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Potential of igr based bio-pesticides in controlling rice brown planthopper, *Nilaparvata lugens* (stål)

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Abstract

Field performance of two insect growth regulators (IGR) viz. Award 40 SC (Buprofezin) and Haron 5 EC (Lufenuron) and one newer Thiacloprid viz. Calypso 280 SC against *Nilaparvata lugens* (Stål) was observed in the Entomology field laboratory, Bangladesh Agricultural University, Mymensingh. The treatments were evaluated on reduction of BPH populations and grain yield (t/ha). At 7 DAT, both IGRs (Award 40 SC: 3.73 hill^{-1}, Haron 5 EC: 5.32 hill^{-1}) and Thiacloprid (Calypso 280 SC: 5.13 hill^{-1}) were found very effective on the reduction of BPH populations (number) with their maximum doses in comparison with that of control (42.90 hill^{-1}). The similar trend was also found in case of grain yield (Award 40 SC @ 0.75 ml/L: 4.8 t/ha; Haron 5 EC @ 1.5 ml/L: 4.72 t/ha; Calypso 280 SC @ 1.00 ml/L: 4.71 t/ha). It is concluded from the present study that Award 40 SC @ 0.75 ml/L or Haron 5 EC @ 1.00 ml/L would be applied to control BPH populations effectively. Although Calypso 280 SC was also found effective on the reduction of BPH populations as well as increasing grain yield but its uses would not be judicious against BPH considering the adverse effects on available components in rice-ecosystem as well as in environment.

Keywords: *nilaparvata lugens*, rice plant, insect growth regulators, neo-nicotinoid

1. Introduction

Rice is the most important staple food worldwide and concerns the world's largest populations of farmers and consumers (Zeigler and Barclay, 2008) [19]. It contributes more than 20.0% of all calories consumed by the entire human population. It is also the predominant food crop of Bangladesh and occupies about 77% of the cropped areas and provides about 75.0% of the calorie and 55% of the protein in average daily diet of a Bangladeshi (Bhuiyan *et al.*, 2004) [3]. It is grown on over eleven million hectares of land which covered approximately 92.43 % of the total area (BBS, 2010) [2]. In recent years rice production has reached to 25 million tons making the country self- sufficient in rice production.

In Bangladesh, 175 species of insect pests have been recorded on rice (Kamal, 1998) [9]. Rice suffers heavy losses every year due to attack of many insect pests and among them, the brown planthopper (BPH), *Nilaparvata lugens* (Stål) (Hemiptera: Delphacidae) is the main constraints to rice production in many parts of Bangladesh. The BPH was formerly a minor pest in Asia but became the most devastating one following the introduction of different insecticides with different mode of action and cultivation of dwarf rice varieties. In recent years, the BPH has become a major problem for rice production in several parts of Bangladesh. BPH is a rice-specific herbivore that causes substantial damage to the rice crop by sucking the phloem sap and blocking the xylem and phloem by laying egg masses in the midrib of the leaf sheath and leaf blade. The damage by BPH spreads in a circular fashion and is technically termed as "hopper burn". The patches of infestation may spread out and cover the entire field. It also acts as a vector of the virus diseases viz. grassy stunt, ragged stunt and wilted stunt (Krishnaiah *et al*., 2002; 2006; 2007) [10, 11, 12].

Modern insecticides research started almost 60 years ago with the chlorinated hydrocarbons, followed shortly by the organophosphates, organ carbamates and nitroguanidines. The main target of these synthetic chemical compounds is the insect nervous system. In the search for safer insecticides technologies, i.e. more selective mode of action and reduced risks for non-target organisms and the environment, progress has been made in the last 20 years with development of natural and synthetic compounds capable of interfering with the processes of growth, development and metamorphosis of the target insects. These chemicals have been called insect growth regulators (IGRs) or third generation insecticides. IGRs differ widely from the commonly used insecticides as they exert their insecticidal effects through their influence on development, metamorphosis and reproduction of the target insects by disrupting the normal activity of the endocrine system.

The most commonly practiced method of controlling brown planthopper in Bangladesh is the application of synthetic insecticides. Uses of synthetic insecticides providing temporary control and furthermore it is evident that the use of broad-spectrum pesticide has almost inevitably been followed by the development of pesticide resistance, pest resurgence and out breaks of secondary pest etc (Luckmann and Metcalf, 1975; Husain, 1993) [13, 8]. Hence, insect growth regulators especially chitin synthesis inhibitor (CSIs) might be potential alternatives of synthetic insecticides to control BPH effectively.

2. Materials and Methods

Location and time of the study

The experiment was conducted in the field laboratory of the Department of Entomology, Bangladesh Agricultural University (BAU), Mymensingh during the period from February to June, 2015.

Experimental design and layout

The experiment was conducted in a Randomized Complete Block Design (RCBD). The experiment consisting of 10 treatments while each of the treatment was replicated thrice. The whole experimental field was divided into 3 equal blocks and each block was then divided into 10 plots. Finally a total of 30 plots were made in the specified area for conducting the experiments. The size of a unit plot was 4.0 m X 2.5 m. Two adjacent unit plots and blocks were separated by 50 cm and 80 cm apart respectively. Plots were allocated randomly and they were separated in such way so thatimpact oftreatments can be quantified.

Procedures of rice cultivation

The experiment was conducted with the rice variety, TN-1 (Taichung Native-1) as this variety is highly susceptible to BPH infestation. Ploughed soil was brought into desirable final tilth by four operations of ploughing and laddering with country plough and also by cross ploughing followed by laddering.

The phosphate, potassium and nitrogenous fertilizers were applied in the experimental plots at the rate of 100, 70 and 135 kg ha^{-1} respectively in the form of Diammonium phosphate (DAP), Muriate of potash (MP) and urea respectively. The entire amount of DAP and MP were broadcasted and incorporated into the soil at final land preparation. Urea at the rate of 135 kg ha^{-1} was applied as top dressing in three installments at 15, 30 and 50 days after transplanting. Except for insecticidal application, all the other agronomic practices were common for all plots and followed as per the recommended package of practices.

Collection and transplantation of seedlings

Seedlings of TN-1 were collected from the farm of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. Collected seedlings were transplanted immediately in the main field on 2nd February, 2015. The plant spacing was followed as 20 cm x 15 cm.

Intercultural operation

Weeding: The crop was infested by different types of weeds. The weeds were controlled by uprooting with hands.

Irrigation: Eight (8) to ten (10) cm water was maintained by irrigation throughout the period of experiment because the test insect, *Nilaparvata lugens* is a water-loving insect. The boarder or boundary of each subplot was so high that irrigated water could not move from one plot to another plot.

Fig 1: [A] Experimental field showing identification tags in different plots,

Fig 1: [B] Treated hills were covered with mosquito net to prevent BPH and natural enemies fromescaping.

Selection of treatments

Two IGR based biopesticides namely, Buprofezin and lufenuron and one synthetic insecticide of neo-nicotinoid were selected to determine the effects of mortality. There were ten treatments including control with three replications for each. The detailed specifications of treatments are presented in the table 1 with their doses, trade name and group.

Table 1: Specification of treatments of the selected insecticides

	Treatments	Active ingredients	Group
T_1	Award 40 SC @ 0.25 ml/L water	Buprofezin	Insect Growth Regulator
T_2	Award 40 SC @ 0.50 ml/L water	Buprofezin	Insect Growth Regulator
T_3	Award 40 SC @ 0.75 ml/L water	Buprofezin	Insect Growth Regulator
T_4	Haron 5 EC @ 0.50 ml/L water	Lufenuron	Insect Growth Regulator
T_5	Haron 5 EC @ 1.00 ml/L water	Lufenuron	Insect Growth Regulator
T_6	Haron 5 EC @ 1.5 ml/L water	Lufenuron	Insect Growth Regulator
T_7	Calypso 280 SC @ 0.50 ml/L water	Thiacloprid	Neo-nicotinoid
T_8	Calypso 280 SC @ 0.75 ml/L water	Thiacloprid	Neo-nicotinoid
T_9	Calypso 280 SC @ 1.00 ml/L water	Thiacloprid	Neo-nicotinoid
T_{10}	Control	-----	-----

Time of spraying and Data collection schedule

All the treatments were applied according to the experimental specifications. Two consecutive sprays were given at 45 and 60 DAT (days after transplantation) with pneumatic knapsack sprayer. Spraying was done in the morning time to avoid bright sun shine. Data were collected on before treatment application and 1, 2, 3, 5 and 7 days after treatment (DAT) application. Data were also collected from untreated control plot.

Data were collected using the following parameters

The mean number of BPH populations per hill was calculated using the following formula:

$$\% \text{ Decrease over control} = \frac{Pc - Pt}{Pc} X\ 100$$

Where,

Pt = Number of BPH populations after treatment application

Pc = Number of BPH populations without treatment application (Control)

Grain yield (t/ha)

$$\% \text{ Yield increase over control} = \frac{Yt - Yc}{Yt} X\ 100$$

Where,

Yt = Yield in treated plot

Yc = Yield in control plot

In case of all parameters [viz. mean number of BPH populations, wolf spiders, carabid beetles per hill, grain yield (t/ha)] data were expressed as the mean of two sprays.

Statistical analysis

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of computer package MSTAT. The mean differences among the treatments were adjudged with Duncan's Multiple Range Test (DMRT) and Least Significant Difference (LSD) when necessary (Gomez and Gomez, 1984) [7].

3. Results and discussion

Field efficacy of different concentrations of Award 40 SC (Buprofezin) on the reduction of BPH populations

Approximately 30 to 33 BPH populations were counted hill^{-1} before treatment application. These numbers were slowly increased when rice plants were left untreated and reached to 42.90 BPH/hill at 7 DAT (Table 2). In contrast with untreated control, BPH populations were significantly reduced when rice plants were sprayed with different concentrations of Award 40 SC ($P<0.01$, Table 2). In case of all doses, BPH populations were decreased gradually with increasing time and reached to the lowest level at 7 DAT. The BPH populations were not reduced significantly within 48 hrs after treatment application in comparison with that in the control. By day 3, the BPH populations were reduced significantly compared to the control, then reduced further with increasing time (by day 5) and reached to the lowest level by day 7 in case of all doses. It was observed that the mortality was clearly dose and time dependent. The lowest numbers of BPH populations (3.73 hill^{-1}, 88.75% mortality) were counted at 7 DAT when rice plants were treated with 0.75 ml/L of Award 40 SC which was followed by 0.50 ml/L (9.41 hill^{-1}, 69.33% mortality) and 0.25 ml/L (17.84 hill^{-1}, 41.52% mortality) respectively. There had significant differences among the doses based on mortality where the highest mortality was recorded from 0.75 ml/L and the lowest was from 0.25 ml/L of Award.

Table 2: Efficacy of different doses of Award 40 SC (Buprofezin) on the reduction of BPH populations in field condition

Treatment	Pre-treated populations (No.)	Mean number of BPH populations per hill at different DAT				
		1 DAT	2 DAT	3 DAT	5 DAT	7 DAT
Award 40 SC @ 0.25 ml/L	30.51	29.81	28.92	22.16b	18.37b	17.84b
Award 40 SC @ 0.50 ml/L	30.69	30.04	28.75	18.21bc	12.09c	9.41c
Award 40 SC @ 0.75 ml/L	33.15	32.52	31.17	14.12c	4.76d	3.73d
Control	31.28	31.69	32.98	35.71a	40.90a	42.90a
P-level	NS	NS	NS	0.01	0.01	0.01
CV%	2.77	1.85	2.19	12.95	6.47	6.86
SE (±)	0.60	0.65	1.22	4.68	7.80	8.64

In a column, means of similar letter (s) do not differ significantly. DAT = Days After Treatment, NS = Not Significant, P-level = Probability Level, CV = Co-efficient of Variation, SE = Standard Error.

Field efficacy of different concentrations of Haron 5 EC (Lufenuron) on the reduction of BPH populations

Approximately 29 to 30 BPH populations were counted hill^{-1} before treatment application. These numbers were slowly increased when rice plants were left untreated and reached to 42.90 BPH/hill at 7 DAT (Table 3). In contrast with untreated control, BPH populations were significantly reduced when rice plants were sprayed with different concentrations of Haron 5 EC ($P<0.01$, Table 3). In case of all doses, BPH populations were decreased gradually with increasing time and reached to the lowest level at 7 DAT. The BPH populations were not reduced significantly within 48 hrs after treatment application in comparison with that in the control. By day 3, the BPH populations were reduced significantly compared to the control, then reduced further with increasing time (by day 5) and reached to the lowest level by day 7 in case of all doses. It was observed that the mortality was clearly dose and time dependent. The lowest numbers of BPH populations (5.32 hill^{-1}, 82.27% mortality) were counted at 7 DAT when rice plants were treated with 1.50 ml/L of Haron 5 EC which was followed by 1.00 ml/L (7.28 hill^{-1}, 75.03% mortality) and 0.50 ml/L (18.33 hill^{-1}, 38.78% mortality) respectively. There had insignificant difference between the doses 1.50 and 1.00 ml/L, while these doses were significantly differed with 0.50 ml/L of Haron.

In the present study, it was found that both IGRs were found highly effective against BPH although Award 40 SC (Buprofezin) provided slightly higher mortality (about 90%) than Haron 5 EC (about 82%) at 7 DAT with their highest doses. Moreover, both of the IGRs had no any acute action on BPH as mortality was raised to significant level after 3 days of treatment application. Therefore, it has been confirmed that at least 3 days required to get significant level of mortality from IGRs (especially chitin synthesis inhibitor) which was absolutely fitted with IGRs mode of action.

Table 3: Efficacy of different doses of Haron 5 EC (Lufenuron) on the reduction of BPH populations in field condition

Treatment	Pre-treated populations (No.)	Mean number of BPH populations per hill at different DAT				
		1 DAT	2 DAT	3 DAT	5 DAT	7 DAT
Haron 5 EC @ 0.50 ml/L	29.94	29.75	29.29	22.50b	19.11b	18.33b
Haron 5 EC @ 1.00 ml/L	29.15	28.83	28.08	14.20c	8.69c	7.28c
Haron 5 EC @ 1.50 ml/L	30.00	29.56	28.43	13.61c	6.94c	5.32c
Control	31.95	31.69	32.98	35.71a	40.90a	42.90a
P-level	NS	NS	NS	0.01	0.01	0.01
CV%	0.98	1.19	2.72	16.27	7.53	9.89
SE (±)	0.44	0.61	1.37	5.15	7.81	8.64

In a column, means of similar letter (s) do not differ significantly. DAT = Days After Treatment, NS =Not Significant, P-level = Probability Level, CV = Co-efficient of Variation, SE = Standard Error.

Efficacy of different concentrations of Calypso 280 SC (Thiacloprid) on the reduction of BPH populations

Calypso 280 SC had significant effect on the mortality of BPH in comparison with that in the control (P<0.01, Table 4). The lowest numbers of BPH populations (5.13 hill^{-1}, 82.42% mortality) were counted at 7 DAT when rice plants were treated with 1.00 ml/L of Calypso 5 EC which was followed by 0.75 ml/L (5.87 hill^{-1}, 79.67% mortality) and 0.50 ml/L (11.13 hill^{-1}, 60.63% mortality) respectively. There had no significant difference between the dose 1.0 and 0.75 ml/L based on the mortality of BPH. On the other hand, the highest number of BPH populations was counted when rice plants were left untreated (42.90 hill^{-1} at 7 DAT).

In contrast with IGRs, Calypso @ 1.00 ml/L has provided the faster mortality of BPH as approximately 50% of BPH were died at 1 DAT which was gradually increased with time and reached to the peak level by day 3 (4.12 BPH hill^{-1}, 85.88% mortality), persisted at least up to day 5 (4.09 BPH hill^{-1}, 85.98% mortality) while slightly increased from day 7 (5.13 BPH hill^{-1}, 82.42% mortality). This result was followed by 0.75 ml/L (5.33 BPH Hill^{-1}, 81.54% mortality) and 0.50 ml/L (10.13 BPH hill^{-1}, 64.17% mortality) of Calypso respectively at 3 DAT. This finding was fitted with the mode of action of neo-nicotinoid insecticides where the Calypso molecules involve with the disruption of the insect's nervous system by stimulating nicotinic acetylcholine receptors. Therefore, the acetylcholine molecules accumulate in the synaptic gap and insects die quickly due to continuous tremor and convulsion. On the contrary, IGRs are not neurotoxic, they prevent moulting process by inhibiting chitin bio-synthesis and this process required at least 2 days.

Table 4: Efficacy of different doses of Calypso 280 SC (Thiacloprid) on the reduction of BPH populations in field condition

Treatment	Pre-treated populations (No.)	Mean number of BPH populations per hill at different DAT				
		1 DAT	2 DAT	3 DAT	5 DAT	7 DAT
Calypso 280 SC @ 0.50 ml/L	28.27	16.89b	15.64b	10.13b	9.79b	11.13b
Calypso 280 SC @ 0.75 ml/L	28.88	15.11b	12.73b	5.33c	4.87c	5.87c
Calypso 280 SC @ 1.00 ml/L	29.18	14.14b	11.89b	4.12c	4.09c	5.13c
Control	31.28	31.69a	33.98a	35.71a	40.90a	42.90a
P-level	NS	0.01	0.01	0.01	0.01	0.01
CV%	2.36	12.68	15.85	14.58	6.82	11.22
SE (±)	0.65	4.12	5.20	7.41	8.78	8.98

In a column, means of similar letter (s) do not differ significantly. DAT = Days After Treatment, NS = Not Significant, P-level = Probability Level, CV = Co-efficient of Variation, SE = Standard Error.

Percent reduction of BPH populations over control treated with different treatments

Approximately 91.31% of BPH populations reduced over control when rice plants were treated with 0.75 ml/L of Award 40 SC which was closely followed by Calypso 280 SC @ 1.00 ml/L (88.04%) and Haron 5 EC @ 1.50 ml/L (87.6%) respectively. The lowest reduction was observed from the lowest doses of each selected treatments (Fig. 1)

Shivashankar and Gowda (2015) [15] also supported that Buprofezin 25 SC @ 200 g a.i./ha was more effective after 3 days up to the 14 days in reducing BPH, followed by Thiamethoxam 25 WG @ 25 g a.i./ha and Imidacloprid 200 SL @ 25 g a.i./ha.

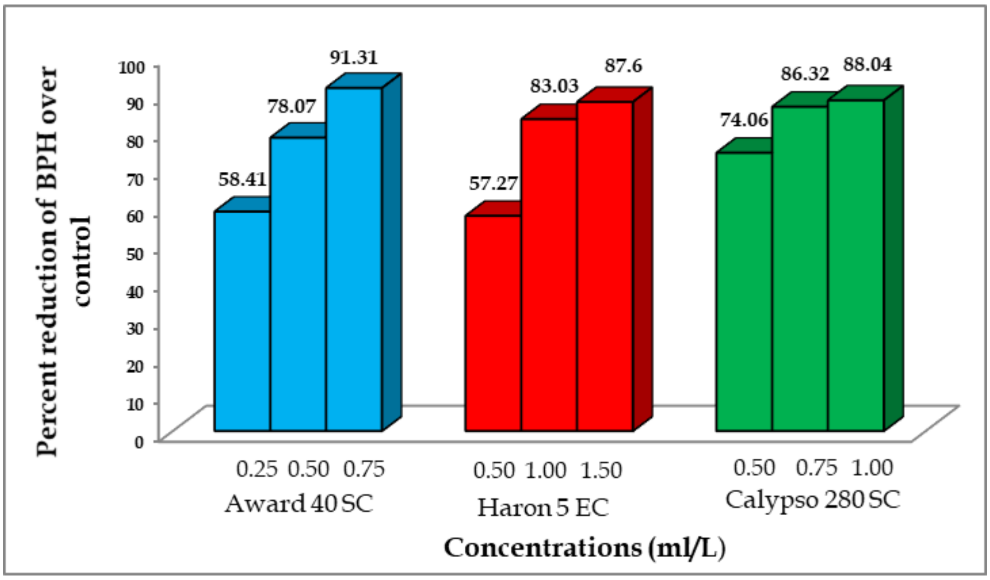

Fig 1: Percent reduction of BPH populations over control when rice plants were treated with different concentrations of Award 40 SC, Haron 5 EC and Calypso 280 SC.

Field efficacy of different treatments on the yield of rice grain

The yield of rice grain was varied due to the application of different treatments. The variation was observed in treated plots in comparison with that of untreated plots. The lowest grain yield (3.25 t/ha) was obtained from untreated control plot but grain yield was increased significantly (P<0.01, Fig. 2) when rice plants were treated with Award 40 SC, Haron 5 EC and Calypso 280 SC. The yield response was clearly dose-dependent. The highest yield (4.8 t/ha) was found from the treatment Award 40 SC @ 0.75 ml/Land this treatment has provided 32.29% yield increase over control (Figs. 2 & 3). This was followed by Haron 5 EC @ 1.5 ml/L (4.72 t/ha, 31.14% yield increased over control) and Calypso 280 SC (4.71 t/ha, yield increased 31.00%) respectively. This result suggests that the grain yield was very close to each other when rice plants were treated with their highest doses of 3 selected pesticides. The similar trend of grain yield was obtained when rice plants were treated with medium doses of Award, Haron or Calypso (Figs. 2 & 3). The lowest doses of selected pesticides has provided the minimum grain yield (3.99, 3.91 and 4.06 t/ha from Award 40 SC @ 0.25ml/L, Haron 5 EC @ 0.50 ml/L and Calypso 280 SC @ 0.50 ml/L respectively) compared to their medium and maximum doses. Although the treatment Calypso 280 SC @ 1.00 ml/L has provided 4.71 t/ha grain yield which was differed insignificantly with the yield of Award 40 SC and Haron 5 EC but Calypso 280 SC may not be suggested because of its adverse effects on the natural enemies in rice-ecosystem. Therefore, considering all the parameters studied, it has been suggested that the IGRs Award 40 SC (Buprofezin) and Haron 5 EC (Lufenuron) might be effective and potent alternatives of chemical insecticides for controlling rice brown planthopper.

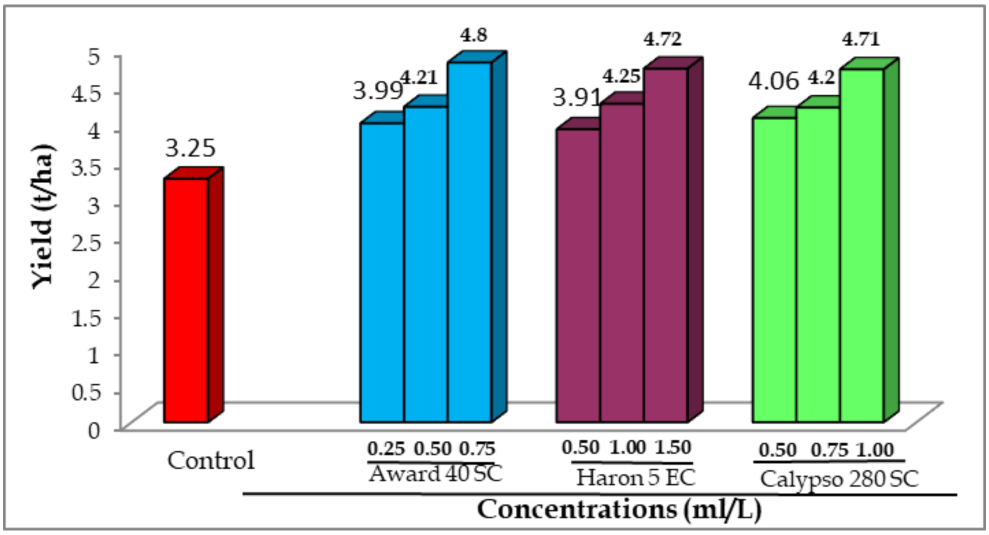

Fig 2: Yield of rice grain following treated with biopesticides and chemical insecticide

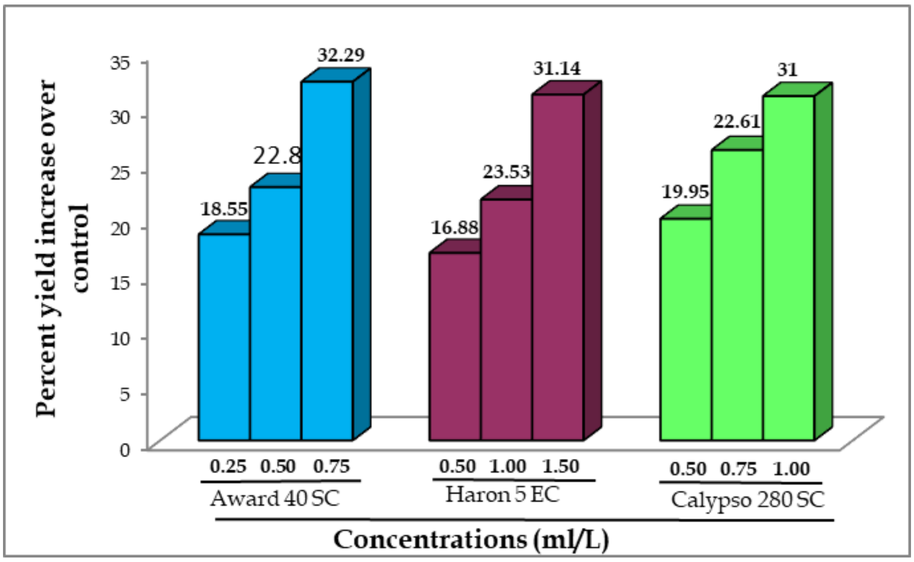

Fig 3: Percent yield increase over control when rice field was treated with biopesticides and chemical insecticide.

4. Conclusion

Considering all the parameters studied, Award 40 SC @ 0.75 ml/L (Buprofezin) can be used effectively as it provided about 90% mortality of BPH and contributed highest grain yield. Alternatively, farmers can choose another IGR i.e. Haron 5 EC (Lufenuron) considering its efficacy on the reduction of BPH populations (82.27% mortality). Calypso 280 SC was found effective on the reduction of BPH populations as well as increasing grain yield but its uses would not be judicious against BPH considering the adverse effects on environmental components. Therefore, it has been concluded that the IGRs Award 40 SC (Buprofezin) and Haron 5 EC (Lufenuron) might be effective and potent alternatives of chemical insecticides for controlling rice brown planthopper.

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