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Evaluation of Bio-intensive Integrated Pest Management Strategies against Sugarcane Borer Complex

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ABSTRACT

One of the major biotic production constraints encountered by sugarcane growing farmers was infestation by sugarcane borers *viz.*, early shoot borer, internode borer and top shoot borer. Over reliance on synthetic pesticides to manage the sugarcane borer complex may lead to ecological adversity, health related tribulations and unintended consequences hampering the sustainability of the production system. Realizing this, studies on bio intensive pest management (BIPM) strategies in sugarcane were undertaken at four locations of Krishna district, Andhra Pradesh during the year 2019. The results inferred that the field release of *Trichogramma chilonis* @ 50,000 ha^{-1} at 30 DAP and two times after node formation at an interval of 7 days in combination with installation of pheromone traps @ 20 ha^{-1} for mass trapping at 30 DAP till harvest had registered comparatively less infestation of sugarcane borers. The cumulative per cent dead hearts (7.28) by early shoot borer and per cent incidence (19.15) and intensity of internode borer (1.45) was found to be minimum in BIPM adopted fields as against highest in control plots with 39.47 per cent dead hearts by early shoot borer, 50.52 and 5.81 per cent incidence and intensity of internode borer infesting sugarcane. The chemical based components and farmers practices also registered less infestation of borer complex in sugarcane and are at par to BIPM based management strategies. Hence, it can be witnessed that the prioritization of bio intensive pest management components for sustainable agriculture is the need of the hour.

Keywords: *BIPM, Sugarcane borers, T.chilonis and Traps.*

Sugarcane occupies a prominent position in India as commercial and industrial crop, is cultivated in both tropical and subtropical regions. It endows raw material to the major agro based industries of our country *i.e.*, the sugar industry and supports rural cottage industries to some extent. It also, provides raw material to power generation, alcohol based factories and bio fertilizers manufacturing companies through by products from sugarcane factories such as bagasse, molasses, ethanol and press mud *etc* (Srikanth *et al.*, 2016). In India sugarcane crop is cultivated in an area of 5.01 M ha with annual production and average productivity of 339 M t and 66.99 t ha^{-1}, respectively (Shobharani *et al.*, 2018). Andhra Pradesh accounts for nearly 8.4 per cent of total cane production of our country covering 10 L ha area with 0.8 L t of annual production abounding nearly 29 sugar factories. Right from germination to till harvest, 212 insect pests and 76 non insect pests were notified to attack the sugarcane crop. Among the destructive pests, infestation by borer pests alone contributes more than 45 per cent of yield loss in sugarcane as inferred by Gupta (1993). The peak incidences of early shoot borer (ESB), *Chilo infuscatellus (snellen)* at formative stage, internode borer (INB), *Chilo sacchariphagus indicus* (Kapur) after formation of internodes till harvest and top shoot borer (TSB), *Scirpophaga excerptalis* (Walker) damage at grand growth stage of sugarcane result in substantial loss with respect to cane yield and sugar recovery.

The young larva of early shoot borer destroys the apical meristem of sugarcane by boring the spindles downwards and upwards, eventually resulting in drying of central leaf spindle forming dead hearts. Early shoot borer destroys 26-65 per cent of mother shoots (Khan and Rao, 1959) resulting in 22-33 per cent loss in cane yield, 12 and 27 per cent loss in sugar recovery and per cent jaggery, respectively (Patil and Hapse, 1981). According to Chaudhary (1973) this pest confers a yield loss of 34.4 tonnes ha^{-1} and 0.25-3.0 units loss with respect to sugar recovery. The internode borer bores the nodal region of the cane, enters the stem and tunnels upwards in characteristic spiral manner resulting in constricted and shortened internodes. The yield loss due to this borer ranges from 10-35 per cent (Shivasharanappa *et al.*, 2010). The pest infestation even at 10 per cent also leads to deterioration in quality of the sugar. The top shoot borer of sugarcane tunnels the upper portion of the stem resulting in dead hearts and bore holes at the shoot top resembles the bunchy top appearance. This pest causes 20 per cent yield loss at early stage, while 50 per cent loss in total crop growth period.

The farmers simply rely on insecticides for managing the sugarcane borers but, over reliance on synthetic pesticides lead to ecological adversity and health related tribulations. Adoption of bio intensive management practices provides long term protection against sugarcane borers, besides enhancing the natural enemy fauna in sugarcane ecosystem. These Control tactics are ecologically valid and environmentally feasible. Hence, an on farm trial was undertaken in farmers fields to assess the efficacy of bio intensive based pest management strategies to suppress the menace of sugarcane borers.

MATERIAL AND METHODS

The trial was undertaken at four locations *viz.*, Kapileswarapuram, Pydikondalapalem, Veerankilakula and Pamulalanka of farmer fields in Krishna district, Andhra Pradesh during 2019. Each location was treated as one replication and the bio intensive integrated pest management components (BIPM) are regarded as treatments. Six modules including BIPM based components and chemical based treatments were imposed in each location in an area of 0.4 ha per treatment *viz.*, T_1: Field release of *Trichogramma chilonis* @ 50000 ha^{-1}; T_2: Installation of pheromone traps (Delta model) @ 25 ha^{-1} ; T_3: Field release of *T. chilonis* @ 50000 ha^{-1} + Installation of pheromone traps @ 25 ha^{-1} ; T_4: Chemical management; T_5: Farmers practice and T_6: Untreated control.

Field release of *T. chilonis* was practiced by inundative release of tricho cards prepared at Sugarcane Research Station, Vuyyuru. The pheromone traps (M/s Sun Agro Biotech Research Centre, Chennai) were erected 3 feet above the ground level at a distance of 10 m and specific lures (M/s Sun Agro Biotech Research Centre, Chennai) were arranged against the targeted borers. Details of the management aspects followed by the farmers were recorded and in control plots application of insecticides was avoided. The details of various BIPM treatments were summarised in Table 1.

The data on moths trapped in pheromone traps during the cropping season was recorded fortnightly to assess the activity of various sugarcane borers in different locations. The per cent dead hearts by ESB was recorded by examining twenty randomly selected places (samples) of each 5 m row in each treated plots at 30, 60, 90 and 120 days after planting (DAP) and accordingly cumulative incidence of ESB was calculated by relating the progressive totals of infested tillers and total number of tillers at 120 DAP (Sithanantham, 1973). The per cent incidence and per cent intensity of INB was calculated through destructive sampling from randomly selected 100 canes from each treated plot. The damage incidence of top shoot borer is recorded basing on bored holes at the top of the shoot. The per cent dead hearts, per cent incidence, per cent intensity and infestation index of the borers were calculated as per the formulae hereunder.

$$\text{Per cent dead hearts} = \frac{\text{Number of dead hearts}}{\text{Total number of tillers}} \times 100$$

$$\text{Per cent incidence} = \frac{\text{Total number of affected canes}}{\text{Total canes}} \times 100$$

$$\text{Per cent intensity} = \frac{\text{Total number of affected internodes}}{\text{Total number of internodes}} \times 100$$

$$\text{Infestation Index} = \frac{\text{per cent incidence x per cent intensity}}{100}$$

The cane yield was recorded per plot and expressed as tonnes per hectare. The data pertaining to borer damage obtained was tabulated by suitable transformations for and were scrutinized by RBD analysis of one way ANOVA. The Critical difference values were calculated at p= 0.05 and mean values were compared using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

The activity of borers complex infesting sugarcane was noticed through moth catches in pheromone traps and the results inferred that, relatively the incidence of TSB during the season 2019 was low compared to ESB and INB (Table 2). Hence, the efficacy of various BIPM treatments was evaluated against ESB and INB only. The maximum moths with respect to ESB were caught in march II fortnight whereas, maximum INB and TSB moths were trapped during July II fortnight (Fig 1).

Efficacy of BIPM treatments against early shoot borer infesting sugarcane

The incidence of early shoot borer in terms of mean per cent dead hearts was comparatively minimum in farmers practice (T_5) with 1.42, 1.98, 1.66 and 0.71 per cent dead hearts at 30, 60, 90 and 120 DAP, respectively and found at par with chemical based

Table 1. Details of Bio intensive IPM based treatments against sugarcane borer complex

Treatments	BIPM components imposed
T_1	Field release of *T. chilonis* @ 50000 ha^{-1} from 30 DAP to 240 DAP at an interval of 10 days (21 releases).
T_2	Installation of Delta traps @ 25 ha^{-1} from 20 DAP to 120 DAP for ESB and from 120 DAP to 240 DAP for INB and for TSB from 150 DAP to 240 DAP for mass trapping.
T_3	Field release of *T. chilonis* @ 50000 ha^{-1} from 30 DAP to 240 DAP at an interval of 10 days (T_1) + Installation of Delta traps @ 25 ha^{-1} from 20 DAP to 120 DAP for ESB and from 120 DAP to 240 DAP for INB and for TSB from 150 DAP to 240 DAP for mass trapping (T_2).
T_4	Sett treatment with imidacloprid 600FS@ 1 ml l^{-1} + Granular application of carbofuran 3G @ 1 kg ai ha^{-1} at basal and soil drenching with chlorantraniliprole 20% SC 75 g a.i. ha^{-1} at 105 and 130 DAP.
T_5	Granular application of carbofuran 3G @ 1 kg ai ha^{-1} at basal + Granular application of *chlorantraniliprole* 0.4G @ 20 kg/ha at 30 DAP + Foliar spray of chlorantraniliprole 20% SC 75 g a.i. ha^{-1} at 60, 90 and 120 DAP.
T_6	Untreated control (No plant protection adopted)

Table 2. Moth catches of sugarcane borer complex in pheromone traps during the season 2019-2020

	Moth catches/ trap/ fortnight intervals (No)					
	Early shoot borer		Internode borer		Top shoot borer	
	T_2	T_3	T_2	T_3	T_2	T_3
Minimum	?0	?0	?0	?0	?0	?0
Maximum	48	31	58	35	6	4
Total in the season	827	558	585	437	38	24

treatment (T_4) and BIPM treatment (T_3) where both inundative releases of *Trichogramma* parasitoids and mass trapping with pheromone traps were practiced with 0.68, 2.12, 2.15 & 1.82 and 1.70, 2.86, 1.94 & 0.81 per cent dead hearts at 30, 60, 90 and 120 DAP, respectively.

The cumulative incidence of early shoot borer at 120 DAP indicated that the least mean per cent dead hearts were registered in plots of farmers practice (6.98) followed by BIPM based treatment (7.28) and chemical based treatment (7.74) as against highest incidence recorded in untreated control (39.47). The order of efficacy of various treatments in suppressing the incidence of ESB in terms of cumulative per cent dead hearts up to 120 DAP represents T_5 (6.98) > T_3 (7.28) >T_4 (7.74) >T_2 (12.91) >T_1 (15.57) with 82.3, 81.6, 80.4, 67.3 and 60.6 per cent reduction of dead hearts over control, respectively (Table 3).

Efficacy of BIPM treatments against internode borer infesting sugarcane

The efficacy of various BIPM treatments in comparison to farmers practice and chemical based treatments in terms of both per cent incidence and per cent intensity of internode borer was presented in the Table 4. The results inferred that, among all the treatments BIPM based treatment *i.e.*, field releases of *T. chilonis* + Mass trapping with pheromone traps (T_3) had recorded least per cent incidence (19.15) and per cent intensity (1.45) followed by chemical based treatment and farmers practice with 24.18 & 25.93 and 2.29 & 2.73 per cent incidence and intensity, respectively. The highest per cent incidence (48.67) and intensity (53.01) of internode borer infesting sugarcane was observed in untreated control with an infestation index of 2.96. The ascending order of infestation index representing the increased INB

Table 3. Efficacy of BIPM treatments against early shoot borer infesting sugarcane during the season 2019-2020

Treatments	Mean per cent dead hearts by early shoot borer					
	30 DAP	60 DAP	90 DAP	120 DAP	Cumulative up to 120 DAP	Per cent ROC
T_1 : Field release of T. chilonis	6.76 (15.07)[d]	4.33 (12.01)[b]	5.04 (12.97)[d]	2.54 (9.17)[c]	15.57 (23.24)[c]	60.6
T_2 : Mass trapping with pheromone traps	3.6 (10.94)[c]	4.27 (11.93)[b]	3.02 (10.01)[c]	2.14 (8.41)[bc]	12.91 (21.06)[b]	67.3
T_3 : $T_1 + T_2$	1.7 (7.49)[b]	2.86 (9.74)[a]	1.94 (8.01)[ab]	0.81 (5.16)[a]	7.28 (15.65)[a]	81.6
T_4 : Chemical management	0.68 (4.73)[a]	2.12 (8.37)[a]	2.15 (8.43)[b]	1.82 (7.75)[b]	7.74 (16.15)[a]	80.4
T_5 : Farmers practice	1.42 (6.84)[b]	1.98 (8.09)[a]	1.66 (7.40)[a]	0.71 (4.83)[a]	6.98 (15.32)[a]	82.3
T_6 : Untreated control	8.95 (17.41)[e]	12.55 (20.75)[c]	13.77 (21.78)[e]	15.2 (22.95)[d]	39.47 (38.92)[d]	-
SEM±	2.05	1.88	2.57	1.87	2.47	
CD(p=0.05)	0.51	1.38	0.94	1.03	0.91	
CV%	28.57	25.13	18.74	28.56	21.62	

DAP: Days after planting
Figures in parenthesis are arcsine transformed values
Mean with same letter are not significantly different at 5% level by Duncan's Multiple Range Test
ROC: reduction over control

Table 4. Efficacy of BIPM treatments against internode borer infesting sugarcane during the season 2019-2020

Treatments	Internode borer mean incidence and intensity				
	Per cent incidence	Per cent ROC	Per cent intensity	Per cent ROC	Infestation index
T1 : Field release of T. *chilonis*	31.75 (34.30)[c]	37.15	3.2 (10.30)[c]	53.1	0.87
T2 : Mass trapping with pheromone traps	30.08 (33.26)[c]	40.46	2.46 (9.02)[c]	58.02	0.74
T3 : T1 + T2	19.15 (25.95)[a]	62.09	1.45 (6.92)[a]	75.26	0.28
T4 : Chemical management	24.18 (29.45)[b]	52.14	2.29 (8.70)[b]	60.92	0.55
T5 : Farmers practice	25.93 (30.61)[b]	48.67	2.73 (9.51)[c]	45.39	0.83
T6 : Untreated control	50.52 -45.3		5.86 (14.01)[d]		2.96
SEM±	2.17			1.83	
CD (p=0.05)	3.18		2.15		
CV %	31.58		27.61		

Figures in parenthesis are arcsine transformed values
Mean with same letter are not significantly different at 5% level by Duncan's Multiple Range Test
ROC: reduction over control

Table 5. Influence of BIPM treatments against cane yield (t ha^{-1})

Treatments	Cane yield (t ha-^{1})
T_1 : Field release of T. *chilonis*	52.38^{c}
T_2 : Mass trapping with pheromone traps	51.51^{c}
T_3 : T1 + T2	61.42^{b}
T_4 : Chemical management	59.55^{b}
T_5 : Farmers practice	65.50^{a}
T_6 : Untreated control	39.58^{d}
CD (p=0.05)	4.58
CV %	19.27

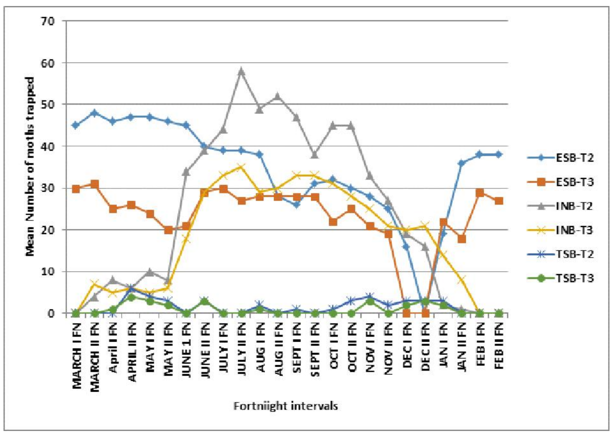

Fig.1 Moth catches of sugarcane borers in pheromone traps at fortnight intervals during 2019-2020

incidence and intensity among various treatments depicts that $T_3 < T_4 < T_5 < T_2 < T_1 < T_6$ with 0.28, 0.55, 0.63, 0.82, 0.87 and 2.96, respectively.

The per cent reduction of INB incidence and intensity over control was highest in T_3 with 62.09 and 75.04 per cent, respectively. The next better treatments *i.e.*, the chemical based treatment (52.14 & 60.59) and farmers practice (48.67 & 57.66) also registered better reduction over control with respect to per cent incidence and intensity, respectively.

From the overall performance of various treatments basing on the results, it was exemplified that the Module 3 where in field releases of *T.chilonis* @ 50000 ha^{-1} from 30 DAP to 240 DAP at an interval of 10 days + Installation of Delta pheromone traps @ 25 ha^{-1} from 20 DAP to 120 DAP for ESB and from 120 DAP to 240 DAP for INB and for TSB from 150 DAP to 240 DAP was practiced had registered minimum incidence of ESB (7.28 % dead hearts) and INB (19.15% incidence & 1.45 % intensity). The per cent reduction of ESB over control was highest in case with farmers practice: T_5 (82.3) but found on par with BIPM based treatment: T_3 (81.6) and chemical management: T_4 (80.4). In terms of per cent reduction of INB over control, superior performance was registered with BIPM based treatment: T_3 (62.09 & 75.04) followed by chemical management: T_4 (52.14 & 60.59) and farmers practice: T_5 (49.67 & 57.66) with respect to incidence and intensity, respectively.

The present findings are in accordance with the results of Chand *et al.* (2018) who studied the efficacy of mass trapping the sugarcane borers through pheromone traps for three consecutive years and inferred that there was a per cent reduction of 55.33, 47.77 and 56.86 per cent incidence of early shoot borer, top borer and stalk borer over control, respectively. Bhavani *et al.* (2016) also witnessed that the plots installed with pheromone traps for mass trapping @ 10 traps per acre and release of *T.chilonis* @ 20,000 per acre for six times at a interval of 10 days recorded lowest cumulative incidence of ESB (3.92%) and INB (6.33%) as against highest in control plots with 26.94 and 84.2 per cent incidence of ESB and INB, respectively.

Analogous results by Jasmine and her co workers (2012) are in agreement with the present findings of efficacy in relation to chemical based treatments as they confirmed that rynaxypyr 20 SC @ 75 g ai ha^{-1} had recorded lowest incidence of early shoot borer (15.43%), incidence of INB (16.50%) and intensity of INB (3.84) as against highest in control with 38.98, 58.33 and 16.09 per cent ESB incidence, INB incidence and INB intensity, respectively. Comparable studies by Nadeem and Hamed (2011) also indicated that the per cent borers damage infesting sugarcane was reduced by 35.1 to 43.1 per cent over control where in the biological control with inundative release of *T.chilionis* was adapted in various locations of farmers fields.

Influence of BIPM treatments against cane yield (t ha^{-1})

The cane yield per plot in various locations was recorded and expressed as t ha^{-1}. Among all the treatments, the highest cane yield (t ha^{-1}) was recorded in farmer's field (65.50) followed by BIPM based treatment, T_3 (61.42) and was on par with chemical based treatment, T_4 (59.55) and the lowest yield was recorded in untreated control, T_6 with 39.58 t ha^{-1} (Table 5).

CONCLUSION

On the basis of the present findings it can be concluded that adaption of bio intensive based pest management components *viz.*, inundative field releases of *T. chilionis* and mass trapping of borer moths through pheromone traps had exerted superior efficacy in suppressing the sugarcane borers and their damage and found at par to chemical treated plots. Although usage of insecticides to check the pests was found to be effective, keeping in view the risks and harmful effects of chemicals, BIPM based management strategies have to be encouraged. BIPM based management strategies are considered as best promising tools for managing the pests as they lack toxicity on non targeted organisms, possess species specificity, long potency and are compatible with other components of IPM.

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