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Botanicals Vs Insecticides : Relative safety of recommended botanicals / insecticides for the management of Fall armyworm against *Telenomus remus*

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Abstract

The present study aimed to assess the safety of insecticides and botanicals for FAW management against *Telenomus remus*. Laboratory investigation on the effect of botanicals / insecticides on the parasitic potential of *T. remus* on FAW eggs revealed maximum parasitization and parasitoid emergence from chlorantraniliprole treated eggs (97.2 and 95.4 %) followed by azadirachtin, emamectin benzoate, flubendiamide and Spinetoram. Similarly, pot culture study revealed maximum parasitization (97.0%) and parasitoid emergence (90.1%) in egg masses treated with chlorantraniliprole indicating the relative safety of chlorantraniliprole to *T. remus*. Chlorantraniliprole and emamectin benzoate control Fall armyworm. The foregoing experimental results show that *T. remus* can be a good candidate for integrated FAW management.

Keywords: *Spodoptera frugiperda, Telenomus remus; FAW; Insecticides; Safety*

Introduction

Invasive alien species pose a serious threat to agriculture and cost billions of dollars in terms of reduced production and productivity, mainly due to increased transboundary movement of agricultural commodities, anthropogenic activities, climate change, etc. Sharanabasappa *et al.,* (2018) initially reported the Fall armyworm (FAW), *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in India. The FAW is native to tropical and subtropical America, where it attacks more than 100 hosts (CABI, 2020). This pest was only found in America until 2015. In 2016, it damaged maize crops in Africa (Goergen et al., 2016) and India (Sharanabasappa *et al.,* 2018). In India, chemical pesticides are being used to combat FAW. Frequent pesticide use can lead to resistance and cause residues.

In order to minimize pesticide use and develop, promote, and execute sustainable FAW control, biological control-based pest management becomes eco-friendly and sustainable. Crop pests' natural enemies play a vital role in biological control. *Telenomus remus* Nixon is a unique lepidopteran parasitoid, and various research has evaluated its effectiveness on FAW eggs (Fernandes *et al.,* 2015). *T. remus* wasps have great fertility, seeking capability, and dispersal ability (Cave, 2000). In their lifetime, they can parasitize 250 eggs (Pomari *et al.,* 2013). These traits make *T. remus* a good fall armyworm biocontrol agent. It's necessary to assess the safety of insecticides and botanicals advised for FAW management against *T. remus*.

Materials and Methods

Host culture of Fall armyworm, *S. frugiperda*

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Disease-free healthy colonies of FAW were maintained at the Department of Agricultural Entomology, Centre for Plant Protection Studies, Tamil Nadu Agricultural University. For culturing the FAW, field-collected larvae were placed individually in plastic containers (30 x 40 x 40 mm) and provided with an artificial diet until pupation (Bueno *et al*., 2009). The lids of the containers were provided with holes of 12 mm in diameter covered with a fine mesh synthetic fabric for ventilation purposes. After pupation, Pupas were kept in adult emergence cages (30 x 30 x 30 cm). The adults emerging from the pupa were sexed and released in pairs into oviposition cages for mating. The adults were fed with sugar: honey solution in the ratio of 1:1, supplemented with two to three drops of Vitamin E and Zincovit. Fifteen-day-old maize seedlings produced through hydroponics were provided as an oviposition substrate. The eggs from the seedlings were collected and transferred to maize seedlings grown in the screen house by hydroponics and left inside clear, transparent plastic boxes (17 x 11 x 5 cm) containing the diet pieces. The second or early third instar larvae were transferred to individual rearing containers with diet pieces until pupation to avoid cannibalism. So, the culture was maintained continuously and used for various experiments (Bueno *et al*., 2010).

Culturing of egg parasitoid, *T. remus*

Telenomus remus Nixon nucleus culture was procured from NBAIR (National Bureau of Agricultural Insect Resources), Bengaluruas parasitized egg cards and kept in a plastic container (18 X 7 X 7 cm exposure container) for emergence. The adult parasitoids were provided with honey through cotton swabs and allowed to mate for 24 hours. Freshly laid egg masses of FAW were glued to paper strips with a thin layer of gum arabic / non–toxic glue (3 to 4 egg masses/paper strips of 3 x 5 cm) and shade dried for 5 to 10 minutes at room temperature. The egg cards were introduced into a plastic container (18 X 7 X 7 cm)for parasitization by mated females of *T. remus* at with the parasitoid host ratio of 1:40 (Pomari *et al*., 2013). Fresh egg cards were provided once in 24 hours until all adults died. The parasitized cards were maintained separately for parasitoid emergence. Thus, the parasitoid culture was maintained continuously for experimental purposes.

Impact of recommended botanicals / insecticides for the management of Fall armyworm on the parasitic potential and adult emergence of *T. remus*

Freshly laid *S. frugiperda* egg masses were glued to paper strips (3 X 5 cm) (Bueno *et al*., 2010), shade dried and kept in a plastic container (18 X 7 X 7 cm). The insecticides / botanicals recommended for the management of Fall armyworm *viz.,* spinetoram 12 SC, flubendiamide 480 SC, chlorantraniliprole 18.5 SC, emamectin benzoate 5 SG and azadirachtin 1500 ppm at 1 / 100 of the field dose were sprayed separately using hand atomizer on the egg cards containing freshly laid FAW eggs and then subjected to parasitization by *T. remus* at the parasitoid: host ratio 1:40 to assess the relative safety (Shankarganesh *et al*., 2013). The experiment was conducted in a CRD with six treatments and four replications. Observations were recorded on the per cent parasitization and per cent parasitoid emergence.

The relative safety of insecticides and botanicals recommended for the management of FAW against *T. remus* – A pot culture experiment

Pot culture study was carried out to assess the relative safety of insecticides / botanicals recommended for the management of FAW against *T. remus* following the standard protocols of International Organization for Biological Control (IOBC) (Hassan, 1985). Maize plants were raised in plastic pots (15 X 8 X 8 cm) and at 15 days of sowing, mated females of FAW were allowed to lay eggs individually in each seedling covered with mylar film cages. After 24 hours of egg laying, the moths were removed from the cages and the number of eggs in each egg masses were counted using a 10 X hand lens. Insecticides / botanicals *viz.,* spinetoram 12 SC @ 0.5 ml/lit, flubendiamide 480 SC @ 0.4 ml/lit, chlorantraniliprole 18.5 SC @ 0.4 ml/lit, emamectin benzoate 5 SG @ 0.4 g/lit and azadirachtin 1500 ppm @ 2 ml/lit recommended for the management of FAW was sprayed on FAW egg masses laid on maize seedlings (15 DAS) using hand atomizer (Shankarganesh *et al*., 2013). The insecticide / botanical sprayed eggs were subjected to parasitization by *T. remus* at the parasitoid:host ratio 1:20 to assess the relative safety. The experiment was conducted in CRD with six treatments and four replications. Observations were recorded on the per cent parasitization and per cent parasitoid emergence.

Statistical Analysis

Percent parasitization and adult emergence were calculated. The data were subjected to arcsine transformation with AGRES software. The means were separated by LSD (Least Significant Difference) (Laminou *et al*., 2020).

Results and Discussion

Laboratory investigation on the effect of botanicals / insecticides on the parasitic potential of *T. remus* on FAW eggs revealed maximum parasitization and parasitoid emergence from chlorantraniliprole treated eggs (97.2 and 95.4 %) followed by azadirachtin (93.7 and 92.1 %), emamectin benzoate (48.6 and 45.2%), flubendiamide (54.6 and 38.1 %) and Spinetoram (33.0 and 25.7 %) (Table 1).

Pot culture experiment on the effect of botanicals / insecticides on the parasitic potential of *T. remus* on FAW eggs revealed that maximum parasitization and parasitoid emergence (97.0 and 90.1%) was in chlorantraniliprole treated eggs, followed by azadirachtin (95.9 and 88.0%), emamectin benzoate (45.9 and 24.0%), flubendiamide (33.2 and 15.9%), and Spinetoram (27.1 and 9.0%) (Table 2; Fig. 1).

The results agree with Liu *et al.* (2016), who found chlorantraniliprole and emamectin benzoate is safe for *T. remus*. When *T. remus* egg mass was sprayed with Azadirachtin, more viable adults emerged. Tomlin (2003) found emamectin benzoate to be reasonably safe for all *T. remus* life stages. Our findings agree with Bueno *et al*. (2009), who found that the parent parasitoid chose the host egg efficiently because it supplies food reserves for the offspring. Chlorantraniliprole's safety to *T. remus* may explain why it parasitizes chlorantraniliprole-treated egg masses. Though, chlorantraniliprole has potent ovicidal properties, it was found to be safe to the FAW egg masses parasitized by *T. remus* which is in affirmation with the findings of Preetha *et al*. (2009) and Sharma (2005) who reported that chlorantraniliprole was safe and harmless to the egg parasitoid, *Trichogramma chilonis.* This may be due to the fact that, the biochemical changes that take place within the host egg due to parasitization might have led to the reduction in ovicidal action and ineffectiveness of chlorantraniliprole on the FAW eggs parasitized by *T. remus*.

Conclusion

Chlorantraniliprole and azadirachtin were found to be safe to the most promising parasitoid, *T. remus*. Hence, the *T. remus* can be effectively deployed in the management of the capsule of Fall armyworm. Further, confirmation under field conditions will pave way for the effective deployment of the parasitoid, *T. remus* for the eco-friendly management of fall armyworm.

Table 1. Effect of botanicals / insecticides on the parasitic potential of *T. remus* on FAW eggs

Treatment	Parasitization (%)*	Parasitoid Emergence (%)*
Spinetoram 12 SC @ 0.5 ml/lit	33.0 (35.06)[c]	25.7 (30.43)[d]
Flubendiamide 480 SC @ 0.4 ml/lit	54.6 (47.61)[b]	38.1 (38.11)[c]
Chlorantraniliprole 18. 5 SC @ 0.4 ml/lit	97.2 (80.39)[a]	95.4 (77.67)[ab]
Emamectin benzoate 5 SG @ 0.4 g/lit	48.6 (44.21)[b]	45.2 (45.13)[c]
Azadirachtin 1500 ppm @ 2 ml/lit	93.7(75.41)[a]	92.1 (75.96)[b]
Control	97.0 (80.07)[a]	97.4 (80.74)[a]
SE (d)	2.69	2.28
CD (0.05)	5.65	4.79

*The values are mean of four replications; Figures in parentheses are arcsine transformed values; Means followed by different letters differ significantly at (p=0.05); Means were differentiated by LSD.

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Table 2. The relative safety of insecticides and botanicals recommended for the management oFAW against *T. remus*– A pot culture experiment

Insecticide	Egg mass laid on Maize seedlings	
	Parasitization (%)*	Parasitoid Emergence (%)*
Spinetoram 12 SC @ 0.5 ml/lit	27.1(31.33)[e]	9.0(17.37)[e]
Flubendiamide 480 SC @ 0.4 ml/lit	33.2(35.19)[d]	15.9(23.41)[d]
Chlorantraniliprole 18. 5 SC @ 0.4 ml/lit	97.0(79.99)[ab]	90.1(71.90)[b]
Emamectin benzoate 5 SG @ 0.4 g/lit	45.9(42.62)[c]	24.0(29.26)[c]
Azadirachtin 1500 ppm @ 2 ml/lit	95.9(78.34)[b]	88.0(69.93)[b]
Control	98.2(82.31)[a]	96.2(78.89)[a]
SE (d)	1.13	2.05
CD (0.05)	2.38	4.32

*The values are mean of four replications; Figures in parentheses are arcsine transformed values; Means followed by different letters differ significantly at (p=0.05). Means were differentiated by LSD.

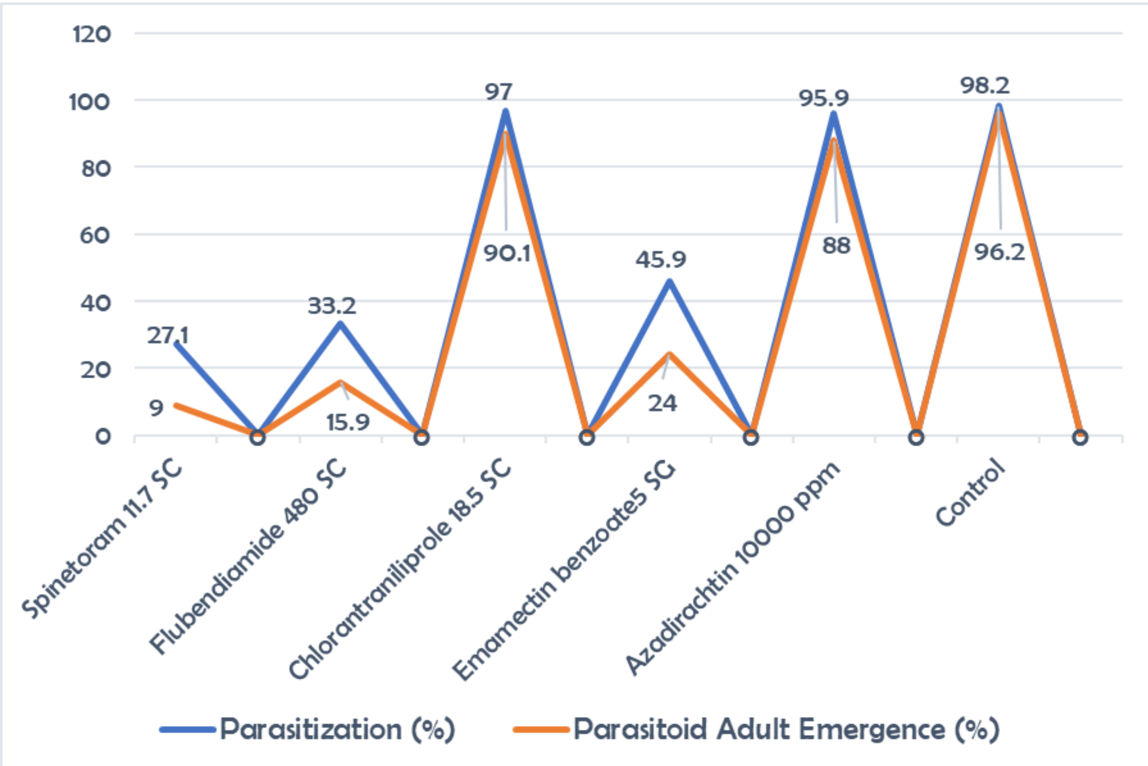

Fig1. Relative safety of insecticides and botanicals recommended for the management of FAW against *T. remus*

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Ethics statement

Consent for publication

All the authors agreed to publish the content.

Competing interests

There was no conflict of interest in the publication of this content

Data availability

Enough data was generated from thisstudy.

Author contributions

SJ, NS, SM and SN provided the technical guidance. SLP carried out the research

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