Studies on management of defoliators and stem borers of soybean with some new and recommended insecticides

THESIS

Submitted to the

RAJMATA VAIJAYARAJE SCINDIA KRISHI VISHWAVIDYALAYA, GWALIOR

In partial fulfillment of the requirements for

The Degree of

MASTER OF SCIENCE

In

AGRICULTURE

(ENTOMOLOGY)

By

Rakesh Kumar Shakya

Department of Entomology

RAJMATA VAIJAYARAJE SCINDIA KRISHI VISHWAVIDYALAYA, GWALIOR

R.A.K. College of Agriculture

Sehore (M.P.)

2010

CERTIFICATE – I

This is to certify that the thesis entitled **"Studies on management of defoliators and stem borers of soybean with some new and recommended insecticides"** submitted in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE IN AGRICULTURE** (Entomology) of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) is a record of the bonafide research work carried out by **Mr. Rakesh Kumar Shakya** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction, RVSKVV, GWALIOR.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigation have been acknowledged by him.

(Dr.K.K. Nema)
Chairman
Advisory Committee

Place : Sehore
Date **:**

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman	Dr.K.K. Nema	----------------------
Member	Dr. Sandeep Sharma	-----------------------
Member	Dr. Smt.N. Khandwe	------------------------

CERTIFICATE –II

This is to certify that the thesis entitled **"Studies on management of defoliators and stem borers of soybean with some new and recommended insecticides"** submitted by **Mr. Rakesh Kumar Shakya** to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, in partial fulfillment 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 the Student's Advisory Committee after an oral examination of the same.

Place : Sehore

Date :

(Dr.K.K. Nema)
Chairman
Advisory Committee

MEMBERS OF THE ADVISORY COMMITTEE

Chairman...

Head of the Department/Section ……...

Director of Instructions...

ACKNOWLEDGEMENT

The author of this manuscript praises the omniscient and almighty god and his parents, who provided him this opportunity of submitting the present thesis for M.Sc (Ag.). Degree.

The word can never express indebtedness but I can take this opportunity to express my deepest and heartfelt sense of gratitude to reverend, Chairman of Advisory Committee, **Dr. K.K.Nema**, (Head) Deptt. Of Entomology, R.A.K.College of Agriculture, Sehore for suggesting the problem, providing necessary facilities and for his valuable guidance and scholarly advice during the course of investigation and his for healthy critisms in preparing the present manuscript of this thesis to make this task a success. He has been a constant source of inspiration and his love and affection to me will ever be remembered.

I wish to render my sincere thanks to the member of my Advisory Committee Dr. Sandeep Sharma (Senior Scientist), Dr. (Smt.) N.Khandwe (Scientist) Deptt. of Entomology, Dr.S.R.J.Singh (Assoc. Prof.) Deptt. of Statistics, R.A.K. College of Agriculture, Sehore for their kind help and constant advisement.

I express my deep feelings of regards to Dr. V.S.Gautam, Dean, R.A.K. College of Agriculture, Sehore for his unique help and fruitful direction for the success of the success of this study.

I am deeply obliged and indebted to Dr. R.Verma (Senior Scientist), Principal Scientist, FRS, Ithkhedi, Berassia Road , Bhopal , Deptt. of Entomology, R.A.K. College of Agriculture, Sehore for his unique help and fruitful direction for the success of this study.

I am highly thankful to Shri Ashok Shrivastava, Shri R.D.Chouksey, and Ramesh Dada, R.A.K.College of Agriculture, Sehore for giving full support during the course of this study.

I express my gratitude to all my seniors Mr. Vivek Singh Tomar, Mr. Bhagwan Patidar, Mr. Sanjay Gayakwad, My colleague,, Mr. Neeraj Rewari, Mr. Veer Singh Jatav, Mr. Ansar Nadaf, Mr. Rajendar Parihar Mr. Hansraj jatav Mr. Sunil jatav Mr.Radheshyam Patidar, Mr. Hemraj Singh Tomar, Mr. Prakash Jhodia, Mr. Rupesh Gupta and my juniors Mr. Mano Mr. Sandeep Dharpure, Mr. Rahul Soni, Mr. Rajesh Tirole, Mr. Rajesh Bhaesania, who helped me directly or indirectly during the course of this investigation.

Lastly, but not the least I pay my dutiful thanks from the core of my heart to my father Shri Chandanram Shakya, my mother Smt.Parwati Shakya, elder brother Shri Bahadhur Shakya,and Shri Mahesh Shakya, Sister Smt. Sunita Shakya with other loving family members and relatives for their love affection, blessing and constant inspiration to continue my study.

I express my sincere thanks to Satish Singh, Sagar Computers, Sehore for all time help and excellent computer typesetting of this manuscript.

Place: Sehore

Date: **(Rakesh Kumar Shakya)**

List of Contents

List of Tables

List of Figures

LIST OF PLATES

CHAPTER – I
INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is now a cash crop and has occupied important place in agriculture and oil economy of the country. In Indian scenario, Madhya Pradesh contributes about 67 and 56 per cent in total area and production of soybean, respectively in the country and is called as “Soya State” (Anonymous, 2005).

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.

It has been experienced that in last few years the soybean crop is facing various challenges and loosing its attraction among the farmers because of reduced yield. Among the various factors responsible for the low yield, the insect pests have been considered to be of prime importance (Singh and Singh, 1999). Singh and Verma (1992) reported 150 insect pests damaging soybean in Madhya Pradesh and about a dozen of them have been reported causing 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 grown up 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 quinalphos 25 EC, endosulfan 35 EC, triazophos 40 EC and monocrotophos 36 SC have been recommended to check the infestation of various insect pests (Singh and Singh 1988, 1990). But of late, farmers and extension officers of State Government of Madhya Pradesh reported failure of some of these insecticides against some existing and new insect pests. With these points in mind, some new insecticides and commonly recommended insecticides were evaluated against the major insect pests of soybean for their better management with following objectives.

Objective of investigation:

1. To find out the bio-efficacy of new insecticides as a seed dresser against early insect pests of soybean (stem fly & blue beetle).
2. To test the efficacy of new and recommended insecticides against defoliators & stem borers management in soybean.

CHAPTER II
Review of Literature

The soybean crop is attacked by about 300 insect pests and some mites in India (Singh, 1999). The work done on the chemical control is reviewed and presented as under.

2.1 Control of seedling insect pests:

Gain and Kundu (1988) tested the efficacy of phorate 10 G, monocrotophos 36 EC and quinalphos 25 EC in field for the control of *Melanagromyza sojae* on soybean in Delhi, India in 1985. They found all these insecticides effective in reducing stem tunneling. The highest grain yield (19.99q/h) was obtained by applying phorate @2.0 kg a.i/ha at sowing, followed by 2 sprays of monocrotophos or quinalphos at 15 and 21days after sowing.

Singh and Singh (1989c) tested phorate and carbofuran for the control of *Obereopsis brevis* and *Melanagromyza sojae* on soybean in Madhya Pradesh, India, in 1984-85. Maximum grain yield and the best cost benefit ratio (1:2:88) were achieved with the treatment of phorate (1.0kg a.i/ha) 25 days after sowing.

Bagle and Verma (1990) tested various insecticides against *Melanagromyza sojae* on soybean in Delhi, India, in 1984-85 and found that 3 applications of monocrotophos at 0.5 kg a.i./ha commencing 15 days after sowing or a single application of granular phorate at 1.5Kg a.i. /ha were effective against the pest.

Kundu and Shrivastava (1991) reported that the application of phorate 10G @ 15 kg/ha before sowing, followed by 1 spray of 0.04% monocrotophos 20 days after germination or phorate 10 G @ 15 kg/ha alone at sowing reduced stem tunnelling (17.07 - 21.00%) as compared with no insecticide (43.70%) and increased the grain yield from 1.1 to 1.7 q/ha in 40 varieties and germplasm tested.

Parsai *et al.,* (1991) worked out the efficacy and economics of some insecticides on soybean and reported quinalphos as more economical for the control of *Melanagromyza sojae* than monocrotophos, endosulfan or methyl parathion.

Kundu and Mishra (1993) studied the effect of some granular insecticides against *Melanagromyza sojae* in Delhi, India, during 1988 by drilling phorate, quinalphos, mephosfolan and carbofuran into the soil. Only phorate, quinalphos and mephosfolan significantly reduced infestation of *Melanagromyza sojae*.

Latha *et al.,* (1993) evaluated nine insecticides in field against *Bemisia tabaci*, *Megaleurothrips distalis* and *Melanagromyza sojae* on soybean. Seed treatment with Carbosulfan @ 20 g/kg seed, followed by spraying with 0.05% monocrotophos at 31 and 51 days after sowing was considered as the most effective treatment against the majority of the insect pests and contributed the highest yield.

Venkateshan and Kundu (1994) tested the effectiveness of 10 insecticides for the control of *Melanagromyza sojae* and *Bemisia tabaci* on soybean. During kharif 1989 insecticides were applied 10, 20 and 30 days after germination (DAG). The least stem tunnelling (31.8%) was observed in plots treated with 0.07% endosulfan, but it was at par with 0.05% quinalphos, 0.018% fenpropathrin, 0.03% fenvalerate, 0.03% phosalone and 0.017% carbosulfan. The highest cost benefit ratio was obtained with endosulfan (1:6.16), followed by carbosulfan (1:4.16) and fenpropathrin (1:3.54).

Sharma (1994) from Maharashtra in 1988-89 reported that the seed dressing of soybean with phosalone (35 EC) or Carbosulfon (25 STD) controlled *Melanagromyza sojae, Bemisia tabaci, Empoasca sp*. and *Ayyaria chaetophora*.

Sontakke *et al.,* (1995) tested the efficacy of six insecticides as seed dressing against the stem fly, *Melanagromyza sojae* in soybean field trails. They found carbosulfan 50 SP, followed by isofenphos 40 SP, both @ 15 g/kg seed, effective in controlling the stem fly both at seeding and vegetative stages without hampering the seed germination. These insecticides also recorded significantly higher grain yield. Endosulfan, quinalphos and chlorpyriphos in EC formulation @ 15 ml/kg seed were also effective with little adverse effect on seed germination.

Rajput *et al.,* (1996b) tested the efficacy of 10 insecticides against major insect pests of soybean at Sehore, Madhya Pradesh and found quinalphos (0.05%) and monocrotophos (0.05%) effective in reducing the stem fly infestation and stem tunnel length. Quinalphos (0.05%), cypermethrin (0.01%) and deltamethrin (0.00125%) were highly effective against the green semilooper (*Chrysodeixis acuta*) larvae. The highest number of pods/plant and lowest number of unfilled pods were observed in plots treated with quinalphos (0.05%), followed by monocrotophos (0.05%). These two insecticides also gave maximum grain yield. They found carbosulfan 50 SP, followed by isofenphos 40 SP, both @ 15 g/kg seed, effective in controlling the stem fly both at seedling and vegetative stages without hampering the seed germination. These insecticides also recorded significantly higher grain yield. Endosulfan, quinalphos and chlorpyriphos in EC formulation @ 15 ml/kg seed were also effective with little adverse effect on seed germination. Yield of these three insecticides ranged from 20.80 to 22.43 q/ha.

Singh and Singh (1998) evaluated the residual toxicity of carbosulfan 25 DS @ 30g/kg seed, thiamethaxam 70 WS @ 3g and 5g/kg seed, chlorpyriphos 20 EC @ 4 ml/kg seed, phorate 10 G@ 10 kg/ha, carbofuran 3 G@30 kg/ha and foliar spray of chlorpyriphos 20 EC @ 0.04% against the adult blue beetle (*Cneorane sp.)* Thiamethaxam 70 WS @ 3g and 5 g/kg seed was found highly and significantly more toxic in comparison to all other insecticides inflicting 85, 95 and 22 per cent blue beetle mortality after 10, 15 and 20 days of crop germination, respectively.

Singh *et al.,* (2000) tested the efficacy of carbosulfan 25 DS @ 30g/kg seed, thiamethaxam 70 WS @ 3 g and 5 g/kg seed, chlorpyriphos 20 EC @ 4 ml/kg seed, phorate 10 G @ 10 Kg/ha, carbofuran 3 G @ 30 kg/ha and foliar spray of chlorpyriphos 20 EC @ 0.04% against the blue beetle (*Cneorane sp*.), grey semilooper (*Gesonia gemma*), green semilooper (*Chrysodeixis acuta*) and stem fly *(Melanagromyza sojae*) on soybean in Madhya Pradesh. Thiamethaxam 70 WS at both doses was found highly effective and inflicted longer residual toxicity up to 20 days after germination against the blue beetle and up to 60 days after germination against the stem fly infestation which resulted in higher grain yield of 1208 to 1222 kg/ha as against 908 kg/ha in untreated control. These treatments were not effective against the grey and green semiloopers. The number and the weight of nodules/plant were also significantly more in thiamethoxam than that in the untreated control.

Salunke *et al*., (2004) evaluated carbosulfan, thiamethoxam, phorate, carbofuran and chlorpyriphos as seed treatment, soil application and as spray against leaf miner (A*proaerema modicella)*, stem fly (M*elanagromyza sojae*), girdle beetle (O*bereopsis 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).

Dahiphale, *et al*., (2007) studied the effects of carbosulfan 25 DS (30 g/kg of seeds), thiamethoxam 70 WS (3 g/kg of seeds), thiamethoxam 70 WS (6 g/kg of seeds), chlorpyriphos 20 EC (4 ml/kg of seeds), thiamethoxam 25 WG (100 g/ha), imidacloprid 200 EC (100 ml/ha), chlorpyriphos 20 EC (1.5 liter/ha), phorate 10 G (10 kg/ha) and carbofuran 3G (30 kg/ha) on the incidence of insect pests and on the performance of soybean (cv. MAUS-32) in Parbhani, Maharashtra, India. 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. 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 DS applied to seeds were superior among the treatments. All the insecticides were effective against jassid (*Empoasca Kerri*) and white fly (*Bemisia tabaci*), although carbosulfan and thiamethoxam were generally most effective. 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.

Debjani *et al.,* (2008) evaluated the efficacy of thiamethoxam 70 WS and imidacloprid 70 WS, thiamethoxam 500 FS and thiamethoxam 350 FS, applied as seed treatment; carbofuran 3 G and phorate 10 G applied as seed dressing at the time of sowing in the field against natural incidence of major insect pests of soybean, *viz*., stem fly (*Melanagromyza sojae*) and whitefly (*Bemisia tabaci*) and revealed that thiamethoxam 70 WS at 1.5 g/kg seed, thiamethoxam 500 FS at 1.5 g/kg seed and imidacloprid 70 WS at 10 g/kg seed were the most effective among all the treatments used during both seasons. Not only were all the three treatments effective in controlling yellow mosaic virus disease incidence due to white fly *B. tabaci* but also reduced stem tunnelling by *M. sojae* resulting in significant increase in grain yield. The residues of thiamethoxam and imidacloprid at harvest in the soybean grains analysed by HPLC-UV detector were below the detectable limits of 0.05 and 0.005 mg/kg, respectively.

Khandwe and Sharma (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 blue beetle significantly and recorded 0.66 to1.16 adult beetle. /mrl. Spinosad 45 EC @ 187.5ml/ha was very effective and recorded significantly lowest beetle population (0.66 beetle/mrl).followed by emamectin benzoate 5SG @ 180 g / ha.

2.2 Control of lepidopterous defoliators

Parasai *et al.,* (1990) tested the efficacy of 11 insecticides applied twice against cerambycid, *Obereopsis brevis* on soybean in Madhya Pradesh. The crop damage was lowest with quinalphos (2.9%), followed by phosalone (3.19%) and endosulfan (4.53%).

Singh and Singh (1990) tested efficacy of ten insecticides against stem fly, *Melanagromyza sojae* (Zehntner) and green semilooper, *Chrysodeixis acuta* (Walker) infestation on soybean in Madhya Pradesh and found quinalphos (0.05%) and monocrotophos (0.04%) as highly effective in checking the plant infestation (36.66 and 46.66%) and stem tunnelling (20.69 and 27.36%) caused by the maggots of stem fly as against 100 and 50.28 per cent plant infestation and stem tunnelling, respectively in the control. They found cypermethrin (0.015%), decamethrin (0.001%) and quinalphos (0.05%) as highly toxic against the larvae of *Chrysodeixis acuta* as treated plots were free from larval population even up to 30 days of treatment. Quinalphos gave the maximum net profit of Rs 1704.30/ha, followed by monocrotophos (Rs 1509.12/ha).

Khandwe *et al.,* (1992) evaluated ovicidal action of 15 commercially available insecticides against the eggs of *Rivula sp*., a serious defoliator of soybean in Madhya Pradesh. They found quinalphos (0.025%) and formothion (0.025%) as highly toxic, both causing 100 per cent egg mortality, followed by methyl parathion (0.05%) and triazophos (0.04%) causing 95.33 per cent egg mortality.

Singh and Singh (1994) tested different spray schedules with monocrotophos 36 SC @ 0.036% for the control of Jassid, grey semilooper and stem fly on soybean. Three sprays at 40, 55 and 70 days after sowing (DAS) significantly reduced incidence of jassid, grey semilooper and stem fly and resulted in maximum grain yield (15.44 q/ha) and net profit (Rs 1731.5/ha). However, one spray at 40 DAS gave the highest cost-benefit ratio (1:5.36), followed by two sprays (1:3.24) at 40 and 55 DAS.

Singh and Singh (1994a) tested persistent toxicity of some insecticides against the grey semilooper, *Gesonia gemma* and thrips, *Caliothrips indicus* on soybean in the field cum laboratory trials and found monocrotophos 0.036%, triazophos 0.04% and fenvalerate 0.01% as highly toxic against the grey semilooper, and decamethrin 0.002%, triazophos 0.04% and cypermethrin 0.002% against the thrips.

Singh (1995) reported triazophos (0.04%), acephate (0.07%), chlorpyriphos (0.05%), methomyl (0.04%), ethion (0.1%), endosulfan (0.07%) and quinalphos (0.05%) as highly toxic against the grey semilooper up to 15 days after treatment on soybean.

Mishra *et al.,* (1995) tested six spray schedules against the green semilooper, *Chrysodeixis acuta* and leaf miner, *Biloba subsecivella* Z. on different stages of crop growth of soybean. One spray with monocrotophos 0.4 kg a.i./ha just at the appearance of the pests (30 DAS) was found to be the best treatment for the control of the two pests on soybean, recording least pests population and highest grain yield.

Rajput *et al.,* (1996a) reported that a specified number of plants were damaged by girdle beetle when phorate was applied at 10 and 15 kg/ha in the furrows at the time of sowing.

Rajput *et al.,* (1996b) tested the efficacy of 10 insecticides against major insect pests of soybean at Sehore, Madhya Pradesh and found quinalphos (0.05%) and monocrotophos (0.05%) effective in reducing the stem fly infestation and stem tunnel length. Quinalphos (0.05%), cypermethrin (0.01%) and deltamethrin (0.00125%) were highly effective against the green semilooper (*Chrysodeixis acuta*) larvae. The highest number of pods/plant and lowest number of unfilled pods were observed in plots treated with quinalphos (0.05%), followed by monocrotophos (0.05%). These two insecticides also gave maximum grain yields. They found carbosulfan 50 SP, followed by isofenphos 40 SP, both @ 15 g/kg seed, effective in controlling the stem fly both at seedling and vegetative stages without hampering the seed germination. These insecticides also recorded significantly higher grain yield. Endosulfan, quinalphos and chlorpyriphos in EC formulation @ 15 ml/kg seed were also effective with little adverse effect on seed germination. Yield of these three insecticides ranged from 20.80 to 22.43 q/ha.

Dubey *et al.,* (1998) compared the bio-efficacy and economics of six microbial agents with triazophos in the field against *Gesonia gemma, 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.

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. *Diachrysia orichalcea, chrysodeixis acuta* and *Mocis undata* 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.

Khandwe and Waghmare (2003) conducted field experiments to evaluate the efficacy of chlorpyriphos sprays against green semiloopers, *C. acuta* and *P. orichalsia* [*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 (A*proaerema modicella)*, stem fly (M*elanagromyza sojae*), girdle beetle (O*bereopsis 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).

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*, *Plusia orichalcea* [*Thysanoplusia orichalcea*] and *Obereopsis brevis*). Triazophos was sprayed at 30 and 55 days after sowing. Triazophos at 825 and 1000 ml/ha resulted in the lowest larval population (0.24 larvae m-1 row-1), whereas O. brevis infestation was lowest with 825 ml triazophos/ha in 2000 (13.31) and with 1000 ml triazophos/ha in 2001 (11.90). The lowest grain yield and benefit: cost ratio were recorded for triazophos at 625 ml/ha in both years, 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 825 ml/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, difenthiuron 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.

CHAPTER-III
MATERIAL AND METHODS

The experiments were carried out during Kharif season of 2009-10 at Zonal Agriculture Research Station, R.A.K. College of Agriculture, Sehore. The details of the methods employed and materials used during the course of investigations are as follows.

3.1 Location:

The experiments were conducted in field No. 11 at the Research Farm of Zonal Agricultural Research Station, R.A.K. College of Agriculture, Sehore, Madhya Pradesh under " All India Co-ordinated Research Project on Soybean" financed by ICAR, New Delhi.

3.2 Climate, Season and Geography:

Sehore is situated in sub tropical zone of Vindhayan Plateau of Madhya Pradesh, North of 27^0 12'latitude and East of 77^0 05' longitudes with an altitude of 498.77m from mean sea level (MSL).

The average annual rainfall of this region is 1200mm. The mean annual maximum and minimum temperatures are 32.89^0C and 18.95^0C, respectively.

During the year of investigation i.e. 2009, rains started in the last week of June and the crop received maximum rains in the month of August (319.4mm), followed by July (205.4mm). There was shortage of moisture in soil from third week of September to October. The meteorological data during course of studies are given in (Table-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- 1: Meteorological data during the crop season of 2009 at Sehore,M.P.

Standard Week No.	Period	Temperature ^{o}C		RH (%)	Rainfall (mm)
		Max.	Min.		
23	04.06. 09 -10.06. 09	40.85	26.71	67.28	-
24	11.06. 09 -17.06. 09	40.28	26.21	68.57	1.1
25	18.06. 09-24.06. 09	41.00	26.35	70.57	19.4
26	25.06. 09- 01.07. 09	37.78	22.92	70.85	22.6
27	02.07.09- 08.07. 09	33.42	21.78	75.71	48.5
28	09.07. 09 15.07. 09	32.64	22.21	73.85	98.7
29	16.07. 09- 22.07. 09	27.42	20.42	82.00	296.7-
30	23.07. 09- 29.07. 09	28.50	20.64	88.85	42.6
31	30.07. 09- 05.08. 09	31.07	22.14	74.42	-
32	06.08. 09-12.08. 09	32.85	21.50	71.00	4.1
33	13.08. 09-19.08. 09	29.85	20.42	71.00	46.6
34	20.08. 09-26.08. 09	32.50	21.85	67.42	1.3
35	27.08. 09-02.09. 09	31.00	20.07	75.85	176.6
36	03.09. 09-09.09. 09	30.14	20.71	80.71	102.3
37	10.09. 09-16.09. 09	30.33	20.91	75.66	39.1
38	17.09. 09-23.09. 09	32.64	21.14	70.14	-
39	24.09. 09-30.09. 09	32.86	21.07	71.00	-
40	01.10. 09-07.10. 09	30.00	19.93	78.29	130

41	08.10. 09-14.10. 09	30.71	19.71	70.86	-

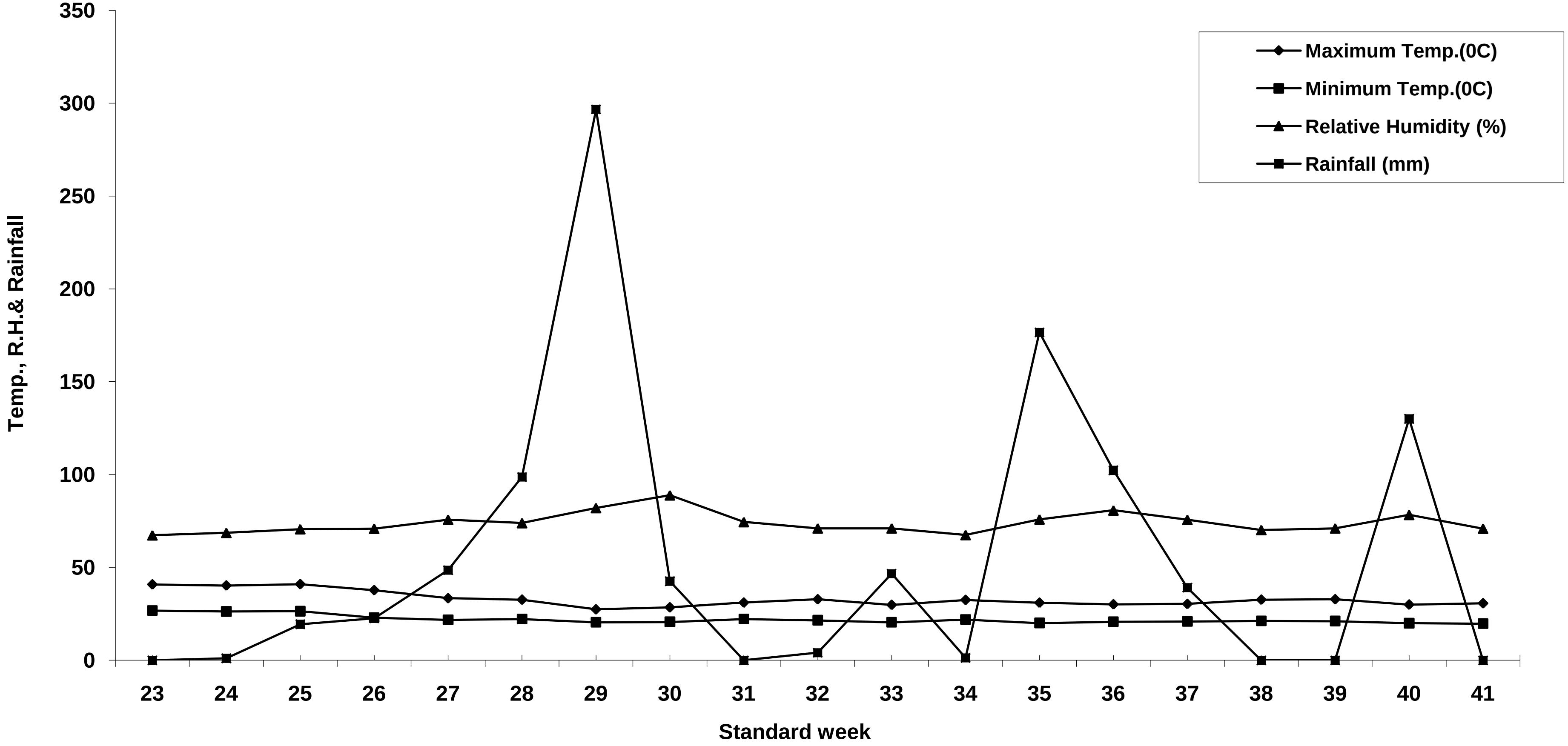


Fig. 1: Meteorological data during the crop season of 2009 at Sehore, M.P.

3.4 Field preparation:
The field was ploughed on 2nd November 2009 with the help of tractor. The stubbles were picked up, and field was crossed with Bakhar on 4th July 2009. Drainage channels were prepared at the time of sowing to drain the excess water from the field.

3.5 Layout:
All the experiments were laid out as per details given below.
Experiment 1: Efficacy of new insecticides as seed dresser against blue beetle and stem fly.
The efficacy of new insecticidal molecules Imidacloprid 600 FS was compared with that of recommended insecticides i.e. Thiamethoxam 70 WS, Chlorpyriphos 20 EC against the major insect pests *viz*. grey semilooper, green semilooper, stem fly and girdle beetle. The experimental details are given below:

1. Design : Randomized Block Design
2. No. of Replications : 4
3. Plot size : 2.8m x 5.0m
4. No. of rows per plot : 7
5. Row to row distance : 40 cm
6. Replication to replication distance: 1.5 m
7. Plot to plot distance : 1.0 m
8. No. of treatments : 8 (7+1)

Details of treatment

No.	Chemical name*	Trade name	Dose (per kg seed)
1.	Imidacloprid 600 FS	Gaucho	0.75ml
2.	Imidacloprid 600 FS	Gaucho	1.00 ml
3.	Imidacloprid 600 FS	Gaucho	1.25ml
4.	Imidacloprid 600 FS	Gaucho	2.25ml
5.	Imidacloprid 600 FS	Gaucho	5.00ml
6.	Thiamethaxam 70 WS	Cruiser	3 g
7.	Chlorpyriphos 20EC (as a foliar spray)	Dursban	1.5 l / ha
8.	Untreated (control)	--------------	------------

* No.1 to 6 seed dressing

9. Date of sowing : 04/07/2009
10. Variety : JS335
11. Date of germination : 07/07/2009

12. Date of treatments

1st (seed dressing) : 04/07/2009

2nd (foliar spray) : 13/07/2009

13. Date of harvesting : 13/10/2009

3.6 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_2O/ha as basal dose.

3.7 Seed rate and method of sowing:

The seed was sown @ 80 kg/ha in lines by putting the seeds in furrows opened by hand plough.

3.8 Plant population (gap filling and thinning) :

In order to maintain the plant population of 5 lakhs/ha, the excess plants were removed at 15 days old crop, keeping a distance of about 5 cm between plant to plant.

3.9. Method of observation:

1. Blue beetle: -

Observations were recorded on adult of blue beetles in per meter row length (mrl) of the crop by shaking the plant on muslin cloth at 10 places at weekly intervals.

2. Stem fly: -

Observation on stem fly infestation were recorded on 10 randomly selected plants at 30 days after germination and at harvesting. To record the stem tunnelling caused by the maggot of stem fly the plants were uprooted and split open vertically. Plant height and tunnel length were measured for calculating per cent tunnelling. Data thus obtained were transformed to angular values for the statistical analysis

3.10 Harvesting and threshing:

Harvesting and threshing were done plot wise manually. Threshed seeds were dried under direct sunlight for two days and yield per plot was recorded.

3.11 Yield:

The grain yield per plot was recorded and converted to kg/ha for comparison.

3.12 Statistical analysis:

The data were subjected to statistical analysis after transformation. The count data were transformed to $\sqrt{x + 0.5}$ values, while percentage were transformed to angular values. The skeleton of analysis of variance is given below.

Analysis of variance Table

S. No.	Source of Variance	d.f.	S.S.	M.S.S.	F. Values	
					Cal.	Tab.
1. 2. 3.	Block Treatment Error	r – 1 t – 1 (r -1) (t – 1)				
	Total	(r × t) - 1				

The difference between the two means was subjected to further testing by computing critical difference at 5% probability level.

The following formulae were used for various estimations.

(i) Standard error for treatments mean :

S.Em± = VE/r

Where, VE = Error of variance

r = Number of replications

(ii) Critical difference (C.D.):

C.D. = S.Em ± x $\sqrt{2}$ x t

"t" = value at 5% probability of error d.f.

Experiment 2: Efficacy of new and recommended insecticides against defoliators and stem borers in soybean.

The efficacy of new insecticidal molecules flubendiamide 480 SC was compared with that of recommended insecticides i.e., Quinalphos 25 EC and Triazophos 40 EC against the major insect pests *viz*. grey semilooper, green semilooper, stem fly and girdle beetle. The experimental details are given below:

EXPERIMENTAL DETAILS

1. Design : Randomized Block Design
2. No. of replication : Four
3. No. of treatment : Six (5+1)

Details of treatments

S .N.	Chemical name	Trade name	Dose	
			(g a.i./ha	(ml/ha)
1.	Flubendiamide 480 SC	Fame	60	125
2.	Flubendiamide 480 SC	Fame	72	150
3.	Flubendiamide 480 SC	Fame	90	187.5
4.	Quinalphos 25 EC	Ekalux	250	1000
5.	Triazophos 40 EC	Hostathion	320	800
6.	Control (Untreated)	………….	………….	…………

4. Plot size : 2.8 m X 5.0 m
5. Row to row distance : 40 cm
6. No. of rows /plot : 7
7. Distance between replication : 1.5 m
8. Plot to plot distance : 1.0 m
9. Variety : JS 335
10. Date of sowing : 04/07/2009
11. Variety : JS 335
12. Date of germination : 07/07/2009
13. Date of harvesting : 15/10/2009
14. Date of insecticidal spray :
    - (i) First spray : 16/08/2009
    - (ii) Second spray : 01/09/2009

15 Date of Observation : Observations were recorded 24 hours before treatment. 1, 3 and 7 days after treatment (DAT)

(a) Lepidopterous defoliators :

(i) First spray : 16/08/2009

24 hours after treatment Obs. : 17/08/2009

3 days after treatment Obs. : 19/08/2009

7 days after treatment Obs. : 23/08/2009

(ii) Second spray : 01/09/2009
24 hours after treatment Obser. : 02/09/2009
3 days after treatment Obser. : 04/09/2009
7 days after treatment Obser. : 08/09/2009

(b) Stem fly : 10 days before harvest.
(c) Girdle beetle : 10 days before harvest.
3.14 Fertilizer application:
As per experiment No.1
3.15 Seed rate and method of sowing:
As per experiment No.1.
3.16 Plant population (gap filling and thinning):
As per experiment No.1.
3.17 Method of observations:
As per experiment No.1. .
3.18 Harvesting and threshing:
As per experiment No.1.
3.19 Yield:
As per experiment No.1
3.20 Statistical analysis:
As per experiment No.1

Chapter-IV
RESULTS

4.1Experiment- 1: Efficacy of new insecticides as seed dresser against blue beetle and stem fly.

The experiment was laid out in randomized block design with 8 treatments including untreated control, each replicated thrice. Sowing of variety JS 335 was done on 4 July, 2009 in plot size of 5 x2.8 m. The seed treated with different dose of imidacloprid 600 FS, thiamethaxam 70 WS and foliar spray of chlorpyriphos 20 EC at 5 days after germination (DAG). The observations on the adult of blue beetle were recorded at 7, 15, 21 and 30 days after germination. The observations of stem fly were recorded at 30 DAG and at harvest.

4.1.1 Effect of seed treatment on population of Blue beetle, *Cneorane sp.*

The observation on blue beetle was recorded at 7, 15, 21, and 30, days after germination. At 7 DAG all the treatments were very effective recording 0.00 to 1.66 beetles/ mrl. However, chlorpyriphos 20 EC as foliar spray was at par with control which recorded 2.00 and 3.00 adult beetle/ mrl. Imidacloprid 600 FS @ 2.25 and 5 ml / kg seed kept the crop free from beetle population.
At 15 DAG, though the population of the blue beetle got reduced in all the treatments including control. Imidacloprid 600 FS @ 1.25, 2.25 and 5 ml/ kg seed were very effective and recorded zero population followed by thiamethaxam 70 WS (0.33 beetle/ mrl) and they were significantly superior over remaining treatments in reducing the population of beetles. Next effective treatments were lower doses of imidacloprid 600 FS (@ 1 and 0.75 ml/ kg seed) and recorded 0.99 and 1.20 beetle / mrl. Chlorpyriphos 20 EC spray recorded 1.85 beetle/ mrl as against 2.66 beetles / mrl in control.

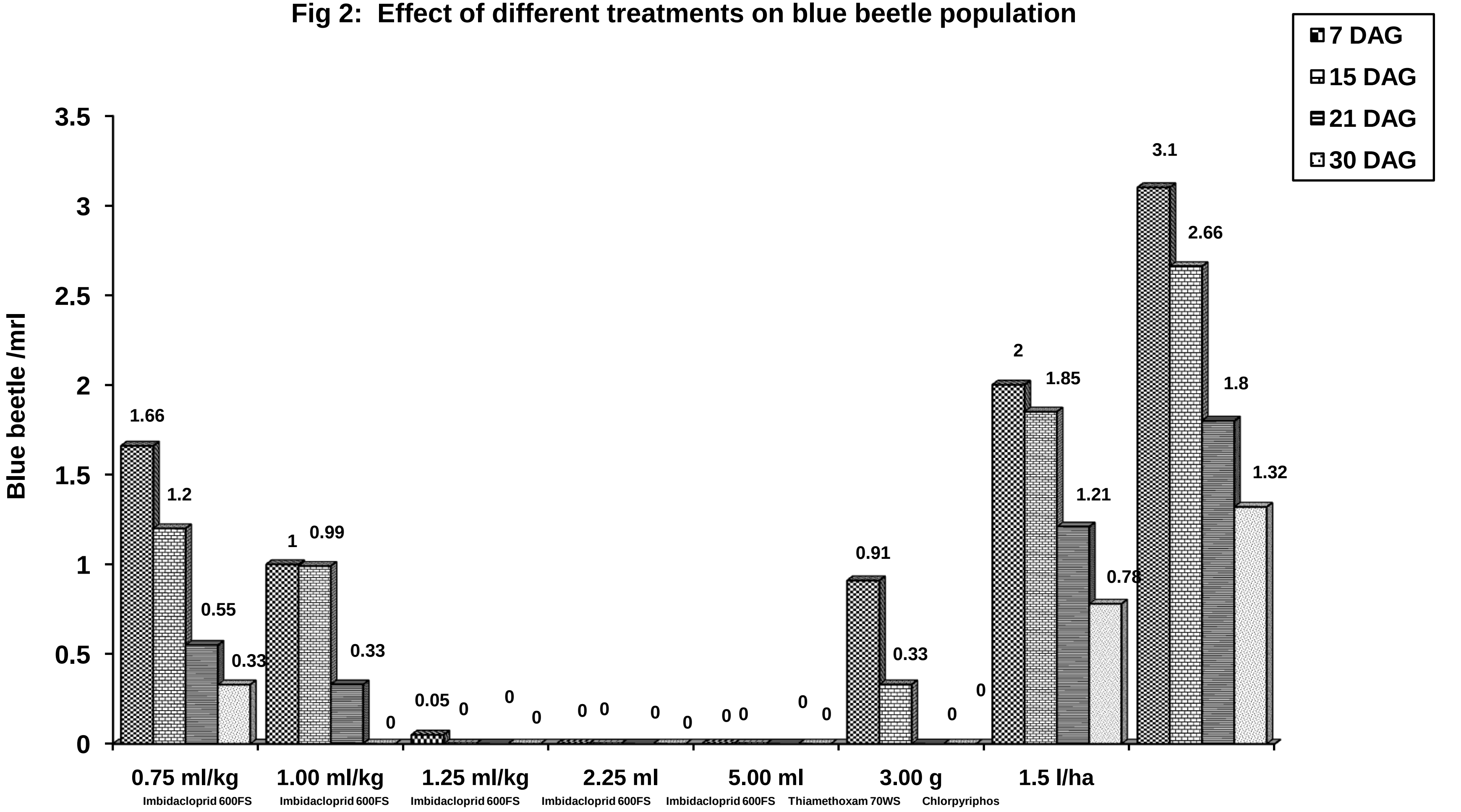
At 21 DAG, imidacloprid 600 FS @ 1.25, 2.25 and 5 ml and thiamethaxam 70 WS @ 3 gm/ kg remained effective and kept crop free from beetle infestation. The remaining treatments were also effective and were at par except control.
At 30 DAG, though the population of blue beetle was found in decreasing trend, but the different dose of imidacloprid 600 FS and thiamethoxam 70 WS as seed treatment remained very effective and kept the crop free from beetle infestation up to 30 days. However, the lowest dose of imidacloprid 600 FS @ 0.75 ml and

Table 2: Effect of different treatments on blue beetle population

S.No.	Treatments	Dose (kg/ seed)	Blue beetle/mrl (meter row length)			
			7 DAG	15 DAG	21 DAG	30 DAG
1.	Imidacloprid 600 FS	0.75 ml	1.66(1.39)	1.20(1.23)	0.55(1.01)	0.33(0.87)
2.	Imidacloprid 600 FS	1.00 ml	1.00(1.18)	0.99(1.21)	0.33(0.91)	0.00(0.70)
3.	Imidacloprid 600 FS	1.25 ml	0.05(0.92)	0.00(0.70)	0.00(0.70)	0.00(0.70)
4.	Imidacloprid 600 FS	2.25 ml	0.00(0.70)	0.00(0.70)	0.00(0.70	0.00(0.70)
5.	Imidacloprid 600 FS	5.00 ml	0.00(0.70)	0.00(0.70)	0.00(0.70	0.00(0.70)
6.	Thiamethoxam 70 WS	3.00g	0.91(1.11)	0.33(0.91)	0.00(0.70	0.00(0.70)
7.	Chlorpyriphos 20 EC	1.5 l/ha	2.00(1.51)	1.85(1.53)	1.21(1.23)	0.78(1.11)
8.	Untreated control	_	3.10(1.90)	2.66(1.77)	1.80(1.67)	1.32(1.33)
	SEm±	_	(0.23)	(0.02)	(0.11)	(0.12)
	CD at 5 %	_	(0.69)	(0.06)	(0.33)	(0.3)

* Figures in parentheses are $\sqrt{x+0.5}$ transformed values DAG = Days After Germination

Fig 2: Effect of different treatments on blue beetle population



spray of chlorpyriphos 20 EC were also effective and at par control, recording the highest beetle population, 1.32 adult beetle / mrl (Table 2, Fig.2 and Plate 1).

4.1.2 Effect on Stem fly, *Melanagromyza sojae* (Zehntner) infestation.

I. Effect on germination: - Germination of soybean seed was not influenced due to application of imidacloprid 600 FS as seed treatment at different concentrations. Germination recorded at 7 days, did not differ significantly among the different treatments and it ranged from 99.50 to 99.80 per cent, respectively including control (Table 3 Fig.4).

II. **Effect on stem fly at 30 DAG: - At 30 (DAG)** all the insecticidal treatments were found significantly superior over control against stem fly in reducing stem tunnelling, caused by maggots of stem fly. The stem tunnelling ranged from 0.99 to 4.37 per cent among all the treatments. Imidacloprid 600 FS @ 5 ml / kg of seed recorded significantly lowest stem tunnelling (0.99 %) being at par with all the treatments except T_1 (Imidacloprid 600 FS @ 0.75 ml / kg seed dressing) and T_7 (spray of chlorpyriphos 20 EC). Untreated control recorded the highest tunnelling i.e. 8.65 per cent.

III. **Effect on stem fly at harvest: -** Observations recorded at harvest revealed that the highest dose of imidacloprid 600 FS i.e. 5 ml / kg seed, recorded significantly lowest stem tunnelling (3.09 %) at par with T_3 and T_4 (Imidacloprid 600 FS @ 1.25 and 2.25 ml / kg seed). Remaining treatments (T_1, T_2 and T_6) were also very effective and significantly at par recording 5.99 to 6.31 per cent stem tunnelling. However, chlorpyriphos 20 EC was comparatively least and effective recorded 8.72 per cent tunnelling. Significantly highest tunnelling (15.94%) was recorded in control plot (Table 3, Fig. 3 and Plate 2).

4.1.3 Effect on yield: -

All the treated plots recorded significantly more grain yield ranged from (2230 to 2505 kg / ha) over control. Imidacloprid 600 FS @ 5 ml / kg seed recorded significantly highest yield (2505 kg / ha) and at par with all the treatment that is a lower doses Imidacloprid 600 FS (2492 to 23 77 kg /ha) and thiamethaxam 70 WS @ 3g/kg seed (2427kg /ha), whereas control recorded minimum yield (1937 Kg/ha) (Table 3, Fig. 4).

Table 3: Bio-efficacy of new and recommended insecticides against early pest, stem fly

S.No.	Treatments	Dose (ml/kg seed)	Germination (%)	% Stem tunnelling caused by Stem fly		Yield (kg/ha)
				30 DAG	At harvest	
1.	Imidacloprid 600 FS	0.75	99.60	3.33 (10.37)	6.33(14.34)	2377.50
2.	Imidacloprid 600 FS	1.00	99.75	3.54 (9.37)	5.89(13.87)	2405.00
3	Imidacloprid 600 FS	1.25	99.88	1.90(6.12)	5.86(13.73)	2480.00
4	Imidacloprid 600 FS	2.25	99.88	1.17(5.50)	4.70(12.41)	2492.00
5	Imidacloprid 600 FS	5.00	99.50	0.99 (5.03)	3.09(8.75)	2505.00
6	Thiamethoxam 70 WS	3.0g	99.80	2.68(8.27)	6.31(14.32)	2427.00
7.	Chlorpyriphos 20 EC	1.5 l/ha	99.80	4.37(11.80)	8.72(17.00)	2230.00
8.	Untreated control	_	99.49	8.65(17.08)	15.94(23.4)	1937.00
	S.Em +	_	1.76	(1.52)	(1.74)	104
	CD at 5 %	_	NS	(4.40)	(5.04)	302

Figures in parentheses are $\sqrt{x+0.5}$ transformed values

DAG = Days After Germination

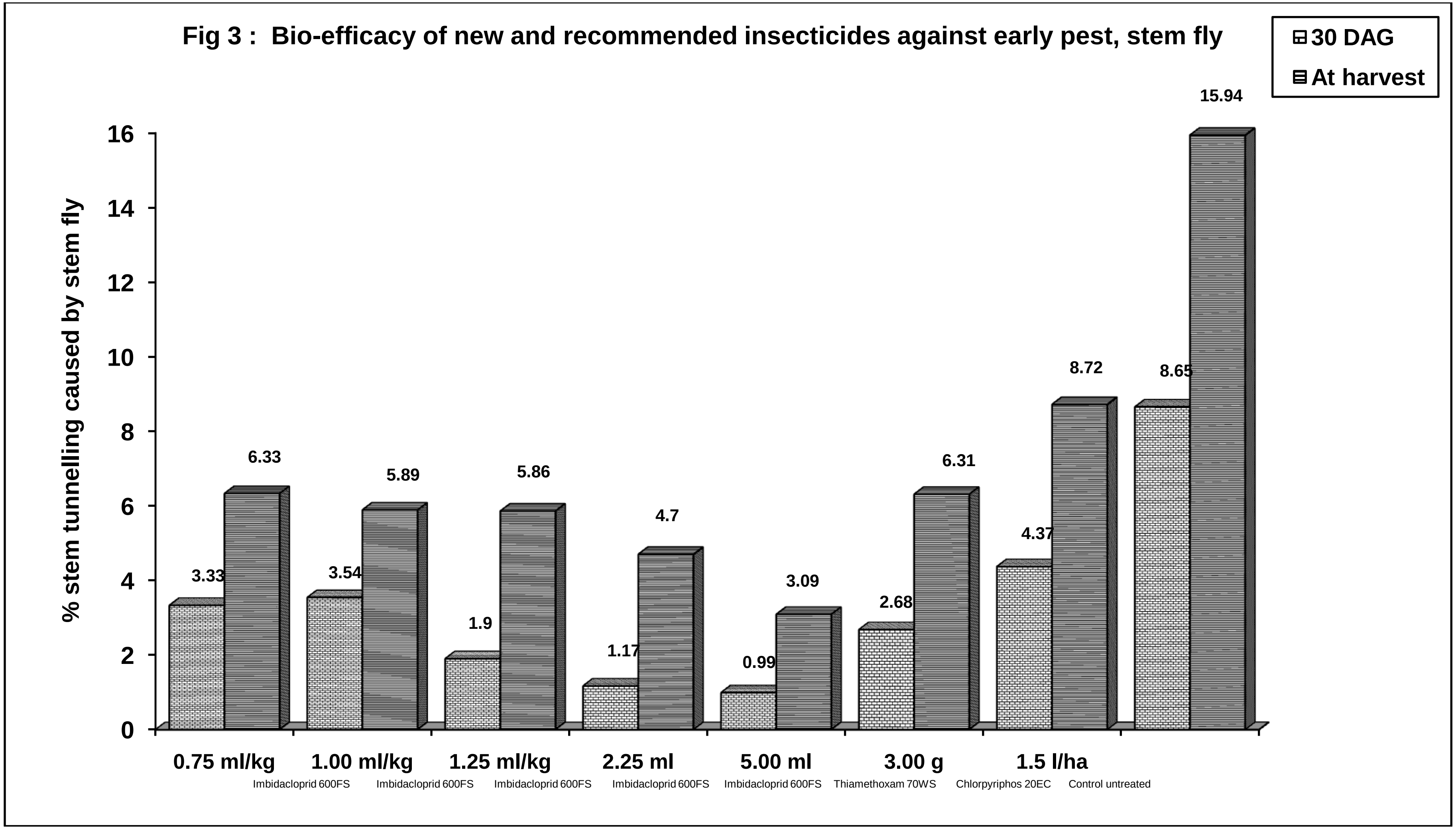


Fig 3 : Bio-efficacy of new and recommended insecticides against early pest, stem fly
30 DAG
At harvest
% stem tunnelling caused by stem fly
0
2
4
6
8
10
12
14
16
3.33
6.33
3.54
5.89
1.9
5.86
1.17
4.7
0.99
3.09
2.68
6.31
4.37
8.72
8.65
15.94
0.75 ml/kg
1.00 ml/kg
1.25 ml/kg
2.25 ml
5.00 ml
3.00 g
1.5 l/ha
Imbidacloprid 600FS
Imbidacloprid 600FS
Imbidacloprid 600FS
Imbidacloprid 600FS
Imbidacloprid 600FS
Thiamethoxam 70WS
Chlorpyriphos 20EC
Control untreated

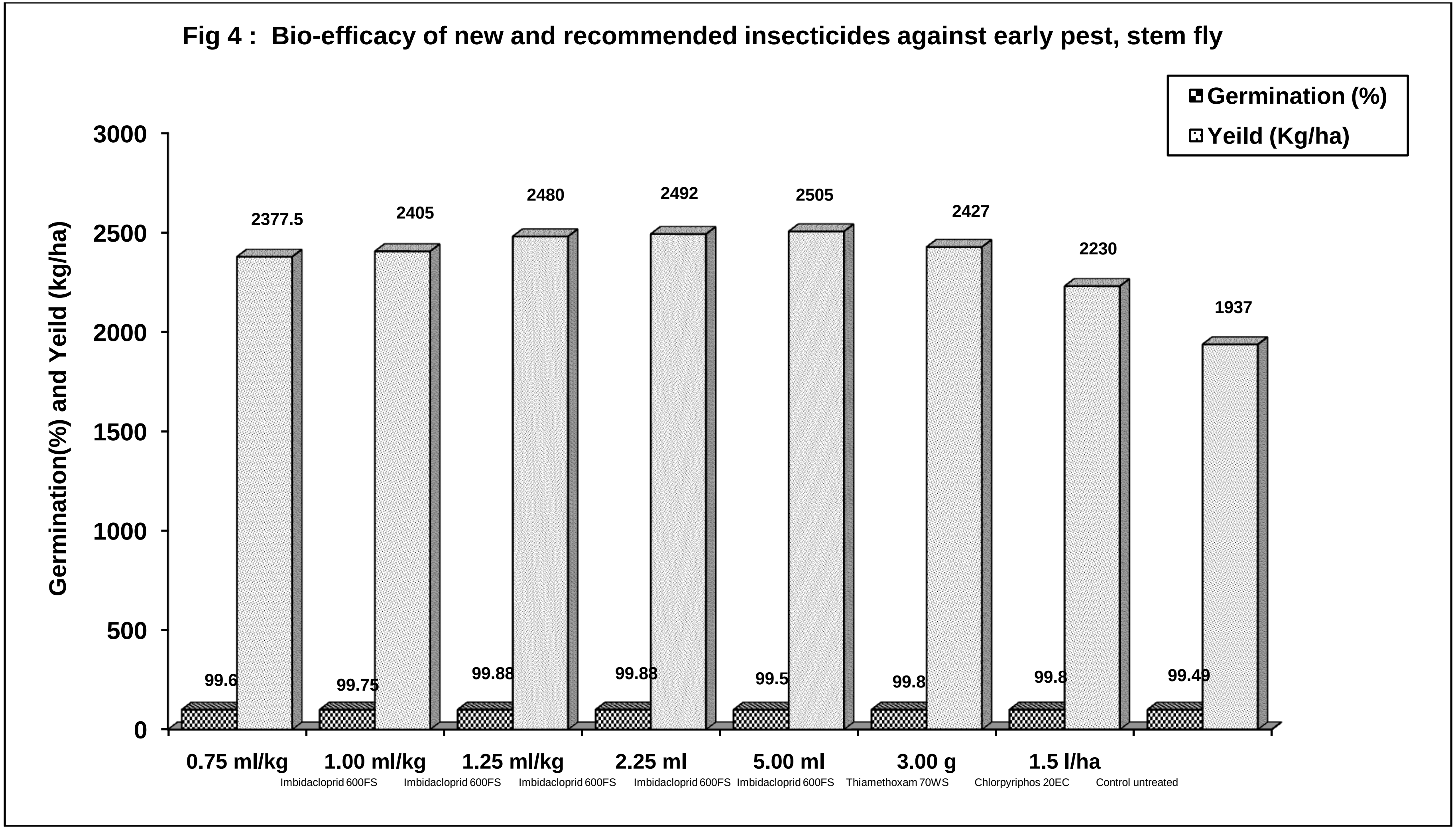


Fig 4 : Bio-efficacy of new and recommended insecticides against early pest, stem fly
Germination (%)
Yeild (Kg/ha)
Germination(%) and Yeild (kg/ha)
3000
2500
2000
1500
1000
500
0
2377.5
2405
2480
2492
2505
2427
2230
1937
99.6
99.75
99.88
99.88
99.5
99.8
99.8
99.49
0.75 ml/kg
1.00 ml/kg
1.25 ml/kg
2.25 ml
5.00 ml
3.00 g
1.5 l/ha
Imbidacloprid 600FS
Imbidacloprid 600FS
Imbidacloprid 600FS
Imbidacloprid 600FS
Imbidacloprid 600FS
Thiamethoxam 70WS
Chlorpyriphos 20EC
Control untreated

4.2 Experiment -2: Efficacy of new and recommended insecticides against defoliators and stem borers in soybean.

The experiment was laid out in randomized block design with 6 treatments including untreated control with four replications. Sowing of JS 335 variety was done on 4 July, 2009 in plot size of 5.0 x 2.8 m. Germination was observed on 7 July, 2009. Two spray treatments were given one 16.08.09 (40DAG) and second on 01.09.09 (55 DAG). Observations on larval population of grey semilooper were recorded 1 day before and 1, 3.and 7 days after treatment (DAT). Observations on plant infestation by girdle beetle and yield were also recorded at harvest.

4.2.1 .Effect on larval population of grey semilooper, *Gesonia gemma* and green semilooper, *C. acuta* (At first spray)

The population of green semiloopers (*C. acuta*) at the time of spray treatment was negligible. The larval population of grey semilooper (*G.gemma)* ranged from 54.33 to 61.58 larvae/mrl before first treatment, which was statistically identical in different plots.

At 1 DAT (Days after treatment) all the insecticidal treatments were significantly superior over untreated control in reducing the larval population of grey semilooper and recorded 3.44 to 9.77 larvae/ mrl in different treatments as against 60.33 larvae/ mrl in control. At one day after treatment quinalphos 25EC recorded significantly lowest population (3.44l/mrl) and at par with triazophos 40 EC. However, all the doses of flubendiamide 480 SC were found very effective and significantly at par (6.88 to 9.77 l/mrl).

At 3 days after insecticidal treatment, all insecticides recorded significantly less larval population (0.66 to 0.99 larvae/mrl) in comparison to control (22.33 larvae/mrl). Among insecticidal treatment, flubendiamide 480 SC @ 187.5 ml recorded significantly lowest population (0.55larvae/ mrl) and at par with all the insecticidal treatment (0.66 to 0.99 larvae /mrl). Whereas control recorded 22.33 larvae/mrl.

At 7 days after treatment, though there was decrease in larval population in all the treatments including control, all the insecticidal treatment were significantly very effective as compared to control .The significantly lowest population was recorded in quinalphos 25 EC (0.16 larvae/mrl) which was at par with rest of the treatment whereas control plot recorded 4.58 larvae /mrl (Table 4 Fig. 5 and Plate 3 & 4).

Table4: Bio-efficacy of new and recommended insecticides against semilooper, *Gesonia gemma* and *C.acuta* in soybean

S.No.	Treatments	Dose (ml/ ha)	Population of semilooper /mrl (1st Spray)			
			Before treatment	1 DAT	3 DAT	7 DAT
1.	**Flubendiamide 480 SC**	125	59.64 (7.74)	9.77 (2.79)	0.99 (1.22)	0.83 (1.11)
2.	Flubendiamide 480 SC	150	61.58 (7.87)	6.88 (2.37)	0.86 (1.05)	0.75 (1.09)
3.	Flubendiamide 480 SC	187.5	52.24(7.25)	8.77 (2.64)	0.55 (0.92)	0.41 (0.92)
4.	Quinalphos 25 EC	1000	54.33(7.39)	3.44 (1.72)	0.99 (1.22)	0.16 (0.81)
5.	**Triazophos 40 EC**	800	57.47 (7.61)	3.99 (1.85)	0.66 (1.03)	0.24 (0.96)
6.	Control untreated	_	59.41(7.73)	60.33 (6.76)	22.33 (4.63)	4.58 (3.92)
	SEm±	_	(0.21)	(0.15)	(0.34)	(0.16)
	CD at 5 %	_	(NS)	(0.44)	(0.98)	(0.47)

* Figures in parentheses are $\sqrt{x+0.5}$ transformed values DAT = Days After Treatment mrl=meter row length

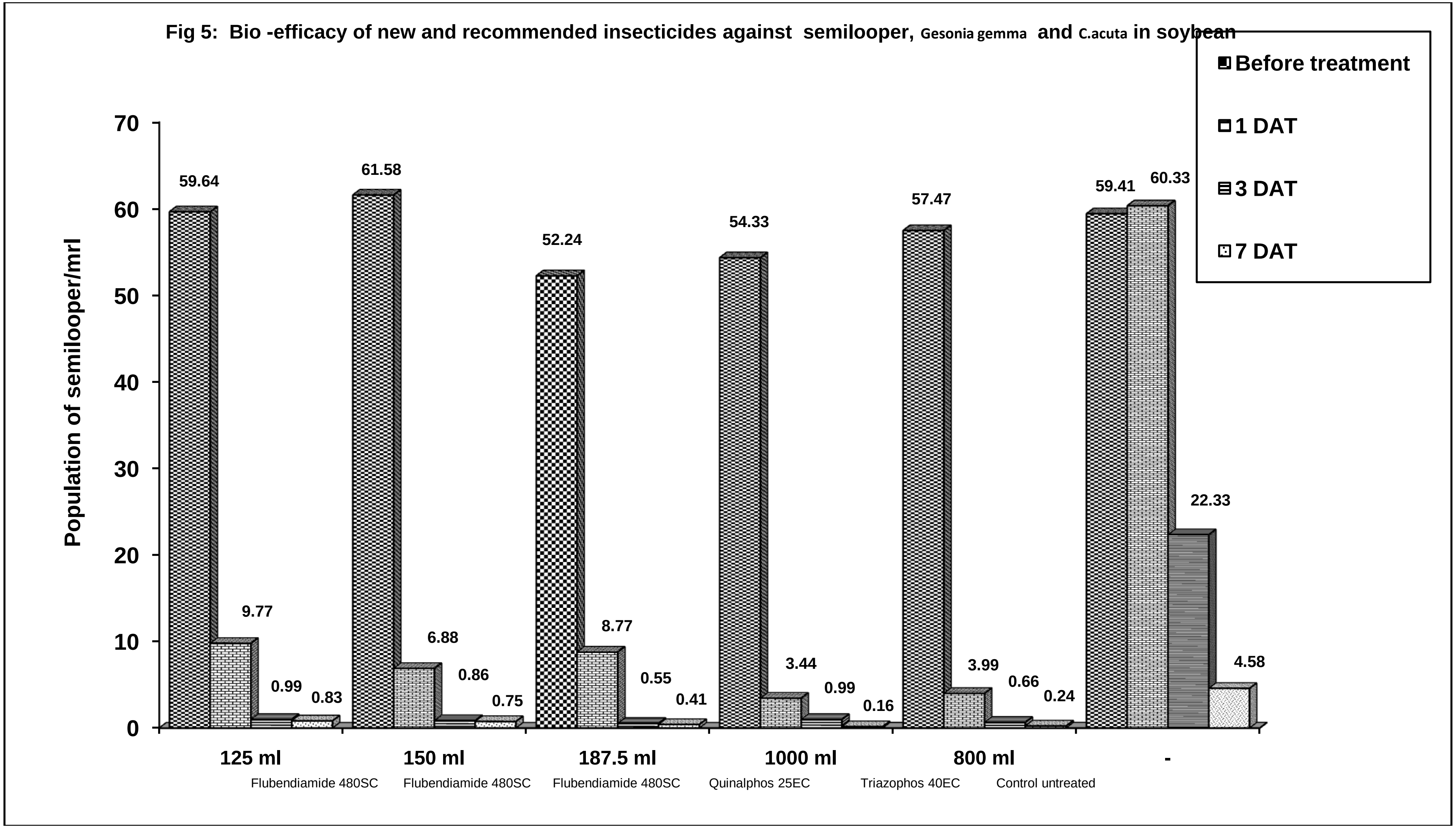


Fig 5: Bio -efficacy of new and recommended insecticides against semilooper, Gesonia gemma and C.acuta in soybean
Before treatment
1 DAT
3 DAT
7 DAT
Population of semilooper/mrl
70
60
50
40
30
20
10
0
59.64
9.77
0.99
0.83
61.58
6.88
0.86
0.75
52.24
8.77
0.55
0.41
54.33
3.44
0.99
0.16
57.47
3.99
0.66
0.24
59.41
60.33
22.33
4.58
125 ml
150 ml
187.5 ml
1000 ml
800 ml
-
Flubendiamide 480SC
Flubendiamide 480SC
Flubendiamide 480SC
Quinalphos 25EC
Triazophos 40EC
Control untreated

4.2.2. Effect on larval population of grey semilooper, *Gesonia gemma* and green semilooper, *C. acuta* (At second spray)

In general due to rains and high humidity larval population was found in decreasing trend. During last week of August again larval population of green and grey semilooper appeared, hence the second treatment was given on 1.9.2009. At the time of 2nd spray treatment, the larval population of defoliators consisted of mostly grey semilooper. Before treatment larval population of green and grey semilooper ranged from 7.41to 23.07 larvae/ mrl in different treatments and 36.57 l/mrl in control, which significantly differed due to effect of first spray treatment. The efficacy of tested insecticide flubendiamide 480 SC remained up to second spray treatment.

At one days after treatment all the insecticidal treatments were significantly superior over to untreated control in reducing the larval population of grey and green semilooper and recorded 2.87 to 4.37 larvae/ mrl in different treatments as against 24.62 larvae/ mrl in control.

At three days after insecticidal treatment, all insecticides recorded significantly less larval population (0.25to 0.58 larvae/mrl) in comparison to control (13.81 larvae/mrl). Among insecticidal treatments, flubendiamide 480 SC @ 187.5 ml recorded significantly lowest population (0.83 larvae/ mrl) and was at par with all the insecticidal treatments recording 0.88 to 1.01 larvae /mrl. However control recorded maximum population (13.81 larvae/mrl).

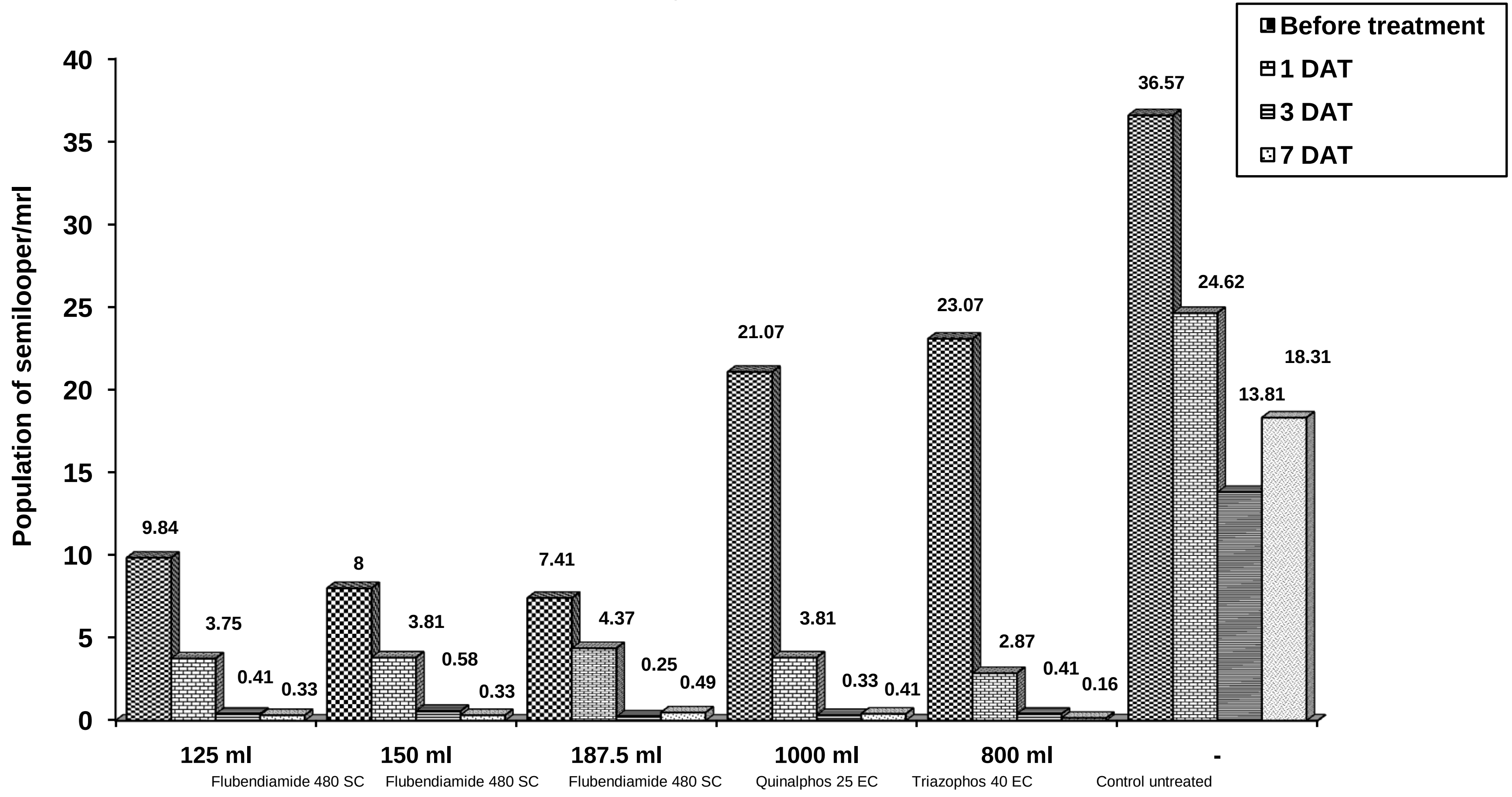
At seven days after treatment, though there was decrease in larval population in all the treatment including control, all the insecticidal treatment were significantly very effective as compared to control .The significantly lowest population was recorded in triazophos 40 EC@ 800ml/ha (0.16 larvae/mrl) which was at par with rest of the treatments where as control plot recorded 18 .31 larvae /mrl (Table 5, Fig. 6 and Plate 3 & 4).

Table 5: Bio-efficacy of new and recommended insecticides against semilooper, *Gesonia gemma* and *C.acuta* in soybean

S.No.	Treatments	Dose (ml/ ha)	Population of semilooper /mrl (2nd Spray)			
			Before treatment	1 DAT	3 DAT	7 DAT
1.	**Flubendiamide 480 SC**	125	9.83 (3.21)	3.75 (2.05)	0.41 (0.94)	0.33 (0.88)
2.	Flubendiamide 480 SC	150	8.00 (2.86)	3.81 (2.05)	0.58 (1.01)	0.33 (0.88)
3.	Flubendiamide 480 SC	187.5	7.41 (2.77)	4.37 (2.20)	0.25 (0.83)	0.49 (0.98)
4.	Quinalphos 25 EC	1000	21.07 (4.52)	3.81 (2.05)	0.33 (0.88)	0.41 (0.95)
5.	**Triazophos 40 EC**	800	23.07 (4.82)	2.87 (1.82)	0.41 (0.92)	0.16 (0.81)
6.	Control untreated	_	36.57 (6.07)	24.62 (4.99)	13.81 (3.67)	18.31(4.22)
	SEm±	_	(0.29)	(0.22)	(0.24)	(0.26)
	CD at 5 %	_	(0.84)	(0.63)	(0.71)	(0.77)

* Figures in parentheses are $\sqrt{x+0.5}$ transformed values DAT = Days After Treatment

Fig 6: Bio -efficacy of new and recommended insecticides against semilooper, *Gesonia gemma* and *C.acuta* in soybean



4.2.3 Effect on girdle beetle (*Obereopsis brevis*):

The infestation of girdle beetle was recorded before harvest of the crop. All the treatments were found significantly superior over control in reducing the girdle beetle infestation ranged from 22.00 to 33.20 per cent. Significantly minimum infestation of girdle beetle (22.00%) was recorded in quinalphos 25EC @1.0 l/ha which was at par with rest of the treatments. whereas control plot recorded 41.41 per cent. However, all the doses of flubendiamide 480 SC @125, 150 and 187.5 ml/ha were found very effective and significantly at par recorded 25.20 to 33.20 per cent infestation respectively (Table 6 and Fig. 7).

4.2.4 Yield:

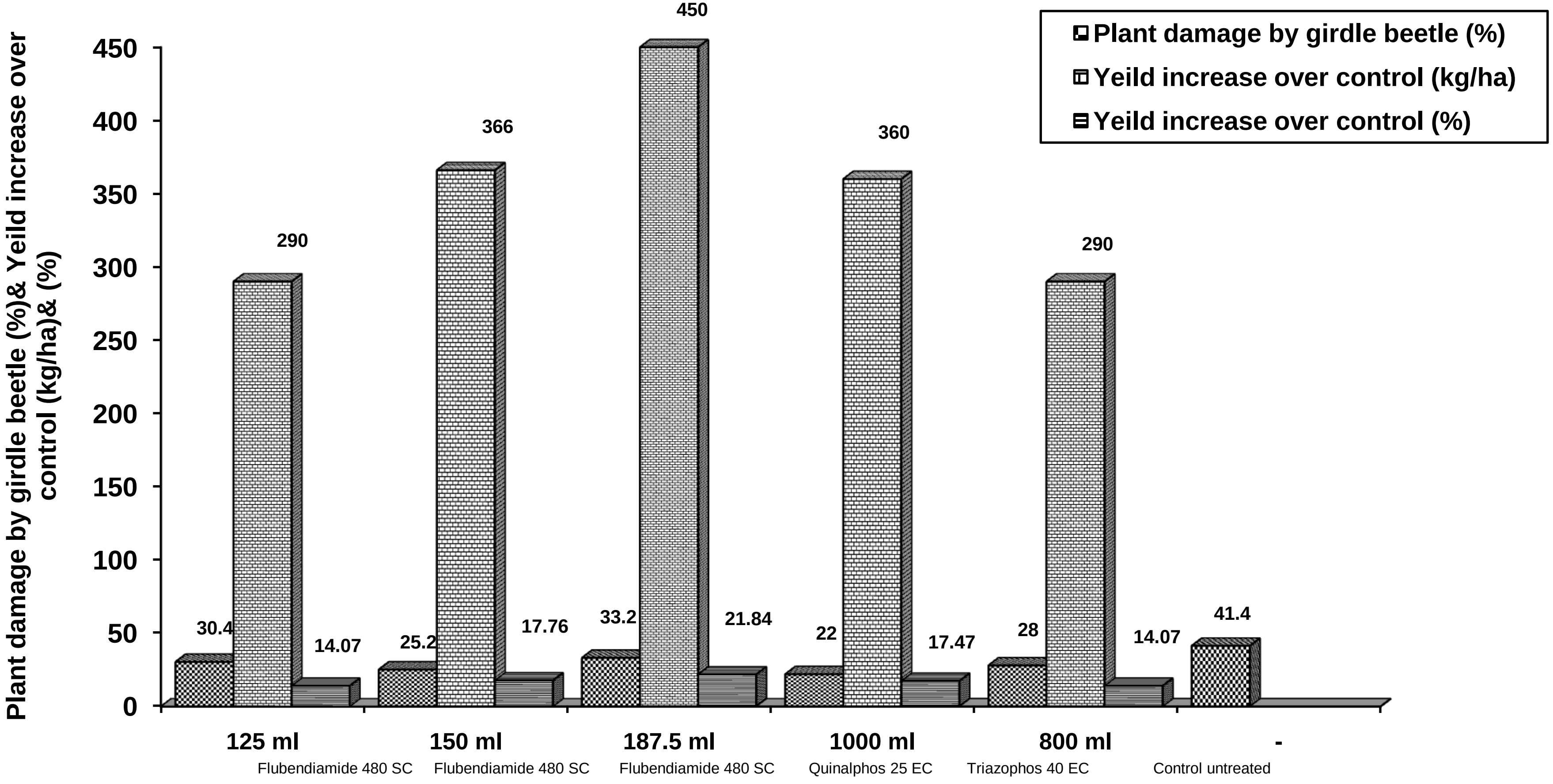
All the insecticidal treatments recorded good yield and significantly at par with untreated control. All the doses of flubendiamide 480 SC and recommended check insecticides like quinalphos 25EC and triazophos 40 EC almost recorded similar yield which ranged from 2350 to 2510 kg/ha. Flubendiamide 480 SC@187.5 ml gave 21.84% yield increase over control followed by quinalphos 25 EC that is (17.47 per cent) (Table 6 and Fig. 7).

Table 6: Efficacy of different insecticides against girdle beetle, and yield of soybean

S.No.	Treatments	Dose (ml/ha)	Plant damage by girdle beetle (%)	Yield (kg/ha)	Yield increase over control	
					(kg/ha)	(%)
1.	Flubendiamide 480 SC	125	30.40(33.37)	2350	290	14.07
2.	Flubendiamide 480 SC	150	25.20(30.17)	2426	366	17.76
3.	Flubendiamide 480 SC	187.5	33.20(32.65)	2510	450	21.84
4.	Quinalphos 25 EC	1000	22.00(27.93)	2420	360	17.47
5.	Triazophos 40 EC	800	28.00(31.80)	2360	290	14.07
6.	Control untreated	_	41.40(37.45)	2060	_	_
	SEm±	–	2.08	116	–	--
	CD at 5 %	–	6.03	334	–	–

* Figures in parentheses are angular transformed values.

Fig 7: Efficacy of different insecticides against girdle beetle and yeild of soybean



CHAPTER - V
DISCUSSION

5.1 Experiment: - 1: Efficacy of new insecticides as seed dresser against blue beetle and stem fly.

Among four major insect pests recorded on soybean crop, blue beetle and stem fly are reported as an early season seedling pest of the crop, hence the seed treated with different doses of Imidacloprid 600 FS, thiamethaxam 70 WS and foliar spray of chlorpyriphos 20 EC at 5 days after germination were evaluated against these two pests and the results are discussed here in following pages:

5.1.1: Effect of seed treatment on population of Blue beetle *Cneorane sp.*

From the results it is concluded that the, imidacloprid 600 FS @ 1.25, 2.25 and 5 ml/ kg seed were very effective (0.00beetle/mrl) and kept crop free from beetle infestation followed by thiamethoxam 70 WS (0.33 beetle/ mrl) and they were significantly superior to remaining treatments in reducing the population of beetles. Next effective treatments were lower doses of imidacloprid 600 FS (@ 1 and 0.75 ml/ kg seed) which recorded 0.99 and 1.20 beetle / mrl. Chlorpyriphos 20 EC spray recorded 1.85 beetle/ mrl as against 2.66 beetles / mrl in control.

Earlier, Singh and Singh (1998) reported that the thiamethaxam 70 WS @ 3g and 5 g/kg seed was found highly and significantly more toxic insecticide inflicting 85, 95 and 22 per cent blue beetle mortality after 10, 15 and 20 days of crop germination, respectively. Similarly, Singh *et al.* (2000) also observed that the thiamethaxam 70 WS at both doses @ 3 and 5 g/kg of the seed was found highly effective and inflicted longer residual toxicity up to 20 days after germination against the blue beetle. In present investigation thiamethoxam 70 WS also gave the good control of the blue beetle and remained effective up to 30 days after germination. .

Recently, Khandwe and Sharma (2009) reported that the foliar spray of spinosad 45EC@187.5ml/ha and emamectin benzoate 5SG@ 180 g / ha was very effective and recorded significantly lowest beetle population. However, in the present investigation foliar spray of Chlorpyriphos 20 EC was least effective as compared to seed treatments.

5.1.2 Effect on Stem fly, *Melanagromyza sojae* (Zehntner) infestation.

At 30 days after germination, the stem tunnelling ranged from 0.99 to 4.37 per cent among all the treatments. Imidacloprid 600 FS @ 5 ml / kg of seed recorded significantly lowest stem tunnelling (0.99 %) and at par with all the treatments except imidacloprid 600 FS @ 0.75 ml / kg and spray of chlorpyriphos 20 EC. Control recorded the highest tunnelling *i.e*. 8.65 per cent. Similarly, at harvest the highest dose of imidacloprid 600 FS i.e. 5 ml / kg seed, recorded significantly lowest stem tunnelling (3.09 %) and at par with imidacloprid 600 FS @ 1.25 and 2.25 ml / kg seeds. and thiamethoxam 70 WS@ 3g/kg seed. Remaining treatments of lower doses of imidacloprid 600 FS i.e.0.75 &1 ml/kg of seed were also very effective and significantly at par and recorded 5.99 to 6.31 per cent stem tunnelling. However, chlorpyriphos 20 EC was comparatively least effective and recorded 8.72 per cent tunnelling. Significantly highest tunnelling was recorded in control plot (15 .94 %). Stem tunnelling was very low in general during the year of investigation. Earlier many workers also tested the various insecticides as seed dresser. Bagle and Verma (1990) reported that the single application of granular phorate at 1.5 kg a.i./ha was effective against the stem fly infeststion,where as Kundu and Shrivastava (1991) reported that the application of phorate 10G @ 15 kg/ha before sowing, followed by 1 spray of 0.04% monocrotophos 20 days after germination or phorate 10 G @ 15 kg/ha alone at sowing reduced stem tunnelling (17.07 - 21.00%).Kundu and Mishra (1993) found that the phorate, quinalphos and mephosfolan significantly reduced infestation of *Melanagromyza sojae*. Sharma (1994) reported that the seed dressing of soybean with phosalone (35 EC) or Carbosulfon (25 STD) controlled *Melanagromyza sojae.* Singh *et al.* (2000) reported that to thiamethaxam 70 WS at both doses was found highly effective and inflicted longer residual toxicity up 60 days after germination against the stem fly infestation. The similar observation is also reported in present investigation. Dahiphale, *et al.* (2007) reported that the reduction in tunnelled stem length due to stem fly (*Melanagromyza sojae*) was greatest with the soil application of phorate 10 G. Debjani *et al.* (2008) evaluated the efficacy of different formulations of thiamethoxam and imidacloprid 70 WS, carbofuran 3 G and phorate 10 G as seed dressing at the time of sowing and found that thiamethoxam 70 WS at 1.5 g/kg seed, thiamethoxam 500 FS at 1.5 g/kg seed and imidacloprid 70 WS at 10 g/kg seed were the most effective and reduced stem tunnelling by *M. sojae* in soybean.

In present investigation foliar spray of Chlorpyriphos 20 EC was least effective as compared to seed treatments but earlier various workers tested the efficacy of many insecticides as foliar spray and their results are reviewed here .investigation as against 43.70 to 50.28 per cent reported by the various workers. Monocrotophos and quinalphos (Singh and Singh, 1990), Quinalphos (Parsai, *et. al.* 1991) and monocrotophos (Kundu and Shrivastava,1991; Latha *et. al.,* 1993 and Venkateshan and Kundu (1994) have been reported effective in checking the plant infestation and stem tunnelling caused by maggots of stem fly. Seed treatment with EC formulation of endosulfan, quinalphos and chlorpyriphos @ 15ml/kg seed has been reported effective against the infestation of *Melanagromyza sojae* in Orissa (Sontakke, 1995). Further, Sharma *et. al.* (1997) found monocrotophos and fenvalerate as effective in reducing larval population of agromyzids.

5.1.3 Effect on grain yield:

All the treated plots recorded significantly more grain yield ranging from (2230 to 2505 kg / ha) over control. Imidacloprid 600 FS @ 5 ml / kg seed recorded significantly highest yield (2505 kg / ha) and at par with all the treatment except control. Earlier maximum grain yield of soybean 19.99 q/h and increased grain yield from 1.1 to 1.7 q/ha over control has been obtained by applying phorate @2.0 kg a.i/ha at sowing, followed by sprays of monocrotophos 0.04% at 15and 21days after sowing. (Gain and Kundu, 1988 and Kundu and Shrivastava 1991).Similarly, maximum grain yield and the best cost -benefit ratio (1:2:88) were achieved with the treatment of phorate alone (1.0kg a.i/ha) at 25 days after sowing. (Singh and Singh,1989c and Kundu and Shrivastava 1991and Dahiphale, *et al*. 2007),where as Latha *et al.* (1993) reported that the seed treatment with Carbosulfan @ 20 g/kg seed, followed by spraying with 0.05% monocrotophos at 31 and 51 days after sowing contributed the highest yield

In present investigation Imidacloprid 600 FS @ 5 ml / kg seed recorded significantly highest yield (2505 kg / ha).Thiamethoxam 70 WS @ 3g/kg seed and other lower doses of Imidacloprid 600 FS recorded better grain yield of soybean . In the conformity with the present finding Singh *et al.* (2000) and (Debjani *et al.* 2008) also reported that thiamethaxam 70 WS @ 3 g and 5g/kg seeds, thiamethoxam 70 WS at 1.5 g/kg seed, thiamethoxam 500 FS at 1.5 g/kg seed and imidacloprid 70 WS at 10 g/kg seed were the most effective and increased the grain yield significantly.

5.2 Experiment 2: Efficacy of new and recommended insecticides against defoliators and stem borers in soybean.

Among four major insect pests recorded on soybean crop, grey and green semilooper are reported as defoliators and girdle beetle as a stem borer on the crop, hence the experiment was laid out in randomized block design with 6 treatments including control with four replication. Two spray treatments of new and recommended insecticides were given for their effectiveness against these pests and the results are discussed here in the following pages:

5.2.1Effect on larval population of grey semilooper, *Gesonia gemma* and green semilooper, *C. acuta*

The population of green semiloopers (*C. acuta*) at the time of spray treatment was observed at negligible level. The larval population of grey semilooper (*G.gemma)* ranged from 54.33 to 61.58 larvae/mrl before first treatment, which was statistically identical in different plots. At one DAT (Days after treatment) all the insecticidal treatments were significantly superior as compared to untreated control in reducing the larval population of grey semilooper and recorded 3.44 to 9.77 larvae/ mrl in different treatments as against 60.33 larvae/ mrl in control. Quinalphos 25EC@ 1l/ha recorded significantly lowest population (3.44 l/mrl) and at par with triazophos 40 EC. However, all the doses of flubendiamide 480 SC were found very effective and significantly at par recorded 6.88 to 9.77 l/mrl. At 3 and 7days after insecticidal treatment, all insecticides recorded significantly less larval population in comparison to control. Among insecticidal treatment, flubendiamide 480 SC @ 187.5 ml and quinalphos 25 EC 1.0 l/ha recorded significantly lowest population and at par with all the insecticidal treatment *i.e.* triazophos 40 EC @ 800 ml/ha and flubendiamide 480 SC @ 125ml and 150 ml/ha.

At the time of 2nd spray treatment, the larval population of defoliators consisted of mostly grey semilooper. Before treatment larval population of green and grey semilooper ranged from 7.41to 23.07 larvae/ mrl in different treatments and 36.57 l/mrl in control, which significantly differed due to effect of first spray treatment. The efficacy of tested insecticides flubendiamide 480 SC, triazophos 40 EC@ 800ml/ha and quinalphos 25 EC 1.0 l/ha remained up to second spray treatment that is up to 55 days of crop stage. At one, three and seven days after spray again all the insecticidal treatments were significantly superior as compared to untreated control in reducing the larval population of grey and green semilooper.

Among insecticidal treatments, flubendiamide 480 SC @ 187.5 ml and triazophos 40 EC@ 800ml/ha significantly lowest population was recorded which was also at par with all the insecticidal treatment. Quinalphos 25 EC 1.0 l/ha recorded significantly lowest population and at par with all the insecticidal treatment *i.e*. quinalphos 25 EC 1.0 l/ha and flubendiamide 480 SC @ 125ml and 150 ml/ha.

Earlier, Singh and Singh (1990) reported cypermethrin (0.015%), decamethrin (0.001%) and quinalphos (0.05%) as highly toxic against the larvae of *Chrysodeixis acuta* up to 30 days of treatment. Further, monocrotophos 0.036%, triazophos 0.04% and fenvalerate 0.01% quinalphos (0.05%), deltamethrin (0.00125%) cypermethrin (0.01%) have been reported as highly toxic against the grey and green semilooper of soybean by various workers.(Singh and Singh 1994, Singh and Singh,1994a, Mishra *et al.* 1995 and Rajput *et al.* 1996).

Singh (1995) reported that the toxicity of triazophos (0.04%), acephate (0.07%), chlorpyriphos (0.05%), methomyl (0.04%), ethion (0.1%), endosulfan (0.07%) and quinalphos (0.05%) against the grey semilooper remained up to 15 days after treatment on soybean. In present findings the efficacy of flubendiamide 480 SC , triazophos 40 EC @ 800ml/ha and quinalphos 25 EC 1.0 l/ha remained up to second spray treatment that is up to 55 days of crop stage which is also supported by the findings of Singh (1995). Similarly, Khandwe *et al.* (1992) reported quinalphos (0.025%) and formothion (0.025%) as highly toxic, both causing 100 per cent egg mortality of *Rivula sp*., a serious defoliator of soybean in Madhya Pradesh. Dubey *et al.* (1998) reported that triazophos40 EC @ 800 ml/ha was significantly more toxic in reducing the larval population as compared to the microbial insecticides.

Yadav *et al.* (2001) reported that the new and recommended insecticides like quinalphos 20 AF and ethofenprox 10 EC, chlorpyriphos 50 EC + cypermethrin 5 EC and profenofos + cypermethrin 44 EC were effective against semilooper ,*Chrysodeixis acuta* and in keeping the larval population below 2 larvae /mrl. Similarly, in present investigation new and recommended insecticides flubendiamide 480 SC@ 187.5 ml, triazophos 40 EC@ 800ml/ha and quinalphos 25 EC 1.0 l/ha were also equally effective and kept the the larval population below 1 larvae /mrl. Khandwe and Waghmare (2003) reported, that a single spray of chlorpyriphos (0.1%) at 30 days after sowing (DAS) was highly effective in reducing the larval population of green semiloopers, *C. acuta.*Whereas, Choudhary *et al.* (2007) found that the triazophos @ 825 and 1000 ml/ha recorded the lowest larval population (0.24 larvae m row^{-1}), of green semiloopers, *C. acuta* on soybean.

Khandwe *et al*. (2009) reported that the spinosad 45 SC @ 187.5ml/ha, difenthiuron 50 WP @0.500 ml/ha and quinalphos 25 EC @ 1.5 lit /ha were also found very effective against grey and green semilooper and recorded less than 1 larvae /mrl.

5.2.3 Effect on girdle beetle, *Obereopsis brevis* (Swedenbord) infestation:

The infestation of girdle beetle was recorded before harvest of the crop. All the treatments were found significantly superior over control in reducing the girdle beetle infestation ranging from 22.00 to33.20 per cent. Significantly minimum infestation of girdle beetle (22.00%) was recorded in quinalphos 25 EC @1.0 l/ha which was at par with rest of the treatments. However, all the doses of flubendiamide 480 SC those is 125, 150 and 187.5 ml/ha were found very effective and significantly at par recording 25.20 to 33.20 per cent infestation as against 41.40 per cent in control. Earlier, Parsai *et al.* (1990) also reported that the crop damage by *Obereopsis brevis* was lowest with quinalphos (2.9%), followed by phosalone (3.19%) and endosulfan (4.53%).In present findings quinalphos 25 EC 1.0 l/ha recorded significantly minimum infestation of girdle beetle. Whereas Rajput *et al* (1996) reported that a specified number of plants were damaged by girdle beetle when phorate was applied at 10 and 15 kg/ha in the furrows at the time of sowing .Yadav *et al.* (2001) found Carbosulfan 25 EC as most toxic insecticides to girdle beetle (*Obereopsis brevis*), followed by chlorpyriphos 50 EC + cypermethrin 5 EC and lambda cyhalothrin 5 EC. Salunke *et al*. (2004) observed that the lowest infestation of girdle beetle was recorded in carbofuran 3 G at 30 kg/ha. Choudhary *et al.* (2007) reported that the *Obereopsis brevis* infestation was lowest (13.31%) with 825 ml triazophos/ha and with 1000 ml triazophos/ha (11.90%).

5.2.4 Effect on grain yield:

All the insecticidal treatments recorded good yield and significantly at par over untreated control. All the doses of Flubendiamide 480 SC that is 125 ,150 and 187.5 ml/ha, recommended check insecticides like quinalphos 25EC @ 1.0 l/ha and triazophos 40 EC@800ml/ha almost recorded similar yield ranging from 2350 to 2510 kg/ha. Flubendiamide 480 SC@187.5 ml gave highest (21.84%) yield increase followed by quinalphos 25 EC 17.47 per cent yield increase over control.

Earlier, Singh and Singh (1990) tested efficacy of ten insecticides against major insect pests and they found that quinalphos gave the maximum net profit of Rs

1704.30/ha, followed by monocrotophos (Rs 1509.12/ha).Singh and Singh (1994) reported that the three sprays of monocrotophos 36 SC @ 0.036%.at 40, 55 and 70 days after sowing (DAS) gave maximum grain yield (15.44 q/ha) and net profit (Rs 1731.5/ha). However, one spray at 40 DAS gave the highest cost-benefit ratio (1:5.36), followed by two sprays (1:3.24) at 40 and 55 DAS, respectively. Dubey *et al.* (1998) reported that triazophos was significantly more toxic and offered the maximum net profit of Rs 2968/ha.Rajput *et al.* (1996) reported that quinalphos (0.05%), cypermethrin (0.01%) and deltamethrin (0.00125%) gave good yield, ranging from 20.80 to 22.43 q/ha when tested against pests of soybean. However, in present findings quinalphos 25 EC gave 17.47 per cent increased soybean in yield over control. Yadav *et al.* (2001) reported maximum grain yield in plot treated with chlorpyriphos 50 EC + cypermethrin 5 EC, 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) reported that triazophos at 825 ml/ha recorded highest grain yield, per cent increase in grain yield, and per cent avoidable yield loss in soybean

Chapter-VI

Summary, conclusions and suggestions for further work

Experiment 1: Efficacy of new insecticides as seed dresser against blue beetle and stem fly.

- At 7 Days After Germination (DAG) imidacloprid 600 FS @ 2.25 and 5 ml / kg seed kept the crop free from beetle population.
- At 15 DAG, though the population of the blue beetle reduced in all the treatments including control, imidacloprid 600 FS @ 1.25, 2.25 and 5 ml/ kg seed were very effective, recording zero population followed by thiamethoxam 70 WS (0.33 beetle/ mrl) and were significantly superior to remaining treatments in reducing the population of beetles.
- At 21 DAG, again imidacloprid 600 FS @ 1.25, 2.25 and 5 ml and thiamethoxam 70 WS @ 3 gm/ kg seed remained effective and kept crop free from beetle infestation.
- At 30 DAG, population of blue beetle was found in decreasing trend, the different doses of imidacloprid 600 FS and thiamethoxam 70 WS as seed treatment remained very effective and the crop escaped from beetle infestation up to 30 days.
- Imidacloprid 600 FS @ 5 ml / kg of seed recorded significantly lowest stem tunnelling (0.99%) caused by maggot of stem fly and was at par with all the treatments except Imidacloprid 600 FS @ 0.75 ml / kg and spray of chlorpyriphos 20 EC at.
- The highest dose of imidacloprid 600 FS i.e. 5 ml / kg seed, recorded significantly lowest stem tunnelling (3.09 %) by girdle beetle grubs and was at par with imidacloprid 600 FS @ 1.25 and 2.25 ml / kg seed.
- Imidacloprid 600 FS @ 5 ml / kg seed recorded significantly highest yield (2505 kg / ha) and was at par with all the treatment *i.e*. a lower doses of imidacloprid 600 FS (2377 to 2492 kg /ha) and thiamethoxam 70 WS @ 3g/kg seed (2427kg /ha) as against lowest (1937 kg/ha) in the untreated control.

Experiment 2:- Efficacy of new and commonly recommended insecticides against defoliators and stem borers of soybean.

- At first spray flubendiamide 480 SC @ 187.5 ml and quinalphos 25 EC 1.0 l/ha recorded significantly lowest population and were at par with all the insecticidal treatments *i.e.* triazophos 40 EC @ 800 ml/ha and flubendiamide 480 SC @ 125ml and 150 ml/ha.
- The efficacy of tested insecticides flubendiamide 480 SC @ 187.5 ml, triazophos 40 EC@ 800ml/ha and quinalphos 25 EC 1.0 l/ha remained up to second spray treatment that is up to 55 days of crop stage. At one, three and seven days after second spray again all the insecticidal treatments were significantly superior as compared to untreated control in reducing the larval population of grey and green semilooper.
- Among insecticidal treatments, flubendiamide 480 SC @ 187.5 ml and triazophos 40 EC@ 800ml/ha recorded significantly lowest population and were at par with all the insecticidal treatment. Quinalphos 25 EC 1.0 l/ha recorded significantly lowest population and were at par with all the insecticidal treatment *i.e.* quinalphos 25 EC 1.0 l/ha and flubendiamide 480 SC @ 125ml and 150 ml/ha.
- Significantly minimum infestation of girdle beetle (22.00%) was recorded in quinalphos 25EC @1.0 l/ha. However, all the doses of flubendiamide 480 SC @125, 150 and 187.5 ml/ha were found very effective and significantly at par, recording 25.20 to 33.20 per cent infestation.
- All the doses of flubendiamide 480 SC and recommended check insecticides like quinolphos 25EC and triazophos 40 EC almost recorded similar yield ranging from 2350 to 2510 kg/ha. Flubendiamide 480 SC@187.5 ml gave 21.84% yield increase followed by quinalphos 25 EC (17.47%) over untreated control.

Conclusion:

- Imidacloprid 600 FS @ 1.25, 2.25 and 5 ml/kg seed and thiamethoxam 70 WS @ 3 g/ kg seed as seed dresser were found effective against blue beetle and stem fly infestation and recorded good range of yield .
- Flubendiamide 480 SC @ 187.5 ml and triazophos 40 EC@ 800ml/ha were found effective against grey semilooper (*Gesonia gemma* Swinhoe) and green semilooper (*Chrysodeixis acuta* Walker).
- Quinalphos 25EC @1.0 l/ha was found effective against girdle beetle infestation.
- Flubendiamide 480 SC@187.5 ml gave 21.84% yield increase followed by quinalphos 25 EC (17.47%) over untreated control.

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.

REFERENCES

Anonymous (2005). Directors report and summary tables of experiments. National Research Centre for Soybean, Indore (M.P.).

Bagle, B.G.andVerma,S.(1990). Bioefficacy and persistence of phorate and monocrotophos on/in soybean. *Indian J. plant Prot*., 18(2):177-185.

Choudhary, H.R; Ali, M; Baldev Ram (2007). Evaluation of integrated pest management components against major insect pests of soybean (*Glycine max*) in Rajasthan. *Indian J. Agri. Sci.,* 77 (8): 540-541.

Dahiphale,K.D; Suryawanshi,D.S; Kamble,S.K; Pole,S.P; Madrap,I.A (2007) Studies on effect of new insecticides against the control of major insect pests and yield of soybean [*Glycine max* (L.) Merrill]. *Soybean Research* 5: 87-90.

Debjani, Dey; Irani,Mukherji; Trimohan (2008). Evaluation of some insecticides against, *Melanagromyza sojae* Zehnt. and *Bemisia tabaci* Genn. on soybean. *Pesticide Research Journal.,* 20 (1) : 72-74.

Dubey, M.P.; Singh, K.J.; Singh, O.P. and S. Chaturvedi (1998). Bio-efficacy and economics of microbial agents in the field against major insect pests of soybean in Madhya Pradesh, *Crop Res*., 15(2): 256-259.

Gain, D. and Kundu, G.G. (1988). Insecticidal control of soybean stem miner, *Melanagromyza sojae* (Zehntner).*Entomon* 13 (1): 99-102.

Khandwe, N.; Gujrati, J.P. and O.P. Singh (1992). Ovicidal action of some insecticides against the eggs of grey semilooper, *Rivula sp.* on soybean. *J. Insect Sci*., 5 (2): 231-232

Khandwe,N. and Sharma,S.(2009).Efficacy of newer and eco-friendly insecticides against defoliators of soybean National Seminar on organic farming for sustainable agriculture and livelihood security held at RVSKVV, Gwalior 22 – 23 December, 2009 pp. 84.

Khandwe,N. Waghmare, S.K. (2003). Chemical control of green semiloopers, *Chrysodeixis acuta* (Walker) and *Plusia orichalsia* (Fabricius) in soybean. *JNKVV Res. Journal* 37(*2*): 108-111.

Kundu, G.G. and K.P. Shrivastava (1991). Management of soybean stem fly, *Melanagromyza sojae* (Zehnt.) in plains of North India. *Indian J. Insect Sci*., 4 (1): 50-53.

Kundu,G.G. and Mishra,S.D.(1993). Efficacy of granular insecticides against stem fly and nematode infestation in soybean with *Rhizobium* inoculants. *Indian J. Ento*., 55(3):225-228.

Latha, C.R.P.; Sriramulu, M. and T.R. Babu (1993). Evaluation of insecticides against insect pest complex of soybean, *Glycine max* (L.) Merrill*. Pesticide Res. J.,* 5(2): 212-224.

Mishra, B.K.; Mandal, S.M.A. and P.R. Mishra (1995). Studies on chemical control schedule for soybean green semilooper*, Chrysodeixis acuta* (Walker) and leaf miner*, Biloba subsecivella* Zeller*. J. Insect Sci., 8* (1): 73-75.

Parsai, S.K.; Shrivastava, S.K. and S.S. Shaw (1990). Comparative efficacy and economics of synthetic pyrethroids in the management of soybean girdle beetle. *Current Res.,* 19(8): 134-136

Parsai, S.K.; Choudhary, R. and R. Deshpande (1991). Efficacy and economics of soybean stem fly, *Melanagromyza sojae* (Zehntner). *Bhartiya Krishi Anusandhan Patrika* 6 (2): 85-90.

Rajput ,R.R.; Singh, O.P.; Das ,S.B.; Saxena, Ashok and A. Saxena (1996a). Bioefficacy of granular insecticides against stem fly and defoliators in soybean. *Bhartiya Krishi Anusandhan Patrika* 11 : 91-97.

Rajput, P.S.; Singh, O.P.; Saxena, A. and S.B. Das (1996b). Studies on efficacy and economics of some insecticides as emulsion against major pests of soybean. *Bhartiya Krishi Anusandhan Patrika* 11(3): 173-178.

Salunke, S.G.; Munde, A.T.; More, D.G.; Mane, P.D. and U.S. Bidgire (2004). Efficacy of some granular insecticides against insect pests of soybean seedlings *Journal Soils and Crop* 14(1): 156-162.

Sharma, A. N. (1994). Control of stem fly and sucking insects of soybean through seed treatment. *J. Maharashtra Agril. University* 19(2): 310-311.0

Sharma, D.; Gargav, V.P. and U. Sharma (1997). Effect of insecticides on the incidence of soybean stem fly *[(Ophiomyia phaseoli* (Tryon)] *Crop Res.*, 13(2): 437-443.

Singh, K.J. and O. P. Singh (1994a) Persistent toxicity of some synthetic pyrethroid and organophosphate insecticides to grey semilooper and thrips on soybean in Madhya Pradesh. *J. Insect Sci*., 7(2): 224-225.

Singh, K.J. and O. P. Singh (1994b). Spray schedule and economics of control of Jassids, grey semilooper and stem fly on soybean in Madhya Pradesh. *Indian J. Plant Prot*., 22(2): 183-186.

Singh, K.J. and O.P. Singh (1998). Residual toxicity of some granular and seed treatment insecticides against blue beetle on soybean *Pestology* 2 (2): 11-13.

Singh, O. P. and K. J. Singh (1988). Effectiveness of some insecticides against the larval population of grey semilooper, *Rivula sp*., a new pest of soybean in Madhya Pradesh, India*. Pesticides* 22 (7): 34-35.

Singh, O.P. (1999). Perspective and prospects of insect pest control in India with reference to sustainable environment in India, pp. 639-640. Proceedings of world soybean conference 6, Aug. 4-7, 641. 1999, Chicago. Illinois, U.S.A.

Singh, O.P. (1995). Summary of results of entomological trials conducted during kharif 1995 pp. 222-223 in project Co-ordinators report and summary tables of experiment, AICRP on Soybean (Indore).

Singh, O.P. and K.J. Singh (1990). Efficacy and economics of some emulsifiable concentrate insecticides against *Melanagromyza sojae* (Zehntner) and *Chrysodeixis acuta* (Walker) on soybean. *J. Insect Sci.,* 3(1): 77-82.

Singh, O.P. and K.J. Singh (1999). Arthropod pests of soybean pp. 171-193. In IPM system in agriculture, Vol. 5 (Eds. Upadhyay, R. K.; Mukherji, K. G. and Rajak, R. L.). *Aditya Book Pvt. Ltd*. New Delhi.

Singh, O.P. and S. N. Verma (1992). Pests of soybean in Madhya Pradesh. In Vistas in insect pests and disease of soybean in India. (Eds. Singh, O. P. and Shrivastava, S. K.). International Book Distributors, Dehra Dun (In Press).

Singh, O.P. and Singh,K.J.(1989 c). Efficacy and economics of granular insecticides in the management of stem borers of soybean in Madhya Pradesh, India *.Pestology* 13(2):8-12.

Singh, O.P., Singh, K.J. and K.K. Nema (2000). Efficacy of some seed dressing and granular insecticides against major insect pests of soybean. *Pestology* 24(1): 8-11.

Sontakke, B. K.; Mukherjee, S. K. and P. R. Mishra (1995). Efficacy of insecticidal seed dressing against soybean stem fly, *Melanagromyza sojae* (Zehntner). *Indian J. Plant Prot*., 23: 35-37.

Venkateshan, T. and G.G. Kundu (1994). Bio-efficacy of insecticides for the control of stem fly and whitefly infesting the soybean crop. *Indian J. Ent.,* 14(4): 418-421.

Yadav, M.K.; Matkar, S.M.; Sharma, A.N.; Billore, M.; Kapoor, K.N. and G.L. Patidar (2001). Efficacy and economics of some new insecticides against defoliators and stem borers of soybean, [*Glycine max* (L.) Merrill]. *Crop Res. Hisar* 21 (1):88-92.

APPENDICES

Experiment - 1: Efficacy of new insecticides as seed dresser against blue beetle and stem fly.

1.1 Effect on population of blue beetle, *Cneorane sp.*

(i) 7 days after first spray treatment application

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1	Block	3	0.01	0.00		
2	Treatment	7	4.81	0.69	3.99	2.49
3	Error	21	3.61	0.17		
	Total	31	8.43	SEm± =0.23 CD at 5% =0.69		

(ii) 15 days after first spray treatment application

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1	Block	3	0.08	0.02		
2	Treatment	7	1.13	0.16	4.00	2.49
3	Error	21	0.91	0.04		
	Total	31	2.12	SEm± =0.02 CD at 5% =0.06		

(iii) 21 days after first spray treatment application

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1	Block	3	0.02	0.016		
2	Treatment	7	2.19	0.312	5.88	2.49
3	Error	21	1.113	0.053		
	Total	31	3.32	SEm± =0.11 CD at 5% = 0.34		

(iv) 30 days after first spray treatment application

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1	Block	3	0.62	0.20		
2	Treatment	7	1.86	0.26	4.44	2.49
3	Error	21	1.26	0.06		
	Total	31	3.74	SEm± =0.12 CD at 5% = 0.36		

1.2 Effect on stem tunnelling (%) at 30 DAG:

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1	Block	3	71.94	23.98	3.44	
2	Treatment	7	447.26	63.89	9.16	2.49

3	Error	21	146.53	6.98		
	Total	31	665.73	SEm± =1.52 CD at 5% =4.40		

1.3Stem fly stem tunnelling (%) at Harvest:-

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1 2 3	Block Treatment Error	3 7 21	8.18 504.24 191.96	2.73 72.03 9.14	0.30 7.88	2.49
	Total	31	704.38	SEm± =1.74 CD at 5% = 5.041		

1.4. Effect of grain yield (kg/ha):

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1 2 3	Block Treatment Error	3 7 21	027 1.28 0.69	0.09 0.18 0.03	2.73 5.61	2.49
S	Total	31	2.24	SEm± =0.104 CD at 5% = 0.302		

Experiment 2: Analysis of variance for the Efficacy of new and recommended Insecticides against defoliators and stem borers in soybean.

2.1 Effect on larval population of grey semilooper, *Gesonia gemma* (Swinhoe)

(i) Pre- treatment (1st spray)

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1 2 3	Block Treatment Error	3 5 15	0.22 1.09 2.10	0.07 0.22 0.14	0.51 1.56	2.90
	Total	23	3.41	SEm± = 0.21 CD at 5% = 0.62		

(ii) 24Hours after treatment:

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1 2 3	Block Treatment Error	3 5 15	0.16 70.67 1.08	0.05 14.13 0.07	0.72 0.002	2.90

	Total	23	71.90	SEm± =0.15 CD at 5% = 0.44		

(ii) 3 DAT after treatment:

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1	Block	3	1.54	0.51	1.49	
2	Treatment	5	43.25	8.65	24.98	2.90
3	Error	15	5.19	0.35		
	Total	23	49.99	SEm± =0.34 CD at 5% = 0.98		

(iii) 7DAT after treatment:

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1	Block	3	0.16	0.05	0.63	
2	Treatment	5	29.13	5.83	70.77	2.90
3	Error	15	1.23	0.08		
	Total	23	30.52	SEm± = 0.16 CD at 5% = 0.47		

2.2 Effect on larval population of green semilooper, *Chrysodeixis acuta* (Walker)

(i) Pre- treatment (2nd spray)

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1	Block	3	0.57	0.19	0.73	
2	Treatment	5	38.11	7.62	29.40	2.90
3	Error	15	3.89	0.26		
	Total	23	42.57	SEm± =0.29 CD at 5% = 0.84		

(ii) 24 Hours after treatment:

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1	Block	3	0.20	0.07	0.47	
2	Treatment	5	29.49	5.90	40.79	2.90
3	Error	15	2.17	0.14		
	Total	23	31.86	SEm± =0.22 CD at 5% = 0.63		

(iii) 3 DAT after treatment:

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1	Block	3	1.37	0.46	2.48	

2	Treatment	5	25.35	5.07	27.63	2.90
3	Error	15	2.75	0.18		
	Total	23	29.47	SEm± =0.24 CD at 5% = 0.71		

iv) 7DAT after treatment:

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1	Block	3	1.08	0.36	1.68	
2	Treatment	5	36.89	7.38	34.45	2.90
3	Error	15	3.21	0.21		
	Total	23	41.18	SEm± = 0.26 CD at 5% = 0.77		

2.3 Damaged plant by girdle beetle (%)

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1	Block	3	101.23	33.74	2.58	
2	Treatment	5	206.69	41.34	3.16	2.90
3	Error	15	196.30	13.09		
	Total	23	504.23	SEm± =2.08 CD at 5% = 6.03		

2.4 Effect on grain yield (kg/ha):

S.No.	Source of variance	D.f.	S.S.	M.S.S.	Cal. F.	Tab. F.
1	Block	3	0.32	0.11	2.64	
2	Treatment	5	0.95	0.19	4.76	2.90
3	Error	15	0.60	0.04		
	Total	23	1.87	SEm± =0.116 CD at 5 %= 0.334		

VITA

The author of this thesis Rakesh Kumar Shakya was born on 10th January, 1983 at Sheopur, Madhya Pradesh.

He completed his earlier education at Vijaypur and passed High School and Higher Secondary Examination from Govt. Boys Higher Secondary School, NO 1 Vijaypur with 58.00 % in 1999 and 65.00 % in 2001, respectively.

He joined the College of Agriculture, Gwalior, affiliated to Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.), in the year 2003 and passed the B. Sc. (Ag.) examination with 6.56 O.G.P.A. in the year 2008.

He joined the R. A. K. College of Agriculture, Sehore (M.P.) in the year 2008-09 for Post Graduation programme in Agricultural Entomology and completed all the requirements for the same. He is submitting thesis for M. Sc. (Ag.) degree.