“Comparative Studies of New Molecules for the Management of Major Insect Pest of Soybean (*Glycine max* (L.) Merr.)”

THESIS

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Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior

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In

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(Entomology)

By

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Department of Entomology

College of Agriculture, Indore

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya

2022

CERTIFICATE - I

This is to certify that the thesis entitled **"Comparative Studies of New Molecules for the Management of Major Insect Pest of Soybean (*Glycine max* (L.) Merr.)"** submitted in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE (Ag.)** in **Entomology** of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Indore is a record of the bonafide research work carried out by **Mr. Sunil Mukati, ID. No. 18121912,** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.

All the assistance and help received during the course of the investigation has been acknowledged by him.

Place: Indore
Date:

Dr. R.K. Choudhary
Chairperson of the Advisory Committee

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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Member	Dr. A.K. Badaya	……………………….
Member	Dr. N.S. Thakur	………………………..

CERTIFICATE – II

Aadhar No....................
ID No............................

This is to certify that the thesis entitled **"Comparative Studies of New Molecules for the Management of Major Insect Pest of Soybean (Glycine max (L.) Merr.)"** submitted by **Mr. Sunil Mukati** to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Indore in partial fulfilment of the requirements for the degree of **Master of Science** in **Agriculture** in the Department of **Entomology** has been, after evaluation, approved by the External Examiner and by Student's Advisory Committee after an oral examination on the same.

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Place : Indore

Date: / / 2022 **Sunil Mukati**

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LIST OF SYMBOLS

Symbol	Abbreviation	Stand for
@		At the rate of
%		Percentage
^0C		Degree Centigrade / celcius
	Ha	Hectare
,		Comma
:		Colon
.		Full stop
	Mm	Milli meter
	CD	Critical difference
	SS	Sum of squares
	MSS	Mean sum of squares
	DF	Degrees of freedom
	F-cal	F test calculated value
	a.i	Active ingredient
	et al	Co-workers
	Etc	et cetera
	Fig.	Figure
	Mg	Milligram
	i.e	That is
	In vitro	Under controlled conditions
	NS	Non-significant
	RH	Relative humidity
	SEm ±	Standard error of mean
	Viz.	Namely
	Kg/ha	Kilogram per hectare
	L	Litre
	T	Tonne
	DAS	Days after spraying
	Mrl	Meter row length
	RBD	Randomized block design

CHAPTER-I

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is a miracle crop originated in china. With its introduction into USA in the 18^{th} century and its systematic breeding in the country in the period of 1940 to 1950, soybean was transformed into an inefficient fodder crop to a highly productive crop. Since than USA has become the largest producer of soybean in the world. The nutritional value of soybean contains 40 per cent protein and 20 per cent edible oil apart from other vitamins and minerals It is now a cash crop and has occupied important place in agriculture and oil economy of the country. Soybean oil is used for manufacturing "Vanaspati Ghee" and several other industrial products including antibiotics. Soybean crop helps in building up the soil fertility by fixing atmospheric nitrogen through the root nodules and also through leaf fall on the ground at maturity.

Modern nutrition of livestock, particularly poultry majorly emphasize on their nutritional fulfillment. Proteins are an integral part of diet of many farm animals which are nowadays provided by plant origin. Such a manner soybean and their products have a significant role. Soybean is a legume crop so it has the ability of formation of root nodules which add biomass and fixes atmospheric nitrogen into the soil which increases the fertility.

The average area under soybean cultivation in the world was 121.53 million ha, with a productivity of 2.76 tonnes per hectare and production of 334.89 million tonnes. America is the leading country in soybean production followed by Asia, Europe and Africa. Soybean is usually the most common *kharif* crop of Madhya Pradesh, which occupies 59.3 and 60.2 per cent in total area and production of the country, respectively and is called "Soya state "(Anonymous, 2009). However, the area of soybean production in India is 10.96 million hectares, with production of 13.45 million tones, productivity of 1228 kg per hectare. The main areas of soybean cultivation are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and Telangana among which Madhya Pradesh occupies 5.51 million hectares in soybean production with yield of 772 million tones and productivity of 4010 kg per hectare (Sopa, 2019). Different factors are responsible for loss of yield, insect pests are considered to be of major importance. About 300 insect pests infest the crop at various stages of its growth in India (Singh and Singh, 1999). It has been experienced that in last few years the soybean crop is facing various challenges and losing its attraction among the farmers because of reduced yield. The loss of potential yield of the crop was influenced by various factors among which insect pests have been considered to be of main importance. Singh and Verma (1992) reported 150 insect pests damaging soybean in Madhya Pradesh and nearly ten of the reported species were known to cause serious damage to soybean from sowing to harvesting. Amongst these, grey semilooper (*Gesonia* *gemma,* Swinhoe), blue beetle (*Cneorane sp*.) and green semilooper (*Chrysodeixis acuta,* Walker) defoliate the plants at seedling and grownup stages. The stem fly (*Melanagromyza sojae, Z*ehntner) and girdle beetle (*Obereopsis brevis,* Swed.) bore the main stem and branches.

For successful management of these insect pests, it is necessary that the recommended insecticides should be economical, effective and eco-friendly. The insecticides like Flubendiamide 39.35 SC, Spinetoram 11.7 SC, Thiamethoxam 12.6 + Lambda cyhalothrin 9.5 ZC, Chlorantraniliprole 18.5 SC, *Beauveria bassiana*, Bifenthrin 10 EC and Diafenthiuron 50 WP have been recommended to check the infestation of various insect pests. But lately, farmers and extension officers of State Government of Madhya Pradesh reported failure of some of these insecticides against some existing and newer pests. Hence, some new insecticides and commonly recommended insecticides were evaluated against the major insect pests of soybean for their better management with following objectives.

Objectives:

1. To study the impact of insecticides on insect pest of soybean at vegetative and reproductive phases.
2. To study the Comparative efficacy of newer insecticides against insect pest of Soybean.
3. To study the economics of new insecticides against insect pest of soybean.

CHAPTER- II

REVIEW OF LITERATURE

Application of suitable and effective insecticides to control the pests of soybean is the major concern in agriculture today due to failure of earlier insecticides to manage these insects. It was thought proper for compiling literature pertaining to incidence and control of pests for making a brief review of the same.

2.1 Effect of insecticides against insect pests at vegetative and reproductive stages.

Mumuni abuduali *et al.* (2012) studied the effect of insecticides on pest population sprayed at vegetative, reproductive and both the crop stages and their influence on yield loss in soybean in Ghana. The insect densities, pod and seed damage were lower while seed yields were significantly greater when the insecticides were applied at vegetative stage. Similar results were observed in plots that were protected at the reproductive stage against pod sucking bugs and those protected at both vegetative and reproductive stages. Yield loss ranged between 25.8 and 42.8% in untreated plots, 11.1 and 34.3% in plots that were protected at the vegetative stage, and 5.2 and 11.3% in plots that were protected at the reproductive stage.

Ndam *et al.* (2012) studied the impact of Chlorpyrifos (50g a.i. /ha), dimethoate (280g a. i /ha), cypermethrin (5g a. i. /ha) and cypermethrin + dimethoate (37.5 + 140g a. i. /ha) applied at mid – vegetative, 50% flowering and 50% podding on the population of pest and beneficial insect species on soybean during 2000 and 2001 cropping seasons. Pest and natural enemy population densities were low in both years, and statistically comparable in sprayed and unsprayed plots. However, in the 2001 cropping season, the number of ants per pitfall trap was significantly ($P<0.05$) higher under chlorpyrifos than under the control at flowering and podding phases of crop growth. The phytophagous species commonly encountered included *Empoasca dolichi,* Paoli (492 from D-Vac, 3 from pitfall trap), *Haliticus tibialis,* Reut (170 from D-vac, 37 from pitfall trap) and *Cicadella nigrifrons,* Dist. (53 from D-vac, 97 from pitfall trap). Natural enemy species were dominated by ants: *Pheidole* sp. (7 from D-vac, 1932 from pitfall trap) and *Camponotus* sp. (1 from D-vac, 80 from pitfall trap). Other predators captured included carabid beetles (72 from pitfall traps only) and spiders.

2.2 Efficacy of insecticide against major insect pest of soybean.

2.2.1 Effect of insecticides on Stem fly *(Melanagromyza sojae).*

Dubey *et al.* (1998) compared the bio-efficacy and economics of six microbial agents with triazophos in the field against *Gesoniagemma*, *Chrysodeixis acuta* and *Melanagromyza sojae* infesting soybean in Madhya Pradesh. Although, triazophos was significantly more toxic and offered the maximum net profit of Rs 2968/ha. All the microbial agents were found effective in reducing the larval population and stem tunnelling.

Salunke *et al*. (2004) evaluated carbosulfan, thiamethoxam, phorate, carbofuran and chlorpyrifos as seed treatment soil application and as spray against leaf miner (*Aproaeremam odicella*), stem fly (*Melanagromyza sojae*), girdle beetle (*Obereopsis brevis*), whitefly (*Bemisia tabaci*) and jassids on soybean seedlings during the 1988-99 Kharif season. All the treatments were significantly superior over the control. Carbosulfan 25 DS @ 30 g/kg seed recorded the lowest number of leaf miner larvae and consequently the leaf damage. Per cent stem tunneling was lowest in phorate 10 G @ 10 kg/ha, whereas the lowest infestation of girdle beetle was recorded in carbofuran 3 G @ 30 kg/ha.

Dahiphale *et al.* (2007a) reported that the tunnelled stem length caused by stem fly was significantly less in the treatment with soil application of phorate 10G followed by carbofuran, seed treatment with thiamethoxam 70WS (6 gram/kg) and spraying of thiamethoxam 25WG (100 gram/ha). They also reported that soil application of phorate showed significantly less damage by girdle beetle followed by carbofuran soil application (30 kg/ha), imidacloprid spray (100g/ha) and chlorpyrifos 1.5 lit/h.

Dahiphale, *et al.* (2007b) tested the effects of newer insecticides namely, carbosulfan 25 DS, thiamethoxam 70 WS, thiamethoxam 70 WS, chlorpyriphos 20 EC, thiamethoxam 25 WG, imidacloprid 200 EC, chlorpyriphos 20 EC, phorate 10 G and carbofuran 3G on the incidence of insect pests and on the performance of soybean(MAUS-32) in Parbhani, Maharashtra. Carbosulfan 25 DS, thiamethoxam 70 WS and chlorpyriphos 20 EC were applied to seeds before sowing, whereas phorate 10 G and carbofuran 3G were applied to the soil during sowing. Imidacloprid 200 EC, thiamethoxam 25 WG and chlorpyriphos 20 EC were sprayed at 28 and 48 days after sowing. Results showed that chlorpyriphos 20 EC, thiamethoxam 25 WG and phorate 10 G reduced leaf miner (*Aproaerema modicella*) incidence and percentage of leaf damage. However, carbosulfan 3 G applied to soil and carbosulfan 25 DS applied to seeds were superior among the treatments. The reduction in tunnelled stem length due to stem fly (*Melanagromyza sojae*) and girdle beetle (*Obereopsis brevis)* was greatest with the soil application of phorate 10 G. The highest seed yield (2231 kg/ha) was obtained with phorate 10 G.

Khandwe *et al.* (2011) Evaluated the bio-efficacy of new and recommended insecticide against defoliators and stem borer of soybean Study concluded that the higher doses of new insecticides like Spinosod 40SC @ 187.5 ml/ha and rynaxypyr 20SC @ 150 ml/ha were very effective and at par with commonly recommended insecticides triazophos, 40EC @ 800 ml /ha and quinalphos 25EC@ 1500 ml/ha. Spinosad 40SC @ 187.5 ml recorded lowest stem tunnelling (3.10%) caused by maggot of stem fly. Triazophos 40EC @ 800 ml/ha recorded significantly minimum plant infestation by girdle beetle. The highest mean yield of 19.72 q/ha was recorded with quinalphos 25EC @ 1500 ml/ha which was 636 kg (47.60%) more than control.

Balaji *et al.* (2012) conducted experiment to study the efficacy of insecticides against lepidopterous defoliator and stem borers of soybean. The bio-efficacy of indoxacarb 14.5 EC at 300 ml and 500 ml/ha, diafenthiuron 50 WP at 500 gm/ha, profenophos 50 EC at 1250 ml/ha, lambda cyhalothrin 5 EC at 300 ml/ha, emamectin benzoate 5 SG at 180 g/ha and triazophos 40 EC at 800 ml/ha were tested against grey semilooper, (*Gesoniagemma*), green semilooper (*Chrysodeixis acuta*), stem fly, (*Melangromyza sojae*) and girdle beetle (*Oberieopsis brevis*) on soybean. All new insecticides and triazophos were found to be equally effective against grey semilooper, green semilooper and remained effective upto 5 days treatment, whereas diafenthiuron 50 WP, profenophos 50 EC, triazophos 40 EC and emamectin benzoate 5 SG were found to be highly effective against stem fly and girdle beetle.

Totanadak *et al.* (2012) reported that the controlled release (CR) formulation of imidacloprid (1-6 chloro-3- pyridinyl methyl)-N-nitro imdazolidin -2-ylideneamine) were prepared using noval amphiphilic (polymers synthensized from polytheleneglycal and aliphatic decides employing encapsulation technique. The bio-efficacy of prepared CR formulation was evaluated against major pest of soybean borer stem fly (*Melanagromyza sojae*). Most of the CR formulation of imidacloprid gave significantly better control of the pests compared to its commercial formulation. However, the CR formulation poly (Poly osyl ethylene -1000) Oxy Suberory] amphiphilic polymer- based formulation performed better over other for controlling of stem fly incidence and recorded higher yield over commercial formulation and control.

Raju *et al*. (2013) tested the recommended and new insecticides like rynaxypyre 20 SC @ 100 ml/ha and quinalphos 25 EC @ 1500 ml/ha against major pests of soybean. Overall mean data reflected that, rynaxypyre 20 SC @ 100 ml/ha, recorded lowest stem tunneling (1.4%) caused by maggot of stem fly. The highest mean yield (1275 kg/ha) was recorded with rynaxypyre 20 SC @ 100 ml/ha which was 495 kg (63.4%) more than the untreated control. Other treatments gave additional yield ranged from 310 to 400 kg/ha. Spraying of quinalphos 25 EC @ 1500ml/h.was economical and most remunerative recording the ratio of 1:5.09.

Curioletti *et al.* (2018) tested Two experiments were carried. In the 1st experiment, 12 insecticides were applied at sowing as a seed treatment (ST) or in the sowing furrow (SF) and combined with presence or absence of foliar spray (FS) of insecticides at 18 and 28 days after soybean emergence (DAE) in a factorial scheme. In the 2nd experiment, 17 insecticides were sprayed foliar at 10 and 22 DAE. Control efficiency of M. sojae was assessed on experiment 1 at 22, 28 and 38 DAE and on experiment 2 at 22 and 38 DAE, by counting the number of larvae, pupae, and damaged plants and length of galleries. The results evidenced the need of a specific management for this pest and recommended application of insecticides such as: Chlorantraniliprole (ST), Imidacloprid + Bifenthrin (ST), Fipronil (ST), Imidacloprid (ST) and Thiamethoxam (SF) at sowing, combined with the foliar spray until 10 DAE of Chlorpyrifos, Thiamethoxam + Lambda-Cyhalothrin, Thiodicarb, Bifenthrin and Imidacloprid + Beta-cyfluthrin. The foliar spray should be repeated at least once in an interval shorter than 10 days, to protect soybeans plants during the most vulnerable development stages to the attack of M. sojae.

2.2.2 Effect of insecticide on white fly ***(Bemisia tabaci).***

Belay *et al.* (2012) evaluated spraying insecticides on white fly (*B. tabaci*) infested soybean leaves. The direct spray experiment showed that nuprid 2f (imidacloprid), capture 2 EC (bifenthrin, thionex, endosulfan), lanate LV (methomyl) and dimethoate gave good level (>805) of control of white fly.

Raghuvanshi *et al.* (2014) reported the activity of blue beetle and white fly was started from 14 days after sowing (DAS) and remained up to first week of September with its peak population during first week of August at 35 DAS. Infestation of green semilooper and tobacco caterpillar was started from third week of July and second week of August, respectively. The infestation of girdle beetle started from second week of august to till harvest.

Ahirwar *et al.* (2015) recorded girdle beetle, *Obereopsis brevis*; tobacco caterpillar, *Spodoptera litura*; green semilooper, *Chrysodeixis acuta*; whitefly, *Bemisia tabaci* and *Empoas Cakerri*as a major pest of soybean. The peak activity of girdle beetle (1.0 damaged plant per meter row) was observed during first week of October. Whereas the peak activity of caterpillar pests that is, *S. litura* (2.5 larvae per meter row) and *C. acuta* (0.7 larvae per mete rrow) was recorded during second fortnight of August. While, *B. tabaci* (3.2whiteflies per plant) and *E. kerri* (3.4 jassids/plant) was recorded during last week of August and second week of August, respectively.

Kalyan *et al.* (2016) tested two sprays were given in the soybean, of which first spray was given against whiteflies, semilooper and girdle beetle at 35 days after germination (DAG) and second spray was given at 55 days gram pod borer and tobacco caterpillar. The significant maximum reduction in white fly population was recorded in case of thiamethoxam 25WG at 3 and 5 days after spray (DAS) during the year 2012 and 2013 respectively.

Arnemann *et al.* (2019) evaluated the most efficient treatment for the control of B. tabaci adults was cyantraniliprole + lambda-cyhalothrin, at the doses of 100 + 7.5 g a. i. ha-1, which provided 65% of average control efficiency. As for nymph control, the most efficient treatment was acetamiprid + pyriproxyfen, at the doses of 60 + 30 g a. i. ha-1, which resulted in 67% of whitefly control in average. Two sequential sprays beginning at the infestation onset are recommended in order to enhance control efficiency.

2.2.3 Effect of insecticide on girdle beetle *(Obereopsis brevis).*

Yadav *et al*. (2001) tested efficacy of eight insecticides against defoliators and stem borers infesting soybean at Indore, Madhya Pradesh, and reported chlorpyriphos 50 EC + cypermethrin 5 EC most effective against tobacco caterpillar *(Spodoptera litura*), followed by quinalphos 20 AF and ethofenprox 10 EC, chlorpyriphos 50 EC + cypermethrin 5 EC and profenofos + cypermethrin 44 EC were effective against semilooper viz. *Diachrysiaorichalcea*, *Chrysodeixis* acuta and Mocisundata in keeping the larval population below 2 larvae /mrl, followed by lambda cyhalothrin 5 EC. Carbosulfan 25 EC was found to be the most toxic to girdle beetle (Obereopsis brevis), followed by chlorpyriphos 50 EC + cypermethrin 5 EC and lambda cyhalothrin 5 EC, chlorpyriphos 50 EC + cypermethrin 5 EC, Quinalphos 20 AF and ethofenprox 10 EC were highly effective against stem fly (*Melanagromyza sojae*). Chlorpyriphos 50 EC + cypermethrin 5 EC gave the maximum grain yield, followed by quinalphos 20 AF and lambda cyhalothrin 5 EC, and these insecticidal treatments gave the net return of Rs. 6212/ha, Rs. 6090/ha and Rs. 5878/ha with cost-benefit ratio of 1:4:63, 1:7.00 and 1:8:61, respectively

Choudhary *et al*. (2007) conducted a field experiment to evaluate the efficacy of triazophos at various rates (625, 750, 875, or 1000 ml/ha) against soybean (*Glycine max* cv. JS-335) insect pests (*Chrysodeixis acuta*, *Plusiaorichalcea* [*Thysano plusiaorichalcea*] and *Obereopsis brevis*). Triazophos was sprayed at 30 and 55 days after sowing. Girdle beetle infestation was lowest with 875 ml triazophos/ha (13.31) and with 1000 ml triazophos/ha. (11.90). The lowest grain yield and benefit: cost ratiowas recorded with triazophos at 625 ml/ha, whereas the highest grain yield, per cent increase in grain yield, and per cent avoidable yield loss were obtained with triazophos at 825 ml/ha. The benefit cost ratio was highest for endosulfan (1000 ml/ha), followed by triazophos at 875 ml/ha.

Kumar *et al*. (2010) tested the efficacy of neem base products [neem seed water extract (NSWE) @ 40 ml/lit and vanguard @ 5 ml/lit] compared with triazophos 40EC @ 1.5 ml/lit against the stem borer complex in soybean. Triazophos proved to be the most effective against the stem borers. Neem seed base products were also superior over control. Maximum grain yield was obtained due to triazophos applied at 30,50 and 70 days after sowing (DAS) but the benefit / cost ratio was highest (3.03:1) in one spray of NSWE, applied at 70DAS which was economical than the other treatments.

More *et al.* (2014) Semilooper, girdle beetle and stem fly are causing great yield losses regularly in Marathwada region of Maharashtra. For the management of these pests, a new combination product Virtako® 40 WG (Chlorantraniliprole 20 % + Thiamethoxam 20 %) was evaluated at various doses (30, 40 and 50 g a.i. /ha) along with the checks Chlorantraniliprole 18.5 per cent SC, Thiamethoxam 25 per cent WG, Ethion 50 per cent EC and Imidacloprid 17.8 SL in a field experiment conducted during kharif2010 at Parbhani (Maharashtra). The new combination product at levels 40 g a. i. per ha and above was found to be the most effective against semiloopers (1.56, 1.00 and 0.44 larvae per MRL at 3, 7 and 10 days after treatment application).

Kothalkar *et al*. (2015) conducted an experiment to evaluate insecticides and their combinations against major insect pest of soybean under field conditions in *kharif* season 2011-2012. The results revealed that Emamectin benzoate 5 SG @0.002% + Triazophos 40 EC @ 0.06%, Emamectin benzoate 5 SG @ 0.002%, Fenvalrate 20 EC @ 0.01%, Triazophos 40 EC @ 0.06% and Flubendiamide 20 WG@ 0.01% + Triazophos 40 EC @ 0.06% were proved to be significantly effective inmanaging the major insect pests of soybean and obtained comparatively highest yield, net monetary return and ICBR. All insecticides proved safer to lady bird beetle and non-phytotoxic. Hence, it is also concluded that above combinations found beneficial or the management of soybean pest.

Chouhan (2016) reported the infestation of girdle beetle (*Obereopsis brevis*) started on 2nd week of August to harvesting period. Results, indicated treatment BAS 450011300 SC @17ml/ha was found very effective against girdle beetle damage.

Kambrekar *et al.* (2017) evaluated bio-efficacy of emamectin benzoate 1.9EC against defoliators and girdle beetle infesting soybean. The highest reduction in the population of *Thysanoplusia orichalcea* (Fab.) over the control was recorded in emamectin benzoate 1.9 EC @ 475 ml/ha and emamectin benzoate 1.9 EC @ 425ml/ha. Across the interval emamectin benzoate 1.9 EC @ 475 and 425 ml/ha successfully reduce the population of *Spodoptera litura.* Across the interval emamectin benzoate 1.9 EC @ 475 and 425 ml/ha were recording reduce the damage of Girdle beetle *(Obereopsis brevis).* The data on seed yield revealed that emamectin benzoate 1.9 EC @ 475 ml/ha recorded the highest seed yield followed by emamectin benzoate 1.9 EC @ 425 ml/ha.

Bhardwaj *et al.* (2018) evaluated the efficacy of Quinalphos 25 EC, Chlorpyriphos 20 EC, Alphamethrin 10 EC was observed the overall maximum reduction in girdle beetle infestation was noticed in Quinalphos 25 EC (82.15%) followed by Alphamethrin 10 EC (79.41%), and it was minimum in Chlorpyriphos 20 EC (950) and it was minimum in Chlorpyriphos 20 EC (940). The best cost benefit ratio was noted in Quinalphos 25 EC (1:1.94) followed by Chlorpyriphos 20 EC (1:1.92), and lowest in Alphamethrin 10EC (1:1.91).

2.2.4 Effect of insecticide on larval population of Semilooper.

Khandwe and Waghmare (2003) conducted field experiments to evaluate the efficacy of chlorpyriphos sprays against green *semiloopers*, *C. acuta* and *P. orichalcea* [*Thysanoplusia orichalcea*], on soybean. A single spray of chlorpyriphos (0.1%) at 30 days after sowing (DAS) was highly effective in reducing the larval population to 0.33 larvae per 10 plants, compared with 8 larvae per plant in the untreated control. Application at 30 and 45 DAS kept the crop free of infestation. Two sprays given at 40 and 45 DAS gave the highest yield (18.24 q/ha) and profit (Rs. 412/ha), but a single spray at 30 DAS gave the highest cost- benefit ratio (1:6.7).

Salunke *et. al.* (2004) evaluated carbosulfan, thiamethoxam, phorate, carbofuran and chlorpyriphos as seed treatment, soil application and as spray against leaf miner (*Aproaerema modicella*), stem fly (*Melanagromyza sojae*), girdle beetle (*Obereopsis brevis*), white fly (*Bemisia tabaci*) and Jassids on soybean seedlings during the 1998-99 *Kharif* season. All the treatments were significantly superior over the control. Carbosulfan 25 DS at 30 g/kg seed recorded the lowest number of leaf miner larvae and consequently the leaf damage. Per cent stem tunnelling was lowest in phorate 10 G at 10 kg/ha, whereas the lowest infestation of girdle beetle was recorded in carbofuran 3 G at 30 kg/ha. The most effective treatment against whitefly was thiamethoxam 70 WS at 3 g/kg seed and chlorpyriphos 20 EC at 1.5 liters/ha against the jassids. The highest yield (27.57 q/ha) was recorded in carbosulfan 25 DS at 30 g/kg seed, followed by thiamethoxam 70 WS at 3 g/kg seed (25.54 g/ha).

Khandwe *et al.* (2009) tested efficacy of six newer ecofriendly biopesticides compared with a commonly recommended insecticide i. e. quinalphos 25 EC. Field experiment was conducted during *Kharif* season of 2007. All the insecticidal treatment reduced the population of semilooper. All the insecticidal treatments were found highly effective, significantly superior and recorded 0.0to 1.23 larvae/mrl over untreated control (6.90 larvae/ mrl). all the three doses of spinosad 45 SC were found very effective against grey and green semilooper and kept crop free from infestation of semilooper. Similarly, diafenthiuron 50 WP @0.500 ml/ha and quinalphos 25 EC @ 1.5 lit /ha were also found very effective and recorded less than 1 larvae /mrl.

Raghuvanshi *et al.* (2014) reported the activity of blue beetle and white fly was started from 14 days after sowing (DAS) and remained up to first week of September with its peak population during first week of August at 35 DAS. Infestation of green semilooper and tobacco caterpillar was started from third week of July and second week of August, respectively. The infestation of girdle beetle started from second week of august to till harvest.

Matti and deotale (2015) tested the efficacy of different insecticide against semilooper (*Thysanoplusia orichalcea,* Fab.) in soybean. Least cumulative average number larvae (0.05/mrl) were recorded in treatment of fenvalerate 20 EC @0.50 ml/l found to be superior compared to other treatments. The next effective treatments were emamectin benzoate 5 SG @ 0.3 g/l (0.06/mrl) and also in Spinosad 45 SC @ 0.25 ml/l (0.07/m row length) indoxacarb 15.8 EC @ 0.60ml/l ((0.08/mrl) found to beat par with T6 and T3. However, the treatments neem oil 2 per cent (T2) recorded 0.78 larvae/mrl. Whereas, NSE @ 5 per cent (0.95/ml) and *Beauveria bassiana* 1×108 CFU @ 4 g/l (0.99/mrl) were found to be least effective in reducing larval population/mrl. Maximum mean larval population (1.48/mrl) was recorded in control (Water spray; T8). Fenvalerate 20 EC @0.50 ml/l, indoxacarb 15.8 EC @0.60 ml/l, Spinosad 45SC @ 0.25 ml/l were found to be most effective treatments which recorded highest yield of 21.05 q/ha, 20.10q/ha and 19.02 q/ha, respectively.

Ahirwar *et al. (2016)* reported that soybean is a fascinating crop with in numerable possibilities of not only improving agriculture but also supporting industries. In the present investigation, attempts were made to study the relative efficacy of different insecticides against leaf feeders. It was found that Profenophos 50 EC @ 1250 ml/ha was most effective against caterpillar pests with 1.22 larvae per meter row and the grain yield was 15.450 q/ha with 13.14:1 benefit cost ratio. In Triazophos 40 EC @ 625 ml/ha (2.36 larvae / meter row) with 12.390 q/ha grain yield and 12.30:1 benefit cost ratio. It was followed by Profenophos 50 EC @ 1000 ml/ha (2.01 larvae per meter row) with 11.700 q/ha grain yield and 10.70:1 benefit cost ratio was least economical.

Babu *et al.* (2016) study was undertaken to find out the bio-efficacy of tetraniliprole SC 200(w/v) (BCS CL 73507 SC 200) of different doses along with chloranthraniliprole 18.5 SC and triazophos 40 EC against semiloopers in soybean. The results revealed that tetraniliprole @ 40 g.ai/ha or 60 g.ai/ha was the most effective dose in reducing the semilooper larval population in soybean. It was followed by tetraniliprole @ 40g.ai/ha or chloranthraniliprole 18.5

SC @ 30g.ai/ha which was significantly superior over triazophos 40 EC @ 250 g ai/ha and untreated control.

2.2.5 Effect of insecticide on defoliators.

Padiwal *et al*. (2008) conducted field experiment for two years in soybean to test the bio-efficacy of insecticides against *S*. *litura* and the results revealed that, spraying of imidacloprid 200 SL @ 125 ml/ha at 40 days after sowing followed by endosulfan 35 EC (0.07%) at 60 days after sowing was found most effective for the management of tobacco caterpillar, S. litura followed by seed treatment with imidacloprid 70 WS @ 7 g/kg seed + spray of acephate 75 WP (0.07%) at 60 days after sowing, soil application of carbofuran 3G @ 25 kg/ha at the time of sowing + acephate 75 WP (0.07%) at 60 days after sowing and seed treatment with imidacloprid 70 WS @ 7 g/kg seed + neem seed oil @ 5 % at 60 days after sowing, which recorded 23.02 & 22.24; 22.29 & 21.33 and 18.71 & 18.14 q/ha during 2003 and 2004, respectively.

Joshi and Patel (2011) conducted trail with eco-friendly approach for the management of *S. litura* on soybean and the results revealed that, the data on mortality of leaf eating caterpillar indicated that triazophos @ 0.06% gave highest 17 mortality (93.44 %) followed by spinosad @ 0.01%, quinalphos @ 0.05% and endosulfan @ 0.007% (91.65, 87.41 and 87.13% mortality, respectively). The treatment with NSKE @ 5%, *Beauveria bassiana* @ 5 g/l, neemazol @ 2.00 ml/l and emamectin benzoate @ 0.5 g/l were the next effective treatments as they recorded 79.55, 79.06, 78.11 and 72.04 per cent mortality, respectively.

Manu *et al*. (2014) studied efficacy of novel insecticides and biorationals in the management of *S*. *litura* and reported that flubendiamide 480 SC @ 0.2 ml/l was the most efficient chemical in managing *S. litura* by giving highest larval reduction followed by the spraying of indoxacarb14.5 SC @ 0.5 ml/l which proved to be the second best treatment among all and among the biorationals Sl NPV @ 250 LE/ha was found to be superior with larval reduction of 55.49 per cent followed by Nomuraearileyi 2 x 108conidia @ 2 g/l and nimbecidine (FS) @ 3 ml/l.

Patil *et al.* (2014) evaluated the insecticide used in experiment chlorantraniliprole 18.5%SC@30g.ai/ha, methomyl 40%SP @ 300g. ai/ha, Spinosad 45%SC @ 75g.ai/ha, indoxacarb 15.8% EC @30g.ai/ha, thiodicarb 75%WP 750g.ai/ha, trizophous 40% EC @ 25g.ai/ha and profenofos 50%EC @500g.ai/ha. The evaluation of novel insecticide for the management of *Spodopteralitura* (Fabrius) and *Chrysodeixisacuta* (Walker) infesting soybean were all effective.

Reddy *et al.* (2014) studied comparative bio-efficacy and phytotoxicity of certain newer and conventional insecticides against pod borer, *S. litura* and thrips, *Scirtothrips dorsalis* (Hood) in chilli and reported that flubendiamide 480 SC @ 48 and 60 g a.i./ha were found to be the most effective against S. litura followed by Indoxacarb 14.5 SC @ 75 g a.i./ha and spinosad 45 SC @ 90 g a.i./ha.

Grigolli *et al.* (2015) studied the field efficacy of chemical pesticides against *Marucavitrata* Fabricius.They reported that pesticide Teflubenzuron, Flubendiamide, Chlorantraniliprole, + lambda-cyhalothrin, and Chlorpyrifos significantly reduced the percent of attacked plants by *M. vitrata.* Chlorpyrifos, teflubenzuron, and chlorantraniliprole + lambda-cyhalotrtin showed higher efficacy to control *M. vitrata*from the first day after application. However, flubendiamide showed good efficacy from 10 days after application, and joined the group with higher efficacy (chlorpyrifos, teflubenzuron, and chlorantraniliprole +lambda-cyhalothrin). Methomyl showed no field efficacy against legume pod borer.

Adams *et al*. (2016) experiment conducted in Mississippi from 2013 to 2015 to determine the systemic and residual efficacy of chlorantraniliprole and flubendiamide against corn earworm, *Helicoverpa zea* (Boddie), in soybean. Both insecticides were applied at V4 and R3. Ten leaves that were present at the time of application and 10 newly emerged leaves that were not present at the time of application were collected to measure residual and systemic efficacy, respectively. Ten pods were removed from each plot at R5.5. For all assays, corn earworm larvae were placed on plant material. Chlorantraniliprole appeared to provide system control of *H. zea,* but was dependent on soybean growth stage at the time of application. In the V4 experiment, chlorantraniliprole resulted in greater mortality than the control on new leaves at 7 days after treatment, but not at 14 d. In the R3 experiment, chlorantraniliprole resulted in greater than 90% mortality on new leaves at all evaluation intervals. Mortality of *H. zea* on new leaves was <17% for flubendiamide and was not different than the control. Both insecticides resulted insignificant mortality of *H. zeaon* leaves that were present at the time of application for at least 31 d after application. Chlorantraniliprole resulted in greater mortality than flubendiamide at 24 and 31 d. Neither insecticide resulted in mortality of *H. zea* feeding on reproductive structures. These results suggest that chlorantraniliprole moves to new vegetative structures but not to reproductive structures of soybean, and that flubendiamide does not move systemically.

Bhale *et al*. (2017) studied bio-efficacy of chlorantraniliprole, quinalphos, lamda-cyhalothrin, diflubenzuron, endosulfan, triazophos and indoxacarb against tobacco leaf eating caterpillar *Spodoptera litura* infesting soybean. The soybean was sprayed twice with respective insecticides at 10 days interval starting from 35 days after germination. The experimental studies revealed that, the larval population of leaf eating caterpillar was significantly reduced by the treatment of quinolphos 25 EC@ 1000 mlha-1 followed by endosulfan 35 EC @ 1000 ml. ha-1 and lambda cyhalothrin 5 EC @ 300 ml. ha-1, which were at par with each other. Highest yield was recorded with the treatment of lambda cyhalothrin 5 EC @ 300 ml ha-1(2500 kg ha^{-1}) followed by triazophos 40 EC @ 800 mlha-1 (2451 kg ha^{-1}), diflubenzuron 25 WP @ 400 g. ha^{-1} (2400 kg ha^{-1}).

Kambrekar *et al*. (2017) Results revealed that during both the years of investigation, Tetraniliprole @ 0.6 ml/l has recorded lower incidence defoliators during both the spray intervals. All the dosages of tetraniliprole have excelled in recording less number of defoliators and were equally effective to the standard check (chlorantraniliprole). During the first year of investigation, tetraniliprole 200 SC @ 0.60 ml/l has recorded 0.72 & 0.52 larvae per meter row length at 15 days after first and second spray respectively. Similarly, during second year also the larval load was minimum in the plots treated with tetraniliprole 200 SC @ 0.60 ml/l (0.27 & 0.75 larvae per meter row length after first and second spray respectively). The seed yield was highest in the treatment with tetraniliprole 200 SC @ 0.60 ml/l with 1623 and 1694 kg/h during 2013-14 and 2014-15, respectively.

Surpam *et al*. (2017) The bio-efficacy of chlorantraniliprole, quinolphos, lamda-cyhalothrin, diflubenzuron, endosulfan, triazophos and indoxacarb were evaluated against tobacco leaf eating caterpillar *Spodoptera litura* infesting soybean. The soybean was sprayed twice with respective insecticides at 10 days interval starting from 35 days after germination. The experimental studies revealed that, the larval population of leaf eating caterpillar was significantly reduced by the treatment of quinolphos 25 EC @ 1000 mlha^{-1} followed by endosulfan 35 EC @ 1000 ml ha^{-1} and lambda cyhalothrin 5 EC @ 300 ml ha^{-1}, which were at par with each other. Highest yield was recorded with the treatment of lambda cyhalothrin 5 EC @ 300 ml ha^{-1} (2500 kgha^{-1}) followed by triazophos 40 EC @ 800 mlha^{-1} (2451 kgha^{-1}), diflubenzuron 25 WP @ 400 gha^{-1} (2400 kg ha^{-1}).

CHAPTER-III

MATERIAL AND METHODS

The experiments were carried out during *Kharif* season of 2019 at an experimental field of farm of College of Agriculture, Indore. The details of the methodology followed during the course of investigations are elucidated as follows.

3.1 Location:

The experiments were conducted in an experimental field at farm field of College of Agriculture, Indore, Madhya Pradesh. Indore is situated in the “Malwa Plateau” which is an agroclimatic zone of Madhya Pradesh located with the following geographical parameters.

- Latitude of 22.43^0North
- Longitude of 75.66^0East
- Altitude of 555.2 meters above sea level

3.2 Climate, Season and Geography:

Indore is situated in west of Madhya Pradesh having semi-arid and sub-tropical climate. The climate pf this season has mild winter and summer with uncertain winter rains. The monsoon occurs mostly from mid-June to end of September. The temperature ranges from 7^0 to 19^0c in winter and 23^0 to 42^0c in summer.

The metrological data regarding the temperature, relative humidity and rainfall recorded during the cropping season (to relate the pest occurrence and intensity) from the metrological observatory located at college of agriculture, Indore presented in table - 1 below and figure-1.

3.3 Soil:

The soil of experimental field was medium black and well drained. The soil was rich in phosphorus but organic matter and potash were medium in availability. The pH and soluble salts were normal.

Table 3.1-: Meteorological data during the *kharif* season of 2019 at College of Agriculture (R.V.S.K.V.V.), Indore (M.P.).

Stand. Week No.	Temp. ^{o}C		Relative Humidity%	Rainfall (mm)	No. Of Rainy Days
	Max	Min			
26	32.14	23.8	79.42	9.03	2
27	27.26	21.9	81.45	28.22	5
28	30.40	24.4	79.35	0.00	0
29	32.47	24.4	75.60	7.71	3
30	29.15	24.12	80.15	8.19	4
31	26.20	22.40	82.05	11.40	3
32	26.87	22.90	81.55	17.96	4
33	26.66	22.30	81.50	11.00	5
34	27.74	22.30	81.26	11.00	3
35	26.61	22.30	79.25	19.71	3
36	27.12	23.21	84.35	13.14	6
37	25.44	21.40	85.71	18.29	7
38	29.20	22.14	83.65	4.57	3
39	28.70	21.51	82.85	10.86	5
40	29.40	20.42	79.60	16.29	3
41	29.50	20.14	76.95	5.86	3

Source: Meteorological Observatory, College of Agriculture, Indore

3.4 Field preparation:

The field was ploughed on 1thJune 2019 with the help of cultivator and stubbles were removed. Drainage channels were prepared at the time of sowing to drain the excess water from field to avoid water logging.

3.5 Fertilizer application:

Fertilizers were applied at the time of sowing to meet requirements of 20 Kg N, 60 Kg P_2O_5 and 20 Kg K_20/ha as basal dose through Diammonium phosphate, Muriate of potash and Gypsum respectively, below and near the seed row as basal.

3.6 Seed rate and method of sowing:

The seed was sown @ 60 kg/ha in lines by putting the seeds in furrow opened by hand plough.

3.7 Plant population (gap filling and thinning):

In order to maintain plant population of 4 lakh/ha, the excess plants were removed at 15 days old crop, keeping a row-row distance of 30cms and plant to plant distance of about 5 cm.

3.8 Layout: The experiment was laid out as per details given below:

Experimental details:

Crop	:	**Soybean *(Glycine max)***
Season	:	***Kharif* season (2019)**
Year	:	**2019-2020**
Experimental Design	:	**RBD (Randomized Block Design)**
Number of treatments	:	**11**
Replications	:	**3**
Number of plots	:	**33**
Variety	:	**JS-95-60**
Plots size	:	**4.0 m × 2.0 m.**
Spacing	:	**40 cm. X 5 cm.**
Number of rows per plot:		**05**
Date of sowing	:	**25/06/2019**
Date of harvesting	:	**14/10/2019**

3.9 Method of observation:

3.9.1 Observations for effect of insecticides on pest population at different growth stages of soybean.

The efficacy of new molecule of insecticide & combination with bio-pesticide was compared. The application of insecticide was made on the crop initially at 40 days after sowing. The pest population is recorded on basis of three plant stages *viz.,* Vegetative stage, Reproductive stage and Maturity stage (Mumuni Abudulai *et al.,* 2012). Observations recorded on pest populations are elucidated below.

3.9.2 Observations for effect of insecticides on pest population

The efficacy of new molecule of insecticide & combination with bio-pesticide was compared. The application of insecticide was made on the basis of ETL of the major pest of the soybean. The observation of the pest populations was recorded one day before application (pre-treatment population) and one, three, seven and 15 days after application (post-treatment population). The second spray was done after rebuild up to pest population and again the observation will be recorded just as in the manner after first spraying.

Table 3.2. Treatment details:

S. No.	Name of Insecticide and bio pesticides	Doses in g. or ml/ha
1	Flubendiamide 39.35% SC w/w (480 g/I SC)	150
2	Flubendiamide 39.35% SC w/w (480 g/I SC)	200
3	Flubendiamide 39.35% SC w/w (480 g/I SC)	300
4	Spinetoram 11.7%	450
5	Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC	125
6	Chlorantraniliprole 18.5% SC	100
7	Chlorantraniliprole 18.5% SC+ *Beauvaria bassiana*	100+1000
8	*Beauvaria bassiana*	1000
9	Bifenthrin 10% EC	800
10	Diafenthiuron 50% WP	600
11	Untreated control	00

Observations of the pest population:

1. **Defoliator pests:** Number of larvae of defoliators has been counted in one meter row length (mrl) by shaking the plants on muslin cloth near each plant on five randomly selected plants in each plot one day before application (pre-treatment population) and one, three, seven and 15 days after application (post-treatment population).
2. **Girdle beetle infestation: -** Number of infested plant by girdle beetle will be counted in one meter row length at the five randomly selected plants.
3. **Stem fly *(Melanagromyza sojae,* Zehntner*)*:** The percent stem tunneling is taken where plant height and length of stem tunnelled per plant in on five randomly selected plants one day before application (pre-treatment population) and one, three, seven and 15 days after application (post-treatment population).
4. **Whitefly:** The observation on the population of white fly were recorded on leaves one each from upper, middle and lower in each plant on five randomly selected plants one day before application (pre-treatment population) and one, three, seven and 15 days after application (post-treatment population).

5. Yield have also been recorded after harvest.

3.3.3 Economics of treatments:

The increase in the yield when compared with control was calculated by deducting the yield obtained from the treated plot with the yield obtained in the control plot. The value of the increased yield was computed by using local market price and expressed in rupees. A comparison of cost of different treatments was done by considering the maximum retail price of the smallest packet available in market. Net return for each treatment was calculated. The cost benefit ratio was calculated by the following formula. The incremental cost-benefit ratio (the net return per rupee expenditure) was calculated by taking note of the expenditure on various crop inputs and also the returns obtained on basis of which the best pocket friendly treatment could be considered for recommended practice at farmer level.

Cost: Benefit ratio = Cost of increased yield /Cost of treatment

Both cost of increased yield and cost of treatment were taken in Rs/ha unit.

3.11 Statistical analysis:

The seasonal incidence studies apply correlation concept to the population to draw out results. While, the management using newer insecticides involves application ANOVA using RBD design before which necessary transformations of the observations are done (Gomez and Gomez, 1984).

Skeleton of Analysis of Variance (ANOVA):

Sources of variation	**Df**	**SS**	**MSS**	**F cal.**	**F table**
Replication	r-1	SSr	MSSr = SSr/r-1	MSSr/MSSe	
Treatments	t-1	SSt	MSSt= SSt / t-1	MSSt / MSSe	F at 5% (t-1), (r-1) (t-1)
Error	(r-1)(t-1)	SSe	MSSe = SSe / (r-1) (t-1)	-	
Total	(r.t-1)	-	-	-	

r = Number of replications

t = Number of treatments

The 'F' test was applied to check the overall significance of various treatments in general and comparison of individual treatment was made with the help of critical difference at 5 % level of significance, which was calculated as given below: -

SEM ± for treatment 't' = $\sqrt{\frac{MSSe}{No. of\ replications}}$ x 100

SEd for treatment = SEm x √2

CD for treatment = SEd x't' value at 5% error degree of freedom

Where,

SEm± = Standard Error of treatment means

SEd = Standard Error of difference between two treatments

CD = Critical difference

CD = SEd x 't' value at 5% error degree of freedom

CHAPTER - IV

RESULTS

The field experiment entitled **"Comparative Studies of New Molecules for the management of Major Insect pest of Soybean (*Glycine max* (L.) Merr.)"** was undertaken during the *kharif* 2019 - 20 at the field experimental site of Soybean experiment, College of Agriculture, Indore (M.P.). The incidence of various major Stem fly, Girdle beetle, semilooper and defoliators on soybean occurred during the study period were recorded and tabulated to assess the effect of new molecules of major insect pest of soybean. The results on different aspects are presented in following headings:

4.1 Impact of different insecticides on insect pest population at different vegetative and reproductive stages of soybean during *Kharif* 2019-20.

A randomized block design experiment with eleven treatments was laid out to compare the efficacy of new insecticides and also different doses as well as in alone and in combinations. Observations on the Infestation of whitefly, stem fly, girdle beetle, defoliator and semilooper were recorded before and after spray treatments during vegetative stages and reproductive stages. The results are explained as below.

4.1.1 Pre-treatment:

The pre-treatment observations recorded showed that the whitefly population ranged from 51.67 to 56 whitefly adults or nymphs per plant, stem fly population ranged from 13.33-15.47% stem tunneling, girdle beetle population ranged from 8.33-9.00% plant infestation, defoliator population ranged from 14.33-15.67% defoliation and semilooper population ranged from 1.92-3.17 larvae per mrl. But all the observations were showing no significant differences.

Table 4.1. Impact of different insecticides on soybean insect pest of Pre-treatment stage

TREATMENTS	Whitefly (*Bemesia tabaci*) (white flies/plant)	STEM FLY (*Melanagromyza sojae*) (% stem tunneling)	GIRDLE BEETLE (*Obereopsis brevis*) (% plant infestation)	DEFOLIATOR (*Spodoptera litura*) (%defoliation)	SEMILOOPER (*Chrysodeixis includes*) (larvae/mrl)
Flubendiamide 39.35% SC @ 150ml/ha	52.33 (7.27)	15.27 (23.00)*	8.60 (17.05)*	15.33 (23.05)*	3.07 (1.89)
Flubendiamide 39.35% SC @ 200ml/ha	53.00 (7.31)	14.53 (22.41)*	8.67 (17.12)*	14.33 (22.25)*	2.53 (1.74)
Flubendiamide 39.35% SC @ 300ml/ha	52.00 (7.25)	14.07 (22.03)*	8.40 (16.85)*	15.00 (22.79)*	3.16 (1.91)
Spinetoram 11.7% SC @ 450ml/ha	52.67 (7.29)	15.47 (23.16)*	8.80 (17.26)*	14.33 (22.25)*	3.17 (1.92)
Thiamethoxam 12.6% + Lambda cyhalothrin9.5% ZC @ 125ml/ha	53.33 (7.34)	13.33 (21.42)*	8.53 (16.98)*	15.00 (22.79)*	2.82 (1.82)
Chlorantraniliprole 18.5% SC @ 100ml/ha	53.67 (7.36)	14.27 (22.19)*	8.73 (17.19)*	15.00 (22.79)*	2.45 (1.72)
Chlorantraniliprole 18.5% SC+ *Beauvaria bassiana @ 10+1000ml/ha*	54.00 (7.38)	15.00 (22.79)*	8.33 (16.78)*	15.33 (23.05)*	2.33 (1.68)
Beauvaria bassiana @ 1000ml/ha	56.00 (7.52)	15.00 (22.79)*	8.67 (17.12)*	15.33 (23.05)*	1.92 (1.56)
Bifenthrin 10% EC @ 800ml/ha	53.00 (7.31)	14.00 (21.97)*	9.00 (17.46)*	15.67 (23.32)*	2.24 (1.66)
Diafenthiuron 50% WP @600ml/ha	51.67 (7.22)	13.67 (21.70)*	8.67 (17.12)*	14.33 (22.25)*	2.59 (1.76)
Untreated control	54.00 (7.38)	14.33 (22.25)*	8.67 (17.12)*	15.33 (23.05)*	3.09 (1.90)
SEM	**0.061**	**0.539**	**0.194**	**0.393**	**0.144**
CD at ±5%	**NS**	**NS**	**NS**	**NS**	**NS**

figures in parenthesis ( ) are square root transformation values and ( )* are arc sine transformation values.

4.1.2 Impact of insecticides on pests of soybean at vegetative stage:

The whitefly population recorded during vegetative stage after spraying ranged from 21.33 to 48.67 whitefly adult or nymph/plant against control (62.00). The lowest population was recorded in Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (21.33) which was at par with Diafenthiuron 50% WP (26.67). The highest population was recorded in the treatment *Beauveria bassiana* (48.67) which was at par with Chlorantraniliprole 18.5% SC + *Beauveria bassiana* (48.33). (Table 4.2 and Fig. 4.2)

The stem fly population recorded during vegetative stage after spraying ranged from 3.67% to 8.27% stem tunneling against control (14.93%). The lowest percent stem tunneling was recorded in Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (3.67%) which was followed by Diafenthiuron 50% WP (4%). While, the highest stem tunneling was recorded in the treatment *Beauveria bassiana* (8.27%) which was at par with Chlorantraniliprole 18.5% SC+ *Beauvaria bassiana @ 10+1000ml/ha* (7.53%).

The girdle beetle population observations were taken in terms of per cent plant infestation. The observations recorded during vegetative stage after spraying ranged from 3.60% to 8.33% plant infestation against control (10.33%). The lowest per cent plant infestation was recorded in Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (3.60%) which was followed by Diafenthiuron 50% WP (4.20%). While, the highest stem tunneling was recorded in the treatment *Beauveria bassiana* (8.33%).

The defoliator (Spodoptera) population observations were taken in terms of percent defoliation. The observations recorded during vegetative stage after spraying ranged from 4.87% to 10.80% defoliation against control (20.00%). The lowest percent defoliation was recorded in Flubendiamide 39.35% SC @300ml/ha (4.87%) which was followed by Flubendiamide 39.35% SC @200ml/ha (6.13%). While, the highest percent defoliation was recorded in the treatment *Beauveria bassiana* (10.80%).

The semilooper populations recorded during vegetative stage after spraying ranged from 1.60 to 2.53 larvae/mrl against control (5.07 larvae/mrl). The lowest population was recorded in Flubendiamide 39.35% SC @300ml/ha (1.60 larvae/mrl) which was followed by Flubendiamide 39.35% SC @200ml/ha (1.73 larvae/mrl). The highest population was recorded in the treatment Diafenthiuron 50% WP (5.07 larvae/mrl).

Table 4.2. Impact of insecticides on insect pest of soybean at vegetative phase.

TREATMENTS	Whitefly (*Bemesia tabaci*) (Whiteflies/Plant)	Stem Fly (*Melanagromyza Sojae*) (%Stem tunneling)	Girdle Beetle (*Obereopsis Brevis*) (%Plant Infestation)	Defoliator (*Spodoptera Litura*) (% Defoliation)	Semilooper (*Chrysodeixis Includes*) (Larvae/Mrl)
Flubendiamide 39.35SC @ 150ml/ha	43.33 (6.62)	6.47 (14.73)*	5.60 (13.69)*	6.53 (14.81)*	2.27 (1.66)
Flubendiamide 39.35%SC@200ml/ha	42.33 (6.54)	5.67 (13.77)*	5.53 (13.61)*	6.13 (14.34)*	1.60 (1.45)
Flubendiamide 39.35%SC@300ml/ha	38.33 (6.23)	5.73 (13.85)*	5.00 (12.92)*	4.87 (12.74)*	1.73 (1.49)
Spinetoram 11.7% SC @ 450ml/ha	46.67 (6.87)	7.13 (15.49)*	6.67 (14.96)*	7.53 (15.93)*	2.53 (1.74)
Thiamethoxam 12.6% + Lambda cyhalothrin9.5% ZC @ 125ml/ha	21.33 (4.67)	3.67 (11.04)*	3.60 (10.94)*	6.80 (15.12)*	2.13 (1.62)
Chlorantraniliprole 18.5% SC @ 100ml/ha	30.00 (5.52)	4.20 (11.83)*	4.60 (12.38)*	7.27 (15.64)*	2.40 (1.70)
Chlorantraniliprole 18.5% SC+ *Beauvaria bassiana @ 10+1000ml/ha*	48.33 (6.99)	7.53 (15.93)*	6.73 (15.04)*	8.13 (16.57)*	2.20 (1.64)
Beauvaria bassiana @ 1000ml/ha	48.67 (7.01)	8.27 (16.71)*	8.33 (16.78)*	10.80 (19.19)*	2.07 (1.47)
Bifenthrin 10% EC @ 800ml/ha	35.33 (5.99)	4.67 (12.48)*	4.67 (12.48)*	8.40 (16.85)*	2.13 (1.62)
Diafenthiuron 50% WP @600ml/ha	26.67 (5.21)	4.00 (11.54)*	4.20 (11.83)*	9.87 (18.31)*	2.37 (1.70)
Untreated control	62.00 (7.91)	14.93 (22.73)*	10.33 (18.75)*	20.00 (26.57)*	5.07 (2.36)
SEM	**0.222**	**0.330**	**0.252**	**0.281**	**0.148**
CD at ±5%	**0.660**	**0.981**	**0.748**	**0.834**	**0.440**

figures in parenthesis () are square root transformation values and ( )* are arc sine transformation values.

4.1.3 Impact of insecticides on insect pests of soybean at reproductive stage:

The whitefly population recorded during reproductive stage after spraying ranged from 25.67 to 55.33 whitefly adult or nymph/plant against control (60,00). The lowest population was recorded in Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (25.67) which was at par with Diafenthiuron 50% WP (28). The highest population was recorded in the treatment *Beauveria bassiana* (55.33) which was at par with Chlorantraniliprole 18.5% SC + *Beauveria bassiana* (52.67).

The stem fly population recorded during reproductive stage after spraying ranged from 0.20 to 6.40% stem tunneling against control (17.67%). The lowest percent stem tunneling was recorded in Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (0.20%) which was followed by Diafenthiuron 50% WP (1%). The highest stem tunneling was recorded in the treatment *Beauveria bassiana* (6.70%).

The girdle beetle population observations were taken in terms of percent plant infestation. The observations recorded during reproductive stage after spraying ranged from 1.07% to 5.53% plant infestation against control (15.60%). The lowest percent plant infestation was recorded in Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (1.07%) which was at par with Diafenthiuron 50% WP (1.27%). The highest %plant infestation was recorded in the treatment *Beauveria bassiana* (5.53%) which was at par with Spinetoram 11.7% SC (5.20%).

The defoliator population observations were taken in terms of percent defoliation. The observations recorded during reproductive stage after spraying ranged from 0.27% to 16.27% defoliation against control (26%). The lowest percent defoliation was recorded in Flubendiamide 39.35% SC @300ml/ha (0.27%) which was followed by Flubendiamide 39.35% SC @200ml/ha (2.33%). While, the highest percent defoliation was recorded in the treatment Bifenthrin 10% EC (16.27%) which was at par with Diafenthiuron 50% WP (14.73%) and *Beauveria bassiana* (14.40%).

The semilooper populations recorded during reproductive stage after spraying ranged from 0.05 to 1.49 larvae/mrl against control (7.53 larvae/mrl). The lowest population was recorded in Flubendiamide 39.35% SC @300ml/ha (0.05 larvae/mrl) which was followed by Flubendiamide 39.35% SC @200ml/ha (0.20 larvae/mrl). The highest population was recorded in the treatment Diafenthiuron 50% WP (1.49 larvae/mrl) which was at par with Bifenthrin 10% EC (1.31 larvae/plant).

Table 4.3. Impact of insecticides on insect pest of soybean at reproductive phase.

TREATMENTS	Whitefly (*Bemesia tabaci*) (whiteflies/plant)	Stem Fly (*Melanagromyza sojae*) (%stem tunneling)	Girdle Beetle (*Obereopsis brevis*) (%plant infestation)	DEFOLIATOR (*Spodoptera litura*) (% defoliation)	SEMILOOPER (*Chrysodeixis includes*) (larvae/mrl)
Flubendiamide 39.35% SC @ 150ml/ha	46.67 (6.87)	4.47 (12.20)*	4.60 (12.38)*	5.00 (12.92)*	0.27 (0.88)
Flubendiamide 39.35% SC @ 200ml/ha	44.67 (6.72)	4.00 (11.54)*	4.47 (12.20)*	2.33 (8.79)*	0.20 (0.84)
Flubendiamide 39.35% SC @ 300ml/ha	41.33 (6.47)	3.53 (10.83)*	3.67 (11.04)*	0.27 (2.96)*	0.05 (0.74)
Spinetoram 11.7% SC @ 450ml/ha	25.67 (5.12)	4.60 (12.38)*	5.20 (13.18)*	10.67 (19.06)*	0.71 (1.10)
Thiamethoxam 12.6% + Lambda cyhalothrin9.5% ZC @ 125ml/ha	50.00 (7.11)	0.20 (2.56)*	1.07 (5.93)*	6.67 (14.96)*	0.28 (0.88)
Chlorantraniliprole 18.5% SC @ 100ml/ha	31.33 (5.64)	1.80 (7.71)*	2.67 (9.40)*	9.00 (17.46)*	0.52 (1.01)
Chlorantraniliprole 18.5% SC+ *Beauvaria bassiana @ 10+1000ml/ha*	52.67 (7.29)	5.67 (13.77)*	5.53 (13.61)*	12.53 (20.73)*	0.39 (0.94)
Beauvaria bassiana @ 1000ml/ha	55.33 (7.47)	6.40 (14.65)*	6.73 (15.04)*	14.40 (22.30)*	1.08 (1.26)
Bifenthrin 10% EC @ 800ml/ha	38.00 (6.20)	2.80 (9.63)*	3.60 (10.94)*	16.27 (23.79)*	1.31 (1.34)
Diafenthiuron 50% WP @600ml/ha	28.00 (5.34)	1.00 (5.74)*	1.27 (6.46)*	14.73 (22.57)*	1.49 (1.41)
Untreated control	60.00 (7.78)	17.67 (24.85)*	15.60 (23.26)*	26.00 (30.66)*	7.53 (2.83)
SEM	**0.497**	**0.400**	**0.373**	**0.943**	**0.030**
CD at ±5%	**1.477**	**1.188**	**1.108**	**2.803**	**0.090**

figures in parenthesis () are square root transformation values and ()* are arc sine transformation values.

4.2 Effect of insecticides on different pests of soybean during *kharif* 2019-2020.

4.2.1 Effect of insecticides on stem fly population:

4.2.1.1 First spray:

One day before spraying the stem fly infestation (% stem tunneling) ranged in between 13.67% to 16.00% against control (15.00%). All the observations were found to be non-significant.

One day after spraying, the stem fly infestation ranged from 12.33% to 15.07% stem tunneling against control (15.27%). The lowest stem fly infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (12.33% stem tunneling) which was at par with Diafenthiuron 50% WP (12.67%). The highest stem fly infestation was recorded in *Beauveria bassiana* @1000ml/ha (15.07%) which was at par with all the other treatments *viz.,* Chlorantraniliprole 18.50% SC + *Beauveria bassiana* (15.00%), Spinetoram 17.50% SC (14.93%), Flubendiamide 39.35% SC @ 150ml/ha (17.33%), Flubendiamide 39.35% SC @ 200ml/ha (14.67%), Bifenthrin 10EC (13.93) and Flubendiamide 39.35% SC @ 300ml/ha (14%).

Three days after spraying, the stem fly infestation ranged from 3.80% to 8.60% stem tunneling against control (15.93%). The lowest stem fly infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (3.80% stem tunneling) which was at par with Diafenthiuron 50% WP (4.13%). The highest stem fly infestation was recorded in *Beauveria bassiana* @1000ml/ha (8.60%).

Seven days after spraying, the stem fly infestation ranged from 3.67% to 8.40% stem tunneling against control (19.93%). The lowest stem fly infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (3.67% stem tunneling) which was at par with Diafenthiuron 50% WP (4%). The highest stem fly infestation was recorded in *Beauveria bassiana* @1000ml/ha (8.40%).

Fourteen days after spraying, the stem fly infestation ranged from 4.07% to 8.80% stem tunneling against control (16.41%). The lowest stem fly infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (4.07% stem tunneling) which was at par with Diafenthiuron 50% WP (4.40% stem tunneling). The highest stem fly infestation was recorded in *Beauveria bassiana* @1000ml/ha (8.80%) which is at par with Chlorantraniliprole 18.5% SC+ *Beauvaria bassiana @ 10+1000ml/ha* (8.00%).

4.2.1.2: Second spray:

One day after spraying, the stem fly infestation ranged from 3.33% to 8.07% stem tunneling against control (21.07%). The lowest stem fly infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (3.33% stem tunneling) which was at par with Diafenthiuron 50% WP (3.67%). The highest stem fly infestation was recorded in *Beauveria bassiana* @1000ml/ha (8.07%).

Three days after spraying, the stem fly infestation ranged from 0.40% to 7.73% stem tunneling against control (22.33%). The lowest stem fly infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (0.40% stem tunneling) which was followed by Diafenthiuron 50% WP (2.33%) which was par with Chlorantraniliprole 18.5% SC (3.33%). The highest stem fly infestation was recorded in *Beauveria bassiana* @1000ml/ha (7.73%).

Seven days after spraying, the stem fly infestation ranged from 0.27% to 6.73% stem tunneling against control (24.00%). The lowest stem fly infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (0.27% stem tunneling) which was followed by Diafenthiuron 50% WP (1.27%). The highest stem fly infestation was recorded in *Beauveria bassiana* @1000ml/ha (6.73%).

Fourteen days after spraying, the stem fly infestation ranged from 0.33% to 7.40% stem tunneling against control (25.93%). The lowest stem fly infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (0.33% stem tunneling) which was followed by Diafenthiuron 50% WP (1.93%). The highest stem fly infestation was recorded in *Beauveria bassiana* @1000ml/ha (7.40%) which is at par with Chlorantraniliprole 18.5% SC+ *Beauvaria bassiana @ 10+1000ml/ha* (6.67%).

Table 4.4. Effect of insecticides on stem fly population (percent stem tunneling) in soybean.

TREATMENTS	First spray					Second spray				Mean
	1 DBS	1 DAS	3 DAS	7 DAS	14 DAS	1 DAS	3 DAS	7 DAS	14 DAS	
Flubendiamide 39.35% SC @ 150ml/ha	14.00 (21.97)*	14.80 (22.63)*	6.73 (15.04)*	6.60 (14.89)*	7.07 (15.42)*	6.33 (14.58)*	6.27 (14.50)*	4.67 (12.48)*	5.33 (13.35)*	7.98 (16.41)*
Flubendiamide 39.35% SC @ 200ml/ha	15.33 (23.05)*	14.67 (22.52)*	6.00 (14.18)*	5.87 (14.02)*	6.53 (14.81)*	5.67 (13.77)*	5.67 (13.77)*	4.07 (11.63)*	4.73 (12.57)*	7.58 (15.98)*
Flubendiamide 39.35% SC @ 300ml/ha	14.33 (22.25)*	14.00 (21.97)*	5.73 (13.85)*	5.60 (13.69)*	6.27 (14.50)*	5.40 (13.44)*	4.67 (12.48)*	3.80 (11.24)*	4.47 (12.20)*	7.14 (15.50)*
Spinetoram 11.7% SC @ 450ml/ha	14.67 (22.52)*	14.93 (22.73)*	7.27 (15.64)*	7.13 (15.49)*	7.73 (16.15)*	6.87 (15.19)*	6.60 (14.89)*	4.93 (12.83)*	5.60 (13.69)*	8.38 (16.82)*
Thiamethoxam 12.6% + Lambda cyhalothrin9.5% ZC @ 125ml/ha	15.00 (22.79)*	12.33 (20.56)*	3.80 (11.24)*	3.67 (11.04)*	4.07 (11.63)*	3.33 (10.52)*	0.40 (3.63)*	0.27 (2.96)*	0.33 (3.31)*	4.80 (12.66)*
Chlorantraniliprole 18.5% SC @ 100ml/ha	16.00 (23.58)*	13.60 (21.64)*	4.53 (12.29)*	4.40 (12.11)*	5.00 (12.92)*	4.27 (11.92)*	3.33 (10.52)*	2.13 (8.40)*	2.80 (9.63)*	6.19 (14.41)*
Chlorantraniliprole 18.5% SC+ *Beauvaria bassiana @ 10+1000ml/ha*	13.67 (21.70)*	15.00 (22.79)*	7.80 (16.22)*	7.60 (16.00)*	8.00 (16.43)*	7.33 (15.71)*	7.00 (15.34)*	6.00 (14.18)*	6.67 (14.96)*	8.82 (17.28)*
Beauvaria bassiana @ 1000ml/ha	15.67 (23.32)*	15.07 (22.84)*	8.60 (17.05)*	8.40 (16.85)*	8.80 (17.26)*	8.07 (16.50)*	7.73 (16.15)*	6.73 (15.04)*	7.40 (15.79)*	9.57 (18.02)*
Bifenthrin 10% EC @ 800ml/ha	15.67 (23.32)*	13.93 (21.92)*	5.00 (12.92)*	4.80 (12.66)*	5.27 (13.27)*	4.53 (12.29)*	4.13 (11.73)*	3.13 (10.20)*	3.80 (11.24)*	6.62 (14.91)*
Diafenthiuron 50% WP @600ml/ha	14.67 (22.52)*	12.67 (20.85)*	4.13 (11.73)*	4.00 (11.54)*	4.40 (12.11)*	3.67 (11.04)*	2.33 (8.79)*	1.27 (6.46)*	1.93 (7.99)*	5.45 (13.50)*
Untreated control	15.00 (22.79)*	15.27 (23.00)*	15.93 (23.53)*	19.93 (22.73)*	16.41 (23.90)*	21.07 (23.63)*	22.33 (23.84)*	24.00 (24.35)*	25.93 (26.05)*	16.42 (23.90)*
SEM	**0.393**	**0.318**	**0.233**	**0.204**	**0.394**	**0.253**	**0.428**	**0.247**	**0.428**	**0.697**
CD at ±5%	**NS**	**0.945**	**0.692**	**0.605**	**1.169**	**0.752**	**1.271**	**0.735**	**1.271**	**1.965**

figures in parenthesis ( )* are arc sine transformation values.

4.2.1.3: Mean stem fly population:

The mean stem fly infestation of the two sprays showed that Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC recorded the lowest infestation with 4.8% stem tunneling which was followed by Diafenthiuron 50% WP (5.45%). The highest stem fly infestation was recorded in *Beauveria bassiana* @1000ml/ha (9.57%) which was at par with Chlorantraniliprole 18.5% SC + *Beauveria bassiana* (8.82%) and Spinetoram 11.7% SC (8.38%).

4.2.2 Effect of insecticides on girdle beetle population:

4.2.2.1: First spray:

One day before spraying, the girdle beetle infestation ranged from 8% to 9.33%. Where there was no significant difference among the treatments.

One day after spraying, the girdle beetle infestation ranged from 5.07% to 8.80% plant infestation against control (9.27%). The lowest girdle beetle infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (5.07%) which was at par with Diafenthiuron 50% WP (5.47%) and Chlorantraniliprole 18.5% SC (5.47%). The highest girdle beetle infestation was recorded in *Beauveria bassiana* @1000ml/ha (8.80%).

Three days after spraying, the girdle beetle infestation ranged from 4.73% to 8.40% against control (10.00%). The lowest girdle beetle infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (4.73%) which was at par with Diafenthiuron 50% WP (5.13%). The highest girdle beetle infestation was recorded in *Beauveria bassiana* @1000ml/ha (8.40%) which was at par with Chlorantraniliprole 18.5% SC + *Beauveria bassiana* @1000ml/ha (7.93).

Seven days after spraying, the girdle beetle infestation ranged from 4.20% to 8.80% plant infestation against control (12%). The lowest girdle beetle infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (4.20%). The highest girdle beetle infestation was recorded in *Beauveria bassiana* @1000ml/ha (8.80%).

Fourteen days after spraying, the girdle beetle infestation ranged from 3.93% to 8.67% plant infestation against control (10.07%). The lowest girdle beetle infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (3.93%). The highest girdle beetle infestation was recorded in *Beauveria bassiana* @1000ml/ha (8.67%).

4.2.2.2: Second spray:

One day after spraying, the girdle beetle infestation ranged from 3.87% to 8.60% plant infestation against control (10.13%). The lowest girdle beetle infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (3.87%) which was followed by Diafenthiuron 50% WP (4.40%). The highest girdle beetle infestation was recorded in *Beauveria bassiana* @1000ml/ha (8.60%).

Three days after spraying, the girdle beetle infestation ranged from 1.60% to 7.93% against control (11.13%). The lowest girdle beetle infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (1.60%) which was followed by Difenthiuron 50% WP (2.07%). The highest girdle beetle infestation was recorded in *Beauveria bassiana* @1000ml/ha (7.93%).

Seven days after spraying, the girdle beetle infestation ranged from 1.47% to 7.73% plant infestation against control (12.00%). The lowest girdle beetle infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (1.47%) which was at par with Diafenthiuron 50% WP (1.93%). The highest girdle beetle infestation was recorded in *Beauveria bassiana* @1000ml/ha (7.73%).

Fourteen days after spraying, the girdle beetle infestation ranged from 1.20% to 7.07% plant infestation against control (14.33%). The lowest girdle beetle infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (1.20%) which was followed by Diafenthiuron 50% WP (1.60%). The highest girdle beetle infestation was recorded in *Beauveria bassiana* @1000ml/ha (7.07%).

4.2.2.3: Mean:

The mean girdle beetle infestation of the two sprays showed that Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC recorded the lowest infestation with 3.81% plant infestation which was at par with Diafenthiuron 50% WP (4.32%). The highest girdle beetle infestation was recorded in *Beauveria bassiana* @1000ml/ha (8.26%).

TITLE 4.5: Effect of insecticides on girdle beetle population (per cent plant infestation) in soybean.

TREATMENTS	First spray					Second spray				Mean
	1 DBS	**1 DAS**	**3 DAS**	**7 DAS**	**14 DAS**	**1 DAS**	**3 DAS**	**7 DAS**	**14 DAS**	
Flubendiamide 39.35% SC @ 150ml/ha	8.27 (16.71)*	7.00 (15.34)*	6.93 (15.27)*	6.33 (14.58)*	5.93 (14.10)*	5.87 (14.02)*	5.27 (13.27)*	5.07 (13.01)*	4.93 (12.83)*	6.18 (14.39)*
Flubendiamide 39.35% SC @ 200ml/ha	8.33 (16.78)*	6.67 (14.96)*	6.27 (14.50)*	6.00 (14.18)*	5.87 (14.02)*	5.80 (13.94)*	5.20 (13.18)*	5.00 (12.92)*	4.73 (12.57)*	5.99 (14.16)*
Flubendiamide 39.35% SC @ 300ml/ha	8.13 (16.57)*	6.47 (14.73)*	6.07 (14.26)*	5.67 (13.77)*	5.33 (13.35)*	5.27 (13.27)*	4.27 (11.92)*	4.07 (11.63)*	3.93 (11.44)*	5.47 (13.52)*
Spinetoram 11.7% SC @ 450ml/ha	8.47 (16.92)*	7.40 (15.79)*	7.20 (15.56)*	7.13 (15.49)*	7.00 (15.34)*	6.93 (15.27)*	6.27 (14.50)*	6.07 (14.26)*	5.80 (13.94)*	6.92 (15.25)*
Thiamethoxam 12.6% + Lambda cyhalothrin9.5% ZC @ 125ml/ha	8.20 (16.64)*	5.07 (13.01)*	4.73 (12.57)*	4.20 (11.83)*	3.93 (11.44)*	3.87 (11.34)*	1.60 (7.27)*	1.47 (6.96)*	1.20 (6.29)*	3.81 (11.25)*
Chlorantraniliprole 18.5% SC @ 100ml/ha	8.40 (16.85)*	5.67 (13.77)*	5.47 (13.52)*	5.07 (13.01)*	4.93 (12.83)*	4.87 (12.74)*	3.53 (10.83)*	3.40 (10.63)*	3.00 (9.97)*	4.93 (12.82)*
Chlorantraniliprole 18.5% SC+ *Beauvaria bassiana @ 10+1000ml/ha*	8.00 (16.43)*	8.00 (16.43)*	7.93 (16.36)*	7.33 (15.71)*	7.07 (15.42)*	7.00 (15.34)*	6.00 (14.18)*	5.93 (14.10)*	5.87 (14.02)*	7.01 (15.36)*
Beauvaria bassiana @ 1000ml/ha	8.33 (16.78)*	8.80 (17.26)*	8.40 (16.85)*	8.80 (17.26)*	8.67 (17.12)*	8.60 (17.05)*	7.93 (16.36)*	7.73 (16.15)*	7.07 (15.42)*	8.26 (16.70)*
Bifenthrin 10% EC @ 800ml/ha	9.33 (17.79)*	6.13 (14.34)*	6.00 (14.18)*	5.33 (13.35)*	5.00 (12.92)*	4.93 (12.83)*	4.13 (11.73)*	4.00 (11.54)*	3.87 (11.34)*	5.41 (13.46)*
Diafenthiuron 50% WP @600ml/ha	9.00 (17.46)*	5.47 (13.52)*	5.13 (13.10)*	4.80 (12.66)*	4.47 (12.20)*	4.40 (12.11)*	2.07 (8.27)*	1.93 (7.99)*	1.60 (7.27)*	4.32 (11.99)*
Untreated control	9.00 (17.46)*	9.27 (17.72)*	10.00 (18.43)*	10.03 (18.45)*	10.07 (18.50)*	10.13 (18.56)*	11.13 (19.49)*	12.00 (20.27)*	14.33 (22.25)*	10.66 (19.06)*
SEM	**0.340**	**0.259**	**0.246**	**0.243**	**0.182**	**0.193**	**0.311**	**0.294**	**0.269**	**0.449**
CD at ±5%	**NS**	**0.769**	**0.730**	**0.722**	**0.540**	**0.573**	**0.924**	**0.873**	**0.798**	**1.266**

figures in parenthesis ()* are arc sine transformation value.

4.2.3 Effect of insecticides on whitefly population:

4.2.3.1: First spray:

One day before spraying, the whitefly population ranged from 53.67 to 56.67. Where there was no significant difference among the treatments.

One day after spraying, the whitefly population ranged from 48.67 to 56.33 adults/nymphs per plant against control (55.33). The lowest whitefly population was recorded in the treatment Spinetoram 11.7% SC (48.67) which was at par with Diafenthiuron 50% WP (49.67) and Thiamethoxam 12.6% + Lambda cyhalothrin9.5% ZC (50.33). The highest population was recorded in *Beauvaria bassiana* (56.33) which was at par with Chlorantraniliprole 18.5% SC (54.00), Flubendiamide 39.35% SC @ 200ml/ha (53.00) and flubendiamide 39.35% SC @150ml/ha (52.67).

Three days after spraying, the whitefly population ranged from 30 to 55 adults/nymphs per plant against control (58.67). The lowest whitefly population was recorded in the treatment Spinetoram 11.7% SC (30) which was followed by Diafenthiuron 50% WP (34.33). The highest whitefly population was recorded in *Beauveria bassiana* @1000ml/ha (55.00).

Seven days after spraying, the whitefly population ranged from 28.33 to 54.33 adults/nymphs per plant against control (63.33). The lowest whitefly population was recorded in the treatment Spinetoram 17.8% SC (28.33) which was at par with Diafenthiuron 50% WP (31.33). The highest whitefly population was recorded in *Beauveria bassiana* @1000ml/ha (54.33) which was at par with Chlorantraniliprole 18.5% SC + *Beauveria bassiana* @ 1000ml/ha (51.67), Chlorantraniliprole 18.5% SC (50.33) and Flubendiamide 39.35% SC @150ml/ha (48).

Fourteen days after spraying, the whitefly population ranged from 29.33 to 55.33 adults/nymphs per plant against control (66). The lowest whitefly population was recorded in the treatment Spinetoram 17.8% SC (29.33) which was at par with Diafenthiuron 50% WP (32.33). The highest whitefly population was recorded in *Beauveria bassiana* @1000ml/ha (55.33) was at par with Chlorantraniliprole 18.5% SC + *Beauveria bassiana* @ 1000ml/ha (52.67), Chlorantraniliprole 18.5% SC (51.33).

4.2.3.2: Second spray:

One day after spraying, the whitefly population ranged from 29 to 55 adults/nymphs per plant against control (70.33). The lowest whitefly population was recorded in the treatment Spinetoram 17.8% SC (29) followed by Diafenthiuron 50% WP (32.00). The highest whitefly population was recorded in *Beauveria bassiana* @1000ml/ha (55.00).

Three days after spraying, the whitefly population ranged from 20.33 to 51.33 adults/nymphs per plant against control (75.00). The lowest whitefly population was recorded in the treatment Spinetoram 17.8% SC (20.33) which was followed by Diafenthiuron 50% WP (22.67). The highest whitefly population was recorded in *Beauveria bassiana* @1000ml/ha (51.33).

Seven days after spraying, the whitefly population ranged from 19.67 to 50.67 adults/nymphs per plant against control (78.00). The lowest whitefly population was recorded in the treatment Spinetoram 17.8% SC (19.67) which was followed by Diafenthiuron 50% WP (22.00). The highest whitefly population was recorded in *Beauveria bassiana* @1000ml/ha (50.67).

Fourteen days after spraying, the whitefly population ranged from 23 to 52.33 adults/nymphs per plant against control (80.33). The lowest whitefly population was recorded in the treatment Spinetoram 17.8% SC (23) which was followed by Diafenthiuron 50% WP (26.33). The highest whitefly population was recorded in *Beauveria bassiana* @1000ml/ha (52.33).

4.2.3.3: Mean:

The mean whitefly population ranged from 31.37 to 54.11 adults/nymphs per plant against control (66.89 adults/nymphs per plant). The overall effect of the two sprays showed that the lowest population was recorded in Spinetoram 11.7% SC (31.37 adults/nymphs per plant) which was at par with Diafenthiuron 50% WP (33.74 adults/nymphs per plant). While, the highest whitefly population was recorded in *Beauveria bassiana* @ 1000ml/ha (54.11 adults/nymphs per plant) which was at par with Chlorantraniliprole 18.5% SC+ *Beauveria bassiana* @ 1000ml/ha (51.41), Chlorantraniliprole 18.5% SC (50.22 adults/nymphs per plant).

Table 4.6: Effect of insecticides on whitefly population (whiteflies/plant) in soybean.

TREATMENTS	First spray					Second spray				Mean
	1 DBS	**1 DAS**	**3 DAS**	**7 DAS**	**14 DAS**	**1 DAS**	**3 DAS**	**7 DAS**	**14 DAS**	
Flubendiamide 39.35% SC @ 150ml/ha	53.67 (7.36)	52.67 (7.29)	50.67 (7.15)	48.00 (6.96)	49.00 (7.04)	48.67 (7.01)	42.00 (6.52)	41.33 (6.47)	43.00 (6.60)	47.67 (6.94)
Flubendiamide 39.35% SC @ 200ml/ha	54.33 (7.40)	53.00 (7.31)	46.33 (6.84)	43.33 (6.62)	44.33 (6.70)	44.00 (6.67)	38.00 (6.20)	37.33 (6.15)	39.00 (6.28)	44.41 (6.70)
Flubendiamide 39.35% SC @ 300ml/ha	53.33 (7.34)	52.33 (7.27)	44.33 (6.70)	40.67 (6.42)	41.67 (6.49)	41.33 (6.47)	30.00 (5.52)	29.33 (5.46)	30.67 (5.58)	40.41 (6.40)
Spinetoram 11.7% SC @ 450ml/ha	54.00 (7.38)	48.67 (7.01)	30.00 (5.52)	28.33 (5.37)	29.33 (5.46)	29.00 (5.43)	20.33 (4.56)	19.67 (4.49)	23.00 (4.85)	31.37 (5.65)
Thiamethoxam 12.6% + Lambda cyhalothrin9.5% ZC @ 125ml/ha	54.67 (7.43)	50.33 (7.13)	38.33 (6.23)	34.00 (5.87)	35.00 (5.96)	34.67 (5.93)	26.00 (5.15)	25.33 (5.08)	28.00 (5.34)	36.26 (6.06)
Chlorantraniliprole 18.5% SC @ 100ml/ha	55.00 (7.45)	54.00 (7.38)	52.00 (7.25)	50.33 (7.13)	51.33 (7.20)	51.00 (7.18)	46.00 (6.82)	45.33 (6.77)	47.00 (6.89)	50.22 (7.12)
Chlorantraniliprole 18.5% SC+ *Beauvaria bassiana @ 10+1000ml/ha*	55.33 (7.47)	54.33 (7.40)	52.33 (7.27)	51.67 (7.22)	52.67 (7.29)	52.33 (7.27)	47.67 (6.94)	47.00 (6.89)	49.33 (7.06)	51.41 (7.20)
Beauvaria bassiana @ 1000ml/ha	56.67 (7.56)	56.33 (7.54)	55.00 (7.45)	54.33 (7.40)	55.33 (7.47)	55.00 (7.45)	51.33 (7.20)	50.67 (7.15)	52.33 (7.27)	54.11 (7.39)
Bifenthrin 10% EC @ 800ml/ha	54.33 (7.40)	52.33 (7.27)	40.67 (6.42)	37.33 (6.15)	38.33 (6.23)	38.00 (6.20)	28.67 (5.40)	28.00 (5.34)	30.00 (5.52)	38.63 (6.26)
Diafenthiuron 50% WP @600ml/ha	53.00 (7.31)	49.67 (7.08)	34.33 (5.90)	31.33 (5.64)	32.33 (5.73)	32.00 (5.70)	22.67 (4.81)	22.00 (4.74)	26.33 (5.18)	33.74 (5.85)
Untreated control	55.00 (7.45)	55.33 (7.47)	58.67 (7.69)	63.33 (7.99)	66.00 (8.15)	70.33 (8.42)	75.00 (8.69)	78.00 (8.86)	80.33 (8.99)	66.89 (8.21)
SEM	**0.055**	**0.086**	**0.072**	**0.154**	**0.138**	**0.133**	**0.130**	**0.153**	**0.069**	**0.153**
CD at ±5%	**NS**	**0.256**	**0.214**	**0.457**	**0.411**	**0.396**	**0.387**	**0.426**	**0.205**	**0.432**

figures in parenthesis () are square root transformation values.

4.2.4 Effect of insecticides on semilooper population:

4.2.4.1: First spray:

One day before spraying, the semilooper population ranged from 3.00 to 4.00 larvae per meter row length. Where there was no significant difference among the treatments.

One day after spraying, the semilooper population ranged from 2.33 to 3.67 larvae per meter row length against control (5.33). The lowest semilooper population was recorded in the treatment flubendiamide 39.35% SC @ 300ml/ha (2.33 larvae per meter row length) which was at par with flubendiamide 39.35% SC @200ml/ha (2.73). The highest semilooper population was recorded in *Beauveria bassiana* (3.73 larvae per meter row length) which was at par with bifenthrin 10% (3.53 larvae per meter row length), diafenthiuron 50 WP (3.60 larvae/mrl) and chlorantraniliprole 18 SC + *Beauveria bassiana* (3.47).

Three days after spraying, the semilooper population ranged from 1.23 to 2.36 larvae per meter row length against control (6.00). The lowest semilooper population was recorded in the treatment flubendiamide 39.35% SC @300ml/ha (1.23 larvae per meter row length). The highest semilooper population was recorded in *Beauveria bassiana* @1000ml/ha (2.36 larvae per meter row length).

Seven days after spraying, the semilooper population ranged from 1.13 to 1.91 larvae per meter row length against control (7.67). The lowest semilooper population was recorded in the treatment flubendiamide 39.35% SC @300ml/ha (1.13 larvae per meter row length) which was at par with flubendiamide 39.35% SC (1.27) and flubendiamide 39.35% SC (1.37). The highest semilooper population was recorded in *Beauveria bassiana* @1000ml/ha (1.91 larvae per meter row length) which is at par with Diafenthiuron 50% WP (1.80 larvae per meter row length).

Fourteen days after spraying, the semilooper population ranged from 1.00 to 2.57 larvae per meter row length against control (8.33). The lowest semilooper population was recorded in the treatment flubendiamide 39.35% SC @300ml/ha (1.00 larvae per meter row length) followed by flubendiamide 39.35% SC applied at 200ml/l (1.30). The highest semilooper population was recorded in *Beauveria bassiana* @1000ml/ha (2.57 larvae per meter row length) which was at par with diafenthiuron 50% WP (2.33).

4.2.4.2: Second spray:

One day after spraying, the semilooper population ranged from 0.93 to 1.83 larvae per meter row length against control (8.93). The lowest semilooper population was recorded in the treatment flubendiamide 39.35% SC @300ml/ha (0.93 larvae per meter row length) which was at par with flubendiamide 39.35% SC @200ml/l (1.24) and flubendiamide 39.35% SC (1.29). The highest semilooper population was recorded in *Beauveria bassiana* @1000ml/ha (1.83 larvae per meter row length) which was at par with all the other remaining treatments.

Three days after spraying, the semilooper population ranged from 0.63 to 1.80 larvae per meter row length against control (11.00). The lowest semilooper population was recorded in the treatment flubendiamide 39.35% SC @300ml/ha (0.63 larvae per meter row length) which was at par with flubendiamide 39.35% SC @ 200ml/l (0.84) and flubendiamide 39.35% SC @ 150ml/l (1.08 larvae per meter row length). The highest semilooper population was recorded in *Beauveria bassiana* @1000ml/ha (1.80 larvae per meter row length) which is at par with Diafenthiuron 50% WP (1.72 larvae per meter row length), chlorantraniliprole + *B. bassiana* (1.52) and bifenthrin (1.47 larvae per meter row length).

Seven days after spraying, the semilooper population ranged from 0.25 to 1.67 larvae per meter row length against control (12.00). The lowest semilooper population was recorded in the treatment flubendiamide 39.35% SC @300ml/ha (0.25 larvae per meter row length) followed by flubendiamide 39.35% SC @200ml/l (0.65) and flubendiamide 39.35% SC @150ml/l (0.84). The highest semilooper population was recorded in *Beauveria bassiana* @1000ml/ha (1.67 larvae per meter row length) which was at par with all other treatments.

Fourteen days after spraying, the semilooper population ranged from 0.32 to 1.73 larvae per meter row length against control (13.33 larvae per meter row length). The lowest semilooper population was recorded in the treatment flubendiamide 39.35% SC @300ml/ha (0.32 larvae per meter row length) which was at par with flubendiamide 39.35% SC @200ml/ha (0.72 larvae per meter row length). The highest semilooper population was recorded in *Beauveria bassiana* @1000ml/ha (1.73 larvae per meter row length) which was at par with all other treatments.

4.2.4.3: Mean:

The mean semilooper population ranged from 1.30 to 2.36 larvae per meter row length against control (8.53). The lowest semilooper population was recorded in the treatment flubendiamide 39.35% SC @300ml/ha (1.30). The highest semilooper population was recorded in *Beauveria bassiana* @1000ml/ha (2.36 per mrl).

Table 4.7: Effect of insecticides on semilooper population (larvae/ meter row length) in soybean.

TREATMENTS	First spray					Second spray				Mean
	1 DBS	**1 DAS**	**3 DAS**	**7 DAS**	**14 DAS**	**1 DAS**	**3 DAS**	**7 DAS**	**14 DAS**	
Flubendiamide 39.35% SC @ 150ml/ha	3.40 (1.97)	2.80 (1.82)	1.57 (1.44)	1.37 (1.37)	1.39 (1.37)	1.29 (1.34)	1.08 (1.26)	0.84 (1.16)	0.91 (1.19)	1.63 (1.46)
Flubendiamide 39.35% SC @ 200ml/ha	3.53 (2.01)	2.73 (1.80)	1.40 (1.38)	1.27 (1.33)	1.30 (1.35)	1.24 (1.32)	0.84 (1.16)	0.65 (1.07)	0.72 (1.10)	1.52 (1.42)
Flubendiamide 39.35% SC @ 300ml/ha	3.87 (2.09)	2.33 (1.68)	1.23 (1.31)	1.13 (1.28)	1.00 (1.22)	0.93 (1.20)	0.63 (1.06)	0.25 (0.87)	0.32 (0.91)	1.30 (1.34)
Spinetoram 11.7% SC @ 450ml/ha	3.27 (1.94)	2.93 (1.85)	1.85 (1.53)	1.59 (1.44)	1.96 (1.57)	1.47 (1.40)	1.33 (1.35)	1.25 (1.32)	1.30 (1.34)	1.88 (1.54)
Thiamethoxam 12.6% + Lambda cyhalothrin9.5% ZC @ 125ml/ha	3.00 (1.87)	2.93 (1.85)	1.63 (1.46)	1.43 (1.39)	1.75 (1.50)	1.32 (1.35)	1.13 (1.28)	1.00 (1.22)	1.13 (1.28)	1.70 (1.48)
Chlorantraniliprole 18.5% SC @ 100ml/ha	3.17 (1.91)	3.00 (1.87)	1.79 (1.51)	1.51 (1.42)	1.91 (1.55)	1.43 (1.39)	1.33 (1.35)	1.29 (1.34)	1.36 (1.36)	1.86 (1.54)
Chlorantraniliprole 18.5% SC+ *Beauvaria bassiana @ 10+1000ml/ha*	3.67 (2.04)	3.40 (1.97)	1.96 (1.57)	1.65 (1.47)	2.09 (1.61)	1.56 (1.44)	1.52 (1.42)	1.27 (1.33)	1.33 (1.35)	2.05 (1.60)
Beauvaria bassiana @ 1000ml/ha	3.73 (2.06)	3.67 (2.04)	2.36 (1.69)	1.91 (1.55)	2.57 (1.75)	1.83 (1.53)	1.80 (1.52)	1.67 (1.47)	1.73 (1.49)	2.36 (1.69)
Bifenthrin 10% EC @ 800ml/ha	4.00 (2.12)	3.53 (2.01)	2.04 (1.59)	1.67 (1.47)	2.13 (1.62)	1.59 (1.44)	1.47 (1.40)	1.33 (1.35)	1.40 (1.38)	2.13 (1.62)
Diafenthiuron 50% WP @600ml/ha	3.93 (2.11)	3.60 (2.02)	2.20 (1.64)	1.80 (1.52)	2.33 (1.68)	1.72 (1.49)	1.67 (1.47)	1.53 (1.43)	1.60 (1.45)	2.27 (1.66)
Untreated control	4.17 (2.16)	5.33 (2.42)	6.00 (2.55)	7.67 (2.86)	8.33 (2.97)	8.93 (3.07)	11.00 (3.39)	12.00 (3.54)	13.33 (3.72)	8.53 (3.00)
SEM	**0.096**	**0.060**	**0.006**	**0.056**	**0.038**	**0.058**	**0.108**	**0.093**	**0.086**	**0.080**
CD at ±5%	**NS**	**0.179**	**0.018**	**0.166**	**0.112**	**0.172**	**0.321**	**0.277**	**0.255**	**0.227**

figures in parenthesis () are square root transformation values.

4.2.5 Effect of insecticides on defoliator (*Spodoptera litura*) population:

4.2.5.1: First spray on defoliator infestation:

One day before spraying, the defoliator (*Spodoptera litura*) infestation ranged from 13.67 % to 15.67 %. Where there was no significant difference among the treatments.

One day after spraying, the defoliator infestation ranged from 11.67 % to 14.60 % plant infestation against control (16.67 %). The lowest defoliator infestation was recorded in the treatment Flubendiamide 39.35 % SC @ 300 ml/ha (11.67 %). The highest defoliator infestation was recorded in *Beauveria bassiana* @1000 ml/ha (14.60 %) which is at par with Bifenthrin 10 % EC (14.47 %).

Three days after spraying, the defoliator infestation ranged from 5.53 % to 11.67 % against control (17.33 %). The lowest defoliator infestation was recorded in the treatment Flubendiamide 39.35% SC @ 300ml/ha (5.53 %). The highest defoliator infestation was recorded in *Beauveria bassiana* @ 1000 ml/ha (11.63 %).

Seven days after spraying, the defoliator infestation ranged from 5.27% to 11.53% plant infestation against control (18.00%). The lowest defoliator infestation was recorded in the treatment Flubendiamide 39.35 % SC @ 300ml/ha (5.27%). The highest defoliator infestation was recorded in *Beauveria bassiana* @1000ml/ha (11.53%).

Fourteen days after spraying, the defoliator infestation ranged from 5.73% to 11.87% plant infestation against control (20.00%). The lowest defoliator infestation was recorded in the treatment Flubendiamide 39.35% SC @300ml/ha (5.73%). The highest defoliator infestation was recorded in in *Beauveria bassiana* @1000ml/ha (11.87%).

4.2.5.2: Second spray on defoliator infestation:

One day after spraying, the defoliator infestation ranged from 5.13% to 11.40% plant infestation against control (20.13%). The lowest defoliator infestation was recorded in the treatment Flubendiamide 39.35% SC @300ml/ha (5.13%). The highest defoliator infestation was recorded in *Beauveria bassiana* @1000ml/ha (11.40%).

Three days after spraying, the defoliator infestation ranged from 3.33% to 9% against control (20.13%). The lowest defoliator infestation was recorded in the treatment Flubendiamide

39.35% SC @300ml/ha (3.33%). The highest defoliator infestation was recorded in *Beauveria bassiana* @1000ml/ha (9.00%).

Seven days after spraying, the defoliator infestation ranged from 3.07% to 8.73% plant infestation against control (22.00%). The lowest defoliator infestation was recorded in the treatment Flubendiamide 39.35% SC @300ml/ha (3.07%). The highest defoliator infestation was recorded in *Beauveria bassiana* @1000ml/ha (8.73%).

Fourteen days after spraying, the defoliator infestation ranged from 3.27% to 9.00% plant infestation against control (25.33%). The lowest defoliator infestation was recorded in the treatment Flubendiamide 39.35 % SC @ 300 ml/ha (3.27 %). The highest defoliator infestation was recorded in *Beauveria bassiana* @1000ml/ha (9.00%).

4.2.5.3: Mean on defoliator infestation:

The mean defoliator infestation of the two sprays showed that the defoliator infestation ranged from 6.37% to 11.39% against control (19.49%). But lowest defoliation was recorded in Flubendiamide 39.35% SC @300ml/ha (6.37%) treatments are at par with Flubendiamide 39.35% SC (7.44). The highest defoliator infestation was recorded in *Beauveria bassiana* @1000ml/ha (11.39%).

Table 4.8: Effect of insecticides on defoliator (*Spodoptera litura*) population (% defoliation) in soybean.

TREATMENTS	First spray					Second spray				Mean
	1 DBS	1 DAS	3 DAS	7 DAS	14 DAS	1 DAS	3 DAS	7 DAS	14 DAS	
Flubendiamide 39.35% SC @ 150ml/ha	14.67 (22.52)*	13.00 (21.13)*	7.47 (15.86)*	7.27 (15.64)*	7.47 (15.86)*	7.13 (15.49)*	5.53 (13.61)*	5.27 (13.27)*	5.60 (13.69)*	8.16 (16.59)*
Flubendiamide 39.35% SC @ 200ml/ha	13.67 (21.70)*	12.53 (20.73)*	6.93 (15.27)*	6.80 (15.12)*	7.13 (15.49)*	6.67 (14.96)*	4.47 (12.20)*	4.20 (11.83)*	4.60 (12.38)*	7.44 (15.83)*
Flubendiamide 39.35% SC @ 300ml/ha	14.33 (22.25)*	11.67 (19.97)*	5.53 (13.61)*	5.27 (13.27)*	5.73 (13.85)*	5.13 (13.10)*	3.33 (10.52)*	3.07 (10.09)*	3.27 (10.41)*	6.37 (14.62)*
Spinetoram 11.7% SC @ 450ml/ha	14.67 (22.52)*	13.93 (21.92)*	8.60 (17.05)*	8.40 (16.85)*	8.53 (16.98)*	8.27 (16.71)*	6.27 (14.50)*	6.00 (14.18)*	6.40 (14.65)*	9.01 (17.47)*
Thiamethoxam 12.6% + Lambda cyhalothrin9.5% ZC @ 125ml/ha	14.33 (22.25)*	13.00 (21.13)*	7.87 (16.29)*	7.80 (16.22)*	8.20 (16.64)*	7.67 (16.07)*	5.87 (14.02)*	5.60 (13.69)*	6.13 (14.34)*	8.50 (16.95)*
Chlorantraniliprole 18.5% SC @ 100ml/ha	14.33 (22.25)*	13.47 (21.53)*	8.27 (16.71)*	8.00 (16.43)*	8.33 (16.78)*	7.87 (16.29)*	6.00 (14.18)*	5.73 (13.85)*	6.07 (14.26)*	8.67 (17.13)*
Chlorantraniliprole 18.5% SC+ *Beauvaria bassiana @ 10+1000ml/ha*	14.67 (22.52)*	14.00 (21.97)*	9.00 (17.46)*	8.87 (17.32)*	9.20 (17.66)*	8.73 (17.19)*	6.93 (15.27)*	6.67 (14.96)*	7.00 (15.34)*	9.45 (17.90)*
Beauvaria bassiana @ 1000ml/ha	14.67 (22.52)*	14.60 (22.46)*	11.67 (19.97)*	11.53 (19.85)*	11.87 (20.15)*	11.40 (19.73)*	9.00 (17.46)*	8.73 (17.19)*	9.00 (17.46)*	11.39 (19.72)*
Bifenthrin 10% EC @ 800ml/ha	15.00 (22.79)*	14.47 (22.36)*	9.60 (18.05)*	9.40 (17.85)*	9.80 (18.24)*	9.27 (17.72)*	7.00 (15.34)*	6.73 (15.04)*	7.27 (15.64)*	9.84 (18.28)*
Diafenthiuron 50% WP @600ml/ha	13.67 (21.70)*	13.27 (21.36)*	10.67 (19.06)*	10.60 (19.00)*	10.93 (19.31)*	10.47 (18.88)*	7.53 (15.93)*	6.93 (15.27)*	7.67 (16.07)*	10.19 (18.62)*
Untreated control	15.67 (23.32)*	16.67 (24.09)*	17.33 (24.60)*	18.00 (25.10)*	20.00 (26.57)*	20.13 (26.66)*	20.27 (26.76)*	22.00 (27.97)*	25.33 (30.22)*	19.49 (26.20)*
SEM	**0.542**	**0.718**	**0.254**	**0.142**	**0.208**	**0.157**	**0.455**	**0.473**	**0.406**	**0.555**
CD at ±5%	**NS**	**0.112**	**0.753**	**0.423**	**0.617**	**0.465**	**1.352**	**1.405**	**1.205**	**1.564**

figures in parenthesis ()* are arc sine transformation values.

4.3 Cost Economics

The highest grain yield was observed in the treatment thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC with 1406.7 kg per hectare followed by diafenthiuron 50% WP (1356.7 kg/ha). The lowest yield was recorded in 1155.3 kg/ha in the treatment *Beauveria bassiana* compared to control (1100 kg/ha). The cost economics of using newer insecticides against pests of soybean are presented in the table 11. The best performing among the treatments was thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC which showed costs of 14,237.50/- and a B:C ratio of 6.32:1, followed by Chlorantraniliprole 18.5% SC with costs of 15,450/- and a B:C ratio of 4.81:1 showing that these two are lucrative treatments. At the same time though diafenthiuron 50% WP yield was higher than Chlorantraniliprole (1346.4 kg/ha) it showed a B: C ratios of 3.64:1. While, *Beauveria bassiana* showed the least B: C ratio 0.29:1 proving that the returns with these treatments are not so profitable.

Table 4.9: Incremental cost-benefit ratio

Treatments	Grain yield (kg/ha)	Increased yield over control	Value of increased yield (340rs/q)	Cost of treatment (Cost of cultivation + cost of plant protection)	Net return	Benefit cost ratio
Flubendiamide 39.35% SC @ 150ml/ha	1248.70	148.70	50,558	17,315	33,243	**1.92:1**
Flubendiamide 39.35% SC @ 200ml/ha	1300.00	200.00	68,000	17,420	50,580	**2.90:1**
Flubendiamide 39.35% SC @ 300ml/ha	1312.30	212.30	72,182	20,630	51,552	**2.49:1**
Spinetoram 11.7% SC @ 450ml/ha	1210.00	110.00	37,400	18,573.60	18,826.4	**1.01:1**
Thiamethoxam 12.6% + Lambda cyhalothrin9.5% ZC @ 125ml/ha	1406.70	306.70	1,04,278	14,237.5	90,041	**6.32:1**
Chlorantraniliprole 18.5% SC @ 100ml/ha	1346.40	246.40	89,896	15,450	74,446	**4.81:1**
Chlorantraniliprole 18.5% SC+ *Beauvaria bassiana @ 10+1000ml/ha*	1200.00	100.00	34,000	14,644	19,356	**1.32:1**
Beauvaria bassiana @ 1000 ml/ha	1155.30	55.30	18,802	14,499	4,303	**0.29:1**
Bifenthrin 10% EC @ 800ml/ha	1328.70	228.70	77,758	14,926.4	62,831.6	**4.20:1**
Diafenthiuron 50% WP @600ml/ha	1356.70	256.70	87,278	18,800	68,478	**3.64:1**
Untreated control	1100.00	**-**	**-**	14,000	-	**-**

Cost of cultivation = 14,00

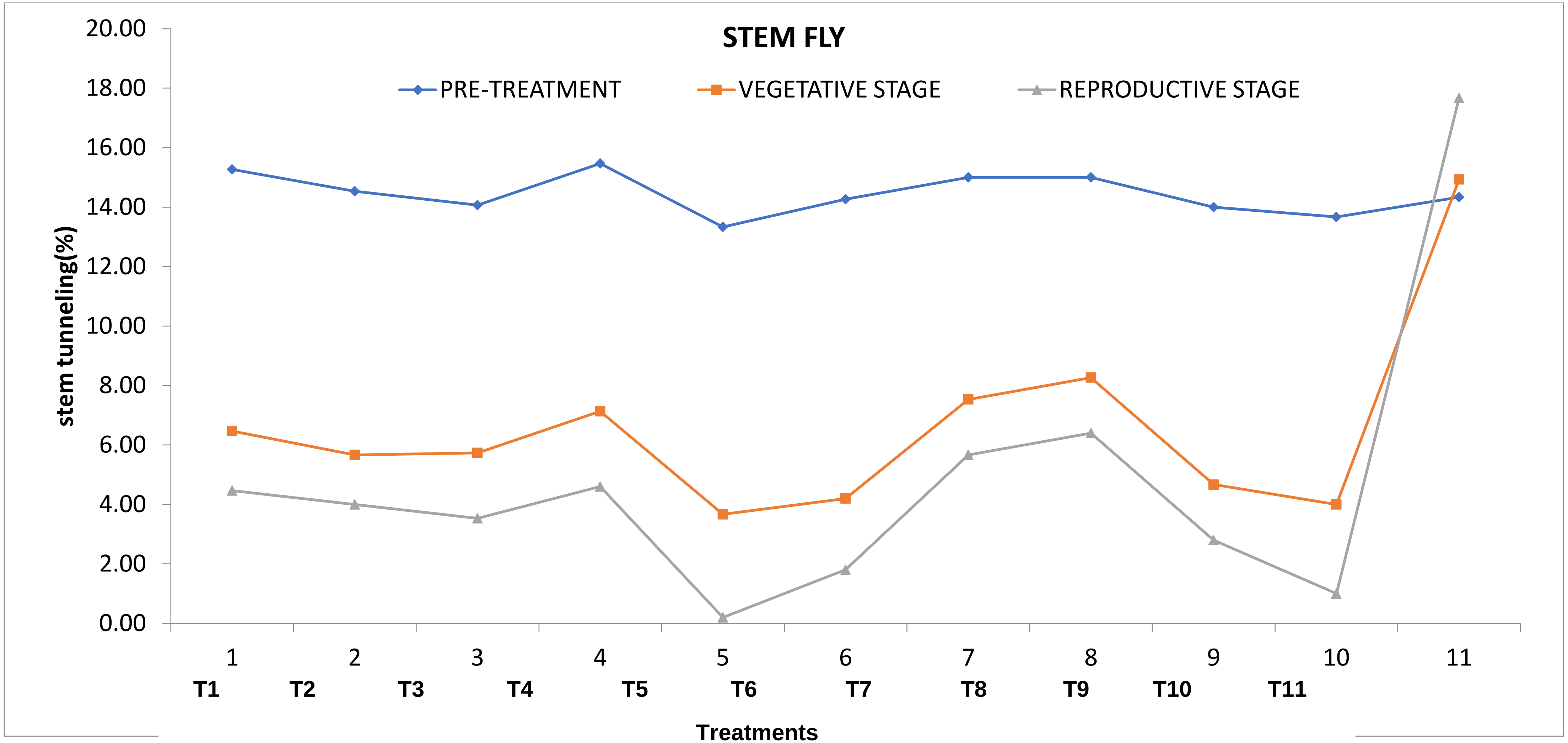

Fig 4.1: Effect of insecticides on stem fly population in two crop stages of soybean

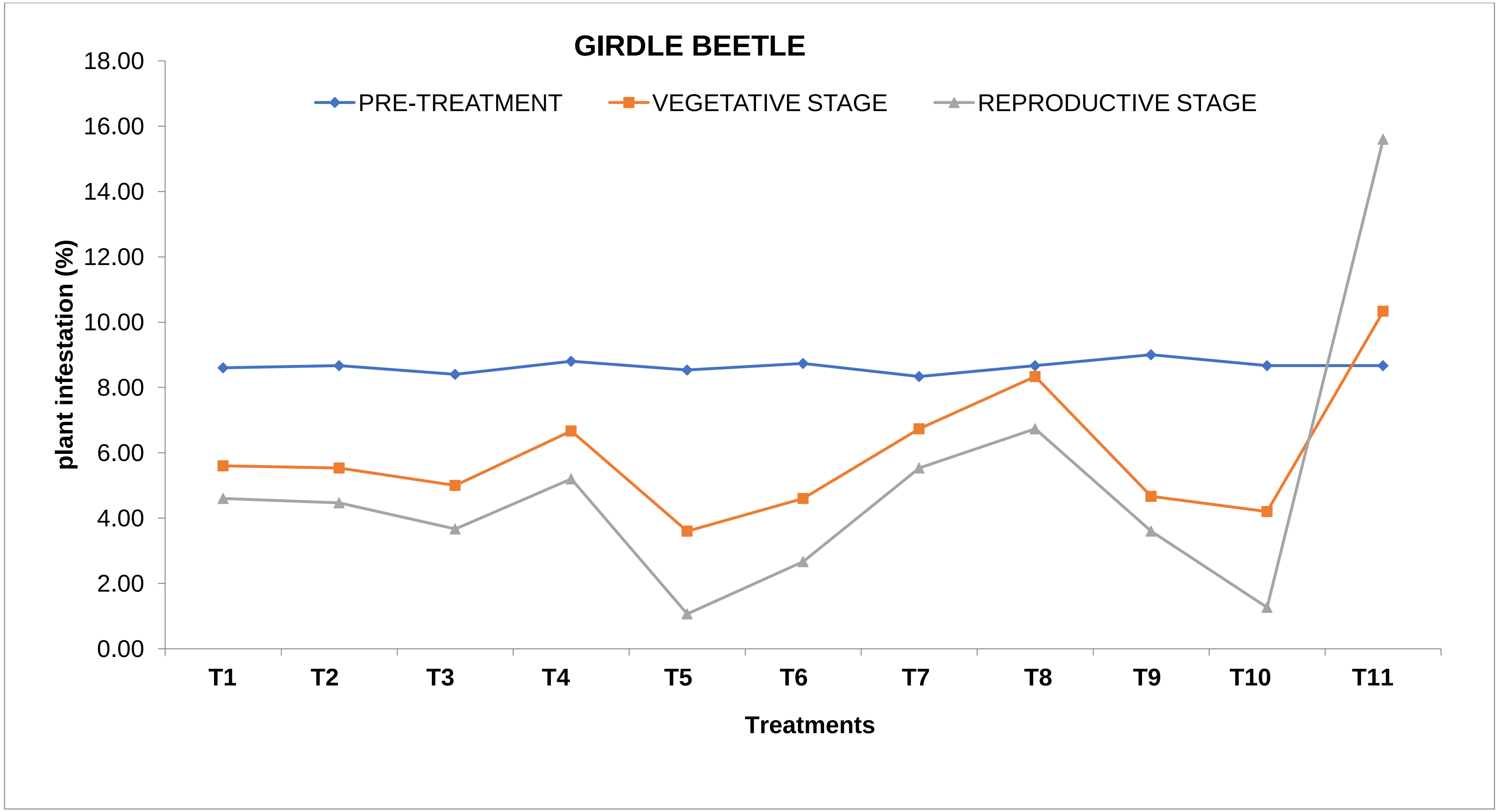

Fig 4.2: Effect of insecticides on girdle beetle population in two crop stages of soybean

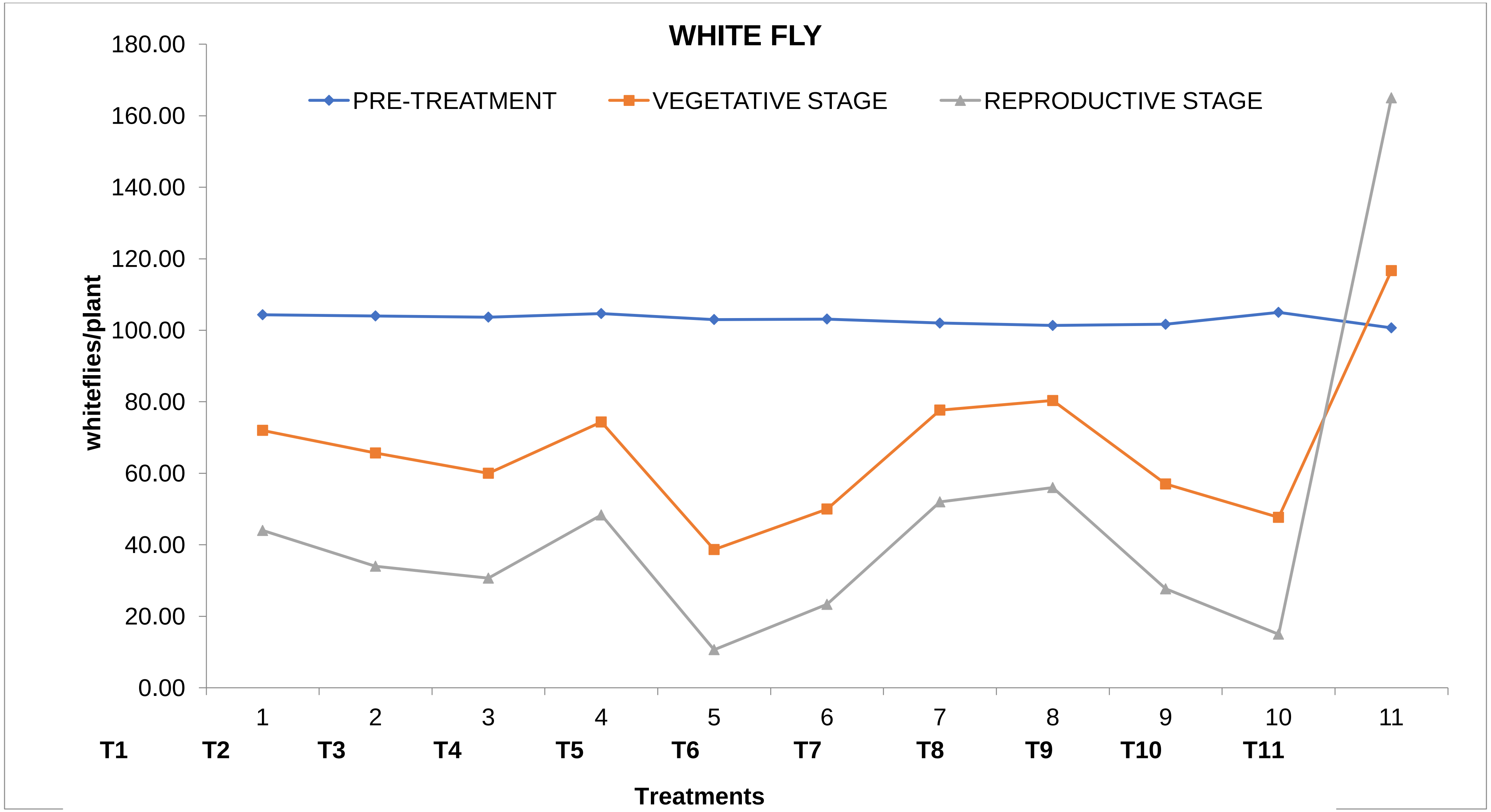

Fig4. 3: Effect of insecticides on whitefly population in two crop stages of soybean

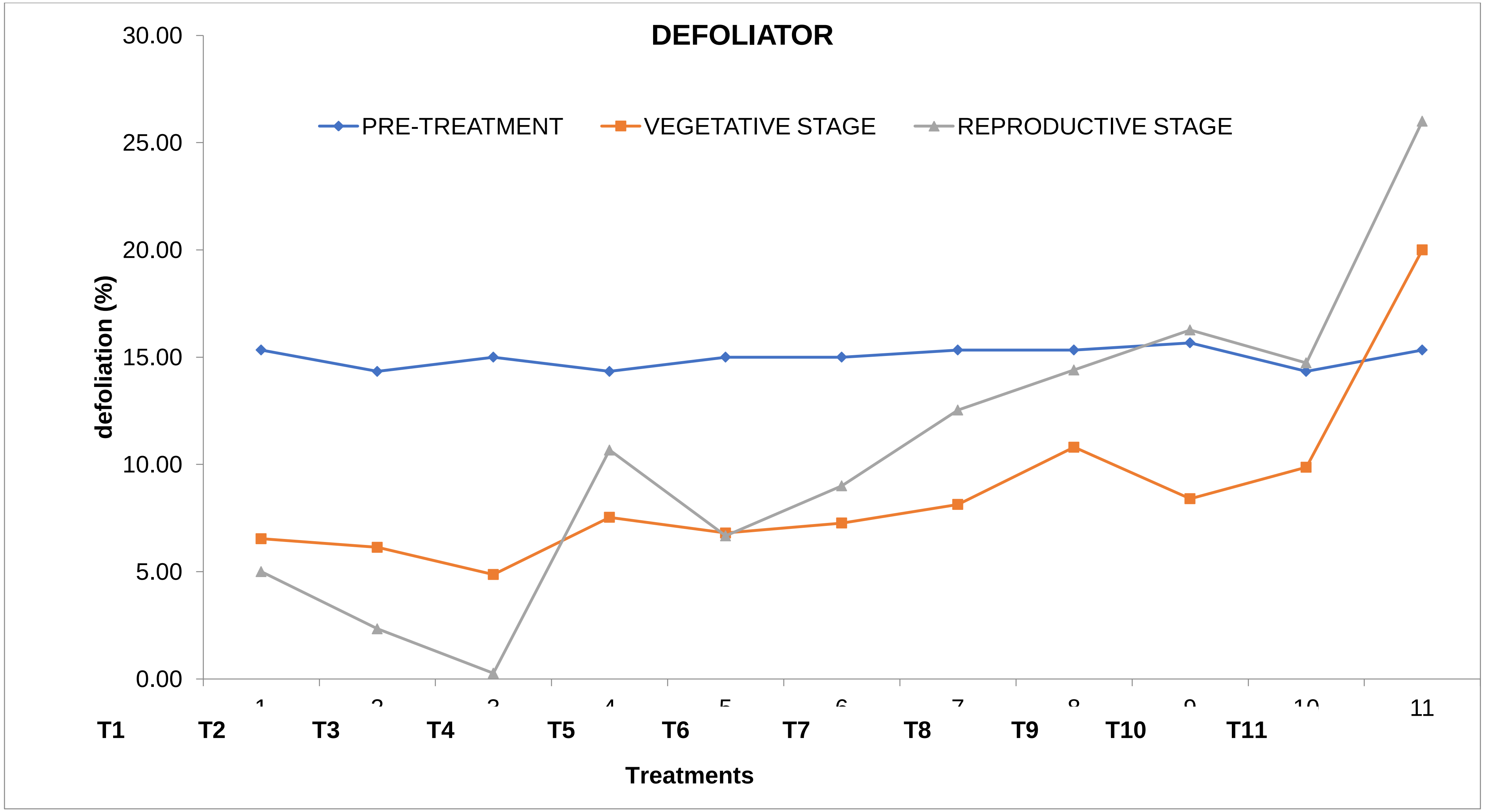

Fig 4.4: Effect of insecticides on defoliator population in two crop stages of soybean

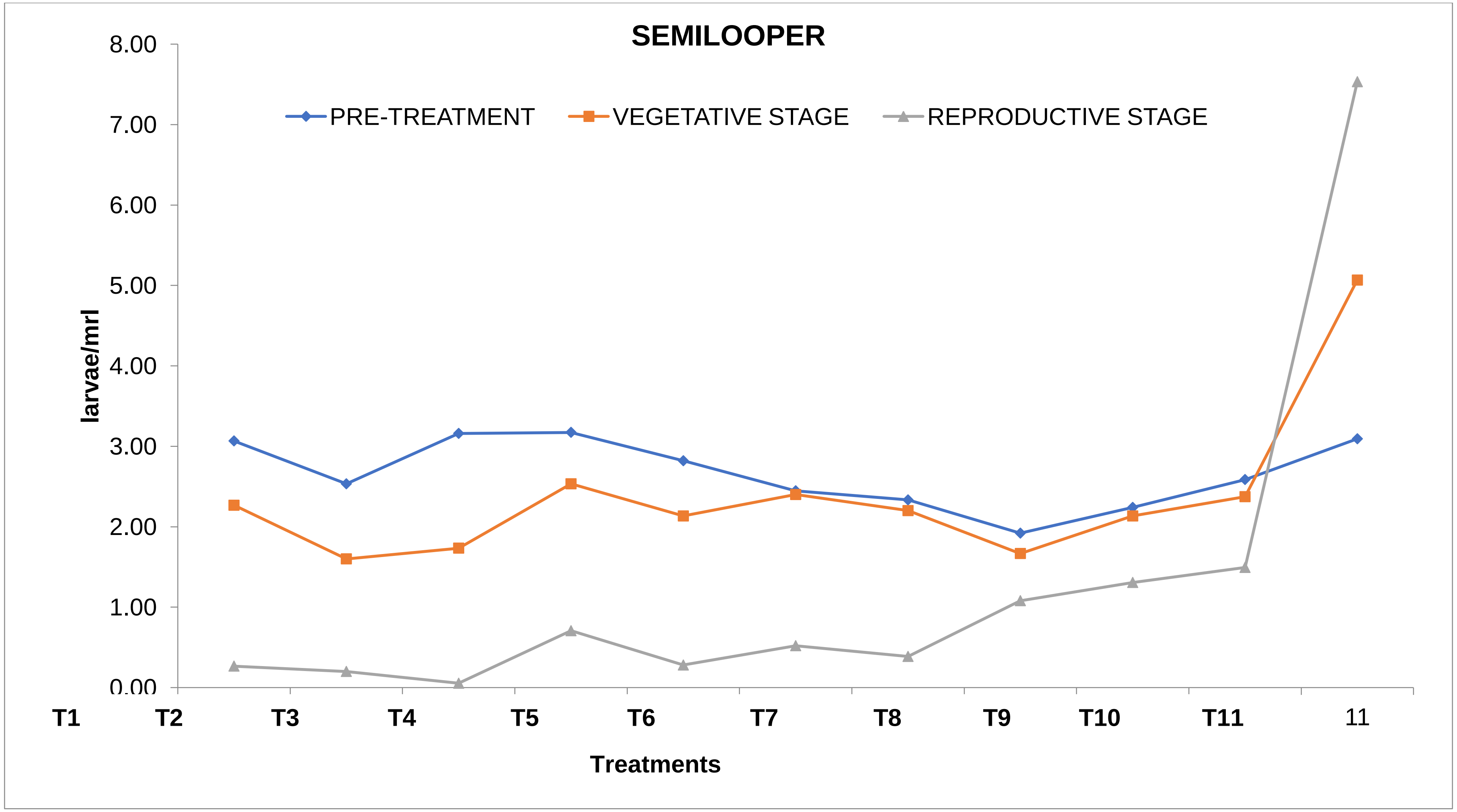

Fig 4.5: Effect of insecticides on semilooper population in two crop stages of soybean.

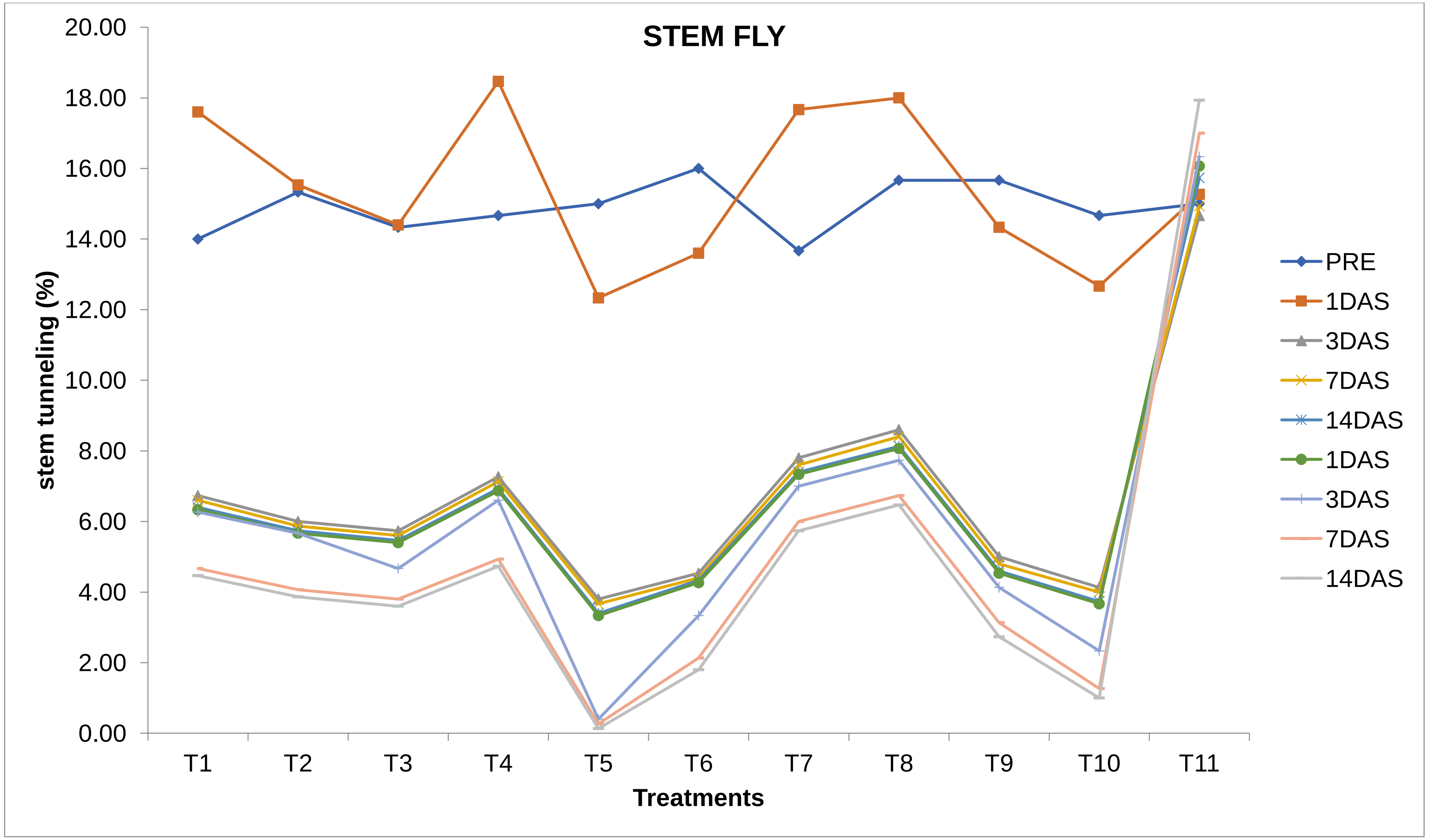

Fig 4.6: Effect of different insecticides on stem fly population in soybean

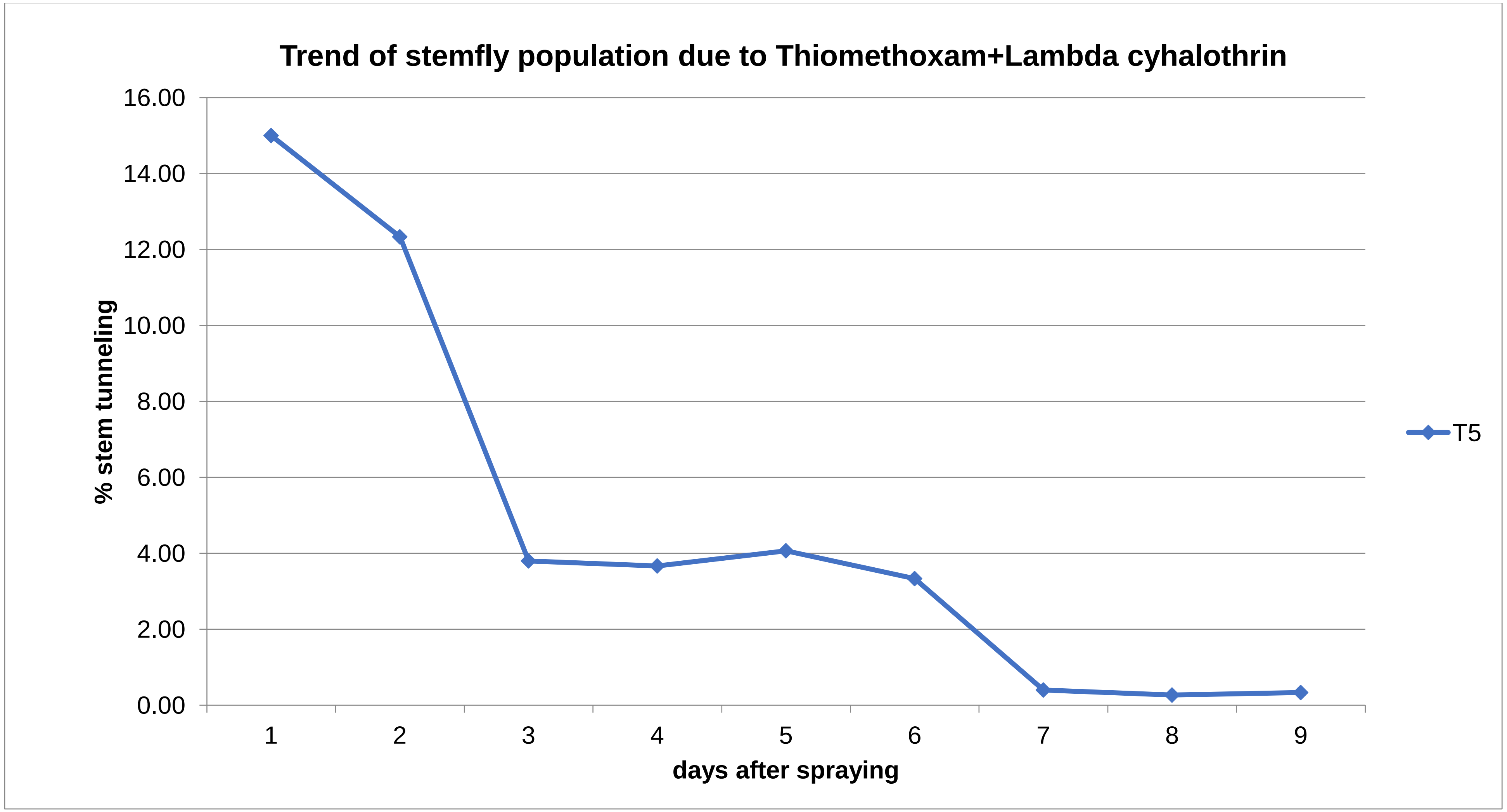

Fig 4.7: Effect of Thiomethoxam + Lambda cyhalothrin on stem fly population

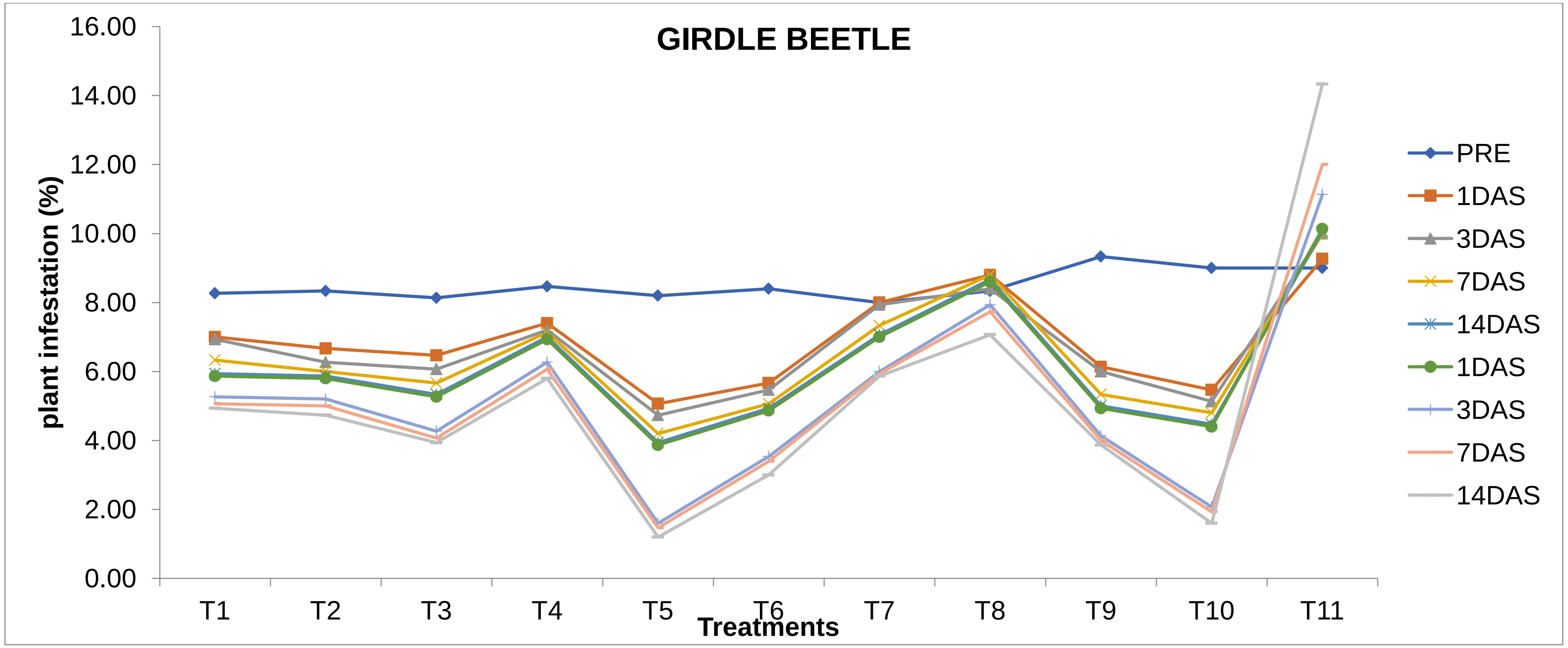

Fig 4.8: Effect of different insecticides on girdle beetle population in soybean.

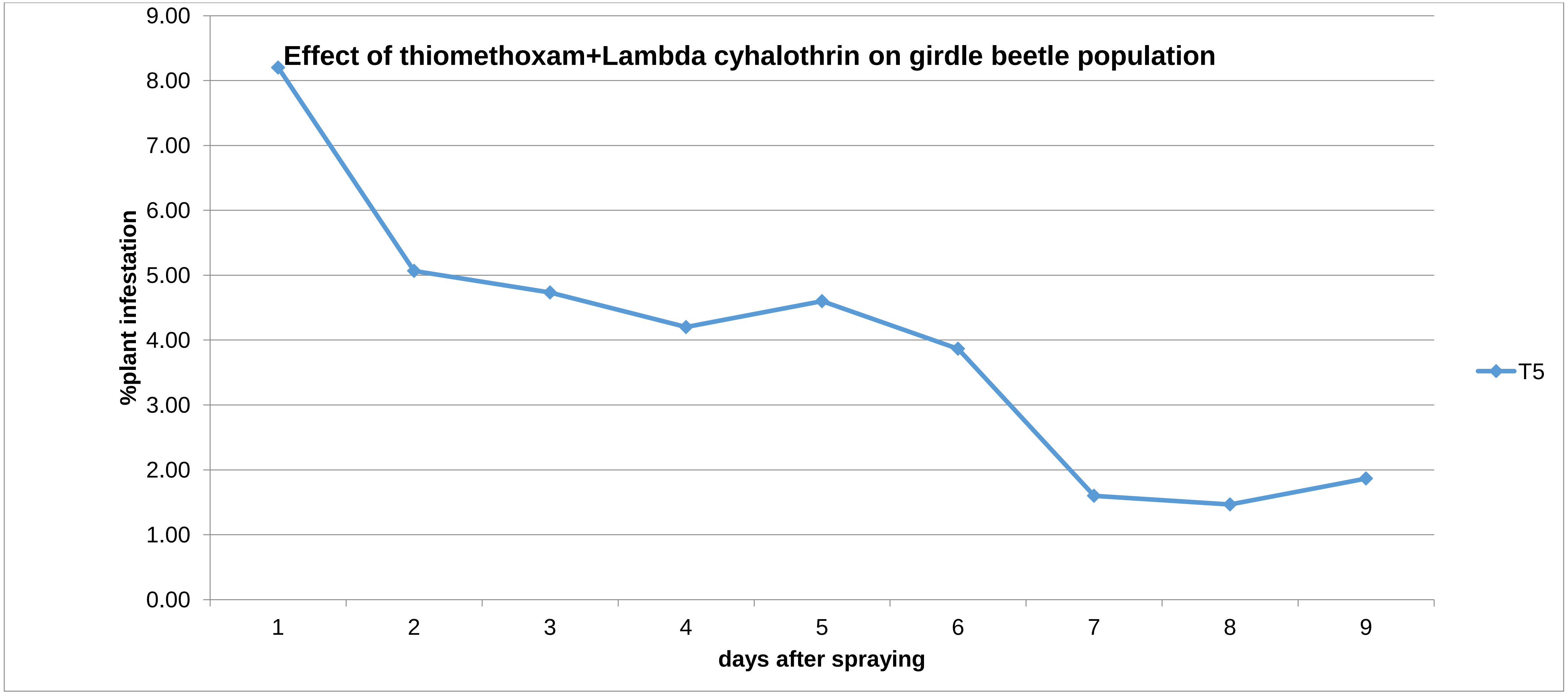

Fig 4.9: Effect of Thiomethoxam+Lambda cyhalothrin on girdle beetle population

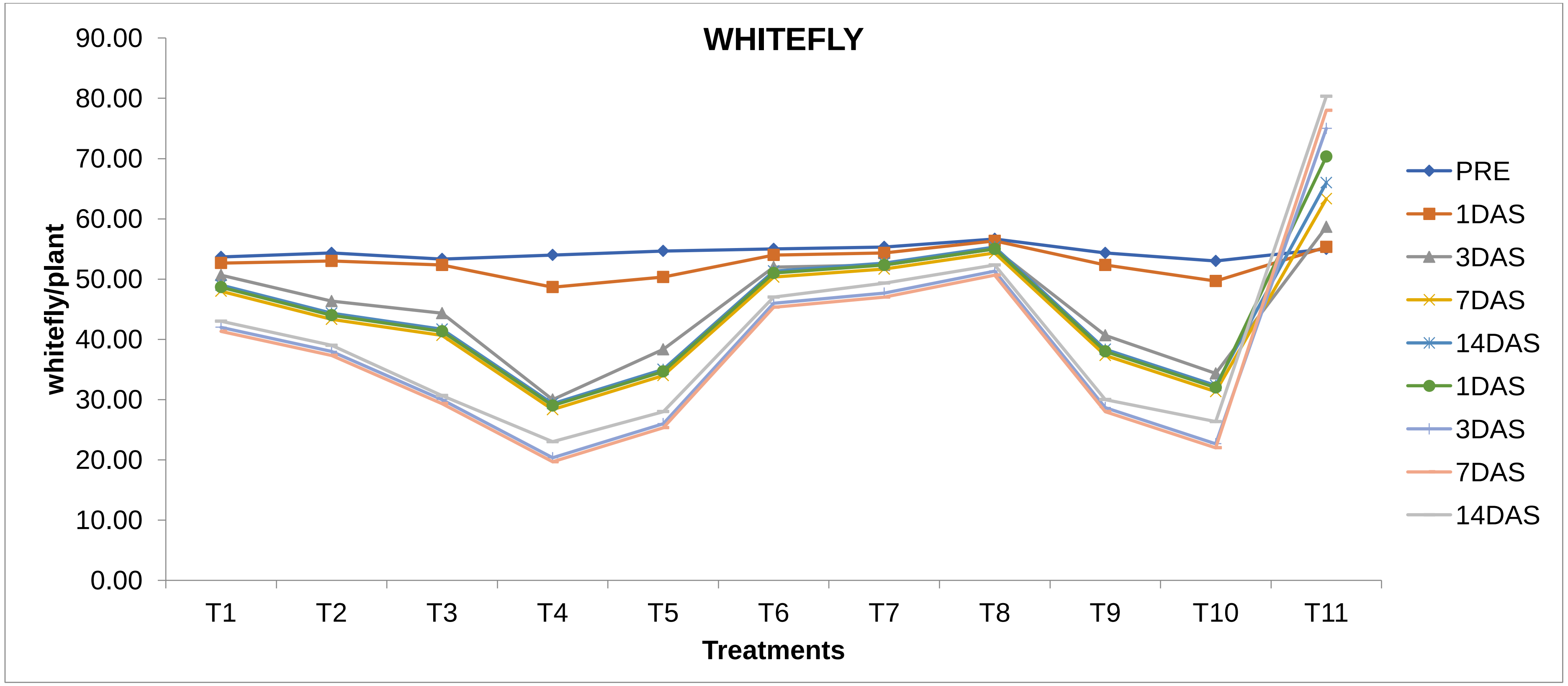

Fig 4.10 Effect of different insecticides on whitefly population in soybean.

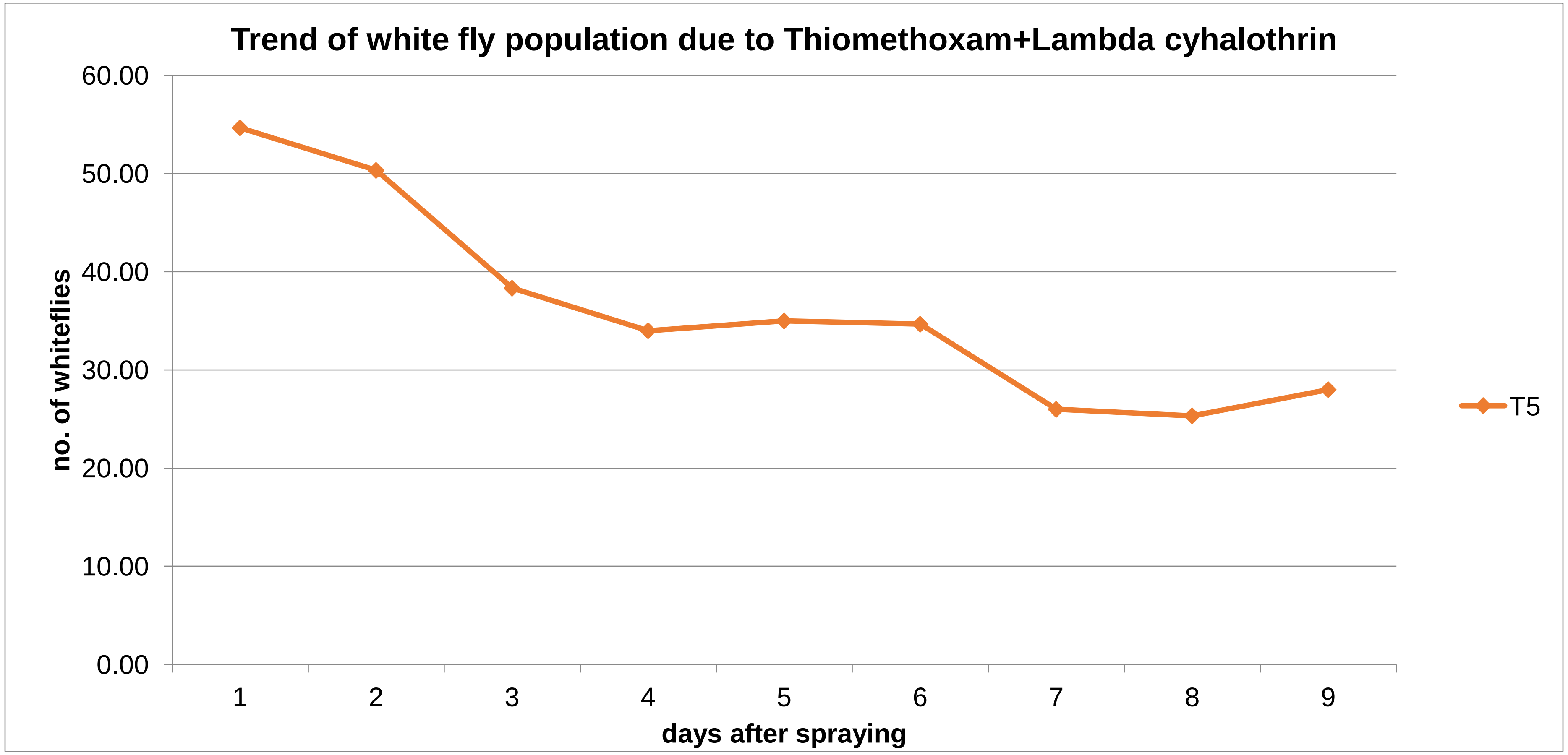

Fig 4.11: Effect of Thiamethoxam+ Lambda cyhalothrin on whitefly population

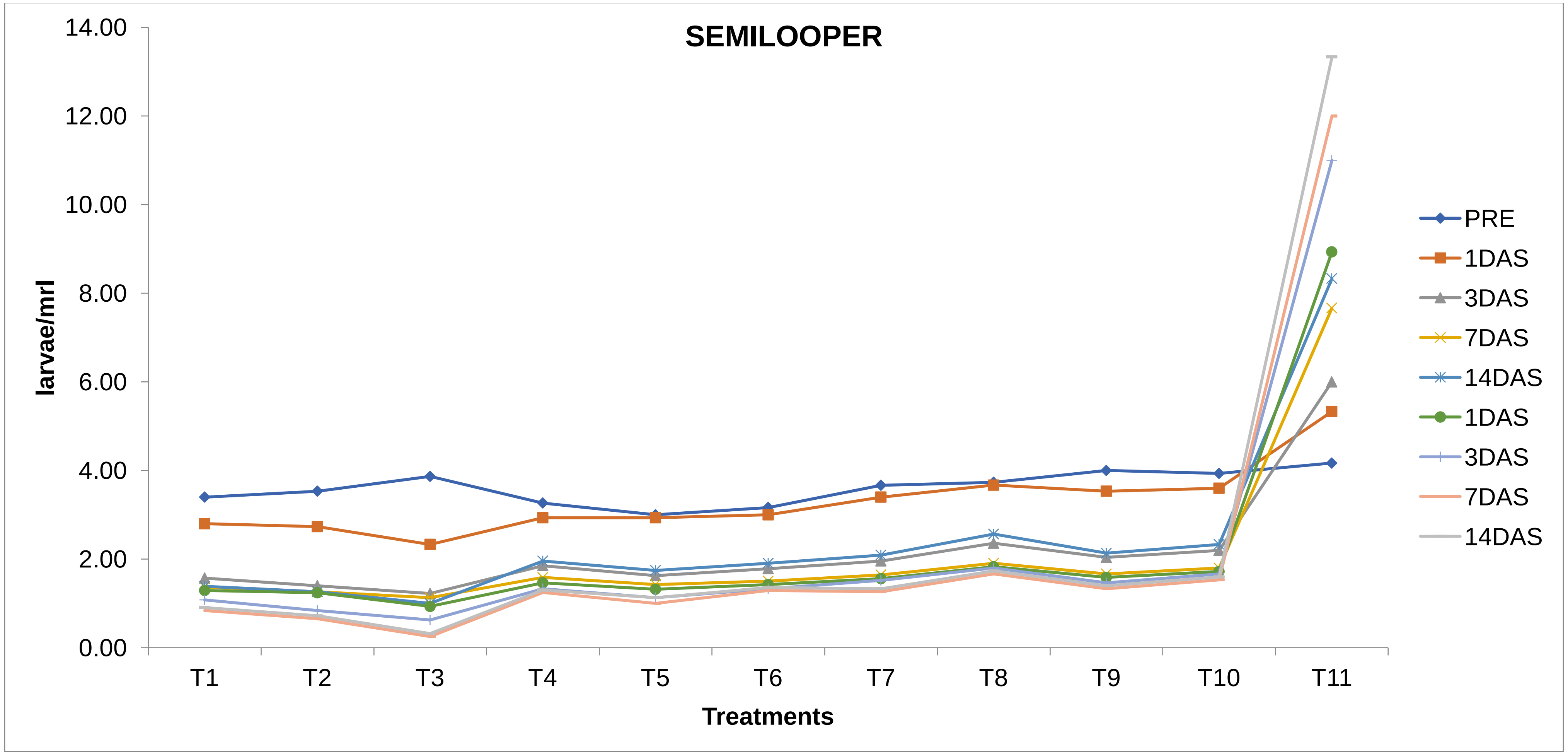

Fig 4.12: Effect of different insecticides on semilooper population in soybean.

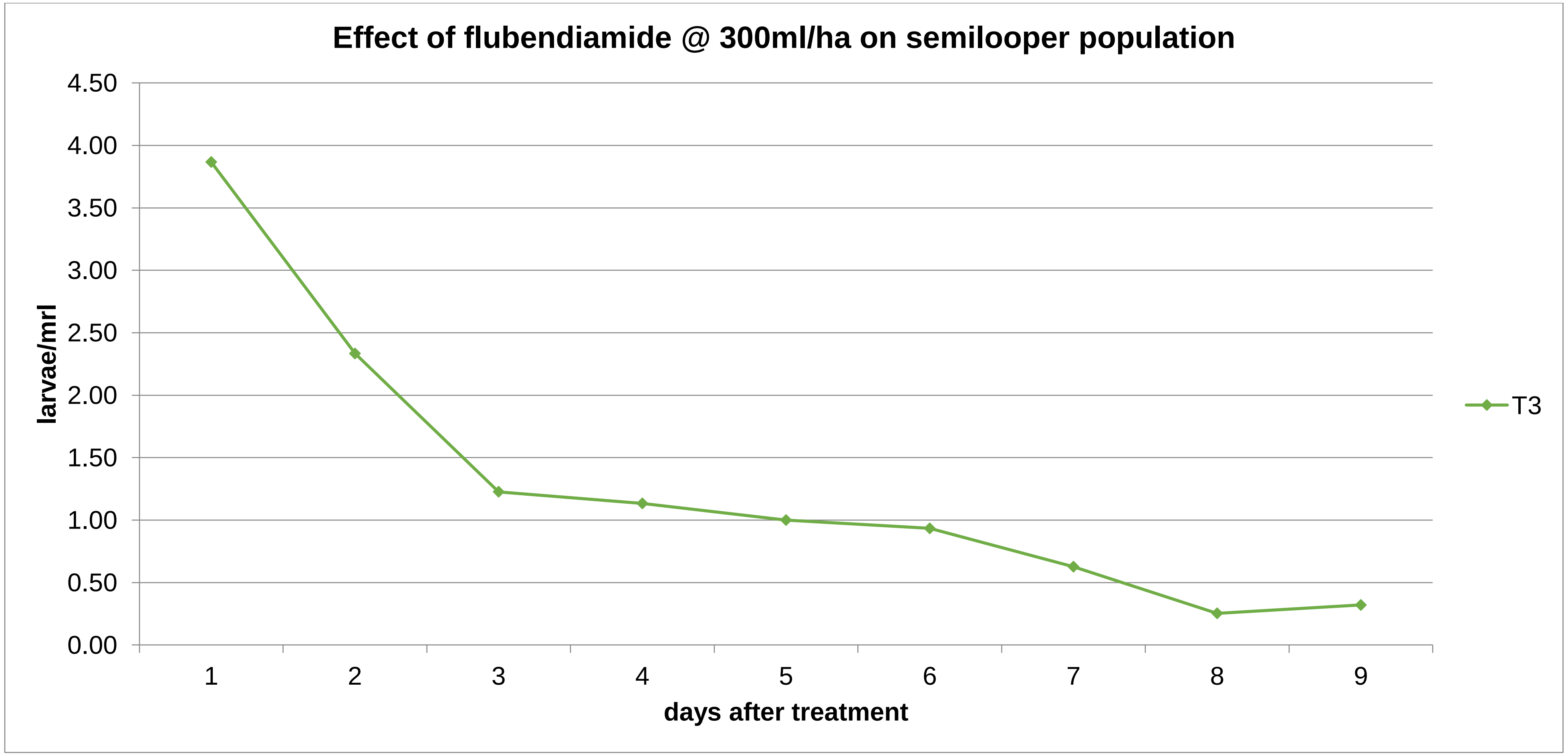

Fig 4.13: Effect of flubendiamide @ 300ml/ha on semilooper population.

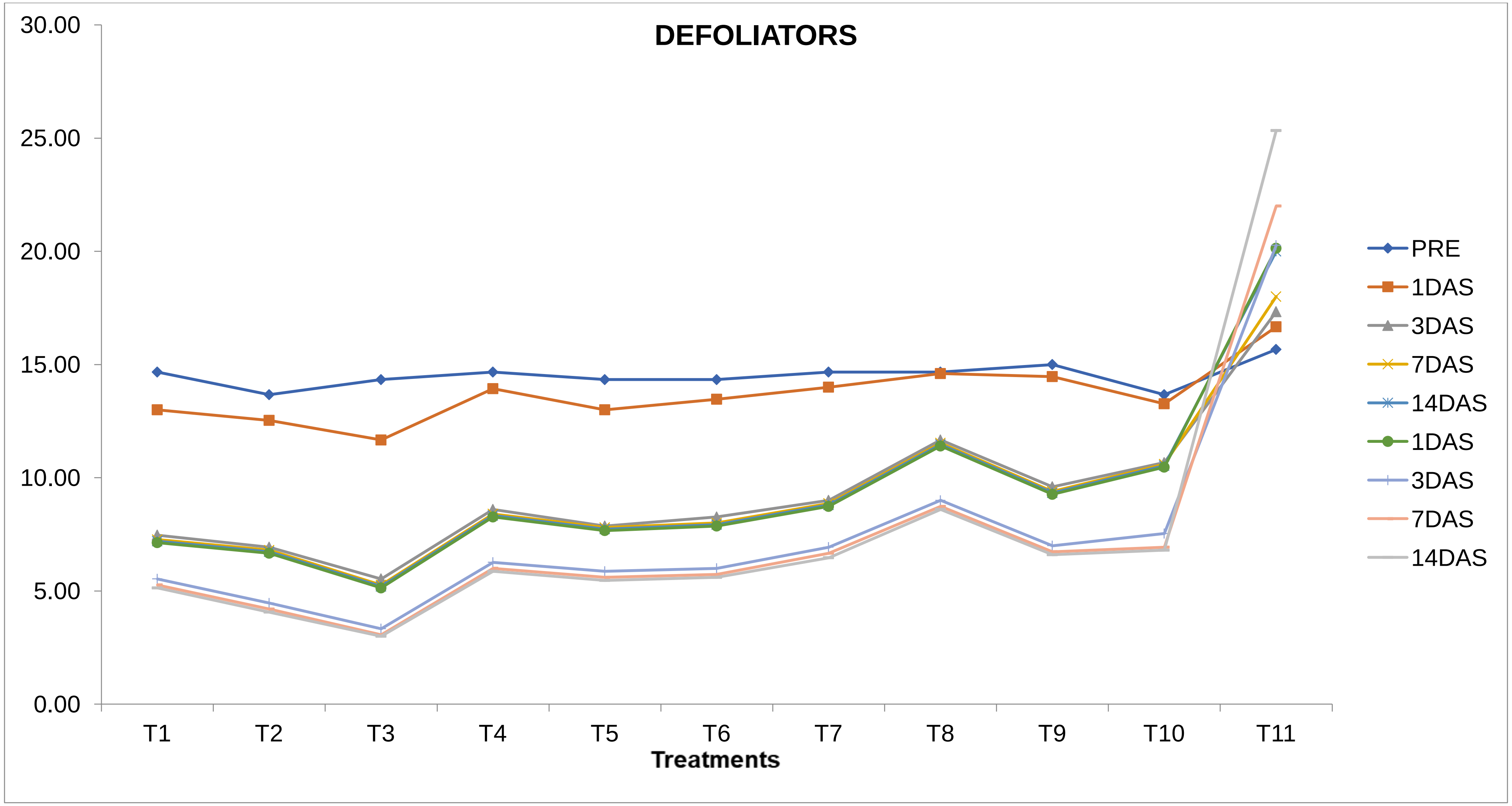

Fig 4.14: Effect of different insecticides on defoliator population in soybean.

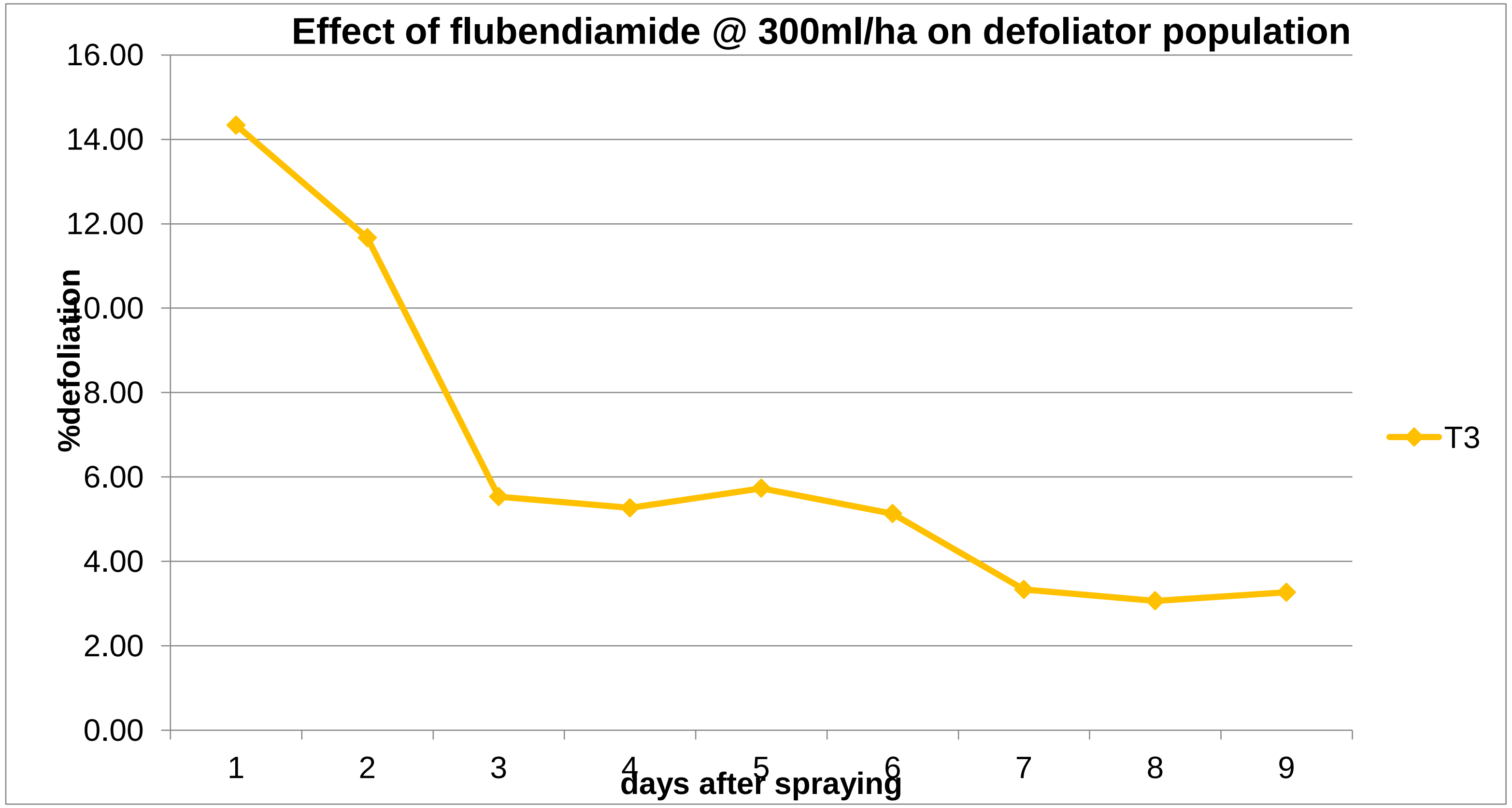

Fig .4.15: Effect of Flubendiamide @300ml/ha on defoliator population.

Plate 1.0 Field view of experiment trial in soybean

View of **Girdle beetle damage** **View of Whitefly**

Plate 2,3. Infestsion of soybean by girdle beetle and whitefly


Plate 4,5. View of Semilooper infestation in soybean

Plate 6. Reproductive stage(Pod formation)

Pate 7. Vegetative stage

Plate 8,9. View of Defoliator (*S. litura*) and foliar damage

Plate 10,11 Stemfly demage of Soybean

Plate 12. Measurement of soybean yield

CHAPTER – V

DISCUSSION

The current study entitled **“Comparative Studies of New Molecules for the management of Major Insect pest of Soybean (*Glycine max* (L.) Merr.)”** was undertaken during the *kharif* 2019 - 20 at the field experimental site of Soybean experiment, College of Agriculture, Indore (M.P.). The incidence of various major insect pest Stem fly, Girdle beetle, Whitefly, semilooper and defoliators on soybean occurred during the study period were recorded and tabulated to assess the effect of new molecules for major insect pest of soybean. The discussion on different aspects has been presented in following below:

5.1 Effect of insecticides on insect pests of soybean at vegetative and reproductive stages of crop:

The soybean crop was taken up for experimental studies during *Kharif* 2020. The experiment was laid in randomized block design. According to Ndam *et al.,*2012 the different insecticides were sprayed at two crop stages *i. e* vegetative and reproductive stages and the pest incidence was recorded after the waiting period of the used pesticides were recorded during the major economically important crop stages of soybean *I. e* vegetative and reproductive stages.

The pre-treatment observations recorded showed that the whitefly population ranged from 51.67 to 56 whitefly adults or nymphs per plant, stem fly population ranged from 13.33-15.47% stem tunneling, girdle beetle population ranged from 8.33-9% plant infestation, defoliator population ranged from 14.33-15.67% defoliation and semilooper population ranged from 1.92-3.17 larvae per mrl. The observations were statistically non-significant. The pest population recorded during vegetative stage after spraying indicated that the lowest pest population was recorded in the treatments of Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC was the best performer against sucking pest and internal feeders;

- It showed 21.33 whiteflies/plant which was at par with Diafenthiuron 50% WP 26.67 in case of managing whiteflies
- 3.67 % stem tunneling in case of stem fly which was followed by Diafenthiuron 50 % WP with 4% stem tunneling.
- 3.6 % plant infestation by girdle beetle which was followed by Diafenthiuron 50 % WP with 4.2% plant infestation.
- Flubendiamide 39.35% @ 300 ml/ha was the best in managing the defoliator population likely, *Spodoptera* and semilooper. The results showed that,
- The lowest percent defoliation was 4.87%. The semilooper populations recorded as lowest population in Flubendiamide 39.35% SC @300ml/ha (1.60 larvae/mrl) which was followed by Flubendiamide 39.35% SC @200ml/ha (1.73 larvae/mrl).

The insecticides had longer persistence in field hence their effect was evidently seen in case of managing the pests but the persistence of biopesticides is lower than that of insecticides hence the highest pest population was recorded in the treatment of *Beauveria bassiana* @ 1000 ml/ha. The highest white fly population was recorded in the treatment *Beauveria bassiana* (48.67) which was at par with Chlorantraniliprole 18.5% SC + *Beauveria bassiana* (48.33). The girdle beetle population observations showed the highest plant infestation was recorded in the treatment *Beauveria bassiana* (8.27%) which was at par with Chlorantraniliprole 18.5% SC + *Beauveria bassiana* (7.53%). While, in case of defoliators the highest percent defoliation was recorded in the treatment *Beauveria bassiana* (10.80%). The highest population was recorded in the treatment Diafenthiuron 50% WP (5.07 larvae/mrl).

The pest population recorded during reproductive stage after spraying indicated that the lowest pest population was recorded in the treatments of Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC;

- The lowest whitefly population was seen in Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (25.67 whiteflies/plant) which was at par with Diafenthiuron 50% WP (28.00 whiteflies/plant).
- The lowest per cent stem tunneling was recorded in Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (0.20%) which was followed by Diafenthiuron 50% WP (1.00%).
- The lowest per cent plant infestation was recorded in Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (1.07%) which was at par with Diafenthiuron 50% WP (1.27%).
- Flubendiamide 39.35% @ 300ml/ha was identified as a potential chemical in management in case of defoliators and semilooper. The results showed that,
- The lowest per cent defoliation was recorded in Flubendiamide 39.35% SC @300ml/ha (0.27%) which was followed by Flubendiamide 39.35% SC @200ml/ha (1%).
- The lowest population was recorded in Flubendiamide 39.35% SC @300ml/ha (0.05 larvae/mrl) which was followed by Flubendiamide 39.35% SC @200ml/ha (0.20 larvae/mrl).

The effect of insecticides in managing the pests in reproductive stage showed that:

The highest whitefly population was recorded in the treatment *Beauveria bassiana* (55.33) which was at par with Chlorantraniliprole 18.5% SC + *Beauveria bassiana* (52.67).

The highest stem tunneling by stem fly was recorded in the treatment *Beauveria bassiana* (6.70%).

The girdle beetle population with highest %plant infestation was recorded in the treatment *Beauveria bassiana* (5.53%) which was at par with Spinetoram 11.7% SC (5.20%). Whereas, the highest percent defoliation was recorded in the treatment

Bifenthrin 10% EC (16.27%) which was at par with Diafenthiuron 50% WP (14.73%) and *Beauveria bassiana* (14.40 %).

The highest population was recorded in the treatment Diafenthiuron 50% WP (1.49 larvae/mrl) which was at par with Bifenthrin 10% EC (1.31 larvae/plant).

Mumuni abuduali *et al.,* 2012, reported that the insect pest densities were managed similarly in both the stages. Hence showing that pesticides application at different times recorded similar pest incidence in both stages. Ndam *et al,* 2012 also reported the similar results. In our present study lower pest population was recorded when applied in reproductive stage but still the differences were very wide apart.

5.2 Effect of insecticides on insect pests of soybean:

5.2.1. Effect of insecticide on stem fly population:

Two sprays are conducted in the experiment. The observations were recorded at 1,3, 7 and 14 days after spraying and second spray was done 15 days after 1st spraying. The results delved indicated that at the end of first spraying, the stem fly infestation ranged from 4.07% to 8.80% stem tunneling against control (16.41%). The lowest stem fly infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (4.07% stem tunneling) which was at par with Diafenthiuron 50% WP (4.40% stem tunneling). The highest stem fly infestation was recorded in *Beauveria bassiana* @1000ml/ha (8.80%) which is at par with Chlorantraniliprole 18.5% SC+ *Beauvaria bassiana @ 10+1000ml/ha* (8%). At the end of second spraying, the stem fly infestation ranged from 0.33% to 7.40% stem tunneling against control (25.93%). The lowest stem fly infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (0.33% stem tunneling) which was followed by Diafenthiuron 50% WP (1.93%). The highest stem fly infestation was recorded in *Beauveria bassiana* @1000ml/ha (7.40%) which is at par with Chlorantraniliprole 18.5% SC+ *Beauvaria bassiana @ 10+1000ml/ha* (6.67%).

The mean stem fly infestation of the two sprays showed that Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC recorded the lowest infestation with 4.8% stem tunneling which was followed by Diafenthiuron 50% WP (5.45%). The highest stem fly infestation was recorded in *Beauveria bassiana* @1000ml/ha (9.57%) which was at par with Chlorantraniliprole 18.5% SC + *Beauveria bassiana* (8.82%) and Spinetoram 11.7% SC (8.38%). Curioletti *et al.* (2018) results were in confirmation with the findings. Dubey *et al.* (1998) reported that the microbial agents were found effective in reducing the larval population and stem tunneled. While, Salunke *et al*. (2004) and Dahiphale *et al.* (2007a) confiemed that Per cent stem tunneled was lowest in phorate 10 G @ 10 kg/ha, whereas the lowest infestation of girdle beetle was recorded in carbofuran 3 G @ 30 kg/ha and Dahiphale *et al.* (2007b) reported reduction in tunneled stem length due to stem fly *(Melanagromyza sojae)* and girdle beetle *(Obereopsis brevis)* was maximum with the soil application of phorate 10 G. Khandwe *et al.* (2011) reports that Spinosad was effective in managing the stemfly. Balaji *et al.* (2012) reported that Diafenthiuron was effective in managing stemfly, Totanadak *et al.* (2012), Raju *et al*. (2013) were contradictory to the experimental findings.

5.2.2. Effect of insecticide on girdle beetle population:

At end of first spraying, the girdle beetle infestation ranged from 3.93% to 8.67% plant infestation against control (10.07%). The lowest girdle beetle infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (3.93%). The highest girdle beetle infestation was recorded in *Beauveria bassiana* @1000ml/ha (8.67%). At the end of second spraying, the girdle beetle infestation ranged from 1.20% to 7.07% plant infestation against control (14.33%). The lowest girdle beetle infestation was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (1.20%) which was followed by Diafenthiuron 50% WP (1.60%). The highest girdle beetle infestation was recorded in *Beauveria bassiana* @1000ml/ha (7.07%).

The mean girdle beetle infestation of the two sprays showed that Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC recorded the lowest infestation with 3.81% plant infestation which was at par with Diafenthiuron 50% WP (4.32%). The highest girdle beetle infestation was recorded in *Beauveria bassiana* @1000ml/ha (8.26%). The experimental findings were in confirmation with Yadav *et al*., (2001), More *et al.* (2014) Choudhary *et al*., (2007), Kumar *et al*. (2010) reported that triazophos was best effective in managing girdle beetle. Kothalkar *et al*. (2015), Chouhan (2016), Kambrekar *et al.* (2017) and Bhardwaj *et al.* (2018), their results were contradictory to the present experimental findings.

5.2.3. Effect of insecticide on whitefly population:

At the end of first spraying, the whitefly population ranged from 29.33 to 55.33 adults/nymphs per plant against control (66.00). The lowest whitefly population was recorded in the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (29.33) which was at par with Diafenthiuron 50% WP (32.33). The highest whitefly population was recorded in *Beauveria bassiana* @1000ml/ha (55.33) was at par with Chlorantraniliprole 18.5% SC + *Beauveria bassiana* @ 1000ml/ha (52.67), Chlorantraniliprole 18.5% SC (51.33). At the end of second spraying, the the whitefly population ranged from 23 to 52.33 adults/nymphs per plant against control (80.33). The lowest whitefly population was recorded in the treatment Spinetoram 17.8% SC (23) which was followed by Diafenthiuron 50% WP (26.33). The highest whitefly population was recorded in *Beauveria bassiana* @1000ml/ha (52.33).

The mean whitefly population ranged from 31.37 to 54.11 adults/nymphs per plant against control (66.89). The overall effect of the two sprays showed that the lowest population was recorded in Spinetoram 11.7% SC (31.37) which was at par with Diafenthiuron 50% WP (33.74). While, the highest whitefly population was recorded in *Beauveria bassiana* @ 1000ml/ha (54.11) which was at par with Chlorantraniliprole 18.5% SC+ *Beauveria bassiana* @ 1000ml/ha (51.41), Chlorantraniliprole 18.5% SC (50.22). The experimental findings were in confirmation with Kalyan *et al.* (2016) and Arnemann *et al.* (2019) whereas. Belay *et al.* (2012), Raghuvanshi *et al.* (2014), Ahirwar *et al.* (2015), their results were contradictory to the present experimental findings as.

5.2.4. Effect of insecticide on semilooper population:

At the end of first spraying, the semilooper population ranged from 1.00 to 2.57 larvae per meter row length against control (8.33). The lowest semilooper population was recorded in the treatment flubendiamide 39.35% SC @300ml/ha (1 larvae per meter row length) followed by flubendiamide 39.35% SC applied at 200ml/l (1.30). The highest semilooper population was recorded in Beauveria bassiana @1000ml/ha (2.57 larvae per meter row length) which was at par with difenthiuron 50% WP (2.33). At the end of second spraying, the semilooper population ranged from 0.32 to 1.73 larvae per meter row length against control (13.33 larvae per meter row length). The lowest semilooper population was recorded in the treatment flubendiamide 39.35% SC @300ml/ha (0.32 larvae per meter row length) which was at par with flubendiamide 39.35% SC @200ml/ha (0.72 larvae per meter row length). The highest semilooper population was recorded in *Beauveria bassiana* @1000ml/ha (1.73 larvae per meter row length) which was at par with all other treatments.

The mean semilooper population ranged from 1.30 to 2.36 larvae per meter row length against control (8.53). The lowest semilooper population was recorded in the treatment flubendiamide 39.35% SC @300ml/ha (1.30). The highest semilooper population was recorded in *Beauveria bassiana* @1000ml/ha (2.36 per mrl). The experimental findings were in confirmation with Khandwe *et al.,* (2009), Matti and deotale (2015), Khandwe and Waghmare (2003), Salunke *et al.* (2004), Raghuvanshi *et al.* (2014), Ahirwar *et al.* (2016) and Babu *et al.* (2016), their results were contradictory to the present experimental findings.

5.2.4. Effect of insecticide on defoliator population:

At the end of first spraying, the defoliator infestation ranged from 5.73% to 11.87% plant infestation against control (20%). The lowest defoliator infestation was recorded in the treatment Flubendiamide 39.35% SC @300ml/ha (5.73%). The highest defoliator infestation was recorded in in *Beauveria bassiana* @1000ml/ha (11.87%). At the end of second spraying, the defoliator infestation ranged from 3.27% to 9% plant infestation against control (25.33%). The lowest defoliator infestation was recorded in the treatment Flubendiamide 39.35% SC @300ml/ha (3.27%). The highest defoliator infestation was recorded in *Beauveria bassiana* @1000ml/ha (9%).

The mean defoliator infestation of the two sprays showed that the defoliator infestation ranged from 6.37% to 11.39% against control (19.49%). But lowest defoliation was recorded in Flubendiamide 39.35% SC @300ml/ha (6.37%) treatments are at par with Flubendiamide 39.35% SC (7.44). The highest defoliator infestation was recorded in *Beauveria bassiana* @1000ml/ha (11.39%). The experimental findings were in confirmation with Manu *et al*. (2014), Patil et al. (2014), Venkat Reddy *et al.,* (2014), Grigolli *et al.,* (2015) and Surpam *et al*. (*2017*), Padiwal *et al*. (2008), Joshi and Patel (2011), Adams *et al*. (2016) and Kambrekar *et al*. (2017), their results were contradictory to the present experimental findings.

5.2.5. Yieid Economic:

The highest grain yield was observed in the treatment thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC with 1406.7 kg per hectare followed by diafenthiuron 50% WP

(1356.7 kg/ha). The lowest yield was recorded in 1155.3 kg/ha in the treatment *Beauveria bassiana* compared to control (1100 kg/ha). The cost economics of using newer insecticides against pests of soybean showed that the best performing among the treatments was thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC which showed costs of 14,237.50/- and a B:C ratio of 6.32:1, followed by Chlorantraniliprole 18.5% SC with costs of 15,450/- and a B:C ratio of 4.81:1 showing that these two are lucrative treatments. While, *Beauveria bassiana* showed the least B: C ratio 0.29:1 proving that the returns with these treatments are not so profitable. The results are in confirmation with Dudh bhale *et al*. (2017).

CHAPTER-VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

6.1 Summary:

6.1.1 Effect of insecticides on insect pests of soybean at vegetative and reproductive stages of crop:

At vegetative stage:

Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC was the most effective treatment in case of sucking pests and internal feeders;

- It recorded lowest whitefly population 29.33 whiteflies/plant which was at par with Diafenthiuron 50% WP 32.33.
- The lowest stem fly population was 3.67% stem tunneling which was followed by Diafenthiuron 50% WP with 4.00% stem tunneling.
- The lowest girdle beetle population was seen as 3.6% plant infestation which was followed by Diafenthiuron 50% WP with 4.2% plant infestation. While, Flubendiamide 39.35% @ 300ml/ha was most effective in case of defoliators and semilooper. The results showed that, the lowest percent defoliation was 4.87%. The lowest semilooper population was recorded in Flubendiamide 39.35% SC @300ml/ha (1.60 larvae/mrl) which was followed by Flubendiamide 39.35% SC @200ml/ha (1.73 larvae/mrl).

At reproductive stage:

Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC was the most effective treatment in case of sucking pests and internal feeders;

- The lowest whitefly population was seen in Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (10.67 whiteflies/plant) which was at par with Diafenthiuron 50% WP (15.00 whiteflies/plant).
- The lowest percent stem tunneling was recorded in Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (0.20%) which was followed by Diafenthiuron 50% WP (1.00%).
- The lowest percent plant infestation was recorded in Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC (1.07%) which was at par with Diafenthiuron 50% WP (1.27%). While, Flubendiamide 39.35% @ 300ml/ha was most effective in case of defoliators and semilooper.
- The results showed that, the lowest percent defoliation was recorded in Flubendiamide 39.35% SC @300ml/ha (0.27%) which was followed by Flubendiamide 39.35% SC @200ml/ha (1.00%).

- The lowest semilooper population was recorded in Flubendiamide 39.35% SC @300ml/ha (0.05 larvae/mrl) which was followed by Flubendiamide 39.35% SC @200ml/ha (0.20 larvae/mrl).

6.1.2 Effect of insecticides on insect pests of soybean:

The mean stem fly infestation of the two sprays showed that Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC recorded the lowest infestation with 4.8% stem tunneling which was followed by Diafenthiuron 50% WP (5.45%). The highest stem fly infestation was recorded in *Beauveria bassiana* @1000ml/ha (9.57%) which was at par with Chlorantraniliprole 18.5% SC + *Beauveria bassiana* (8.82%) and Spinetoram 11.7% SC (8.38%).

The mean girdle beetle infestation of the two sprays showed that Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC recorded the lowest infestation with 3.81% plant infestation which was at par with Diafenthiuron 50% WP (4.32%). The highest girdle beetle infestation was recorded in *Beauveria bassiana* @1000ml/ha (8.26%).

The mean whitefly population ranged from 31.37 to 54.11 adults/nymphs per plant against control (66.89). The overall effect of the two sprays showed that the lowest population was recorded in Spinetoram 11.7% SC (31.37) which was at par with Diafenthiuron 50% WP (33.74). While, the highest whitefly population was recorded in *Beauveria bassiana* @ 1000ml/ha (54.11) which was at par with Chlorantraniliprole 18.5% SC+ *Beauveria bassiana* @ 1000ml/ha (51.41), Chlorantraniliprole 18.5% SC (50.22).

The mean semilooper population ranged from 1.30 to 2.36 larvae per meter row length against control (8.53). The lowest semilooper population was recorded in the treatment flubendiamide 39.35% SC @300ml/ha (1.30). The highest semilooper population was recorded in *Beauveria bassiana* @1000ml/ha (2.36 per mrl).

The mean defoliator infestation of the two sprays showed that the defoliator infestation ranged from 6.37% to 11.39% defoliation against control (19.49%). But lowest defoliation was recorded in Flubendiamide 39.35% SC @300ml/ha (6.37%) treatments are at par with Flubendiamide 39.35% SC (7.44). The highest defoliator infestation was recorded in *Beauveria bassiana* @1000ml/ha (11.39% defoliation).

The cost economics of using newer insecticides against pests of soybean showed that the best performing among the treatments was thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC which showed costs of 14,237.50/- and a B:C ratio of 6.32:1, followed by Chlorantraniliprole 18.5% SC with costs of 15,450/- and a B:C ratio of 4.81:1 showing that these two are lucrative treatments.

6.2 Conclusion:

- At both vegetative and reproductive stages, Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC was effective in managing stem fly, girdle beetle and whitefly populations while, Flubendiamide 39.35% @300ml/ha was effective in managing lepidopteran pest *I.e,* semilooper and defoliator population.
- The insecticides Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC, Chlorantraniliprole 18.5% SC (5.22%) and Diafenthiuron 50% WP were effective in managing stem fly population.
- The insecticides Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC, Flubendiamide 39.35% @300ml/ha, Bifenthrin 10% EC and Diafenthiuron 50% WP were effective in managing girdle beetle population.
- The insecticides Spinetoram 17.8% SC (24) and Diafenthiuron 50% WP were effective in managing whitefly population.
- The insecticides Flubendiamide 39.35% SC @300ml/ha and Flubendiamide 39.35% SC @200ml/ha were effective in managing semilooper population.
- The insecticides Flubendiamide 39.35% SC @300ml/ha and Flubendiamide 39.35% SC @200ml/ha were effective in managing defoliator population.

6.3 Suggestions for further work:

It is evident from the present studies that the insect-pests of soybean may be managed by the new insecticidal molecules and already recommended insecticides, but it is necessary to find out relatively more eco-friendly and selective insecticides, safer for parasitoids and predators and showing toxicity against eggs, larvae and adults of the new and already existing pests.

- The phytotoxic effect and residual effect of the insecticides must also be studied.
- The effect of insecticides on non-target organisms like natural enemies and pollinators
- Need for *invitro* studies on the effect on pest and natural enemy biology.
- The baseline toxicity studies are needed.
- The effect of newer molecules on honey bees must be studied on their forging behavior, survival as pollinators conservation has become the major global hot topic in crop protection and entomological forums.
- The synergistic effect of these effective insecticides with bioagents and their compatibility must be considered for further experimentation.

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APPENDICES

Appendix I:

ANOVA 1: Impact of different insecticides on insect pest population at different vegetative and reproductive stages of soybean during *Kharif* 2019-20.

i. Pre-treatment:

a. Whitefly

	DF	SS	MSS	F cal	F tab
REP	2	0.669			
TREAT	10	0.153	0.015	1.004	2.16
ERROR	20	0.305	0.015		
TOTAL	32	1.126			SEm ± 0.071 CD at 5% non significant

b. Stemfly

	DF	SS	MSS	F cal	F tab
REP	2	8.127			
TREAT	10	8.746	0.875	1.002	2.16
ERROR	20	17.453	0.873		
TOTAL	32	34.326			SEm ± 0.539 CD at 5% non significant

c. Girdle beetle

	DF	SS	MSS	F cal	F tab
REP	2	30.642			
TREAT	10	1.129	0.113	1.005	2.16
ERROR	20	2.248	0.112		
TOTAL	32	34.020			SEm ± 0.194 CD at 5% non significant

d. Defoliator

	DF	SS	MSS	F cal	F tab
REP	2	41.884			
TREAT	10	4.657	0.466	1.003	2.16
ERROR	20	9.289	0.464		
TOTAL	32	55.829			SEm ± 0.393 CD at 5% non significant

e. Semilooper

	DF	SS	MSS	F cal	F tab
REP	2	9.056			
TREAT	10	0.034	0.003	1.025	2.16
ERROR	20	0.067	0.003		
TOTAL	32	9.158			SEm ± 0.033 CD at 5% non significant

ii. Vegetative stage:

f. Whitefly

	DF	SS	MSS	F cal	F tab
REP	2	0.311	0.015	0.012	3.49
TREAT	10	46.213	4.621	3.93	2.16
ERROR	20	23.476	1.174		
TOTAL	32	70.00			SEm ± 6.26 CD at 5% = 1.858

g. Stemfly

	DF	SS	MSS	F cal	F tab
REP	**2**	4.610	2.305	7.048	3.49
TREAT	**10**	327.34	32.734	99.99	2.16
ERROR	**20**	6.549	0.327		
TOTAL	**32**	**338.50**			SEm ± 0.330 CD at 5% = 0.981

h. Girdle beetle

	DF	SS	MSS	F cal	F tab
REP	**2**	5.008	2.204	11.6	3.49
TREAT	**10**	158.62	15.862	83.48	2.16
ERROR	**20**	3.800	0.190		
TOTAL	**32**	**167.43**			SEm ± 0.252 CD at 5% = 0.748

i. Defoliator

	DF	SS	MSS	F cal	F tab
REP	**2**	34.634	17.317	73.377	3.49
TREAT	**10**	406.447	40.645	172.22	2.16
ERROR	**20**	4.724	0.236		
TOTAL	**32**	**447.805**			SEm ± 0.281 CD at 5% = 0.834

j. Semilooper

	DF	SS	MSS	F cal	F tab
REP	**2**	0.301	0.150	2.34	3.49
TREAT	**10**	12.99	1.299	20.29	2.16
ERROR	**20**	0.128	0.064		
TOTAL	**32**	**13.425**			SEm ± 0.046 CD at 5% = 0.137

iii. Reproductive stage:

k. Whitefly

	DF	SS	MSS	F cal	F tab
REP	**2**	0.158	0.79	4.51	3.49
TREAT	**10**	194.59	19.45	111.14	2.16
ERROR	**20**	3.515	0.175		
TOTAL	**32**	**198.266**			SEm ± 0.242 CD at 5% = 0.719

l. Stemfly

	DF	SS	MSS	F cal	F tab
REP	**2**	4.930	2.465	5.14	3.49
TREAT	**10**	980.68	98.068	204.71	2.16
ERROR	**20**	9.588	0.479		
TOTAL	**32**	**995.20**			SEm ± 0.400 CD at 5% = 1.188

m. Girdle beetle

	DF	SS	MSS	F cal	F tab
REP	**2**	8.711	4.355	10.44	3.49
TREAT	**10**	651.91	65.191	156.33	2.16
ERROR	**20**	8.349	0.417		
TOTAL	**32**	**668.97**			SEm ± 0.373 CD at 5% = 1.108

n. Defoliator

	DF	SS	MSS	F cal	F tab

REP	2	87.561	43.78	16.45	3.49
TREAT	10	1758.51	175.851	66.10	2.16
ERROR	20	53.399	2.669		
TOTAL	32	1899.47			SEm ± 0.943 CD at 5% = 2.803

o. **Semilooper**

	DF	SS	MSS	F cal	F tab
REP	2	1.335	0.667	29	3.49
TREAT	10	64.04	6.404	278.43	2.16
ERROR	20	0.479	0.023		
TOTAL	32	65.85			SEm ± 6.26 CD at 5% = 1.858

ANOVA 2: Effect of insecticides on stemfly population

i. **First spray**

a. **1DBS**

	DF	SS	MSS	F cal	F tab
REP	2	3.182	1.59	5.2	3.49
TREAT	10	91.58	9.15	30.1	2.16
ERROR	20	6.065	0.303		
TOTAL	32	100.83			SEm ± 0.393 CD at 5% = NS

b. **1DAS**

	DF	SS	MSS	F cal	F tab
REP	2	3.182	1.59	5.2	3.49
TREAT	10	91.58	9.15	30.1	2.16
ERROR	20	6.065	0.303		
TOTAL	32	100.83			SEm ± 0.318 CD at 5% = 0.945

c. **3 DAS**

	DF	SS	MSS	F cal	F tab
REP	2	0.086	0.043	0.265	3.49
TREAT	10	301.6	30.16	186.17	2.16
ERROR	20	3.255	0.162		
TOTAL	32	304.99			SEm ± 0.233 CD at 5% = 0.692

d. **7 DAS**

	DF	SS	MSS	F cal	F tab
REP	2	0.661	0.330	1.81	3.49
TREAT	10	893.56	89.356	490.93	2.16
ERROR	20	3.673	0.182		
TOTAL	32	879.88			SEm ± 0.247 CD at 5% = 0.735

e. **14 DAS**

	DF	SS	MSS	F cal	F tab
REP	2	2.463	1.23	5.94	3.49
TREAT	10	371.47	37.14	179.42	2.16
ERROR	20	4.158	0.207		
TOTAL	32	378.09			SEm ± 0.539 CD at 5%=0.782

ii. Second spray

f. 1DAS

	DF	SS	MSS	F cal	F tab
REP	2	0.937	0.468	2.43	3.49
TREAT	10	391.53	39.15	203.90	2.16
ERROR	20	3.849	0.192		
TOTAL	32	396.35			SEm ± 0.253 CD at 5%=0.752

g. 3 DAS

	DF	SS	MSS	F cal	F tab
REP	2	0.672	0.336	0.613	3.49
TREAT	10	757.73	75.77	138.26	2.16
ERROR	20	10.975	0.548		
TOTAL	32	769.38			SEm ± 0.194 CD at 5%= 1.271

h. 7 DAS

	DF	SS	MSS	F cal	F tab
REP	2	2.172	1.081	8.71	3.49
TREAT	10	322.726	32.27	260.24	2.16
ERROR	20	2.492	0.124		
TOTAL	32	327.39			SEm ± 0.204 CD at 5%=0.605

i. 14 DAS

	DF	SS	MSS	F cal	F tab
REP	2	9.626	0.481	1.73	3.49
TREAT	10	1049.8	104.98	377.62	2.16
ERROR	20	7.569	0.278		
TOTAL	32	1067.09			SEm ± 0.539 CD at 5%=1.055

ANOVA 3: Effect of insecticides on girdle beetle population.

1. First spray

a. 1DBS

	DF	SS	MSS	F cal	F tab
REP	2	39.32	19.66	56.65	3.49
TREAT	10	6.028	0.602	1.73	2.16
ERROR	20	6.945	0.347		
TOTAL	32	1.126			SEm ± 0.340 CD at 5%=NS

b. 1DAS

	DF	SS	MSS	F cal	F tab
REP	2	0.438	0.219	1.08	3.49
TREAT	10	69.59	6.959	34.62	2.16
ERROR	20	4.020	0.201		
TOTAL	32	74.04			SEm ± 0.259 CD at 5%= 0.769

c. 3 DAS

	DF	SS	MSS	F cal	F tab
REP	2	0.010	0.005	0.027	3.49
TREAT	10	92.14	9.214	50.90	2.16
ERROR	20	3.627	0.181		
TOTAL	32	95.785			SEm ± 0.246 CD at 5%= 0.730

d. 7 DAS

	DF	SS	MSS	F cal	F tab
REP	**2**	2.037	1.018	6.25	3.49
TREAT	**10**	120.93	12.09	68.30	2.16
ERROR	**20**	3.54	0.177		
TOTAL	**32**	**126.512**			SEm ± 0.243 CD at 5%=0.722

e. 14 DAS

	DF	SS	MSS	F cal	F tab
REP	**2**	0.702	0.351	0.353	3.49
TREAT	**10**	136.73	13.673	13.78	2.16
ERROR	**20**	1.984	0.992		
TOTAL	**32**	**139.42**			SEm ± 0.182 CD at 5% = 0.540

iii. Second spray

f. 1DAS

	DF	SS	MSS	F cal	F tab
REP	**2**	1.889	0.994	8.95	3.49
TREAT	**10**	141.57	14.157	127.54	2.16
ERROR	**20**	2.228	0.111		
TOTAL	**32**	**145.68**			SEm ± 0.193 CD at 5% = 0.573

g. 3 DAS

	DF	SS	MSS	F cal	F tab
REP	**2**	3.765	1.882	6.48	3.49
TREAT	**10**	361.84	36.184	124.77	2.16
ERROR	**20**	5.803	0.290		
TOTAL	**32**	**371.41**			SEm ± 0.311 CD at 5% = 0.924

h. 7 DAS

	DF	SS	MSS	F cal	F tab
REP	**2**	0.330	0.165	0.637	3.49
TREAT	**10**	409.01	40.90	157.91	2.16
ERROR	**20**	5.186	0.259		
TOTAL	**32**	**414.53**			SEm ± 0.294 CD at 5% = 0.873

i. 14 DAS

	DF	SS	MSS	F cal	F tab
REP	**2**	0.520	0.260	1.20	3.49
TREAT	**10**	551.01	55.10	255.60	2.16
ERROR	**20**	4.327	0.216		
TOTAL	**32**	**555.86**			SEm ± 0.269 CD at 5% = 0.798

ANOVA 4: Effect of insecticides on whitefly population

1. First spray

a. 1DBS

	DF	SS	MSS	F cal	F tab
REP	2	0.622	0.311	25.91	3.49
TREAT	10	0.102	0.010	0.83	2.16
ERROR	20	0.240	0.0120		
TOTAL	32	**0.964**			SEm ± 0.063 CD at 5% non significant

b. 1DAS

	DF	SS	MSS	F cal	F tab
REP	2	0.331	0.165	9.70	3.49
TREAT	10	0.442	0.045	2.64	2.16
ERROR	20	0.353	0.017		
TOTAL	32	**1.127**			SEm ± 0.077 CD at 5% = 0.228

c. 3 DAS

	DF	SS	MSS	F cal	F tab
REP	2	0.058	0.029	0.43	3.49
TREAT	10	57.361	5.74	85.67	2.16
ERROR	20	0.135	0.067		
TOTAL	32	**57.55**			SEm ± 0.047 CD at 5%= 0.141

d. 7 DAS

	DF	SS	MSS	F cal	F tab
REP	2	0.825	0.412	5.02	3.49
TREAT	10	77.68	7.67	93.53	2.16
ERROR	20	0.165	0.082		
TOTAL	32	**78.67**			SEm ± 0.052 CD at 5% = 0.156

e. 14 DAS

	DF	SS	MSS	F cal	F tab
REP	2	0.219	0.109	36.33	3.49
TREAT	10	86.66	5.66	188	2.16
ERROR	20	0.061	0.003		
TOTAL	32	**86.94**			SEm ± 0.032 CD at 5% = 0.095

2. Second spray

f. 1DAS

	DF	SS	MSS	F cal	F tab
REP	2	1.889	0.944	8.50	3.49
TREAT	10	141.57	14.15	127.38	2.16
ERROR	20	2.228	0.111		
TOTAL	32	**145.69**			SEm ± 0.193 CD at 5% = 0.573

g. 3 DAS

	DF	SS	MSS	F cal	F tab
REP	2	3.765	1.88	6.48	3.49

TREAT	**10**	36.185	3.62	12.48	2.16
ERROR	**20**	5.803	0.290		
TOTAL	**32**	**371.41**			SEm ± 0.311 CD at 5% = 0.924

h. 7 DAS

	DF	SS	MSS	F cal	F tab
REP	**2**	0.080	0.04	40	3.49
TREAT	**10**	85.433	8.54	854	2.16
ERROR	**20**	0.025	0.001		
TOTAL	**32**	**85.54**			SEm ± 0.021 CD at 5% = 0.061

i. 14 DAS

	DF	SS	MSS	F cal	F tab
REP	**2**	0.041	0.02	0.256	3.49
TREAT	**10**	190.93	19.09	244.74	2.16
ERROR	**20**	0.157	0.078		
TOTAL	**32**	**191.13**			SEm ± 0.051 CD at 5% = 0.152

ANOVA 5: Effect of insecticides on semilooper population.

1. First spray

a. 1DBS

	DF	SS	MSS	F cal	F tab
REP	**2**	0.197	0.985	35017	3.49
TREAT	**10**	0.249	0.025	0.89	2.16
ERROR	**20**	0.551	0.028		
TOTAL	**32**	**0.998**			SEm ± 0.096, CD at 5% non significant

b. 1DAS

	DF	SS	MSS	F cal	F tab
REP	**2**	0.382	0.191	17.36	3.49
TREAT	**10**	1.159	0.116	10.54	2.16
ERROR	**20**	0.219	0.011		
TOTAL	**32**	**1.760**			SEm ± 0.060 CD at 5% = 0.179

c. 3 DAS

	DF	SS	MSS	F cal	F tab
REP	**2**	0	0	0	3.49
TREAT	**10**	3.308	0.330	3300	2.16
ERROR	**20**	0.002	0.0001		
TOTAL	**32**	**3.311**			SEm ± 0.006 CD at 5% = 0.018

d. 7 DAS

	DF	SS	MSS	F cal	F tab
REP	**2**	0.480	0.240	2.58	3.49
TREAT	**10**	5.877	0.588	6.32	2.16
ERROR	**20**	0.187	0.093		
TOTAL	**32**	**6.544**			SEm ± 0.066 CD at 5% = 0.166

e. 14 DAS

	DF	SS	MSS	F cal	F tab
REP	**2**	0.010	0.05	12.5	3.49

TREAT	**10**	6.516	0.652	163	2.16
ERROR	**20**	0.085	0.004		
TOTAL	**32**	**6.611**			SEm ± 0.038 CD at 5% = 0.112

2. **Second spray**

f. **1DAS**

	DF	SS	MSS	F cal	F tab
REP	**2**	0.766	0.383	38.3	3.49
TREAT	**10**	8.026	0.803	80.3	2.16
ERROR	**20**	0.202	0.01		
TOTAL	**32**	**8.994**			SEm ± 0.058 CD at 5% = 0.172

g. **3 DAS**

	DF	SS	MSS	F cal	F tab
REP	**2**	0.469	0.234	6.68	3.49
TREAT	**10**	12.23	1.22	34.85	2.16
ERROR	**20**	0.70	0.035		
TOTAL	**32**	**13.40**			SEm ± 0.108 CD at 5% = 0.321

h. **7 DAS**

	DF	SS	MSS	F cal	F tab
REP	**2**	0.004	0.002	0.076	3.49
TREAT	**10**	15.081	1.508	58	2.16
ERROR	**20**	0.522	0.026		
TOTAL	**32**	**15.60**			SEm ± 0.093 CD at 5% = 0.277

i. **14 DAS**

	DF	SS	MSS	F cal	F tab
REP	**2**	0.089	0.044	2.0	3.49
TREAT	**10**	17.023	1.702	77.36	2.16
ERROR	**20**	0.442	0.022		
TOTAL	**32**	**17.549**			SEm ± 0.086 CD at %5 = 0.255

ANOVA 7: Effect of insecticides on defoliator population.

1. **First spray**

a. **1DBS**

	DF	SS	MSS	F cal	F tab
REP	**2**	74.688	37.344	42.38	3.49
TREAT	**10**	6.698	0.669	0.759	2.16
ERROR	**20**	17.637	0.881		
TOTAL	**32**	**99.023**			SEm ± 0.542 CD at 5% non significant

b. **1DAS**

	DF	SS	MSS	F cal	F tab
REP	**2**	18.15	9.07	5.88	3.49
TREAT	**10**	34.93	3.49	2.26	2.16
ERROR	**20**	30.94	1.54		
TOTAL	**32**	**84.01**			SEm ± 0.080 CD at 5% = 0.322

c. **3 DAS**

	DF	SS	MSS	F cal	F tab
REP	2	0.881	0.440	2.29	3.49
TREAT	10	252.73	25.27	131.61	2.16
ERROR	20	3.857	0.192		
TOTAL	32	257.46			SEm ± 0.254 CD at 5% = 0.753

d. 7 DAS

	DF	SS	MSS	F cal	F tab
REP	2	0.191	0.950	1.55	3.49
TREAT	10	287.78	28.78	47.25	2.16
ERROR	20	1.218	0.609		
TOTAL	32	289.19			SEm ± 0.142 CD at 5% = 0.423

e. 14 DAS

	DF	SS	MSS	F cal	F tab
REP	2	0.203	0.101	0.163	3.49
TREAT	10	365.21	36.52	59.09	2.16
ERROR	20	1.237	0.618		
TOTAL	32	366.65			SEm ± 0.144 CD at 5% = 0.427

2. Second spray

f. 1DAS

	DF	SS	MSS	F cal	F tab
REP	2	0.659	0.329	0.447	3.49
TREAT	10	374.93	37.49	51.0	2.16
ERROR	20	1.471	0.735		
TOTAL	32	377.06			SEm ± 0.167 CD at 5% = 0.465

g. 3 DAS

	DF	SS	MSS	F cal	F tab
REP	2	2.139	1.069	1.72	3.49
TREAT	10	530.80	53.08	85.47	2.16
ERROR	20	12.43	0.621		
TOTAL	32	545.37			SEm ± 0.455 CD at 5% = 1.352

h. 7 DAS

	DF	SS	MSS	F cal	F tab
REP	2	1.687	0.843	1.258	3.49
TREAT	10	644.62	64.46	96.21	2.16
ERROR	20	13.414	0.670		
TOTAL	32	659.72			SEm ± 0.473 CD at 5% = 1.405

i. 14 DAS

	DF	SS	MSS	F cal	F tab
REP	2	5.724	2.86	3.51	3.49
TREAT	10	845.25	84.52	103.71	2.16
ERROR	20	16.31	0.815		
TOTAL	32	867.29			SEm ± 0.521 CD at 5% = 1.549

VITA

The author of this thesis Mr. Sunil Mukati s/o Shri Radheshyam Mukati was born on 11th July 1994 at Village Sajod, Tehsil Sardarpur, District Dhar (M.P.). He completed his primary education and H. S. C. (10th) passed with (63%) in the year 2010 from Jain Public School, Badnawar M.P. and passed Higher Secondary School (12th) with (79.8%) in the year 2012 from Shakti Vidhya Pith School Rajod Dhar (M.P.).

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For the partial fulfillment of the master's degree he has successfully conducted this piece of research work entitled **"Comparative Studies of New Molecules for the Management of Major Insect Pest of Soybean (*Glycine max (L.) Merr.)"*** which is duly completed by him and is presented in the form of thesis and successfully completing the post graduate degree MSc. (Ag.) Entomology in 2022. He completed his M. Sc. (Ag) course with OGPA of 7.14 out of 10.00 scale.