Journal of Entomology and Zoology Studies
Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(5): 714-719

Received: 10-07-2018
Accepted: 12-08-2018

VVL Renuka
Department of Entomology, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, India

Arundhati Sasmal
Regional Research and Technology Transfer Station (Coastal zone), Bhubaneswar, Odisha, India

Correspondence
VVL Renuka
Department of Entomology, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, India

Evaluation of efficacy and economics of certain bio-intensive and chemo-intensive management modules against stem borer of rice

VVL Renuka and Arundhati Sasmal

Abstract
A field trial was conducted for two consecutive *kharif* seasons of 2016 and 2017 to evaluate the efficacy of certain bio-intensive and chemo-intensive modules against stem borer of rice at Regional Research and Technology Transfer Station, Orissa University of Agriculture & Technology, Bhubaneswar, Odisha, India. The treatment module consisting of Nursery treatment (NT) with fipronil 0.3G@20kg/ha + chlorantraniliprole 0.4G@10kg/ha at 40 DAT + buprofezin 25% SC @825ml/ha at 65DAT proved to be most effective in controlling the stem borer recorded 5.32% dead heart (DH) and 2.67% white ear head (WEH), with highest grain yield (58.5 q/ha), highest net profit (Rs 18267/-) and highest incremental benefit cost ratio (5.85) clearly proved to be the best option for stem borer management. Two bio-intensive management modules comprising of 'NT + *T. japonicum* + *B. bassiana* @2 lt/ha at 30 & 50 DAT+ NSKE 5% at 65DAT' and 'NT + *T. japonicum* + Bt spray@1kg/ha at 30 and 50 DAT + neem oil (1500ppm) spray @1.5lt/ha at 65 DAT' were found to be statistically at par and stood to be the next best treatment by reducing the stem borer damage during both vegetative and reproductive stages. The bio-intensive management modules showed their eco-friendly attributes towards beneficial insects.

Keywords: Bio-intensive, chemo-intensive, stem borer, rice

1. Introduction

Rice is the most important staple food crop grown in the world particularly of Asia. It is the basic food for about 65% of people in India. It has a major role in India's diet and it is very crucial to food security. Rice being the tropical crop, it comfortably grows in the hot humid climate of India. National Economy of India is greatly governed by rice production. India is the 2nd largest producer of rice in the world. Worldwide rice production estimate is about 484 Million tons and India produces 114 Million tons [1]. However loss in yield is caused due to various biotic and abiotic factors of the environment. Among them pest and diseases are responsible for about 37% of yield loss in rice [2]. They are the major threat to the crop productivity. There are many different insect pests that attack the rice crop in different stages of its growth period. Among them the stem borer is considered as the major constraint that is responsible for the deterioration of rice yield in form of dead hearts and white ear heads. The symptoms of damage are seen in both vegetative stage (dead heart) and reproductive stage (white ear head). The incidence of stem borer starts from July and remains to be mild till September but it gets intensified from October to December. The larva after hatching enters into the stem and starts to feed on the growing shoot as a result of which the central shoot dries and results in the form of dead heart, the characteristic symptom of stem borer. The tillers are the effected parts of the crop. When the infestation occurs during heading stage the grains become chaffy and are called as white ear heads. Keeping the view of the above, present investigation has been made in *Kharif* 2016 and *Kharif* 2017 to evaluate the efficacy and economics of certain bio intensive and chemo intensive management modules against stem borer of rice and and their effect on natural enemies of the pest.

2. Materials and Methods

Field studies were conducted during *Kharif* seasons of 2016 and 2017 in a Randomized block design with four replications and six treatments at Regional Research and Technology Transfer Station of OUAT, Bhubaneswar, Odisha. The experiment has evaluated the efficacy of various bio-intensive and chemo-intensive modules against stem borer and also the natural enemy population in rice ecosystem. Two nursery beds of (22mX1m) size were prepared. One nursery bed was treated with fipronil 0.3G@20kg/ha at 20 days after sowing. Another nursery bed was kept untreated. Pooja, a long duration variety of 150 days was planted with row to row and plant to plant spacing of 20cm x 15cm respectively in plots of size 40m^2. The modules experimented include: M1: Nursery treatment (NT) with fipronil 0.3G@20kg/ha + pheromone trap (PT) @5/ha for monitoring of yellow stem borer + release of *Trichogramma japonicum* @50000/ha six times at weekly intervals started after moth catch in pheromone trap+ Bt spray @1kg/ha during evening hours at 30 and 50 days after transplanting (DAT) + neem oil (1500 ppm) spray @1.5l/ha at 65DAT. M2: Nursery treatment (NT) with fipronil 0.3G@20kg/ha + pheromone trap(PT) @5/ha for monitoring of yellow stem borer + release of *Trichogramma japonicum* @ 50000/ha six times at weekly intervals started after moth catch in pheromone trap + *Beauveria bassiana* spray @ 2lt/ha at 30 and 50 days after transplanting (DAT) + Spray of Neem seed kernel extract (NSKE) @5% at 65DAT. M3: Nursery treatment (NT) with fipronil 0.3G@20kg/ha + pheromone trap(PT) @5/ha for monitoring of yellow stem borer + release of *Trichogramma japonicum* @ 50000/ha six times at weekly intervals started after moth catch in pheromone trap + spraying of neem oil 0.15%(1500 ppm) @ 1.5l/ha at 30 and 50 DAT + soil application of neem leaf powder @12 kg/ha at 65 DAT. M4: Nursery treatment (NT) with fipronil 0.3G@20kg/ha + application of chlorantraniliprole 0.4 G @10kg/ha at 40 DAT + spray of buprofezin 25% SC @825ml/ha at 65DAT. M5: Farmers practice which includes the spraying of (Triazophos 35 EC + Deltamethrin 1%) spray@ 1 lt/ha at 30 and 50 DAT + thiamethoxam spray @ 150gm/ha at 65 DAT. M6: Untreated control. Ten plants in each treatment plot of each replication were randomly selected for observations

Method of observations

The recording of the observations commenced from 30 DAT and continued at 7 days interval. The total number of tillers and number of dead hearts (DH) were counted in ten randomly selected hills of each treatment plot of each replication. The conversion to percentage of infestation was calculated by the following formula. The mean dead heart per cent was calculated by making average of all the observations.

$$\text{Percentage of dead heart (\%DH)} = \frac{\text{Total number of dead hearts in 10 hills}}{\text{Total number of tillers in 10 hills.}}$$

At reproductive stage total panicle bearing tillers and borer infested ones (White ear head), were recorded in ten randomly selected hills. The data obtained was converted to the percentage of white ear head in different treatments.

$$\text{Percentage of white ear head (\%WEH)} = \frac{\text{Total number of white ear heads in 10 hills}}{\text{Total number of tillers in 10 hills.}}$$

Natural enemy

The number of natural enemies' viz. spiders were counted from 10 randomly selected hills per each treatment plot of each replication. Then the number of spiders per hill was calculated. The recording of the observations commenced from 30 DAT and continued at 7 days interval. The mean population was calculated by making average of all the observations.

Statistical analysis

The weekly data was collected and the average of those observations was found out and the data so obtained for various insect counts and their damage symptoms were subjected to square root transformation and were analyzed following procedures by Gomez and Gomez (1984). The treatment variations were tested for significance by 'F' test. The standard error of means SE (m) ± and critical differences (CD) at 5% level of significance were calculated following the standard procedure and treatment means were compared using critical differences (CD). Pooled mean analysis was done considering both the seasons. Based on the statistically analyzed data, the results of the investigation have been interpreted and conclusion has been drawn.

3. Results and Discussion

3.1 Dead heart

The results of the experiments conducted during *Kharif* 2016 and *Kharif* 2017 are summarized in the Table 1. According to the observations recorded before spray treatments where nursery treated with fipronil showed lesser incidence of stem borer compared to the untreated plots. The incidence in fipronil treated plots ranged from 11.45 to 11.82 and 13.06 to 13.27% DH in 2016 and 2017 respectively. Fipronil belongs to phenyl pyrazole group which enhances resistance against stem borer in nursery stage because of which comparatively less dead hearts were found in fipronil treated plots as against untreated plots before 30 DAT. This is corroborated by Dash and Mukherjee (2003) who found that fipronil a new granular insecticide @ 0.075 kg a.i./ha gave maximum protection against stem borer [3]. The stem borer incidence during the pretreatment period varies from 11.45 to 12.52% DH in 2016 and 13.06 to 15.45%DH in 2017. First spray was given after 30 DAT when the ETL of stem borer was crossed. In *Kharif* 2016, according to the mean data of 7 and14 days after the first spray, the treatment module M4(NT + chlorantraniliprole 0.4G@10kg/ha at 40 DAT buprofezin 25% SC @825ml/ha at 65DAT) recorded the lowest per cent of dead heart with 7.23%DH as against untreated control with 17.26%DH and is at par with M2(NT + *T. japonicum* +*B. bassiana* @2lt/ha at 30&50 DAT+ NSKE (5%) at 65DAT) with 7.32% DH and M1 with 8.24% DH. The mean after second spray proved M4 to be superior with 3.46% DH as against untreated control with 19.66% DH. It was followed by M5 with 6.51% DH which is at par with M1 with 8.20%DH. Mean of the first and second sprays show that M4 is superior to all other treatments which is followed by M1, M2 and M5 which are at par with each others. This is in line with the findings of Panda *et al* (2014) who stated that chlorantraniliprole at 40 g a.i./ha is the best treatment against rice stem borer, environmental safety and grain yield [4]. During *Kharif* 2017, mean of observations after 1st spray show that M4 accounts the least% of DH (6.58% DH). M1 (NT + *T. japonicum* + Bt spray@1kg/ha at 30 and 50 DAT + neem oil (1500ppm) @1.5l/ha at 65 DAT) with 8.94%DH and M2 (NT + *T. japonicum* +*B. bassiana* @2lt/ha at 30&50 DAT+ NSKE (5%) at 65DAT) with 9.17%DH were the next best treatments in controlling the stem borer. According to Sharma *et al.*(2014) Neemazal 1% @ 1000, Dipel WP @ 2.0 kg/ha, *Karanja* oil 2.0% and Myco-Jaal 10% SC @ 2.0 litre per ha significantly reduced the incidence, dead hearts and white ear heads and also increased grain yields [5]. The mean after 2nd spray follows the same trend in reducing the stem borer damage. The mean of 1st and 2nd sprays indicate that M4 is best with 5.29% DH followed by M1 and M2 with 7.88% and 8.11% DH respectively.

The pooled mean of both the *kharif* seasons clearly depicts that M4 had the minimum dead heart damage with 5.32%DH (Table 1). According to Omprakash *et al*. (2017) chlorantraniliprole 0.4G was most effective in controlling the rice stem borer damage during both vegetative and reproductive stage due to its novel mode of action, which is in agreement with present findings [6]. The bio- intensive modules M1 and M2 were proved to be the next best modules for controlling the stem borer which is in line with the findings of Farzad Majidi-Shilsar (2017) who reported that *B. bassiana* was the most pathogenic to the immature stages of stem borer and also reduced percentage egg hatching of yellow rice stem borer [7]. Highest percentage reduction in dead heart (DH) over untreated control was recorded in Module 4 (M4) (69%) followed by Module 1(M1) (54%) and Module 2(M2) (51%) as is seen in Figure 1.

3.2 White ear head

The per cent white ear head damage was computed by dividing the total number of white ear heads by the total number of tillers per 10 hills. During *Kharif* 2016, module 4 (M4), (Nursery treatment (NT) with fipronil 0.3G@20kg/ha + chlorantraniliprole 0.4G@10kg/ha at 40 DAT + buprofezin 25% SC @825ml/ha at 65DAT) recorded lowest percentage of white ear head (1.65% WEH) as compared to 16.81% WEH found in untreated control plot (Module 6). Module 2 (M2) (NT + *T. japonicum* + *B. bassiana* @2 lt/ha at 30&50 DAT+ NSKE (5%) at 65DAT) which recorded 5.21% WEH which is at par with Module 1 (M1) (NT + *T. japonicum* + Bt spray@1kg/ha at 30 and 50 DAT + Neem oil (1500ppm) @1.5l/ha at 65 DAT) which recorded 5.56%WEH.

During *Kharif*, 2017, module 4(M4), (Nursery treatment (NT) with fipronil 0.3G@20kg/ha + chlorantraniliprole 0.4G@10kg/ha at 40 DAT + buprofezin 25% SC @825ml/ha at 65DAT) recorded lowest percentage of white ear head (3.69% WEH) as compared to 19.59% WEH found in untreated control plot (module 6). The present finding is in accordance with Sarao *et al*. (2014) who reported that chlorantraniliprole (Ferterra @ 40 and 50 g a.i/ ha) was significantly better than other treatments in reducing white ear heads incidence [8]. The Module 1(M1) (NT + *T. japonicum* + Bt spray@1kg/ha at 30 and 50 DAT + neem oil (1500ppm) @1.5l/ha at 65 DAT) recorded 8.38%WEH which is found to be statistically at par with Module 2 (M2) (NT + *T. japonicum* + *B. bassiana* @2 lt/ha at 30&50 DAT+ NSKE (5%) at 65DAT) where 8.54% WEH was recorded.

The pooled mean of both the seasons shows that Module 4 (M4), (Nursery treatment (NT) with fipronil 0.3G@20kg/ha + chlorantraniliprole 0.4G@10kg/ha at 40 DAT + buprofezin 25% SC @825ml/ha at 65DAT) was proved to be best in controlling the stem borer attack at heading stage which recorded only 2.67% WEH (Table 2). The Module 2 (M2) (NT + *T. japonicum* + *B. bassiana* @2 lt/ha at 30&50 DAT+ NSKE (5%) at 65DAT) with 6.88%WEH was found to be statistically at par with module 1 (M1) (NT + *T. japonicum* + Bt spray@1kg/ha at 30 and 50 DAT + neem oil (1500ppm) @1.5l/ha at 65 DAT) with 6.97%WEH. Both the bio intensive modules (Module 1 and module 2) could reduce the white ear head damage next to module 4 is corroborate with the statement by Aswal *et al.* (2010) who reported that *B. thuringiensis* was highly effective against yellow stem borer [9]. Highest percentage reduction in white ear head (WEH) over untreated control was recorded in Module 4 (M4) (85%) followed by Module 2 (M2) (62%). Lowest percent reduction in white ear head (37%) was noticed in Module 3 (Figure 2)

3.3 Spiders

During *kharif*, 2016, significant difference was found between treatment modules and untreated control plot. The population ranged from 0.17 to 1.35spiders/hill in different treatment modules. The highest population (1.35 spiders/hill) was recorded in Module 3(M3) (NT + *T. japonicum* + neem oil (1500ppm)@1.5l/ha at 30 and 50 DAT + neem leaf powder @12kg/ha at 65DAT) compared to 1.48spiders/hill in untreated control plot. This is in agreement with Singh *et al.* (2008) who conducted field study on combination of botanicals with egg parasitoid *Trichogramma japonicum* resulting in reduced populations of stem borer as well as resulted in conservation of spider population compared to insecticidal treatments [10]. Module 1(M1) (NT + *T. japonicum* + Bt spray@1kg/ha at 30 and 50 DAT + neem oil (1500ppm) @1.5lt/ha at 65 DAT) with 0.96 spiders/hill at par with Module 4 (M4), (Nursery treatment (NT) with fipronil 0.3G@20kg/ha + chlorantraniliprole 0.4G@10kg/ha at 40 DAT + buprofezin 25% SC @825ml/ha at 65DAT) where 0.89 spiders/hill was noticed.

During *kharif*, 2017 though population of spiders was higher than *kharif*, 2016 still similar trend was noticed. The highest number was found in Module 3 (M3) (NT + *T. japonicum* + neem oil (1500ppm)@1.5lt/ha at 30 and 50 DAT + neem leaf powder @12kg/ha at 65DAT) with 2.59 spiders/hill as compared to untreated control with 3.06 spiders/hill. This result corroborates with Ogah *et al.* (2011) who stated that the presence of almost the same number of natural enemies on neem seed extracts treated and untreated plots indicates that this biopesticide is nontoxic to beneficial insects [11]. The clear superiority was shown in bio intensive modules recording 2.32 spiders/hill in Module 1 M1) (NT + *T. japonicum* + Bt spray@1kg/ha at 30 and 50 DAT + neem oil (1500ppm) @1.5l/ha at 65 DAT) and 2.18 spiders/hill in Module 2 (M2) (NT + *T. japonicum* + *B. bassiana* @2 lt/ha at 30&50 DAT+ NSKE (5%) at 65DAT). As such Singh *et al*. (2008) also stated the safety of Bt (*Bacillus thuriengenesis*) and *Beauveria bassiana* in conserving spider population [10].

The pooled mean of both seasons shows that module 3 was proved to be safe and best for natural enemies population build up which recorded 1.97 spiders/hill which was followed by Module 1 (1.64 spiders/hill) and Module 2 with 1.40 spiders /hill. Module 4 had registered 0.96spiders/hill which is significantly inferior to Module 1, Module 2 and Module 3. Only 0.21spiders/hill was recorded in Module 5 which clearly indicates that chemical pesticides are harmful to natural enemies (Table-2). The reduction in spider population over both the seasons was found to be minimum (13%) in Module 3 (M3). Other two bio intensive modules (M1 and M2) has shown their friendliness with the natural enemies by registering 28% to 38% reduction in spider population as compared to 91% reduction in Module 5 (Figure 3).

3.4 Yield

During first season of experiment (*kharif*, 2016), Module 4 (M4), (Nursery treatment (NT) with fipronil 0.3G@20kg/ha + chlorantraniliprole 0.4G@10kg/ha at 40 DAT + buprofezin 25% SC @825ml/ha at 65DAT) achieved highest grain yield (57.10q/ha) which is statistically superior to all other treatments. Module 2 (M2) (NT + *T. japonicum* + *B. bassiana* @2kg/ha at 30&50 DAT+ NSKE (5%) at 65DAT) had

(53.30q/ha) grain yield which is statistically at par with Module 5 (M5) (spray of (Triazophos 35 EC + Deltamethrin 1%) at 30 and 50 DAT + thiamethoxam 25WG spray @150gm/ha at 65DAT) (51.70q/ha). Module 1(M1) (NT + *T. japonicum* + Bt spray@1kg/ha at 30 and 50 DAT + neem oil (1500ppm) @1.5l/ha at 65 DAT) recorded 50.60 q/ha yield. During *kharif*, 2017, same trend was found where grain yield in Module 4 (M4), (Nursery treatment (NT) with fipronil 0.3G@20kg/ha + chlorantraniliprole 0.4G@10kg/ha at 40 DAT + buprofezin 25% SC @825ml/ha at 65DAT) was 59.80 q/ha which is statistically superior to all other treatments. The next best grain yield (56.30q /ha) was observed in module 2 (M2) (NT + *T. japonicum* + *B. bassiana* @2 lt/ha at 30&50 DAT+ NSKE (5%) at 65DAT). Module 1(M1) (NT + *T. japonicum* + Bt spray@1kg/ha at 30 and 50 DAT + neem oil (1500ppm) @1.5lt/ha at 65 DAT) recorded 53.10q/ha which is statistically at par with Module 5 (M5) (spray of (Triazophos 35 EC + Deltamethrin 1%) at 30 and 50 DAT + thiamethoxam 25WG spray @150gm/ha at 65DAT) (51.80q/ha).

The pooled mean of both the seasons shows that Module 4 (Nursery treatment (NT) with fipronil 0.3G@20kg/ha + chlorantraniliprole 0.4G@10kg/ha at 40 DAT + buprofezin 25% SC @825ml/ha at 65DAT) recorded highest grain yield (58.50q/ha). Among the bio intensive modules; Module 2 (M2) (NT + *T. japonicum* + *B. bassiana* @2 lt/ha at 30&50 DAT+ NSKE (5%) at 65DAT) recorded highest grain yield (54.80 q/ha). Module 1 (M1) (NT + *T. japonicum* + Bt spray@1kg/ha at 30 and 50 DAT + neem oil (1500ppm) @1.5lt/ha at 65 DAT) had 51.90q/ha which is statistically at par with Module 5 (M5) (spray of (Triazophos 35 EC + Deltamethrin 1%) at 30 and 50 DAT + thiamethoxam 25WG spray @150gm/ha at 65DAT) where 51.80q/ha was recorded. The highest per cent improvement in yield over untreated control was observed in module 4 (31%) followed by module 2 (23%) and module 1 (16%) over untreated control (Figure 4).

3.5 Economics of Treatment modules

Comparative economics of treatment modules has been presented in Table 3**.** Module 4 (Nursery treatment (NT) with fipronil 0.3G@20kg/ha + chlorantraniliprole 0.4G@10kg/ha at 40 DAT + buprofezin 25% SC @825ml/ha at 65DAT) achieved highest additional grain yield (13.80q/ha) over untreated control followed by Module 2 (NT + *T. japonicum* + *B. bassiana* @2lt /ha at 30 & 50 DAT+ NSKE (5%) at 65DAT) where 10.10q/ha additional grain yield was obtained. Module 1 (NT + *T. japonicum* + Bt spray@1kg/ha at 30 and 50 DAT + neem oil (1500ppm) @1.5lt /ha at 65 DAT) had registered 7.20q/ha additional grain yield where as Module 5 had 7.10q/ha extra yield. Additional income generated from this grain yield was maximum in Module 4 (Rs 21,390/ha) followed by Module 2 (Rs 15655/ha), Module 1(Rs11160/ha), Module 5 (Rs 11005/ha) and Module 3 (Rs5890/ha). Highest net profit (Rs18267/ha) was achieved by Module 4(Nursery treatment (NT) with fipronil 0.3G@20kg/ha + chlorantraniliprole 0.4G@10kg/ha at 40 DAT + buprofezin 25% SC @825ml/ha at 65DAT) followed by Module 2 (Rs11690/ha), Module 5 (Rs9125/ha), Module 1 (Rs4660/ha) and Module 3 (Rs3290/ha). The finding on incremental benefit cost for different treatment modules revealed that highest IBCR (5.85: 1.00) was obtained in module 4 followed by Module 5 (4.85:1.00) and among bio intensive modules Module 2 (NT + *T. japonicum* + *B. bassiana* @2lt /ha at 30 & 50 DAT+ NSKE (5%) at 65DAT) recorded higher IBCR (2.95:1.00) which can be considered as economically viable treatment**.** This corroborates with the findings of Sahu (2016) who stated that Chlorantraniliprole being a green label insecticide showed best incremental yield over control which in turn makes it to be an effective component in the IPM by the farmers [12].

Table 1: Stem borer incidence at tillering stage

Treatment No	**Treatment details**	**Dead heart (%) in *Kharif*, 2016 and *Kharif*, 2017**								
		Mean at 29 DAT (Before spray)		**Mean at 37 and 45 DAT(After 1st spray)**		**Mean at 57 and 65 DAT(After 2nd spray)**		**Pooled mean of DH% (After spray)**		
		2016	2017	2016	2017	2016	2017	2016	2017	Mean
M1	NT + *T. japonicum* +Bt spray@1kg/ha at 30 and 50 DAT +neem oil (1500ppm)@1.5lt/ha at 65 DAT.	11.82 (3.51)	13.16 (3.69)	8.24 (2.96)^{a}	8.94 (3.07)^{a}	8.20 (2.95)^{ab}	6.82 (2.70)^{a}	8.22 (2.95)^{a}	7.88 (2.89)^{a}	8.05 (2.92)
M2	NT + *T. japonicum* +*B. bassiana* @2lt/ha At 30&50 DAT+ NSKE (5%) at 65DAT.	11.56 (3.47)	13.23 (3.71)	7.32 (2.79)^{a}	9.17 (3.11)^{ab}	10.20 (3.26)^{b}	7.04 (2.74)^{ab}	8.76 (3.04)^{a}	8.11 (2.93)^{a}	8.44 (2.99)
M3	NT + *T. japonicum* +neem oil (1500ppm)@1.5lt /ha at 30&50 DAT +neem leaf powder @12kg/ha at 65DAT.	11.45 (3.46)	13.06 (3.68)	12.54 (3.61)	12.92 (3.67)	13.15 (3.69)	13.57 (3.75)	12.85 (3.65)	13.25 (3.71)	13.05 (3.68)
M4	NT + chlorantranilip-role 0.4G@10kg/ha At 40 DAT + buprofezin 25% SC @825ml/ha at 65DAT.	11.71 (3.50)	13.27 (3.71)	7.23 (2.78)^{a}	6.58 (2.66)	3.46 (1.99)	4.00 (2.12)	5.35 (2.42)	5.29 (2.41)	5.32 (2.41)
M5	FP(Triazophos 35 EC + Deltamethrin 1%)@ 1 lt/ha at 30 and 50 DAT + thiamethoxam 25WG Spray @150gm/ha At 65DAT.	12.35 (3.59)	15.45 (3.99)	10.28 (3.28)	10.86 (3.37)^{b}	6.51 (2.65)^{a}	7.26 (2.78)^{b}	8.39 (2.98)^{a}	9.06 (3.09)	8.73 (3.04)
M6	Untreated control	12.52 (3.61)	15.12 (3.95)	17.26 (4.22)	16.74 (4.15)	19.66 (4.49)	15.71 (4.03)	18.46 (4.35)	16.23 (4.09)	17.35 (4.22)
	SE(m) ±	0.03	0.02	0.06	0.09	0.12	0.08	0.03	0.08	0.06
	CD(0.05)	0.08	0.07	0.17	0.27	0.36	0.24	0.09	0.24	0.12

Values followed by same letters in each column are statistically not significant. NT= Nursery treatment, FP= Farmers practice*, T. japonicum= Trichogramma japonicum, B. bassiana= Beauveria bassiana*, DAT= Days after Transplanting.

Table 2: Stem borer incidence at panicle stage, population of spiders and yield in different treatment modules.

Treatment no	Treatment details	White ear head (%)			Spiders/hill			Grain Yield (q/ha)		
		2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
M1	NT + *T. japonicum* +Bt spray@1kg/ha at 30 and 50 DAT +neem Oil (1500ppm)@1.5lt/ha At 65 DAT.	5.56 (2.46)[a]	8.38 (2.98)[a]	6.97 (2.72)[a]	0.96 (1.21)[a]	2.32 (1.68)	1.64 (1.44)	50.60	53.10	51.9
M2	NT + *T. japonicum* +*B. Bassiana* @2lt/ha at 30&50 DAT+ NSKE (5%) at 65DAT.	5.21 (2.39)[a]	8.54 (3.01)[a]	6.88 (2.70)[a]	0.62 (1.06)	2.18 (1.64)	1.40 (1.35)	53.30	56.30	54.8
M3	NT + *T. japonicum* +neem oil (1500ppm)@1.5lt /ha at 30&50 DAT +neem leaf Powder @12kg/ha at 65DAT.	10.52 (3.32)	12.57 (3.62)	11.55 (3.47)	1.35 (1.36)	2.59 (1.76)	1.97 (1.56)	47.80	49.1	48.5
M4	NT + chlorantraniliprole 0.4G@10kg/ha At 40 DAT + buprofezin 25% SC @825ml/ha at 65DAT.	1.65 (1.47)	3.69 (2.05)	2.67 (1.76)	0.89 (1.18)[a]	1.03 (1.24)	0.96 (1.21)	57.10	59.80	58.5
M5	FP(Triazophos 35 EC + Deltamethrin 1%) @ 1 lt/ha at 30 and 50 DAT + thiamethoxam 25WG spray @150gm/ha at 65DAT.	8.84 (3.06)	9.76 (3.20)	9.30 (3.13)	0.17 (0.82)	0.25 (0.87)	0.21 (0.84)	51.70	51.8	51.8
M6	Untreated control	16.81 (4.16)	19.59 (4.48)	18.20 (4.32)	1.48 (1.41)	3.06 (1.89)	2.27 (1.65)	44.20	45.20	44.7
	SE(m) ±	0.04	0.01	0.02	0.009	0.01	0.01	0.795	0.733	0.592
	CD(0.05)	0.12	0.03	0.06	0.03	0.03	0.02	2.42	2.23	1.71

Figures in parentheses are √(x+0.5) transformed values.
*Values followed by same letters in each column are statistically not significant.
NT= Nursery treatment, FP= Farmers practice, *T. japonicum*= *Trichogramma japonicum*, *B. bassiana*= *Beauveria bassiana*, DAT= Days after Transplanting.

Table 3: Comparative economics of IPM modules

Module no	Treatment details	Yield (q/ha)	Additional Yield (q/ha)	Additional Income (@Rs1550/q) (Rs /ha)	Cost IPM modules (Rs/ha) of	Net profit (Rs/ha)	Incremental Benefit Cost ratio.
M1	NT + *T. japonicum* +Bt spray@1kg/ha at 30 and 50 DAT +neem oil (1500ppm)@1.5lt/ha At 65 DAT.	51.9	7.20	11160	6500	4660	0.71: 1.00
M2	NT + *T. japonicum* +*B. bassiana* @2lt /ha at 30&50 DAT+ NSKE (5%) at 65DAT.	54.8	10.10	15655	3965	11690	2.95: 1.00
M3	NT + *T. japonicum* +neem oil (1500ppm) @1.5lt /ha at 30&50 DAT +neem leaf powder @12kg/ha at 65DAT.	48.5	3.80	5890	2600	3290	1.27: 1.00
M4	NT + chlorantraniliprole 0.4G@10kg/ha at 40 DAT + buprofezin 25% SC @825ml/ha at 65DAT.	58.5	13.80	21390	3123	18267	5.85: 1.00
M5	FP(Triazophos 35 EC + Deltamethrin 1%)@ 1 lt/ha at 30 and 50 DAT + thiamethoxam 25WG spray @150gm/ha at 65DAT	51.8	7.10	11005	1880	9125	4.85: 1.00
M6	Untreated control	44.7					

NT= Nursery treatment, FP= Farmers practice, *T. japonicum*= *Trichogramma japonicum*, *B. bassiana*= *Beauveria bassiana*, DAT= Days after Transplanting.

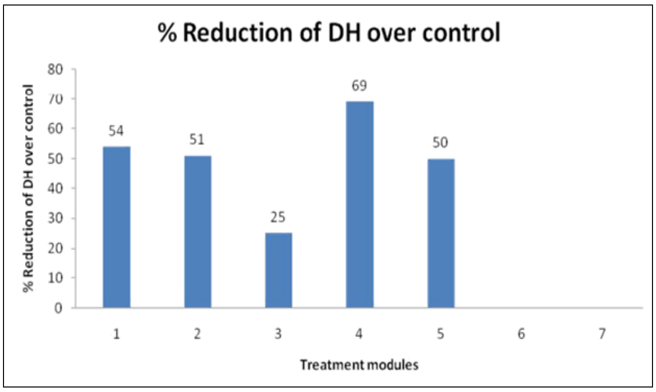

Fig 1: Percent reduction of DH over control

Treatment module	% reduction in white ear head
M1	54
M2	51
M3	25
M4	69
M5	50
M6	

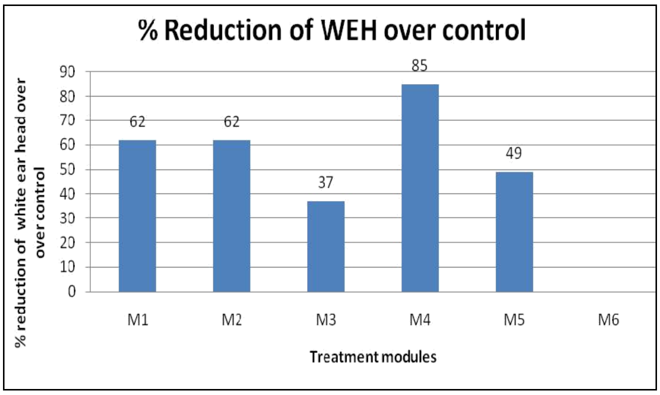

Fig 2: Percent reduction of WEH over control

Treatment module	% reduction in white ear head
M1	62
M2	62
M3	37
M4	85
M5	49
M6	

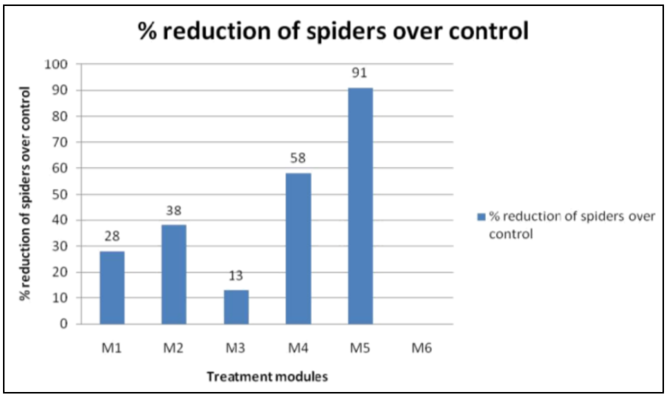

Fig 3: Percent reduction of spiders over control

Treatment	% reduction of spiders over control
M1	28
M2	38
M3	13
M4	58
M5	91
M6	

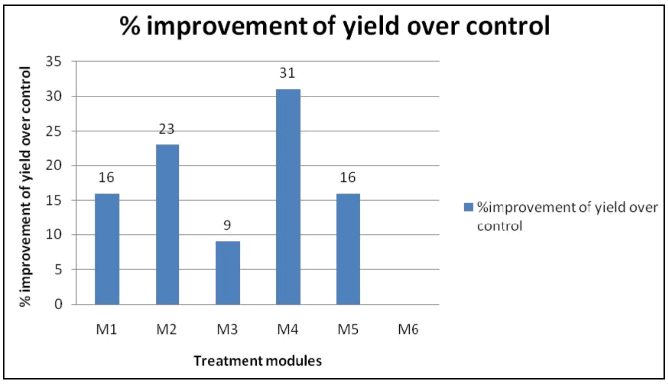

Fig 4: Percent Improvement of Yield over control

Treatment module	%improvement of yield over control
M1	16
M2	23
M3	9
M4	31
M5	16
M6	

4. Conclusion

Based on the result of present investigation it can be concluded that treatment module (Nursery treatment (NT) with fipronil 0.3G@20kg/ha + chlorantraniliprole 0.4G@10kg/ha at 40 DAT + buprofezin 25% SC @825ml/ha at 65DAT) was found to be the best with respect to the stem borer management in rice and grain yield along with the incremental benefit cost ratio. This module includes green label insecticide which makes it compatible to be integrated into the IPM system. The bio-intensive modules (NT + *T. japonicum* + *B. bassiana* @2lt /ha at 30 & 50 DAT+ NSKE (5%) at 65DAT) and (NT + *T. japonicum* + Bt spray@1kg/ha at 30 and 50 DAT + neem oil (1500ppm) @1.5lt /ha at 65 DAT) performed as second best modules in controlling the stem borer damage in rice as well as conserving beneficial insects and maintaining environmental safety and sustainability.

5. Acknowledgement

We gratefully acknowledge Regional Research and Technology Transfer Station (Coastal Zone), Orissa University of Agriculture and Technology (OUAT) for providing required facilities.

6. References

1. Commodity Profile for Rice. http://agricoop.gov.in. March, 2018
2. Rice knowledge bank. http://www.knowledgebank.irri.org
3. Dash AN, Mukherjee SK. Insecticidal control of major insect pests of rice. Pest management and Economic Zoology. 2003; 11(2):147-151
4. Panda SK, Mishra IOP. Field efficacy of granular chlorantraniliprole (E 2Y 45) against rice stem borers in Odisha. Journal of Plant Protection and Environment. 2014; 11(2):107-110.
5. Sharma S, Aggarwal N. Comparing Efficacy of Biopesticides for the Management of Insect Pests in Aromatic Rice under Organic Farming System, Journal of Biological Control. 2014; 28(2):87-92.
6. Omprakash M, Venkataiah M, Laxman S. Comparative efficacy of some new insecticides against rice yellow stem borer, *Scirpophaga incertulas* Walker under field conditions. Journal of Entomology and Zoology Studies. 2017; 5(5):1126-1129
7. Farzad Majidi-Shilsar. Pathogenicity of the Entomopathogenic Fungi *Beauveria bassiana* and *Metarhizium anisopliae* to the Striped Rice Stem Borer, *Chilo suppressalis*. Journal of Agriculture and Veterinary Science. 2017; 4(12):552-55
8. Sarao PS, Kaur H. Efficacy of Ferterra 0.4% GR (chlorantraniliprole) against stem borers and leaffolder insect-pests of basmati rice, Journal of Environmental Biology. 2014; 35:815- 819.
9. Aswal JS, Kumar J, Binita Shah. Evaluation of bio-pesticides and Plant products against rice stem borer and leaffolder. Journal Eco-friendly Agriculture. 2010; 5(1):59-61.
10. Singh S, Prasad CS, Nath L, Tiwari GN. Ecofriendly Management of *Scirpophaga incertulas* (Walk.) and *Cnaphalocrocis medinalis* (Guen.) in Basmati Rice, Annals of Plant Protection Sciences. 2008; 16(1):11-16
11. Ogah OO, Omoloye AA, Nwilene FE, Nwogbaga AC. Effect of Neem Seed Kernel Extracts in the Management of Rice Stem Borers in the Field in Nigeria. Nigerian Journal of Biotechnology. 2011; 23:13-21.
12. Sahu L. Comparative performance of granular and sprayable formulations of newer insecticides in management of insect pests of rice and their impact on soil micro flora. M Sc (Ag.) thesis. Orissa University of Agriculture and Technology, Bhubaneswar.