' north latitude and 81°10' and 81°36' east longitude of 317 meter above the mean sea level.

### **3.3 Agro-climatic condition**

The general climate prevailing in the district Durg, Chhattisgarh is tropical type. Summer is a little bit hotter. Rise of temperature begins from the month of March to May. May is hottest amongst other. Durg district's annual average rainfall is 1052 mm. During the year, most rainfall occurs during the monsoon months June to September. July is the month of highest rainfall.

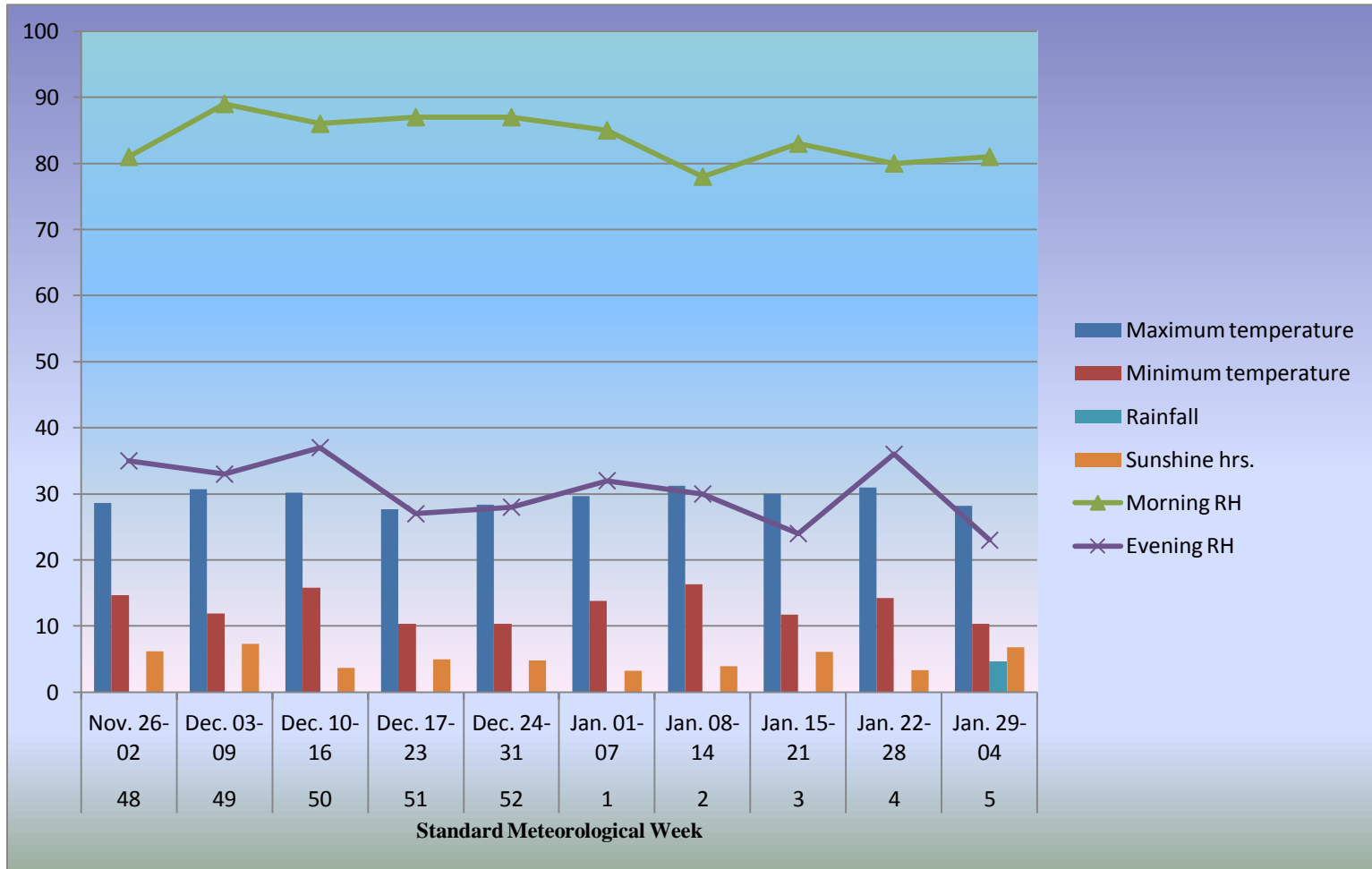
### **3.4 Weather conditions during crop period**

The meteorological observations *viz.*, maximum temperature, minimum temperature, relative humidity, rainfall and sunshine hours from November 2020 to February 2021 were collected from Department of Agrometeorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G) and average weekly weather data has been summarized in Table No - 3.1 and fig. No - 3.1.

**Table 3.1: Average Weekly Meteorological Data during 2020-21.**

Standard Meteorological Week (SMW)	Date	Temperature (°C)		R.H. (%)		Rainfall (mm)	Sunshine(hrs)
		Max.	Min.	Mor.	Eve.		
48	<b>Nov.</b> 26-02	28.6	14.7	81	35	0.0	6.2
49	<b>Dec.</b> 03-09	30.7	11.9	89	33	0.0	7.3
50	<b>Dec.</b> 10-16	30.2	15.8	86	37	0.0	3.7
51	<b>Dec.</b> 17-23	27.7	10.3	87	27	0.0	5.0
52	<b>Dec.</b> 24-31	28.4	10.3	87	28	0.0	4.8
01	<b>Jan.</b> 01-07	29.7	13.8	85	32	0.0	3.2
02	<b>Jan.</b> 08-14	31.2	16.3	78	30	0.0	3.9
03	<b>Jan.</b> 15-21	30.0	11.7	83	24	0.0	6.1
04	<b>Jan.</b> 22-28	31.0	14.2	80	36	0.0	3.3
05	<b>Jan.</b> 29-04	28.2	10.3	81	23	4.6	6.8

**Fig 3.1 Average Weekly Meteorological Data during 2020-21**



### 3.5 Field preparation

The preparation of field was done by tractor-drawn cultivator followed by two cross-harrowing to pulverize the soil.

### 3.6 Experimental details

The experiment will be conducted at Research cum Instructional Farm of Sant Vinoba Bhave College of Agriculture and Research Station, Marra (Patan), Durg (Chhattisgarh) with one variety in RBD Design, during *Rabi* 2020-21 with the technical programme as follows:

<b>Crop</b>	Mustard
<b>Variety</b>	PM 25 (Pusa Mustard 25)
<b>Year</b>	2020-21
<b>Season</b>	<i>Rabi</i>
<b>Design</b>	RBD
<b>Replications</b>	Three
<b>No. of Plots</b>	Five
<b>Plot size</b>	5m X 3m (15m <sup>2</sup> )
<b>Planting distance (Row × Plant)</b>	30cm X 10 cm
<b>Date of sowing</b>	10/11/2020
<b>No. of rows/plot</b>	16
<b>No. of plants/row</b>	30
<b>Fertilizer dose (N:P:K)</b>	80:40:20 kg/ha

### **3.7 Observation Methodology**

#### **3.7.1 To study the seasonal incidence of insect pests of mustard and their natural enemies**

A study on seasonal incidence of insect pests of mustard was carried out on variety PM-25 (Pusa Mustard-25). The crop was raised after following standard agronomical practices in large plot for recording observations of insect pests *viz.*, mustard aphid, *Lipaphis erysimi* (Kalt.), flea beetle, *Phyllotreta striolata*, painted bug, *Bagrada hilaris*, saw fly, *Athalia lugens proxima*, diamondback moth, *Plutella xylostella*, leaf webber, *Crocidolomia binotalis*, as well as natural enemies *viz.*, *Cheilomenes sexmaculata*. Whole crop plot was divided into five equal plots. The plots were kept free from any insecticidal spray throughout the crop period. The observations recorded at weekly intervals soon after their appearance during crop season till harvesting of the crop.

##### **3.7.1.1 Aphid, *Lipaphis erysimi* (Kalt.)**

Five plants were selected randomly and tagged with label for recording the observation of aphid population at weekly intervals and note the first appearance of aphid on plants from each plot. As the aphid first appeared, the population was recorded from central apical twigs (10 cm). The aphid populations were recorded till the maturity of crop. The weekly average aphid populations were correlated with the meteorological parameters like maximum and minimum temperature ( $^{\circ}\text{C}$ ), morning and evening relative humidity (%), rainfall (mm) and sunshine (hrs) and the method has been summarized in Table No.-3.2.

##### **3.7.1.2 Flea beetle, *Phyllotreta striolata* (Fabricus)**

The observations on number of flea beetles were recorded at weekly intervals from randomly selected five plants from each plot. Five plots were examined for each observation thus, total twenty five plants were observed to record the population of flea beetle and the method has been summarized in Table No.-3.2.

### **3.7.1.3 Painted bug, *Bagrada hilaris* (Kirkaldy)**

The observations on number of painted bugs were recorded at weekly intervals by randomly selected five plants from each plot. Five plots were examined for each observation thus, total twenty five plants were observed to record the population of painted bug and the method has been summarized in Table No.-3.2.

### **3.7.1.4 Saw fly, *Athalia lugens proxima* (Klug)**

The observations on the population of mustard saw fly was recorded at weekly intervals by randomly selected five plants from each plot. Observations started from a week after the sowing, till the maturity of crop. Total twenty five plants were observed from five plots for recording the larval and adult population of mustard saw fly the method has been summarized in Table No.-3.2.

### **3.7.1.5 Diamondback moth, *Plutella xylostella* (Linnaeus)**

The observations on number of larvae and adult were recorded at weekly intervals by randomly selected five plants from each plot. Five plots were examined for each observation thus, total twenty five plants were observed to record the population of diamond back moth the method has been summarized in Table No.-3.2.

### **3.7.1.6 Leaf webber, *Crociodolomia binotalis* (Zeller)**

The observations on number of larvae and adult were recorded at weekly intervals by randomly selected five plants from each plot. Five plot were examined for each observation thus, total twenty five plants were observed to record the population of leaf webber the method has been summarized in Table No.-3.2.

### **3.7.1.7 Natural enemies, *Cheilomenes sexmaculata***

The population of aphid parasitoid, *Cheilomenes sexmaculata* was recorded by counting the number of the maggots and adults on the five selected plants from each plot at weekly intervals. Thus, total twenty five plants were

observed to record the population of lady bird beetle the method has been summarized in Table No.-3.2.

### **3.7.2 Monitoring of alate form of mustard aphid through yellow sticky trap in relation to meteorological parameters**

Yellow sticky traps size (11cmX7cm) were installed on a 1.5 meter long Bamboo sticks, so that the height of the trap was similar with the mustard crop and five such traps were installed around the mustard field at uniform distance. The observations on the adhered alate aphid were recorded every day morning and after taking observations, aphids were removed with the help of needle and soft brush.

The meteorological parameters *viz.*, maximum temperature, minimum temperature, morning and evening relative humidity, rainfall and sunshine hours from November 2020 to February 2021 were collected from Department of Agrometeorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G) and average weekly meteorological data has been summarized in Table No.-3.1. From the collected meteorological observations, Correlation co-efficient was determined, to find out the relationship of catches of alate aphid with meteorological parameters.

### **3.7.3. Correlation studies of insect pests of mustard with the meteorological parameters.**

In order to determine the seasonal incidence of insect pests, the periodical observations of the major insect pests and natural enemies were recorded as per the methods mentioned in table 3.2. The collected data on insect pests, its natural enemies and meteorological parameters were used for statistical analysis.

To study the effect of weather parameters on population incidence of various insect pests *viz.*, mustard aphid, *Lipaphis erysimi* (Kalt.), flea beetle, *Phyllotreta striolata*, painted bug, *Bagrada hilaris*, saw fly, *Athalia lugens proxima*, diamondback moth, *Plutella xylostella*, leaf webber, *Crocidolomia binotalis*, as well as natural enemy *viz.*, *Cheilomenes sexmaculata*. The data of meteorological parameters *viz.*, maximum and minimum temperature ( $^{\circ}\text{C}$ ),

morning and evening relative humidity (%), rainfall (mm) and sunshine (hrs) were correlated with the insect-pests population. Weekly data on various meteorological parameters recorded from Department of Agrometeorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G) during *Rabi* 2020-2021 (research period). The compiled weekly meteorological data (*Rabi*, 2020-21) are presented in table no. 3.1 and figure 3.1. and same method were used for various insect pest to work in correlation.

## CHAPTER – IV

### RESULTS AND DISCUSSION

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This chapter deals with the brief description of results obtained under different objectives of the experiment entitled “**Seasonal dynamics of insect pests and natural enemies in relation to meteorological parameters on mustards**” were carried out in the Research cum Instructional Farm at Sant Vinoba Bhave College of Agriculture and Research Station, Marra, (Patan), Durg (Chhattisgarh), during *Rabi* 2020-21. The results are being presented and discussed under the following sub headings:

- 4.1 To study the seasonal incidence of insect pests of mustard and their natural enemies.
- 4.2 Monitoring of the alate form of mustard aphid through yellow sticky trap in relation to meteorological parameters.
- 4.3 Correlation studies of insect pests of mustard with the meteorological parameters.

#### **4.1. To study the seasonal incidence of insect pests of mustard and their natural enemies.**

To study the incidence of various insect pests on mustard crop *viz.*, mustard aphid, *Lipaphis erysimi* (Kalt.), flea beetle, *Phyllotreta striolata*, painted bug, *Bagrada hilaris*, saw fly, *Athalia lugens proxima*, diamondback moth, *Plutella xylostella*, leaf webber, *Crocidolomia binotalis*, as well as natural enemies *viz.*, *Cheilomenes sexmaculata* an experiment was conducted from November to February, during *Rabi*, 2020-21 at the experimental area of Research cum Instructional Farm at Sant Vinoba Bhave College of Agriculture and Research Station, Marra, (Patan), Durg (Chhattisgarh). The mean data of various insect pests observed in mustard crop at weekly intervals during the crop period are presented here under and depicted in Table No 4.1, Table No 4.2 and Fig. 4.1.

#### **4.1.1. Aphid, *Lipaphis erysimi* (Kalt.)**

The data (table 4.2 and fig.4.2) revealed that the first appearance of the mustard aphid insect-pest incidence was recorded from the last week of November (48<sup>th</sup> SMW) with (1.21 aphid per ten cm apical twig/plant) during 2020-21. Its multiplication varies from 1.21 to 143.86 aphid per ten cm apical twig/plant. The nymph and adult population of aphids were found maximum with 143.86 aphid per ten cm apical twig/plant in 3<sup>rd</sup> week of January (3<sup>rd</sup> SMW) gradually the populations were decline and reach up to 98.43 aphid per ten cm apical twig/plant in last week (5<sup>th</sup> SMW) of January 2021. Further, the aphid population seems to be declining in subsequent weeks as the crop moved towards maturity.

Sahito *et al.*, (2010) also found the appearance of aphid from 2<sup>nd</sup> week of November to till harvest of the crop. At initial stage low population was recorded. Thereafter, population increased slowly, gradually and reached its maximum in 2<sup>nd</sup> week of December. Similar results were also reported by the earlier other workers Mandawi *et al.* (2017) and Pradhan *et al.* (2020).

#### **4.1.2. Flea beetle, *Phyllotreta striolata***

The (table 4.2 and fig.4.3) first appearance of incidence of flea beetle per plant recorded at weekly intervals during *Rabi* 2020-21 on the mustard crop revealed that the population of flea beetle started from last week of November (48<sup>th</sup> SMW) with 1.2 beetle per plant and continue till 5<sup>th</sup> week of January, 2021 (5<sup>th</sup> SMW). Flea beetle population ranged from 1.2 to 11.5 beetle per plant and peak during in the 3<sup>rd</sup> week of January (3<sup>rd</sup> SMW) afterwards the population showed declined trend up to the end of the crop season with the minimum beetle population of 7.3 per plant on last week of January 2021 (5<sup>th</sup> SMW).

Present findings are in accordance with the findings of earlier workers Ghosh *et al.* (2005), Nayak (2010), Kashyap *et al.* (2018) and Pradhan *et al.* (2019).

#### **4.1.3. Painted bug, *Bagrada hilaris***

The (table 4.2 and fig.4.4) painted bug, *Bagrada hilaris* population ranged from 0.19 - 2.5 bugs per plant. Its population was first observed from last week of December (52<sup>nd</sup> SMW) with 0.19 bugs per plant. Thereafter, slowly increased in population and reached to peak of 2.5 bugs per plant in 4<sup>th</sup> week of January (4<sup>th</sup> SMW). Thereafter the population gradually decreased up to 5<sup>th</sup> week of January. Present findings are in accordance with the findings of earlier workers Singh and Malik (1993), Jat *et al.* (2006), Nagar *et al.* (2011), Divya *et al.* (2015) and Pal *et al.* (2018).

#### **4.1.4. Saw fly, *Athalia lugens proxima***

The (table 4.2 and fig.4.5) pest saw fly, did not appeared from last week of November to 2<sup>nd</sup> week of December. First appearance of incidence of saw fly, *Athalia proxima* occurred from 3<sup>rd</sup> week of December (51<sup>st</sup> SMW) to 4<sup>th</sup> week of January (4<sup>th</sup> SMW) with the population range from 0.12 to 0.67 larvae per plant, respectively. The larvae incidence slowly increased and reached to peak 1.02 larvae per plant in the 3<sup>rd</sup> week of January (3<sup>rd</sup> SMW). Thereafter, larval population showed decreasing trend and showed minimum 0.67 larvae per plant in the 4<sup>th</sup> week of January, 2021 (4<sup>th</sup> SMW). Similar results are reported from the earlier workers Sandhya (1995), Ansari *et al.* (2007), Choudhury and Pal (2009) and Pradhan *et al.* (2019).

#### **4.1.5. Diamondback moth, *Plutella xylostella***

The (table 4.2 and fig.4.6) diamondback moth, *Plutella xylostella* population ranged from 0.10 to 1.03 per plant during, Rabi 2020-21. Diamondback moth was first appeared in second week of December (50<sup>th</sup> SMW) with 0.10 larvae per plant. Thereafter, slowly increased in population and reached to maximum of 1.03 adult per plant in first week of January (2<sup>nd</sup> SMW). Further, the population gradually decreased up to 0.19 adult per plant in fourth week of January in (4<sup>th</sup> SMW) and became 0.00 in the fifth week of January (5<sup>th</sup> SMW).

The findings of earlier workers *viz.*, Bana *et al.* (2012), Bhagat *et al.* (2018) and Sahu *et al.* (2020) were similar with the present findings.

#### **4.1.6. Leaf webber, *Crocidolomia binotalis***

The (table 4.2 and fig.4.7) leaf webber, *Crocidolomia binotalis* population ranged from 0.24 to 4.1 per plant during 2020-21 and it was first appeared in second week of December (50<sup>th</sup> SMW) with 0.24 larvae per plant. Thereafter, slowly increased in population and reached to maximum of 4.1 bug per plant in 3<sup>rd</sup> week of January (3<sup>rd</sup> SMW). Further, the population gradually decreased up to 5<sup>th</sup> week of January (5<sup>th</sup> SMW).

#### **4.1.7. Natural enemies, *Cheilomenes sexmaculata***

The (table 4.2 and fig.4.8) first appearance of lady bird beetle, *Cheilomenes sexmaculata* occurred from 3<sup>rd</sup> week of December (51<sup>st</sup> SMW) and continue till 5<sup>th</sup> week of January (5<sup>th</sup> SMW) and its population ranged from 0.12 to 1.29 per plant and attained highest level of lady bird beetle population (1.29 beetle per plant) in 2<sup>nd</sup> week of January (3<sup>rd</sup> SMW). Thereafter, the number of lady bird beetle gradually decreased up to 5<sup>th</sup> week of January (5<sup>th</sup> SMW) with 0.65 lady bird beetle per plant. Similar reports were reported by the earlier workers *viz.*, Singh *et al.* (2009), Varshney *et al.* (2017) and Pradhan *et al.* (2019).

## **4.2. Monitoring of the alate form of mustard aphid through yellow sticky trap in relation to meteorological parameters.**

Monitoring of alate mustard aphid (Fig.4.9) revealed that initial appearance of the alate aphid was noticed during 48<sup>th</sup> Standard Meteorological Week (last week of November), then it gradually increased with slight fluctuation and finally declined after 4<sup>th</sup> SMW (last week of January) over the period of experimentation. During 2020-21, maximum alate aphid was trapped in the sticky trap at 4<sup>th</sup> SMW (106.34 alate aphid per trap) which was favoured by maximum temperature 31.0<sup>o</sup>C, minimum temperature 14.2<sup>o</sup>C, morning relative humidity 80%, evening relative humidity 36% and sunshine 3.3 hrs.. Thereafter, aphid population showed

decreasing trend and showed minimum population of 70.85 aphid per trap in the last week of January (5<sup>th</sup> SMW) (Table - 4.3).

Meteorological factors, particularly maximum temperature showed the positive correlation with the incidence of alate mustard aphid (Table - 4.4 & fig.4.10). Data revealed that as the maximum temperatures increases, the alate population of alate mustard aphid also gradually increased. Maximum and minimum temperatures during maximum trapping of the alate mustard aphid were 31.0<sup>0</sup>C and 14.2<sup>0</sup>C, respectively. Population of alate mustard aphid increased with the increasing trend of temperature upto a certain period after that the alate aphid population declined. In general during the experiment more population of alate aphid were observed when maximum temperature was <31<sup>0</sup>C and minimum temperature was >14<sup>0</sup>C.

The correlation between alate aphid population and maximum temperature and rainfall showed positive correlation however, minimum temperature, relative humidity (morning and evening) showed negatively correlation. It is also revealed from the table - 4.4 that except maximum temperature and rainfall all the weather parameters had negative correlation with the incidence of the aphid. Among all the meteorological factors, maximum temperature resulted positive correlation ( $r = 0.260$ ). This might be due to the fact that the rate of development of pests will enable a more rapid response to a change in temperature (Karuppaiah and Sujayanad, 2012). Present studies are in accordance with the report of earlier workers Singh and Lal (2012) and Sahoo and Saha (2018).

### **4.3. Correlation studies of insect pests of mustard with the meteorological parameters.**

#### **4.3.1. Aphid population and meteorological parameters**

The correlation between aphid population and meteorological parameters are presented in Table - 4.5. The aphid population exhibit positive correlation with maximum temperature ( $r = 0.394$ ), minimum temperature ( $r = 0.078$ ) and rainfall ( $r = 0.194$ ) while negative relationship with evening relative humidity ( $r = -0.388$ ) and sunshine hrs. ( $r = -0.293$ ). But all the correlations were non-significant except the correlation of morning relative humidity with negative significant ( $r = -$

0.645\*). Ishwarbhai (2015) and Kashyap *et al.* (2018) were also reported aphid population exhibited positive correlation with maximum and minimum temperature and negative correlation with evening relative humidity and rainfall. The regression equation between aphid and morning relative humidity ( $Y = -9.809x + 889.2$ ,  $R^2 = 0.401$ ) shows that for every unit increase in relative humidity, the infestation level decrease by 9.809. (Table 4.6 & Fig.4.11)

#### **4.3.2. Flea beetle population and meteorological parameter**

The correlation between painted bug and meteorological parameters are presented in Table - 4.5. The population of flea beetle exhibit positive non-significant correlation with maximum temperature ( $r = 0.283$ ) and rainfall ( $r = 0.011$ ), whereas, minimum temperature ( $r = -0.100$ ) morning relative humidity ( $r = -0.331$ ), evening relative humidity ( $r = -0.479$ ) and sunshine hrs. ( $r = -0.412$ ) showed non-significantly negative correlation. Kashyap *et al.* (2018) and Pradhan *et al.* (2019) were also reported the flea beetle population exhibit positive correlation with maximum and minimum temperature and negative correlation with morning and evening RH.

#### **4.3.3. Painted bug population and meteorological parameter**

The correlation between painted bug and meteorological parameter are presented in **Table - 4.5**. The weather parameters, maximum temperature ( $r = 0.431$ ), minimum temperature ( $r = 0.084$ ) and rainfall ( $r = 0.201$ ) were positively non-significant and morning relative humidity ( $r = -0.653^*$ ) negatively significant correlated with the population of painted bug. Whereas, evening relative humidity ( $r = -0.207$ ) and sunshine ( $r = -0.233$ ) were negatively and non-significantly correlated with painted bug population. Nagar (2011) were reported the painted bug population showed positive correlation with maximum and negatively and non-significantly correlated with RH. Divya *et al.* (2015) were also reported the painted bug population showed positive correlation with maximum and minimum temperature and negative correlation with evening RH, support the present findings.

The regression equation between painted bug and morning relative humidity ( $Y = -0.164x + 14.50$ ,  $R^2 = 0.426$ ) shows that for every unit increases in relative humidity, the infestation level decreases by 0.164 (Table 4.6 & Fig.4.12).

#### **4.3.4. Saw fly population and meteorological parameter**

The correlation between painted bug and meteorological parameters are presented in Table - 4.5. The weather parameters, maximum temperature ( $r = 0.536$ ), minimum temperature ( $r = 0.232$ ) were positively and non-significantly correlated with saw fly population. Whereas, morning relative humidity ( $r = -0.476$ ), evening relative humidity ( $r = -0.205$ ), rainfall ( $r = -0.302$ ) and sunshine hrs. ( $r = -0.368$ ) showed negative non-significant correlation. Patel and Patel (1997), Kashyap *et al.* (2018) and Pradhan *et al.* (2019) also reported the saw fly population showed positive correlation with maximum and minimum temperature and negative correlation with evening RH and sunshine hrs. support the present findings.

#### **4.3.5. Diamondback moth population and meteorological parameter**

The correlation between diamond back moth and meteorological parameters are presented in Table -4.5. Simple correlation worked out between diamond back moth and weather parameters on mustard crop. The result revealed that there was positive non-significant correlation with maximum temperature ( $r = 0.210$ ) and minimum temperature ( $r = 0.113$ ) and negative non-significant correlation with morning relative humidity ( $r = -0.170$ ), evening relative humidity ( $r = -0.326$ ), rainfall ( $r = -0.352$ ) and sunshine hrs. ( $r = -0.451$ ), respectively.

#### **4.1.6. Leaf webber, *Crocidolomia binotalis* and meteorological parameter**

The correlation between Leaf webber, *Crocidolomia binotalis* and meteorological parameters are presented in Table – 4.5. The meteorological parameters *viz*; maximum temperature ( $r = 0.406$ ), minimum temperature ( $r = 0.049$ ) and rainfall ( $r = 0.124$ ) were positive and non-significant correlation. Whereas, morning relative humidity ( $r = -0.619$ ), and evening RH ( $r = -0.349$ ) and sunshine hrs. ( $r = -0.225$ ) had negative and non-significant correlation with *Crocidolomia binotalis* population.

#### **4.3.7. Ladybird beetle, *C. sexmaculata* population and meteorological parameters**

The correlation between population of *Cheilomenes sexmaculata* and weather parameters are presented in Table - 4.5. The meteorological parameters viz; maximum temperature ( $r = 0.407$ ), minimum temperature ( $r = 0.112$ ) and rainfall ( $r = 0.077$ ) had positive non-significant correlation with *Cheilomenes sexmaculata*. Whereas, morning relative humidity ( $r = -0.601$ ), evening relative humidity ( $r = -0.385$ ) and sunshine hrs. ( $r = -0.316$ ) had negative non-significant correlation with the population of *C. sexmaculata*.

## CHAPTER – V

### SUMMARY AND CONCLUSIONS

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The experiment entitled “**Seasonal dynamics of insect pests and natural enemies in relation to meteorological parameters on mustards**” was undertaken during the year 2020-21 at Research cum Instructional Farm of Sant Vinoba Bhave College of Agriculture and Research Station, Marra (Patan) Durg (Chhattisgarh). The results obtained and conclusion drawn on different aspects of investigations are summarised as below -

1. To study the seasonal incidence of insect pests of mustard and their natural enemies.
2. Monitoring of the alate form of mustard aphid through yellow sticky trap in relation to meteorological parameters.
3. Correlation studies of insect pests of mustard with the meteorological parameters.

The investigations of seasonal incidence of major insect pests of mustard revealed that the appearance of different pests *viz.*, mustard aphid, *Lipaphis erysimi*, mustard sawfly, *Athalia lugens proxima*, flea beetle, *Phyllotreta striolata*, painted bug, *Bagrada hilaris*, diamond back moth, *Plutella xylostella*, leaf webber, *Crocidolomia binotalis* were recorded at different stages of mustard crop. On the other hand, one predator *viz.*, lady bird beetle, *Cheilomenes sexmaculata* was recorded as natural enemies of aphid on mustard crop under field conditions.

The aphid, (*Lipaphis erysimi*) populations were commenced on the crop in the last week of November (48<sup>th</sup> SMW). The pest populations were observed on the crop from the last week of November (48<sup>th</sup> SMW) to last week of January (5<sup>th</sup> SMW). Initially the pest populations were observed 1.21 aphid per ten centimeter apical twig/plant. Population **slowly** increased and reached a high of 143.86 aphid per ten centimeter apical twig/plant in 3<sup>rd</sup> week of January (3<sup>rd</sup> SMW). Thereafter, the pest activity decreased and its lowest population of 98.43 aphid per ten centimetre apical twig/plant were observed during last week of January

(5<sup>th</sup> SMW). The results of correlation studies indicated that mustard aphid was negatively correlated with evening relative humidity and sunshine hrs. while positively effect with temperature (max. and min.) and rainfall but all the correlations were non-significant except the correlation of morning relative humidity which was negative significant. Regression equation between aphid and morning relative humidity shows that for every unit increase in relative humidity, the infestation level decrease by 9.80 numbers.

The populations of flea beetle, (*Phyllotreta striolata*) were commenced on the mustard in the last week of November (48<sup>th</sup> SMW). Initially the populations were observed 1.2 beetle per plant in the last week of November. When the pest started its multiplication from 2.5 beetle/plant and reached to its peak level of 11.5 beetle/plant in 3<sup>rd</sup> week of January (3<sup>rd</sup> SMW). Thereafter, the pest activity slowly decreased and its lowest population 7.3 beetle/plant were observed during last week of January (5<sup>th</sup> SMW). The results of correlation studies indicated that flea beetle was positive effect with max. temperature and rainfall while negatively effect with morning relative humidity, evening relative humidity, minimum temperature and sunshine hrs. but all the correlations were non-significant.

The populations of painted bug, (*Bagrada hilaris*) were commenced on the mustard crop in the last week of December (52<sup>nd</sup> SMW) with 0.19 bug per plant. The populations of painted bug gradually increased and reached to its peak 2.5 bug per plant in 4<sup>th</sup> week of January (4<sup>th</sup> SMW). Thereafter, its lowest population 1.3 bug per plant were observed in the last week of January (5<sup>th</sup> SMW). According to the findings of correlation studies, the populations of painted bug were positively non-significant correlated with max. and min. temperature and rainfall while negative non-significant effect with the evening RH and sunshine hrs. Whereas, negatively significantly correlated with morning relative humidity. The regression equation between painted bug and morning relative humidity shows that for every unit (%) increases in relative humidity, the infestation level decreases by 0.164%.

The populations of saw fly, (*A. lugens proxima*) were commenced on the mustard crop in the 3<sup>rd</sup> week of December (51<sup>th</sup> SMW) with 0.12 larva/plant and continue till 4<sup>th</sup> week of January (4<sup>th</sup> SMW) with 0.67 adults per plant. The pest

populations reached to its peak with 1.02 adults per plant in 3<sup>rd</sup> week of January (3<sup>rd</sup> SMW). According to the findings of correlation studies, the saw fly insect pest showed positive effect with temperature (max. and min.) whereas, negatively effect with morning and evening relative humidity, sunshine hrs. and rainfall but all the correlations were non-significant.

The populations of diamond back moth, (*Plutella xylostella*) were commenced on the mustard crop in the 2<sup>nd</sup> week of December (50<sup>th</sup> SMW). Initially the population of diamond back moth was observed 0.10 larvae per plant and gradually increased and reached to its peak with 1.03 larvae per plant in 2<sup>nd</sup> week of January (2<sup>nd</sup> SMW). According to the findings of correlation studies, the populations of diamond back moth showed positive effect with temperature (max. and min.) however, negative effect with morning relative humidity, and evening relative humidity, rainfall and sunshine hrs. but all the correlations were non-significant.

The populations of Leaf webber, (*Crocidolomia binotalis*) were commenced on the mustard crop in the 2<sup>nd</sup> week of December (50<sup>th</sup> SMW) with 0.24 bug/plant and reached to its peak with 4.1 bug /plant in 3<sup>rd</sup> week of January (3<sup>rd</sup> SMW) and its lowest population 2.1 bug /plant were observed in the last week of January (5<sup>th</sup> SMW). According to the findings of correlation studies, the populations of leaf webber were positively effect with temperature (max. and min.) and rainfall while, negatively effect with relative humidity (mor. and eve.) and sunshine hrs. but all the correlations were non-significant.

The predatory populations of lady bird beetle, *Cheilomenes sexmaculata* as natural enemies occurred in the 3<sup>rd</sup> week of December (51<sup>st</sup> SMW) and continue till the last week of January (5<sup>th</sup> SMW) and attained highest level with 1.29 per plant in 3<sup>rd</sup> SMW. The results of correlation studies indicated that *Cheilomenes sexmaculata* populations were positively effect with temperture (max. and min.) and rainfall while negatively correlated with relative humidity (mor. and eve.) and sunshine hrs. but all the correlations were non-significant.

The studies on monitoring of alate mustard aphid revealed that initial appearances of the alate aphids were noticed during last week of November (48<sup>th</sup> SMW). Its populations gradually increased with slight fluctuation and finally declined after 5<sup>th</sup> SMW (last week of January). During 2020-21, maximum alate aphids were trapped in the sticky trap with 106.34 alate aphid per trap at 4<sup>th</sup> SMW, which was favoured by max. temperature (31.0<sup>o</sup>C), min. temperature (14.2<sup>o</sup>C), morning RH (80%), evening RH (36%), rainfall (0.00mm) and sunshine (3.3hrs.), respectively. The correlation between alate aphid populations with maximum temperature and rainfall showed positive correlation while minimum temperature, morning relative humidity, evening relative humidity and sunshine hrs. showed negatively correlated values.

## **Conclusions**

The following conclusions emerge from the current research:

- Aphid was observed to be the most dangerous and significant pest among all mustard pests. The aphid population incidence occurred between November and February however, during this period the crop was in the vegetative, flowering, and podding stages.
- Aphid population activity peaked between the 2nd to 4th SMW.
- Flea beetle population activity peaked between the 52nd to 4th SMW.
- The aphid population had a positive correlation with maximum temperature ( $r = 0.394$ ), minimum temperature ( $r = 0.078$ ), and rainfall ( $r = 0.194$ ), but a negative relationship with evening relative humidity ( $r = -0.388$ ) and sunshine (hrs) ( $r = -0.293$ ) whereas, negative significant correlation with morning relative humidity ( $r = -0.645$ ).
- Yellow sticky traps are a typical way for monitoring a many of pests, but there is no evidence that they can be used to manage them.
- It can be recorded from the above study that the highest alate mustard aphid trapping was observed around the end of January. This might be due to crop maturity and rising temperatures at that time.
- This has been the case since the last week of January. The incidence of alate aphid was not significantly linked with weather parameters such as

temperature (minimum), relative humidity (maximum & minimum), rainfall and wind speed, with the exception of maximum temperature, which had a positive correlation.

- This data on migration might be used to provide forewarning to farmers, allowing them to make informed decisions about future pest management tactics.

### **Suggestions for future research work:**

The following suggestions are given for further work:

- Long term studied of abiotic factors in relation to population activity of the pest on mustard should be carried out.
- To develop an IPM module against mustard aphid.
- Natural enemies play an important role in minimizing the aphid populations. So, it is needed to take up an exhaustive study to record the natural enemies of various aphid species particularly the ladybird beetle and syrphid fly.

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**Table 3.2: Mode of observation for insect-pests and predators of mustard.**

<b>S. No.</b>	<b>Insects- pests</b>	<b>Mode of observation</b>
1	Mustard aphid	No. of aphids/10cm apical twig on 5 plants/plot
2	Flea beetle	No. of beetles/5 plants/plot
3	Painted bug	No. of bugs (nymph+ Adults)/5 plants/ plot.
4	Saw fly	No. of grubs/5 plants/ plot
5	Diamond back moth	No. of larvae and adult/5 plants/plot
6	Leaf webber	No. of larvae and adult/5 plants/plot
<b>Natural enemies (Predator)</b>		
7	<i>Cheilomenes sexmaculata</i>	No. of grubs and adults/10 plants/ plot

**Table 4.1: List of insect pests and natural enemies observed on mustard crop during 2020-21.**

Common name	Systematic position			period of activity	Peak period
	scientific name	order	Family		
Mustard aphid	<i>Lipaphis erysimi</i> (Kalt.)	Hemiptera	Aphidae	Nov - Feb	Third week of January
Flea beetle	<i>Phyllotreta striolata</i>	Coleoptera	Chrysomelidae	Nov - Feb	Third week of January
Painted bug	<i>Bagrada hilaris</i>	Hemiptera	Pentatomidae	Dec - Feb	Forth week of January
Saw fly	<i>Athalia lugens proxima</i>	Hymenoptera	Tenthredinidae	Dec - Jan	Third week of January
Diamond back moth	<i>Plutella xylostella</i>	Lepidoptera	Plutellidae	Dec - Jan	Second week of January
Leaf webber	<i>Crocidolomia binotalis</i>	Lepidoptera	Pyraustidae	Dec - Feb	Third week of January
Ladybird beetle	<i>Cheilomenes sexmaculata</i>	Coleoptera	Coccinellidae	Dec - Feb	Third week of January

**Table 4.2: Average no. of pest population and natural enemies per plant on mustard crop during Rabi, 2020-21.**

SMW	Date	Meteorological parameter						Insect pest of mustard					Natural enemies	
		Tem. ( <sup>0</sup> C)		R.H. (%)		Rainfall (m.m)	Sunshine (hrs.)	Aphid	Flea beetle	Painted bug	Sawfly	DBM*	Leaf webber	<i>C. sexmaculata</i>
		Max.	Min.	Mor.	Eve.									
48	Nov. 26-02	28.6	14.7	81	35	0.0	6.2	1.21	1.2	0.00	0.00	0.00	0.00	0.00
49	Dec. 03-09	30.7	11.9	89	33	0.0	7.3	4.23	3.7	0.00	0.00	0.00	0.00	0.00
50	10-16	30.2	15.8	86	37	0.0	3.7	9.04	4.6	0.00	0.00	0.10	0.24	0.00
51	17-23	27.7	10.3	87	27	0.0	5.0	30.32	6.9	0.00	0.12	0.39	0.45	0.12
52	24-31	28.4	10.3	87	28	0.0	4.8	48.29	8.1	0.19	0.20	0.67	0.91	0.38
01	Jan. 01-07	29.7	13.8	85	32	0.0	3.2	89.52	8.7	0.72	0.51	0.89	1.4	.87
02	08-14	31.2	16.3	78	30	0.0	3.9	127.65	10.3	1.2	0.79	1.03	2.7	1.13
03	15-21	30.0	11.7	83	24	0.0	6.1	143.86	11.5	1.9	1.02	0.83	4.1	1.29
04	22-28	31.0	14.2	80	36	0.0	3.3	129.76	9.7	2.5	0.67	0.19	3.7	0.96
05	29-04	28.2	10.3	81	23	4.6	6.8	98.43	7.3	1.3	0.00	0.00	2.1	0.65

DBM\* = Diamond back moth

**Table 4.3: Average population of alate mustard aphid on yellow sticky traps during *Rabi*, 2020-21.**

Standard Meteorological Week (SMD)	Date	Temperature ( <sup>0</sup> C)		R.H. (%)		Rainfall (mm)	Sunshine(hrs)	No. of alate aphids/trap
		Max.	Min.	Mor.	Eve.			
48	Nov. 26-02	28.6	14.7	81	35	0.0	6.2	0.352
49	Dec. 03-09	30.7	11.9	89	33	0.0	7.3	0.933
50	10-16	30.2	15.8	86	37	0.0	3.7	1.40
51	17-23	27.7	10.3	87	27	0.0	5.0	2.223
52	24-31	28.4	10.3	87	28	0.0	4.8	3.919
01	Jan. 01-07	29.7	13.8	85	32	0.0	3.2	9.585
02	08-14	31.2	16.3	78	30	0.0	3.9	21.871
03	15-21	30.0	11.7	83	24	0.0	6.1	63.247
04	22-28	31.0	14.2	80	36	0.0	3.3	106.347
05	29-04	28.2	10.3	81	23	4.6	6.8	70.852

**Table 4.4: Correlation (r) between population of alate mustard aphid, *L. erysimi* and meteorological parameters during 2020-21**

Insect	Temperature ( <sup>0</sup> C)		Relative Humidity. (%)		Rainfall (mm)	Sunshine (hrs)
	Max.	Min.	Mor.	Eve.		
Aphid/trap	0.260	-0.075	-0.575	-0.212	0.395	-0.065

\*Significant at 5% level of significance.

***Test of Significance***

*The result of significant if the calculated value of r is higher than the table value.*

Degree of freedom = (n-2) = (10-2) = 8

n = No. of observation

<i>df</i>	<i>p=0.05</i>	. <b>T table</b> = 2.306
8	0.632	

**Table 4.5: Correlation (r) between insect pest in infesting mustard and meteorological parameters during *Rabi*, 2020-21**

Insect pest and natural enemies	Meteorological parameters					
	Temperature (°C)		R.H. (%)		Rainfall (mm)	Sunshine(hrs)
	Max.	Min.	Mor.	Eve.		
Aphid	0.394	0.078	-0.645*	-0.388	0.194	-0.293
Flea beetle	0.283	-0.100	-0.331	-0.479	0.011	-0.412
Painted bug	0.431	0.084	-0.653*	-0.207	0.201	-0.233
Saw fly	0.536	0.232	-0.476	-0.205	-0.302	-0.368
Diamond back moth	0.210	0.113	-0.170	-0.326	-0.352	-0.451
Leaf webber	0.406	0.049	-0.619	-0.349	0.124	-0.225
<i>C. sexmaculata</i>	0.407	0.112	-0.601	-0.385	0.077	-0.316

\*Significant at 5% level of significance

*The result of significant if the calculated value of r is higher than the table value..*

Degree of freedom = (n-2) = (10-2) = 8

n = No. of observation

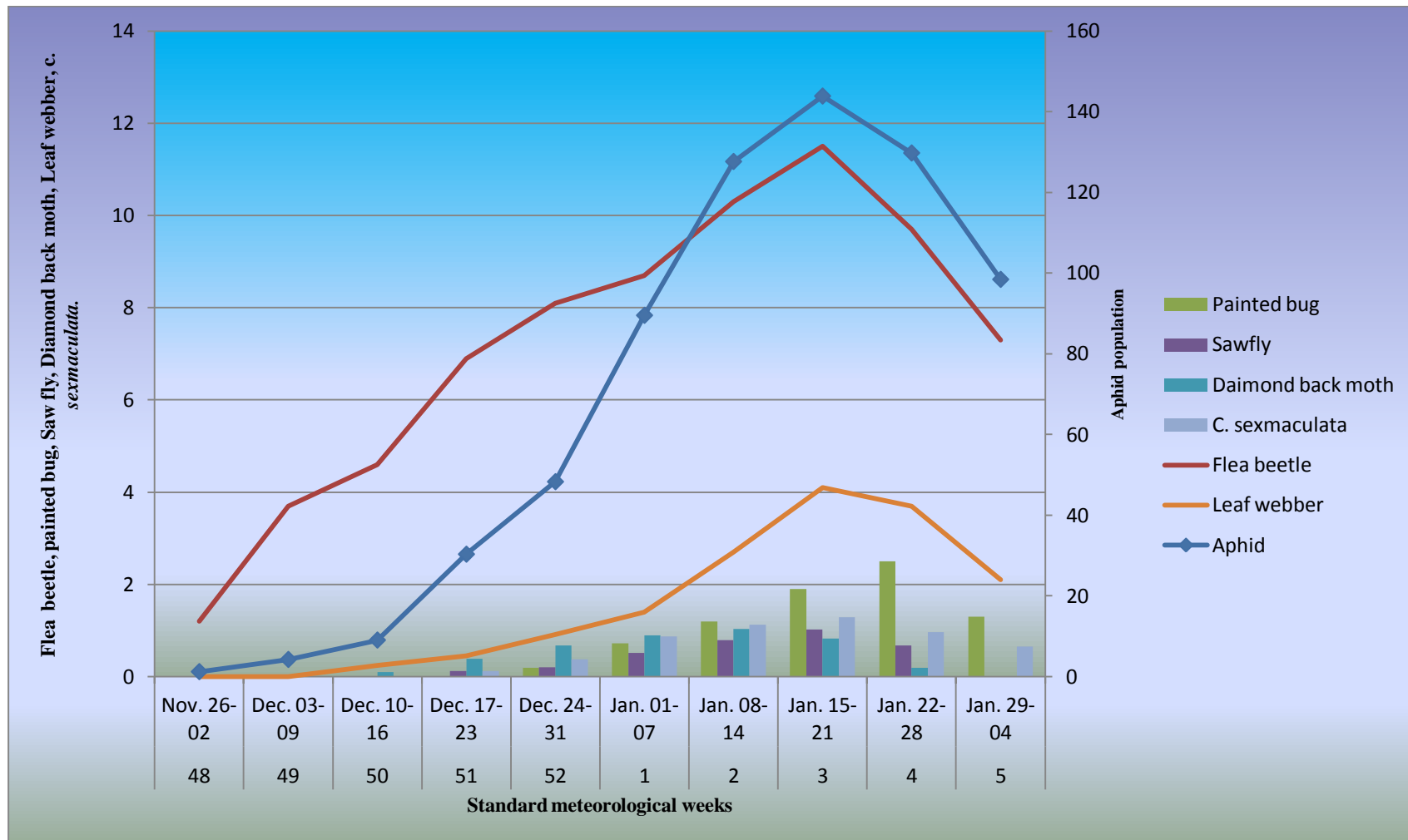
<i>df</i>	<i>p=0.05</i>	. <b>T table</b> = 2.306
8	0.632	

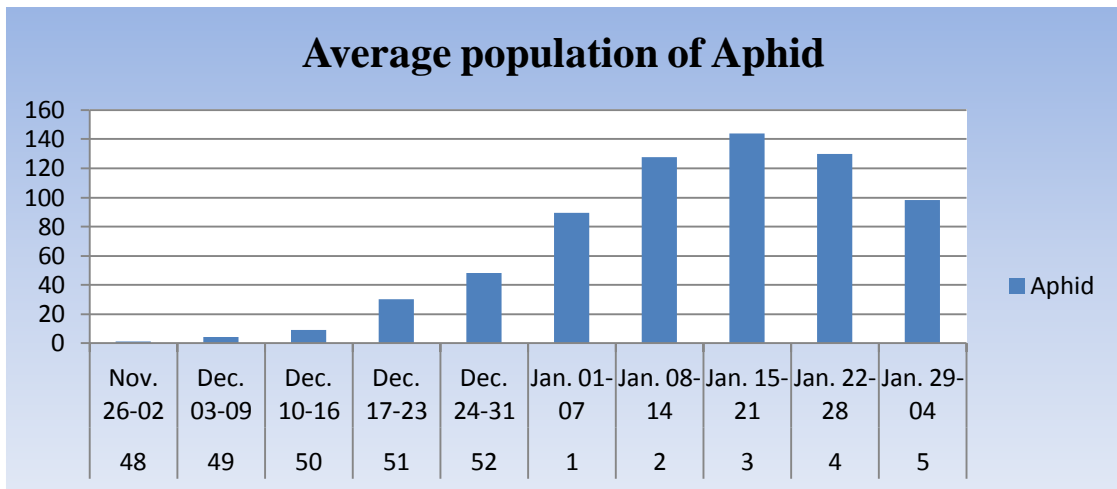
**Table 4.6: Correlation (r) and regression (b<sub>xy</sub>) coefficient between morning RH and Aphid and painted bug population of mustard, Rabi, 2020-21**

Meteorological parameter	Aphid		Painted bug	
	r	b <sub>yx</sub>	r	b <sub>yx</sub>
<b>Morning RH</b>	-0.645*	-9.8	-0.653*	<b>-0.16</b>
Except all population of insect pest of mustard and meteorological parameters non-significant				

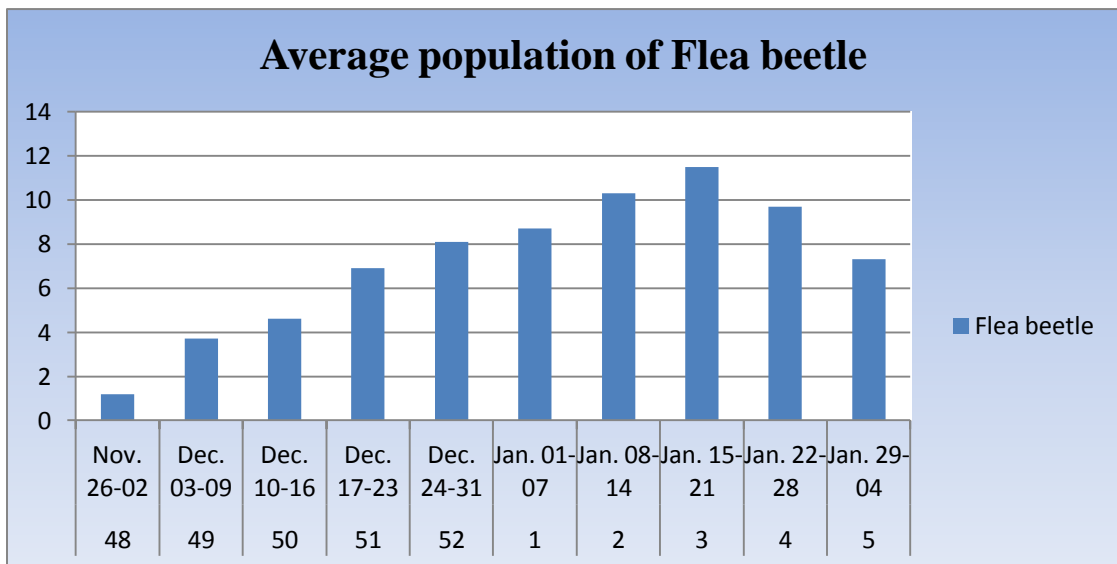
\*Significant at 5% level of significance

**Fig. 4.1: Average population of insect pests and natural enemies on mustard crop during 2020-21.**

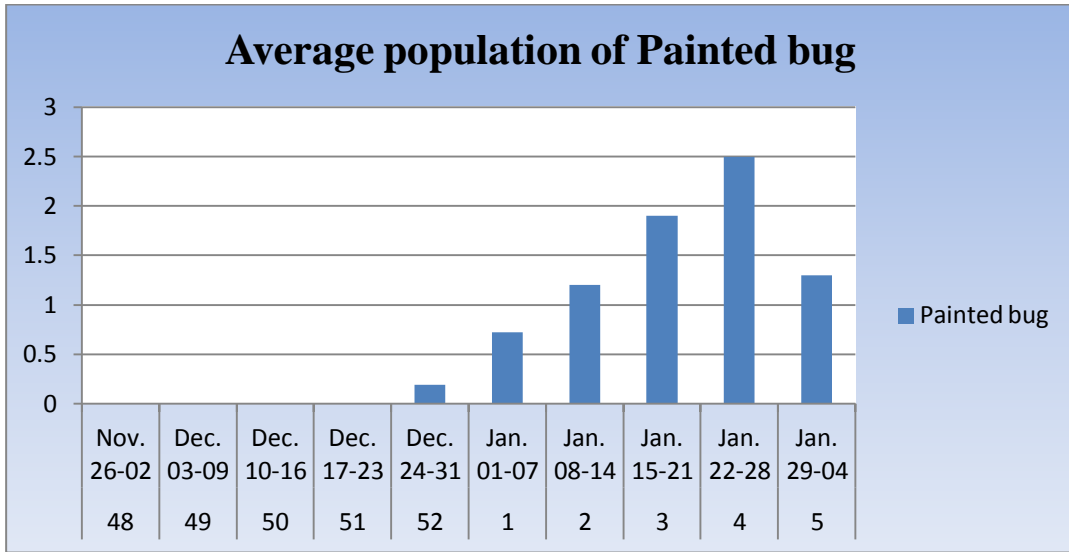




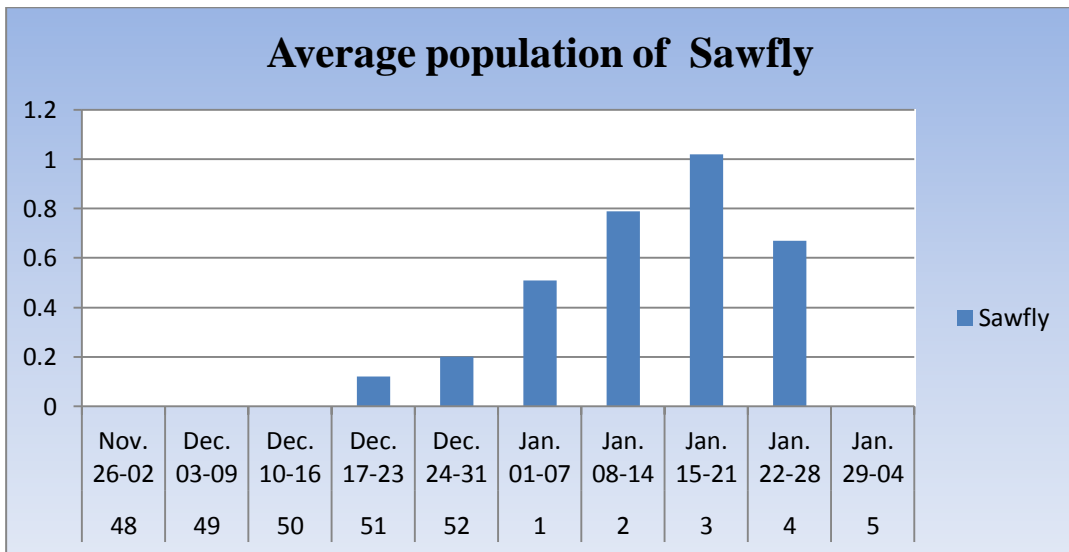
**Fig. 4.2: Average aphid population on mustard crop during 2020-21.**



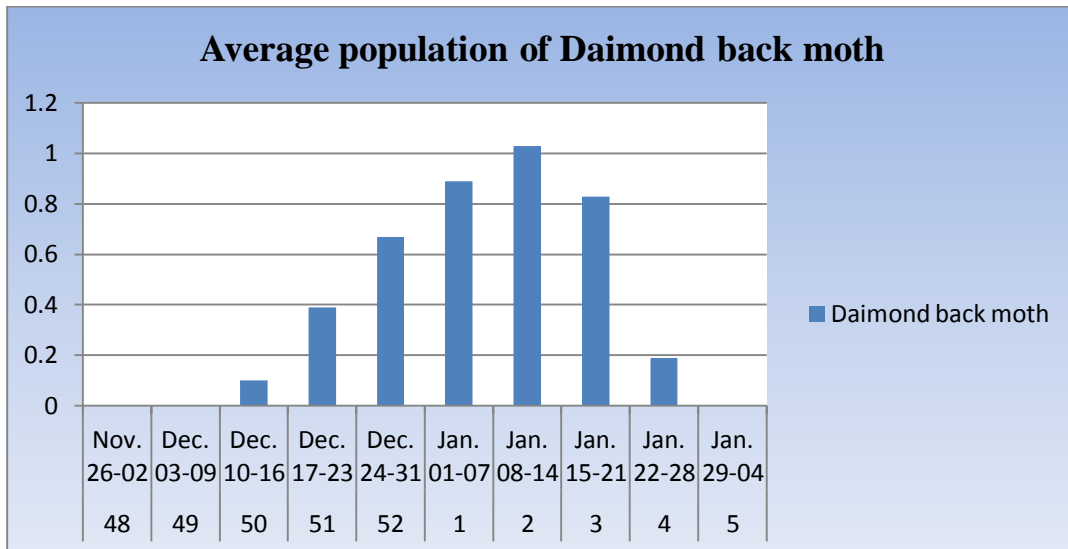
**Fig.4.3: Average flea beetle population on mustard crop during 2020 21.**



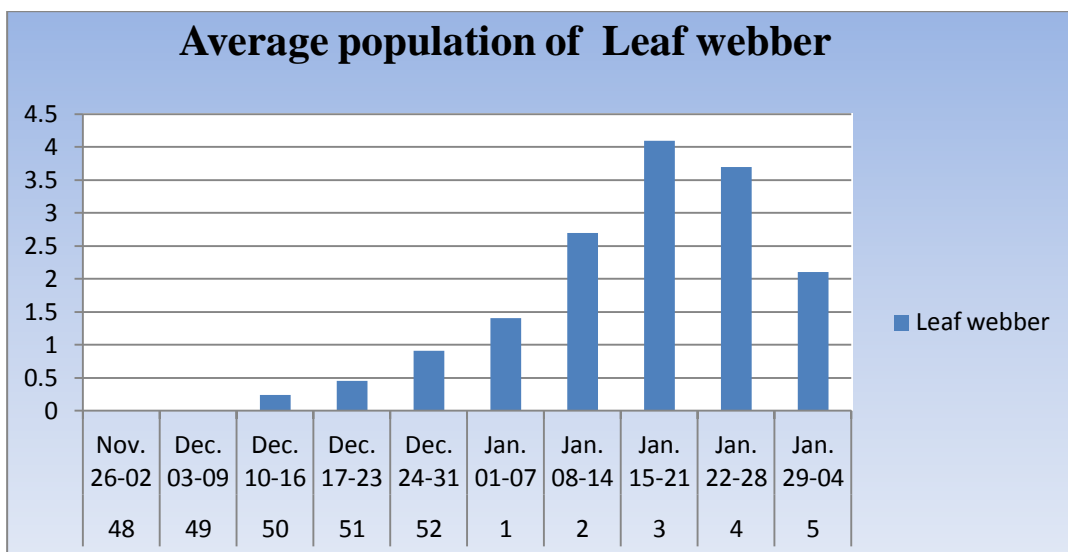
**Fig. 4.4: Average painted bug population on mustard crop during 2020 - 21.**



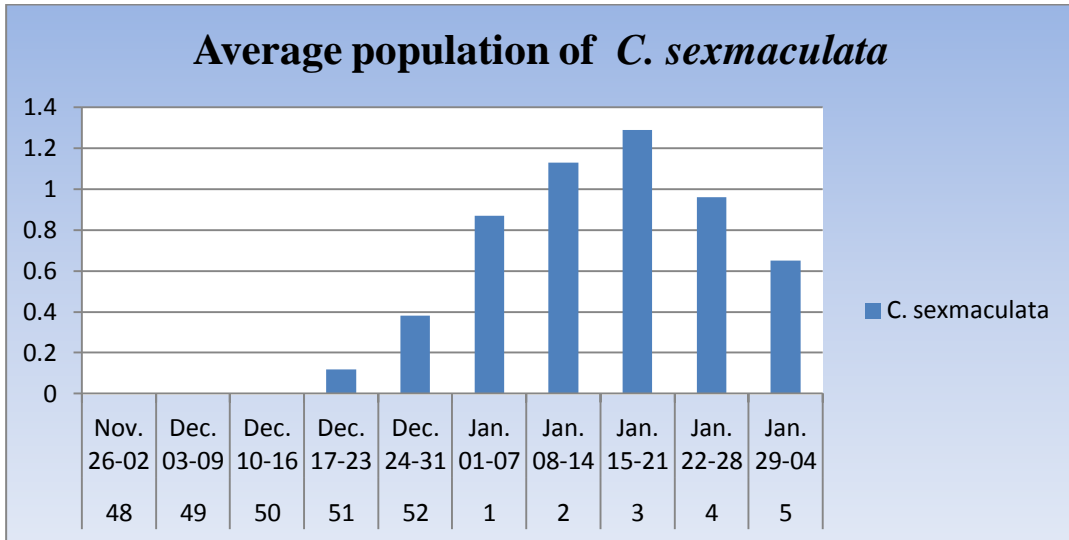
**Fig.4.5: Average saw fly population on mustard crop during 2020-21.**



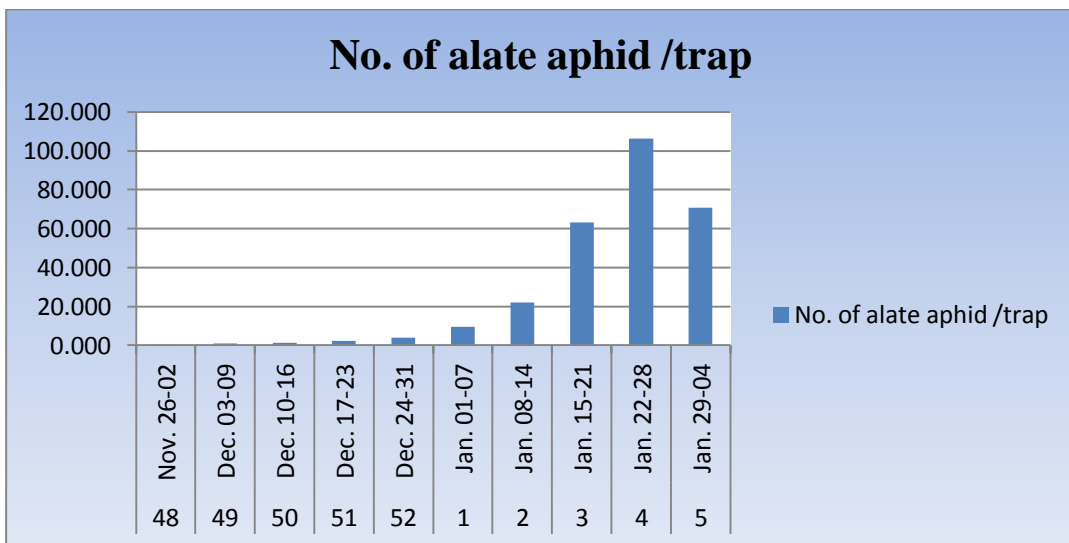
**Fig. 4.6: Average diamondback moth population on mustard crop during 2020-21.**



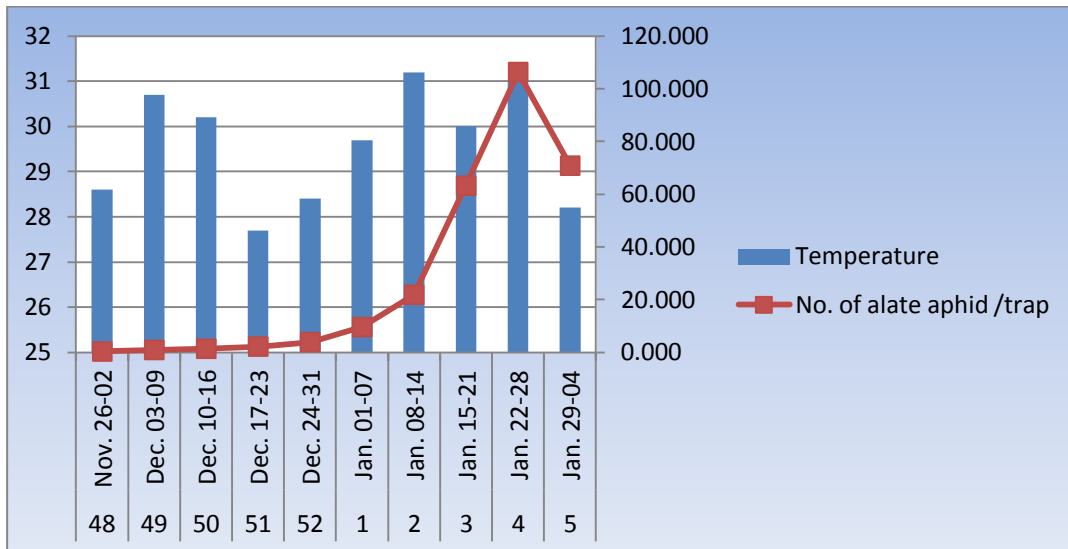
**Fig. 4.7: Average leaf webber population on mustard crop during 2020-21.**



**Fig. 4.8: Average *Cheilomenes sexmaculata* population on mustard crop during 2020-21**

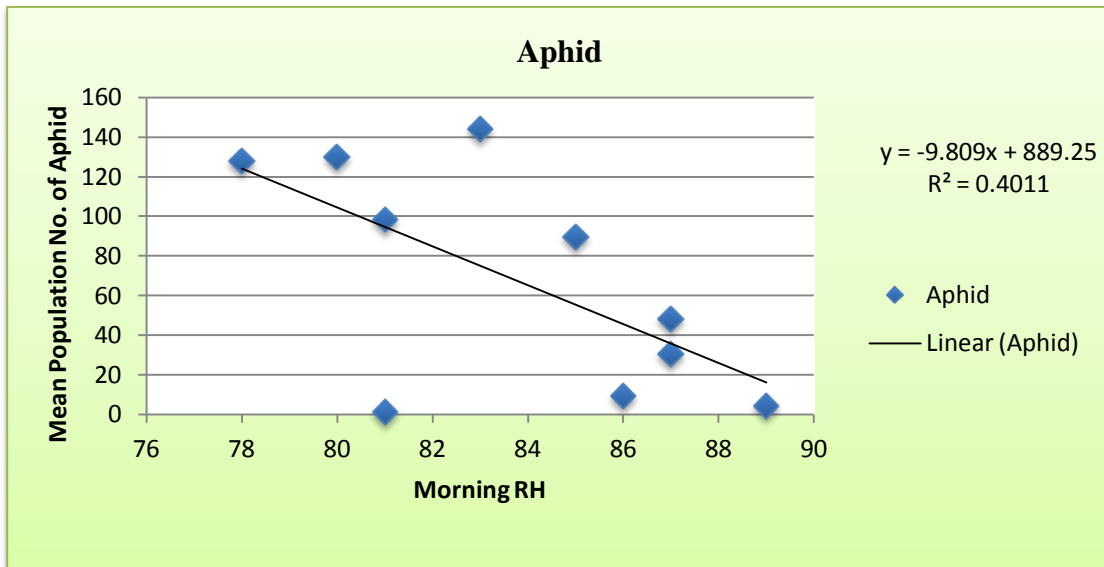


**Fig. 4.9: Average alate aphid population on mustard crop during 2020-21**

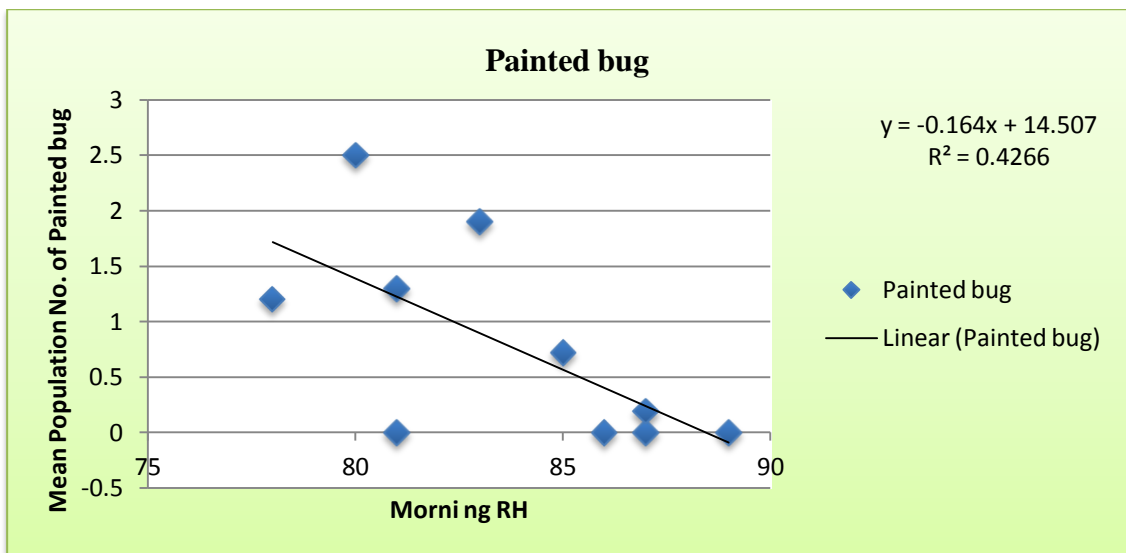


**Fig.4.10: Monitoring of alate mustard aphid using yellow sticky trap in relation to temperature during 2020-21**

**Fig.4.11: Correlation (r) and regression (bxy) coefficient between morning RH and Aphid population of mustard, Rabi, 2020-21**



**Fig.4.12: Correlation (r) and regression (bxy) coefficient between morning RH and Painted bug population of mustard, Rabi, 2020-21**





**Plate 1:** Instructional Farm, Marra, Patan



**Plate 2:** Field view



**Plate 3:** Vegetative stage



**Plate 4:** Flowering stage



**Plate 5:** Maturity stage



**Plate 6:** Healthy plant



**Plate 7:** Infested plant by flea beetle



**Plate 8:** Painted bug



**Plate 9:** Aphid



**Plate 10:** Adult aphid



**Plate 11:** Natural enemies



**Plate 12:** Yellow sticky trap

## APPENDIX

### Appendix 1. The skeleton of analysis of variance for Randomized Complete Block Design (RBD)

Source of variation	Degree of freedom	Sum of squares	Mean sum of Squares	„F“ value
Replications	(r-1)	SSR	MSR	MSR / MSE
Treatments	(t-1)	SST	MST	MST / MSE
Error	(r-1)(t-1)	SSE	MSE	-
Total	(rt-1)	TSS	-	-

Where, r = Number of replications.

t = number of treatments.

#### ***Test of Significance***

*To test the significance of treatment, the calculated value of „F“ was compared with tabular value of „F“ at 0.05 and 0.01 per cent levels of probability against error degree of freedom, i.e. (r-1) (t-1).*

*The result of significant if the calculated value of r is higher than the table value.*

$$\text{Degree of freedom} = (n-2) = (10-2) = 8$$

Where, n = No. of observation

<i>df</i>	<i>p=0.05</i>
8	0.632

. **T table** = 2.306

## RESUME

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Signature