Effect of Pesticide Mixtures on the predatory mite, *Neoseiulus cucumeris* (Oudemans) (Acarina: Phytoseiidae)

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Figure 1. High impact polystyrene tray with 16 filter paper lined, pesticide treated cells into which one *N. cucumeris* was transferred and sealed.

ABSTRACT

Neoseiulus cucumeris (Oudemans) is a predatory mite utilized in greenhouses for managing western flower thrips (*Frankliniella occidentalis* Pergande). However, greenhouses contain insects, mites, and fungal pathogens, which requires the use of multiple pesticides. In order to manage the array of pests, greenhouse managers often mix several pesticides even though information on how these mixtures impact non-target arthropods, such as *N. cucumeris*, is lacking. This laboratory study was conducted to determine the impact of spinosad, abamectin, thiophanate-methyl, and fenhexamid, on survival of *N. cucumeris*. Deutonymph and adult stages of *N. cucumeris* were exposed to the pesticides or a water control. Mortality assessment after a 24 hour treatment indicated that pesticide mixtures differentially affected *N. cucumeris* survival. Five out of seven pesticide mixtures containing spinosad and four out of seven mixtures containing abamectin resulted in deutonymph mortality from 50 to 68.8%. Thiophanate-methyl alone and in combination with spinosad or abamectin resulted in >35% mortality of deutonymphs. These results suggest that spinosad, abamectin, and thiophanate-methyl when used alone or in pesticide mixtures can reduce *N. cucumeris* populations primarily through the death of deutonymphs. This information is important to greenhouse managers who want to use pesticide mixtures in combination with the predatory mite, *N. cucumeris* to manage western flower thrips.

Figure 2. High impact polystyrene bioassay rearing tray utilized to rear *N. cucumeris* to the deutonymph and adult stages.

Introduction

A major insect pest in greenhouses is the western flower thrips (WFT), *Frankliniella occidentalis* (Pergande) because their feeding directly damages crops, and they transmit tospoviruses [1,2]. To combat high WFT populations, greenhouse managers use insecticides[3], which has led to resistance in WFT populations [3, 4]. Therefore, the use the use of alternative control options as part of an integrated pest management (IPM) program is essential.

An alternative strategy utilized to manage WFT is the release of the predatory mite *Neoseiulus cucumeris* (Oudemans). However, WFT may not be the only plant-feeding pest in the greenhouse. Additionally, even when biological control agents are used against an arthropod pest, chemical treatment may be necessary to manage fungal diseases or other arthropod pests. Since greenhouses generally contain an array of arthropod pests and fungal pathogens, pesticide mixtures are oftentimes used to broaden the activity of the application.

The use of pesticide mixtures can impact biological control agents with side-effects, such as sublethal effects, secondary pest outbreaks, and population reductions, which can interfere with an IPM program [5,6]. Since greenhouse managers oftentimes mix pesticides, it is critical to test the effects that they may have on biological control agents so as not to render the biologicals ineffective. The compatibility of *N. cucumeris* with mixtures of insecticides and fungicides used in greenhouses has not been determined.

The objective of this study was to evaluate, under laboratory conditions, the lethal effect of selected insecticides and fungicides alone and in all combinations on the deutonymph and adult stage of *N. cucumeris*.

Materials and Methods

One insecticide, one miticide/insecticide, and two fungicides commonly used in production greenhouses and/or labeled as safe to use with biological control agents were evaluated alone and in all possible mixtures to test their effects on *N. cucumeris* survival.

Rearing Same Aged Mites

- *N. cucumeris* obtained from commercial shipment
- Mite eggs extracted and upon hatching, reared in bioassay rearing tray (Fig. 2)
- Mites fed WFT instars daily

Adult Life Stage

- Same as Deutonymph Life Stage except with 15 replications

Deutonymph Life Stage

- Completely randomized design with 16 replications
- Treatments were spinosad, abamectin, fenhexamid, and thiophanate-methyl alone and in all possible mixtures
- One same-aged mite transferred to treated cell in high impact polystyrene tray (Fig. 1)
- Mite mortality assessed after 24 h
- Data analyzed and logistic regression performed by PROC GENMOD with differences between treatment means estimated with LSMEANS at $P \leq 0.05$

Results

Adult Life Stage

- There were significant differences in the number of dead adult mites among the treatments
- Adults were less susceptible to the pesticide treatments than deutonymphs
- SP + TH resulted in significantly more dead mites than the control

Deutonymph Life Stage

- There were significant differences in the number of dead deutonymph mites among the treatments
- SP + AB + TH resulted in one of the highest mortality percentages
- Spinosad and abamectin are lethal to deutonymphs

Table 1. Percent mortality of *N. cucumeris* deutonymphs and adults after 24 hours of exposure to selected pesticides and pesticide mixtures.

Treatment[z]	Deutonymph[y]	Adult
SP	43.8 (16)*	35.7 (14)
AB	43.8 (16)*	26.7 (15)
FE	26.7 (15)	6.7 (15)
TH	37.5 (16)	0.0 (15)
SP + AB	50.0 (16)*	28.6 (14)
SP + FE	60.0 (15)*	33.3 (12)
SP + TH	37.5 (16)	66.7 (15)*
AB + FE	31.3 (16)	20.0 (15)
AB + TH	50.0 (16)*	21.4 (14)
FE + TH	12.5 (16)	14.3 (14)
SP + AB + FE	31.3 (16)	33.3 (15)
SP + FE + TH	62.5 (16)*	26.7 (15)
SP + AB + TH	68.8 (16)*	20.0 (15)
AB + FE + TH	31.3 (16)	14.3 (14)
SP + AB + FE + TH	68.8 (16)*	6.7 (15)
Water Control	6.7 (15)	6.7 (15)

[z] Treatment designations: SP=Spinosad, AB=Abamectin, FE=Fenhexamid, and TH=Thiophanate-methyl.
[y] Percentages followed by the symbol (*) within a column are significantly different from the water control (P=0.05) as determined by the least square means (LSMEANS) procedure.

Table 2. Percent mortality of *N. cucumeris* deutonymphs and adults after 24 hours of exposure to selected pesticides and pesticide mixtures.

Treatment[z]	Deutonymph[y]	Adult
SP	43.8 (16) abc	35.7 (14) ab
AB	43.8 (16) abc	26.7 (15) a
FE	26.7 (15) bcd	6.7 (15) a
TH	37.5 (16) abcd	0.0 (15) *
SP + AB	50.0 (16) ab	28.6 (14) a
SP + FE	60.0 (15) ab	33.3 (12) ab
SP + TH	37.5 (16) abcd	66.7 (15) b
AB + FE	31.3 (16) bcd	20.0 (15) a
AB + TH	50.0 (16) ab	21.4 (14) a
FE + TH	12.5 (16) cd	14.3 (14) a
SP + AB + FE	31.3 (16) bcd	33.3 (15) ab
SP + FE + TH	62.5 (16) ab	26.7 (15) a
SP + AB + TH	68.8 (16) a	20.0 (15) a
AB + FE + TH	31.3 (16) bcd	14.3 (14) a
SP + AB + FE + TH	68.8 (16) a	6.7 (15) a
Water Control	6.7 (15) d	6.7 (15) a

[z] Treatment designations: SP=Spinosad, AB=Abamectin, FE=Fenhexamid, and TH=Thiophanate-methyl.
[y] Mortality percentages followed by a common letter within a column are not significantly different (P=0.05) as determined by the Least Square Means (LSMEANS) procedure.
* Significant differences in mortality for thiophanate-methyl could not be determined by the LSMEANS procedure due to the data consisting of all zeros. This caused a computational error to occur.

Discussion

Eight of the 15 pesticide treatments resulted in significantly more dead deutonymphs compared to the water control, while one of the 15 pesticide treatments resulted in significantly more dead adults compared to the water control (Table 1). Thus, the deutonymph life stage appeared to be more susceptible to the pesticide treatments than the adult life stage.

Spinosad is labeled as safe to use with predatory mites. However, the four treatments that resulted in the highest percent mortality of deutonymphs (60-68.8%) contained spinosad (Table 1). Further, all but two pesticide mixtures containing spinosad (SP + TH; SP + AB + FE) had significantly more dead deutonymphs than the water control (Table 2).

Similar to spinosad, abamectin resulted in 43.8% mortality of deutonymphs, and five out of eight treatments containing abamectin had significantly more dead deutonymphs than the water control (Table 1). We found the SP + AB mixture to be just as lethal (50%) to deutonymphs as either pesticide alone.

The thiophanate-methyl treatment did not result in significantly more dead deutonymphs (37.5%) or adults (0.0%) compared to the water control. However, deutonymph mortality almost doubled when this fungicide was mixed with abamectin and spinosad (68.8%). In fact, the SP + AB + TH mixture resulted in the highest deutonymph mortality along with the SP + AB + FE + TH treatment. In addition, percent dead adults increased almost seven-fold from 0% to 66.7% when thiophanate-methyl was mixed with spinosad.

Studies, such as this, testing the lethal effects of pesticide mixtures on biological control agents are rare. Based on our results, spinosad, abamectin, and mixtures with these insecticides have potential to reduce *N. cucumeris* populations. This is important information to managers who want to utilize pesticide mixtures without negatively impacting biological control of WFT with *N. cucumeris*.

Conclusions

- *N. cucumeris* deutonymphs were more susceptible to most pesticide treatments than adults
- Spinosad, abamectin, and thiophanate-methyl may reduce *N. cucumeris* populations when used alone or in combination with each other
- Adults may be more susceptible than deutonymphs to the mixture spinosad + thiophanate-methyl

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