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Parasitism potential of biological control agents of fruit fly under natural enemy field reservoirs (NEFR) technology

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Abstract

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The tephritid fruit flies are the major pest of horticultural crops, causing severe economic losses globally. The present study was focused on natural enemies' field reservoir (NEFR) technique for providing a safe habitat to the already existing natural enemies of the target pest by manipulating the existing environment on the farmer field. The current study investigated different techniques to maximize the NEFR activity. The infested guava fruits were collected and placed in NEFR trays to record the percent parasitism at Sharaqpur district Punjab Pakistan. Three biological agent species i.e., *Diachasmimorpha longicaudata, Trybliographa daci* and *Dirhinus giffardii* were recorded with maximum parasitism in September and minimum in November. The current study provides baseline to support the use of NEFR technology to conserve the natural enemies for fruit flies management in other regions of Pakistan.

Keywords: fruit fly; Biological control; NEFR technology; parasitism

Introduction

The fruit flies (Diptera: Tephritidae) are major economic horticultural and agricultural pests worldwide (Dhillon et al., 2005). More than 5000 species have been reported as a considerable threat to vegetables and fruits throughout the globe (Quilici et al., 2005; Vargas et al., 2008; Ryckewaert et al., 2010) causing severe economic damage resulting in 40% to 100% yield reduction (Shi et al., 2017; Mateos et al., 2020).

Globally, chemical control is excessively adopted as the first line of defence strategy against fruit flies. However, the non-judicious use of chemicals has resulted in insecticides resistant development. In addition, chemical pesticides have contributed to negative effects on the environment, health and biodiversity (Vayssieres et al., 2008: Ryckewaert et al., 2010; Alam et al., 2016).

There is a dire need to adopt eco-friendly alternate management techniques (Vargas et al., 2012). Currently, the integrated pest management (IPM) approach combines different pest control methods to mitigate the adverse effects of pesticides (Deguine et al., 2011).

Under the category of sustainable pest management solutions, biological control has a long history. The number of available biological control agents and their area of usage is still expanding (Pilkington et al., 2010; Van Lenteren, 2012). The efforts to increase the persistence of natural enemies in field conditions could greatly enhance the robustness, efficacy and cost-effectiveness of biological control. In this regard, the use of orchard sanitation and release of parasitoid is one of the important techniques in the management of fruit flies' populations (Mziray et al., 2010). This preventive sanitation technique has been studied by United States Department of Agriculture (USDA)

in Huwaii against fruit flies, especially in the last decade with the use of augmentorium (Jang et al., 2007).

To adopt this concept as a management strategy, efforts have been made to study the different techniques to maximize the impact of biological control agents through conservation and augmentation of natural enemies (Mahmood et al., 2018). To enhance the impact of already existing natural enemies in the environment, a natural enemies field reservoir (NEFR) was established for fruit flies in the study area at Sharaqpur (mentioned below). The NEFR is a tent-like structure placed in a cultivated field. Farmer can regularly deposit infested fruits and vegetables. The parasitoid that are produced from trays disperse naturally in the environment (Bajwa et al., 2018) and parasitoids in the host stages including egg, larva and pupa. This technology can produce millions of parasitoids which dispersed in the environment (Mahmood et al., 2018) and reduce the pest population. The current study was conducted to assess the different approaches for placing infested fruits in the NEFR to maximize the impact of natural enemies.

Materials and Methods

Study area

This 2-year study (2018 and 2019) was carried out in Sharaqpur (31°27′48″ N 74°6′0″ E). The study was conducted under the consent of participating farmer.

Fruit sampling

During this study, the infested guava fruits were collected from June-November the peak (harvesting periods for the area). Three different approaches were tested for placing infested fruit in NEFR trays and recording the percent parasitism by natural enemies. The metallic box trays were prepared with dimension [75 cm (length) × 50 cm (width) × 50 cm (height)] and each tray was supported on 10cm long pegs at the four corners and place the trays under the shed which built-in Rawalpindi. The plastic bowls were filled with burn fuels and dip the pegs of the trays in the burn fuel to avoid the access of ants and other crawling insects. The infested guava fruits, collected from field were placed in NEFR trays containing sand as follows (Table 1).

After 9 days, the pupae were collected from NEFR trays for the emergence and parasitism percentage of natural enemies.

Species Identification

The collected pupae boxes (15 x 15 x 10 cm) were kept under control conditions i.e. 25 ± 2°C, 65 – 75% RH, and 14:10 (L:D) photoperiod as adopted earlier (Farooq et al., 2020). The emerged natural enemies' species were identified using Braconidae and Figitidae keys and maintained in ventilated transparent plastic cages (22.86 × 22.86 cm) with a mesh cloth sleeve and later released in the field areas.

Statistical Analysis

The data was pooled and the statistical analyses were performed with the help of Statistix (Version 8.1), Analytical Software. Data on means for different parameters were subjected to analysis of variance ANOVA followed by Tukey's Post Hoc LSD Test for the significance of data.

Results and Discussion

Fruit fly species composition

The results of the current study showed that two fruit fly species i.e., *Bactrocera zonata* and *Bactrocera dorsalis* emerged from the collected pupae. The species composition data showed that *B. zonata* specie was abundant in the area of study (Figure 1).

Natural enemies-species composition

The results of the current study showed that three fruit fly natural enemies i.e., *Diachasmimorpha longicaudata*, *Trybliographa daci* and *Dirhinus giffardii* emerged from the collected pupae (Table 2).

Table 1. Treatment description

Treatment	Description
T1	Fruits were first placed in plastic trays and then trays were placed on sand in NEFR trays
T2	Fruits were first placed in plastic plates and then trays placed on sand in NEFR trays
T3	Fruit were directly placed on the sand in NEFR trays
Control	Fruits were placed directly on ground with no shade provided

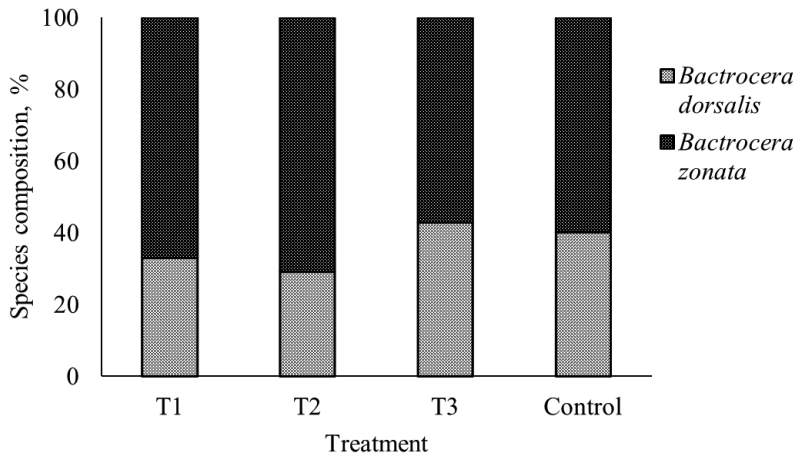

Fig. 1. Species composition for seasonal abundance of fruit fly species

The species diversity data showed that district Sharaqpur has greater abundance of *T. daci* followed by the *D. longicaudata;* while *D. giffardii* showed the least abundance in the area of study. Also, current study showed a similar trend in specie composition of natural enemies and were not significantly affected by the type of approach to place the infested fruit in NEFR trays (Figure 2).

Seasonal parasitism percentage of natural enemies

The results of current study showed that seasonal parasitism level for fruit fly natural enemies at Sharaqpur district was highest in month of September; irrespective of the approach to place the infested fruit in NEFR trays for both years (Figure 3). In addition, to maximise parasitism different approaches were used and maximum parasitism rate was observed in T3 where infested fruits were directly placed on the sand for both years.

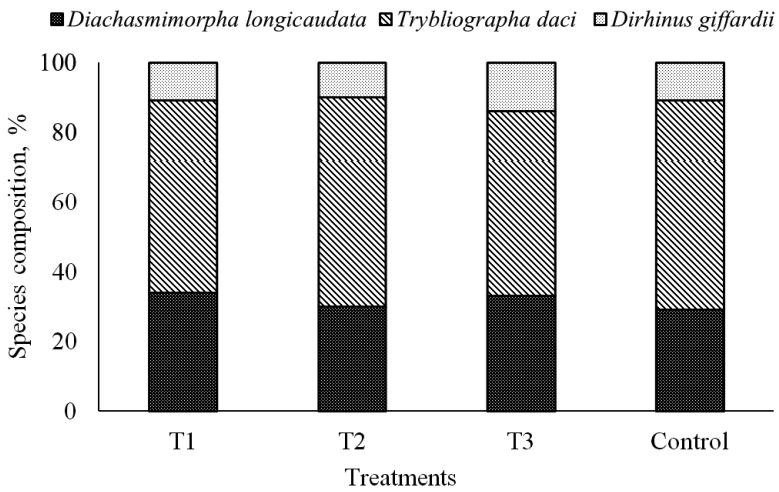

Fig. 2. Species composition for seasonal parasitism of natural enemies

Table 2. List of natural enemies emerged from NEFR

S/N	Type	Name	Family	Order
1	Larval-pupal parasitoid	*Diachasmimorpha longicaudata* (Ashmed)	Braconidae	Hymenoptera
2	Larval-Pupal parasitoid	*Trybliographa daci* (Weld)	Eucoilidae	Hymenoptera
3	Pupal parasitoid	*Dirhinus giffardii* (Silvestri)	Chalcididae	Hymenoptera

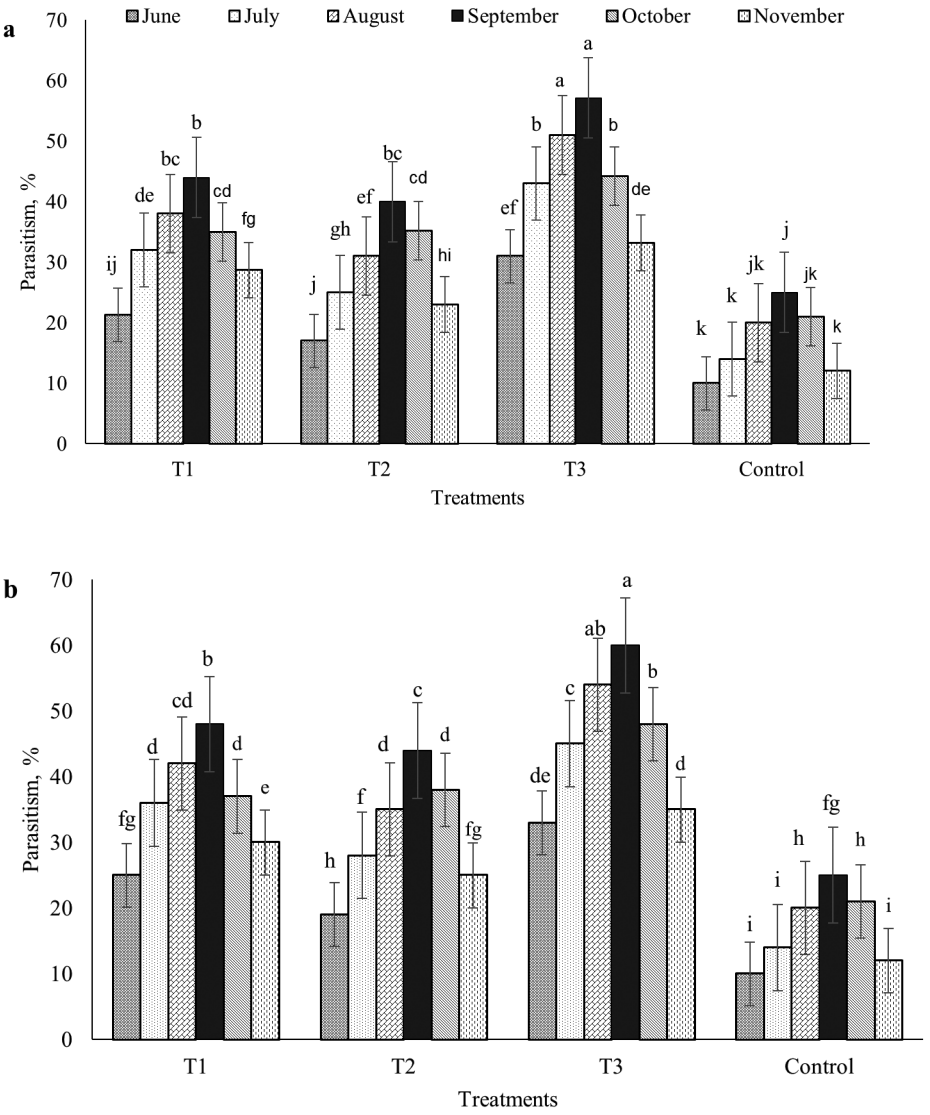

Fig. 3. Seasonal parasitism levels of natural enemies of fruit flies using different approaches for natural enemy field revisors at district Sharaqpur, Pakistan (a) 2018; (b) 2019

For year 2018, a maximum parasitism percentage of (57.1) was observed for T3 in September while minimum parasitism percentage (10.0) was observed for control treatment in June ($F = 161.36$, $P < 0.001$, $df = 2.53$) (Figure 3a).

For year 2019, a similar trend was observed where T3 showed a maximum parasitism percentage of (60.0) in month of September while minimum parasitism percentage (10.0) was observed for control treatment in month of June ($F = 157.2$, $P < 0.001$, $df = 2.53$) (Figure 3b).

The current study was based on the concept of conservation biological control which is a main approach to identify the need of reducing of pesticide application and integration of natural enemies into cropping system for natural control. For effective conservation and enhancement of natural enemies there is dire to understand the factors depressing natural enemy populations and inhibiting their ability to control pest populations.

In the current study efforts were made to document the seasonal activity of fruit flies and their related natural en-

emies in the area of study. The current study showed that two major fruit flies species (*Bactrocera zonata* and *Bactrocera dorsalis*) along with their two larval pupal (*Diachasmimorpha longicaudata*; *Trybliographa daci*) and one pupal parasitoid (*Dirhinus giffardii*) were recorded. The current showed that a higher level of *T. daci* presence in the infested fruits. Similar results were reported by Zain et al. (2020) where higher level of *T. daci* presence was observed in the study area.

The current study was based on the innovation to conserve natural enemies in the field conditions by providing them refugia. Based on suggestion from Mahmood et al. (2018) some modifications were made to apply this technique for fruit flies. Although there were some costs involved for the construction NEFR structure but that was only one-time investment as there are future advantages to be gained like environment protection and sustainability in pest management.

As NEFR technique is unique and limited studies are available therefore it is difficult to compare the result obtained with published literature. However, the NEFR technique can play an important role in conservation of natural enemies by providing natural habitat and act as revisors for increasing the population of biocontrol agents especially parasitoids (Mahmood et al., 2018).

Conclusions

Research activities conducted have given us more effective, cheaper, environmentally friendly, healthy, and sustainable Agro-ecological crop protection. The Biological control interventions of phytosanitary risk management program in Pakistan (PRMP) for fruit fly has relieved guava grower who were depriving due to immense losses caused by the fruit fly. Growers are willing to adopt biological control interventions for fruit fly because of its sustainability and profit generation. It also increased satisfaction level of guava growers for continuation and rather increasing guava farming as their primary source and income and livelihood. Furthermore, studies may also be conducted for technological improvements.

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