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Original Paper

Population Dynamics of Predatory Mites on Chilies and their Efficacy Against Whitefly (Aleyrodidae) Under Laboratory Conditions

Bilal Saeed Khan[a]*, Rehan Ahmad[a], Muhammad Farooq[b], Asif Qayyoum[a], Abdul Ghaffar[b] and Zahid Mehmood Sarwar[c]

[a]Department of Entomology, Faculty of Agriculture, University of Agriculture, Faisalabad, Pakistan
[b]Entomological Research Institute, Ayub Agricultural Research Institute, Faisalabad, Pakistan.
[c]Department of Entomology, BZU, Multan.

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Abstract

Almost 160 plant species are being infested by whiteflies (Aleyrodidae) throughout South Asian countries including Pakistan. Whiteflies are tiny, sap-sucking insects that may become an abundant pest in vegetable and ornamental plantings, especially during warm weather. Whitefly was initially controlled by using different synthetic chemicals, but now resistance is developed in sucking pests against different groups of chemicals, so the trend has now lifted towards the use of biological control agents. Predatory mites are voracious predators that can feed on all instars of whiteflies including adults. The objective of this trial was to check the population fluctuation of predatory mites on chilies in relation to metrological factors and to know the feeding rates of predatory mites against whiteflies instars under laboratory conditions. According to the results, the maximum population (3.49) of a predatory mite on chilies leaves was observed in the last week of March, while the minimum population (1.34) was observed during 3rd week of February and March which was mainly due to heavy rainfall (34mm in February and 46mm in March). Overall, there was also a small increase in the population with the temperature rise. To evaluate the predatory potential, four treatments (T1, T2, T3, T4) were considered by using different instars of mites in each cell as prey with a predator and T4 as control. Fifteen individuals of each stage of whitefly from eggs to 4th instar were provided in different cells of each predatory mite. From the results, it was observed that predatory behavior tends to decrease while feeding against the egg stage to the 4th instar. As in the case of Treatment # 3 (T_3), the feeding was gradually reduced against prey from 7.33 to 5.00 while feeding on the 1st to 4th instar. The predatory potential of T_1 was less than T_3 due to fewer mites in T_1 (2/cell). Thus, it is concluded that predatory mites can be used as potential biocontrol agents against all stages of *Bemisia species*.

Keywords: Whitefly, population dynamics, feeding potential, predatory mites, meteorological factors

Introduction

Pakistan's economy is supported by the agriculture sector and always expect its significant role in national income. This sector contributes 21% of GDP and provide employment (labor) to almost 43% of the community. In Pakistan, different vegetables are grown in a region of 385578 ha with a production of 3116808 tons. Among them, the chili crop is an important one that is sown on large scales. Chili is grown as a spice, medicinal and nutritional crop. Almost 21 insect species are documented as pest that attack and infest chilies. Among various pests and diseases, *Bemisia tabaci* (Gen.) proved as a serious pest in India and Pakistan [1]. It is an obligate pest which sucks fluid from the plant and estimated that more than 600 plants are known to be affected by whitefly including both field and horticultural crops [2, 3].

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Corresponding author
bilalentomologyuaf@gmail.com

Its pest status in different crops is much more complicated with almost 11 genotypes and more than 24 morpho-cryptic species at the morphological level [4]. Biotype B of whitefly is considered to be the best species to establish its population in field crops and have a viable course of plant viruses, while biotype Q proves itself to be a more resistant species against many novel insecticides [5]. Whitefly is known to be one of the most devastating pests in both harsh and mild climates [4]. It has been considered a problematic insect in green-house crops for several years, that is responsible for reducing plant vigor, production and also acts as a vector of many plant diseases and most importantly, cotton leaf curl virus [6, 7], a real threat that reasoned a heavy loss of about 38.7% yield in 1993 in Pakistan.

Among predators, the predatory mites of the family Phytoseiidae have played a leading role against different sucking insect pest species including whiteflies. These predators are standard eaters of phytophagous mites and other delicate pests. Among different genera of Phytoseiid, *Neoseiulus* and *Euseius* are important in the biological control programs. *Amblyseius swirskii* is a new biological control agent against whitefly species on different crops [8]. *Swirskii* species is also a very competent predator of western flower thrips and whitefly in greenhouses [9], whereas, in laboratory experiments, it was noted a considerable decrease in cucumber leaves and isolated plants regarding the population of *B. tabaci* by *A. swirskii* [10].

The increase in the number of predatory mites (higher reproduction rate) is an important factor for its success as a biocontrol agent. Lifecycles of phytoseiid predators are influenced due to the field temperatures and the presence of food. In some research findings, 30°C of temperature gave the shortest developmental time for predatory mites, while the longest one was at 15°C [11]. The number of mites in a population was increased by an increase in temperature. According to a simple correlation, there was productive coherence between pest population and a rise in temperature. As the temperature starts to increase from April onward, the mite population also starts to increase, but surprisingly the correlation is non-significant. There was a recorded positive correlation between predator *Amblyseius alstoniae* (Phytoseiidae) population indices and temperature, while rainfall showed a negative correlation [12]. The predatory mite population is significantly affected by the perceived surface quality of the leaves. The development and reproduction periods of the Phytoseiidae and Stigmaeidae families are highly affected by the characteristics of leaves [13]. The grip of hunting members of Phytoseiidae is affected by hard and rough leaf areas also, which creates difficulty in their movement [14]. The main objectives of this study were to observe the population dynamics of phytoseiid predators on chilies following metrological elements and to examine the predatory potential of phytoseiid predators against multiple stages of whiteflies (Aleyrodidae).

Materials and Methods

Location

Population dynamics of predatory mites were studied on chili at the vegetable area (Horticulture section), University of Agriculture, Faisalabad.

Experiment layout

One variety "Golden heart" was sown in three rows. In the first two rows, early plantation (Sowing date: 10/10/2018; Transplanting date: 22/11/2018) was done while in the third row late plantation (Sowing date: 25/10/2018; Transplantation date 20/11/2018) was done. A total of hundred plants were sown in each row.

Studies on the population dynamics

For the population dynamics, experiment 15 plants were considered by random selection from the area. Three replications were made with five plants, and these were considered blocks. The population was observed by hand lenses and by shaking the leaves on hard white paper covers and counting the visible running predatory mites. Data of the population was checked monthly, and weeks were considered as treatments following [15]. Data were collected after 12, 24, and 36 hours.

Studies on the predatory efficacy

Bemisia tabaci were collected directly from cotton planted on pots from Soil Science Area, Department of Entomology, University of Agriculture, Faisalabad for daily feeding and were provided to the Phytoseiid mites within mite cells. Collected *B. tabaci* individuals were transferred to the Phytoseiid mite cells using a fine camel hairbrush [16]. Regarding the evaluation of predatory potential, mite cells were prepared by using rings of cotton around leaves within a petri dish. Mites were released within the cells and this culture was maintained in laboratory conditions in the Acarological Laboratory, University of Agriculture Faisalabad. The temperature was maintained to 25±2ºC and relative humidity was maintained to a level of 70±5%. A total of sixty cells were prepared, fifteen for each treatment.

In the second experiment, the efficacy of predatory mite was checked in laboratory conditions at the Acarological Lab, Department of Entomology. For this experiment, mite arenas were prepared and four treatments T_1, T_2, T_3, and T_4 were considered containing 2, 3, 4, and no mite respectively. Fifteen

(15) numbers of each stage from egg to 4th instar were provided by fresh collection from the field and then predatory efficacy after 12, 24, and 36 hours were observed.

Statistical analysis

The data on the population dynamics and predatory efficacy were subjected to one-way ANOVA using the computer-based software Statistix 9.0. The means were then compared by Tukey's Honestly Significant Difference test (HSD) at a 5% level of probability. The mean population was then averaged for all months to perform the correlation analysis with the weather parameters [17].

Results

The population of predatory mites was checked during December 2018, January, February, and March 2019 on the chili crop. During December, the population was maximum (3.4) in the case of T_2 and minimum (2.4) in the case of T_1 (Table 1). The population was maximum (3.20) in T_1 and minimum (1.60) at T_3 during January 2019 (Table 1). In February 2019, the population was maximum (2.48) for T_1 and minimum (1.34) for T_3 (Table 1). The population was maximum (3.49) for T_4 and minimum (1.34) for T_3 during March 2019 (Table 1).

Table 1. Population variation of predatory mites during different months on chili crop.

Treatments	Months			
	December 2018	January 2019	February 2019	March 2019
T_1	2.45 ± 0.10B	3.20 ± 0.00A	2.47 ± 0.07A	2.63 ± 0.02B
T_2	3.45 ± 0.02A	2.03 ± 0.02C	1.63 ± 0.06B	3.07 ± 0.04AB
T_3	2.47 ± 0.08B	1.60 ± 0.10D	1.34 ± 0.12B	2.76 ± 0.10B
T_4	2.71 ± 0.10B	2.43 ± 0.06B	2.45 ± 0.02A	3.49 ± 0.21A
F	27.83	127.52	51.86	10.63
P	0.00	0.00	0.00	0.00

The correlation was checked between metrological factors and the predatory mite population. The population was more in the case when there was no rainfall, and the temperature was higher. It was seen from the 3rd week of March that the predatory mite population was very low which was mainly due to heavy rainfall. So, there was a negative effect due to rainfall and the population increased with an increase in temperature. Overall, there was a negative and nonsignificant correlation between humidity and population, a positive and nonsignificant correlation between temperature and population while the only significant and negative correlation between rainfall and population of predatory mites on chilies (Table 2).

Table 2. Correlation between the population of predatory mites and abiotic factors

Metrological factors	Population	
	Correlation	p-value
Rainfall	-0.62	0.01
Humidity	-0.11	0.69
Temperature	0.39	0.13

The results of predatory efficacy showed the higher predatory potential of T_3 which was mainly due to a higher number of mites (4 mites per cell) as compared to other treatments. Also, it was seen that the predatory potential was more in the egg and 1st instar stage which started decreasing when moving from 1st instar to 4th instar (Fig 1).

The data on the feeding potential of predatory mites on whitefly eggs (Fig 1a) is showing that feeding on whitefly eggs was increased over time and it was more for treatment having more numbers of mites. It increased from 5.00 to 12.67 as a period from 12 hours to 36 hours, in the case of T_1. This same trend was followed by all the other treatments.

The data on the feeding potential of predatory mites on the 1st instar of whitefly (Fig 1b) is showing that feeding was increased over time and it was more for treatment having more numbers of mites. It increased from 5.00 to 11 as the time from 12 hours to 36 hours, in the case of T_1. The trend was the same for all the other treatments.

The data on the feeding potential of predatory mites on the 2nd instar of whitefly (Fig 1c) is showing that feeding was increased over time and it was more for treatment having more numbers of mites. It increased from 4.00 to 10.33 as the time from 12 hours to 36 hours, in the case of T_1. This same trend was followed by all the other treatments.

The data on the feeding potential of predatory mites on the 3rd instar of whitefly (Fig 1d) is showing that feeding was increased over time and it was more for treatment having more numbers of mites. It increased from 4.00 to 10.33 as the time from 12 hours to 36 hours, in the case of T_1. The trend was the same for all the other treatments.

The data on the feeding potential of predatory mites on the 4th instar of whitefly (Fig 1e) is showing that feeding was increased over time and it was more for

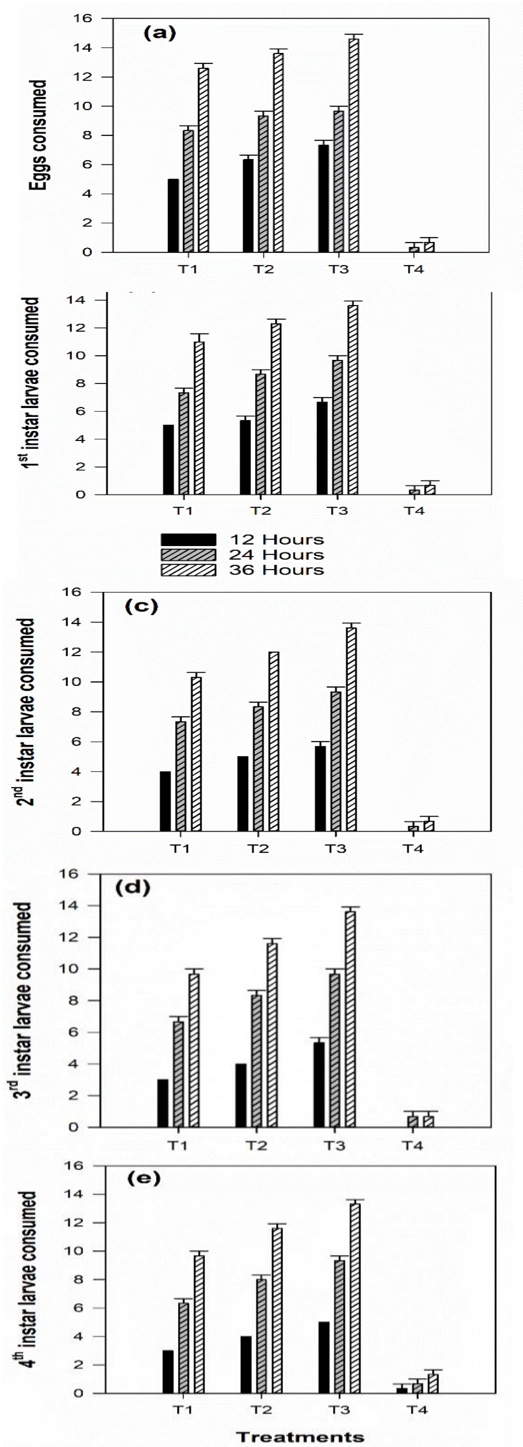

Figure 1. Feeding efficacy of predatory mites fed on different stages of whiteflies

treatment having more numbers of mites. It increased from 3.00 to 9.67 as the time from 12 hours to 36 hours, in the case of T_1. The trend was the same for all the other treatments.

Discussion

Phyllis *et al.* [18] directed analysis to study the impact of metrological and biological elements on the population of *N. cucumeris* and said that the population was not affected by temperature, relative humidity, and pollens. They said that distribution was not affected by changes in these parameters from top to bottom leaves of the plants but it was negatively phototaxis. The population was only influenced by the presence of *Orius laevigatus* in that case no mite was seen on those leaves containing the predatory mite which was due to the chances of intraguild predation from which predatory mites want to escape which was in accordance with the current study as the correlation was non-significant between population and some weather factors. This study coincides with current research in which almost all the studied factors, except rainfall, were non-significantly correlated with the population of the predatory mite. Heung-Su and Gillespie [19] studied the lifecycle of *A. swirskii* at 9 different temperatures in the presence of *Typha latifolia* pollens. According to the results, they concluded that the population was strikingly low at 13ºC in which case no development was seen but it started increasing with an increase in temperature and the population was marked to improve between 20-30ºC when other conditions were favorable. These findings contradict the present study (due to high rainfall) as the population was non-significantly correlated with temperature.

Calvo *et al.* [20] contemplated the feeding potential of *A. swirskii* according to the release rate. They found that the predatory potential on *B. tabaci* was higher when the release rate was higher (75 *A. swirskii* m^{-2}) as compared to other release rates which coincides with this study where maximum predatory potential was seen by T_3 containing maximum numbers of predatory mites per cell. Cuthbertson [16] said that the population of sweet potato whitefly was markedly controlled by three different predatory mites and the predatory potential was maximum in the case of the egg stage (≥ 30%) and it was decreased when feeding on 1st instar (≤ 27%) was checked and again decreased to a very low level when 2nd instar (≤ 10%) was studied. The results of the current experiment are upheld by this investigation as in present research it was seen that the least feeding was observed on the 4th instar and maximum mortality was on eggs and 1st instar stage of whiteflies.

Conclusions

The population of predatory mites was affected by high rainfalls and minimum densities were seen during the third week of February and March. Overall, the correlation of predatory mite population with rainfall, humidity, and the temperature was non-significant, but the population was increased due to an increase in temperature and decreased drastically due to rainfall. The predatory potential tends to decrease while feeding on the 1st instar to the 4th instar of *B. tabaci.* It was also noted that feeding was affected by the number of mites present in each treatment, as the number increases, feeding potential also rises instantly.

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Conflict of interest

The authors declare that no conflict of interest exists.

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