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Full Length Research Paper

The potential of four mite species (Acari: Phytoseiidae) as predators of sucking pests on protected cucumber (*Cucumis sativus* L.) crop

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Protected crop experiments were conducted to study the suitability and efficacy of Phytoseiid mite species as predators of western flower thrips *Frankliniella occidentalis* (Pergande), carmine spider mite *Tetranychus cinnabarinus* (Boisduval) and greenhouse whitefly *Trialeurodes vaporariorum* (Westwood) in cucumber (*Cucumis sativus* L.) under greenhouse conditions. In this study, predatory mites *Neoseiulus pseudolongispinosus Euseius castaneae Euseius utilis* and *Euseius finlandicus* (Oudemans) (Phytosiidae) were investigated for their potential as biological control agents in treated along with untreated check. The current findings to judge the biocontrol potential of predators showed that laboratory bred adults and nymph instars of all predators efficiently preyed upon sucking arthropods and pests populations were drastically reduced in treated plants than in untreated control where their intensities were numerous. Among all predators, *N. pseudolongispinosus* was the most proficient and steadfast predator in controlling thrips and whitefly populations, contrary to *E. finlandicus* that proved better in reducing spider mite density in treated crop. The current findings indicated the potential of Phytoseiid predators for their augmentative releases to give best control of sucking pests in protected cucumber plants.

Keywords: Biological control, predaceous mite, greenhouse, cucumber, phytoseiidae.

INTRODUCTION

The cucumber, *Cucumis sativus* L., is a new greenhouse crop which can be grown successfully under protective structures year-round. Several insect pests that cause stunting plant and low yield attack cucumber crop; as a result, these pests must be controlled for optimal crop production (Bashir and Abdalhadi, 1986). Hence, the insect are major challenge to greenhouse production, however, some of the most common cucumber pests are western flower thrips *Frankliniella occidentalis* (Pergande), greenhouse whitefly *Trialeurodes vaporariorum* (Westwood) and carmine spider mite *Tetranychus cinnabarinus* (Boisduval).

Thrips are serious insect pests of crops throughout the world, causing damage through direct feeding as well as being vectors of destructive plant viruses (Ananthakrishnan, 1993). Two hundred and forty-four species of plants belonging to 62 different families have been found to host by *F. occidentalis* (Tommasini and Maini, 1995), and its number is increasing with time and expansion to new areas. Following crop colonization, their thigmotactic behavior can make thrips difficult to detect; short generation times can result in rapid population increases and the development of insecticide resistance, leading to control failures (Cox et al., 2006). The carmine spider mite *T. cinnabarinus* infests over 100 host plants, which are sprayed more often and this increased the exposure of spider mite on crops to pesticides. Because of its short life cycle and high reproductive rates, spider mite develops resistance faster than most insects (Guo et al., 1998). Whitefly species, for instance *Bemisia tabaci* (Homoptera: Aleyrodidae) debilitates Cucurbitaceae plants by sucking the sap,

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introducing toxins into the plant's vascular system, coating the leaf with honey dew, which facilitates the growth of soots mold fungi, as well as inducing leaf physiological disorders (Mcauslane et al., 1996). Many growers control theses pests with selective pesticides, however, the realized and potential development of pesticides resistance and the high costs associated with their multiple applications have created a need for other pest management options.

Biological control is one of the most important alternatives to conventional pesticide used in pest management today. Predatory mites in the Family of Phytoseiidae (Acari) are important components in mite biological control (Jung et al., 2006). Phytoseiidae mites are abundant in different types of habitat and these are well known predators of phytophagous mites and small insects. Among different genera, *Neoseiulus* and *Euseius* are very important in biological control of certain soft bodied pests (Muma and Denmark, 1970; Kasap and Sekeroglu, 2004; Sarwar et al., 2009). Therefore, objective of this work was to test the technical viability of four different phytoseiids commonly found in China to control three primary pests in cucumber crop.

MATERIALS AND METHODS

Predator source and study site

The experiment on cucumber *Cucumis sativus* L. crop (a pollen-producing cultivar to enhance the establishment of predatory mites) was conducted during the growing season of 2007 (March - June) at the study site Bikun Greenhouse, Mentougou District, Beijing, China. Adult individuals of predators were collected from field's survey of different crops, then taken to the laboratory and reared on snap bean (*Phaseolus vulgaris* L.) seedlings infested with *T. urticae* as prey in sufficient numbers. The individual stock colonies of predators were maintained at the laboratory of Insect Natural Enemies, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing, China. After the colony culture established, the predators were removed from leaves and collected in containers for use in the experiment. For predator production, a temperature of 25 - 30°C, the natural ambient humidity set at 70% and a photoperiod of (16 L: 8 D) in 24 h of a day were maintained for efficient egg incubation, proper nymph growth and adult reproduction of the predators before using them for the tests.

Greenhouse experiment and design

The five treatments including predatory mites *Neoseiulus pseudolongispinosus, Euseius castaneae, Euseius utilis* (Liang and Ke, 1981) and *Euseius finlandicus* (Oudemans) (Phytosiidae) were introduced on cucumber crop and compared with a control without any provisioning of predator. The experimental unit comprised three blocks each measuring an area of 50 m^2 having 50 cm plant to plant distance. The cucumber plants were grown on ridges that were equally spaced and mulched with materials such as polytehene sheets spread on the soil surface. The plants were irrigated and fertilized as and when needed. Releases of predators in greenhouse were carried out when cucumber plants were about 2 months of age where the number of leaves per plant averaged 8 and the plant heights ranged from 50 to 60 cm. A randomized complete block design with 3 replicates was used for experimentation. The plants were not treated with any pesticide before or during the release of predators. One top, 1 middle, and 1 bottom leaf of 3 plants was selected at random and pests populations prior to release of predators were recorded with the help of magnifier and the mean values per leaf were calculated. Laboratory mass-reared predators from the Entomology Research Unit were transported in containers, and released in the test crop by manually shaking the containers while the appliers walked along the plant rows. Releases were made at the top portion of each plant, so that the moving ability of the predator could also be noted. Each cucumber plant was inoculated with 10 predators per plant at the crown-growing portion. A buffer zone of at least 20 m was kept within each block to prevent contamination among treatments. Observations on reduction or increase of pest populations were counted at one-week intervals after the releases of the predators on plants and plants left without predators (control treatment). To detect infestations, crop-scouting program included visual inspection of pest populations per leaf. To judge the biocontrol potential of predators in treatment and control plots, pest and predator populations were examined from 3 plants selected at random in each replicate of a treatment. A hand lens was used to detect live pests as well as signs of pest activity e.g., frass, cast skins, honeydew, etc. Data on adult and nymphal populations of predators and thrips, spider mite and whitefly per leaf were determined by counting their numbers per 3 randomly selected plants from each treatment in a way that one leaf from upper portion of plant, 2nd leaf from middle portion of plant and third leaf from bottom portion of plant and so on were sampled. The predatory mites sampled were slide-mounted and identified under a microscope to ensure that the right species were present in the right treatment. For assessing arthropods populations on per leaf basis, their mean numbers were pooled to analyze statistically.

Data analysis

The data recorded on numbers of 3 pests and 4 predators were transformed in to mean values prior to subjecting these to statistical analysis for observing population reduction by predators (success or failure). The results of all experimental replicates were analyzed using one-way ANOVA and Least Significance Difference Test was used to determine significant differences among treatments using SPSS (2005) software.

RESULTS

The results of current findings showed the potential of Phytoseiid predators for the control of sucking pests of cucumber. All treatments were significantly different from control at the ending of the experimentation ($P < 0.05$). Pretreatment monitored densities of thrips, spider mite and whitefly differed from 0 to 0.11, 0, and 0 to 0.03 individual per leaf, respectively, in all treatments (Table 1).

Thrips (*Frankliniella occidentalis*)

The data presented in Table 2, is pertaining to nymph and adult populations of thrips sampled on leaves and flowers within different investigating times. Before treatment, the insignificant differences between numbers

Table 1. Pretreatment mean numbers of pests in control and treated cucumber plants.

Treatments	Arthropod Populations per leaf		
	Thrips	Spider mite	Whitefly
T^1 = *N. pseudolongispinosus*	0.03 ± 0.03	0.00 ± 0.00	0.00 ± 0.00
T^2 = *E. castaneae*	0.03 ± 0.03	0.00 ± 0.00	0.00 ± 0.00
T^3 = *E. utilis*	0.11 ± 0.06	0.00 ± 0.00	0.00 ± 0.00
T^4 = *E. finlandicus*	0.00 ± 0.00	0.00 ± 0.00	0.03 ± 0.03
T^5 = Check	0.07 ± 0.03	0.00 ± 0.00	0.00 ± 0.00

Table 2. Densities of Thrips on various observations after release of predaceous phytoseiids.

Treatments	Numbers of Thrips per leaf during different time		
	April, 30	May, 16	May, 30
T^1= *N. pseudolongispinosus*	0.81 ± 0.31	3.03 ± 0.79	6.92 ± 1.22
T^2= *E. castaneae*	0.53 ± 0.12	2.22 ± 0.60	7.83 ± 1.59
T^3= *E. utilis*	0.64 ± 0.21	4.25 ± 0.74	10.14 ± 1.58
T^4= *E. finlandicus*	1.42 ± 0.73	2.67 ± 0.60	11.81 ± 2.51
T^5= Check	1.06 ± 0.31	2.06 ± 0.52	18.78 ± 3.43

Table 3. Mean numbers of Whitefly on different sampling dates in control and treated plants.

Treatments	Numbers of whitefly per leaf during different times	
	May, 30	June, 6
T^1= *N. pseudolongispinosus*	0.11 ± 0.06	1.78 ± 0.85
T^2= *E. castaneae*	0.11 ± 0.06	3.41 ± 1.52
T^3= *E. utilis*	0.63 ± 0.03	4.00 ± 1.25
T^4= *E. finlandicus*	0.41 ± 0.03	6.56 ± 1.58
T^5= Check	0.78 ± 0.06	7.22 ± 2.59

of nymphs and adults per leaf in each treatment were recorded. After treatments, thrips densities were quite apparent and the significant differences were observed between treatments. The untreated plants hosted significantly more numbers of thrips populations per leaf compared to treated plants. The differences between predator treatments were non significant for mean populations of nymph and adult thrips in *N. pseudolongispinosus, E. castaneae, E. utilis* and *E. finlandicus* treated plants (Table 2). The pest population decreased greatly after May 30, probably due to the application of pesticides. Pest started its appearance in the 2nd week of April and then increased gradually during 4th week (F = 0.783; df = 175; P = 0. 537). The net populations of thrips per leaf observed during mid week of May started at higher rate of increase (F = 1.742; df = 175; P = 0.143) and peaked at the end of May (F = 4.488; df = 175; P = 0.002) in treated versus non released plants.

Whitefly (*Trialeurodes vaporariorum*)

Following predatory mite releases, whitefly seasonal mean numbers varied on different sampling dates in between test and control plants (Table 3). After predator releases, significant differences regarding whitefly were recorded in untreated and treated plants, where population ranged from 0.11 to 7.22 per leaf. The results revealed that predator treatments *E. finlandicus* and *E. utilis* differed non-significantly in holding pest population at the end of May (F = 0.650; df = 130; P = 0.628), while, the pest density was maximum at the initiation of June (F= 1.845; df= 130; P= 0.124). Minimum number of whitefly appeared from leaves observed in plants treated with *N. pseudolongispinosus* followed by *E. castaneae*

Table 4. Comparison of different treatments for the control of spider mite.

Treatments	Numbers of spider mite per leaf during different time		
	May, 16	May, 30	June, 6
T^1= *N. pseudolongispinosus*	0.04 ± 0.03	1.07 ± 0.66	6.37 ± 1.44
T^2= *E. castaneae*	0.00 ± 0.00	0.37 ± 0.15	5.48 ± 1.41
T^3= *E. utilis*	0.04 ± 0.03	2.93 ± 1.30	5.22 ± 1.11
T^4= *E. finlandicus*	0.07 ± 0.05	1.07 ± 0.69	3.15 ± 0.71
T^5= Check	2.33 ± 1.58	4.55 ± 2.18	27.70 ± 7.24

Table 5. Pre and Post treatment numbers of predators in control and treated plants.

Treatments	Numbers of predators per leaf during crop season	
	Pretreatment population	Post treatment population
T^1= *N. pseudolongispinosus*	0.00 ± 0.00	0.33 ± 0.00
T^2= *E. castaneae*	0.00 ± 0.00	0.29 ± 0.03
T^3= *E. utilis*	0.00 ± 0.00	0.29 ± 0.09
T^4= *E. finlandicus*	0.00 ± 0.00	0.25 ± 0.03
T^5= Check	0.00 ± 0.00	0.07 ± 0.03

and *E. utilis*.

Spider mite (*Tetranychus cinnabarinus*)

Number of spider mite was significantly higher in untreated plants compared with treated plants; however, the number was not significantly different among that of treated plants. Impacts of *E. finlandicus* on spider mite pest suppression were more severe and reduction was higher than noticed in *E. utilis, E. castaneae* and *N. pseudolongispinosus* treatments. Comparisons of pest's population across all sampling dates revealed that after the releasing of predators, spider mite start its appearance at the end of April. Within treated plants, the pest became visible during mid May ($F = 2.091$; $df = 130$; $P = 0.086$), increased during last week ($F = 2.250$; $df = 130$; $P = 0.067$), peaked at beginning of June ($F = 8.906$; $df = 130$; $P = 0.000$) and then declined (Table 4).

Occurrence of mite predators

During the fourth week of crop sowing before the releases of natural enemies, the predators' density was zero that remained similar in control and treated plants. However, between late February and late March, predators were significantly more numerous per leaf after they are released and comprised *N. pseudolongispinosus* (0.33), *E. castaneae* (0.29), *E. utilis* (0.29) and *E. finlandicus* (0.25). Among these, *N. pseudolongispinosus* was most predominant predator and its density significantly varied in treated and non-treated control plants (Table 5).

DISCUSSION AND CONCLUSIONS

The current findings showed the potential of four Phytoseiid predators for the control of the sucking pests of cucumber. All treatments were different from control for holding pest populations at the ending of the experimentation ($p < 0.05$). Moreover, overall among these predators *N. pseudolongispinosus* was the most efficient predator in controlling thrips and whitefly populations, contrary to *E. finlandicus* that proved better in controlling spider mite, though these predators gave non significant overall control effects in treated plants. Some potentially important factors that could have prevented *Euseius* predatory mites releases from being more successful compared to *Neoseiulus* may be that their releases might have negatively affected predators viability, and laboratory reared predatory mites might have been negatively affected by the transition to greenhouse conditions. The release rates of *Euseius* predators may have been too low, and interactions with naturally occurring predatory mites or insects could have negatively affected their establishment, or the cucumber plant itself may not be conducive to predatory mite's persistence. Further research is needed to determine which limiting factors are most important in preventing *Euseius* predators from performing better than *Neoseiulus* in protected cucumber crop. However, the current findings to judge the biocontrol potential of predators showed that laboratory bred adult and nymph instars of all predators efficiently preyed upon sucking arthropods and pests populations were drastically reduced per leaf in treated plants than in control where their intensities were numerous. These observations are partially in conformity with research conducted previously, where mites of the family Phytoseiidae have been successfully used for the control of pests by earlier researchers. Nomikou et al. (2002) evaluated phytoseiid as biological control agents to manage *Bemisia tabaci* (Gennadius). In greenhouse experiments, each of the two predators, *E. scutalis* (Athias-Henriot) and *Typhlodromips swirskii* (Athias-Henriot), suppressed *B. tabaci* populations on cucumber plants. The two predator species were found in higher numbers on plants infested with whiteflies than on uninfected plants but this difference was consistently significant in all experiments only for *T. swirskii*. Watanabe et al. (1994) tested technical viability using phytoseiids to control *T. urticae* in cucumber, only *Amblyseius* species was successfully established on cucumber, significantly reducing *T. urticae* population. Releasing the predatory mite *P. macropilis* on cucumber indicated the possibility of controlling *T. urticae* in the greenhouses by applying only one release in early season on cucumber when the pest population was low (Mowafi, 2005). Similar to present observation, Messelink et al. (2006) when evaluated phytoseiid predatory mite species, for control of *F. occidentalis* on greenhouse cucumber, *E. finlandicus* did not establish better to give better control of thrips than other species. The present study reflects that both predators' *N. pseudolongispinosus* and *E. finlandicus* were the key natural enemies on crop, but both predators' *E. castaneae* and *E. utilis* did not develop successfully under greenhouse conditions. In fact they may be lost soon after releases and their minimum representatives could be encountered on leaf sampled inspite of their supplementary releases. Reasons for the failure of both predators to survive on greenhouse cucumber are a subject of future research. Further, in the study, the technique for releasing the predatory mites onto cucumber may not have delivered predators evenly and in good condition suggesting that releasing system may be an important limiting factor or could be due to attributes specific to the cucumber plant. Our research is also motivated by earlier work in which releases of few mite predators were unsuccessful in establishing their populations. Phytoseiid mites may be especially susceptible to predation by predatory insects because they are relatively small compared with insects (Polis et al., 1989). Since the cucumber has high climatic demands especially humidity, air temperature and light intensity, and these main factors affect cucumber crop quality and quantity, therefore, their instability during the changing season should be considered. The research by Gajc-Wolska (2008) proved that the best quality cucumber was obtained in the cultivation period - between April and August, due to the optimum climatic conditions. Further research is needed to determine which limiting factors are most important in preventing mite predators from performing better in protected crop ecosystem.

Since these predators have been found effective in controlling all primary pests, their integration in biocontrol is necessary. Early detection of pests in the greenhouse is imperative because moderate infestations can cause plant wilt in cucumber and immediate releases of these predators would be required to achieve a significant level of pest management, thereby providing growers with a control tactic along with use of resistant varieties to minimize the uses of chemicals. Further studies are intended to determine the exact timing of predator releases and to improve the method for their rearing to minimize pests' damage to cucumber crop.

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