“STUDIES ON BIOEFFICACY OF NEW CHEMISTRY INSECTICIDES AGAINST RICE BROWN PLANT HOPPER, *Nilaparvata lugens* (Stal.) (Homoptera :Delphacidae)

By

Mr. MANGESH DATTATRAY JADHAV

(Reg. No. 10/186)

A Thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI-413 722, DIST. AHMEDNAGAR,
MAHARASHTRA STATE, INDIA

In partial fulfillment of the requirements for the degree

Of

MASTER OF SCIENCE (AGRICULTURE)

In

AGRICULTURAL ENTOMOLOGY

AGRICULTURAL ENTOMOLOGY SECTION
COLLEGE OF AGRICULTURE,
KOLHAPUR - 416004

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2012

CANDIDATE'S DECLARATION

I hereby declare that this thesis or a part

there of has not been submitted

by me or any other person

to any other University

or Institute for

a Degree or

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This is to certify that the thesis entitled,**"STUDIES ON BIOEFFICACY OF NEW CHEMISTRY INSECTICIDES AGAINST RICE BROWN PLANTHOPPER,*Nilaparvatalugens* (Stal.) (Homoptera:Delphacidae)**submitted to the Faculty of Agriculture, Mahatma PhuleKrishiVidyapeeth, Rahuri, Dist. Ahmednagar,Maharashtra State, India in partial fulfillment of the requirements for the degree of**MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ENTOMOLOGY,**embodies the results of a bona-fideresearch work carried out by**MANGESH DATTATRAY JADHAV,** under my guidance and supervision and no part of the thesis has been submitted for any other degree or diploma in other form.

The assistance and help received during the course of this investigation and sources of literature referred to have been duly acknowledged.

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Place: Kolhapur

Date: / /2012 *(Mangesh Dattatray Jadhav)*

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LIST OF ABBREVIATIONS

@	At the rate of
a.i.	Active ingredient
BPH	Brown planthopper
CD	Critical difference
^{o}C	Degree Celsius
DAS	Days after spraying
DAT	Days after treatment
DBS	Days before spraying
EC	Emulsifiable concentrate
et al.	Etalli (and other)
etc.	Etcetra
e.g.	For example
Fig.	Figure(s)
G	Granular
GLH	Green leaf hopper
g	Gram(s)
ha	Hectare
IRRI	Indian Rice Reserch Institute
i.e.	Id est (That is)
kg	Kilogram(s)
MW	Meteorological week
m	meter
mg	milligram
mm	mili meter
viz.,	Namely
PT	Persistent toxicity

r	Pearson correlation coefficient value
%	Per cent
/	Per
SC	Soluble concentrate
SG	Soluble granules
SL	Soluble liquid
SP	Soluble powder
q	Quintal
Spp.	Species
WAT	Week after transplanting
WG	Wettable granular

ABSTRACT

"BIOEFFICACY OF NEW CHEMISTRY INSECTICIDES AGAINST RICE BROWN PLANT HOPPER,
Nilaparvata lugens **(Stal.) (Homoptera :Delphacidae)"**

By

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A candidate for the Degree of

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An investigation was undertaken with an objective to evaluate the relative bioefficacy of new insecticide molecules *viz.,* triazophos 40 EC, clothianidin 50 WDG, buprofezin 25 SC, lambda-cyhalothrin 5 EC, thiamethoxam 25 WG, imidacloprid 17.8 SL, acetamiprid 20 SP and *Metarhizium anisopliae* WP against brown plant hopper. All

the newer insecticide treatments were observed to be effective in reducing brown planthopper population. Among the evaluated the treatment with clothianidin 50 WDG was found to be the most effective and significantly superior over all other treatments in reducing the hoppers population (1.40) per hill. The treatment with buprofezin 20 SC recorded 1.73 hopper per hill, found at par with acetamiprid 20 SP, thiamethoxam 25 WG and imidacloprid 17.8 SL in which 1.87, 1.99 and 2.05 hopper per hill were observed. Respectively, this was followed by the treatment lambda cyhalotrin 5 EC, triazophos 17.8 SL and *M. anisoplae* WP in which (2.96), (4.16) and (4.43) hoppers per hill were noticed, respectively as against (12.20) hoppers population in untreated control.

Among the evaluated granular insecticides, overall performance of various granular insecticidal treatments based on the mean survival population indicated that treatment with fipronil + imidacloprid 80 WG was found to be the most effective and significantly superior over all other treatments, (8.42 per hill). Rynaxypyr 0.4 G stood second in order of effectiveness which recorded 9.13 hopper population per hill. Treatment with fipronil 0.3 G proved as next effective treatment by recording 11.33 hopper population and found at par with cartap hydrochloride recorded 11.64 hopper population per hill. This was followed by the treatments chloropyriphos, carbofuron and phorate in which 13.23, 14.56 and 15.53 hopper population per hill were noticed as against 22.61 hoppers per hill, respectively in untreated control.

The mean population of hopper 6.50 per hill was first observed at eleven week after transplanting in 36th MW which was increased gradually and reached to maximum of 36.64 hopper population per hill the 20th week after transplanting during 45th MW. The peak hopper population was observed during 15th to 22th MW. There after hoppers population was declined to 8.3 at 24th WAT in 49th MW. Thus, it seems that hopper burns due to *N. lugens* went on increasing till panicle stage to harvesting stage of rice crop, and then it was found to be declined with age of rice crop.

The treatmentwith *M. anisoplae* was relatively safe to natural enemies. This was followed by buprofezin, imidacloprid, acetamiprid, thiamethoxam, clothianidin, triazophos and lambda cyhalothrin which were proved moderately safe to natural enemies in rice ecosystem.

The results of the present investigations are indicative for the harmonious integration of precise utilization of the best performing newer insecticide, correlation of population dynamics of brown plant hopper and weather parameter, and use insecticides safety to natural enemy and environmental safety for management of brown planthopper.

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1. Introduction

Rice (*Oryza sativa L)* is staple food grain crop of the 60 per cent of the world human population. In India 2/3 population depends on rice (Mathur *et al.* 1999). India is the world second largest rice producer and consumer next to China. Total area under rice in India is 45.4 million ha. with annual production of 99.2 million tonnes and productivity is 2018 kg/ha (Anonymous, 2010). Among the major food crops, rice (paddy),*O. sativa* is the one of that is almost exclusively human food providing about 80% of the calories to over two billion Asians (Chang,1984) .

However, in Maharashtra state it is cultivated over an area about 14.30 lakh ha with a production about 20.47 lakh tonnes having productivity1431 kg/ha (Anonymous, 2009). Major rice growing districts in Maharashtra are Thane, Ratnagiri, Raigad, Sindhudurg and Kolhapur.

Rice is an important crop because of its nutritional as well as commercial value as 100 g of rice supplies 365 kcal energy, 0.12 g sugar, 7.12 g protein 1.3 g diatery fiber, thiamine, riboflavin, zinc, calcium, iron, manganese stress quantity (Anonymous, 2010).

Besides high economic value now a day's cultivation is becoming means to the farmer because of attack of insect pest causing damage from seedling stage to its maturity.

In India, about 300 species of insects have been reported to attack rice crop, of which 20 have been found to be major pests (Pathak,1977;Arora and Dhaliwal,1996) causing 21 to 51 per cent loss (Singh and Dhaliwal,1999). The insect pests like yellow stem borer, brown plant hopper, green plant hopper, paddy gall midge, leaf folder and white backed plant hopper are national significance major pests of paddy (Krishnaiah *et al.,* 1999). The stem borer and brown plant hopper are the worst pests which can cause severe damage and yield loss to rice crop in later stage.

In India, losses incurred by different insect pests of rice have been reported to the tune of 55,120 million rupees which in turn workout to 18.16 per cent of total losses. Brown plant hopper is the major pest of rice throughout Asia. Rice crop is prone to severe yield losses by both abiotic and biotic stresses to an extent of 46.4 per cent out of which 26.7 per cent is due to insect pests, (Jayaraj, 1996). Brown plant hopper *Nilparvata lugens* (Stal.), causes substantial damage to the crop both directly and indirectly (Reddy *et al.*, 1993) and loss of crop yield due to brown plant hopper is estimated between 10 and 30 per cent (Dale,1994).

In the present investigation, the nature and symptoms of damage observed were different in case of brown plant hopper. The *N. lugens* infested the rice crop at all stages of plant growth. It inhibited the plant growth and destroys the crop by sucking the sap and damaging the crop by its exploratory feeding behavior and oviposition. As a result of feeding by both nymphs and adults at the base of the tillers, plant turned brownish due to drying up of the plants and the condition was referred as “hopper burn”, (Rao. *et al.*, 2003). The patches of infestation of then spread out and covered the entire field. Heavy infestation of *N. lugens* during *kharif* season rice crop of various fields causing 70-100 per cent loss. In addition, the honey dew excreted by the nymphs and adults at the base of the plants is covered with sooty mold. The brown plant hoppers also a vector transmitting virus disease such as grassy stunt, ragged stunt and wilted stunt (Hibino,1979; Pathak and Khush, 1979; Heinrichs and Mendrano,1984).

However, the indiscriminate use of insecticides has caused many side effects including loss of biodiversity, biological imbalance, resulting in changes in community structure, the problem of secondary pests, insecticide resistance, residual toxicity and resurgence of selected insect pest and environmental pollution. Though, the over dependence and excessive use of chemical pesticides resulted in development of resistance to insecticides and resurgence of pests, destruction of natural enemies and pollution in environment (Pasalu *et al.,*2002), chemical control still first line of defense against various insect pests of rice. In order to evolve effective and economic pest control, it is necessary to evaluate the new groups, new formulation and new insecticide combination of chemicals for their bioefficacy.

Most of the insecticides used on agricultural crop belongs to any one of the chemical group *viz.,* organophosphates, carbametes and pyrethroids. The wide sprade use of structurally similar preparation which have same mode of action carries the risk of resistance development. To overcome this, discovery of newer classes of insecticide molecules which belongs to formulation technology, active at low doses, least exposure to an environment and their incorporation in integrated pest management system is gaining importance.

To cope with ever challenging insect pest problem in rice, the farmer needs to have the latest technological knowledge in pest management. The present investigation was therefore undertaken to evaluate the new generation, low dose ecofriendly pesticides *viz.,* triazophos, clothianidin, buprofezin, acetamiprid, thiamethoxam, imidachloprid, *Metarhizium anisopliae* and lambda-cyhalothrin were studied with following objectives.

1) To study bioefficacy of new chemistry insecticides against brown plant hopper under field condition.

2) To study population dynamics of rice brown plant hopper.

3) To study the impact of new chemistry insecticides on natural enemies.

2. REVIEW OF LITERATURE

There are several ways of suppressing the population of insect pest *viz.*, chemical insecticide, cultural methods, mechanical methods, physical method, biological method, chemosterilant and other genetic method. The use of chemical insecticide to control brown plant hopper is known since long back. But the indiscriminate use of chemical pesticide has led to many problems like resistance, resurgence, residues and environmental pollution. Therefore it is necessary to evaluate new ecofriendly insecticides which effective against target pest, requires few round of spray, having no adverse effect on parasite and predators.

The present investigation therefore undertaken to study the efficacy of new insecticides against brown plant hopper and their influence on natural enemies. Attempts was also made to study population dynamics of brown plant hopper in rice ecosystem.

An account of work of work done by earlier workers on management of brown plant hopper is presented under following heads.

2.1 Bio-efficacy of new insecticides against rice brown plant hopper, *Nilaparvata lugens* (Stal.)

Burges (1998) reported that many *Metarhizium* fungus genera have been applied world wide to control insect pest of rice and similar result reported by But and Copping (2000).

Barwal (1999) were found that superior to the granular formulations of phorate, quinolphos and HCH, when applied by root-zone placement in clay soil and root zone placement in cow dung balls.

Nghiep *et al.* (1999) evaluated the pathogenicity tests with isolates of *B. bassiana* and *M. anisopliae* against third instar nymphs and adults of brown plant hopper including Omon (Vietnam), Pantnagar and Tamil nadu (India) . The most effective concentration of of *B. bassiana* is 6 x 10^{12} spores/ha and *M. anisopliae* gave good result to control brown plant hopper at 7 days after spraying treatment.

Sontakke and Dash (2000) evaluated that new granular insecticides against the major pests of rice and the concluded that chlorpyrifos, quinolphos and fipronil were effective against rice brown planthopper. Carbofuran followed by isazofos reduced the population of planthoppers.

Manjunatha and Shivanna (2001) observed that imidacloprid treated rice plot showed mortality of 69.28 per cent and 85.68 per cent at 100 ml/ ha to at 400 ml/ha of brown plant hopper and increased yield over control plot and similar result were also observed by Tanaka *et al.,* (2000)

Anilkumar (2002) indicated the effectiveness of combination product flubendiamide 20 WDG and buprofezin against brown plant hoppers.

The clothianidin at 10 ppm was found to be effective against GLH with good persistance toxicity DRR (2002).

Krishnaiah *et al.* (2003) reported that thiamethoxam a neonicotinoid insecticide, alone is highly effective against BPH and WBPH both initially and exhibited good persistency but moderately effective against GLH.

Reddy and Krishnaiah (2003) evaluated the efficacy ofimidacloprid and silafluronand recorded 100 per cent mortality of brown plant hopper within 4 hours of exposure.

Geng and Zhang (2004) reported that the virulence of the entomopathogenic fungus *M. anisopliae* var. Acridum to different stages of the brown planthopper (BPH) *N. lugens*, and the whitebacked planthopper (WBPH), *S. furcifera*,with three dosages ranging from 10.5, 116.3 and 1027.1 conidia/2mm were used in the experiment. The tested stages of host included three developmental stages, young nymphs (1-2 instars), old nymphs (3-5 instars) and adults. All tested stages of the plant hoppers were susceptible to fungal infection. The degree of virulence values of *M. anisopliae* var. Acridum at the 3 dosages, respectively, used were >21, 20.82 and 16.55 against young nymphs, 17.68, 15.49 and 13.98 against old nymphs, and 17.10, 12.57 and 9.14 against adults of brown planthopper . On the other hand, the LT50 values of *M. anisopliae* var. Acridum at the 3 dosages were >21, 17.29 and 13.13 against young nymphs, 16.94, 15.02 and 13.03 against old nymphs, and 12.78, 10.16 and 7.64 against adults. Adults were more susceptible to *M. anisopliae* var. Acridum infection than their nymphs and the young nymphs were most resistant to the fungal infection. The cumulative mortality of each stage was dosage-dependent of all the developmental stages, WBPH was more susceptible than BPH to *M. anisopliae* var. Acridum infection with the same dosages.

Panda *et al.* (2004) evaluated fipronil (Regent 5FS) at 50.75 and 100 g a.i./ha against *S. incertulas* (Walker) in rice. Treatment with Fipronil at 100 g a.i./ha resulted in only 4.02 and 6.13 per cent dead heart (DH) at 14 and 21 days after transplanting, proving the effective was over rest of the treatment.

Hedge (2005) evaluated new insecticides thiamethoxam 25 WG @ 50 g a.i. Ha^{-1} and imidacloprid 17.8 SL and found that thiamethoxam 50 g a.i. per ha recorded lowest BPH population after 3 and 7days of both season and was at par with imidacloprid 17.8 SL @ 50 g a.i. Ha^{-1} and significantly superior to rest of the treatments.

Misra (2005) evaluated clothianidin, triazophos and cypermethrinthe new molecules in the field against the rice brown plant hopper at 25, 400 and 25 g a. i./ ha^{-1}, respectively and revealed that the clothianidin established superiority over other insecticides evaluated in suppressing the population of 92.05-95.03 per cent over both the seasons of evaluation at 15 days after spraying.

Prasad *et al.*(2005) evaluated new insecticide cartap hydrochloride (0.6, 0.8, 1.0 Kg ai./ha) and they reported that cartap hydrochloride 4G @ 0.6 kg a.i./ha were found to be most effective against rice yellow stem borer with lower per cent of infestation.

Vo Thi Bich Chi *et al.* (2005) observed that the bioinsecticides namely Ometar and Biovipwhich were produced from *M. anisopliae* and *Beauveria bassiana,* respectively suppressed the population of BPH and rice leaf folder and safe to natural enemies *viz.* spiders, plant bugs and other predators of rice insect pest.

Bhavani (2006) indicated the effictiveness of standalone products buprofezin 25 SC at 200 g a. i./ha and thiamethoxam 25 WG at 25 g a. i./ha against brown plant hopper and studied that the relative bio-efficacy of new insecticides against mixed population of planthoppers (BPH and WBPH) and revealed that among the granulares, phorate 10G @ 1000 g a i./ha and carbofuran 6G 1000 g a i./ha were found inferior to standard check, carbofuron 3G @ 1000 g a i./ha in reducing plant hopper population. Among spray formulations, thiamethoxam 25WG @ 25 g a i/ha followed by buprofezin 2SC @ 200 g a i./ha were most effective in suppressing planthopper population while lambda cyhalothrin recorded high planthopper populations than untreated control.

Rahman and Jahan (2006) conducted that a field experiment investigates the effectiveness of different chemical insecticides against brown planthopper, *N. lugens* (Stal). The insecticide carbofuran was applied at 50 and 75 days after transplanting and found that carbofuran was effective against brown plant hopper.

Sahithi and Misra (2006) concluded that clothianidin @ 25 g a. i./ ha. was effective in suppressing GLH population.

Sekh *et al.* (2007) reported the efficacy of Ethiprole 10 SC alone and in combination with imidacloprid 200 SL against the brown plant hopper of rice was evaluated under field condition. The reduction of brown plant hopper population recorded in these plots was superior in combination to those observed in other treated plots.

In field trial Elanchezhian *et al.* (2008) evaluated lambda cyhalothrin, new capsule suspension formulation and indicated that lambda cyhalothrin at 50, 25 and 12.5 g a.i. ha^{-1} were more effective against brown plant hoppers as compared to the standard checks. In terms of cumulative reduction of pest incidence, lambda cyhalothrin treatments were found to be superior to the standard checks. However, the lambda cyhalothrin at 50 and 25 g a.i. ha^{-1} were slightly harmful to the green mirid bugs in the rice ecosystem. Lambda cyhalothrin at 12.5 g a.i. ha^{-1} exhibited significant pest control and also not harmful to the natural enemy. Hence, this dose was recommended for the brown plant hopper management in rice.

Wang *et al.* (2008) observed that buprofezin was effective against homopteran pests such as plant hopper, with very low risks to environment including human beings.

Misra (2009a) evaluated a new insecticides molecule, imidacloprid 17.8%SL, thiamethoxam 25% WG both @ 25g a.i. /ha and clothianidin 50% WDG @ 12.5g a.i. /ha against the brown planthopper, *N. lugens* (Stal.) infesting rice during *kharif* 2007 and summer 2008. Significantly low BPH population (1.40–1.30/hill) was observed with the new molecule insecticides was a reduction of 88.73 and 90.30% over untreated control during *kharif*, 2007 and summer 2008, respectively.

Misra (2009b) evaluated the result revealed that during both the seasons of trial, the population of GLH remained significantly in low in insecticide treatments compared to control at 5,10 and 15 day after spraying. Lowest population was recorded with newer molecule of clothianidin @ 25 g a. i. / ha with a reduction 91.8 per cent over control at 15 DAS. The next best treatments followed by thiamethoxam and imidacloprid.

Sidde Gowda *et al.* (2009) evaluated combination product clorantraniliprole and thiamethoxam insecticides against sucking insects and were also found effective in suppression the brown plant hopper population in rice.

The insecticidal treatments *viz.*, buprofezin 25 SP, imidacloprid 17.8 SL in two doses, thiamethoxam 25 WG, acetamiprid 20 SP and imidacloprid 1.8% + acephate 50% at 200, 50 & 25; 40; 40 and 518 g a.i./ha, respectively were evaluated in the field against rice brown plant hopper *N. lugens* Stal. (BPH), during *kharif*, 2007 and 2008 and by Ghosh *et al.* (2010) and results revealed that buprofezin 25 SC @ 200g a.i./ha and imidacloprid 17.8 SL @ 50 g a.i./ha showed superiority over other insecticides by reducing the

BPH population by 99.13 and 94.97%, respectively over control.

Vinothkumar *et al.* (2010) evaluate dethiprole 40 per cent and imidacloprid 40 per cent 80 WG as foliar application for itsbio efficacy against plant and leaf hoppers of rice and recorded 90 per cent reduction population of brown plant hopper and leaf hopper besides higher grain yield.

Sidde Gowda *et al.* (2012) indicated the effectiveness of the combination product flubendiamide 20 WDG and buprofezin against pest complex of recorded the lower per cent of dead hearts and white ears, per cent damaged leaves, reduced population of brown plant hopper and besides higher grain yield.

2.2 Population dynamics of brown plant hopper under field condition.

Bae *et al.* (1995) observed that the effect of temperature on egg-hatching, nymphal development, preoviposition, longevity and oviposition of *N. lugens* collected from rice in the Philippines. During the three succeeding generations, the egg-hatching period (from initial hatching to final hatching) averaged about 7, 8 and 5 days at 25, 30 and 35 degrees C. The peak egg-hatching day was 3 days after initial hatching at 25 degrees C, and 2 and 3 days after initial hatching in the IRRI and the Banaue insects at 30 and 35 degrees C, respectively. At 40 degrees C, none of the eggs hatched. The nymphal durations of the

IRRI and the Banaue insects were 16.3 and 16.4 days at 25 degrees C, and 14.0 and 13.7 days at 30 degrees C. At 35 degrees C, none of the nymphs emerged. The adult emerging periods from initial to final emergence were about 5 days at 25 degrees C and 4 days at 30 degrees C. The peak day of adult emergence was 2 days after initial emergence at 25 degrees C, and 3 days after initial emergence in the 1st and 2nd generations and 2 days after initial emergence in the 3rd generation at 30 degrees C. The pre oviposition periods of the macropterous and the brachypterous females were about 3.3 and 3.4 days at 25 degrees C and 2.6 and 2.2 days at 30 degrees C, respectively. Adult longevity of females and males was about 25 days and 20-21 days at 25 degrees C, and 20-22 days and 17 days at 30 degrees C, respectively. The peak oviposition day was 8-9 days after emergence at 25 degrees C and 6-7 days after emergence at 30 degrees C. The average number of egg batches oviposited by the macropterous and brachypterous females were 5.7 and 6.7 at 25 degrees C, and 6.0 and 7.7 at 30 degrees C, respectively.

Dai *et al.* (1997) observed that the effects of different temperatures (27.8-38 degrees C) on the duration of nymphal stages, egg laying, pre-oviposition period and longevity of *N. lugens* were investigated. The duration of developmental stages increased above 34 degrees C. The numbers of eggs reduced when 4th-instar nymphs were exposed to high temperatures and also when adult females were treated to high temperatures at different days, especially one day after the emergence of the brachypterous form and 3 days after emergence of the macropterous form. High temperatures shortened the lifespan. A constant high temperature had little effect on the pre-oviposition period of brachypterous female adults, while the pre-oviposition period of macropterous females was prolonged when 4th instar nymphs were reared under constant high temperatures. When treated with changing high temperatures, pre-oviposition periods of both brachypterous and macropterous females were prolonged. Changing high temperatures had greater effects on reproduction than constant high temperatures. Mating of females was more affected by high temperatures than that of males. The critical temperature for development and reproduction was 34 degrees C.

Vijaykumar and Patil (2003) reported that BPH populations and abiotic and biotic factors revealed non-significant negative correlation. Whereas, positive and non significant correlation was found with morning and evening relative humidity BPH per hill showed positive but non-significant correlation with spiders per hill and significant positive correlation with mirid bug per hill.

Heong *et al.* (2007) studied that climatic factors such as temperature, rainfall and relative humidity have known to greatly influence the insect population change. Similar observations were reported by Siswanto *et al.* (2008), they indicated that climatic factors such as temperature, rainfall and relative humidity have known to greatly influence the insect population change.

Jadhao and Khurad (2011) observed that overall population growth rate and peak density of *N. lugens* during rabi season were much lower as compared to the *kharif* season. The correlation analysis study showed that in rabi season *N. lugens* exhibited highly positive correlation with relative humidity and significant negative correlation with maximum temperature where as it showed highly significant negative correlation with relative humidity and minimum temperature during *kharif* season.

Win *et al.* (2011) reported that in population fluctuation study revealed at 64 and 74 days after transplanting (in mid September) associated with high humidity, high temperature and high rainfall. The BPH population was lowest (in mid week of October) suggesting that low rainfall and low humidity were at least partially responsible for the decrease population of brown plant hopper.

2.3 Impact of new insecticides on natural enemies.

The studies on the effect of new chemical insecticides on *N. lugens* and their natural enemies has already documented by earliar workers (Heinrichs, 1984; Choi *et al.,* 1996; Cole *et al.*, 1997; Panda and Mishra, 1998; Ruberson *et al.*,1999).

Dhawan (2000) studied the effect of new molecules, methazoid, lufenuron, flufenoxuron, lambda cyhalothrin, B-cyfluthrin (Synthetic pyrethroids), thiodicarb (Carbamate), chlorpyriphos, methyl demeton (organophosphate), indoxacarb (oxadiazine) and spinosad compared with commonly used insecticides and delfin on natural enemies including *T. chilonis.* All the IGR, delfin and spinosad were found safer to *T. chilonis* followed by B-cyfluthrin and lambda cyhalothrin while chlorpyriphos and methyl demeton were highly toxic followed by quinalphos.

Katole and Patil (2000) studied biosafety of imidacloprid and thiamethoxam with seed treatment and foliar spray to some predators and results revealed that seed treatment was safer than foliar sprays.

Kochi *et al.* (2000) observed that *C. lividipennis* decreased to low level in many insecticides treated plots except those treated with buprofezin.

Nayak *et al.* (2000) observed initial reduction in spider population in rice after application of several combination insecticides however, the population built up in two weeks.

The residual toxicities of thiamethoxam (Actara 25 WG) at 50, 25 and 12 ppm; imidacloprid (Confidor 200 SL) at 50 ppm; nymphs and adults of *Tytthus parviceps* predating brown plant hoppers on rice cv. TN1 were evaluated in glasshouse by Jhansi Lakshmi *et al.* (2001a) and were sprayed with the insecticides and insects were placed on the plants at 1, 7, 14, 21 and 28 days after spraying. Exposure durations were 24, 48 and 72 h. almost all treatments recorded 100% adult *T. parviceps* mortality in the first 7 days after spraying, regardless of exposure duration. By 28 days after spraying, the highest adult mortality was caused by imidacloprid (97.5%) and thiamethoxam at 50 ppm (95%), after 72 h exposure. The lowest mortality was caused by acephate (12.5%), followed by thiamethoxam at 12 ppm (32.5%). When nymphs were exposed at 14 days after spraying, all treatments caused 100% mortality after 72 h exposure, except acephate (28%). However, by 28 days after spraying, only fipronil caused 100% mortality after 72 h exposure, followed by thiamethoxam at 50 ppm (90%). The lowest mortalities were recorded from acephate (20%) and thiamethoxam at 12 ppm (35%). Based on the percentage mortality data and persistent toxicity values calculated for adult and nymph mortality, the authors conclude that thiamethoxam at 50 and 25 ppm is as safe for *T. parviceps* as imidacloprid at 50 ppm, less safe than acephate at 1200 ppm, but safer than fipronil at 100 ppm.

Jhansi Lakshmi *et al.* (2001b) conducted studies to investigate the relatively safety of thiamethoxam (Actara 25 WG) at 50, 25 and 12 ppm; imidacloprid (Confidor 200 SL) at 50 ppm; fipronil (Regent 5 SC) at 100 ppm; and acephate (Starthene 75 WP) at 1200 ppm on *C. lividipennis,* a predator of the rice brown planthoppers. The predators were exposed for 24, 48 and 72 h to rice cv. TN1 infested with *C. lividipennis* at 1, 7, 14, 21 and 28 days after spraying with the insecticides. Results showed that acephate caused the lowest mortality of both nymph and adult predators.

Persistent toxicity (PT) values after 24 h exposure revealed that the PT value of acephate was the lowest, followed by fipronil (PT value of 1126), imidacloprid (PT value of 1284) and thiamethoxam at 12 ppm (PT value of 1342).

Vadodaria *et al.* (2001) reported that thiamethoxam 70 WS and imidacloprid 70 SL had no adverse effect on natural enemies in cotton ecosystem.

Acharya *et al.* (2002) suggested that the newer molecules *viz.*, acetamiprid (20 g a.i./ha), thiamethoxam (25 g a.i./ha), imidacloprid (25 g a.i./ha), NACLFMOA (20 g a.i./ha) and abamectin (20 g a.i./ha) were relatively safer to the predatory ladybird beetles.

Satheesan *et al.* (2002) reported that nodeleterious effect was observed on the populationsof *C. lividipennis* and spiders in rice field applied with imidacloprid at 0.4 ml $lit^{-1}$of water.

Elanchezhian *et al.* (2003) found that lambda cyhalothrin (25 g a.i. / ha) was safer to green lace bug.

Studies were conducted to determine the pathogenicity of the entomopathogenic fungus *M. anisopliae* var. acridum on paddy field spiders *Pirata subpiraticus and Ummeliata insecticeps*, to evaluate the effects of the fungus on the predating efficiency of the spiders on the brown planthopper by Geng and Zhang (2004) the results indicated that *M. anisopliae* var. acridum had no pathogenicity on both *P. subpiraticus* and *U. insecticeps.* However, the activity of brown planthoppers decreased apparently after being infected with conidia of *M. anisopliae* var. acridum that caused increase of the predating efficiency of the paddy field spiders. Statistical analysis indicated that the differences between the treatments and control were significant. The predating efficiency of the spiders on planthopper increased slightly with the increasing of conidia concentrations of *M. anisopliae* var. acridum.

Bhavani and Rao (2005) conducted a field trial for two seasons to evaluate the bio-efficacy of imidacloprid (Confidor 200SL), acephate (Starthene75SP), carlap hydrochloride (Caldan 50WP or Padan 50WP), chlorpyriphos (Dursban 10G), cartap hydrochloride (Caldan 4G) and triazophos (Trelka 20EC) against planthoppers and its natural enemies in rice ecosystem. The pooled data on planthoppers revealed that imidacloprid was the best insecticide comparable to acephate followed by cartap hydrochloride (Padan 50WP) as compared to untreated control. Imidachloprid ranked first in safety to spiders followed by acephate as per Pest: Defender (P: D) ratio. Against mirid bugs (*C. lividipennis*). acephate ranked first in safety followed by imidachloprid and cartap hydrochloride and significantly superior to all other treatments.

Jiang *et al.* (2006) studied the effects of triazophos, shachongshuang, abamectin, and Bt + imidacloprid on the insect pest-natural enemy community in early rice fields in the Yangtze-Huaihe region of Anhui Province. The results showed that all of the test insecticides had significant effects in controlling the growth of major insect pest populations.

The average value of insect pest-natural enemy community diversity under effects of triazophos, shachongshuang, abamectin, and Bt + imidacloprid was 1.545, 1.562, 1.691 and 1.915, respectively, while that in control plot was 1.897. After two weeks of applying insecticides, the plots applied with shachongshuang and abamectin had a similar composition of insect pest-natural enemy community, but the community composition was significantly different between the plots applied with triazophos and Bt + imidacloprid. From the viewpoints of community stability and pest control, Bt + imidacloprid had the best effect, and shachongshuang and abamectin were better than triazophos.

Sunita Devi (2006) evaluated insecticides *viz.,* acetamiprid, imidacloprid, spinosad, acephate and fipronil for their toxicity against immature and adult stage of *Chrysoperla carnea.* The populations of natural enemies were more in water sprayand untreated control in comparison with other insecticides.

Shinde *et al.* (2007) tested the effect of various insecticides and biopesticides against lady bird beetle and spiders in okra ecosystem. They reported that lambda cyhalothrin 5EC @ 30 g a.i./ha found toxic to spiders and lady bird beetle in okra ecosystem.

Wayal (2007) studied influence of new pesticides on emergence of parasitoid of cotton bollworm and reported that the treatment with lambda cyhalothrin 5 CS @ 12.5 g a.i./ha and 15 g a.i./ha recorded significantly higher average emergence (4.43 and 4.03) of parasitoids percent 40 infested green bolls.

The field trial was conducted by Hedge and Nidagundi (2009) to study the effect of buprofezin 25 sc at 0.75 ml/l which recorded lower plant hopper population and was at per with standard check thiamethoxam 25 WG at 0.2 g/l, while imidacloprid 17.8 SL at 0.3 ml/l was on per with buprofezin 25 SC at 0.75 ml/l and significantly higher predatory mirid bug population over other treatmants.

The insecticides namely imidacloprid, thiamethoxam and clothianidin were tested to evaluate their toxicity to the parasitoid *Trichogramma chilonis* and Preetha *et al.* (2009a) found that all these insecticides tested showed different degree of toxicity to the parasitoid. Thiamethoxam showed the highest toxicity to *T. chilonis* with 0.0014 mg a.i.l^{-1} followed by imidacloprid.

Preetha *et al.* (2009b) observed that nine insecticides, namely, imidacloprid, thiamethoxam, chlorantraniliprole, clothianidin, pymetrozine, ethofenprox, BPMC, endosulfan, acephate, and the product Virtako® (Syngenta; chlorantraniliprole 20% + thiamethoxam 20%) were tested to determine their toxicity to the parasitoid *T. chilonis* using an insecticide-coated vial (scintillation) residue bioassay. All the insecticides tested showed different degrees of toxicity to the parasitoid. Thiamethoxam showed the highest toxicity to *T. chilonis* with an of 0.0014 mg a.i. l^{-1} followed by imidacloprid (0.0027 mg a.i .l^{-1}). The insecticides thiamethoxam, imidacloprid, Virtako® and ethofenprox were found to be dangerous to the parasitoid.

Fang *et al.* (2010) studies effect of imidacloprid on orientation behavior and parasitizing capacity of *A. nilaparvatae*. Imidacloprid disrupted the foraging ability of *A. nilaparvatae* exposed to contact or oral routes. These effects involving disrupted the foraging ability and reduced capacity of *A. nilaparvatae* indicated that imidacloprid could decrease the performance of this parasitoid.

Jhansi Lakshmi *et al.* (2010) observed effect of insecticides to *N. lugens* and their important preadators in rice ecosystem, *viz.*, green mirid bug, *C. lividipennis,* brown mirid bug, *T. parviceps*. Ethiprole + imidacloprid and thiamethoxam + lambda cyhalothrin initial and persistence toxicity against *N. lugens* but these two combinations were highly toxic to all three natural enemies recording 100 per cent mortality.

Preetha *et al.* (2010) assessed the impact of certain potential insecticides used in the rice ecosystem on the mired bug predator and brown planthopper through contact toxicity. Eleven insecticides, including neonicotinoids, diamides, azomethine pyridines, carbamates, pyrethroids, organophosphates and cyclodienes were selected to test their toxicities against the nymphs of *C. lividipennis* and *N. lugens.* The insecticides tested, clothianidin are regarded as highly toxic to *C. lividipennis* based on selectivity ratio.

Sharma and Kaushik (2010) reported that spinosad 45 SC and lambda-cyhalothrin observed to be safer to the natural enemies in brinjal ecosystem.

Chaiwong *et al.,* (2011) result showed that clothianidin and thiamethoxam were mostly harmless to moderately harmful to the spiders, mired bug; predators egg parasites of leafhoppers and planthopper.

3. MATERIAL AND METHODS

The present field investigations were undertaken with on view to find out the relative efficacy of new insecticide molecules *viz.,* triazophos 40 EC, clothianidin 50 WDG, buprofezin25 SC, lambda-cyhalothrin 5 EC, thiamethoxam 25 WG, imidacloprid 17.8 SL, *Metarhizium anisopliae* WP and acetamiprid 20 SP against rice brown plant hopper. Attempts were also made to study population dynamics of rice and to study the influence of above insecticides on natural enemies.

The material used and method adopted for recording observation during the course of investigation is described in this chapter under following sub heads.

3.1 Experimental Site:-

The research work comprising field trial of novel insecticides molecules against rice brown plant hopper, *Nilaparvata lugens* Stal. in rice crop was conducted during Kharif 2011/12 at village Ambap, Tal. Hatkanangale, Dist. Kolhapur on farmer's field.

3.2 Soil type:-

The field selected for experiment was uniform with sandy loam soil having high fertility and fairly drainage.

3.3 Plan of layout

3.3.1 Plan of layout (chemical insecticides)

N ↑

R-I	R-II	R-III
T_6	T_5	T_2
T_9	T_3	T_4
T_1	T_8	T_7
T_4	T_2	T_9
T_7	T_6	T_5
T_8	T_9	T_1
T_3	T_7	T_8
T_2	T_4	T_6
T_5	T_1	T_3

3.3.2 Plan of layout (granular insecticides)

N ↑

R-I	R-II	R-III
T_6	T_5	T_2
T_5	T_3	T_4
T_1	T_8	T_7
T_4	T_2	T_3
T_7	T_6	T_5
T_8	T_1	T_1
T_3	T_7	T_8
T_2	T_4	T_6

3.4 Climate and location :-

The climate of Hatkanangaleis generally subtropical with average rainfall of 1194 mm. It lies between 16.41^{0}North to 74.13^0 East latitude with maximum temperature of 40^{0}C and minimum of 11.4^{0}C.

3.5 Design of experiments:-

i.	Design	:	Randomized Block Design
ii.	Plot Size	:	a) Gross : 20 m^2
			b) Net : 20 m^2
iii.	No. of replications	:	Three
iv.	No. of treatments	:	Nine
v.	Spacing	:	a) Plant to plant : 15 cm
			b) Row to row : 15 cm
vi.	Variety	:	Suruchi
vii.	Season	:	Kharif 2011-2012
viii.	Spraying dates	:	1st Spraying 15/09/2011.
			2nd Spraying 18/10/2011.
ix.	Granular application	:	1st application 07/09/2011.
			2nd application 22/10/2011.

3.6 Agronomical practices:-

All the agronomical practices like field preparation, puddling, transplanting of seedling and application of fertilizer and intercultivation operations were carried out as per recommended cultivation practices except plant protection measures. Popular varity Suruchi seedlings were raised in nursery bed and transplanted in main field.

3.7 Details of Experiments:-

In the present experiment with foliar insecticides nine treatments including control were maintainedand particulars of evaluated pesticides *viz.,* common name, chemical name, trade name, formulation and source and are presented in Table 1 and Table 2, respectively.

In the present experiment with granular insecticides seven granular treatments including control were maintained and particulars of evaluated pesticides *viz.,* common name, chemical name, trade name, formulation and source and the details of treatment for field experiments are represented in Table 3 and Table 4, respectively.

Table 1 : Details of insecticides used against rice brown plant hopper, *Nilaparvata lugens* (Stal) under field condition.

Sr. No	Technical name	Chemical name	Trade name	Formu-lation	Source
1	Triazophos	O,o-diethyl-o-(1-phenyl-1,2,4-triazol-3-base) suifer phosphate	Hostathion	40 EC	Bayer crop science Ltd. Mumbai
2	Imidacloprid	(E)-1-(6-chloro-3-pyridylmethyl)-N-nitroimidazolidin-2-ylideneamine.	Confidor	17.85 SL	M/S. Rallis, India Ltd. Mumbai.
3	Thiamethoxam	(EZ)-3-2(2-Cloro-1,3-thiazol-5-methyl-1,3,5-oxadiazinan-4-ylidene (nitro) amine)	Actara	25 WG	Syngenta India Ltd.
4	Clothianidin	(E)-1-(2-cloro-1,3-thiazol-5-ylmethyl)-3-methyl-2-nitroguanidine	Dantop	50 WDG	Sumitumo India Ltd.

5	Lambda-cyhalothrin	[1α (S),3α (Z)]-(I)-Cyano (3-phenoxyphenyl) methyl -3-(2-chloro-3-3-3=trifluro dimethyl-cyclopropane carboxylate.	Judo	5 EC	M/S.Syngenta Crop protection Ltd. Mumbai
6	*Metarhizium anisopliae*	Laboratory preparation	Phule *Metarhizium*	5 EC	M.P.K.V. Rahuri
7	Acetamiprid	[E]-N-[(2-cloropyridin)-3-sulfuryl]- N - nitril group-N-methylacetamipride	Tata Manik	20 SP	Rallis India Ltd.
8	Buprofezin	2-tert-butylimino-3-isopropyl-5-phenylperhydro-1,3,5-thiadiazin-4-one	Tata Apland	25 SC	Rallis India Ltd.

Table 2 : Details of treatments for field experiment on rice.

Sr.No	**Insecticide Treatment**	**Formulation**	**Dose/ha**
T_1	Triazophos	40 EC	600 g a.i./ha
T_2	Imidacloprid	17.8 SC	25 g a.i./ha
T_3	Thiamethoxam	25 WG	25 g a.i./ha
T_4	Clothianidin	50 WDG	25 g a.i./ha
T_5	Lambda – cyhalothrin	5 EC	25 g a.i./ha
T_6	*Metarhizium anisopliae*	WP	2000 g/ha
T_7	Buprofezin	25 SC	500 g a.i./ha
T_8	Acetamiprid	20 SP	30 g a.i./ha
T_9	Untreated Control		

Table 3: Details of insecticides used against rice brown planthopper, *Nilaparvata lugens* (Stal) under field condition. (Granular application)

Sr. No	Technical name	Chemical name	Trade name	Formu lation	Source
1	Fipronil	5-amino-1-(2-6-dicloro-α,α,α-trifuoro-p-tolyl)-4-[(trifluromethyl)sulfinyl]pyrazole-3-carbonitrile.	Regent	0.3 G	M/S. Bayer Crop Science Ltd. Mumbai
2	Carbofuran	2,2-dimethyl-2,3-dihydro-1-benzofuran-7-yl methylcarbamate	Fury	3 G	M/S. Nagarjun aagrochem ltd. Hydrabad
3	Phorate	0,0-diethyl S-[(ethylthio)methyl]phosphorodithioate	Thimet	10 G	Gujrat pesticide Ahmedabad - 382330, Gujarat, India
4	Cartap hydrochlorie	S,S'-[2-(dimethyl amino)-1,3-propaneduyl] dicarbamothioate hydrochloride.	Caldan	4G	M/S. Rallis, India Ltd. Mumbai
5	Rynaxypyr	3-bromo-N-{4-cloro-2-methyl-6[(methylamino) carbonyl]phenyl}-1-(3-chloro-2-pyridinyl)-1H-pyrazole-5-carboxamide	Fertera	0.4 G	E.I.Dupont, Pvt. Ltd. Gujrath
6	Fipronil 40% + Imidacloprid40%	5-amino-1-(2-6-dicloro-α,α,α-trifuoro-p-tolyl)-4-[(trifluromethyl)sulfinyl]pyrazole-3-carbonitrile + (E)-1-(6-chloro-3-pyridylmethyl)-N-nitroimidazolidin-2-ylideneamine.	Lassenta	80 WG	M/S. Bayer Crop Science Ltd. Mumbai
7	Chloropyripos	0,0-Diethyl 0-3,5,6-trichloropyridin-2-yl phosphorothioate	Deviban	10 G	Devidayal sales ltd. Mumbai.

Table 4: Details of treatments for field experiment on rice (Granular)

Sr. No	Insecticide Treatment	Formulation	Dose/ha
1	Fipronil	0.3 G	7.5g a.i./ha
2	Carbofuran	3 G	750 g a.i./ha
3	Phorate	10 G	750 g a.i./ha
4	Cartap hydrochloride	4G	750 g a.i./ha
5	Rynaxypyr	0.4 G	30 g a.i./ ha
6	Fipronil + Imidacloprid	80 WG	250 g a.i./ha
7	Chloropyriphos	10 G	1kg a.i /ha
8	Untreated Control		

3.8 Application of pesticide

The required quantity of spray solution was calibrated by spraying the control plot with water alone. Insecticide required for spraying for preparation of spray fluid per plot of different concentrations were worked out at the time of spraying and mixed in clean water. The spraying of insecticides was carried out during evening hours by hand operated knapsack sprayer. All the three plots of treatment in three replications were treated at a time. In all total two sprays were given at 60and 85 days after transplanting during tillering stage which coincided with the reproductive phase of the crop when maximum BPH population is observed. The spray pump was thoroughly washed with water while switching on over one insecticide to another.

3.9 Methods of recording observations

1) Bioefficacy of new insecticide molecules against rice brown plant hopper, *Nilaparvata lugens* (Stal).

The efficacy of various insecticides against paddy brown plant hopper, *N. lugens* was judged on the basis of survival population of hoppers at reprodutive stage. The spraying was done on ETL basis when sufficient population of BPH was observed. The granular application was done in endemic area on ETL basis.

The observations were recorded on the number of BPH nymphs and adults present at the base of the rice plants on selected per hills randomly for each plot and tagged. Hoppers were recorded one day before spraying and 5, 10, 15 days after application. The data were transformed andanalysed statistically. The application of granular insecticides on brown planthoppers population in rice field was also recorded as pretreatment, 7 and 10 days after treatment (DAT) separately from plot area. Grain yield was recorded separately from net plot area of each treatment after harvesting of crop. The mean data were subjected to analysis of variance.

2) To study the population dynamics of paddy brown planthopper

The infestation of *N. lugens* was recorded from active tillering stage up to harvesting stage in each meteorological week. Ten plants from each plot were selected randomly and tagged. Regular monitoring of the occurrence and abundance of the pest in rice ecosystem was made visually as well as by hand collection. Observations were recorded by counting total hoppers at weekly interval starting from transplanting and continued till harvesting. Hoppers were recorded 10 days before maturity. The data on survival population of *N. lugens* (Stal) were correlated with meteorological parameters like temperature, relative humidity, rainfall and sunshine hours during experimental period.

3) Impact of new insecticide molecules on natural enemies

The observation on natural enemy population count was taken simultaneously. The number of living predators and parasitoids *viz.,* green mirid bug, brown mirid bug, vellid bug, *Cyrtorhinus lividipennis* Reuter, *Anagrus nilaparvatae, Tytthus perviceps* and spiders was recorded observation on five tagged plants at 1 day before spraying and 0,3,7 and 10 days after each spraying

3.10 Statistical analysis

The values of mean no. of hoppers were first transformed to their corresponding square root transformed values before and 5, 10, 15 days after spraying and then statistically analyzed.

4. RESULTS AND DISCUSSION

Investigations were made on the bioefficacy of novel insecticides *viz.,* triazophos 40 EC, clothianidin 50 WDG, buprofezin 25 SC, lambda-cyhalothrin 5 EC, thiamethoxam 25 WG, imidacloprid 17.8 SL, *Metarhizium anisopliae* WP and acetamiprid 20 SP against rice brown plant hopper. Attempts were also made to study population dynamics of rice and to study the influence of above insecticides on natural enemies at evaluated doses during *kharif* season 2011-2012.

The field experiments were conducted to study these aspects and the results obtained are presented and discussed in this chapter in the light of earlier studies.

4.1. Bioefficacy of new insecticide molecules against rice brown plant hopper, *N. lugens.*

The efficacy of different insecticides against rice brown planthopper of rice was judged on the basis of observations recorded on survival mean population of hoppers recorded 5, 10 and 15 days after each spraying. In all two sprayings were given. The results obtained are presented and discussed with following sub headings.

4.1.1Bioefficacy of new insecticide molecules against rice brown plant hopper, *N. lugens* (Spraying).

Table 5: Influence of new chemical insecticides on Brown plant hopper. (1st spray)

Sr. No.	Insecticides	Dose/ha	Mean survival population BPH per hill				Mean population
			PRETREATMENT	5 DAS	10 DAS	15 DAS	
1	Triazophos 40 EC	600 g a.i./ha	12.60* (3.62)**	3.91 (2.10)	4.16 (2.16)	4.52 (2.24)	4.16 (2.17)
2	Imidacloprid 17.8 SL	25 g a.i./ha	12.74 (3.59)	1.87 (1.54)	2.03 (1.59)	2.22 (1.67)	2.05 (1.60)
3	Thiamethoxam 25 WG	25 g a.i./ha	12.38 (3.64)	1.84 (1.53)	1.93 (1.56)	2.19 (1.64)	1.99 (1.58)
4	Clothianidin 50 WDG	25 g a.i./ha	12.82 (3.65)	1.19 (1.30)	1.21 (1.31)	1.81 (1.52)	1.40 (1.37)
5	Lambda – cyhalothrin 5 EC	25 g a.i./ha	12.53 (3.61)	2.29 (1.67)	3.11 (1.90)	3.50 (2.00)	2.96 (1.86)
6	*Metarhizium anisopliae* WP	2000 g/ha	11.96 (3.53)	4.21 (2.17)	4.42 (2.22)	4.65 (2.27)	4.43 (2.21)
7	Buprofezin 25 SC	500 g a.i./ha	12.31 (3.58)	1.29 (1.34)	1.72 (1.49)	2.18 (1.63)	1.73 (1.49)
8	Acetamiprid 20 SP	30 g a.i./ha	12.24 (3.57)	1.57 (1.44)	1.84 (1.53)	2.22 (1.65)	1.87 (1.54)
9	Untreated Control		11.75 (3.50)	11.61 (3.48)	12.17 (3.56)	12.82 (3.65)	12.20 (3.56)
	S.E.	-	N.S	0.03	0.07	0.01	0.04
	C.D.@5%	-	N.S	0.10	0.20	0.04	0.11

** Figures in parenthesis are X+0.5 square root transformed values

*Mean of three replications

First spraying

The data representing survival population of brown plant hoppers *N. lugens* under field condition are given in Table 5 and graphically duplicated in Fig.1. The results revealedthat the BPH population did not vary among the treatments at 1 DBS during *kharif,* 2011 (11.75-12.85/hill). This indicates the uniform population in the experimental plot.

5 Days after spraying

It could be seen from Table 5 on 5th days after spraying that the population of BPH observed in different insecticide treatments were between 1.19 and 4.21 as against 11.61 in untreated control. When observationswere recorded 5 DAS among the insecticides tested the treatment with clothianidin 50 WDG @ 25 g a.i. / ha proved to be the most effective and superior over the rest of the treatments recording the lowest 1.19 hoppers per hill. However, it was on par with the treatment buprofezin 25 SC @ 500 g a.i. /ha where 1.29 hoppers per hill was recorded. The next best treatment in order of efficacy was acetamiprid 20 SP @ 30 g a.i./ha (1.57 hoppers per hill) and was found at par with thiamethoxam 25 WDG @ 25 g a.i./ha (1.84 hoppers) and imidacloprid 17.8 SL @ 25 g a.i./ha (1.87 hoppers per hill). The treatments with lambda cyhalothrin, triazophos and *M. anisoplae* were next in order of efficacy where 2.29, 3.91 and 4.21 hoppers per hill was observed, respectively which was significantly low as compared to untreated control.

10 Days after spraying

The population of BPH observed in different insecticide a treatment wasranged from 1.21 to 4.42 as against 12.17 in untreated controlwhen observation was recorded 10 DAS. Among the insecticides tested, treatment with clothianidin 50 WDG @ 25 g a.i./ ha proved to be the most effective and superior over the rest of the treatments recording the lowest of 1.21 hoppers per hill and at par with the treatments with buprofezin 25 SC @ 500 g a.i. /ha where 1.54 hoppers per hill was recorded. Significant differences did not exist among the treatments with acetamiprid 20 SP @ 30 g a.i. (1.84 hoppers per hill), thiamethoxam 25 WDG @ 25 g a.i./ha (1.93 hoppers per hill) and imidacloprid 17.8 SL @ 25 g a.i./ha (2.03 hoppers per hill). The next best treatments in order of their efficacy were lambda cyhalothrin, triazophos and *M. anisoplae* in which 3.11, 4.16 and 4.42 hoppers population was observed, respectively which were significantly less as compared to untreated control.

15 Days after spraying

All the insecticidal treatments were superior over untreated control, when observations were recorded 15 DAS. Among the treatments, clothianidin 50 WDG was found to be significantly superior over all other insecticide treatments recording 1.81 hoppers/hill. The treatments with buprofezin 25 SC,thiamethoxam 25 WG, acetamiprid 20 SP, and imidacloprid 17.8 SL were found to be equally effective in reducing survival population in which 2.18, 2.19, 2.22 and 2.22 population of hopper per hill, respectively was observed. This was followed by the treatments with lambda cyhalotrin, triazophos and *M. anisoplae* was in which 3.50, 4.52 and 4.65 hopper per hill was observed.

Overall performance of various insecticidal treatments based on the mean indicated the treatment with clothianidin 50 WDG was most effective and significantly superior over other treatments in reducing the hoppers population 1.40 per hill. The treatment with buprofezin 20 SC (1.73 hopper per hill) acetamiprid 20 SP, thiamethoxam 25 WG and imidacloprid 17.8 SL which 1.87, 1.99 and 2.05 hopper per hill observed, respectively significant differences did not exist among them. This was followed by the treatment lambda cyhalotrin 5 EC, triazophos 17.8 SL and *M. anisoplae* WP in which 2.96, 4.16, and 4.43 hoppers per hill noticed as against 12.20 hoppers population in untreated control.

Second spraying

The data representing brown planthoppers population by *N. lugens* under field condition are given in Table 6 and duplicated in Fig. 2. The results revealed that the BPH population did not vary among the treatments at 1 DBS during *kharif,* 2011 (7.39–11.75 hoppers/hill). This indicates the uniform population in the experimental plot.

Table 6: Influence of new chemical insecticides on Brown planthopper. (2nd spray)

Sr. No.	Insecticides	Dose/ha	Mean survival population BPH per hill				Mean population
			1 DBS	5 DAS	10 DAS	15 DAS	
1	Triazophos 40 EC	600 g a.i./ha	8.14* (2.94)**	2.89 (1.84)	2.99 (1.87)	3.58 (2.02)	3.15 (1.95)
2	Imidacloprid17.8 SL	25 g a.i./ha	7.85 (2.88)	2.15 (1.63)	2.28 (1.67)	2.56 (1.75)	2.33 (1.68)
3	Thiamethoxam 25 WG	25 g a.i./ha	7.79 (2.87)	2.12 (1.62)	2.18 (1.64)	2.39 (1.70)	2.26 (1.66)
4	Clothianidin 50 WDG	25 g a.i./ha	7.39 (2.81)	1.66 (1.47)	1.72 (1.49)	2.09 (1.61)	1.80 (1.52)
5	Lambda – cyhalothrin 5 EC	25 g a.i./ha	7.91 (2.90)	2.49 (1.73)	2.59 (1.76)	2.92 (1.85)	2.66 (1.78)
6	*Metarhizium anisopliae* WP	2000 g/ha	8.56 (3.01)	3.14 (1.91)	3.22 (1.93)	3.70 (2.05)	3.35 (1.96)
7	Buprofezin 25 SC	500 g a.i./ha	7.39 (2.81)	2.02 (1.59)	2.09 (1.61)	2.35 (1.69)	2.15 (1.63)
8	Acetamiprid 20 SP	30 g a.i./ha	7.67 (2.86)	2.09 (1.61)	2.16 (1.63)	2.49 (1.73)	2.21 (1.65)
9	Untreated Control		11.75 (3.50)	15.74 (4.03)	15.90 (4.05)	15.98 (4.06)	15.87 (4.05)
	S.E.	-	N.S	0.02	0.02	0.02	0.02
	C.D.@5%	-	N.S	0.07	0.06	0.06	0.06

** Figures in parenthesis are X+0.5 square root transformed values

*Mean of three replications

5 Days after spraying

It could be seen from Table 6 on 5th days after spraying, the population of BPH observed in different insecticide treatments were between1.66 to 3.14 as against 15.74 in untreated control. Among the insecticides tested treatment with clothianidin 50 WDG @ 25 g a.i./ ha proved to be most effective and superior over the rest of the treatments and recorded lowest 1.66 hoppers population per hill. The next best treatment was buprofezin 25 SC @ 500 g a.i. /ha where 2.02 hoppers population per hill were recorded however it was on par with the treatment with acetamiprid 20 SP @ 30 g a.i./ha (2.09 hoppers per hill) thiamethoxam 25 WDG @ 25 g a.i./ha (2.12 hoppers per hill) and imidacloprid 17.8 SL @ 25 g a.i./ha (2.15 hoppers per hill) as significant differences did not exist among them. The next best treatments in order of their efficacy were lambda cyhalothrin, triazophos and *M. anisoplae* in which 2.49, 2.89 and 3.14 hoppers per hill was observed significantly low as compare to untreated control.

10 Days after spraying

It could be seen 10th day after sprayingthat the population of BPH in different insecticide treatments was ranged from 1.72 to 3.22 as against 15.90 in untreated control. Among the insecticides tested treatment with clothianidin 50 WDG @ 25 g a.i./ ha found to be most effective and superior over the rest of all the treatments which recorded lowest population of 1.72 hoppers per hill. The treatment with buprofezin 25 SC @ 500 g a.i. /ha where it was recorded 2.09 hoppers per hill where at par with the treatment in order of efficacy with acetamiprid 20 SP @ 30 g a.i./ha (2.16 hoppers per hill), thiamethoxam 25 WDG @ 25 g a.i./ha (2.18 hoppers per hill) and imidacloprid 17.8 SL @ 25 g a.i./ha (2.28 hoppers per hill). The next best treatments in order of their efficacy were lambda cyhalothrin, triazophos and *M. anisoplae* in which 2.59, 2.99 and 3.22 hoppers per hill respectively which was significantly low in as compare to untreated control.

15 Days after spraying

All the insecticidal treatment found to be superior over untreated control, when observation was recorded 15 DAS. Among the treatment with clothianidin 50 WDG was found to be significantly superior over all other insecticide treatments and recorded 2.09 hoppers population per hill. The treatment with buprofezin 25 SC, thiamethoxam 25 WG, acetamiprid 20 SP, and imidacloprid 17.8 SL found to be equally effective in reducing survival population in which 2.35, 2.39, 2.49 and 2.56 hoppers per hill, respectively. The treatment with lambda cyhalotrin, triazophos and *M. anisoplae* were used in order of efficacyin which 2.92, 3.58 and 3.70 hoppers population per hill observed, respectively.

Overall performance of various insecticidal treatments based on the mean indicated the treatment with clothianidin 50 WDG was the most consistantly effective and significantly superior over all other treatments in reducing the hoppers population 1.80 per hill. The treatment with buprofezin 20 SC (2.15 hopper per hill), acetamiprid 20 SP, thiamethoxam 25 WG and imidacloprid 17.8 SL which 2.21, 2.39 and 2.56 population of hoppers per hill observed, respectively where significant difference did not exist. This was followed by the treatment lambda cyhalotrin 5 EC, triazophos 17.8 SL and *M. anisoplae* WP in which 2.92, 3.58 and 3.70 of hoppers per hill noticed as against 15.87 hoppers population in untreated control.

4.1.2 Bioefficacy of new insecticide molecules against rice brown plant hopper, *N. lugens* (Stal). (Granular application).

The efficacy of different granular insecticides against rice brown plant hopper was judged on the basis of observation recorded mean population of hoppers one day before the treatment, 7thdays after treatment and 10th days after the treatment. In all two application were given in one application recorded at tillering stage and second application was recorded at the time of grain filling stage.

First application

The data presenting on mean population of hoppers *N. lugens* under field condition are given in Table 7 and duplicated inFig. 3. The observation recorded pretreatment indicated that the population of BPH ranged from 18.94 to 22.54 per hill. However, there were no significant differences in the brown planthopper population/hill the amongst treatment plots indicating the uniform population throughout experimental field.

Table 7 : Influence of new granular insecticides on Brown planthopper. (1st application)

Sr. No.	Insecticides	Dose/ha	Mean survival population BPH per hill			Mean
			Pretreatmet	7 DAT	10 DAT	
1	Fipronil O.3 G	7.5 g a. i.	20.02* (4.53)**	11.89 (3.52)	10.77 (3.29)	11.33 (3.40)
2	Carbofuran 3 G	750 g a. i.	18.94 (4.41)	14.50 (3.87)	14.63 (3.89)	14.56 (3.88)
3	Phorate 10 G	750 g a. i.	20.20 (4.55)	15.26 (3.97)	15.80 (4.03)	15.53 (4.00)
4	Cartap hydrochloride4 G	750 g a. i.	21.21 (4.66)	12.38 (3.59)	10.99 (3.39)	11.64 (3.49)
5	Rynaxypyr 0.4G	30 g a. i.	21.87 (4.73)	9.80 (3.31)	8.47 (2.99)	9.13 (3.00)
6	Fipronil + Imidacloprid 80WG	250 g a. i.	21.59 (4.70)	9.67 (3.18)	7.17 (2.75)	8.42 (2.96)
7	Chloropyriphos 10 G	1 kg a.i.	22.54 (4.80)	12.82 (3.65)	13.63 (3.73)	13.23 (3.69)
8	Untreated Control		19.93 (4.52)	21.43 (4.67)	23.80 (4.90)	22.61 (4.78)
	S.E.	-	N.S	0.03	0.04	0.03
	C.D.@5%	-	N.S	0.08	0.12	0.10

** Figures in parenthesis are X+0.5 square root transformed values

*Mean of three replications

Seven day after treatment

It could be seen from Table 7 on seven day after treatment the hoppers population observed in different granular treatments were between 9.67 to 15.26 hoppers per hill against 21.43 hoppers per hill in untreated control. Among the insecticide tested the drenching with Fipronil + Imidacloprid 80 WG (drenching) @ 250 g a.i./ha found to be most effective and superior over all the rest of the treatment and recorded lower population 9.67 hoppers per hill. The treatment with Rynaxypyr0.4 G @ 30 g a.i./ha stood second in order of efficacy recorded 9.80 population of hoppers per hill. The next best treatment in order of their efficacy was fipronil 0.3 G @ 7.5 g a.i. /ha recorded 11.89population of hoppers per hill and found at par with cartap hydrochloride 4G @ 750 g a.i./ha recording 12.38 population of hoppers per hill. This was followed by the treatment with chloropyriphos 10 G, carbofuran 3 G and phorate 10 G in which 12.82, 14.50 and 15.26 population of hoppers per hill was noticed.

Ten day after treatment

At 10 days after the applications all the treatment were found significantly superior over untreated control and the population has ranged from 7.17 to 23.80 hoppers per hill. Among the insecticide tested the treatment with Fipronil + Imidacloprid 80 WG (drenching) @ 250 g a.i./ha proved to be most effective and superior overall the rest of the treatment recorded lower hopper population per hill as 7.17. The treatment with Rynaxypyr 0.4 G @ 30 g a.i. /ha stood second in order of effectiveness recording 8.47 hopper population per hill. Treatment with fipronil 0.3 G @ 7.5 g a.i./ha recorded 10.77 hoppers population per hill found at par with cartap hydrochloride 4 G @ 750 g a.i./ha recording 10.99 hopper population per hill. This was followed by the treatment with chloropyriphos 10 G, carbofuran 3 G and phorate 10 G in which 13.63, 14.63 and 15.80 hoppers population per hill noticed.

Overall performance of various granular insecticidal treatments based on the mean indicated that treatment with Fipronil + Imidacloprid 80 WG was the most effective and significantly superior over all other treatments in reducing hopper population minimum level of 8.42 per hill. Rynaxypyr 0.4 G stood second in order of effectiveness which recorded 9.13 hopper populations per hill. Treatment with fipronil 0.3 G proved next effective treatment by recording 11.33 and found at par with cartap hydrochloride recorded 11.64 hopper populations per hill. This was followed by the treatment chloropyriphos, carbofuron and phoratein which 13.23, 14.56 and 15.53 hopper population per hill noticed as against 22.61 hoppers per hill in untreated control.

Second application

The data presenting on mean population of hoppers by *N. lugens* under field condition are given in Table 8 and duplicated graphically in Fig 4.

Table 8: Influence of new granular insecticides on Brown planthopper.(2nd application)

Sr. No.	Insecticides	Dose/ha	Mean survival population BPH per hill			Mean
			Pretreatment	7 DAT	10 DAT	
1	Fipronil O.3 G	7.5 g a. i.	24.20* (4.97)**	17.22 (4.21)	11.75 (3.50)	14.47 (3.86)
2	Carbofuran 3 G	750 g a. i.	25.82 (4.13)	19.48 (4.47)	15.58 (4.01)	17.53 (4.24)
3	Phorate 10 G	750 g a. i.	24.40 (4.99)	20.57 (4.59)	16.55 (4.13)	18.50 (4.36)
4	Cartap hydrochloride 4 G	750 g a. i.	27.06 (5.25)	17.73 (4.27)	12.10 (3.55)	14.92 (3.89)
5	Rynaxypyr 0.4 G	30 g a. i.	25.20 (5.07)	16.23 (4.09)	10.99 (3.39)	13.64 (3.74)
6	Fipronil + Imidacloprid 80WG	250 g a. i.	26.12 (5.16)	15.34 (3.98)	9.67 (3.18)	12.51 (3.58)
7	Chloropyriphos 10 G	1 kg a.i.	26.95 (5.24)	18.68 (4.38)	14.39 (3.86)	16.69 (4.12)
8	Untreated Control		24.80 (5.03)	26.43 (5.19)	19.42 (5.17)	27.93 (5.33)
	S.E.	-	N.S	0.02	0.02	0.02
	C.D.@5%	-	N.S	0.07	0.07	0.07

** Figures in parenthesis are X+0.5 square root transformed values

* Mean of three replication

The result reveled that all the insecticide treatment recorded significantly lower hoppers population compared to untreated control up to 10 DAT. The observation recorded one pre treatment indicated that the population of BPH ranged from 24.20 to 27.06 per hill. However, there were no significant differences in the brown planthopper population/hill the amongst treatment plots.

Seven day after treatment

It could be seen from Table 8 on seven day after treatment the hoppers population observed in different granular insecticide treatment was between 15.34 to 20.57 hoppers per hill against 26.43 hoppers per hill in untreated control. Among the insecticide tested the drenching with Fipronil + Imidacloprid 80 WG (drenching) @ 250 g a.i./ha proved to be most effective and superior over all the rest of the treatment and recorded lower population of 15.34 hoppers per hill. The treatment withRynaxypyr 0.4 G @ 30 g a.i./ha stood second in order of effectiveness recording 16.23 population of hoppers per hill. The next best treatment in order of their efficacy was fipronil 0.3 G @ 7.5 g a.i./ha recorded 17.22 population of hoppers per hill and found at par with cartap hydrochloride 4G @ 750 g a.i./ha recording 17.73 population of hoppers per hill. This was followed by the treatment with chloropyriphos 10 G, carbofuran 3 G and phorate 10 G in which 18.68, 19.48 and 20.57 population of hoppers per hill was noticed.

Ten day after treatment

At 10 days after the applications all the treatment were found significantly superior over untreated control and the population has ranged from 9.67 to 29.42 hoppers per hill. Among the insecticide tested the treatment withFipronil + Imidacloprid 80 WG (drenching) @ 250 g a.i. /ha proved to be most effective and superior overall the rest of the treatment recorded lower hopper population per hill as 9.67. The treatment with Rynaxypyr 0.4 G @ 30 g a.i./ha stood second in order of effectiveness recording 10.99 hopper population per hill. Treatment with fipronil 0.3 G @ 7.5 g a.i./ha recorded 11.75 hoppers population per hill found at par with cartap hydrochloride 4 G @ 750 g a.i./ha recording 12.10 hopper population per hill. This was followed by the treatment with chloropyriphos 10 G, carbofuran 3 G and phorate 10 G in which 14.39, 15.58 and 16.55 hoppers population per hill noticed.

Overall performance of various granular insecticidal treatments based on the mean indicated that treatment with Fipronil + Imidacloprid 80 WG was the most effective and significantly superior over all other treatments in reducing hopper population minimum level of 12.51 per hill. Rynaxypyr 0.4 G stood second in order of effectiveness which recorded 13.64 hopper population per hill. Treatment with fipronil 0.3 G proved next effective treatment by recording 14.47 and found at par with cartap hydrochloride recorded 14.92 hopper population per hill. This was followed by the treatment chloropyriphos ,carbofuron and phoratein which 16.69, 17.53 and 18.50 hopper population per hill noticed as against 27.93 hoppers per hill in untreated control.

The overall results of the present investigation revealed that among the evaluated insecticides clothianidin 50 WDG @ 25 g a.i./ha was found to be most effective against rice brown plant hopper by recording lower population of hopper per hill. The treatment with buprofezin 25 SC @ 500 g a.i./ha, acetamiprid 20 SP @30 g a.i/ha, thiamethoxam 25 WG @ 25 g a.i./ha, imidacloprid 17.8 SL 25 g a.i./ha and lambda cyhalotrin 5 EC @ 25 g a.i./ha also showed better results against *N. lugens.* Treatment with triazophos and *M. anisoplae* least effective against rice brown plant hopper of rice.

The results are in agreement with Misra (2005) who reported at clothianidin 50 WDG @ 25 g a.i./ha was found superior in supressing the BPH population. Sahithi and Misra (2006) and Misra (2009) who reported at clothianidin 50 WDG @ 25 g a.i./ha was found superior in supressing the GLH population.

Bhavani (2006) and Wang *et al.* (2008) who reported the effectiveness of buprofezin 25 SC @ 500 g a.i./ha for the management the BPH. Ghosh *et al.*(2010) who reported at acetamiprid 20 SP @ 40 g a.i./ha was found superior in supressing the BPH population. Krishnaiah *et al.* (2003) and Hegde (2005) who found that thiamethoxam 25 WG @ 50 g a.i./ha. Was found very effective on rice brown plant hopper.

Hedge and Nidagundi (2009) also reported that effect of buprofezin 25 sc at 0.75 ml/l which recorded lower plant hopper population and thiamethoxam 25 WG at 0.2 g/l, imidacloprid 17.8 SL at 0.3 ml/l were next in order of efficacy.

The effectiveness of new molecules *viz.* clothianidin 50%WDG, acetamiprid 20 SP, thiamethoxam 25% WG and imidacloprid 17.8%SL were in the supressing the population of BPH also documented by Misra (2009), Sidde Gowda *et al.* (2009), Ghosh *et al.* (2010).

Jhansi Lakshmi *et al.* (2010) postulated that thiamethoxam was hightly effective against BPH. However, BPH has started developing resistance to thiamethoxam hence there in need to alter this new molecules of insecticides along with conventional insecticides to deley the insecticide resistance. Results of present investigations are in accordance with previous workers

In case of granular insecticides Fipronil + Imidacloprid 80 WG (drenching) @ 250 g a.i./ha proved to be most effective against rice brown plant hopper recording lower hoppers population. Rynaxypyr 0.4 G @ 30 g a.i./ha , fipronil 0.3 G @ 7.5 g a.i./ha, Cartap hydrochloride 4 G @ 750 g a.i./ha, carbofuran 3 G @ 750 a.i./ha, Phorate 10 G @ 750 g a.i./ha, and chloropyriphos 10 G @ 1 kg a.i./ha also showed better results against *N. lugens.*

The new molecules Fipronil + Imidacloprid 80 WG (drenching) and Rynaxypyr 0.4G were first time used for management of BPH and hence due to the references, the results were not compared. However the new combination product Ethioprole 40% + Imidacloprid 40% - 80WG recorded were than 90 per cent reduction in population of BPH and recorded higher yield Vinothkumar *et al.*(2010).

These results corroborate with the finding of the earlier workers.

4.2 Population dynamics of *N. lugens* under field condition.

The data on mean population of hoppers by *N. lugens* under field condition along with weather parameters *viz.,* temperature (Maximum and Minimum), relative humidity (Morning and Evening) rainfall and sunshine are given in Table 9 and graphically duplicted in Fig 5.

The mean population of hopper 6.50 was first observed at eleven week after transplanting in 36th MW which increased gradually and reached to maximum of 36.64 hopper population the 20th week after transplanting during 45th MW. The peak hopper population was observed during 15th to 22th MW. There after hoppers population was declined to 8.3 at 24th WAT in 49th MW. Thus, it seems that hoppers population went on increasing till panicle stage to harvesting stage of rice crop, and then it was found to be declined with increase in the age of rice crop.

The incidence of the brown plant hopper started at the 36 meteorological weeks corresponding to 11 weeks after trasplanting where 93% RH with 67.5mm rainfall. The population started gradually increasing thereafter with increasing temperatures, RH and reduction in rainfall. Population increased up to 36.64/hill high temperature 32^0C and 90% RH in absence of rainfall in 45 meteorological week corresponding to 20 week after transplanting. The population of hoppers decreased as the crop turned towardsmaturity. Thisindicated that increasing in temperature, RH and in absence of rainfall with thick crop canopy is the congenial condition for the BPH. The incidance of BPH was positively correlated to the temperature and sunshine. However, rainfall and relative humidity negatively correlated to the population density of BPH.

The temperature, relative humidity and rainfall has great influence on the population dynamics of BPH. Similar results also reported by Isichaikul and Ichikawa. (1993), Muhamad and Chung, (1993), Isichaikul *et al.* (1994) and Bae *et al.* (1995).

Win *et al.* (2011) reported that in population fluctuation study revealed at 64 and 74 days after transplanting (in mid-September) associated with high humidity, high temperature and high rainfall. The BPH population was lowest (in mid-week of October) suggesting that low rainfall and low humidity were at least partially responsible for the decrease population of brown plant hopper.

4.2.1 Correlation between brown plant hopper of rice and weather parameters.

The data pertaining to the mean hoppers population *N. lugens* and their correlation with weather parameters are presented in Table 10.

The influence of the meteorological parameters *viz.,* temperature (Maximum and Minimum), relative humidity (Morning and Evening), rainfall and sunshine on brown planthopper infestation was assessed and presented here under.

It is reveled from the Table 10 that the infestation of *N. lugens* hopper population was correlated positively significant with maximum temperature (+0.878**) and the correlation of hopper minimum temperature significant (-0.701*).

The population of hopper was negatively correlated with morning relative humidity (-0.74**). The hoppers were correlated negatively significant with evening humidity (-0.945**), respectively. The population of hoppers were negatively correlated with rainfall (-0.697**) and positively with sunshine (+0.894*).

The similar results were also reported by Narayanswamy *et al.* (1979), Reddy *et al.* (1983) and Vijaykumar and Patil (2003).

Table No 10 : Correlation between rice brown plant hopper infestation with weather parameters

Sr. No.	Name of pest	Meteorological parameters					
		Max. Temp.	Min. Temp.	Morning humidity	Evening humidity	Rainfall	Sunshine
1	Mean hopper population	+0.878**	-0.701*	-0.74**	-0.945**	-0.697**	+0.894*

* =Significant at 5 per cent level

** =Significant at 1 per cent level

Jadhao and Khurad (2011) observed that overall population growth rate and peak density of *N. lugens* during rabi season were much lower as compare to the *kharif* season. The correlation analysis study showed that in rabi season *N. lugens* exhibited highly positive correlation with relative humidity and significant negative correlation with maximum temperature where as it showed highly significant negative correlation with relative humidity and minimum temperature during *kharif* season.

4.3 Impact of new insecticide molecules on natural enemies

The number of predators and parasitoids *viz.,* Green mirid bug, Brown mirid bug, Vellid bug, *C. lividipennis*, *A. nilaparvatae, T. perviceps* and spiders in different insecticide treatments are presented in Table 11 and graphically duplicated in Fig 6. It is revealed from the Table 11 that population of natural enemies per 5 hills does not vary significantly at one day before spraying (1DBS) recording 3.50 to 3.87 natural enemies per five hills indicating their uniform distribution throughout the experimental plot.

The observation on 0 DAS indicated that the untreated control recorded highest population of natural enemies (3.91). The treatment with *M. anisoplae* recorded relatively more population of natural enemies (3.82). This was followed by buprofezin (3.78), imidacloprid (3.76), acetamiprid (3.73), thiamethoxam (3.69), clothianidin (3.65), triazophos (3.64) lambda cyhalothrin (3.54), respectively. Thus it is revealed from the data that population of natural enemies did not vary significantly immediately after spraying indicating that instant death or dispersal of natural enemies had not occurred due to exposure to different insecticides. Therefore the population of natural enemies in treated plots was more or less similar with untreated control.

On 3 DAS, the population of natural enemies registerd significantly low count in various treatments as compared to untreated control. Among the insecticide treatments *M. anisoplae* recorded highest natural enemies population (2.22) and found at par with buprofezin which recorded (2.15) natural enemy per plant showing their saftyness to the natural enemies. This was followed by imidacloprid (1.99) found at par with acetamiprid (1.93), thiamethoxam (1.87) and clothianidin (1.87) which were found moderately safe to natural enemies. The treatment with triazophos (1.63) and lambda cyhalothrin (1.60) found least selective for conserving natural enemies population.

The significant differences did not existed among the population of natural enemies in insecticidal treatments when observations were recorded 7th and 10th DAS. This indicated that chemical did not exhibit of experimental effect on the natural enemies after a week of spraying.

The overall influence of insecticides against number of natural enemies in rice ecosystem revealed that there was considerable decrease in natural enemies population initially in all treatments imposed and gradually it started increasing, but less than in untreated check. Nayak *et al.*

(2000) observed initial reduction in spider population in rice after application of several combination insecticides but, their population built up in two weeks. Based on mean population data revealed that the treatment with *M. anisoplae* (2.22) and buprofezin (2.15) proved to be safe to natural enemies. The synthetic insecticides *viz.,*imidacloprid (1.99), acetamiprid (1.93), thiamethoxam (1.87), clothiadin (1.87), triazophos (1.63) and lamdacyhalothrin (1.60) found moderately safe to natural enemies.

The results are agreement with Geng and Zhang (2004) and Vo Thi Bich Chi *et al.* (2005) who reported the *M. anisoplae* was found safety to natural enemy on brown plant hopper in rice field.

Heinrichs (1984), Choi *et al.* (1996), Krishnaiah *et al.* (1996) and Hedge and Nidagundi (2009) also reported that buprofezin is safe to nymphs and adults of the natural enemies.

Jiang *et al.* (2006) studied the effects of triazophos, shachongshuang, abamectin, and Bt + imidaclopridon the insect pest-natural enemies community in early rice fields. The results showed that all of the test insecticides had significant effects in controlling the growth of major insect pest populations. The average value of insect pest-natural enemy community diversity under effects of triazophos, shachongshuang, abamectin, and Bt + imidacloprid was 1.545, 1.562, 1.691 and 1.915, respectively, while that in control plot was 1.897.

Table 11 : Influence of novel insecticides on natural enemies

Sr. No.	Insecticides	Dose/ha	Natural enemies per five hill				
			1 DBS	O DAS	3 DAS	7 DAS	10 DAS
1	Triazophos 40 EC	600 g a.i./ha	3.87* (2.09)**	3.64 (2.03)	1.63 (1.46)	1.72 (1.49)	1.84 (1.53)
2	Imidacloprid17.8 SL	25 g a.i./ha	3.70 (2.05)	3.76 (2.06)	1.99 (1.58)	2.12 (1.62)	2.42 (1.70)
3	Thiamethoxam 25 WG	25 g a.i./ha	3.66 (2.04)	3.69 (2.04)	1.87 (1.54)	1.99 (1.58)	2.22 (1.65)
4	Clothianidin 50 WDG	25 g a.i./ha	3.83 (2.08)	3.65 (2.03)	1.87 (1.54)	1.96 (1.57)	2.12 (1.62)
5	Lamda – cyhalothrin 5 EC	25 g a.i./ha	3.50 (2.00)	3.54 (2.01)	1.60 (1.45)	1.69 (1.48)	1.84 (1.66)
6	*Metarhizium anisopliae* WP	2000 g/ha	3.74 (2.06)	3.82 (2.08)	2.22 (1.65)	2.35 (1.70)	2.86 (1.83)
7	Buprofezin 25 SC	500 g a.i./ha	3.70 (2.05)	3.78 (2.07)	2.15 (1.63)	2.25 (1.66)	2.56 (1.74)
8	Acetamiprid 20 SP	30 g a.i./ha	3.54 (2.01)	3.73 (2.05)	1.93 (1.56)	2.06 (1.60)	2.25 (1.65)
9	Untreated Control		3.50 (2.00)	3.26 (1.94)	3.50 (2.00)	3.58 (2.02)	3.86 (2.09)
	S.E.	-	N.S	N.S	0.03	N.S	N.S
	C.D.@5%	-	N.S	N.S	0.08	N.S	N.S

** Figures in parenthesis are X+0.5 square root transformed values
*Mean of three replication

Jhansi Lakshmi *et al.* (2010) observed the selected insecticides to *Nilaparvata lugens* and their important predators in rice ecosystem, viz., green mirid bug, *C. lividipennis,* brown mirid bug, *Tytthus parviceps*. Ethiprole + imidacloprid and thiamethoxam + lambdacyhalothrin initial and persistence toxicity against *N. lugens* but these to combinations were highly toxic to all three natural enemies recording 100 per cent mortality.

Preetha*et al.,* (2010) reported the green miridbug, *C. lividipennis*, an important natural enemy of the rice brown planthopper (BPH), *N. lugens* plays a major role as a predator in suppressing the pest population. The study assessed the impact of certain potential insecticides used in the rice ecosystem on the miridbug predator and brown planthopper through contact toxicity. The insecticides tested, clothianidin are regarded as highly toxic to *C. lividipennis* based on selectivity ratio.

Chaiwong*et al.,* (2011) result showed that clothianidin and thiamethoxam were mostly harmless to moderately harmful to the spiders, miridbug, predators egg parasites of leafhoppers and planthopper.

The results of present investigations are in accordance with the previous workers.

4.4. Influence of newer insecticides on grain yield of rice.

The data on yield of rice influenced by various insecticide treatments are presented in Table 12. It could be seen from the data that all the insecticide treatments recorded higher yield over untreated control.

The highest grain yield of rice (48.93 q/ha) was obtained in a treatment with clothianidin. This treatment recorded 18.8 q/ha and 62.39 per cent increase in yield over control.

The next best treatment was buprofezin which recorded 46.25 q/ha grain yield of rice with 16.12 q/ha and 53.50 per cent increase over control. However it was on par with acetamiprid, thiamethoxam in which 46.01 and 45.90 q/ha grain yield was recorded. This was followed by the treatment with imidacloprid, lambda cyhalotrin, triazophos and *M. anisoplae* 39.73, 36.17, 34.04 and 31.23 q/ha grain yield of rice was observed. The untreated control recorded lowest of 30.13 q/ha grain yield of rice.

Hegade (2005) observed the thiamethoxam 25 WG 25 g a.i./ha and imidacloprid 200 SL 25 g a.i./ha recorded 49.53 and 48.47 q/ha significantly higher grain yield of rice.

Sekh *et al.* (2007) observed the thiamethoxam 25 WG 25 g a.i./ha and imidacloprid 200 SL 25 g a.i./ha recorded 29.66 and 30.33 q/ha grain yield of rice.

Hegade and Nidagundi (2009) showed the buprofezin 25 SC @ 1 ml/l recorded highest grain yield of rice followed by thiamethoxam 25 WG @ 0.20g/l and imidacloprid 17.8 SL @ 0.30 ml/l.

Table No. 12: Influence of new insecticide molecules on yield of rice (spraying).

Sr. No.	Insecticides	Dose/ha	Mean yield of paddy q/ha	Increase over control q/ha	Percent increase over control
1.	Triazophos 40 EC	600 g a.i./ha	34.04	3.91	12.97
2.	Imidacloprid17.8 SL	25 g a.i./ha	39.73	9.60	31.86
3.	Thiamethoxam 25 WG	25 g a.i./ha	45.90	14.87	45.45
4.	Clothianidin 50 WDG	25 g a.i./ha	48.93	18.8	62.39
5.	Lamda – cyhalothrin5 EC	25 g a.i./ha	36.17	6.04	20.04
6.	*Metarhizium anisopliae* WP	2000 g/ha	31.23	1.10	3.65
7.	Buprofezin 25 SC	500 g a.i./ha	46.25	16.12	53.50
8.	Acetamiprid 20 SP	30 g a.i./ha	46.01	15.88	52.70
9.	Untreated Control	--	30.13	-	-
	S.E.		0.60	-	-
	C.D. @ 5%		1.79	-	-

The results of present investigations are in agreement with previous workers.

4.4.1. Influence of granular insecticides on yield of rice.

The data on yield of rice influenced by various insecticide treatments are presented in Table 13. It could be seen from the data that all the insecticide treatments recorded higher yield over control.

The highest grain yield of rice (43.54 q/ha) was obtained in a treatment with Fipronil + Imidacloprid. This treatment recorded 14.00 q/ha and 47.39 per cent increase in yield over control.

The next best treatment was Rynaxypyr which recorded 40.99 q/ha yield of rice with 11.45 q/ha and 38.76 per cent increase over control. The next best treatment was fipronil which recorded 38.75 q/ha grain yield of rice with 9.21 q/ha and 31.17 per cent increase over control however, it was on par with Cartap hydrochloride where 37.74 q/ha grain yield of rice was obtained. This was followed by the treatment with Chloropyriphos, Furadan and Phorate in which 36.44, 34.30 and 31.76 q/ha yield of rice was observed. The untreated control recorded lowest of 29.54 q/ha grain yield of rice.

Similar results were also reported Reddy *et al.* (2012) who reported that Cartap hydrochloride 50 SP @ 50 g a.i./ha recorded rice grain yield was 50.8 q/ha.

Table No.13: Influence of new insecticide molecules on yield of rice (granular application).

Sr. No.	Insecticides	Dose/ha	Mean yield paddy q/ha	Increase over control q/ha	Percent increase over control
1.	Fipronil O.3 G	7.5g a.i./ha	38.75	9.21	31.17
2.	Carbofuran 3 G	750 g a.i./ha	34.30	4.76	16.11
3.	Phorate 10 G	750 g a.i./ha	31.76	2.22	7.51
4.	Cartap hydrochloride 4 G	750 g a.i./ha	37.34	7.8	26.40
5.	Rynaxypyr 0.4 G	30 g a.i./ ha	40.99	11.45	38.76
6.	Fipronil + Imidacloprid80WG	250 g a.i./ha	43.54	14	47.39
7.	Chloropyriphos 10 G	1 kg a.i /ha	36.44	6.9	23.35
8.	Untreated Control	--	29.54	-	-
	S.E.		0.70		
	C.D. @ 5%		2.15		

5. SUMMARY AND CONCLUSION

The present investigations were undertaken with a view to study the bio efficacy of novel insecticides against rice brown plant hopper. Attempts were also made to study population dynamics of rice and to study the influence of above insecticides on natural enemies.The results obtained are summarized here under.

5.1. Bioefficacy of new insecticide molecules against ricebrown planthopper, *Nilaparvata lugens* (Stal).

Among the evaluated novel insecticides, overall performance of various insecticidal treatments based on the mean indicated the treatment with clothianidin 50 WDG was the most effective and significantly superior over all other treatments in reducing the hoppers population 1.40 per hill. The treatment with buprofezin 20 SC recorded 1.73 hopper per hill found at par with acetamiprid 20 SP, thiamethoxam 25 WG and imidacloprid 17.8 SL which 1.87, 1.99 and 2.05 hopper per hill were observed. This was followed by the treatment lambda cyhalotrin 5 EC, triazophos 17.8 SL and *M. anisoplae* WPin which 2.96, 4.16 and 4.43 hoppers per hill noticed as against 12.20 hoppers population in untreated control.

5.1.1. Bioefficacy of new insecticide molecules against ricebrown plant hopper, *Nilaparvata lugens* (Stal). (Granular application).

Among the evaluated granular insecticides, overall performance of various granular insecticidal treatments based on the mean survival population indicated that treatment with fipronil + imidacloprid 80 WG was found to be most effective and significantly superior over all other treatments, where 8.42 per hill. Rynaxypyr 0.4 G stood second in order of effectiveness which recorded 9.13 hopper population per hill. Treatment with fipronil 0.3 G proved next effective treatment by recording 11.33 and found at par with cartap hydrochloride recorded 11.64 hopper populations per hill. This was followed by the treatment chloropyriphos, carbofuron and phorate in which 13.23, 14.56 and 15.53 hopper population per hill noticed as against 22.61 hoppers per hill, respectively in untreated control.

5.2. Population dynamics of the *N. lugens* under field condition.

The mean population of hopper 6.50 was first observed at eleven week after transplanting in 36th MW which was increased gradually and reached to maximum of 36.64 hopper population the 20th week after transplanting during 45th MW. The peak hopper population was observed during 15th to 22th MW. There after hoppers population was declined to 8.3 at 24th WAT in 49th MW. Thus, it seems that hoppers population due to *N. lugens* went on increasing till panicle stage to harvesting stage of rice crop, and then it was found to be declined with age of rice crop.

5.3. Correlation between brown plant hopper of rice and weather parameters.

Correlation between brown plant hopper of rice and weather parameters was correlated positively significant with maximum temperature (+0.878**) and minimum temperature was negatively significant (-0.701*). In case of relative humidity the hoppers was correlated negatively significant with morning relative humidity (-0.74**) and evening humidity (-0.945**) respectively. In case of rainfall the hoppers were correlated negatively significant with rainfall (-0.697**). The hoppers were positively significant with sunshine (+0.894*).

5.4. Influence of novel insecticides on natural enemies

The results of investigation revealed that treatment with *Metarhizium anisopliae* proved most effective in conserving natural enemies. Overall influence of insecticides on number of natural enemies in rice ecosystem based on mean population data revealed that the treatment with *M. anisoplae* (2.22/hill). This was followed by buprofezin, imidacloprid, acetamiprid, thiamethoxam, clothianidin, triazophos and lambda cyhalothrin which were proved moderately safe to natural enemies.

5.5. Influence of newer insecticides on grain yield of rice

Among the various insecticide treatments tested the highest grain yield of rice (48.93 q/ha) was obtained in a treatment with clothianidin. The next best treatment was buprofezin which recorded (46.25 q/ha) grain yield. This treatment was on par with acetamiprid, thiamethoxam in which 46.01 and 45.90 q/ha grain yield of rice was obtained. This was followed by the treatment with imidacloprid, lambda cyhalotrin, triazophos and *M. anisoplae* where 39.73, 36.17, 34.04 and 31.23 q/ha grain yield of rice was observed, respectively. The untreated control recorded lowest of 30.13 q/ha grain yield of rice.

5.5.1. Influence of granular insecticides on grain yield of rice

Among the various insecticide treatments tested the highest grain yield of rice (43.54 q/ha) was obtained in a treatment with Fipronil + Imidacloprid. The next best treatment was Rynaxypyr which recorded 40.99 q/ha and treatment fipronil which recorded 38.75 q/ha grain yield of rice. The Fipronil was on par with cartaphydrochlorid in which 37.74 q/ha grain yield of rice was obtained. This was followed by the treatment with chloropyriphos, furadan and phorate in which 36.44, 34.30 and 31.76 q/ha yield of rice was observed, respectively. The untreated control recorded lowest of 29.54 q/ha grain yield of rice.

Conclusions

- The evaluated newer insecticides *viz.,* clothianidin, buprofezin, acetamiprid, thiamethoxam, imidacloprid, and lambda cyhalotrin offered excellent control of brown planthopper by recording lowest population of hopper.
- The evaluated granular insecticides *viz.,* fipronil + imidacloprid, rynaxypyr, fipronil, cartap hydrochloride, carbofuran, phorate and chloropyriphos offered excellent control of brown planthopper by recording lowest population of hopper.

- Correlation studies between population dynamics of brown plant hopper and weather parameters may assist to develop suitable forecasting model for initiation of insecticide application.
- The evaluated synthetic insecticides and bio pesticides were observed to be moderately safe and safe, respectively to the natural enemies in paddy ecosystem.
- Therefore it is concluded that perfect utilization of best performing newer insecticide and granular insecticide and their safety to natural enemy will be the important component in the integrated management of BPH.

Table 11 : Influence of novel insecticides on natural enemies

Sr. No.	Insecticides	Dose/ha	Natural enemies per five hill					Mean population
			1 DBS	O DAS	3 DAS	7 DAS	10 DAS	
1	Triazophos 40 EC	600 g a.i./ha	3.87* (2.09)**	3.64 (2.03)	1.63 (1.46)	1.72 (1.49)	1.84 (1.53)	1.63 (1.46)
2	Imidacloprid 17.8 SL	25 g a.i./ha	3.70 (2.05)	3.76 (2.06)	1.99 (1.58)	2.12 (1.62)	2.42 (1.75)	1.99 (1.58)
3	Thiamethoxam 25 WG	25 g a.i./ha	3.66 (2.04)	3.69 (2.04)	1.87 (1.54)	1.99 (1.58)	2.22 (1.65)	1.87 (1.54)
4	Clothianidin 50 WDG	25 g a.i./ha	3.83 (2.08)	3.65 (2.03)	1.87 (1.54)	1.96 (1.57)	2.12 (1.71)	1.87 (1.54)
5	Lamda – cyhalothrin5 EC	25 g a.i./ha	3.50 (2.00)	3.54 (2.01)	1.60 (1.45)	1.69 (1.48)	1.84 (1.66)	1.60 (1.45)
6	*Metarhizium anisopliae* WP	2000 g/ha	3.74 (2.06)	3.82 (2.08)	2.22 (1.65)	2.35 (1.70)	2.86 (1.62)	2.22 (1.65)
7	Buprofezin 25 SC	500 g a.i./ha	3.70 (2.05)	3.78 (2.07)	2.15 (1.63)	2.25 (1.66)	2.56 (1.53)	2.15 (1.63)
8	Acetamiprid 20 SP	30 g a.i./ha	3.54 (2.01)	3.73 (2.05)	1.93 (1.56)	2.06 (1.60)	2.25 (1.62)	1.93 (1.56)
9	Untreated Control		3.50 (2.00)	3.26 (1.94)	3.50 (2.00)	3.58 (1.68)	3.86 (2.09)	3.50 (2.00)
	S.E.	-	N.S	N.S	0.03	N.S	N.S	0.03
	C.D.@5%	-	N.S	N.S	0.08	N.S	N.S	0.08

** Figures in parenthesis are X+0.5 square root transformed values

*Mean of three replication

Table 5 : Influence of new chemical insecticides on Brown planthopper. (1st spray)

Sr. No.	Insecticides	Dose/ha	Mean survival population BPH per hill				Mean population
			1 DBS	5 DAS	10 DAS	15 DAS	
1	Triazophos 40 EC	600 g a.i./ha	12.60* (3.62)**	3.91 (2.10)	4.16 (2.16)	4.52 (2.24)	4.16 (2.17)
2	Imidacloprid 17.8 SL	25 g a.i./ha	12.74 (3.59)	1.87 (1.54)	2.03 (1.59)	2.22 (1.67)	2.05 (1.60)
3	Thiamethoxam 25 WG	25 g a.i./ha	12.38 (3.64)	1.84 (1.53)	1.93 (1.56)	2.19 (1.64)	1.99 (1.58)
4	Clothianidin 50 WDG	25 g a.i./ha	12.82 (3.65)	1.19 (1.30)	1.21 (1.31)	1.81 (1.52)	1.40 (1.37)
5	Lamda – cyhalothrin 5 EC	25 g a.i./ha	12.53 (3.61)	2.29 (1.67)	3.11 (1.90)	3.50 (2.00)	2.96 (1.86)
6	*Metarhizium anisopliae* WP	2000 g/ha	11.96 (3.53)	4.21 (2.17)	4.42 (2.22)	4.65 (2.27)	4.43 (2.21)
7	Buprofezin 25 SC	500 g a.i./ha	12.31 (3.58)	1.29 (1.34)	1.72 (1.49)	2.18 (1.63)	1.73 (1.49)
8	Acetamiprid 20 SP	30 g a.i./ha	12.24 (3.57)	1.57 (1.44)	1.84 (1.53)	2.22 (1.65)	1.87 (1.54)
9	Untreated Control		11.75 (3.50)	11.61 (3.48)	12.17 (3.56)	12.82 (3.65)	12.20 (3.56)
	S.E.	-	N.S	0.03	0.07	0.01	0.04
	C.D.@5%	-	N.S	0.10	0.20	0.04	0.11

** Figures in parenthesis are X+0.5 square root transformed values
*Mean of three replications

Table 6 : Influence of new chemical insecticides on Brown planthopper. (2nd spray)

Sr. No.	Insecticides	Dose/ha	Mean survival population BPH per hill				Mean population
			1 DBS	5 DAS	10 DAS	15 DAS	
1	Triazophos 40 EC	600 g a.i./ha	8.14* (2.94)**	2.89 (1.84)	2.99 (1.87)	3.58 (2.02)	3.15 (1.95)
2	Imidacloprid 17.8 SL	25 g a.i./ha	7.85 (2.88)	2.15 (1.63)	2.28 (1.67)	2.56 (1.75)	2.33 (1.68)
3	Thiamethoxam 25 WG	25 g a.i./ha	7.79 (2.89)	2.12 (1.62)	2.18 (1.64)	2.39 (1.70)	2.26 (1.66)
4	Clothianidin 50 WDG	25 g a.i./ha	7.39 (2.81)	1.66 (1.47)	1.72 (1.49)	2.09 (1.61)	1.80 (1.52)
5	Lamda – cyhalothrin 5 EC	25 g a.i./ha	7.91 (2.90)	2.49 (1.73)	2.59 (1.76)	2.92 (1.85)	2.66 (1.78)
6	*Metarhizium anisopliae* WP	2000 g/ha	8.56 (3.01)	3.14 (1.91)	3.22 (1.93)	3.70 (2.05)	3.35 (1.96)
7	Buprofezin 25 SC	500 g a.i./ha	7.39 (2.81)	2.02 (1.59)	2.09 (1.61)	2.35 (1.69)	2.15 (1.63)
8	Acetamiprid 20 SP	30 g a.i./ha	7.67 (2.86)	2.09 (1.61)	2.16 (1.63)	2.49 (1.73)	2.21 (1.65)
9	Untreated Control		11.75 (3.50)	15.74 (4.03)	15.90 (4.05)	15.98 (1.06)	15.87 (4.05)
	S.E.	-	N.S	0.02	0.02	0.02	0.02
	C.D.@5%	-	N.S	0.07	0.06	0.06	0.06

** Figures in parenthesis are X+0.5 square root transformed values

*Mean of three replications

Table 7 : Influence of new granular insecticides on Brown planthopper. (1st application)

Sr. No.	Insecticides	Dose/ha	Mean survival population BPH per hill			Mean
			Pretreatmet	7 DAT	10 DAT	
1	Fipronil O.3 G	7.5 g a. i.	20.02* (4.53)**	11.89 (3.52)	10.77 (3.29)	11.33 (3.40)
2	Carbofuran 3 G	750 g a. i.	18.94 (4.41)	14.50 (3.87)	14.63 (3.89)	14.56 (3.88)
3	Phorate 10 G	750 g a. i.	2.20 (4.55)	15.26 (3.97)	15.80 (4.03)	15.53 (4.00)
4	Cartap hydrochloride4 G	750 g a. i.	21.21 (4.66)	12.38 (3.59)	10.99 (3.39)	11.64 (3.49)
5	Rynaxypyr (fertera) 0.4G	30 g a. i.	21.87 (4.73)	9.80 (3.31)	8.47 (2.99)	9.13 (3.00)
6	Fipronil + Imidacloprid 80 WG	250 g a. i.	21.59 (4.70)	9.67 (3.18)	7.17 (2.75)	8.42 (2.96)
7	Chloropyriphos 10 G	1 kg a.i.	22.54 (4.80)	12.82 (3.65)	13.63 (3.73)	13.23 (3.69)
8	Untreated Control		19.93 (4.52)	21.43 (4.67)	23.80 (4.90)	22.61 (4.78)
	S.E.	-	N.S	0.03	0.04	0.03
	C.D.@5%	-	N.S	0.08	0.12	0.10

** Figures in parenthesis are X+0.5 square root transformed values
*Mean of three replications

Table 8 : Influence of new granular insecticides on Brown planthopper. (2nd application)

Sr. No.	Insecticides	Dose/ha	Mean survival population BPH per hill			Mean
			Pretreatment	7 DAT	10 DAT	
1	Fipronil O.3 G	7.5 g a. i.	24.20* (4.97)**	17.22 (4.21)	11.75 (3.50)	14.47 (3.86)
2	Carbofuran 3 G	750 g a. i.	25.82 (4.13)	19.48 (4.47)	15.58 (4.01)	17.53 (4.24)
3	Phorate 10 G	750 g a. i.	24.40 (4.99)	20.57 (4.59)	16.55 (4.13)	18.50 (4.36)
4	Cartap hydrochloride 4 G	750 g a. i.	27.06 (5.25)	17.73 (4.27)	12.10 (3.55)	14.92 (3.89)
5	Rynaxypyr (fertera) 0.4 G	30 g a. i.	25.20 (5.07)	16.23 (4.09)	10.99 (3.39)	13.64 (3.74)
6	Lassenta(drenching) 40 G + 40 G	250 g a. i.	26.12 (5.16)	15.34 (3.98)	9.67 (3.18)	12.51 (3.58)
7	Chloropyriphos 10 G	1 kg a.i.	26.95 (5.24)	18.68 (4.38)	14.39 (3.86)	16.69 (4.12)
8	Untreated Control		24.80 (5.03)	26.43 (5.19)	19.42 (5.17)	27.93 (5.33)
	S.E.	-	N.S	0.02	0.02	0.02
	C.D.@5%	-	N.S	0.07	0.07	0.07

** Figures in parenthesis are X+0.5 square root transformed values
* Mean of three replications

Table 9 : Population dynamics of *N. lugens* on rice crop

Week after transplanting (WAT)	Meteorological week (MW)	Hopper population	Temperature		Relative humidity		Rainfall (mm)	Sunshine (hr)
			Maximum	minimum	Morning	evening		
1	26	0	27.8	22	91.8	81.4	52.71	1.7
2	27	0	29	21.4	93.5	76.4	27.57	2.6
3	28	0	26.5	21	94.4	84.8	29.85	2.3
4	29	0	26.1	22.2	95.8	86	89	2.3
5	30	0	27	21.7	95	87.7	40	2
6	31	0	26.1	21.7	95.28	89.7	46.28	0.61
7	32	0	27.8	22.4	94	83.7	34.71	2.5
8	33	0	26.7	21.6	95.4	84.5	28.42	1.8
9	34	0	28.5	21.6	92.7	78.2	8.42	3
10	35	0	25.3	21.4	95.4	88.5	65.71	0
11	36	6.50	26.3	21.7	93.7	84.1	67.14	1.74
12	37	8.23	28.5	20.1	91.8	74	5.16	4.3
13	38	14.15	28.2	19.7	92.8	67.5	4	4
14	39	18.54	31	18.9	87.5	48.5	0	9.2
15	40	19.57	31.3	19.9	94	56.2	2	5.7
16	41	20.36	32	21.2	90	61.7	0	6.7
17	42	19.29	31.8	18.3	93.5	54.1	0	7
18	43	24.29	31.9	16.94	90	36.7	0	6.7
19	44	30.72	31.7	22	90	45.4	0	6.8
20	45	36.64	32.3	17.5	90	39	0	8.5
21	46	29.74	32.64	20.03	81	43	0	8.4
22	47	24.56	30.11	19.4	83	43	0	9.1
23	48	18.22	31.03	21.2	91	41	0	8.5
24	49	8.30	31.6	`17.7	91	49	0	6.7
25	50	0	31.7	14.3	94	31	0	9.2

Table No 10 : Correlation between rice brown plant hoppeer infestation with weather parameters

Sr. No.	Name of pest	Meteorological parameters					
		Max. Temp.	Min. Temp.	Morning humidity	Evening humidity	Rainfall	Sunshine
1	Mean hopper population	+0.878**	-0.701*	-0.74**	-0.945**	-0.697**	+0.894*

* =Significant at 5 per cent level

** =Significant at 1 per cent level

Table No. 12: Influence of new insecticide molecules on yield of rice (spraying).

Sr. No.	Insecticides	Dose/ha	Mean yield of paddy q/ha	Increase over control q/ha	Percent increase over control
1.	Triazophos 40 EC	600 g a.i./ha	34.04	3.91	12.97
2.	Imidacloprid 17.8 SL	25 g a.i./ha	39.73	9.60	31.86
3.	Thiamethoxam 25 WG	25 g a.i./ha	45.90	14.87	45.45
4.	Clothianidin 50 WDG	25 g a.i./ha	48.93	18.8	62.39
5.	Lamda – cyhalothrin5 EC	25 g a.i./ha	36.17	6.04	20.04
6.	*Metarhizium anisopliae* WP	2000 g/ha	31.23	1.10	3.65
7.	Buprofezin 25 SC	500 g a.i./ha	46.25	16.12	53.50
8.	Acetamiprid 20 SP	30 g a.i./ha	46.01	15.88	52.70
9.	Untreated Control	--	30.13	-	-
	S.E.		0.60	-	-
	C.D. @ 5%		1.79	-	-

Table No.13 : Influence of new insecticide molecules on yield of rice (granular application).

Sr. No.	Insecticides	Dose/ha	Mean yield of paddy q/ha	Increase over control q/ha	Percent increase over control
1.	Fipronil O.3 G	7.5g a.i./ha	38.75	9.21	31.17
2.	Carbofuran 3 G	750 g a.i./ha	34.30	4.76	16.11
3.	Phorate 10 G	750 g a.i./ha	31.76	2.22	7.51
4.	Cartap hydrochloride 4 G	750 g a.i./ha	37.34	7.8	26.40
5.	Rynaxypyr (fertera) 0.4 G	30 g a.i./ ha	40.99	11.45	38.76
6.	Lassenta (drenching) 40 G + 40 G	250 g a.i./ha	43.54	14	47.39
7.	Chloropyriphos 10 G	1 kg a.i /ha	36.44	6.9	23.35
8.	Untreated Control	--	29.54	-	-
	S.E.		0.70		
	C.D. @ 5%		2.15		

PLATE 4: BROWN PLANTHOPPER INFESTED IN FARMERS RICE FIELD

PLATE 5 : HOPPER BURN SYMPTOM IN FARMERS FIELD

PLATE 1 : EXPERIMENTAL PLOT OF RICE

PLATE 2 : PLOT TREATED WITH CLOTHIANIDIN

PLATE 3 : UNTREATED PLOT