# “Studies on the aphid parasitoid (*Diaeretiella rapae*) with special reference to toxic effect of biopesticide against parasitoid on Brassica species”

**THESIS**

***Submitted to the***

**Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya,**

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**AGRICULTURE**

**(ENTOMOLOGY)**

*BY*

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**College of Agriculture, Gwalior (M.P.)**

**2021**

## CERTIFICATE – I

*This is to certify that the thesis entitled* **"Studied on the aphid parasitoid (*Diaeretiella rapae*) with special reference to toxic effect of biopesticideagainst parasitoid on Brassica species."** *submitted in partial fulfillment of the requirements for the degree of* **MASTER OF SCIENCE** in **AGRICULTURE** department of **ENTOMOLOGY** of **Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.)** *is a record of the bona-fide research work carried out by* **Ms. ANAMIKA SINGH,** *under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and Director of Instruction.*

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

**Place: Gwalior** **(Dr. M. L. Sharma)**

**Date: ……** **Chairman of the Advisory Committee**

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*This is to certify that thesis the entitled* **Studied on the aphid parasitoid (*Diaeretiella rapae*) with special reference to toxic effect of biopesticide against parasitoid on Brassica species "."** *submitted by* **Ms. ANAMIKA SINGH, Roll No.19111901** to *the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) in partial fulfillment of the requirements for the degree of* **Master of Science** in **AGRICULTURE** in the **Department of Entomology,** *College of Agriculture Gwalior has been accepted after evaluation by the External Examiner and approved by the Student's Advisory Committee after an oral examination of the same.*

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**Place: Gwalior**

**Date: ……** **Anamika Singh**

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# ABBREVIATIONS

| S. No. | Legends | Description |
|---|---|---|
| 1. | % | Per cent |
| 2. | & | And |
| 3. | $^{\circ}C$ | Degree Celsius |
| 4. | *a.i.* | Active ingredient |
| 5. | ANOVA | Analysis of variance |
| 5. | C.D. | Critical difference |
| 6. | C.V. | Coefficient of variation |
| 7. | CD at P = 0.05 | Probability Value |
| 8. | CD at P = 0.01 | Probability Value |
| 10. | cm | Centimetre |
| 10. | $cm^2$ | Centimetre square |
| 11. | DAS | Day After Sowing |
| 12. | DAE | Day After Emergence |
| 13. | DF | Degrees of freedom |
| 14. | DH | Dead heart |
| 15. | EC | Emulsify concentrate |
| 16. | EMS | Error means sum of square |
| 17. | *et al.* | Allied (and other) |
| 18. | Fig. | Figure |
| 19. | FS | Flow able concentrate for seed treatment |
| 20. | g | Granule |
| 21. | gm | Gram |
| 22. | $q\text{-}ha^{-1}$ | Quintal per hectare |
| 23. | i.e. | That is (in reference) |
| 24. | Kg | Kilogram |
| 25. | L | Liter |
| 26. | mm | Milli meter |
| 27. | $m^2$ | Meter square |
| 28. | Max. | Maximum |
| 29. | Min. | Minimum |

| | | |
|---|---|---|
| 30. | ml | Millie liter |
| 32. | MSS | Mean Sum of Square |
| 33. | NS | Non significant |
| 34. | M | Meter |
| 35. | OV | Original value/ Observed value |
| 36. | R | Replication |
| 37. | RBD | Randomized Block Design |
| 38. | RH | Relative humidity |
| 39. | SC | Suspension concentrate |
| 40. | SL | Soluble concentrate |
| 41. | SP | Soluble power |
| 42. | S.S. | Sum of Square |
| 43. | S. Em± | Standard error of mean |
| 45. | SMW | Standard Meteorological Week |
| 46. | S. No. | Serial number |
| 47. | S.V. | Source of variance |
| 48. | WP | Wettable powder |
| 49. | WS | Wettable sulphur |
| 50. | WG | Water dispersible granules |
| 51. | w/w | Weight for weight |
| 52. | TV | Transformation value |
| 53. | *viz.* | Wide list |

# CHAPTER – I
# INTRODUCTION

Mustard, *Brassica juncea* (Linnaeus), is a major *rabi* oilseed crop grown in an area of 6.34 million hectares and yielding 7.82 million tonnes with a productivity of 1234 kg/ha in 2012-13 (Thomas *et al.,* 2014). The main mustard growing states in India are Rajasthan, Uttar Pradesh, Madhya Pradesh, West Bengal, Haryana, Punjab and Assam. The mustard crop is grown on 7.79 lakh ha in Madhya Pradesh, with an output of 6.63 lakh tonnes and a productivity of 851 kg/ha (Anonymous, 2015) and in Chambal division rapeseed – mustard is grown on 365 ha with 693.5 mt production and 1897 kg/h productivity (AICRP 2019-20) .

The average productivity of rapeseed-mustard crops is quite low in India due to a number of abiotic and biotic stresses. Among them insect-pests and diseases cause heavy losses to the yield potential of these crops. Amid the various biotic factors, the infestation by insect pests is the major limiting factor in achieving higher productivity. A number of insect pests are known to cause economic damage to rapeseed-mustard right from sowing till harvest. Out of 43 species of insect pests reported on mustard, *Lipaphis erysimi* (Kalt), *Athalia lugens proxima* (Klug), *Bagrada hilaris* (Burmeister) and *Phytomyza horticola* (Goureau) are considered as major and serious pests in India. the crop generally suffers a 30 per cent yield loss due to insect pest (Dhaliwal *et al*., 2004).

Among all the insect pests, the mustard aphid, *Lipaphis erysimi* (Kaltenbach), (Hemiptera: Aphididae) has picked up the status of key pest of rapeseed-mustard in India. It nourishes by sucking sap and can inflict 9 to 96 per cent yield losses up to maturity in various agroclimatic conditions of India (Chorbandi and Bakhetia, 1987; Singh and Sachan, 1995; Parmar *et al.,* 2007). The misfortune may go up to 100 per cent in certain mustard developing regions (Singh and Sachan, 1999). The nymph and adult both suck the sap from the leaves, buds, flowers and pods as a result curling occurs in infested parts and the plants remain stunted later, at advanced stage, the plants may wither and die. Sooty moulds grow on the honey dew excreted by the insects. The infested field looks sickly and blighted in

occurrence. Singh and Sachan (1994) reported avoidable losses due to mustard aphid up to 69.6 per cent.

During the outbreaks of insect-pests, farmers want instant relief, which is usually accomplished through the use of insecticides. Synthetic insecticides not only cause pesticide threat to human beings and other non-target animals, like parasitoids, predators and pollinators. Biological control can furnish an alternative to chemical pesticide and it is not only effective in regulating pest populations, but is also considered as a sustainable, eco-friendly pest management tool, which can improve the ecosystem by minimizing pesticide use to avoid pesticide hazards.

Biological control or biocontrol is a method of pests by using other organisms. It depends on predation, parasitism, or other natural mechanisms, but typically also necessitates an active human management role. It can be a chief component of integrated pest management (IPM) programs. It is high time that alternate practices are utilized to combat with noxious insect pests. The parasitoid, *Diaeretiella rapae* (Mc'Intosh) (Hymenoptera: Braconidae) is the biological control agent has been observed to parasitize different species of aphids. It is the most common natural enemy of the cabbage aphid (*Brevicoryne brassicae,* Linnaeus) (Saleh, 2008; Maghraby, 2012).

*Diaeretiella rapae* was earliest described by Mc'Intosh in (1855) as *Aphidius rapae*. *D. rapae* (Mc'Intosh) is an endoparasitoid with a considerable role in preventing the outbreak of aphids in mustard crops. Adult female lays single egg into the bodies of aphid hosts, the wasp larvae feed on the tissues within the aphid body, killing it within 2 to 3 days. When the host dies, it becomes a 'mummy' consisting of the hardened exoskeleton of the aphid; the parasitoid larva pupates inside the mummy and comes out as an adult. Under laboratory conditions, egg-to-adult development ranges from 9 to 15 days. Adult females live for 10 to 15 days and have lifetime fecundity, while the male lives for 7 to 10 days. *D*. *rapae* is a solitary parasitoid species i.e., it lays one or more eggs in a host but only one develops into an adult (Godfray, 1994) and females appear with fully developed eggs (Kant *et al*., 2008; Ralec *et al*., 2011).

Dhiman (2006) reported fluctuating percentage of parasitization by *D. rapae* according to the host species and climatic conditions that ranged from

46.57 to 68.69 per cent in the field and 91.13 to 98.92 per cent in the laboratory. He also reported multiple parasitism or superparasitism although, only one parasitized larva developed within a single host. This parasitoid prefers to live on Brassicaceae such as *L. erysimi* (Blande *et al*., 2004).

Lot of work on morphological studies and chemical pesticide has been done on parasitism of *Diaeretiella rapae* but little work was reported on efficacy of bio-pesticide on parasitization of *D. rapae*. In view of the above fact, the study of *D. rapae* is undertaken with the following objectives:

1. To study the seasonal activity of *Diaeretiella rapae* on different brassica species.
2. To study correlation effects on *Diaeretiella rapae* with abiotic factors.
3. To find out the effect of biopesticides on *Diaeretiella rapae*.

# CHAPTER – II

# REVIEW OF LITERATURE

The present investigation entitled **"Studies on the aphid parasitoid (*Diaeretiella rapae)* with special reference to toxic effect of biopesticide against parasitoid on Brassica species"** was carried out during *rabi* crop season of 2020-21 at College of Agriculture, Gwalior (M.P.). The literature related to present study is described in this chapter reported by previous workers under following headings:

## 2.1 Effect of biopesticides on aphid and natural enemies

El-Sayed and El-Ghar – (GESA) (1989) tested three insecticides on cabbage in Egypt at several dosages to determine the lowest rate that would control *Brevicoryne brassicae* with the least adverse effects on its parasitoid *Diaeretiella rapae*. The minimum adverse effects on the parasitoid were found with profenophos followed by triazophos and malathion in that order.

Makhmoor and Malhotra (1993) tested the relative toxicity of six insecticides against the larvae of *Epysyrphus balteatus* and adults of *Lipaphis erysimi* on the basis of intrinsic toxicity. Phosphamidon was highly toxic to the syrphid larvae followed by dimethoate, oxydemeton-methyl and malathion. Endosulfan was the safest followed by chlorpyriphos. Phosphamidon was toxic to the adults of *L. erysimi* followed by dimethoate, oxydemeton-methyl and chlorpyriphos. Endosulfan was comparatively less toxic to the aphid followed by malathion. Safety incidices confirmed the innocuity of chlorpyriphos to the larvae of *E. balteatus* followed by endosulfan. Chlorpyriphos and endosulfan at the recommended concentrations could be used for aphid control along with the larve of syrphid fly in IPM.

Sundari (1998) found azadiractin and dichlorvos to have lowest toxicity to coccinallids, while, acephate and dimethoate were found to be highly toxic and fenvalerate was intermediate.

Dhingra (1999) determined the safety margin of twenty-four insecticides for the adults of aphid predator, *Coccinella septempunctata* by bioassay technique. On the basis of LC50 the relative toxicity of different insecticides the least toxic insecticides were lindane, endosulfan, aphidon and

menazol which gave less than 50 per cent mortality even at 1 per cent concentration. A comparison of relative resistance values of adults of *C. septempunctata* vis-à-vis important aphid pests, viz., *Lipaphis erysimi, Dactynotus carthami, Aphis craccivora* and *Myzus persicae* indicated that out of various insecticides tested, methyl demeton, lindane, endosulfan and aphidan exhibited a very high safety margin for the predatory adults, being at the same time most effective and commonly used against these various aphid species.

Singh *et al.* (1999) recorded the population of aphid predator, *Coccinella septempunctata* on aphid with six insecticides in the rapeseed field. The data of two years revealed that malathion (0.05%) was found safest insecticide to *C. septempunctata* however, it was at par to endosulfan (0.07%) and phosolone (0.05%). The treatments of phosphamidon (0.03%), fenvalerate (0.01%) and cypermethrin (0.01%) were found to be toxic to the predators.

Lowery and Isman (1995) tested the neem (*Azadirachta indica*) seed oil (NSO) with 3 concentrations (0.5, 1 and 2%) showed that the rate of parasitism of *M. persicae* by *D. rapae* did not reduce. Under field condition, the spray of NSO and neem seed extract on plant failed to give significant impact on the number of aphids parasitized. Neem insecticides might be suitable for use in the integrated pest management, as in the field they appeared to be relatively harmless to aphid predators and parasitoids.

Vekaria and Patel (2000) evaluate the efficacy of two plant products [Neem oil and nicotine sulfate (nicotine)], applied alone or in combination with chemical insecticides on natural enemies of *L. erysimi* showed that both plant products were less toxic to *D. rapae* and *C. septempunctata* than the chemical insecticides.

Kushwaha (2003) tested the efficacy of ethanol extracts of fourteen plant material against *Lipaphis erysimi* under laboratory conditions and reported that gulabas and biskhapra leaf extract showed knocked down effect on aphid, Thuja and garlic leaf extracts were effective in 72 hours after treatment. All the plant extracts were quite safe against the parasitoid.

Bhavani and Punnaiah (2006) evaluated the efficacy of insecticides against aphid, *L. erysimi.* The treatment of flufenoxuron 10 EC (0.01%)

proved effective in reducing the population of cabbage aphid by 78.97 per cent over control and was at par with other insecticidal treatments, viz., neem oil mixed with endosulfan, profenofos, acephate, neem oil, biobit and endosulfan.

Dhingra *et al.* (2006) In a field evaluation on mustard crop (*Brassica juncea*), phot\table tetra hydro azadirachtin-A provided superior control on mustard aphid (*Lipaphis erysirni* Kalt.) as compared to azadirachtin. Oxydemeton-methyl, providing 88.73 % reduction in aphid population was the most effective followed by tetra hydro azadirachtin that provided 64.02% reduction over untreated control. Neemazal and neem oil EC (25 per cent) were the least effective, recording 17.1 and 7.28 % reduction in aphid population respectively over untreated control. The coccinellid beetle (*Coccinella septempunctata*) population was the maximum in tetra hydro azadirachtin treatment followed closely by azadirachtin and minimum in oxydenleton-methyl, neem oil EC and Neemazal. Besides being effective against the mustard aphid.

Farag and Gesraha (2007) Four insecticides, thiomethoxam (Actara 25% WG), Imidacloprid (Confidor 35% SC), natural oil of jatropa plant (Nat-1), formulated as 96% FC and Pirimicarb (Aphox 50% DG) were tested against the parasitoid wasp, *Diaertiella rapae* (McIntosh) and its host aphid, *Brevicoryne brassicae* (L). Actara and Aphox scored the highest efficacy against the parasitoid wasp followed by Confider, then Nat-1.

Jadon (2008) tested water and ethanol of extracts of botanicals, in comparison to oxydemeton methyl and control. Among the plants extracts neem seed kernel extract found most effective in reducing aphid population followed by Gulbas and Biskhapra. All the tested plant extracts were found safer to natural enemies, *C. septempunctata* and *D. rapae* in comparison to insecticides. The grain yield and number of siliquae also increased significantly by spray of all the plant extracts.

Singh *et al.* (2009) tested four bio – agents, víz, *Coccinella septempunctata* L, *Menochilus sexmaculatus* (F.). *Chrysoperla carnea* (Stephens) and *Verticilium lecanii* (Zimmerman), against mustard aphid, *Lipaphis erysimi* (Kaltenbach), on single plants covered with muslin cloth in the field at National Research Center on Rapeseed – Mustard, Sewar,

Bharatpur (Rajasthan) during 2005-06 and 2006-07. *C. septempunctata* @ two adults / plant was found to be the most effective, reducing 96.19% of the aphid population in 10 days followed by *C. septempunctata* @ two larvae per plant (93.42%), *V. lecanii* @ 108 spores (84.90%), *M. sexmaculatus* @ two adults (84.62%) and *C. carnea* @ four larvae plant (82.98%). *C. septempunctata* @ one adult per plant reduced the aphid population by 77.49% and *M. sexmaculatus* by 69.08%.

Kumar (2016) conducted experiment on bio-efficacy of bio-pesticides and certain chemical insecticides against mustard aphid (*Lipaphis erysimi* Kalt.) on mustard and revealed that treatments of Dimethoate 30 EC followed by spraying of Malathion 50 EC and Neem oil (0.5%) were found more effective for control of *Lipaphis erysimi* Kalt., respectively. Whereas, the descending order of treatments were Neem oil > NSKE > Tobacco Leaf extract > *Bacillus thuringiensis* > *Beauveria bassiana* > *Metarhizium anisopliae*. The least effective treatment was *Verticillium lecanii*. Maximum infestation was recorded in control.

Patel (2017) A field study was conducted at Pantnagar (India) to determine the effectiveness of seven insecticides viz., quinalphos 25 EC, thiamethoxam 25 WG, malathion 50 EC, fenvalerate 20 EC, chlorpyrifos 20 EC, dimethoate 30 EC and imidacloprid 17.8 SL against mustard aphid, *Lipaphis erysimi* Kalt. The observations were recorded at 3, 7 and 10 days after spraying of insecticides. The results revealed that thiamethoxam 25 WG was the most effective among the seven insecticides showing the minimum numbers of *L. erysimi* Kalt followed by imidacloprid and dimethoate. The maximum seed yield (12.36 q/ha) was obtained from the treatment of imidacloprid which remained on par with the treatments of thiamethoxam (10.0 q/ha) and quinalphos (9.31 q/ha). The lowest seed yield was obtained from untreated plots (6.04 q/ha). So, neonicotinoid insecticides (thiamethoxam and imidacloprid) could be used in mustard ecosystem to control mustard aphid, *Lipaphis erysimi* with high yield.

**2.2 Seasonal activity of *Diaeretiella rapae* on different brassica crops**

Batra and Wadhi (1962) identified parasitoids emerging from parasitized aphids on cabbage plants as *D. rapae*.

Kundu *et al.,* (1966) recorded *D. rapae* (Curtis) as a parasite of mustard aphid, *L. erysimi* for the first time from India.

Singh and Rawat (1981) reported *Diaeretiella rapae* parasitizing the mustard aphid *Lipaphis erysimi* during 1978 from Madhya Pradesh. They observed that the parasitoid started its activity from second or third week of January about a fortnight after the commencement of the mustard aphid infestation. Parasitization increased from the second week of February and reached to its peak (96.49-97.50%) in the fourth week of February. Thereafter both the aphid and parasitoid population decreased gradually and disappeared by the second week of March.

Dhiman and kumar (1991) investigated the effects of temperature and relative humidity on development of *D. rapae* parasitizing *L. erysimi* (kalt) and revealed that the optimum temperature for rapid multiplication of the parasitoid was 24 to 28 $^{0}$C and the adult parasitoid tolerated temperature of 18 to 30 $^{0}$C. Relative humidity of 50 to 70 % was suitable and development was fastest at 50 to 70 % RH and 26 to 28 $^{0}$C temperature.

Desh and Lakhanpal (1998) reported that the peak parasitization by *D. rapae* was recorded as 31.69 and 29.89% in *L. erysimi* and *B. brassicae* during first week of March 1993 while 52.86 and 30.74% during second week of March 1994, respectively. During both the years, peak parasitization by the parasitoid was observed during first fortnight of March. The parasitoid commenced its activity from first week of February to first week of April when mean maximum and minimum temperature was varied from 14.3 to 25.08 and 5.1 to 14.3 ° C, respectively. The other abiotic factors pertaining to relative humidity were 26 to 60%, total rainfall 174.4 mm, wind velocity 6.0 to 7.4 km / hour and 4.7 to 9.2 sunshine hours per day

Patel (1998) studied the population dynamics of various species of aphids and their natural enemies at Anand (Gujarat) and reported that the parasitoid. *D. rapae* was found on late sown mustard and its activity positively correlated with minimum temperature. The emergence of the parasitoid was greater at higher (25 + 1 and 30 + 1 °C) temperature. The parasitoid followed

to *L. erysimi* after 3 weeks of aphid events in cauliflower in the first week of February

Vekaria and Patel (1999) from North Gujarat reported that the *D. rapae* appeared in mustard crop on eleventh week after sowing and remained active till harvest of the crop. Highest (66.47% parasitism) population of *D. rapae* was reported during fifteenth week after sowing. The non-significant positive (r = 0.462) correlation between *D. rapae* with aphid population on mustard crop.

Nayak and Sharma (2000) observed that under agro-climatic conditions of Gird region, the extents of parasitization of *L. erysimi* by *D. rapae* were started after 11 weeks of aphid appearance which conceded in the month of January when the aphid population was at its peak. After that, percent parasitization was increased and reached with the minimal activity of aphid. The parasitization by *D. rape* under Gird agro- climatic zone ranged from 0.3 to 98.8 % during the crop season.

Kulkarni and Patel (2001) assessed that the incidence of mustard aphid (*Lipaphis erysimi* Kalt.) was commenced from nine weeks after sowing i.e. first week of January and reached to its peak intensity (2.90 A.I./plant) at fourteen weeks after sowing. The activity of *Diaeretiella rapae* M. was noted more in the fourth week of February (43.68%), whereas *Coccinella septempunctata* Linn. beetles were active in the last week of January and reached to its peak level (2.90 beetle/plant). The larvae of syrphid fly observed more in the second week of February (1.70 larvae/plant).

Dogra *et al*. (2003) studied the parasitization of *L. erysimi* by *D. rapae* in Palampur and recorded maximum parasitization (51.07%) when mean maximum, minimum temperature and relative humidity was $22.5^0$C, $10.3^0$ C and 36%, respectively.

Blande *et al.* (2004) *Lipaphis erysimi* (Kaltenbach) is a specialist crucifer feeding aphid and *Myzus persicae* (Sulzer) is a generalist feeding aphid. The foraging behavior of *Diaeretiella rapae* (McIntosh), a parasitoid with the ability to parasitize both of these species, was assessed using a series of attack rate and success bioassays, with turnip, *Brassica rapa* var rapifera, as the host plant. The attack rate of *D. rapae* was significantly greater on *L. erysimi* than on *M. persicae* when aphids were feeding on turnip leaf discs in Petri dishes, irrespective of the aphid species

upon which the parasitoids were originally reared. Excision of *D. rapae* pupae from mummy cases and subsequent use of the fully developed adults in attack rate bioassays showed that cues received by *D. rapae* at the time of adult emergence provide cues that prime *D. rapae* to attack *L. erysimi* at a greater rate than *M. persicae*. However, the relative success of *D. rapae* on these two aphid species, in terms of the percentage of attacks resulting in a successful adult parasitoid, was not significantly different.

Dhiman (2006) reported variable percentage of parasitization by *D. rapae* according to the host species and climatic conditions that varied from 46.57 to 68.69% in the field and 91.13 to 98.92% in the laboratory. He also reported multiple parasitism or superparasitism although, only one parasitized larva developed within a single host.

Dhiman (2007) observed maximum adult population of *D. rapae* during morning (up to 10 am) and evening (3 to 6 pm) hours in mustard. Maximum mummies were observed on ventral side of leaves and influenced population density of both adults and nymphs. Mummified aphids were found minimum during December- January and were maximum during February-April on mustard *D. rapae* parasitized 75.46 and 68.96% aphids on mustard crop during 2006-07 and 2007-08, respectively.

Silva *et al*. (2007) was studied the development time and parasitization rate of *Diaeretiella rapae (*M'Intosh) on *Brevicoryne brassicae* (L.) feeding on different Brassica cultivars in the laboratory at 20°C. The shortest development time from egg to adult parasitoid was 11.6 days on cabbage cv. 'Yalova 1' and the longest was 12.1 days on turnip cv. 'Antep' and rapeseed cv. local variety. Females lived significantly longer than males on the host plants used in the study. Females and males had the shortest longevity on rapeseed at 11.1 and 5.1 days, respectively. The highest percent parasitism of *B. brassicae* by *D. rapae* was found on cabbage (40.20%), and the lowest was recorded on turnip (32.64%). Our results demonstrate that parasitism rate could be influenced by the plant quality, probably due to the nutritional status of the aphids or to toxic compounds ingested through the plant. Cabbage, cauliflower and broccoli were found to be suitable plants for the parasitoid, considering the development time of pre-adults, and the parasitization rate of *D. rapae*.

Bayhan*, et al.* (2007) study aimed to evaluate the quality of the aphid *Myzus persicae* (Sulzer), *Lipaphis erysimi* (Kaltenbach) and Brevicoryne *brassicae* (L.) as hosts for the parasitoid *Diaeretiella rapae* (McIntosh). Parasitization by *D. rapae* was higher on *M. persicae* than on *L. erysimi* and *B. brassicae*. The time of development of *D. rapae* from egg to mummy or egg to adult male or female were shorter on *M. persicae* than on *L. erysimi* and *B. brassicae*. Moreover, *D. rapae* showed no significant differences in the emergence rate, sex ratio and longevity when reared on the three aphid species. *Myzus persicae* was the largest aphid host, with *B. brassicae* and *L. erysimi* being of intermediate and of small size, respectively. *Diaeretiella rapae* reared on *M. persicae* was larger than when reared on *L. erysimi* and *B. brassicae*, and females of *D. rapae* were significantly larger than males on *M. persicae*, but males of *D. rapae* were larger than females when reared on *L. erysimi*. No difference in size was detected between males and females in parasitoids reared on *B. brassicae*. Among the aphid species studied, *M. persicae* was found to be the most suitable to *D. rapae.*

Hugar *et al.* (2008) from Karnataka identified *D. rapae* as egg parasitoid of mustard aphid and found that it reached to a maximum (16.9%) level during last week of February on mustard.

James *et al.* (2008) generalist endoparasitoid *Diaeretiella rapae* (Hymenoptera: Aphidiidae) displays specialist characteristics on brassica feeding aphids. Previously, they studied differential signaling to *D. rapae* by specialist and generalist brassica feeding aphids on turnip. They reported no differences in the attractiveness of volatile compounds from the two turnip/aphid complexes. However, we reported a significantly greater *D. rapae* attack rate on the specialist *Lipaphis erysimi* (Kaltenbach) than the generalist *Myzus persicae* (Sulzer). As a consequence, we predicted that *D. rapae* would forage more efficiently and produce more offspring on *L. erysimi*.

Akhtar *et al.* (2010b) observed the correlation coefficient of average relative humidity (%) with aphid*, L. erysimi* on mustard (r = - 0.52) and parasitoid, *D. rapae* (r = -0.59) were negatively significant whereas day (r = 0.65) and night (r = 0.61) temperature had significant positive correlation with

the parasitoid population. The number of mummified aphids due to activity of *D. rapae* on mustard was observed from eleventh week of crop age (i.e. 5$^{th}$ standard week) and increased gradually till sixteenth week of crop age. The population of aphid and parasitoid peaked during the thirteenth week of crop. The per cent parasitism was as high as 75.81 during 2006-07. In 2007-08 the mummified aphids were observed a week ahead of the last crop season i.e. from the tenth week of crop age (5$^{th}$ standard week). The number of aphids increase gradually and seen field up to eighteenth week of crop age. During the crop season of 2007-08, the population of aphids peaked during the fifteenth week and continued to remain at that level during sixteenth week of crop age (342 aphids / plant) i.e. peak population of aphids was observed during both tenth and eleventh standard on an average 1.8 to 66.50 aphid parasitoids emerged per week till eighteenth week of crop age. Maximum number of parasitoid emergence (165) was found during sixteenth week of crop. This was slightly different from what was observed in the previous year with slightly lower per cent parasitism (68.92%) compared to the previous year.

Khedkar (2011) observed that the parasitization due to *D. rapae* on *L. erysimi* in mustard crop initiated from eighth week after sowing (2.73% parasitism) i.e. third week of January and reached to its peak (88.33%) at twelfth week after sowing (third week of February) and then declined. Though the population of aphids declined, the activity of *D. rapae* was continued in the field up to fifteenth week after sowing correlation coefficient between *D. rapae* and weather parameters at Anand (Gujarat) and found that none of the abiotic factors showed significant association with *D. rapae*. Evening vapour pressure deficit and wind speed exhibited positive, whereas morning relative humidity, evening relative humidity, morning vapour pressure and evening vapour pressure showed negative correlation. But failed to exert the significant impact on *D. rapae*. There was significant positive (r = 0.87) correlation between the activity of *L. erysimi* on mustard crop and its parasitoid.

Sangekar (2012) the cabbage transplanted during third week of December showed highest per cent parasitism in *L. erysimi* due to *D. rapae*. Relationship between *D. rapae* and biotic as well as abiotic factors

parasitization by *D. rapae* was significantly correlated with increase in number of parasitized aphids (r = 0.805). Parasitization by the parasitoid was varied from 0.7 to 8.3% (mean 3.6%) and 1.80 to 8.2% (mean 4.4%) for *B. brassicae* and *M. persicae*, respectively.

Bodlah *et al.* (2012) *Diaeretiella rapae* (M'Intosh) (Hymenoptera: Braconidae, Aphidiinae) aphid parasitoid is reported from various districts of Punjab Province of Pakistan from a wide range of host aphids and plant associations, including some new evidences. Biology of the parasitoid reared on *Myzus persicae* aphids in the laboratory at 23±1°C have been discussed. The development cycle from larva to adult was completed in about 11.5 days at 21-23°C. The pre-mating period of males (n=10) varied between 20 and 40 minutes (mean: 28.8 min), however it was longer in females most of which rejected all copulatory attempts at least two hours after emergence. When newly emerged females were confined with males for a period of 12 h, all mated i.e., they produced progeny of both sexes. Copulation time (n = 10 pairs) was between 30 and 60 s (mean: 46.3 s). Oviposition time (n = 10 females) was between 46 and 64 s (mean: 52.6 s). Female lived longer (11.1± 0.16 days) than males (9.4 ± 0.18 days) when offered honey and water. The lifespan of adult females was shorter (10.2 ± 0.05 days) in the presence of host aphids and host plant leaves than only with honey and water.

Bharat lal *et al*. (2018) study the seasonal incidence of major insect pests of mustard crop and their natural enemies and its correlation with weather parameters. The incidence of mustard aphid, painted bug and flea beetle were started during 47th SMW and attained their peaks during 5th, 8th and 52nd SMW respectively. While the activity of *C. septumpunctata* and *D. rapae* were started from 4th SMW and reached its peak during 9th SMW respectively. Correlation studies revealed that aphid population was positive correlated with morning and evening relative humidity (r = 0.49, 0.44 respectively) and negatively correlated with maximum and minimum temperature, while significant and positive correlation was observed between population buildup of painted bug and maximum and minimum temperature (r =0.48 and 0.61). Whereas the flea beetle population exhibited significant positive correlation (r = 0.35 respectively) with maximum temperature and negatively correlated with morning and evening relative humidity to the level

of significance. The correlation study between natural enemies and weather parameters 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, and 0.26 respectively), while morning and evening relative humidity were found to be negatively correlated (r = -0.11, -0.28 respectively).

Pradhan *et al.* (2020) study the seasonal incidence of insect pests and natural enemies revealed that aphid *(L. erysimi*), flea beetle (*P. cruciferae*) and sawfly (*A. lugens proxima*) were appeared during 51st SMW i.e. 3rd week of December, 2018 while the natural enemies viz., ladybird beetle (C. transversalis) and *D. rapae* appeared during 4th SMW i.e. (last week of January, 2019). The correlation studies between different weather parameters and population of major insect pests revealed that maximum temperature recorded positive correlation with aphid, flea beetle and sawfly with correlation coefficient, r= 0.502, r= 0.510 and r= 0.461, respectively. In case of natural enemies observed 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 non-significant positive correlation with aphid (r= 0.456) but had a significant positive correlation with ladybird beetle (r= 0.669) and *D. rapae* population (r= 0.682). Morning relative humidity had non-significant negative correlation with all the insect pests observed in mustard crop except aphid where it was found to be significant (r= -0.606). Evening relative humidity had non-significant negative correlation with aphid (r= -0.251) and *D. rapae* (r= -0.047) also it was found to be negatively correlated. Rainfall had positive and nonsignificant correlation with aphid (r= 0.038), *C. transversalis* (r= 0.066) and D. rapae (r= 0.080) population.

# CHAPTER – III
# MATERIALS AND METHODS

The present investigation entitled **"Studies on the aphid parasitoid (*Diaeretiella rapae*) with special reference to toxic effect of biopesticide against parasitoid on Brassica species"** was conducted at the experimental field at College of Agriculture, RVSKVV, Gwalior, Madhya Pradesh during the rabi season of 2020-2021.

## 3.1 Geographical location and Climate:

Gwalior is situated in the northern part of Madhya Pradesh at an altitude of 211.52 MSL and lies in the latitude and longitude at $26^{o}$ 14' North at and $78^{o}$ 16' East. The topographical status of the field is said to be plain and with good irrigation facilities. Gwalior has sub-tropical climate showing high temperature during summers from late March to early July, the humid monsoon season starts from late June to early October, and cold dry winter starts from early November to late February. The average annual rainfall is 764.4mm, while the most rainfall is seen during mid-June to mid September. Gwalior alone receives 700mm of rainfall per year most of which is only during the monsoon months, the highest rainfall is received during the month of August. Winter starts in late October and, is generally very mild with daily average temperature of 14-16$^{o}$C and occasional cold snaps brings down the temperature upto 0$^{o}$C.

The meteorological data regarding the temperature, relative humidity and rainfall were recorded during the cropping season (to relate the pest incidence and intensity) from the Meteorological Observation Centre, Department of Meteorology, College of Agriculture, Gwalior presented in table below.

**Table 3.1: Meteorological data during crop growth period (*rabi* 2020-21)**

| PERIOD | SMW | Temperature ($^{o}$C) | | Relative humidity (%) | |
|---|---|---|---|---|---|
| | | Maximum | Minimum | Morning | Evening |
| 3-9 Dec | 49 | 29.4 | 9.7 | 94.3 | 43.1 |
| 10-16 Dec | 50 | 25.3 | 11.7 | 92.7 | 63.4 |
| 17 - 23 Dec | 51 | 22.5 | 5.1 | 90.7 | 58.9 |
| 24 – 31 Dec | 52 | 22.7 | 5.2 | 93.9 | 73.1 |
| 1– 7 Jan | 1 | 22.5 | 10.1 | 93.1 | 75.7 |
| 8 – 14 Jan | 2 | 20.8 | 8.2 | 90.3 | 78.4 |
| 15 – 21 Jan | 3 | 22.9 | 5.9 | 94.1 | 78.7 |
| 22 – 28 Jan | 4 | 21.3 | 5.5 | 96.1 | 75 |
| 29 Jan - 04 Feb | 5 | 25.3 | 5 | 89.6 | 63.8 |
| 05 – 11 Feb | 6 | 25.5 | 8.3 | 89.4 | 64.5 |
| 12 – 18 Feb | 7 | 28.6 | 9.2 | 93.2 | 55.5 |
| 19 – 25 Feb | 8 | 30.2 | 9.9 | 89.1 | 42 |
| 26 Feb– 04 March | 9 | 32.6 | 12.8 | 75.7 | 38.7 |
| 05 – 11 March | 10 | 34.5 | 14.6 | 75.8 | 36 |
| 012 – 18 March | 11 | 32.8 | 15.4 | 79 | 47 |
| 19 – 25 March | 12 | 36.3 | 17.1 | 72.2 | 47.7 |
| 26 March – 01 April | 13 | 37.7 | 18.2 | 72.7 | 41.1 |

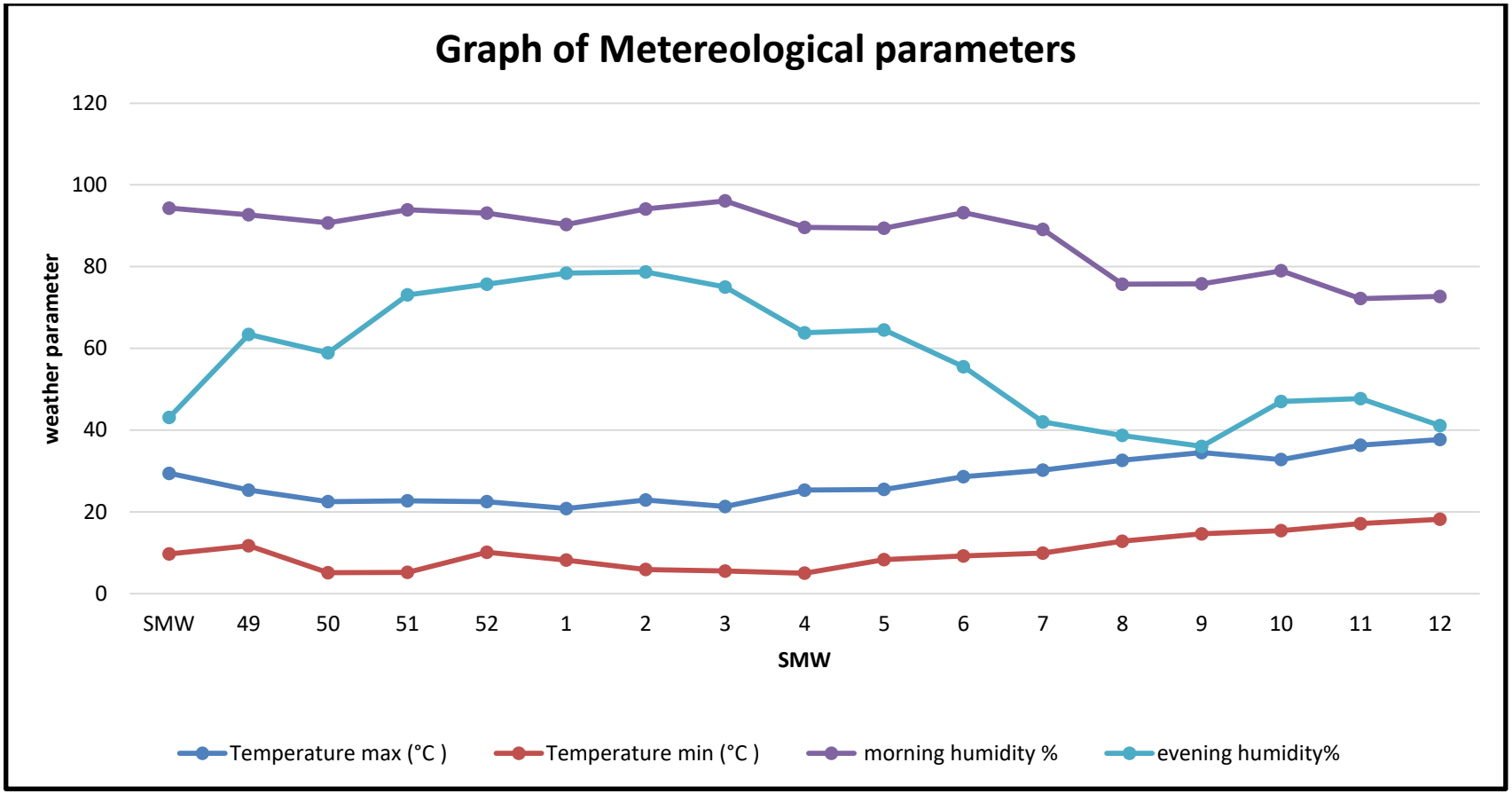



**Fig-3.1 Meteorological data during crop growth period (*rabi* 2020-21)**

**Source**: Meteorological Observation Centre, Department of Meteorology, College of Agriculture, Gwalior (M.P.)

## 3.2 Methodology

### 3.2.1Material required

Material required for conducting the experiments - Biopesticides, chemical pesticide, Seeds of *Brassica compestris* var. BSH-1, *Brassica juncea* var. Pusa Bold, Pusa Jagannath, Kranti, agricultural implements, manures, inorganic fertilizers, measuring cylinder buckets, labels, threads and polythene bags, were used. These materials were provided by College of Agriculture, Gwalior during the study period.

### 3.2.2 Preparation of land:

Land was prepared as per recommended standard agronomical practices.

### 3.2.3 Method of sowing

The sowing was done on 6 December 2020 manually about 3cm deep in furrows. Chemical fertilizers were applied below the seed in furrows before sowing then seed was covered with thin layer of moist soil. After emergence, thinning was done retaining a single healthy plant per hill.

### 3.2.4 Intercultural operations

All agronomical operations like weeding and hoeing were carried out as and when required to get healthy crop.

### 3.2.5 Method of application of fertilizers

Method of application of fertilizers Nitrogen (N) was applied 80 kg/ha in the form of urea, (40) kg/ha at the time of sowing and remaining 40 kg/ha 30 days after sowing, whereas phosphorus @40 kg/ha and potash @20 kg/ha were applied each in a dose in the form of super phosphate and muriate of potash, respectively before sowing.

## 3.3 Details of the experiment:

The experiment was conduct during 2020-21 at experimental field at College of Agriculture, RVSKVV, Gwalior, (M.P).

**Objective 1:** To study the seasonal activity of *D. rapae* on different Brassica species.

**Experimental details:**

| | | |
|---|---|---|
| Brassica species | : | 1. *Brassica compestris* var. BSH-1<br>2. *Brassica juncea* var. Pusa Bold |
| Plot size | : | 5m x 5m |
| Plant to plant | : | 10cm |
| Row to row | : | 30cm |
| Date of sowing | : | 6$^{th}$ December 2020 |
| Fertilizer dose | : | 80:40:20(NPK) kg/ha |

**Method of observation**

Observations were recorded for healthy and mummified aphids at weekly intervals on 10 cm top twig of the 05 plants selected randomly from each plot and converted it into percentage of aphid parasitization by *D. rapae*. Aphid parasitization by *D. rapae* was periodically computed by dividing number of mummified aphids per leaf/total number of aphids present on that leaf at weekly interval from December to April, 2021 and the data were expressed in percentage

**Objective 2:** To study correlation effects on *D. rapae* with abiotic factors.

**Experimental details:**

| | | |
|---|---|---|
| Variety | : | Pusa Jagannath |
| Plot size | : | 5m x 5m |
| Plant to plant | : | 10cm |
| Row to row | : | 30cm |
| Date of sowing | : | 6$^{th}$ December 2020 |
| Fertilizer dose | : | 80:40:20(NPK) kg/ha |

**Method of observation**

The population density of aphid was recorded once in a week on the Brassica species grown under completely pesticide free conditions on healthy and mummified aphids and counted from randomly selected five plants regularly till the maturity of crop were summed up and correlated with meteorological data on atmospheric temperature, RH and Rainfall will be collected from the Meteorological Laboratory, College of Agriculture, Gwalior for analysis.

**Objective No. 3:** To find out the effect of biopesticides on *D. rapae*.

**Experimental details:**

| | | |
|---|---|---|
| Design | : | RBD |
| Crop variety | : | Kranti |
| No. of replications | : | 03 |
| No. of treatments | : | 08 |
| No. of plots | : | 24 |
| Plot size | : | 4m x 3m |
| Rep. to Rep. | : | 1.5 m |
| Plot to plot | : | 1m |
| Date of sowing | : | 6$^{th}$ December 2020 |

**Method of observation**

Observations on healthy and mummified aphids were taken in pre and post treatments. Pre-treatment observations were recorded at 24 hrs. before spray and post treatment observations were recorded at 3, 7 and 15 days after first, second and third spraying on 10 cm top twig of the 05 plants selected randomly from each plot.

**Table – 3.2: Treatments details**

| Tr. No. | Biopesticides | Dose/ha. |
|---|---|---|
| **T1** | *Beauveria bassiana* | 2.5 kg/ha. |
| **T2** | *Verticillium lecanii* | 2.5kg/ha. |
| **T3** | Neem oil 2% | 10 lit/ha. |
| **T4** | Neem leaf extract 5% | 25kg/ha. |
| **T5** | NSKE 5% | 25kg/ha. |
| **T6** | Parthenium leaf extract 5% | 25kg/ha. |
| **T7** | Dimethoate 30EC | 0.5lit/ha. |
| **T8** | Control | Water spray |

### 3.4 Correlation analysis

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

Where

$r_{xy}$ = Simple correlation coefficient

X = Variable i.e. abiotic component (Average temperature, relative humidity, rainfall and number of rainy day)

Y = Variable i.e.

n = Number of observation

To find out the significance of correlation following formula was used

$$t = \frac{1}{\sqrt{1-r^2}} \times \sqrt{n-2} \sim t_{n-2} d.f.$$

The calculated t value obtained was compared with tabulated t - value at 5% level of significance

### 3.5 Regression analysis – Simple Linear Regression

Simple linear regression is a model that asses the relationship between a dependent variable and an independent variable the simple linear model expressed using the following equation

**$Y = a + bx (R^2)$**

Where

Y = Dependent variable abiotic component (Average temperature, relative humidity, rainfall and number of rainy day)

X = Independent variable

a = Intercept

b = Slope

$R^2$ = Coefficient of determination

### 3.6 Statistical analysis

The data obtained from a set of observations for each character were tabulated and analysed by the method of "Analysis of variance" as suggested by Fisher and Yates, (1963).

**Table 3.3 ANOVA**

| **Source of variance** | **Degree of Freedom (D.F.)** | **Sum of Square (S.S.)** | **Mean Sum of Square (M.S.S.)** | **F Cal.** | **F Tab. At 5%** |
|---|---|---|---|---|---|
| Replication | (r-1) | SSR | MSR | MSR/MSE | |
| Treatment | (t-1) | SST | MSTr | MSTr/MSE | |
| Error | (r-1) (t-1) | SSE | MSE | | |
| Total | (rt-1) | TSS | | | |

The significant differences between different treatments were judged by using critical differences (CD) which was calculated as follows:

MSE (ve) = Error mean sum of square (Error variance).

ve = SSE/ e.d.f.

SEm = Standard error of mean

SEm = $\pm\sqrt{\frac{ve}{r}}$

SEd = Standard error of difference

SEd = $\sqrt{2} \times SEm$

CD = Critical difference

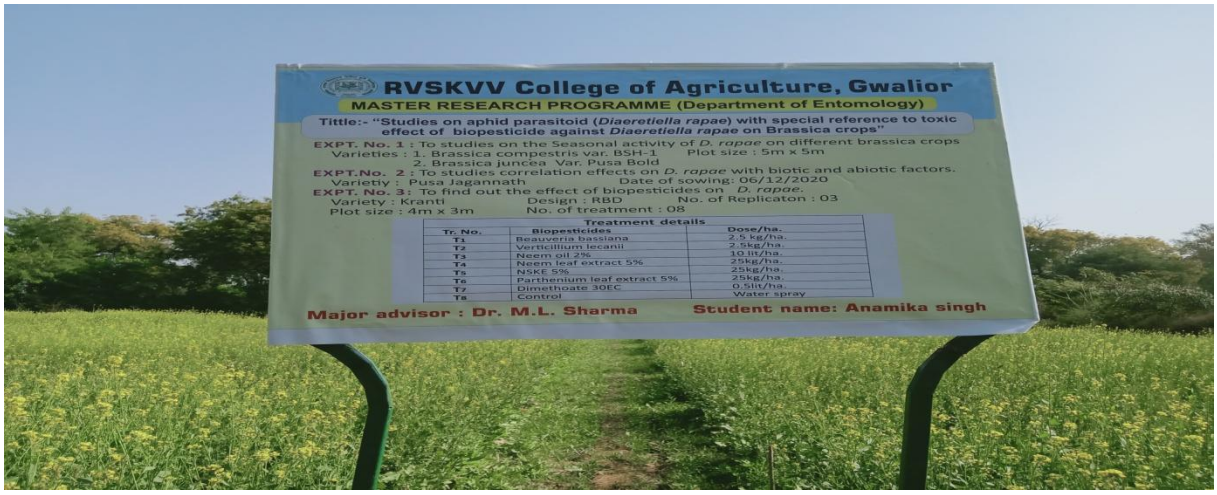
CD for treatment at 5% = SEd. X (e.d.f.) at 5%

t = Value for Fishers table for error degree of Freedom at 5%

r = Number of replications

e.d.f. = Error degree of freedom.

(A)




(B)

Plate I - General view of experimental field

# CHAPTER - IV

# RESULTS

The present investigation on **"Studies on the aphid parasitoid (*Diaeretiella rapae*) with special reference to toxic effect of biopesticide against parasitoid on Brassica species"** was conducted at the experimental field at College of Agriculture, RVSKVV, Gwalior, Madhya Pradesh during the rabi season of 2020-2021.

The data of the experiments was tabulated, analyzed using suitable transformations and findings as per the objectives of the study. The result obtained during the course of investigations are presented in this chapter under the following headings.

1. To study the seasonal activity of *D. rapae* on different brassica species
2. To study correlation effects on *D. rapae* with abiotic factors.
3. To find out the effect of biopesticides on *D. rapae*

## 4.1 Seasonal activity of *D. rapae* on two Brassica species

The activity of *D. rapae* on *Brassica compestris* var. BSH-1 and *Brassica juncea* var. Pusa Bold in terms of aphid parasitization per cent recorded on healthy and mummified aphids at weekly intervals on 10 cm top twig of the five plants selected randomly from the plot during December, 2020 to April, 2021. (Table 4.1, Fig. 4.1).

First appearance of the aphid parasitization by *D. rapae* was recorded during 8 -14$^{th}$ January (2$^{nd}$ SMW) on variety BSH-1 with parasitization range 1.75 per cent at appearance and 72.13 at its peak during 12$^{th}$ -18$^{th}$ February (7$^{TH}$ SMW) thereafter population was decline and reached their minimal level 0.92 per cent during 27 March – 1$^{st}$ April (13$^{th}$ SMW).

Whereas first appearance of *D. rapae* on var. Pusa Bold was recorded one week later during 15$^{th}$ – 21$^{st}$ Jan (3$^{rd}$ SMW) with 0.32 per cent aphid parasitization thereafter it was increased and reached their peak level (68.43 %) during 19 – 25$^{th}$ Feb (8$^{th}$ SMW) and after that parasitization was decreased and reached lower level during 26 March – 1$^{st}$ April (13$^{th}$ SMW).

During this period maximum and minimum temperature were 28.6°C and 9.2°C whereas, morning and evening relative humidity were 93.2 and 55.5 per cent respectively. No rainfall was received during this period.

**Table – 4.1 Seasonal activity of *D. rapae* on two Brassica species.**

| S. No. | PERIOD | SMW | Aphid parasitization (%) by *D. rapae* | |
|---|---|---|---|---|
| | | | BSH-1 | PUSA BOLD |
| 1 | 8 – 14 Jan | 2 | 1.75 | - |
| 2 | 15 – 21 Jan | 3 | 9.23 | 0.32 |
| 3 | 22 – 28 Jan | 4 | 39.84 | 7.32 |
| 4 | 29 Jan - 04 Feb | 5 | 53.73 | 27.65 |
| 5 | 5 – 11 Feb | 6 | 69.23 | 41.76 |
| 6 | 12 – 18 Feb | 7 | 72.13 | 53.7 |
| 7 | 19 – 25 Feb | 8 | 32.1 | 68.43 |
| 8 | 26 – 04 March | 9 | 18.34 | 22.54 |
| 9 | 5 – 11 March | 10 | 11.2 | 12.43 |
| 10 | 12 – 18 March | 11 | 5.32 | 4.43 |
| 11 | 19 – 25 March | 12 | 2.11 | 1.9 |
| 12 | 26 March – 01 April | 13 | 0.92 | 0.11 |

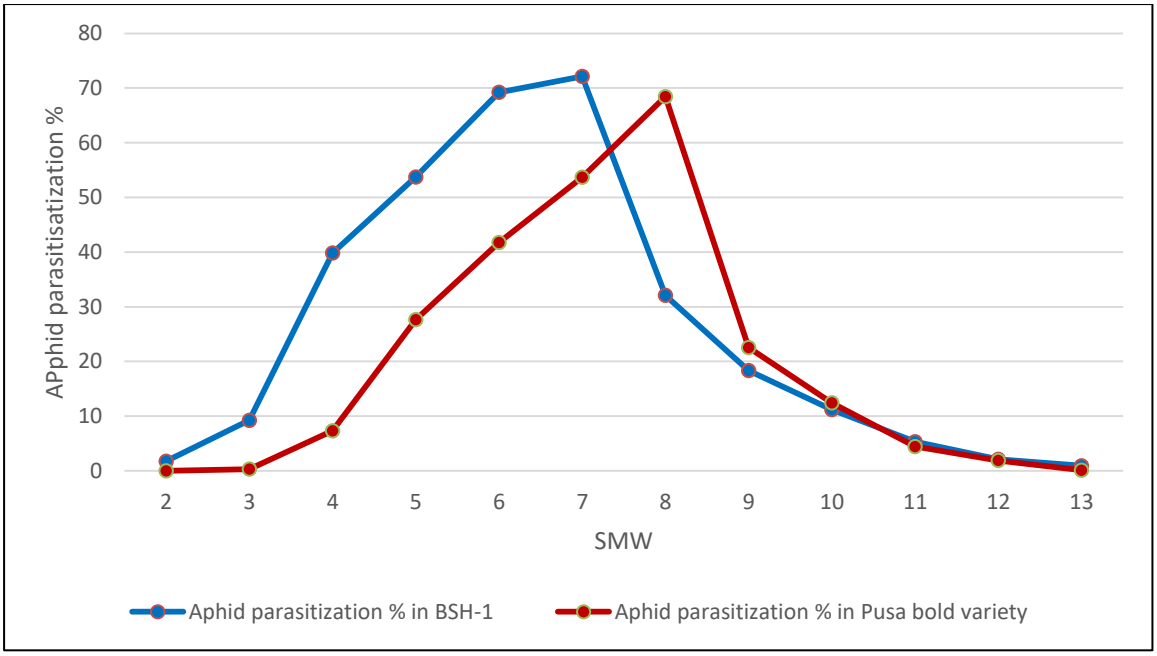



**Figure 4.1 Seasonal activity of *D. rapae* on BSH-1 and Pusa bold variety**

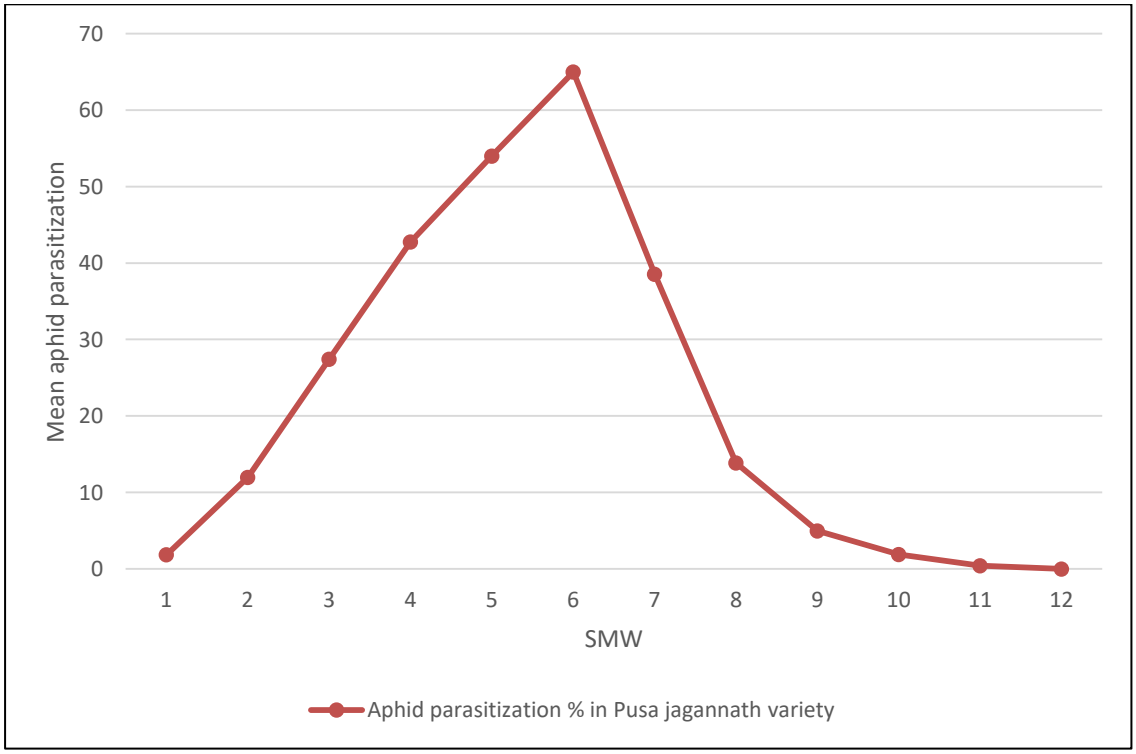



**Figure 4.2 Seasonal activity of *D. rapae* on Pusa Jagannath variety**

**Table – 4.2 Influence of abiotic factors of the environment on mustard aphid parasitization.**

| SMW | Aphid parasitization % | Temperature$^0$ C | | Relative humidity% | |
|---|---|---|---|---|---|
| | Pusa Jagannath | Maximum | Minimum | Morning | Evening |
| 49 | - | 29.4 | 9.7 | 94.3 | 43.1 |
| 50 | - | 25.3 | 11.7 | 92.7 | 63.4 |
| 51 | - | 22.5 | 5.1 | 90.7 | 58.9 |
| 52 | - | 22.7 | 5.2 | 93.9 | 73.1 |
| 1 | - | 22.5 | 10.1 | 93.1 | 75.7 |
| 2 | 1.87 | 20.8 | 8.2 | 90.3 | 78.4 |
| 3 | 11.98 | 22.9 | 5.9 | 94.1 | 78.7 |
| 4 | 27.43 | 21.3 | 5.5 | 96.1 | 75 |
| 5 | 42.76 | 25.3 | 5 | 89.6 | 63.8 |
| 6 | 53.98 | 25.5 | 8.3 | 89.4 | 64.5 |
| 7 | 64.98 | 28.6 | 9.2 | 93.2 | 55.5 |
| 8 | 38.54 | 30.2 | 9.9 | 89.1 | 42 |
| 9 | 13.87 | 32.6 | 12.8 | 75.7 | 38.7 |
| 10 | 4.98 | 34.5 | 14.6 | 75.8 | 36 |
| 11 | 1.9 | 32.8 | 15.4 | 79 | 47 |
| 12 | 0.43 | 36.3 | 17.1 | 72.2 | 47.7 |
| 13 | - | 37.7 | 18.2 | 72.7 | 41.1 |

(A)

(B)

Plate II - Parasitization of aphid by *Diaeretiella rapae* (M'Intosh)

**Table- 4.3 Correlation coefficient (r) and regression coefficient (byx) with abiotic factor**

| S. NO. | Pusa Jagannath Variety | | Metereological parameter | | | | |
|---|---|---|---|---|---|---|---|
| | | | Rainfall (mm) | Temperature ($^{o}$C) | | Relative humidity (%) | |
| | | | | Max | Min | Morning | Evening |
| 1. | Aphid parasitization by *D.rapae*. | R | NS | -0.371 | -0.583 | 0.627 | 0.193 |
| | | Byx | - | NS | -2.89* | 1.6* | NS |

****significant at 5% level, NS = Non-Significant**

## 4.2 Correlation effects of *D. rapae* on Brassica spp. variety Pusa Jagannath

Data depicted in table 4.2 indicate that the activity of *D. rapae* in terms of aphid parasitization commenced during the 2$^{nd}$ standard meteorological week (8 -14 Jan, 2021).

From the figure 4.2 it is seen that the aphid parasitization started increasing gradually from 2$^{nd}$ SMW (i.e., 8 – 14 Jan) During this period maximum and minimum temperature were 20.8°C and 8.2°C whereas, morning and evening relative humidity were 90.3 and 78.4 per cent respectively. At peak (64.98%) activity of *D. rapae* recorded at 7$^{th}$ SMW (i.e., 12 – 18 Feb, 2021) at that time maximum and minimum temperature were 28.6°C and 9.2°C whereas, morning and evening relative humidity were 93.2 and 55.5 percent respectively. Further, rainfall 0 mm during this period. After 7$^{th}$ SMW there was a sharp decline in the aphid parasitization per cent and it was available 0.43 % up to 12$^{th}$ SMW (19-25 March).

### 4.2.1 Correlation of *D. rapae* with minimum temperature

Correlation studies with minimum temperature showed a significant negative correlation (r = -0.58) with aphid parasitization percent (Table 4.3).

The regression equations being:

In case of minimum temperature: $\hat{Y} = -2.894x + 53.268$ ($R^2 = 0.340$)

From the above equation it may be expressed that with every unit increase in minimum temperature there was decrease of 2.89 aphid parasitization percent (Fig-4.3).

### 4.2.2 Correlation of *D. rapae* with morning relative humidity

Correlation studies morning relative humidity showed a significant positive correlation (r= 0.627) with aphid parasitization percent (Table 4.3)

The regression equations being:

In case of morning evening relative: $\hat{Y} = 1.611 \times -114.657$ ($R^2 = 0.393$)

From the above equation it may be expressed that with every unit increase in morning relative humidity there was an increase of 1.6 aphid parasitization per cent. Rainfall was nil (Fig 4.4). While maximum temperature shows negative and evening relative humidity show positive non-significant relation and rainfall show no correlation with aphid parasitization percent.

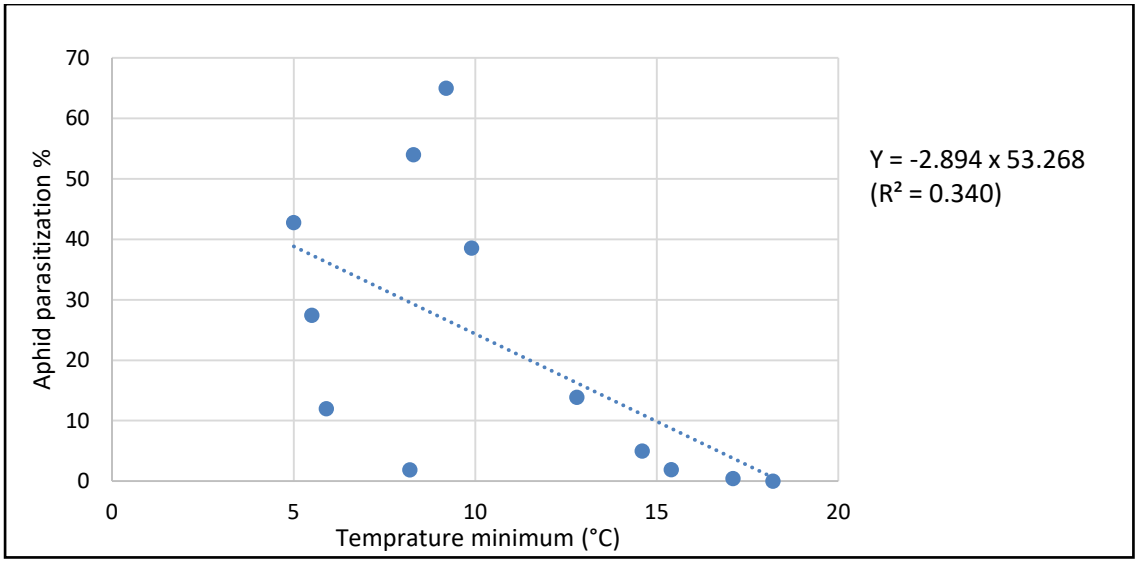



**Figure 4.3 Regression of Temperature minimum (°C) with aphid parasitization per cent**

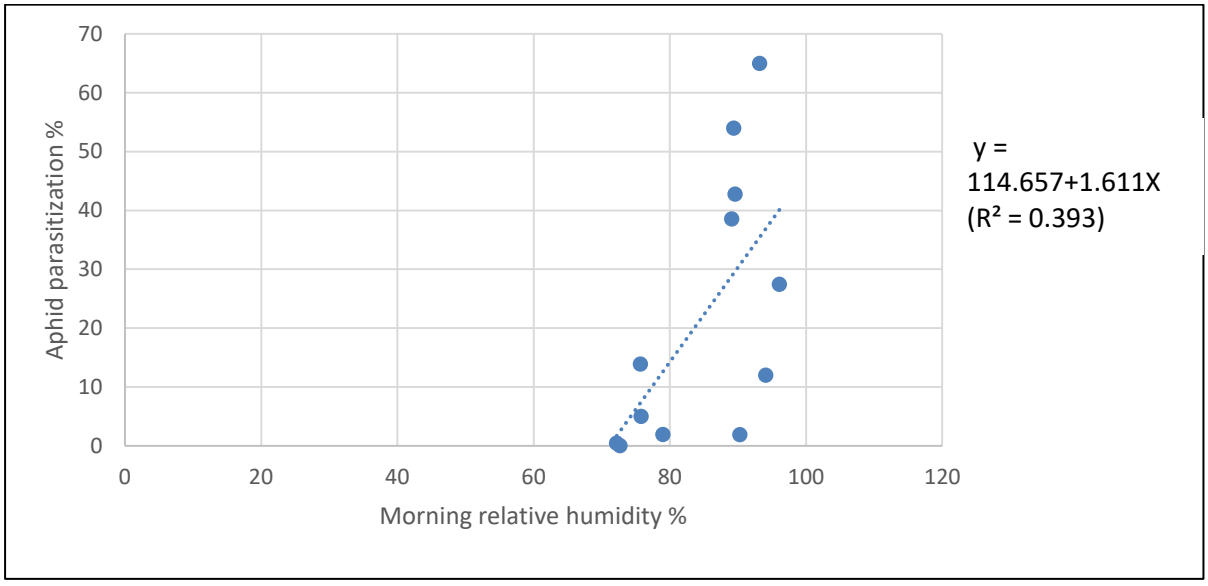



**Figure 4.4 Regression of morning relative humidity (%) with aphid parasitization per cent**

### 4.3 Effect of different biopesticides on parasitization of *D. rapae*.

#### 4.3.1 Pre- treatment observation

Pre-treatment observations were recorded at 24 hours before spray on 10 cm top twig of the 05 plants selected randomly from each plot and was converted to the percentage of aphid parasitization which ranged between 65.26 to 68.20. Aphid parasitization per cent in various treatment plots did not differ significantly (table 4.4)

#### 4.3.2 Post treatment observations

#### 4.3.2.1 Third days after first spray

Data presented in the table 4.4 and fig 4.5 showed that at 3rd day after first spray all the biopesticide treatments significantly reduced the aphid parasitization percent as compared to control (63.74%). Minimum parasitization (28.02 %) was recorded in plots treated with dimethoate 30EC which was significantly less than all other treatments. Among the treated plots, maximum parasitization (49.84%) was recorded in plots treated with NSKE 5% which was at par with parthenium leaf extract 5% (47.72%). The next effective treatments were neem leaf extract 5% (45.98%) and *Beauveria bassiana* (42.84%) which were at par with each other followed by *Verticillium lecanii* (39.42%) and neem oil 2% (33.20%).

#### 4.3.2.1 Seven days after first spray

Significant differences were observed (Table 4.4, Fig 4.5) in different treatments with regard to aphid parasitization by *D. rapae* recorded at seven days after first spray. Parasitization Percent of aphid in all the treated plots was significantly less then untreated plots (65.68%). Among the treated plots, maximum parasitization (55.69%) was recorded in plots treated with parthenium leaf extract 5% followed by NSKE 5% (53.05%) which was at par with neem leaf extract 5% (48.53%). The next best treatment was *Beauveria bassiana* (44.53%) *and Verticillium lecanii* (41.24%). Minimum parasitization (23.91 %) was recorded in plots treated with dimethoate 30EC which was significantly less than all other treatments followed by neem oil 2% (27.98%).

#### 4.3.2.3 At 15 days after first spray

Aphid parasitization Percent by *Diaeretiella rapae* in (Table 4.4, Fig 4.5) all the treated plots was significantly less then untreated plots (68.19%) but at par with *Beauveria bassiana* (65.40%). The next best treatment was NSKE 5% (63.71%), by *Verticillium lecanii* (62.03%) and parthenium leaf extract 5% (60.08%) which were at par with each other. Minimum parasitization (40.72%) was recorded in plots treated with dimethoate 30EC followed by neem oil 2% (46.02%) and neem leaf extract 5% (58.51%).

#### 4.3.2.4 Overall mean of first spray

On the basis of overall mean(Table 4.4, Fig 4.5) of first spray all the bio-pesticide treatments significantly reduced the aphid parasitization percent as compared to control (65.60 %). Among the treatments, NSKE 5% was found to be small toxicity effect as it recorded maximum parasitization (55.53 %) but at par with parthenium leaf extract 5% (54.49 %). Moderate toxic treatments were neem leaf extract 5% (51.01 %) which was at par with *Beauveria bassiana* (50.92 %) followed by *Verticillium lecanii* (47.57 %) and neem oil 2% (35.73%). Whereas dimethoate 30EC (30.88) was showed highest toxicity towards *D. rapae* and recorded minimum parasitization (30.88 %).

### 4.3.3 After second spray:

#### 4.3.3.1 Third days after second spray

Data presented in the table 4.5 showed that at 3rd day after second spray all the biopesticide treatments significantly reduced the aphid parasitization percent as compared to control (65.93%). Minimum parasitization (26.61 %) was recorded in plots treated with dimethoate 30EC which was significantly less than all other followed by neem oil 2% (34.21%). Among the treated plots, maximum parasitization (51.51%) was recorded in plots treated with NSKE 5% which was at par with parthenium leaf extract 5% (49.99%). Treatment with neem leaf extract 5% (45.60%), *Beauveria bassiana* (48.79%) and *Verticillium lecanii* (43.98%) were found at par with each other.

**Table – 4.4 Effect of first spray of biopesticides on *D. rapae*.**

| S. No. | Treatments | Dose/ ha | Pre-treatment | Percent Parasitization | | | MEAN |
|---|---|---|---|---|---|---|---|
| | | | | Day after spray | | | |
| | | | | 3 | 7 | 15 | |
| **1.** | *Beauveria bassiana* | 2.5 kg/ha. | 68.20 (55.68) | 42.84 (38.8) | 44.53 (41.86) | 65.40 (53.97) | 50.92 (45.53) |
| **2.** | *Verticillium lecanii* | 2.5kg/ ha. | 65.84 (54.24) | 39.42 (40.89) | 41.24 (39.95) | 62.03 (51.96) | 47.57 (43.61) |
| **3.** | Neem oil 2% | 10 lit/ha. | 65.26 (53.89) | 33.20 (35.18) | 27.98 (31.93) | 46.02 (42.71) | 35.73 (36.71) |
| **4.** | Neem leaf extract 5% | 25kg/ ha. | 67.16 (55.04) | 45.98 (42.69) | 48.53 (44.16) | 58.51 (49.91) | 51.01 (45.58) |
| **5.** | NSKE 5% | 25kg/ ha. | 67.67 (55.36) | 49.84 (44.91) | 53.05 (46.75) | 63.71 (52.97) | 55.53 (48.18) |
| **6.** | Parthenium leaf extract 5% | 25kg/ ha. | 65.43 (53.99) | 47.72 (43.69) | 55.69 (48.27) | 60.08 (50.82) | 54.49 (47.58) |
| **7.** | Dimethoate 30EC | 0.5lit/ ha. | 66.07 (54.38) | 28.02 (31.96) | 23.91 (29.26) | 40.72 (39.65) | 30.88 (33.76) |
| **8.** | Control | Water spray | 66.36 (54.56) | 63.74 (52.98) | 65.68 (54.14) | 68.19 (55.66) | 65.60 (54.09) |
| **SEm±** | | | **0.69** | **0.25** | **0.62** | **0.89** | **0.56** |
| **CD at 5%** | | | **NS** | **0.76** | **1.87** | **2.70** | **1.71** |
| **CV** | | | **2.19** | **1.05** | **2.55** | **3.10** | **2.11** |

**Value () in parenthesis are corresponding arc sine transformed**

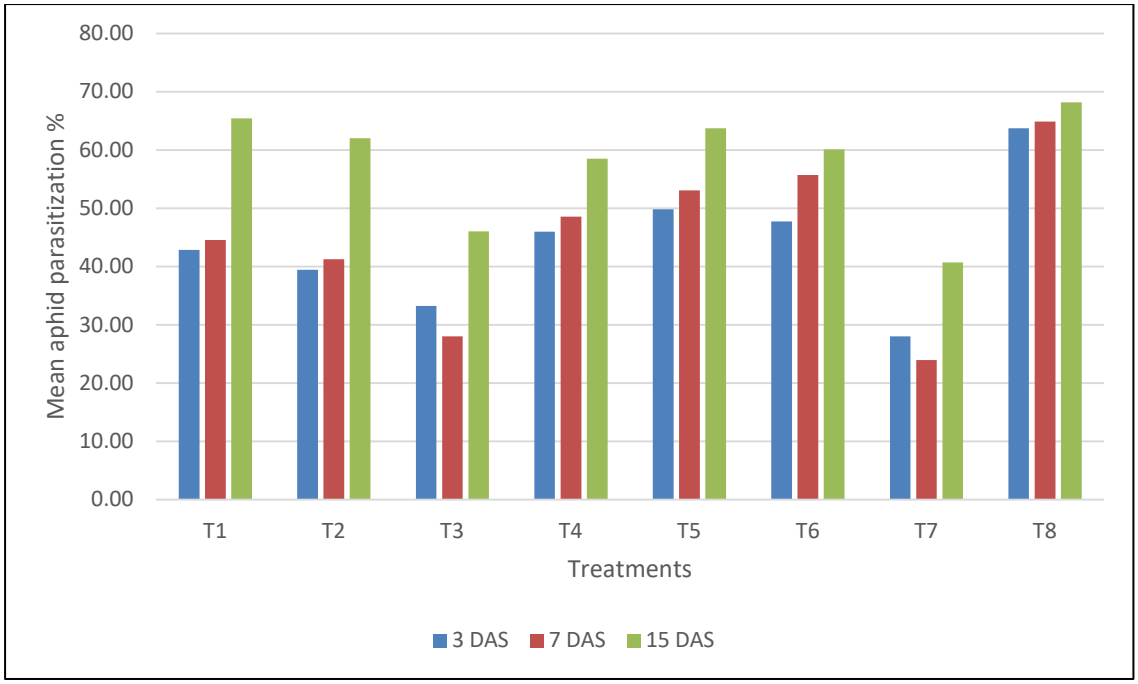



**Figure 4.5 Effect of first spray of biopesticides on *D. rapae*.**

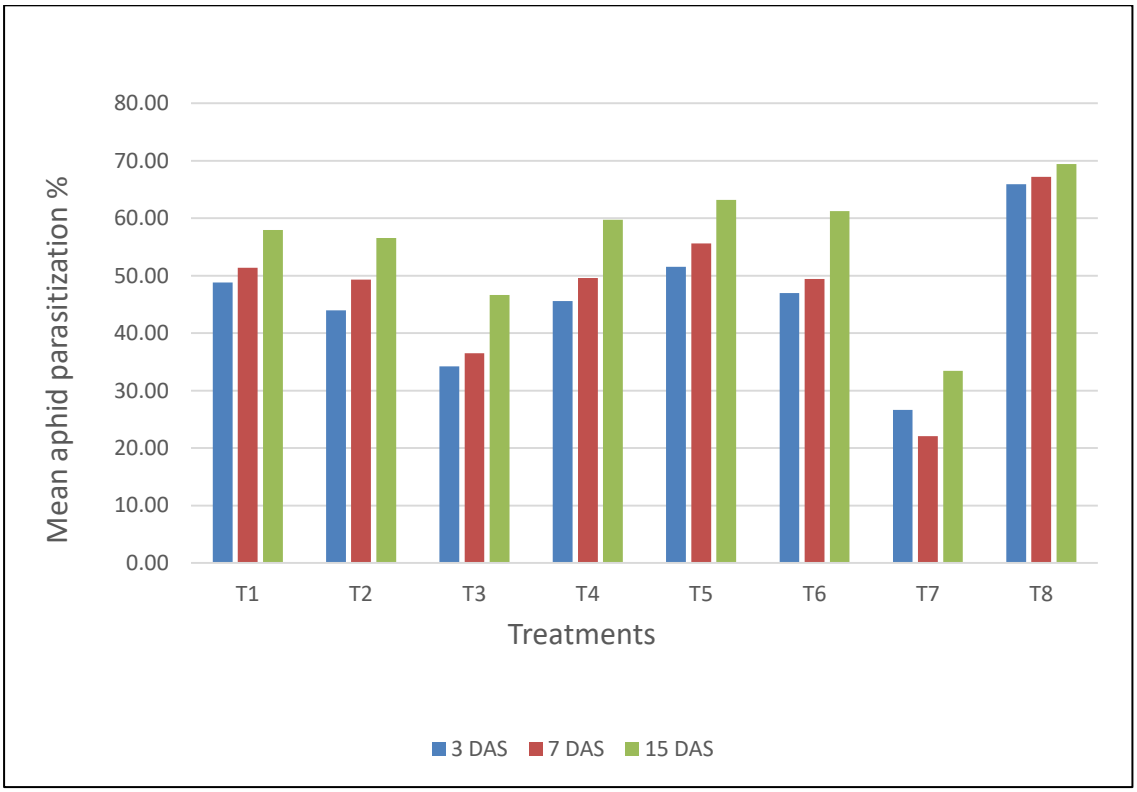



**Figure-4.6 Effect of second spray of biopesticides on *D. rapae*.**

#### 4.3.3.2 Seven days after second spray

Significant differences were observed in different treatments (Table 4.5, Fig 4.6) with regard to aphid parasitization by *Diaeretiella rapae* recorded at seven days after second spray. Parasitization percent of aphid in all the treated plots was significantly less then untreated plots (67.22%). Among the treated plots, maximum parasitization (55.61%) was recorded in plots treated with NSKE 5%. Plot treated with *Beauveria bassiana* (51.37%), neem leaf extract 5% (49.61%), parthenium leaf extract 5% (49.40 %) and *Verticillium lecanii* (49.33%) were found to be at par with each other. Minimum parasitization (22.04 %) was recorded in plots treated with dimethoate 30EC which was significantly less than all other treatments followed by neem oil 2% (36.48%).

#### 4.3.3.3 At 15 days after second spray

Data presented in the table 4.5, fig 4.6 showed that at 15$^{th}$ day after second spray all the biopesticide treatments significantly reduced the aphid parasitization percent as compared to control (69.41%). Minimum parasitization (33.43 %) was recorded in plots treated with dimethoate 30EC which was significantly less than all other treatments. Among the treated plots, maximum parasitization (63.20 %) was recorded in plots treated with NSKE 5% followed by parthenium leaf extract 5% (61.21 %) which was at par with neem leaf extract 5% (59.71 %). *Beauveria bassiana* (57.92 %) and *Verticillium lecanii* (56.53%) found to be at par with each other followed by neem oil 2% (46.66 %) treatment.

#### 4.3.3.4 Overall mean of second spray

On the basis of overall mean (Table 4.5) of second spray of seven biopesticide treatments showed significantly toxic to the aphid parasitization percent as compared to control (67.52 %). Among the treatments, NSKE 5% was found to be less toxic to aphid parasitization as it recorded maximum parasitization (56.77 %). The moderate toxic treatments were parthenium leaf extract 5% (52.54 %), neem leaf extract 5% (51.64 %) *Beauveria bassiana* (52.69 %) and *Verticillium lecanii* (49.95 %) found to be at par with each other.

Treatment with dimethoate 30EC was found to be highly toxic to the *D. rapae* to reduce the aphid parasitization by 27.36% followed by neem oil 2% (39.12 %).

**Table – 4.5 Effect of second spray of biopesticides on *D. rapae*.**

| S. No. | Treatements | Dose/ha | Percent parasitization Day after spray | | | MEAN |
|---|---|---|---|---|---|---|
| | | | 3 | 7 | 15 | |
| **1.** | *Beauveria bassiana* | 2.5 kg/ha. | 48.79 (44.31) | 51.37 (45.78) | 57.92 (49.56) | 52.69 (46.54) |
| **2.** | *Verticillium lecanii* | 2.5kg/ha. | 43.98 (41.54) | 49.33 (44.61) | 56.53 (48.76) | 49.95 (44.97) |
| **3.** | Neem oil 2% | 10 lit/ha. | 34.21 (35.79) | 36.48 (37.14) | 46.66 (43.08) | 39.12 (38.71) |
| **4.** | Neem leaf extract 5% | 25kg/ha. | 45.60 (42.48) | 49.61 (43.78) | 59.71 (50.60) | 51.64 (45.94) |
| **5.** | NSKE 5% | 25kg/ha. | 51.51 (45.87) | 55.61 (48.22) | 63.20 (52.65) | 56.77 (48.89) |
| **6.** | Parthenium leaf extract 5% | 25kg/ha. | 49.99 (43.27) | 49.40 (46.66) | 61.21 (51.48) | 52.54 (46.45) |
| **7.** | Dimethoate 30EC | 0.5lit/ha. | 26.61 (31.05) | 22.04 (29.10) | 33.43 (35.32) | 27.36 (31.54) |
| **8.** | Control | Water spray | 65.93 (54.30) | 67.22 (55.07) | 69.41 (56.42) | 67.52 (55.26) |
| SEm± | | | **0.72** | **1.51** | **0.43** | **0.54** |
| CD at 5% | | | **2.19** | **4.57** | **1.29** | **1.63** |
| CV | | | **2.95** | **5.99** | **1.52** | **2.08** |

**Value () in parenthesis are corresponding arc sine transformed**

**4.3.4 After Third spray:** Data presented in Table 4.6, Fig 4.7

**4.3.4.1 Third day after third spray**

Data presented in the table 4.6 showed that at 3rd day after third spray all the biopesticide treatments significantly reduced the aphid parasitization percent as compared to control (61.54 %). Minimum parasitization (19.44 %) was recorded in plots treated with dimethoate 30EC which was significantly less than all other treatments followed by neem oil 2% (34.21%). Among the treated plots, maximum parasitization (43.62 %) was recorded in plots treated with NSKE 5% which was at par with parthenium leaf extract 5% (39.91 %), neem leaf extract 5% (39.50%), *Beauveria bassiana* (42.88 %) and *Verticillium lecanii* (40.05 %),

**4.3.4.2 Seven day after third spray**

Significant differences were observed in different treatments (Table 4.6, Fig 4.7) with regard to aphid parasitization by *Diaeretiella rapae* recorded at seven days after third spray parasitization percent of aphid in all the treated plots was significantly less then untreated plots (45.23 %). Among the treated plots, maximum parasitization (34.21 %) was recorded in plots treated with parthenium leaf extract 5% followed by NSKE 5% (36.70 %), neem leaf extract 5% (32.01 %), *Beauveria bassiana* (32.83 %) *Verticillium lecanii* (31.23 %) and all the treatment found to be at par with each other. Minimum parasitization (16.99 %) was recorded in plots treated with dimethoate 30EC which was significantly less than all other treatments followed by neem oil 2% (23.65 %).

**4.3.4.3 At 15 days after third spray**

Data presented in the table 4.6, fig 4.7 showed that at 15$^{th}$ day after third spray all the biopesticide treatments significantly reduced the aphid parasitization percent as compared to control (31.06 %). Among the treated plots minimum parasitization (7.60 %) was recorded in plots treated with dimethoate 30 EC which was significantly less than all other treatments followed by Neem oil 2% (12.97%). Maximum parasitization (24.99 %) was recorded in plots treated with NSKE 5% followed by parthenium leaf extract 5% (22.03 %) which was at par with neem leaf extract 5% (20.18 %) and *Beauveria*

*bassiana* (21.19 %) and the next best treatment in the series *Verticillium lecanii* which was recorded (18.01 %) aphid parasitization.

#### 4.3.4.4 Overall mean of third spray

On the basis of overall mean (Table 4.6) of third spray all the biopesticide treatments significantly reduced the aphid parasitization percent as compared to control (45.94 %). Among the treatments, NSKE 5% was show lowest toxicity as it recorded maximum parasitization (35.10). The next best treatments were parthenium leaf extract 5% (32.05 %), neem leaf extract 5% (30.56 %), *Beauveria bassiana* (32.30 %) and *Verticillium lecanii* (26.76 %) which was at par with each other. Treatment with dimethoate 30EC (14.68 %) was found to be highly toxic for aphid parasitization followed by neem oil 2% (23.95%). All the insecticidal treatment differs significant.

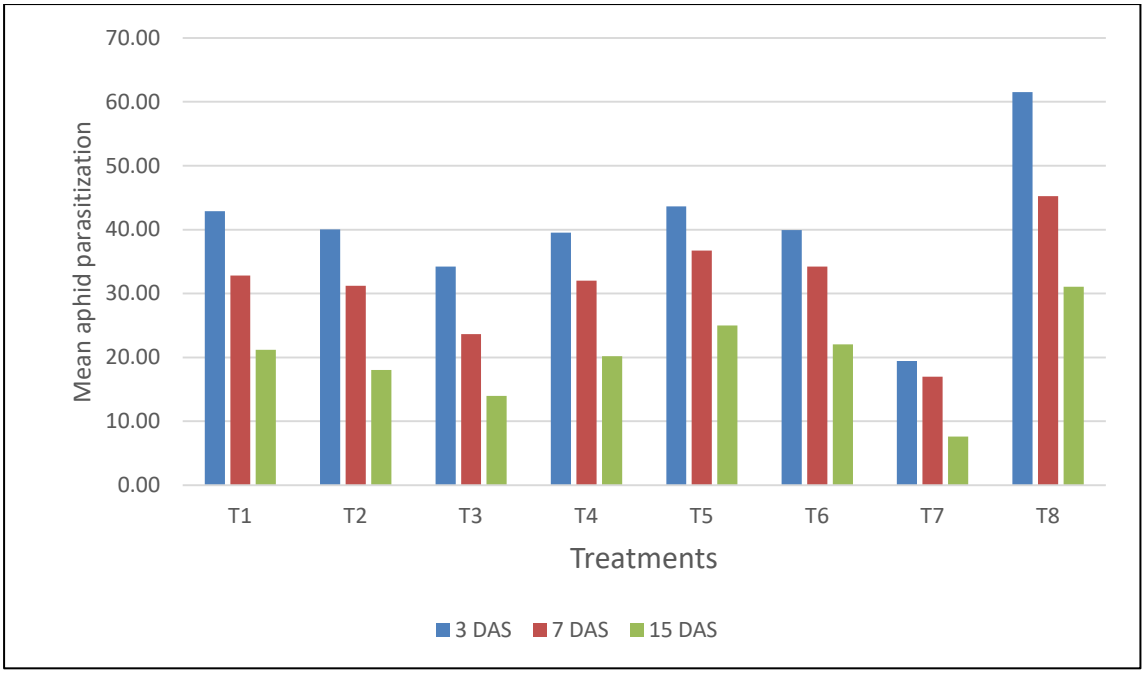



**Figure- 4.7 Effect of third spray of biopesticides on *D. rapae*.**

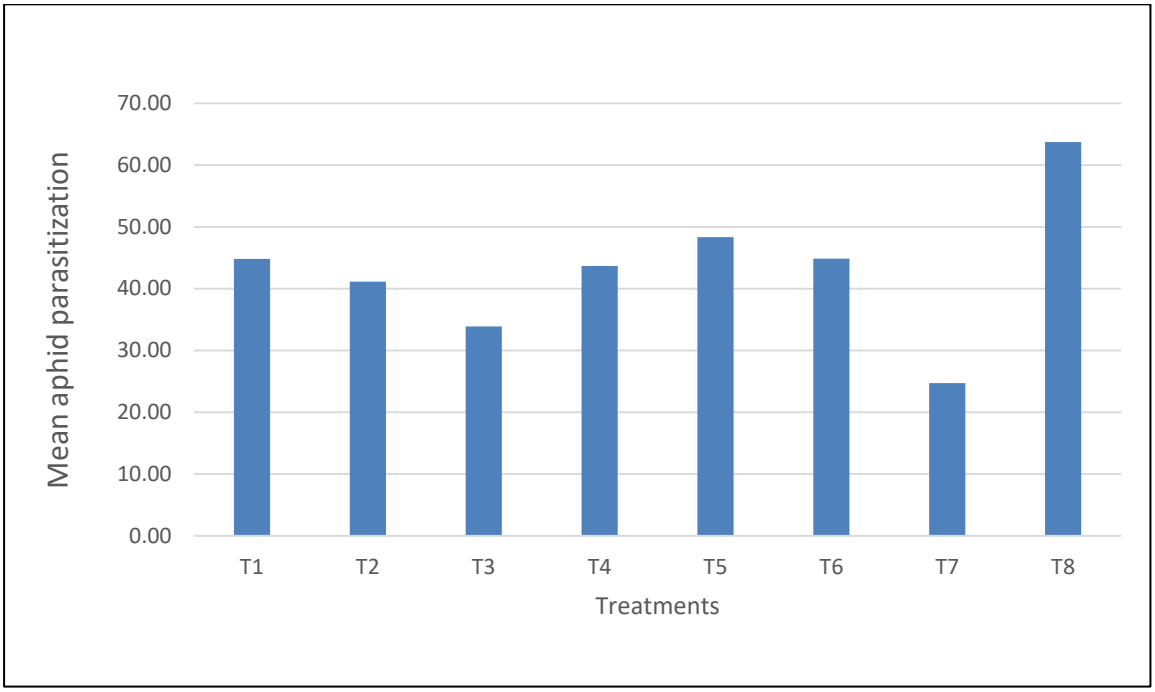



**Figure-4.8 Effect of Mean of all three sprays of biopesticides on *D. rapae***

**Table – 4.6 Effect of third spray of biopesticides on *D. rapae*.**

| S. No. | Treatments | Dose/ha. | Percent Parasitization | | | MEAN |
|---|---|---|---|---|---|---|
| | | | Day after spray | | | |
| | | | 3 | 7 | 15 | |
| **1.** | *Beauveria bassiana* | 2.5 kg/ha. | 42.88 (40.90) | 32.83 (34.92) | 21.19 (27.40) | 32.30 (34.63) |
| **2.** | *Verticillium lecanii* | 2.5kg/ha. | 40.05 (39.25) | 31.23 (33.94) | 18.01 (25.11) | 26.76 (33.06) |
| **3.** | Neem oil 2% | 10 lit/ha. | 34.21 (35.79) | 23.65 (29.10) | 13.97 (21.95) | 23.95 (29.30) |
| **4.** | Neem leaf extract 5% | 25kg/ha. | 39.50 (38.94) | 32.01 (34.31) | 20.18 (26.70) | 30.56 (33.56) |
| **5.** | NSKE 5% | 25kg/ha. | 43.62 (41.32) | 36.70 (37.28) | 24.99 (29.99) | 35.10 (36.33) |
| **6.** | Parthenium leaf extract 5% | 25kg/ha. | 39.91 (39.18) | 34.21 (35.79) | 22.03 (27.99) | 32.05 (34.48) |
| **7.** | Dimethoate 30EC | 0.5lit/ha. | 19.44 (26.15) | 16.99 (24.33) | 7.60 (15.96) | 14.68 (22.53) |
| **8.** | Control | Water spray | 61.54 (51.67) | 45.23 (42.26) | 31.06 (33.87) | 45.94 (42.67) |
| **SEm±** | | | **0.90** | **1.43** | **0.48** | **0.59** |
| **CD at 5%** | | | **2.74** | **4.34** | **1.45** | **1.80** |
| **CV** | | | **3.99** | **7.28** | **3.18** | **3.08** |

**Value () in parenthesis are corresponding arc sine transformed**

**4.4 Mean of three sprays:** Data depicted in Table 4.7

### 4.4.1 Overall mean of three sprays

Conclusion on the basis of overall mean of all three spray of biopesticide were recorded significantly toxic as compared to control (59.69 %). Among the treatments, NSKE 5% was found to be safer as it recorded maximum parasitization (49.14 %) followed by parthenium leaf extract 5% (46.36 %) and *Beauveria bassiana* (45.31 %) which were found to be at par with each other. The next safer treatments were neem leaf extract @ 5% (44.40 %) which was at par with *Verticillium lecanii* (42.43 %) and neem oil @ 2% (32.93%). Standard check Dimethoate 30EC was found highly toxic to *D. rapae* with minimum 24.31% aphid parasitization.

(A)

(The Different biopesticide used)

(B)

Plate 3 - Bio – pesticide spray on mustard at the experimental field

**Table – 4.7 Effect of spray of biopesticides on *D. rapae*. (Mean of all three spray)**

| S. No. | Treatments | Dose/ ha | Pre-treatment | Percent Parasitization | | | MEAN |
|---|---|---|---|---|---|---|---|
| | | | | Day after Spray | | | |
| | | | | 3 | 7 | 15 | |
| **1.** | *Beauveria bassiana* | 2.5 kg/ha. | 68.20 (55.68) | 44.84 (42.04) | 42.91 (40.91) | 48.17 (43.91) | 45.31 (42.31) |
| **2.** | *Verticillium lecanii* | 2.5kg/ha. | 65.84 (54.24) | 41.15 (39.90) | 40.60 (39.58) | 43.53 (42.43) | 42.43 (40.64) |
| **3.** | Neem oil 2% | 10 lit/ha. | 65.26 (53.89) | 33.83 (35.59) | 29.37 (32.81) | 35.55 (36.60) | 32.93 (35.02) |
| **4.** | Neem leaf extract 5% | 25kg/ha. | 67.16 (55.04) | 43.69 (41.38) | 43.38 (41.19) | 46.13 (42.78) | 44.40 (41.79) |
| **5.** | NSKE 5% | 25kg/ha. | 67.67 (55.36) | 48.33 (44.04) | 48.45 (44.11) | 50.63 (45.36) | 49.14 (44.51) |
| **6.** | Parthenium leaf extract 5% | 25kg/ha. | 65.43 (53.99) | 44.87 (42.06) | 46.43 (42.95) | 47.77 (43.72) | 46.36 (42.91) |
| **7.** | Dimethoate 30EC | 0.5lit/ha. | 66.07 (54.38) | 24.69 (29.79) | 20.98 (27.26) | 27.25 (31.47) | 24.31 (29.54) |
| **8.** | Control | Water spray | 66.36 (54.56) | 63.74 (52.97) | 59.11 (50.25) | 56.22 (48.57) | 59.69 (50.59) |
| **SEm±** | | | **0.69** | **0.41** | **0.88** | **0.33** | **0.41** |
| **CD at 5%** | | | **NS** | **1.24** | **2.66** | **1.01** | **1.24** |
| **CV** | | | **2.19** | **1.73** | **3.80** | **1.38** | **1.73** |

**Value () in parenthesis are corresponding arc sine transformed**

# Chapter- V
# DISCUSSION

The result of present investigations on **"Studies on the aphid parasitoid (*Diaeretiella rapae*) with special reference to toxic effect of biopesticide against parasitoid on Brassica species"** are presented in preceding chapter and discussed here with appropriate headings *viz*, Seasonal activity of *D. rapae* on different brassica crops, correlation effects on *D. rapae* with abiotic factors and effect of spray of biopesticides on *D. rapae*

## 5.1 Seasonal activity of *D. rapae* on different Brassica species

The first appearance of the aphid parasitization by *D. rapae* on *Brassica compestris* var. BSH-1 (1.75%) was recorded on 8 January 2021 during the 2$^{nd}$ SMW (i.e. 8 – 14 Jan, 2021) it started increasing gradually from 2$^{nd}$ SMW with higher peak, (72.13%) during 7$^{th}$ SMW (i.e. 12 – 18 Feb, 2021). The results of the present studies are in close agreement with the findings of Dhiman (2007).

While, first appearance of the aphid parasitization by *D. rapae* on *Brassica juncea* var. Pusa Bold (0.32 %) was recorded during the 3$^{rd}$ SMW (15 – 21 Jan, 2021) and It was increasing gradually with peak, (68.43%) during 8$^{th}$ SMW (19 - 25 Feb, 2021). The results of the present studies are in close agreement with the findings of Dhiman (2006).

Major activity period was 1st week of January to last week of February after that there was a sharp decline in the aphid parasitization per cent and it was available up to 13$^{th}$ SMW (26 March – 01 April, 2021) on different Brassica crop. The results of the present studies are in close agreement with the findings of Singh and Rawat (1981), reported *D. rapae* parasitizing mustard aphid from second or third week of January about a fortnight after the commencement of the mustard aphid infestation. Parasitization increased from the second week of February and reached to its peak in the fourth week of February; thereafter both the aphid and parasitoid population decreased gradually and disappeared by the second week of March. February and peaked in the fourth week. Following that, both the aphid and parasite populations declined steadily and vanished by the second week of March.

These findings are in partial agreement with the study by Khedkar (2011), who observed that the parasitization due to *D. rapae* on *L. erysimi* in mustard crop initiated from eighth week after sowing (2.73% parasitism) i.e. third week of January and reached to its peak (88.33%) in the 12$^{th}$ week after sowing (third week of February) and then declined. Though the population of aphids declined, the activity of *D. rapae* continued in the field up to fifteenth week after sowing.

**5.2. Seasonal activity of *D. rapae* on Brassica spp. variety Pusa Jagannath and its correlation with abiotic factors**

The activity of *D. rapae* on in terms of aphid parasitization started increasing gradually from 2$^{nd}$ SMW (i.e. 8 – 14 Jan, 2021) with higher peak, (64.98%) during 7$^{th}$ SMW (i.e. 12 – 18 Feb, 2021). During this period maximum and minimum temperature were 28.6°C and 9.2°C respectively, whereas, morning and evening relative humidity were 93.2 and 55.5 percent respectively. After 7$^{th}$ SMW there was a sharp decline in the aphid parasitization per cent and it was available 0.43 % up to 12$^{th}$ SMW (19 - 25 March, 2021). Correlation studies with minimum temperature showed a significant negative correlation (r = -0.58) and morning relative humidity showed a significant positive correlation (r= 0.627) with aphid parasitization percent. While the maximum temperature shows negative evening relative humidity, showed positive non- significant correlation and rainfall shows no relation with whether parameter.

The results of the present studies are in close agreement with the findings of Dhiman and Kumar (1991), investigated the effects of temperature and relative humidity on development of *D. rapae* parasitizing *L. erysimi* (kalt) and revealed that the optimum temperature for rapid multiplication of the parasitoid was 24 to 28$^{0}$C. Relative humidity of 50 to 70 per cent was suitable for fastest development. Patel (1998) reported that the parasitoid *D. rapae* was found on late sown mustard and its activity positively correlated with minimum temperature. The emergence of the parasitoid was greater at higher (25 + 1 and 30 + 1 $^{o}$C).

In the line of Vekaria and Patel (1999) reported that the *D. rapae* appeared in mustard crop on eleventh week after sowing and remained active till harvest of the crop. Highest (66.47% parasitism) population of *D. rapae* was reported during fifteenth week after sowing. The population of the cauliflower aphid, B. brassicae, varied from the 51st to the 4th meteorological week, according to the research of Malik et al (2000). The relationship between aphid population and maximum-minimum temperatures was inverse, while the relationship with morning relative humidity was positive. Dogra et al., (2003) examined the parasitization of L. erysimi by D. rapae in Palampur and found that the mean maximum, minimum temperature, and relative humidity were 22.50 C, 10.30 C, and 36%, respectively.

**5.3 Effect of different biopesticides on *D. rapae***

The effect of seven biopesticide treatments namely NSKE 5% 25kg/ha, parthenium leaf extract 5% 25kg/ha, neem leaf extract 5% 25kg/ha, *Beauveria bassiana* 2.5 kg/ha, *Verticillium lecanii* 2.5 kg/ha, neem oil 2% 10 lit/ha, dimethoate 30EC 0.5lit/ha were tested toxicity toward parasitoid *D. rapae* parasitization on mustard crop.

On the basis of overall mean of all three spray the biopesticide treatments significantly reduced the aphid parasitization percent as compared to control (59.69 %). Among the treatments, NSKE 5% was found to be least toxic for *D. rapae* as it recorded maximum parasitization (49.14%). The next effective treatments were Parthenium leaf extract 5% (46.36 %) and *Beauveria bassiana* (45.31 %) which were found to be at par with each other. Neem leaf extract 5% (44.40 %) *Verticillium lecanii* (42.43 %) and neem oil 2% (32.93 %) was also a least toxic. Treatment with dimethoate 30EC recorded minimum parasitization (24.31 %) was found to be highly toxic against *D. rapae* parasitization.

The effect of seven bio-pesticide treatments namely NSKE 5% 25kg/ha, parthenium leaf extract 5% 25kg/ha, neem leaf extract 5% 25kg/ha, *Beauveria bassiana* 2.5 kg/ha, *Verticillium lecanii* 2.5 kg/ha, neem oil 2% 10 lit/ha, dimethoate 30EC 0.5lit/ha were tested toxicity toward parasitoid *D. rapae* parasitization on mustard crop.

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These findings are in partial agreement with the present study in the line of Jadon (2008), who found neem seed kernel extract to be most effective in reducing aphid population. All the other tested plant extracts were found safer to natural enemies *D. rapae* in comparison to insecticides.

# CHAPTER - VI
# SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

The mustard aphid was the most common aphid species, especially in crucifer crops. Aphid numbers in all fields remained relatively low throughout the early phases of crop development and grew as the season proceeded. Seasonal trends were similar across locations due to climate, crop growth stage, and interactions between these elements. This is most likely due to the availability of comparable host plants along field boundaries and in neighbouring crops, allowing the same aphid species to persist in both regions. *Diaeretiella rapae* (McIntosh) was the most frequent parasitoid in our research, especially in crucifers, however it was only found in low numbers near field boundaries. The findings point to possible focus management locations and parasitoids that might aid in the control of aphid pests in mustard crops.

## 6.1 Summary

The results obtained during the course of investigation have been summarized below.

### 6.1.1 Studies the seasonal activity of *D. rapae* on different brassica species

First appearance of the aphid parasitization by *D. rapae* on *Brassica compestris* var. BSH-1 was recorded on 8 January 2021 during the 2$^{nd}$ standard meteorological week and thereafter observations were recorded regularly. It is seen that the aphid population started increasing gradually from 2$^{nd}$ SMW with higher peak, during 7$^{th}$ SMW. After that there was a sharp decline in the aphid parasitization per cent and it was available up to 13$^{th}$ SMW (26 March – 01 April, 2021).

Aphid parasitization by *D. rapae* on *Brassica juncea* var. Pusa Bold was recorded 1$^{st}$ time on 15 January 2021 during the 3$^{rd}$ standard meteorological week. It is seen that the aphid population started increasing gradually from 3$^{rd}$ SMW with higher peak, during 8$^{th}$. After 8$^{th}$ SMW there was

a sharp decline in the aphid parasitization per cent and it was available up to 13th SMW.

### 6.1.2 Seasonal activity of *D. rapae* on brassica spp. variety Pusa Jagannath

Activity of *D. rapae* on brassica spp. variety Pusa Jagannath in terms of aphid parasitization commenced during the 2nd standard meteorological week (8 -14 Jan, 2021). It is seen that the aphid population started increasing gradually from 2nd SMW with higher peak, (64.98%) during 7th SMW. After 7th SMW there was a sharp decline in the aphid parasitization per cent and it was available 0.43 % up to 12th SMW (19-25 March).

Correlation studies with minimum temperature showed a significant negative correlation (r = -0.58) and morning relative humidity showed a significant positive correlation (r = 0.627) with aphid parasitization percent. While the maximum temperature shows negative, evening relative humidity, showed positive non- significant correlation and rainfall shows no relation with whether parameter.

### 6.1.3 Effect of different biopesticides on *D. rapae*

All the biopesticide treatments significantly reduced the aphid parasitization percent as compared to control. Among the treatments, NSKE 5% was found significantly safer to *D. rapae* as it recorded maximum parasitization (49.14 %) followed by Parthenium leaf extract 5% and *Beauveria bassiana,* Neem leaf extract 5%, *Verticillium lecani* and Neem oil 2%. Treatment with dimethoate 30EC (24.31 %) was found to be toxic against *D. rapae* parasitization.

## 6.2 Conclusion

- Activity of *D. rapae* on brassica spp. variety Pusa Jagannath in terms of aphid parasitization commenced during the 2nd standard meteorological week and peak during 7th SMW.
- Aphid parasitization by *D. rapae* on *Brassica juncea* var. Pusa Bold was recorded on 15 January 2021. it is seen that the aphid population

started increasing gradually from 3rd SMW with higher peak, during 8th SMW.

- Activity of *D. rapae* on brassica spp. variety Pusa Jagannath in terms of aphid parasitization started during the 2nd SMW. And peak activity noted during 7th SMW.
- *D. rapae* on brassica spp. variety Pusa Jagannath Correlation with minimum temperature showed a significant negative correlation (r = -0.58) and morning relative humidity showed a significant positive correlation (r= 0.627) with aphid parasitization percent. While the other showed non- significant correlation.
- NSKE 5% was found to be highly safe botanical to *D. rapae* parasitization. Parthenium leaf extract 5%, *Beauveria bassiana,* neem leaf extract 5%, *Verticillium lecani* also found narrow range toxicity.
- dimethoate 30EC was found to be highly toxic against *D. rapae* parasitization.

**6.3 Suggestions for further work**

1. It is evident from the present study that plant product safer for natural enemies but it is necessary to find out most selective biopesticide for management of *D. rapae.*
2. Indiscriminative use of pesticide and their adverse effect on environment which create problem of resurgence so best approach to study on specific predator parasitoid for crop pest management.
3. Population dynamics of major natural enemies with their associated pest should be studied continuously for more than three years in order to establish natural enemies.
4. New botanicals pesticide combination should be used on field trial to studied the effect on natural enemies.
5. Neem kernel may be tested in different concentration to find safer dose for the natural enemies.
6. Critical study of weather factors correlated with doses be carried at more than one locality.

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# APPENDICES

| Appendix I : (24 hours before first spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S. | M.S.S. | F(CAL) | F(TAB) at 5% | |
| REPLICATION | 2.00 | 0.71 | 0.35 | **0.25** | **3.74** | |
| TREATMENT | 7.00 | 8.86 | 1.27 | **0.88** | **2.76** | |
| ERROR | 14.00 | 20.05 | 1.43 | | **S.Em±** | **0.69** |
| TOTAL | 23.00 | | | | **CD At 5%** | **2.10** |
| | | | | | | |

| Appendix II : (3rd day after first spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S | M.S.S. | F(CAL) | F(TAB) at 5% | |
| REPLICATION | 2.00 | 0.52 | 0.26 | **1.39** | **3.74** | |
| TREATMENT | 7.00 | 862.69 | 123.24 | **657.64** | **2.76** | |
| ERROR | 14.00 | 2.62 | 0.19 | | **S.Em±** | **0.25** |
| TOTAL | 23.00 | | | | **CD At 5%** | **0.76** |
| | | | | | | |

| Appendix III : (7th day after first spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S | M.S.S. | F(CAL) | F(TAB) at 5% | |
| REPLICATION | 2.00 | 4.87 | 2.43 | **2.13** | **3.74** | |
| TREATMENT | 7.00 | 1410.74 | 201.53 | **176.09** | **2.76** | |
| ERROR | 14.00 | 16.02 | 1.14 | | **S.Em±** | **0.62** |
| TOTAL | 23.00 | | | | **CD At 5%** | **1.87** |
| | | | | | | |

| Appendix IV : (15th day after first spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S | M.S.S. | F(CAL) | F(TAB) at 5% | |
| REPLICATION | 2.00 | 0.53 | 0.26 | **0.11** | **3.74** | |
| TREATMENT | 7.00 | 662.45 | 94.64 | **39.79** | **2.76** | |
| ERROR | 14.00 | 33.30 | 2.38 | | **S.Em±** | **0.89** |
| TOTAL | 23.00 | | | | **CD At 5%** | **2.70** |

| Appendix V : (Mean of first spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S | M.S.S. | F(CAL) | F(TAB) at 5% | |
| REPLICATION | 2.00 | 35.55 | 17.77 | **18.74** | **3.74** | |
| TREATMENT | 7.00 | 608.13 | 86.88 | **91.61** | **2.76** | |
| ERROR | 14.00 | 13.28 | 0.95 | | **S.Em±** | **0.56** |
| TOTAL | 23.00 | | | | **CD At 5%** | **1.71** |

| Appendix VI : (3rd day after second spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S | M.S.S. | F(CAL) | F(TAB) at 5% | |
| REPLICATION | 2.00 | 2.59 | 1.30 | **0.83** | **3.74** | |
| TREATMENT | 7.00 | 993.71 | 141.96 | **90.99** | **2.76** | |
| ERROR | 14.00 | 21.84 | 1.56 | | **S.Em±** | **0.72** |
| TOTAL | 23.00 | | | | **CD At 5%** | **2.19** |
| | | | | | | |

| Appendix VII : (7th day after second spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S | M.S.S. | F(CAL) | F(TAB) at 5% | F(TAB) at 1% |
| REPLICATION | 2.00 | 4.52 | 2.26 | **0.33** | **3.74** | 5.12 |
| TREATMENT | 7.00 | 1339.40 | 191.34 | **28.10** | **2.76** | 2.28 |
| ERROR | 14.00 | 95.34 | 6.81 | | **S.Em±** | **1.51** |
| TOTAL | 23.00 | | | | **CD At 5%** | **4.57** |
| | | | | | | |

| Appendix VIII : (15th day after second spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S | M.S.S. | F(CAL) | F(TAB) at 5% | F(TAB) at 1% |
| REPLICATION | 2.00 | 2.03 | 1.02 | **1.86** | **3.74** | 5.12 |
| TREATMENT | 7.00 | 892.41 | 127.49 | **233.73** | **2.76** | 2.28 |
| ERROR | 14.00 | 7.64 | 0.55 | | **S.Em±** | **0.43** |
| TOTAL | 23.00 | | | | **CD At 5%** | **1.29** |
| | | | | | | |

| Appendix IX : (Mean of second spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S | M.S.S. | F(CAL) | F(TAB) at 5% | |
| REPLICATION | 2.00 | 0.05 | 0.02 | **0.03** | **3.74** | |
| TREATMENT | 7.00 | 1038.54 | 148.36 | **171.07** | **2.76** | |
| ERROR | 14.00 | 12.14 | 0.87 | | **S.Em±** | **0.54** |
| TOTAL | 23.00 | | | | **CD At 5%** | **1.63** |

| Appendix X : (3rd day after third spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S | M.S.S. | F(CAL) | F(TAB) at 5% | |
| REPLICATION | 2.00 | 1.12 | 0.56 | **0.23** | **3.74** | |
| TREATMENT | 7.00 | 1034.49 | 147.78 | **60.46** | **2.76** | |
| ERROR | 14.00 | 34.22 | 2.44 | | **S.Em±** | **0.90** |
| TOTAL | 23.00 | | | | **CD At 5%** | **2.74** |
| | | | | | | |

| Appendix XI: (7th day after third spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S | M.S.S. | F(CAL) | F(TAB) at 5% | |
| REPLICATION | 2.00 | 13.14 | 6.57 | **1.07** | **3.74** | |
| TREATMENT | 7.00 | 602.24 | 86.03 | **14.04** | **2.76** | |
| ERROR | 14.00 | 85.81 | 6.13 | | **S.Em±** | **1.43** |
| TOTAL | 23.00 | | | | **CD At 5%** | **4.34** |
| | | | | | | |

| Appendix XII: (15th day after third spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S | M.S.S. | F(CAL) | F(TAB) at 5% | |
| REPLICATION | 2.00 | 1.09 | 0.55 | **0.79** | **3.74** | |
| TREATMENT | 7.00 | 606.50 | 86.64 | **125.98** | **2.76** | |
| ERROR | 14.00 | 9.63 | 0.69 | | **S.Em±** | **0.48** |
| TOTAL | 23.00 | | | | **CD At 5%** | **1.45** |
| | | | | | | |

| Appendix XIII: (Overall mean of third spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S | M.S.S. | F(CAL) | F(TAB) at 5% | |
| REPLICATION | 2.00 | 1.67 | 0.83 | **0.79** | **3.74** | |
| TREATMENT | 7.00 | 697.56 | 99.65 | **94.68** | **2.76** | |
| ERROR | 14.00 | 14.74 | 1.05 | | **S.Em±** | **0.59** |
| TOTAL | 23.00 | | | | **CD At 5%** | **1.80** |
| | | | | | | |

| Appendix XIV: (3rd day overall mean of all three spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S | M.S.S. | F(CAL) | F(TAB) at 5% | |
| REPLICATION | 2.00 | 0.17 | 0.08 | **0.17** | **3.74** | |
| TREATMENT | 7.00 | 932.99 | 133.28 | **265.23** | **2.76** | |
| ERROR | 14.00 | 7.04 | 0.50 | | **S.Em±** | **0.41** |
| TOTAL | 23.00 | | | | **CD At 5%** | **1.24** |
| | | | | | | |

| Appendix XV : (7th day overall mean of all three spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S | M.S.S. | F(CAL) | F(TAB) at 5% | |
| REPLICATION | 2.00 | 2.14 | 1.07 | **0.46** | **3.74** | |
| TREATMENT | 7.00 | 1040.98 | 148.71 | **64.65** | **2.76** | |
| ERROR | 14.00 | 32.20 | 2.30 | | **S.Em±** | **0.88** |
| TOTAL | 23.00 | | | | **CD At 5%** | **2.66** |
| | | | | | | |

| Appendix XVI : (15th day overall mean of all three spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S | M.S.S. | F(CAL) | F(TAB) at 5% | |
| REPLICATION | 2.00 | 0.16 | 0.08 | **0.23** | **3.74** | |
| TREATMENT | 7.00 | 606.09 | 86.58 | **258.40** | **2.76** | |
| ERROR | 14.00 | 4.69 | 0.34 | | **S.Em±** | **0.33** |
| TOTAL | 23.00 | | | | **CD At 5%** | **1.01** |
| | | | | | | |

| Appendix XVII : (overall mean of all spray) | | | | | | |
|---|---|---|---|---|---|---|
| S.V. | D.F. | S.S | M.S.S. | F(CAL) | F(TAB) at 5% | |
| REPLICATION | 2.00 | 0.17 | 0.08 | **0.17** | **3.74** | |
| TREATMENT | 7.00 | 932.99 | 133.28 | **265.23** | **2.76** | |
| ERROR | 14.00 | 7.04 | 0.50 | | **S.Em±** | **0.41** |
| TOTAL | 23.00 | | | | **CD At 5%** | **1.24** |
| | | | | | | |

# VITA


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| Qualification | Board / University | Year | Stream | Percentage | Division |
|---|---|---|---|---|---|
| High school | M.P. Board | 2011 | All Subjects | 74.66% | First |
| Higher Secondary | M.P. Board | 2013 | Biology | 81% | First |
| Graduation | RVSKVV | 2019 | Agriculture | 7.32 OGPA | First |
| Post Graduation | RVSKVV | 2021 | M.Sc. (Entomology) | 7.76 OGPA | First |

I have submitted my thesis in 2020-2021, during the course work in partial fulfillment of the requirement for the degree of M.Sc. (Ag) in Entomology.

**Date : ……..**

**Place : …….** **(ANAMIKA SINGH)**