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Effect of releases of *T. chilonis*, application of cypermethrin and their combination against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenée (Lepidoptera: Crambidae)

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Abstract
The field study during the summer season, 2013-14 was conducted for investigation on infestation of a devastating pest, brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenée, the data on the overall mean of healthy and infested shoots and percent shoot infestation indicated significant differences between various treatments. Highest mean number of healthy shoots recorded was in *T. chilonis* + cypermethrin treatment plots (112.23 shoots/plot), while in cypermethrin treated plots 109.3 shoots/plot were recorded, in *T. chilonis* 106.06 shoots/plot, whereas the minimum number of healthy shoots were recorded in untreated control (102.03 shoots/plot). The percent shoot infestation ranged from 8.65 to 16.95 percent in various treatments and differed significantly among different treatments. The healthy fruit ranged from 10.25 to 30.73 Kg per plot. The maximum number of healthy fruits was recorded in *T. chilonis* + cypermethrin treatment (30.73 Kg/plot), which was significantly higher in different compared to the treatments, followed by cypermethrin treatment (22.42 Kg/plot), *T. chilonis* (16.31 Kg/plot) and minimum number was recorded in the control (10.25 Kg/plot). Highest fruit infestation was recorded in the control (53.80%), which was significantly more over other treatments and minimum percent fruit infestation was recorded in *T. chilonis* + cypermethrin treatment (8.97%).

Keywords: Brinjal, shoot infestation, fruit infestation, summer, *T. chilonis,* cypermethrin

1. Introduction

The brinjal, *Solanum melongena* L. (Solanaceae), often referred as an eggplant or an aubergine in other regions of the world and is grown for its fleshy fruits. It is one of the widely used vegetable crops by most of the people and is popular in many countries, *viz.*, Central, South and South East Asia, some parts of Africa and Central America [1]. Brinjal is grown throughout the country, all round the year [2] and is believed to be cultivated in India for the last 4,000 years. South East Asian countries account for almost 50 percent of the world's area under brinjal cultivation. Brinjal assumes special significance among the vegetables in the hot wet season when other vegetables are in short supply and it is the only vegetable that is available at an affordable price for rural and urban poor. So, it is known as a poor man's crop.

Brinjal is cultivated in an area of 2.00 mha across the globe, with a production of 34.5 mt and productivity of 17.25 t/ha. In India, the area under brinjal cultivation is estimated at 0.72 mha with total production of 13.4 mt and the productivity of 18.6 t/ha and production share of brinjal is 38.8 percent in India. In Karnataka, it is grown in an area of 0.016 mha, with a total production of 0.42 mt and the productivity of 26.2 t/ha [3].

Brinjal is attacked by a plethora of insect and mite pests, starting from seedling stage to senescence. A survey carried out by the Asian Vegetable Research and Development Centre [4] indicated that the brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenée, leaf hopper, *Amrasca biguttula biguttula* Ishida and epilachna beetle, *Henosepilachna* (*Epilachna*) *vigintioctopunctata* Fabricius are the most destructive pests on brinjal in Asia. Independently, in the entire South Asian region, the shoot and fruit borer has been identified as the primary limiting factor in brinjal production. Occasionally, brinjal is severely infested by mites, *Tetranychus* sp., aphids, *Aphis gossypii* Glover and whiteflies including *Bemisia tabaci* Guenée and *Trialeurodes* sp. In Himachal Pradesh, 27 diverse insect species and one mite species are reported to be related with brinjal crop [5], shoot and fruit borer, *L. orbonalis* (Lepidoptera: Pyralidae) is observed to be the key pest throughout Asia [6-9].

In India, this pest has a countrywide distribution and has been categorized as the most destructive and most serious pest causing huge losses in brinjal. The yield loss could be as high as 20-90 percent in certain conditions in different states [10- 15]. The yield loss due to the pest is to an extent of 70-92 percent [16, 17]. It is also reported that there will be reduction in vitamin C content to an extent of 68 percent in the infested fruits [17].

Therefore, in the view of attempts made so far, there is a need to look into developing the method of management that not only provides higher yield, but also avoids the indiscriminate use of insecticide, protects the environment and prevents health hazards. The present investigations were carried out for determining the effect of release of *T. chilonis*, application of cypermethrin and their combinations against brinjal shoot and fruit borer management.

2. Materials and Methods

2.1 Influence of selected insecticide and *Trichogramma chilonis* on BSFB

In order to study the influence of selected insecticide and *Trichogramma chilonis* on *L. orbonalis*, an experiment was conducted at NBAIR, Yelahanka Campus, Attur layout, Bengaluru, during summer season, 2013-14. The details of the treatments are presented below.

2.2 Brinjal seedlings

The variety, Mahyco - 11 was used in this study and the seedlings were collected from the M/s Ekalavya nursery, Hessaraghatta, Bengaluru.

2.3 Transplantation of seedlings and management

The experimental plots were prepared by ploughing and cross-ploughing followed by laddering. All the plots were prepared with proper proportions of manure and fertilizers. The unit plot size was 3.3 × 4.2 m being 75 cm × 60 cm plant spacing. The plot was divided into four blocks on equal size, *i.e.*, 69.30 sq. mtr for distribution of treatments was followed with five replications. For each replication of treatments 2 m space was left to avoid the effect of insecticidal treatment effect and movement of *T. chilonis* from one plot to another. Forty-days-old healthy seedlings (3/4 leaf stage) were transplanted in the experimental plots. All agronomic practices were started after seedling transplantation and continued up to fruiting stage.

2.4 Treatments

The experiments consisting of four treatment combinations;
T_1 = *Trichogramma chilonis* @ 100,000 adults/ha; T_2 = *Trichogramma chilonis* @ 100,000 adults/ha + Cypermethrin 25% EC @ 0.4 ml/lit; T_3 = Cypermethrin 25 EC @ 0.4 ml/lit; T_4 = Untreated control. Each treatment was replicated five times to reduce heterogeneity among the treatments. The imposition of treatments was started 45 - 50 days after transplanting and observations were taken at fifteen days interval.

The insecticide was selected against BSFB for the field trial was based resistance study and also commonly used insecticide in farmers' fields, *viz*., Cypermethrin 25% EC (@ 0.4 ml/lit). The selected chemical was sprayed in blocks separately by using knapsack sprayer at fifteen days intervals once the imposition of treatments was started.

2.5 Observations were recorded

- Number of infested shoots/ 10 plants
- Number of healthy shoots/ 10 plants
- Total number of shoots/ plot
- Weight of infested fruits/ plot
- Weight of healthy fruits/ plot
- Total weight of fruits/ plot

The number of the damaged shoots per plant on the ten randomly selected and pre-marked sample plants from each treatment was recorded at fifteen days intervals after commencing the treatments. For shoot infestation, the number of healthy and infested shoots was recorded starting from the appearance of the pest. The percentage of the infested shoots was worked out in ten randomly selected plants.

The number of healthy and damaged fruits from each treatment was recorded at each picking. All the fruits in each sub-plot were plucked, kept separately and carefully examined. Those fruits having exit holes were easily separated, whereas some fruits, that the entry point of caterpillars in the form of minute plugged holes surrounded by small-decolorized patches were seen after careful examination of the fruits, were cut open to confirm the damage. After sorting out the fruits as healthy and damaged ones, they were counted and also weighted separately.

2.6 Shoot infestation

The observations on a number of shoots showing withering symptoms due to shoot borer damage and total number of shoots per plant were recorded in the early stage before fruit formation at an interval of fifteen days on randomly selected 10 plants per plot. The data on the incidence of shoot borer were converted to percent value. The percent shoot damage was worked out for 10 plants.

$$\text{\% Shoot damage} = \frac{\text{Number of damaged shoots}}{\text{Total number of shoots}} \times 100$$

$$\text{\% Reduction in shoot infestation} = \frac{\text{\% Shoot infestation in control - \% Shoot infestation in treatment}}{\text{\% Shoot infestation in control}} \times 100$$

Observations on number of damaged shoots and total number of shoots per plot was recorded 15, 30, 45, 60, 75 and 90 days after imposition of treatment and was recorded at fifteen days intervals. The data was transformed to $\sqrt{(X + 0.5)}$ transformation before analysis by Two way ANOVA. The data on fruit damage by the pest was converted into percent values and transformed to arc sine transformation before analysis by two way ANOVA (Snedecor and Cochran, 1956).

2.7 Fruit infestation

Total number of fruits and number of fruits damaged per plant due to fruit borer damage were counted and percent fruit damage was worked out for per plot.

$$\text{\% Fruit damage} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits}} \times 100$$

$$\% \text{ Reduction in fruit infestation} = \frac{\% \text{ Fruit infestation in control} - \% \text{ Fruit infestation in treatment}}{\% \text{ fruit infestation in control}} \times 100$$

$$\% \text{ Increase in yield over control} = \frac{\text{Treatment} - \text{Control}}{\text{Treatment}} \times 100$$

$$\% \text{ Decrease in yield over control} = \frac{\text{Control} - \text{Treatment}}{\text{Control}} \times 100$$

Observations on number of damaged fruits and total number of fruits per plot 15, 30, 45, 60, 75 and 90 days after imposition of treatments were recorded at fifteen days intervals. The data was transformed to $\sqrt{(X + 0.5)}$ transformation before analysis by Two-way ANOVA. The data on fruit damage by the pest was converted into percent values and transformed to arc sine transformation before analysis by two-way ANOVA (Snedecor and Cochran, 1956).

3. Results

3.1 Pre-treatment count

The observations on pre-treatment count indicated that differences in the percent shoot infestation and reduction in shoot infestation between the treatments were non-significant (Table 1).

3.2 At fifteen days after imposition of treatments

The results obtained revealed significant differences between the treatments at fifteen days after initiation of treatments. The shoots infestation ranged from 13.40 to 28.40 percent. Highest shoot infestation was recorded in the control (28.40%) which was significantly more than that recorded in the rest of the treatments, followed by *T. chilonis* (23.00%), insecticide treatment (18.00%). However, minimum shoot infestation was recorded in *T. chilonis* + cypermethrin treatment (13.40%) (CD = 2.04; *P* = 0.05) (Table 1). The analysis shows that the reduction of shoot infestation over control showed significant differences between treatments, which ranged from 19.01 to 52.81 percent, the highest reduction was recorded in the treatment of *T. chilonis* + cypermethrin (52.81%), followed by cypermethrin treatment (36.61%) and the lowest reduction was recorded in case of *T. chilonis* (19.01%) (CD = 6.04; *P* = 0.05) (Table 1).

3.3 At thirty days after imposition of treatments

At thirty days after treatment imposition, significant differences were observed between the treatments for infested shoots, which was ranging between 9.93 to 20.00 percent. Highest shoot infestation was recorded in control (20.00%), which was significantly more than that observed in rest of the treatments, however, minimum shoot infestation was recorded in *T. chilonis* + cypermethrin treatment (9.93%) (CD = 1.69; *P* = 0.05) (Table 1). The reduction of shoot infestation over control showed significant differences between treatments, which ranged from 16.15 to 50.35 percent. The highest reduction on shoot infestation was recorded in case of *T. chilonis* + cypermethrin treatment combination (50.35%) and minimum reduction was recorded *T. chilonis* (16.15%) (CD = 4.44; *P* = 0.05) (Table 1).

3.4 At forty five days after imposition of treatments

At forty five days after imposition of treatments, the results indicated significant differences on the shoot infestation, which ranged from 7.67 to 17.33 percent. Highest shoot infestation was recorded in control (17.33%), which was significantly more than that over rest of the treatments, followed by *T. chilonis* (12.83%), cypermethrin treatment (10.00%). However, minimum shoot infestation was recorded in *T. chilonis* + cypermethrin treatment (7.67%) (CD = 2.07; *P* = 0.05) (Table 1). The reduction of shoot infestation ranged from 25.96 to 55.74 percent, the highest reduction was recorded in *T. chilonis* + cypermethrin (55.74%), followed by cypermethrin treatment (42.29%) and the lowest reduction on shoot infestation was recorded in case of *T. chilonis* (25.96%) (CD = 4.17; *P* = 0.05) (Table 1).

3.5 At sixty days after imposition of treatments

The results revealed that among the various treatments there was a significant difference in the data recorded after sixty days after imposition of treatments. The percent shoot infestation ranged from 3.86 to 13.14 percent. Highest shoot infestation was recorded in control (13.14%), which was significantly more over rest of the treatments, followed by *T. chilonis* (10.14%), cypermethrin treatment combination (6.57%). However, minimum shoot infestation was recorded in *T. chilonis* + cypermethrin treatment (3.86%) (CD = 1.83; *P* = 0.05) (Table 1). The reduction of shoot infestation ranged from 22.83 to 70.62 percent, the highest reduction was recorded in treatment combination *T. chilonis* + cypermethrin (70.62%), followed by cypermethrin treatment (50.00%) and the lowest reduction on shoot infestation was recorded in case of *T. chilonis* alone (22.83%) (CD = 5.50; *P* = 0.05) (Table 1).

3.6 At seventy five days after imposition of treatments

The results revealed significant differences between various the treatments, the percent infested shoots ranged from 2.14 to 9.43 percent. Highest shoot infestation was recorded in control (9.43%), which was significantly more than that recorded in rest of the treatments (CD = 2.00; *P* = 0.05) (Table 1).The reduction of shoot infestation ranged from 30.32 to 77.30 percent, the highest reduction was recorded in *T. chilonis* + cypermethrin (77.30%), followed by cypermethrin treatment (54.50%) and the lowest reduction in shoot infestation was recorded in case of *T. chilonis* (30.32%) (CD = 8.10; *P* = 0.05) (Table 1).

3.7 At ninety days after imposition of treatments

The percent shoot infestation ranged between 1.63 to 6.75 percent in various treatments, with highest shoot infestation recorded in control (6.75%) and the least was recorded in treatment of *T. chilonis* + cypermethrin treatment combination (1.63%) (CD = 1.62; *P* = 0.05) (Table 1). The reduction of shoot infestation ranged from 33.33 to 75.85 percent, the highest reduction was recorded *T. chilonis* + cypermethrin combination (75.85%), followed by cypermethrin treatment (51.85%) and the lowest reduction in shoot infestation was recorded in case of *T. chilonis* alone (33.33%) (CD = 7.85; *P* = 0.05) (Table 1).

3.8 Overall effect of treatments on the number of healthy shoots, infested shoots and percent shoot infestation

The data on the overall mean number of healthy and infested shoots and percent shoot infestation indicated significant differences between various treatments. Highest mean number of healthy shoots recorded was in case of *T. chilonis* + cypermethrin treatment combination (112.23 shoots/plot), while in cypermethrin treated plots 109.3 shoots /plot were recorded, in *T. chilonis* treatment it was 106.06 shoots/plot, whereas minimum number of healthy shoots were recorded in untreated control (102.03 shoots/plot) (CD = 0.12; *P* = 0.05) (Table 2). The percent mean infested shoots ranged from 8.65 to 16.95 percent in various treatments and it differed significantly among different treatments (CD = 1.76; *P* = 0.05) (Table 2). The reduction of shoot infestation ranged from 19.35 to 48.96 percent, the highest reduction was recorded in case of *T. chilonis* + cypermethrin (48.96%), followed by cypermethrin treatment (34.74%) and the lowest reduction in shoot infestation was in case of *T. chilonis* (19.35%) (CD = 4.50; *P* = 0.05) (Table 2).

3.9 Healthy, infested fruits, percent fruit infestation and reduction of fruit infestation over control in different treatments

3.9.1 Mean number of healthy fruits, infested fruits and fruit infestation per plot

The results suggested that there were significant differences between the treatments on healthy fruits. The healthy fruit ranged from 10.25 to 30.73 Kg per plot. Highest number of healthy fruits was recorded in *T. chilonis* + cypermethrin treatment combination (30.73 Kg/plot), which was significantly higher in different compared to the treatments, followed by cypermethrin treatment (22.42 Kg/plot), *T. chilonis* (16.31 Kg/plot) and minimum number was recorded in control (10.25 Kg/plot) (CD = 1.98; *P* = 0.05) (Table 3). The mean infested fruits ranged from 3.03 to 11.94 Kg per plot. Highest number of infested fruits was recorded in control (11.94 Kg/plot), which was significantly higher over the rest of the treatments and mean number of infested fruits was recorded in case of *T. chilonis* + cypermethrin treatment (3.03 Kg/plot) (CD = 0.94; *P* = 0.05) (Table 3).

The overall fruit infestation on a weight basis ranged from 8.97 to 53.80 percent. Highest fruit infestation was recorded in the control (53.80%) which was significantly more than that observed in the rest of the treatments and minimum percent fruit infestation was recorded in *T. chilonis* + cypermethrin treatment combination (8.97%) (CD = 3.81; *P* = 0.05) (Table 3). The reduction of fruit infestation ranged from 36.43 to 83.32 percent, the highest reduction was recorded in case of *T. chilonis* + cypermethrin (83.32%), followed by cypermethrin treatment (61.22%) and the lowest reduction on shoot infestation was recorded in *T. chilonis* (36.43%) (CD = 6.46; *P* = 0.05) (Table 3).

3.10 Total quantity of fruits per plot

3.10.1 Healthy fruit yield/ha

The healthy fruits in various treatments ranged from 7.50 to 22.50 ton/ha. Highest healthy fruit yield was recorded in *T. chilonis* + cypermethrin treatment (22.50 ton/ha), which was significantly higher over rest of the treatments. This was followed by cypermethrin treatment (16.41 ton/ha), *T. chilonis* (11.94 ton/ha). However, the lowest healthy fruit yield was recorded in untreated control (7.50 ton/ha) (CD = 1.66; *P* = 0.05) (Table 4).

3.10.2 Increase over control (%)

The results suggested that the increase of healthy fruit yield over control ranged from 37.18 to 66.66 percent. The highest increase of healthy fruit yield was recorded in case of *T. chilonis* + cypermethrin (66.66%) combination, followed by cypermethrin treatment (54.29%) and the lowest increase of healthy fruit yield was recorded in case of *T. chilonis* (37.18%) (CD = 3.62; *P* = 0.05) (Table 4).

3.10.3 Infested fruit yield/ha

Significant differences were observed between various treatments for infested fruit yield which was ranging from 2.22 to 8.74 ton/ha. Highest infested fruit yield was recorded in untreated control (8.74 ton/ha) which was significantly higher over rest of the treatments, followed by *T. chilonis* (6.21 ton/ha) and cypermethrin treatment (4.32 ton/ha). However, lower infested fruits yield was recorded in *T. chilonis* + cypermethrin treatment (2.22 ton/ha) (CD = 0.78; *P* = 0.05) (Table 4).

3.10.4 Decrease over control (%)

The results suggested that the decrease of infested fruit yield over control shows statistically significant differences between treatments which ranged from 28.94 to 74.59 percent. Highest decrease of infested fruit yield was recorded in case of *T. chilonis* + cypermethrin (74.59%), followed by cypermethrin treatment alone (50.57%) and the lowest decrease of infested fruit yield was recorded in case of *T. chilonis* alone (28.94%) (CD = 6.07; *P* = 0.05) (Table 4).

3.10.5 Total fruit yield/ha

The overall total quantity of fruits per ha ranged from 16.24 to 24.72 ton/ha. The highest quantity of fruits was recorded in *T. chilonis* + cypermethrin treatment (24.72 ton/ha) which was significantly superior over the rest of the treatments, followed by cypermethrin treatment (20.73 ton/ha) and *T. chilonis* (18.15 ton/ha). However, minimum quantity of fruits was recorded in untreated control (16.24 ton/ha) (CD = 1.69; *P* = 0.05) (Table 4).

3.10.6 Increase over control (%)

The results suggested that the increase of total fruit yield over control ranged from 10.52 to 34.30 percent. The highest increase of total fruit yield was recorded in case of *T. chilonis* + cypermethrin (34.30%), followed by cypermethrin treatment (22.18%) and the lowest increase of total fruit yield was recorded in case of *T. chilonis* release alone (10.52%) (CD = 3.62; *P* = 0.05) (Table 4).

4. Discussion

4.1 Overall season mean healthy shoots, infested shoots and shoot infestation per plot

The data on seasonal mean on healthy and infested shoots and percent shoot infestation is scanty in the literature. The highest number of healthy shoots was recorded during 2013-14 in *T. chilonis* + cypermethrin treatment plots (112.23 shoots/plot), which was significantly higher over other treatments like cypermethrin alone (109.3 healthy shoots), *T. chilonis* alone (106.1 healthy shoots), while in untreated control 102.0 healthy shoots were recorded. The results show that there was significant differences were observed between the treatments of overall mean infested shoots. The infested shoots ranged from 10.63 to 20.83 shoots per plot. Highest number of infested shoots was recorded in control (20.83 shoots/plot), which was significantly more over rest of the treatments during summer season. Consequent upon efficacy of the combination, least infested shoots were recorded compared to other treatments.

The results were contrary to present investigation, the average percent shoot infestation on different cultivars during 2007 varied from 19.27 to 43.15, minimum being on Nirala and maximum on 43.15 percent, whereas during 2008 shoot infestation percent varied from 15.81 to 33.75, minimum being observed on Nirala and maximum on Neelam [19], while reports of Alam *et al*. [20] suggest that during studies conducted in Bangladesh, India, Sri Lanka and Thailand, the maximum shoot infestation recorded on brinjal was 28 percent. These variations may be due to soil conditions and weather factors.

The present findings is in agreement with study done by Rahman *et al.* [21], who also reported that the combinations of two or three options was better than individual treatments.

4.2 Overall mean of healthy fruits, infested fruits and fruit infestation per plot

During summer crop, the results suggested that there were significant differences between the treatments on healthy fruits. Highest number of healthy fruits was recorded in *T. chilonis* + cypermethrin treatment (30.73 Kg/plot), which was significantly more over rest of the treatments, like cypermethrin treatment (22.42 Kg/plot) and *T. chilonis* (16.31 Kg/plot). The infested fruit ranged between 3.03 to 11.94 Kg per plot. The present findings is in variance with the study done by Satpathy *et al.* [21], who reported that the relative level of fruit damage between treated and untreated plot was not prominent. However, in later harvests the treatment effect became more pronounced. In Tamil Nadu, Raja *et al*. [22] also found *T. chilonis* to be effective against *L. orbonalis*. The efficacy of *T. chilonis* may further be enhanced by improving the release technique and better integration with other tactics. However, results are in agreement with Rahman *et al*. [23], who also reported that any single option such as sole mechanical control, schedule spray of Marshal® at 7 days interval or sole sex pheromone trap was inferior to any of other combined options and the combinations of three options was better than that of any two options.

The results of the present study reported the combination treatment was followed by chemical treatment *i.e.,* cypermethrin resulted as the most effective treatment against BSFB recording 7.70 and 7.97 percent fruit damage on number and weight basis, in summer. Earlier reports also suggested that high yield obtained in cypermethrin treated plots was higher than spinosad and other treatments [24- 27].

The current results were agreement with chemical treatment was better after combination treatment reported that evaluation of eco-friendly insecticides against *L. orbonalis* was done and cypermethrin was found to be the most effective followed by carbaryl and endosulfan with high yield potentials. Neem based insecticides were found least effective against this pest [28].

The release of *T. chilonis* was dosage @ 1 00000/ha showed more than the fifty percent parasitization from the present findings this was contrary to earlier work done by researchers. The inundative releases of egg parasitoid, *T. chilonis* in eggplant fields reduced the damage caused by *L. orbonalis*. A release rate of 2.5 lakh adults/ha was attempted to manage the pest population and recorded only about 19 percent fruit damage at the end. Further reduction in fruit borer damage to 10 percent was obtained when release of egg parasitoid, *T. chilonis* was commenced, coinciding the flower initiation with a release rate of @ 5.00 lakh adults/ha. From the southern part of India, Ganga Visalakhi and Krishnamoorthy (2005) reported that releasing of egg parasitoid *T. chilonis* alone @ 5 lakh/ha minimized infestation of BSFB to 10 percent, accounting for 80 percent reduction in borer infestation over control. However, at present cost of per release @ 1.0 lakh will be Rs. 300, while at higher dosages @ 5.0 lakh, it will be Rs. 1500 per release, which will be exorbitant considering that six releases per season will cost Rs. 9000.

4.3 Total fruit yield/ha

The overall total quantity of fruits per ha ranged from 16.24 to 24.72 ton/ha in summer season. The highest quantity of fruits was recorded in *T. chilonis* + cypermethrin treatment (24.72 ton/ha), in cypermethrin treatment (20.73 ton/ha), in *T. chilonis* (18.15 ton/ha) and minimum in control (16.24 ton/ha).

Raja *et al*. [29] recorded the yield of 20.3 t per ha in *T. chilonis* released plots compared to 13.06 t/ha in control on brinjal crop. Similar findings shown by Shobharani and Nandihalli [30] reported that Dipel 8L @ 2.0 ml/l sprayed three times and inundative release of *T. chilonis* Ishii @ 2.0 lakh/ha were found significantly superior in reducing the shoot infestation and recorded higher tuber yields of 33.05 and 29.72 q/ha, respectively. However, Rahman *et al*. [23] recorded highest yield in insecticide treated plots (32.7 tons/ha) compared to other treatments.

The present findings showed that the management of *L. orbonalis* sole control of the pest is not possible when comparing with the integration of different management practices was effective for the managing *L. orbonalis*. The present study revealed that combination of *T. chilonis* + cypermethrin were effective when compared to single management practices. The results were positive with the release of *T. chilonis* alone was not effective to control *L. orbonalis* which is similar to the observation of Alam *et al*. [31], Visalakhi and Krishnamoorthy [32], Krishnamoorthy [33], Singh *et al.* [34], Suradkar *et al*. [35]. Ghananand *et al.* [36], Dutta *et al.* [37] and Krishnamoorthy [38], and indicating that two or more combination are better for the management of brinjal shoot and fruit borer.

Table 1: Effect of release of *T. chilonis*, application of cypermethrin and their combinations on percent shoot infestation and percent reduction of shoot infestation by brinjal shoot and fruit borer over control under field condition during summer (2013-14)

Treatments	*** Shoot infestation/10 plants - Days after treatment (DAT) with insecticide/release of T. chilonis**													
	Pretreatment		**15 DAT**		**30 DAT**		**45 DAT**		**60 DAT**		**75 DAT**		**90 DAT**	
	% shoot infestation	**% reduction of shoot infestation over control**	**% shoot infestation**	**% reduction of shoot infestation over control**	**% shoot infestation**	**% reduction of shoot infestation over control**	**% shoot infestation**	**% reduction of shoot infestation over control**	**% shoot infestation**	**% reduction of shoot infestation over control**	**% shoot infestation**	**% reduction of shoot infestation over control**	**% shoot infestation**	**% reduction of shoot infestation over control**
T. c	36.25 (37.01)	3.97 (11.41)	23.00 (28.64)^{b}	19.01 (25.49)^{c}	16.77 (24.14)^{b}	16.15 (23.55)^{c}	12.83 (20.94)^{b}	25.96 (30.19)^{c}	10.14 (18.53)^{b}	22.83 (28.45)^{c}	6.57 (14.79)^{b}	30.32 (32.67)^{c}	4.50 (12.19)^{b}	33.33 (34.76)^{c}
T. + I	36.50 (37.16)	3.31 (10.42)	13.40 (21.44)^{d}	52.81 (46.40)^{a}	9.93 (18.35)^{d}	50.35 (45.22)^{a}	7.67 (16.04)^{d}	55.74 (48.24)^{a}	3.86 (11.27)^{d}	70.62 (57.27)^{a}	2.14 (8.32)^{d}	77.30 (61.80)^{a}	1.63 (7.29)^{d}	75.85 (60.22)^{a}
I	36.75 (37.31)	2.64 (9.24)	18.00 (25.65)^{c}	36.61 (34.94)^{b}	11.93 (20.17)^{c}	40.35 (39.40)^{b}	10.00 (18.38)^{c}	42.29 (40.44)^{b}	6.57 (14.77)^{c}	50.00 (44.84)^{b}	4.29 (11.84)^{c}	54.50 (46.25)^{b}	3.25 (10.34)^{c}	51.85 (45.49)^{b}
C	37.75 (37.83)	-	28.40 (32.69)^{a}	-	20.00 (26.56)^{a}	-	17.33 (24.58)^{a}	-	13.14 (21.24)^{a}	-	9.43 (17.83)^{a}	-	6.75 (15.02)^{a}	-
S. Em±	-	-	0.66	1.85	0.55	1.36	0.67	1.28	0.59	1.69	0.65	2.48	0.53	2.41
CD (5%)	-	-	2.04	6.04	1.69	4.44	2.07	4.17	1.83	5.50	2.00	8.10	1.62	7.85
CV (%)	6.81	13.10	5.50	11.64	5.52	8.44	7.53	7.22	8.80	8.67	11.04	11.84	10.49	11.49

Note: *Mean of five replications; Figures within the Parentheses are arc sine; In a column means followed by same letter(s) are not significantly different as per DMRT;* Significant at 5%; NS= Non-Significant; T. c- Trichogramma chilonis; I – Insecticide (Cypermethrin); C – control.

Table 2: Effect of different treatments on number of shoots per plot and percent shoot infestation caused by brinjal shoot and fruit borer during summer (2013-14)

Treatments	**No. of healthy shoots/plot**	**No. of infested shoots/plot**	**% infestation by number basis**	**% reduction in shoot infestation over control**
	Number basis			
T. chilonis	106.06 (10.16)^{c}	16.80 (4.00)^{b}	13.67 (22.35)^{b}	19.35 (27.52)^{c}
***T. chilonis* + Cypermethrin**	112.23 (10.46)^{a}	10.63 (3.02)^{d}	8.65 (17.16)^{d}	48.96 (47.87)^{a}
Cypermethrin	109.26 (10.31)^{b}	13.60 (3.54)^{c}	11.06 (19.83)^{c}	34.74 (38.38)^{b}
Control	102.03 (9.96)^{d}	20.83 (4.49)^{a}	16.95 (24.98)^{a}	-
S. Em±	0.04	0.10	0.59	1.46
CD (5%)	0.12	0.31	1.76	4.50
CV %	1.05	7.45	7.45	10.20

Note: Mean of fifteen days interval observation; Figures within the Parentheses are square root and arc sine transformations; In a column means followed by same letter(s) are not significantly different as per DMRT;* Significant at 5%; NS= Non-Significant.

Table 3: Effect of different treatments on number of fruits per plot and percent fruit infestation caused by brinjal shoot and fruit borer during summer (2013-14)

Treatments	No. of healthy fruits/ plot	No. of infested fruits/ plot	Total no. of fruits/plot	% infestation by weight basis	% reduction in fruit infestation over control
	* Weight basis (Kg)				
T. chilonis	16.31^{c}	8.48^{b}	24.79^{c}	34.20 (35.04)^{b}	36.43 (37.21)^{c}
***T. chilonis* + Cypermethrin**	30.73^{a}	3.03^{d}	33.76^{a}	8.97 (18.46)^{d}	83.32 (62.37)^{a}
Cypermethrin	22.42^{b}	5.91^{c}	28.32^{b}	20.86 (27.16)^{c}	61.22 (50.81)^{b}
Control	10.25^{d}	11.94^{a}	22.19^{d}	53.80 (47.56)^{a}	-
S. Em±	0.67	0.32	0.83	1.29	2.10
CD (5%)	1.98	0.94	2.46	3.81	6.46
CV %	8.87	11.52	8.03	10.60	11.06

Note: *Mean of fifteen days interval observation; Figures within the Parentheses are arc sine transformations; In a column means followed by same letter(s) are not significantly different as per DMRT;* Significant at 5%; NS= Non-Significant

Table 4: Effect of different treatments on fruit yield of brinjal against brinjal shoot and fruit borer infestation during summer (2013-14)

Treatments	Healthy fruit yield		Infested fruit yield		Total fruit yield	
	t/ha	Increase over control (%)	t/ha	Decrease over control (%)	t/ha	Increase over control (%)
T. chilonis	11.94^{c}	37.18 (37.26)^{c}	6.21^{b}	28.94 (32.18)^{c}	18.15^{c}	10.52 (19.07)^{c}
T. chilonis + Cypermethrin	22.50^{a}	66.66 (53.59)^{a}	2.22^{d}	74.59 (59.66)^{a}	24.72^{a}	34.30 (35.89)^{a}
Cypermethrin	16.41^{b}	54.29 (44.94)^{b}	4.32^{c}	50.57 (45.50)^{b}	20.73^{b}	22.18 (27.83)^{b}
Control	7.50^{d}	-	8.74^{a}	-	16.24^{d}	-
S. Em±	0.55	1.47	0.26	1.97	0.56	1.07
CD (5%)	1.66	3.62	0.78	6.07	1.69	3.32
CV %	10.13	6.20	12.97	11.39	7.66	10.35

Note: Mean of fifteen days interval observation; Figures within the Parentheses are arc sine transformations; In a column means followed by same letter(s) are not significantly different as per DMRT;* Significant at 5%; NS= Non-Significant

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