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# Safety evaluation of natural products and insecticides to *Encarsia formosa* Gahan, an endoparasitoid of *Trialeurodes vaporariorum* Westwood

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# Abstract

*Encarsia formosa* Gahan (Hymenoptera: Aphelinidae) is one of the most efficacious natural enemies used as biological control against *Trialeurodes vaporariorum* Westwood. Insecticides have a negative impact on non-target species such as natural enemies. Therefore, present studies were conducted to evaluate cattle bye-products based natural products namely, *Agniastra, Darekastra*, fermented butter milk, *Tamralassi* and vermiwash at 10%, biopesticide (azadirachtin @ 0.00045%) and chemical insecticides, spiromesifen (0.02%) and imidacloprid (0.005%) for the safety to adults of *E. formosa*. Dry film method of bioassay was deployed under laboratory conditions. Results revealed that *Agniastra, Darekastra*, fermented butter milk, *Tamralassi*, vermiwash and azadirachtin resulted in 23.15, 13.66, 17.36, 15.74, 15.74 and 30.22% adult mortality, respectively being harmless, whereas, spiromesifen and imidacloprid resulted in 53.27 and 58.83% mortality, respectively being slightly harmful to *E. formosa.*


# Introduction

Greenhouse whitefly (GHWF), *Trialeurodes vaporariorum* Westwood and red spider mite, *Tetranychus urticae* Koch are the serious pests of vegetable crops grown under protected environment in north-western Indian Himalayan regions (Sood et al., 2018, Ghongade and Sood, 2021). Under protected environment, greenhouse whitefly breeds throughout the year and completes thirteen generations in a year (Sood et al. 2014). *Trialeurodes vaporariorum* inflicts losses to the extent of 50 per cent in different crops (Byrne and Bellows, 1991; McKee et al., 2007; Sood et al., 2018). *Encarsia formosa* Gahan (Hymenoptera: Aphelinidae) is one of the most efficacious and commercialized natural enemies used as biological control against *T. vaporariorum* throughout the world (Hoddle et al., 1998). *Encarsia formosa* is a thelytokus endoparasitoid, which not only parasitizes their hosts, but also kill them by host feeding (Zang and Liu 2008). In India, Singh and Sood (2018) and Singh et al. (2018) for the first time observed parasitization of *T. vaporariorum* by *E. formosa* to vary from 31.8 to 93.6 per cent during different seasons in tomato crop grown in polyhouses where no or minimum insecticidal applications were made.

At present, chemical insecticides are being commonly used for the greenhouse whitefly suppression. Use of chemical insecticides has caused the whitefly to develop resistance to compounds with various modes of action, including newer chemical classes such as neonicotinoids (Sood et al., 2003; Wang et al., 2017). In addition, insecticides have a negative impact on non-target species such as natural enemies (Gorman et al., 2002; Singh and Sood 2018; Wang et al., 2019). Therefore, integrated pest management comprising biological control agents and safe use of insecticides is considered to be a sustainable approach for the suppression of the whitefly. Also, Thakur and Sood (2020) evaluated and documented the toxic properties of cattle bye-products derived natural products. Yankoval et al. (2011) reported Bio Neem Plus 1.5 EC (azadirachtin) to be non-toxic to *E. formosa.* Singh and Sood (2018) observed soil application of imidacloprid (0.009%) followed by foliar application of azadirachtin (0.00003%) to be safer to *E. formosa*. Considering the importance of *E. formosa* as a potential biological control agent of the greenhouse whitefly, studies were undertaken to evaluate natural products, biopesticides and insecticides for their safety to adults of *E. formosa.*

# Material And Methods

Laboratory culture of the parasitoid, *E. formosa* was maintained at room temperature on young potted plants of French bean infested with greenhouse whitefly. For this purpose, mummified immatures of GHWF were initially collected from tomato plants grown in the polyhouses and were brought to the laboratory and kept for adult emergence in Petri plates (5x1.5 cm dia). The adults were transferred to potted French bean plants having different nymphal instars of GHWF with the help of aspirator. The plants having GHWF immatures were exposed periodically to ensure continuous supply of the parasitoid.

Toxicity of natural products (*Agniastra, Darekastra*, fermented butter milk, *Tamralassi* and vermiwash), biopesticide (azadirachtin) and insecticides (imidacloprid and spiromesifen) was evaluated at their recommended field dose against *E. formosa* adults. The composition of natural products is being presented in Table 1. Dry film method of bioassay was used to evaluate the safety of these products to the natural enemy. These products/ formulations were diluted with distilled water. Leaf discs of French bean (dia 4.5 cm) were dip treated for one minute in each test concentration, shade dried and placed on bed of agar gel (1.5%) in glass Petri plates (dia: 5 cm) by keeping the abaxial leaf surface upward. The experimentation was replicated three times. One set of leaf discs dipped in distilled water was kept as check with equal number of replications. Ten adults of *E. formosa* (2 days old), were transferred to each Petri dish which were then covered with cling film perforated with paper pin to avoid deposition of moisture. Observations on mortality of *E. formosa* adults were recorded at 48 hrs after treatment. Moribund adults were also considered as dead. Corrected mortality was determined using Abbot's formula (1925). Evaluated natural products/ insecticides were grouped from harmless to harmful to *E. formosa* adults as per method suggested by Hassan *et al.* (1995).

Table 1
Natural products/ biopesticide formulations evaluated for safety to Encarsia formosa

| Natural product/ biopesticide/ insecticide | Composition/ Formulation | Recommended field application rate (%) |
|---|---|---|
| *Agniastra* | Ipomoea leaves (1kg), Melia leaves (5kg), red chilly (500g), cow urine (10 L), garlic (500 g), water (10–12 L) | 10.0 |
| Azadirachtin | Neem-baan 0.15 EC* | 0.00045 |
| *Darekastra* | Melia leaves (5 kg), cow urine (5 L), cow dung (2 kg) and water (100 L) | 10.0 |
| Fermented butter milk | Prepared from cultured milk | 10.0 |
| Imidacloprid | Confidor 17.8 SL* | 0.005 |
| Spiromesifen | Oberon 240 SC* | 0.02 |
| *Tamralassi* | Prepared by keeping the fermented butter milk in copper pot for 10 to 15 days | 10.0 |
| Vermiwash | Cow dung (3 kg), biomass (2 kg) and adult earthworms (200–300) | 10.0 |
| * Commercial formulation | | |

# Results And Discussion

Safety of natural products, biopesticide and insecticides evaluated against *E. formosa* adults revealed the insecticidal treatments to influence the adult survival significantly (Table 2). Based on mean mortality, maximum adult mortality was recorded in insecticidal treatments namely, imdiacloprid (0.005%) and spiromesifen (0.02%) which being at par to each other. It was followed by the mortality recorded in azadiractin (0.00045%) and *Agniastra* (10%). *Darekeastra* (10%) resulted in minimum mortality and was preceded by vermiwash and *Tamarlassi*. The interaction amongst the insecticidal treatments and the presence and absence of host was found to be non-significant. All natural products at evaluated concentration of 10 per cent and azadirachtin (0.00045%) were categorized to be harmless as these resulted in mortality being less than 50 per cent, whereas imidacloprid (0.005%) and spiromesifen (0.02%) were categorised as slightly harmful to the adults of *E. formosa* (Table 3; Fig. 1).

Table 2

**Toxicity of natural products, biopesticides and insecticides to adults of** Encarsia formosa

| **Natural product/ biopesticide/ insecticides** | **Conc. (%)** | **Adult mortality (%) after 48 hrs in the prence and absence of immatures of GHWF** | | |
|---|---|---|---|---|
| | | **Host present (+)** | **Host absent (-)** | **Mean** |
| *Darekastra* | 10 | 15.28 (22.76) | 12.04 (20.29) | 13.66 (21.52) |
| *Agniastra* | 10 | 22.68 (28.03) | 23.61 (28.65) | 23.15 (28.32) |
| Vermiwash | 10 | 15.28 (22.76) | 16.20 (23.39) | 15.74 (23.08) |
| Fermented butter milk | 10 | 22.68 (28.03) | 12.04 (20.29) | 17.36 (24.16) |
| *Tamarlassi* | 10 | 15.28 (22.76) | 16.20 (23.39) | 15.74 (23.08) |
| Azadirachtin | 0.00045 | 32.67 (34.70) | 27.78 (31.75) | 30.22 (33.27) |
| Imidacloprid | 0.005 | 57.93 (49.61) | 59.72 (50.65) | 58.83(50.14) |
| Spiromesifen | 0.02 | 54.23 (47.43) | 52.31 (46.35) | 53.27(46.90) |
| Mean | | 29.50 (32.01) | 27.49 (30.60) | |

Figures in parentheses indicate arc sine transformed values; Mean values within the columns bearing the same letters are not significantly different- LSD (*P*=0.05)

| LSD $_{(P=0.05)}$ | |
|---|---|
| Treatments (A) | 5.84 |
| Host +/- (B) | NS |
| A × B | NS |

Table 3

**Categorization of toxicity of natural products/ biopesticides/ insecticides to *Encarsia formosa***

| Natural products/ biopesticides/ insecticides | Conc. (%) | Mean mortality | Toxicity category* |
|---|---|---|---|
| *Agniastra* | 10 | 23.15 | Harmless |
| Azadirachtin | 0.00045 | 30.22 | Harmless |
| *Darekastra* | 10 | 13.66 | Harmless |
| Fermented butter milk | 10 | 17.36 | Harmless |
| Imidacloprid | 0.005 | 58.83 | Slightly harmful |
| Spiromesifen | 0.02 | 53.27 | Slightly harmful |
| *Tamarlassi* | 10 | 15.74 | Harmless |
| Vermiwash | 10 | 15.74 | Harmless |
| * As per Hassan *et al.* (1995) | | | |

In our findings it was revealed that chemical insecticides namely, imidacloprid and spiromesifen were slightly harmful to the adults of *E. formosa* which derives support from the findings of Singh and Sood (2018) where they recorded lower activity of the parasitoid in spiromesifen and thiamethoxam treatments in tomato crop grown under protected environment. Zhan et al. (2018) reported imidacloprid to have high or medium acute toxicity against *E. formosa.* The natural products and biopesticide formulations evaluated in present studies were found to be harmless which derives support from the findings of Simmonds et al. (2002) who observed *Azadirachta indica* derived products to have potential for use in IPM system for the control of whitefly as it being highly toxic to whitefly and less toxic to the parasitoids. Feldhege and Schmutterer (1993) observed application of 10 ppm of azadirachtin to be relatively non-toxic to *E. formosa*, whereas the concentration of 20 ppm led to a slight but significant reduction of the fitness of *E. formosa.* Yankoval et al. (2011) reported Bio Neem plus 1.5 EC (azadirachtin) to be non-toxic to *E. formosa.*

# Conclusion

Imidacloprid and spiromesifen proved to be slightly harmful to the adults of *E. formosa* whereas natural products and azadirachtin were found to be harmless which can be incorporated in integrated greenhouse whitefly management programme.

# Declarations

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### Declarations of Competing interests

The authors declare no competing interests.

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# Figures

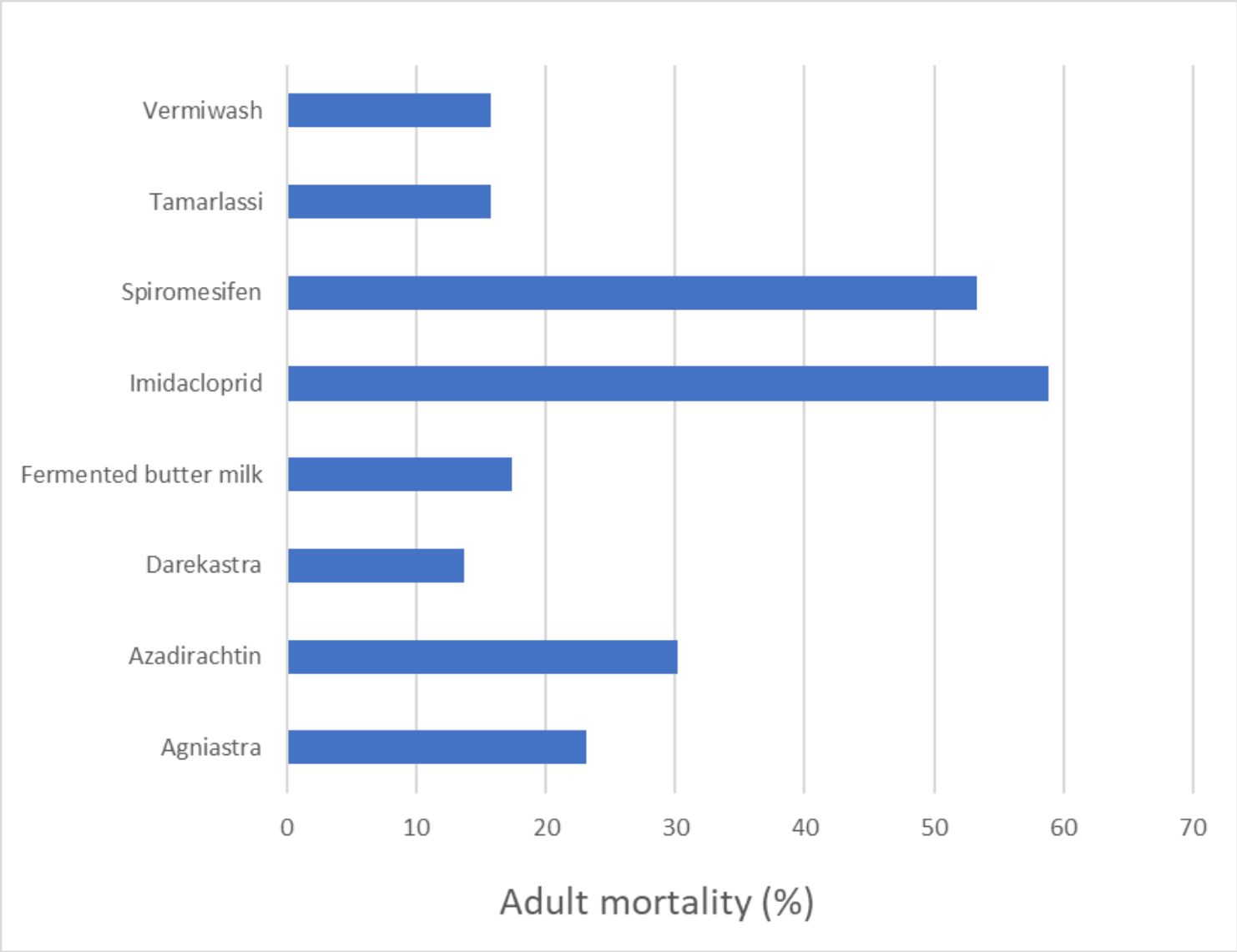


**Figure 1**

**Toxicity spectrum of natural products/ biopesticides/ insecticides to *Encarsia formosa***