Evaluation of Various Pest Management Modules Against Rice Yellow Stemborer, *Scirpophaga incertulas* (Walker) (Crambidae: Lepidoptera)

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**ABSTRACT**

**Background:** Globally, rice yellow stem borer alone causes yield losses of 10 m t accounting for 50 per cent of all insecticides usage in the rice field. Farmers depend upon a plenty of insecticide applications, even though a lot of insecticide applications are not effective (Sarwar et al., 2005). The over-reliance on chemicals to manage this pest had lead to numerous undesirable consequences like disrupting natural enemy complexes, secondary pest outbreaks, pest resurgence, development of insecticide resistance and environmental pollution. Keeping in view the deleterious effects of chemical pesticides, there is a need to evaluate alternate methods or integrated methods to manage the rice stem borer effectively with no menace to the ecological niche. Hence, a research trial was conducted to evaluate the efficacy of various pest management modules against rice stem borer in comparison to farmers practice and sole chemical control, besides in concern to yield and cost economics.

**Methods:** The field efficacy of various pest management modules viz., non-chemical based, non-chemical + biorational methods, chemical-based, IPM module and farmers practice against rice yellow stem borer were evaluated during the wet season and dry seasons of 2016 and 2017. The experimental was laid in a net area of 10 m x 20 m each plot laid in Randomized Block Design which comprised of five treatments (modules) with four replications. The incidence of rice yellow stem borer (YSB) in various modules in terms of percent dead hearts (% DH) during tillering stage and percent white ears (%WE) during maturing stage were recorded.

**Result:** It was evident from the pooled mean data that among various modules, the least percent dead hearts (2.68 and 2.56% DH) and white ears (2.79 and 2.31% WE) were registered in IPM based module followed by farmers practice (2.31 and 2.32% dead hearts and 3.92 and 4.77% white ears) and chemical-l based module (2.90 and 4.24% dead hearts and 5.59 and 5.18% white ears) as against highest incidence in non-chemical (13.78 and 13.7% dead hearts; 18.24 and 17.94% white ears) and non-chemical + bio rational (11.40 and 9.88% dead hearts; 13.09 and 11.25% white ears) based modules during the wet season and dry season, respectively.

**Key words:** Dead hearts, IPM modules, Rice, Stem borer, White ears.

**INTRODUCTION**

Rice (*Oryza sativa* L.) is one of the most important staple foods for more than half of the world’s population (IRRI, 2006) influencing the livelihoods and economics of several billion people. Rice cultivation constitutes about 52 per cent of the total food grain production in our country (Kakde and Patel, 2014) and according to the Directorate of Economics and Statistics, Government of India, the area, production and productivity of rice crop for the year 2014-15 was 44.11 m ha🎂, 105.48 m t and 2391 kg ha🎂, respectively. The fourth estimates for the year 2015-16 with respect to rice area was 43.39 m ha🎂, production was 104.32 m t and average yield is 2404 kg ha🎂. In Andhra Pradesh for the year 2015-16, rice crop was cultivated in an area of 2.16 m ha🎂 with a production of 7.49 m t and productivity of 3466 kg ha🎂 (Anon., 2016). The major biotic production constraint for rice is attack by insect pests and the average yield loss by stem borers accounts for 30 per cent, while plant hoppers, gall midge, leaf folder and other pests contribute yield loss of 20, 15, 10 and 25 per cent, respectively (Krishnaiah and Varma, 2015).

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The rice yellow stem borer (YSB), *Scirpophaga incertulas* (Walker) (Crambidae: Lepidoptera) is considered to be the focal and destructive pest resulting in an annual yield loss of 27-34 per cent (Prasad et al., 2007). Globally, YSB alone...
causes yield losses of 10 m t accounting for 50 per cent of all insecticides usage in the rice field (Huesing and English, 2004). The larval feeding of stem borer and their subsequent inter nodal penetration during vegetative and reproductive stages of rice results in characteristic symptom of dead hearts and white ears, respectively (Sherawat et al., 2007). To suppress the pest the farmers depend upon a plenty of insecticide applications, even though a lot of insecticide applications are not effectual (Sarwar et al., 2005). The over-reliance on use of chemicals to manage the rice stem borer may lead to numerous undesirable consequences like disrupting natural enemy complexes, secondary pest outbreaks, pest resurgence, development of insecticide resistance and environmental pollution. Keeping in view the deleterious effects of chemical pesticides, there is a need to evaluate alternate methods or integrated methods to manage the rice stem borer effectively without any menace to the ecological niche. Hence, a research trial was conducted to evaluate the efficacy of various pest management modules against rice stem borer in comparison to farmers practice and sole chemical control, besides in concern to yield and cost economics.

**MATERIALS AND METHODS**

The research studies were conducted at the Agricultural Research Station, Garikapadu, Krishna district andhra Pradesh, India for four successive seasons viz., wet season 2016, dry season 2016-17, wet season 2017 and dry season, 2017-18 to evaluate the efficacy of various pest management modules viz., T1: non-chemical based, T2: non-chemical + biorational methods, T3: chemical-based, T4: IPM module and T5: farmers practice against rice yellow stem borer (Table 1). The experiment was laid in Randomized Block Design which comprised of five treatments (modules) with four replications in a net experimental area of 10 m x 20 m each plot. Judicious fertilizer application and other agronomic practices were employed as per recommendations. Rice variety BPT-5204 which is prone to all pest attacks was used for experimentation and the treatments were imposed as per the modules.

The incidence of rice yellow stem borer (YSB) in various modules in terms of percent dead hearts (%DH) was recorded during the wet season and dry seasons starting from 15 days after transplantation (DAT) to 90 DAT at 15 days interval and the mean of six observations was worked out. Similarly, percent white ears (%WE) was recorded during the wet season and dry seasons starting from 105 to 135 DAT at 15 days interval and the mean of three observations was worked out as per the formulae hereunder.

\[
DH \text{ per cent } = \frac{\text{Total number of dead hearts in 25 hills}}{\text{Total number of tillers in 25 hills}} \times 100
\]

\[
WE \text{ per cent } = \frac{\text{Total number of white ears in 25 hills}}{\text{Total number of panicle bearing tillers in 25 hills}} \times 100
\]

Plot-wise yields were also recorded after removing the two border rows and marked hills from each plot and expressed in kg ha\(^{-1}\). For economic evaluation of various pest management modules the net profit and cost-benefit ratio were also calculated.

**RESULTS AND DISCUSSION**

Efficacy of pest management modules against rice YSB in terms of per cent dead hearts

The various pest management modules (five) were evaluated against rice YSB for four seasons and the results notified that all the modules were significantly different among themselves. The mean incidence of YSB in terms per cent DH during the wet season and dry seasons ranged from 2.26 to 15.58 and 1.58 to 14.00 per cent, respectively.

The mean per cent dead hearts during the vegetative stage of the wet season, 2016 affirmed that, among various modules assessed for efficacy against YSB infesting rice the lowest per cent DH was recorded in T5 (2.33) and is found on par with T2 (2.36) and T3 (2.79). The per cent DH were found above ETL in both non-chemical (T1) and non-chemical + bio rational methods (T4) with 15.58 and 13.51 per cent, respectively. The data on pooled mean per cent dead hearts during the dry season, 2016-17 revealed that among various modules, the order of efficacy in suppressing the stem borer pest load in terms of per cent DH represents T5>T3>T1>T2>T4 with 2.36, 3.54, 4.09, 11.09, 13.99 per cent, respectively. Both the non-chemical and non-chemical + bio rational methods articulated the pest load above ETL. During the wet season, 2017 the pooled results on mean per cent dead hearts due to YSB indicated that the farmers practice, IPM and chemical-based modules were superior and found statistically on par to each other harbouring 2.26, 2.83 and 3.48 per cent DH, respectively. These three modules were superior to T1 (9.23) and T5 (11.98) modules in minimizing the pest infestation. The collective mean of per cent dead hearts during the dry season, 2017-18 indicated that three modules viz., IPM module (1.58), farmers practice (2.28) and chemical-based module (4.39) were found significantly superior to other modules in recording minimum per cent DH. The other two modules viz., non-chemical (8.81) and non-chemical + bio rational (81.87) modules had exhibited increased percent damage over IPM module.

Efficacy of pest management modules against rice YSB in terms of per cent white ears

The characteristic damage symptom of rice yellow stem borer at the reproductive stage i.e., white ears was recorded at 105, 120 and 135 DAT for both the seasons. The mean per cent WE ranged from 2.31 to 18.69 and 1.35 to 18.69 during the wet season and dry seasons, respectively.

During the wet season, 2016 the per cent WE were recorded to be lowest in T4 (IPM module) with 3.23 per cent at 105 DAT and was found on par with T5 and T2 with 3.43 and 3.70 per cent WE, respectively. Similar succession was observed with regards to per cent white ears at 120 and
Chemical-based methods

that among various modules in Farmer’s practice, Non-chemical methods ·
Details of the treatment imposed

Non-chemical methods + Bio-rational methods ·
All non chemical methods (T₁); · Spraying of Beauveria bassiana @ 1.0 Kg ha⁻¹ or Bacillus thuringiensis (Bt) @ 1.0 Kg/ha during 35 and 75 DAT

Chemical-based methods · Application of carbofuran 3G @ 1.0 Kg a.i. ha⁻¹ in nursery 7 day before pulling · Spraying with acephate 75 WP 300 g a.i. ha⁻¹ or cartaphydrochloride 50 SP 400 g a.i. ha⁻¹ at 30, 45, 60 DAT and chlorantiniliprole 18.5 SC 200g a.i. ha⁻¹ at 45, 75, 90 and 110 DAT.

Integrated pest management module · Seed treated with carbendazim 2.5g Kg⁻¹ seed · Balanced application of organic manure (1t FYM ha⁻¹ · Clipping leaf tips before transplantation · Erection of bird perches @ 20 ha⁻¹ and removed at P.I. stage · Installation of pheromone traps @ 20 with 5.0 mg lure ha⁻¹ · Field release of T. japonicum @ 1 lakh ha⁻¹ starting from 15 (DAT) at 7-10 days intervals 5-6 times · Clean cultivation with the retention of some weedy bund-vegetation for the natural enemy propagation · Application of acephate 75 WP 300 g a.i. ha⁻¹ or cartaphydrochloride 50 SP 400 g a.i. ha⁻¹ during tillering stage or chlorantiniliprole 18.5 SC 200g a.i. ha⁻¹ during reproductive stage if the pest crosses the ETL · Summer plough, field sanitation, early and synchronous planting · Mechanical killing of adults and egg mass by clipping leaf tips before transplantation · Erection of bird perches @ 20 ha⁻¹ and removed at panicle initiation stage · Mass trapping with pheromone traps @ 20 with 5.0 mg lure ha⁻¹ · Field release of Trichogramma japonicum @ 1 lakh ha⁻¹ starting from 15 (DAT) at 7-10 days intervals 5-6 times

Farmer’s practice · Schedule based spraying at 15 days interval from 30 DAT (Acephate @ 500 g a.i + Chlorantiniliprole @ 300g a.i ha⁻¹) till harvest.

135 DAT where in T₄ (3.74, 2.18) had recorded less per cent WE and is on par with T₃ (4.58, 3.52) and T₂ (4.14, 3.54). The data of mean per cent white ears represents the superiority order of various modules as T₃ (3.05) > T₂ (3.79) > T₄ (3.84) > T₅ (17.29) > T₁ (15.13) (Table 6). The data on per cent WE during the dry season, 2016-17 in various modules exemplified that at 105, 120 and 135 DAT the module T₃ expressed its superiority over other modules in suppressing the stem borer recording 1.70, 4.97 and 3.15 per cent WE, respectively. The modules T₄ found on par to T₆ in concealing the pest population with 4.49, 4.40 and 5.01 per cent WE at 105, 120 and 135 DAT, respectively. The treatments without chemical intervention have no significant result in reducing the pest population. Even the bio rational chemicals also did not result in noticeable management. The mean per cent white ears during the reproductive stage of rice crop confirmed that among various modules, the T₄ (IPM module) had recorded less infestation with 3.27 per cent WE and on par with farmers practice (4.63) and chemical control (6.07) where in the cost incurred towards chemical inputs were high.

The pooled mean per cent WE data inferred that among all the modules evaluated for efficacy against YSB during the wet season, 2017 the IPM based module was proven to be superlative in suppressing YSB infestation with 2.31 per cent WE and the module was the best on par to T₅ (farmer’s practice) with 3.21 per cent WE. The subsequent best modules were chemical based followed by non-chemical + bio rational and non-chemical modules with 5.10, 12.56 and 17.84 per cent WE, respectively. Comparable results were registered with respect to performance of various modules against per cent white ear damage during the wet season, 2017-18. The pooled mean of per cent WE represents the best performance in decreasing order of various modules as IPM module (1.35) > chemical module (4.29) > farmers practice (4.90) > non-chemical + bio rational (8.89) > non-chemical based module (17.19).

Cumulative Efficacy of various Integrated Management Modules against S. incertulas in terms of per cent Dead Hearts and White Ears

It was evident from the pooled mean of per cent DH pertaining to two wet seasons that among various modules evaluated for efficacy towards suppression of infestation by rice yellow stem borer, the least per cent dead hearts were registered in farmers practice (2.31) followed by IPM module and chemical-based module with 2.68 and 2.90 per cent DH, respectively and were statistically on par. The non-
Efficacy of various management modules on rice yield (kg ha\(^{-1}\)) and cost economics

The pooled mean grain yield (kg ha\(^{-1}\)) pertaining to the impact of various pest management modules in rice ranged from 2763 to 5275 and 2833 to 5207 during the wet season and dry season seasons, respectively.

### Wet season

Among the various modules evaluated, the farmers practice module (5234 and 5315) registered highest grain yield and it was on par with IPM module (5074 and 5265) and chemical-based module (4595 and 4846) during the dry season 2016 and 2017, respectively. The lowest yield was recorded in non-chemical based module with 2710 and 2815 kg ha\(^{-1}\) followed by non-chemical + bio rational based module with 2950 and 3150 Kg ha\(^{-1}\), respectively. The cumulative mean of two season’s data revealed that IPM and farmer’s practice-based modules were significantly superior over other modules with 5140 and 5275 kg ha\(^{-1}\), respectively.

With respect to cost-benefit ratio the highest C:B ratio was recorded in IPM based module (1: 2.68 and 1.282) followed by chemical-based module (1: 2.39 and 1: 2.03), farmer’s practice (1:2.31 and 1:2.08) and non-chemical + bio rational module (1:1.21 and 1:1.36) as against lowest in non-chemical based module with a C: B ratio of 1:1.10 and 1:1.18, during the wet season, 2016 and wet season, 2017, respectively. In IPM based module a net return of Rs.1,47,767.00 and Rs.1,55,407.00 per hectare was obtained during the dry season, 2016 and 2017, respectively. The net returns (Rs. ha\(^{-1}\)) in farmer’s practice (140281 and 143521) and chemical-based module (139824 and 135344)
were low compared to IPM module during the wet seasons, 2016 and 2017, respectively (Table 3).

**Dry season**

During the wet seasons 2016-17 and 2017-18, IPM based module recorded significantly highest grain yield with 5224 and 5290 as against lowest in non-chemical based module with 2765 and 2898 Kg ha⁻¹, respectively. The order of efficacy of various modules with regards to cumulative mean yield (Kg ha⁻¹) of two dry seasons was IPM module (5207) > farmer’s practice (5183) > chemical (5119) > non-chemical + bio rational (3466) > non-chemical (2832). The experimentation was executed in the same piece of land for the consecutive four seasons and it was indicated that there was an increasing trend of yields in plots with non-chemical and non-chemical + bio rational based modules and the constant trend was noticed in IPM based module.

Analogous trend was recorded during dry season also and the chronological efficacy order in relation to C:B ratio represents IPM based module (1: 2.46 and 1:2.51) > chemical-based module (1: 2.16 and 1: 2.04) > farmer’s practice (1:1.66 and 1:1.62) > non-chemical + bio rational module (1:1.11 and 1:1.68) > non-chemical module (1.097 and 1:1.07) during the dry season 2016-17 and dry season 2017-18, respectively. A net gain of Rs. 18,503.00 and Rs. 23,823.00 was realized in IPM based module against farmer’s practice during the dry season, 2016-17 and 2017-18, respectively. It was also inferred from the economic evaluation of various modules that the cost of cultivation was higher during the dry seasons, besides recording lower C: B ratio in comparison to the wet season (Table 4).

The overall results of the present investigation indicated that the IPM module exhibited significant superiority over all other modules in suppressing the yellow stem borer, *S. incertulas* infesting rice both in terms of minimizing the per cent dead hearts and per cent white ears during vegetative and reproductive stages, respectively. With regards to managing the stem borer incidence the farmer’s practice and chemical-based module also registered superiority and all the three modules viz., IPM, farmers practice and chemical based modules were on par with each other.

However, the IPM module resulted in the highest grain yield and highest cost-benefit ratio compared to other modules with an average net gain of Rs. 9,686.00 during the wet season and Rs. 21,163.00 during the dry season against the farmers practice confirming its supremacy as the best module against YSB in rice.

The present findings are in close agreement with the results of Arvind et al. (2018) who conducted front line demonstrations at farmers fields to demonstrate the efficacy of IPM technologies in rice in comparison to non-IPM technologies and their analysis confessed that the lower incidence of stem borer (8.85% DH and 7.50 %WE) was registered in IPM adopted fields as against highest in non-IPM fields (11.83% DH and 17.88%WE). It is also witnessed that the yield (q/ha) was also higher in IPM fields (31.88) with a C: B ratio of 1:2.39 as against the non-IPM plots

| Year | T.No. | Module | C.D.(P=0.05) | C.V.(%) | S.Em | C.B ratio | Net Cost (Rs. ha⁻¹) | Net benefit returns (Rs. ha⁻¹) | C: B ratio |
|------|-------|--------|-------------|-------|------|-----------|-----------------|--------------------------|-----------|
| 2016 | T₁    | Non-chemical methods + Bio-rational methods | 1.40 | 1.40 | 56.06 | 1.15 | 108.75 | 108.75 | 1:2.94 |
| 2017 | T₂    | IPM module | 1.40 | 1.40 | 60.06 | 1.15 | 108.75 | 108.75 | 1:2.94 |
| 2016 | T₃    | Farmers practice | 1.40 | 1.40 | 56.06 | 1.15 | 108.75 | 108.75 | 1:2.94 |
| 2017 | T₄    | C.D.(P=0.05) | 1.40 | 1.40 | 60.06 | 1.15 | 108.75 | 108.75 | 1:2.94 |
| 2016 | T₅    | S.Em | 1.40 | 1.40 | 56.06 | 1.15 | 108.75 | 108.75 | 1:2.94 |
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(23.55) with a C:B ratio of 1:1.92. Similar findings by Rajadurai (2017) confirmed that among five modules evaluated for efficacy against rice YSB, the module comprising chemical interventions has harboured significantly less per cent stem borer damage (2.36 and 3.25) followed by Biointensive IPM (3.56 and 4.61) and both are found superior over farmers practice (8.95 and 8.84) during the dry season and wet season, 2012-13 respectively.

Analogous investigations by Mohammed et al. (2016) disclosed that IPM employed rice field has a positive impact on healthy tillers, hills and grain weight besides registering lowest stem borer pest infestation (1.03% DH and 2.00% WE) and highest yield (7.4 t/ha). Anitha and Parimala, (2014) also conducted related studies to assess the efficacy of bio-intensive IPM technologies against farmers practice in rice for two years and concluded that highest per cent of completely parasitized egg masses of YSB (88.6%) with lowest per cent dead hearts (2.2-2.8% at 30 DAT; 8.6-11.0% at 50 DAT) and white ears (7.7-10.0%) were noticed in bio-intensive IPM module as against farmers practice with only 55.45% of egg parasitization resulting in highest per cent dead hearts (7.8-8.9% at 30 DAT; 16.2-19.0% at 50 DAT) and white ears (16.9-17.9%). The studies of Visalakshmi et al. (2013), Chandrakar (2013) and Chakraborty et al. (2012) also asserted that IPM modules have comparatively recorded lowest per cent infestation of stem borer over other chemical and farmer’s practices.

CONCLUSION

The results of the present study led to the conclusion that IPM module is superior over other modules in managing the rice yellow stem borer. IPM implies the rational integration of various methods especially the integration of chemical insecticides with other environmentally compatible tools to suppress the pest below ETL. It is also inferred from the above facts that timing of application of insecticides based on ETL assumes greater importance than indiscriminate and non recommended combination of chemicals applied at an improper time which increases the cost of cultivation even though the stem borer attack was minimized. Keeping in view the deleterious effects of chemical pesticides and increased cost of cultivation in their usage, it can be concluded that IPM module is a holistic approach for sustainability in rice cultivation that focuses on managing rice yellow stem borer and has been enshrined as the best module which is economically viable and environmentally feasible.

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