Evaluation of Predatory Mites and Acramite for Control of Twospotted Spider Mites in Strawberries in North Central Florida

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ABSTRACT Greenhouse and field experiments were conducted from 2003 to 2005 to determine the effectiveness of two predatory mite species, *Phytoseiulus persimilis* Athias-Henriot and *Neoseiulus californicus* (McGregor), and a reduced-risk miticide, Acramite 50 WP (bifenazate), for control of twospotted spider mite, *Tetranychus urticae* Koch, in strawberries (*Fragaria x ananassa* Duchesne). In greenhouse tests, three treatments consisting of releases of *P. persimilis*, *N. californicus*, and an untreated control were evaluated. Both species of predatory mites significantly reduced twospotted spider mite numbers below those found in the control during the first 3 wk of evaluation. However, during week 4, twospotted spider mite numbers on the plants treated with *P. persimilis* increased and did not differ significantly from the control. Field studies used releases of *P. persimilis* and *N. californicus*, applications of Acramite, and untreated control plots. Both *N. californicus* and *P. persimilis* significantly reduced populations of twospotted spider mite below numbers recorded in the control plots. During the 2003–2004 field season *P. persimilis* took longer than *N. californicus* to bring the twospotted spider mite population under control (<10 mites per leaflet). Acramite was effective in reducing twospotted spider mite populations below 10 mites per leaflet during the 2003–2004 field season but not during the 2004–2005 field season, possibly because of a late application. These findings indicate that *N. californicus* releases and properly timed Acramite applications are promising options for twospotted spider mite control in strawberries for growers in north Florida and other areas of the southeast.

KEY WORDS Acramite, *Neoseiulus californicus*, *Phytoseiulus persimilis*, twospotted spider mite, strawberry

The twospotted spider mite, *Tetranychus urticae* Koch, is the key arthropod pest affecting strawberries (*Fragaria x ananassa* Duchesne) in Florida (Mossler and Nesheim 2003). Their feeding causes injury to chlorophyll containing mesophyll cells within the leaf tissue, which results in a decrease of photosynthetic capacities of infested leaves (Sances et al. 1982). Early season infestations of twospotted spider mites cause reductions in photosynthesis and transpiration at a much lower population level than the population level that causes the same level of injury later in the season (Sances et al. 1981).

Development from egg to mature adult takes ≈19 d (Mitchell 1973), although this time can be as short as 5 d (Ho and Lo 1979). Optimal conditions for development are high temperatures (up to 38°C) and low humidity (White and Liburd 2005). Their high fecundity and short life cycle allow twospotted spider mites to quickly become resistant to miticides used to control them. The use of reduced-risk miticides and periodic releases of predatory mites may give growers more options for management of twospotted spider mites.

Acramite 50 WP (bifenazate) (Crompton, Morgantown, WV) is a reduced-risk miticide that has shown promising results in strawberries (Liburd et al. 2003). This miticide has a low toxicity toward predatory mites (White 2004). Acramite can only be applied twice in a season at 0.85–1.125 kg of product per hectare with applications at least 21 d apart (Price 2002, Mossler and Nesheim 2003). In laboratory studies using leaf disks, White (2004) recorded a higher rate of twospotted spider mite mortality using Acramite 50 WP compared with the conventional miticide Vendex (fenbutatin oxide) (DuPont, Wilmington, DE).

Phytoseiulus persimilis Athias-Henriot and *Neoseiulus californicus* (McGregor) are predatory mites belonging to the family Phytoseiidae. They have been shown to effectively control twospotted spider mites on strawberry and other crops in various parts of the world (Port and Scopes 1981, Cross 1984, Charles et al. 1985, Charles 1988, Waite 1988, Easterbrook 1992, Decou 1994, Cross et al. 1996, Garcia-Mari and Gonzalez-Zamora 1999, Easterbrook et al. 2001, Barber et al. 2003, Liburd et al. 2003). *Phytoseiulus persimilis* and *N. californicus* are also effective in controlling twospotted spider mites on strawberries in California (Oatman et al. 1967, 1968, 1976, 1977a,b; Trumble and Morse 1993). *Phytoseiulus persimilis* is a type I specialist that feeds exclusively on *Tetranychus* mites (McMurtry and Croft 1997). In contrast, *N. californicus* has traits of both a type II specialist and a type III generalist (Croft et al. 1998). *N. californicus* prefer spider mites as food but can subsist on other sources of food such as thrips and pollen when mite populations are low, and they also prey upon other predatory mite species (Gerson et al. 2003).

In Florida, seasonal releases of *P. persimilis* have been fairly successful in controlling twospotted spider mite populations in the southern regions of the state (Decou 1994). However, releases of *P. persimilis* have not been effective in northern Florida, possibly because it may not be able to survive the winter typical of this area (White 2004). Preliminary studies by Liburd et al. (2003) indicate that *N. californicus* may be able to effectively control twospotted spider mite in north Florida strawberries where *P. persimilis* is ineffective.

The objective of these experiments was to compare the efficacy of both species of predatory mites for control of twospotted spider mites under controlled greenhouse conditions and under field conditions in north Florida. Under controlled greenhouse conditions, *P. persimilis* would be expected to perform as well as or better than *N. californicus* because temperature effects are not a factor.

In the field, our hypothesis was that *N. californicus* would provide better control of twospotted spider mites compared with *P. persimilis.* Furthermore, both *N. californicus* and Acramite would significantly reduce populations of twospotted spider mites in strawberries to below levels found in untreated (control) plots.

Fig. 1. Mite-free cages (60 by 30 by 20 cm) containing strawberry plants.

Materials and Methods

Colony. A twospotted spider mite colony reared on strawberries was maintained in the laboratory to ensure that only twospotted spider mites predisposed to strawberries were used in the experiments. The colony consisted of mite-infested strawberry plants that were kept under a photoperiod of 14:10 (L:D) regime at a temperature of ≈27°C with 65% RH. Plants were watered twice weekly.

Predatory mites used in all experiments were obtained from Koppert Biological Systems (Romulus, MI). Predatory mites were used within 48 h of their arrival dates.

Greenhouse Experiment. Fifteen mite-free 'Festival' strawberry plants with a total of four trifoliates were placed into previously constructed mite-free cages (Fig. 1). Each plant was placed into an individual cage (60 by 30 by 20 cm). Cages were constructed of nylon fabric. Velcro was placed on three sides of the cage to gain easy access to the plants. Each cage was attached to a pot containing a strawberry plant by using a pull cord sown into the bottom of the cage. Cages were used to keep both twospotted spider mites and predatory mites from dispersing between plants. Ten twospotted spider mites were released onto each plant and allowed to multiply for 1 to 2 wk (this varied depending on when the predatory mite shipment arrived). Before the release of predatory mites, a leaflet was collected from each plant. The number of twospotted spider mite motiles and eggs on each leaflet was counted, and the mean number per leaflet was calculated. The average release rate was approximately a 10:1 ratio (10 twospotted spider mite to one predatory mite). Also, a representative sample (one bottle from each species of predatory mite) was observed for at least 15 min to ensure that the shipped predatory mites were active and in good condition before use.

Experimental design was a completely randomized block with three treatments. Each treatment was replicated five times. Treatments included 1) 10 *P. persimilis* adults released per infested plant (≈100 twospotted spider mites), 2) 10 *N. californicus* adults released per infested plant (≈100 twospotted spider mites), and 3) untreated (control) plants (≈100 twospotted spider mites) without predatory mites.

Sampling. Each week the population of predators and twospotted spider mites was sampled by taking one leaflet from each plant (five leaflets from each individual treatment) and counting the numbers of twospotted spider mites as well as predatory mites (motiles and eggs). The term motiles refers to all life stages except eggs. Samples were recorded for 4 wk. Three trials of this experiment were run: the first trial was conducted in February/March 2004, the second in December 2004/January 2005, and the third in March/April 2005.

Data Analysis. Twospotted spider mite motile and egg data were log transformed. Mean twospotted spider mites per leaflet was compared each week across treatments by using an analysis of variance (ANOVA), and means were separated using a least significant difference (LSD) test (SAS Institute 2002).

Field Experiment. The field experiment was conducted at the University of Florida, Plant Science Research Unit, Citra, FL. Festival strawberry plants were planted in mid-October. They were grown as an annual crop on raised beds covered by black plastic mulch. A combination of overhead and drip irrigation was used for the first 3 wk to help establish the transplants. After this establishment period, only drip irrigation was used. Strawberries were planted in plots 7.3 by 6.1 m consisting of six rows 0.5 m wide with 0.5-m row spacing. There were 24 plots arranged in a 4 by 6 grid and spaced 7.3 m apart. The experiment was a completely randomized block design with six replicates. Four treatments were evaluated and included 1) two releases of *P. persimilis* (P), 2) two releases of *N. californicus* (N), 3) two applications of the reduced-risk miticide Acramite 50 WP at the rate of 1.125 kg of product per hectare (A), and 4) an untreated control (C). In the 2003–2004 field season, all treatments were applied during the weeks of 11 December and 11 February. In the 2004–2005 field season, all treatments were applied on 9 December and again on 10 March. Predatory mites were applied at a rate of one bottle (2000 mites) per plot by hand by gently rotating the bottle over each plant. Acramite was sprayed using a 11-liter (3-gal) backpack sprayer.

Sampling. Sampling was initiated once the plants had established (≈3 wk after planting). Each week, six leaves per plot (36 leaves per treatment) were collected randomly from the middle and lower strata of each plant and brought back to the laboratory where the number of twospotted spider mite motiles and eggs and predatory mite motiles and eggs on each leaf were counted under a dissecting microscope. Only *P. persimilis* and *N. californicus* mites were counted.

Data Analysis. The twospotted spider mite motile and egg data were separated into five periods based on treatment application dates and time during the season. This was also important to examine trends throughout the 4-mo field season. These periods were 1) pretreatment (3 wk before any treatment), 2) early-season (posttreatment to week 7), 3) mid-season (week 8 to when the second application was applied in 2003–2004 at week 12), 4) early-late season (week 13 to when the second treatment was applied in the 2004–2005 season at week 16), and 5) late season (weeks 17–19). The late season was split into two periods because of the difference in timing of the second application between seasons. For example, during the 2003–2004 season, the second application occurred at the beginning of the late season, whereas in the 2004–2005 field season, the second application occurred in the middle of the late season. In each period, data were log transformed and then treatments were compared using an ANOVA, and means were separated using an LSD test (SAS Institute 2002).

Yield. Yield data were collected beginning in early January in both seasons. Strawberries were harvested weekly by hand. Marketable strawberries from the four inner rows were weighed on a bench scale (Mettler Toledo, Columbus, OH). Damaged, rotten, and severely deformed strawberries were discarded. The two outer rows served as border rows and the strawberries from these rows also were discarded.

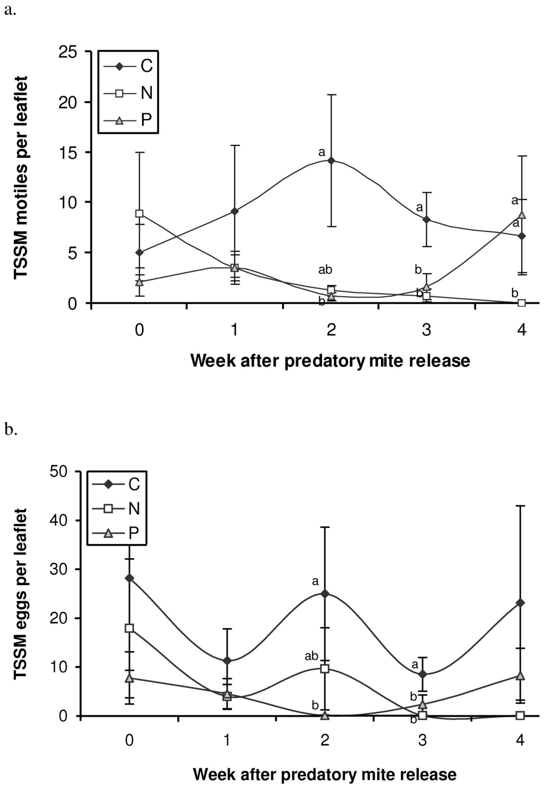

Fig. 2. Weekly mean ± SEM twospotted spider mite (TSSM) (a) motiles and (b) eggs per leaflet in each treatment in the greenhouse experiment. Week 0 is the initial sample taken before predatory mites were released. Means on the same date followed by the same letter are not significantly different by LSD (P = 0.05) (C, control; P, *P. persimilis*; and N, *N. californicus*).

Data Analysis. The mean yield per treatment for the whole season was compared across treatments using an ANOVA (SAS Institute 2002). A LSD test was used to show treatment differences for the yield data. This was done for both field seasons.

Results

Greenhouse Experiment. There were no significant differences in twospotted spider mite motile and egg populations among treatments when the initial sample was taken (week 0) (motiles: F = 1.1; df = 2, 24; P = 0.3638; eggs: F = 0.94; df = 2, 24; P = 0.4046) and 1 wk after predatory mite release (motiles: F = 0.08; df = 2, 24; P = 0.9257; eggs: F = 0.45; df = 2, 24; P = 0.6441) (Fig. 2). Two weeks after the release of predatory mites, *P. persimilis* significantly reduced twospotted spider mite motile and egg numbers below numbers in the control (motiles: F = 3.4; df = 2, 24; P = 0.0513; eggs: F = 4.4; df = 2, 24; P = 0.0230). However, twospotted spider mite numbers on plants where *N. californicus* was released were intermediate, averaging

1.3 ± 1.3 motiles and 9.7 ± 8.4 eggs per leaflet (Fig. 2). Both species of predatory mites significantly reduced numbers of twospotted spider mite motiles and eggs below the control by week 3 (motiles: $F = 6.2$; df = 2, 24; $P = 0.0068$; eggs: $F = 6.0$; df = 2, 24; $P = 0.0075$). Twospotted spider mite motile and egg numbers on plants where *P. persimilis* were released began to increase at week 4 and were not significantly different from the control. At this time, there were significantly fewer motiles per leaflet in the *N. californicus* treatment compared with the other two treatments (motiles: $F = 4.3$; df = 2, 24; $P = 0.0256$). However, the difference in egg numbers was not significant (eggs: $F = 1.9$; df = 2, 24; $P = 0.1717$).

One week after predatory mite release, there were an average of 0.1 ± 0.1 *P. persimilis* motiles per leaflet in the *P. persimilis* treatment. This increased to 0.5 ± 0.2 motiles per leaflet at week 2 and 0.7 ± 0.6 motiles per leaflet at week 3. The population then decreased to 0.3 ± 0.2 motiles per leaflet at week 4. Only one *P. persimilis* egg was recorded in the study at week 4 in the third trial of the experiment.

In contrast, *N. californicus* numbers in the *N. californicus* treatment were similar throughout the study. There were an average of 0.7 ± 0.5, 0.7 ± 0.4, 0.6 ± 0.3, and 0.6 ± 0.3 motiles per leaflet at weeks 1, 2, 3, and 4, respectively. In total, seven eggs were laid during the experiment: four at week 1 in the first trial, one at week 2 in the third trial, and two at week 3 in the second trial.

Field Experiment. *2003–2004 Field Season.* There were no significant differences in motile and egg numbers among treatments in the pretreatment period (motiles: $F = 0.8$; df = 3, 15; $P = 0.5041$; eggs: $F = 0.7$; df = 3, 15; $P = 0.5805$) or in the early-season (motiles: $F = 0.7$; df = 3, 15; $P = 0.5511$; eggs: $F = 1.4$; df = 3, 15; $P = 0.2755$) (Fig. 3). The *N. californicus* and Acramite treatments had significantly fewer motiles and eggs per leaflet than the control plots during the mid-season (motiles: $F = 3.9$; df = 3, 15; $P = 0.0297$; eggs: $F = 5.0$; df = 3, 15; $P = 0.0137$) and during the early-late season (motiles: $F = 5.1$; df = 3, 15; $P = 0.0121$; eggs: $F = 4.0$; df = 3, 15; $P = 0.0280$) (Fig. 3). During these two periods, twospotted spider mite numbers in the *P. persimilis* treatment were fairly high but were not significantly different from twospotted spider mite numbers in the *N. californicus* treatment. Also, numbers of twospotted spider mite in the *P. persimilis* treatment were not significantly different from those in the control with the exception of the early-late season in terms of the numbers of motiles (Fig. 3). There were no significant differences in twospotted spider mite motile and egg numbers among treatments in the late season (motiles: $F = 1.2$; df = 3, 15; $P = 0.3461$; eggs: $F = 0.68$; df = 3, 15; $P = 0.5777$).

Predatory mites were observed from 17 December until 17 March (mid- and early-late seasons). In the *P. persimilis* treatment, the *P. persimilis* population began increasing on 7 January reaching a peak of 1.4 ± 0.4 motiles and 1.6 ± 0.4 eggs per leaflet on 20 January. The population remained high for several weeks then declined sharply on 20 February and remained low.

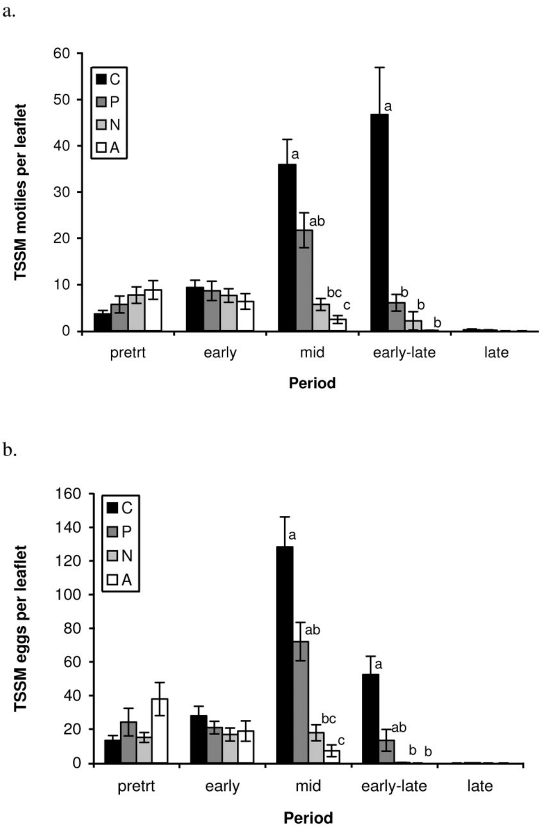

Fig. 3. Mean ± SEM twospotted spider mite (TSSM) (a) motiles and (b) eggs per leaflet for five periods of the 2003–2004 field season. Means on the same date followed by the same letter are not significantly different by LSD ($P = 0.05$) (C, control; P, *P. persimilis*; N, *N. californicus*; A, Acramite).

No *P. persimilis* were recorded after 17 March. In the *N. californicus* treatment, the *N. californicus* population began to increase at 17 December, reaching a peak of 1.0 ± 0.3 motiles and 0.6 ± 0.1 eggs per leaflet on 2 February. The population declined sharply at 25 February. After this date, no *N. californicus* were recorded with the exception of a small number noted on 30 March (no twospotted spider mites were recorded after 25 February in this treatment either). Very small numbers of motiles of both species were recorded from the Acramite treatment the week after each release. However, no eggs were ever recorded. Small numbers of both species dispersed into the control plots and were recorded from 2 February until 9 March. The combined population never exceeded 0.4 ± 0.3 motiles or 0.2 ± 0.2 eggs per leaflet.

2004–2005 Field Season. During the 2004–2005 field season, the twospotted spider mite population peaked much later in the season. There were no significant differences in twospotted spider mite motile and egg numbers in the pretreatment period (motiles: $F = 0$; df = 3, 15; $P = 1$; eggs: $F = 0$; df = 3, 15; $P = 1$) or in the early-season (motiles: $F = 0.47$; df = 3, 15; $P = 0.7073$; eggs: $F = 0.57$; df = 3, 15; $P = 0.6432$) (Fig. 4).

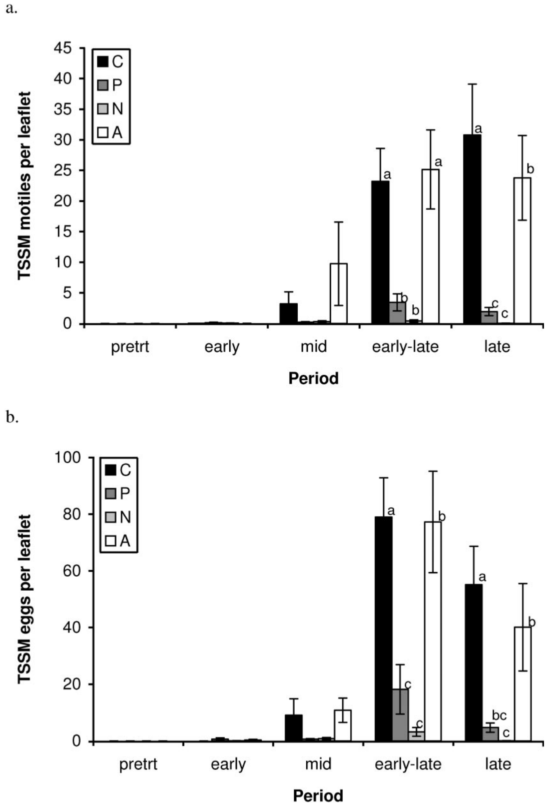

Fig. 4. Mean ± SEM twospotted spider mite (TSSM) (a) motiles and (b) eggs per leaflet for five periods of the 2004–2005 field season. Means on the same date followed by the same letter are not significantly different by LSD ($P = 0.05$) (C, control; P, *P. persimilis*; N, *N. californicus*; and A, Acramite).

There were also no significant differences in twospotted spider mite motile or egg numbers in the midseason (motiles: $F = 1.9$; df = 3, 15; $P = 0.1699$; eggs: $F = 2.4$; df = 3, 15; $P = 0.1129$). However, twospotted spider mite egg numbers showed a trend of being higher in the Acramite treatment compared with the *N. californicus* treatment during the mid-season (Fig. 4). The control treatment had significantly higher numbers of twospotted spider mite motiles and eggs than the *N. californicus* and *P. persimilis* treatments in the early-late season (motiles: $F = 11.1$; df = 3, 15; $P = 0.0004$; eggs: $F = 13.0$; df = 3, 15; $P = 0.0002$) and the late season (motiles: $F = 14.6$; df = 3, 15; $P = 0.0001$; eggs: $F = 14.6$; df = 3, 15; $P = 0.0001$) (Fig. 4). During the early-late season, numbers of twospotted spider mite motiles in the Acramite treatment did not differ significantly from those found in the control. However, there were significantly less twospotted spider mite eggs in the Acramite treatment during this period than in the control. The Acramite treatment had significantly higher numbers of twospotted spider mite motiles and eggs than both predatory mite treatments in the early late season. In the late season, the Acramite treatment had significantly more twospotted spider mite motiles than both predatory mite treatments and significantly more twospotted spider mite eggs than the *N. californicus* treatment (Fig. 4).

Table 1. Mean total marketable strawberry yield from each treatment for the 2003–2004 and 2004–2005 field season

Treatment	Mean ± SEM total yield (kg) of strawberries	
	2003–2004	2004–2005
Acramite	93.9 ± 4.9ab	39.2 ± 1.8
N. californicus	98.3 ± 3.8a	35.1 ± 1.4
P. persimilis	83.1 ± 4.8b	37.2 ± 0.9
Control	83.1 ± 7.6b	38.9 ± 1.1

Means within a season followed by the same letter are not significantly different (LSD test; $P = 0.05$).

Predatory mites were observed from 12 January until 30 March (mid, early-late, and late seasons). Observations were sporadic until 23 February. In the *P. persimilis* treatment, *P. persimilis* motiles and eggs were recorded continuously from 9 March until 30 March. The population never rose above 0.1 ± 0.1 motiles or 0.1 ± 0.03 eggs per leaflet. In the *N. californicus* treatment, *N. californicus* motiles and eggs were recorded continuously from 23 February until 25 March. The population never rose above 0.2 ± 0.1 motiles or 0.3 ± 0.1 eggs per leaflet. In total, two *P. persimilis* motiles and four *P. persimilis* eggs were recorded in the Acramite treatment on 25 March, and one egg was recorded on 16 March. Both species dispersed into the control plots and were recorded from 23 February until 30 March. The combined population reached a peak of 0.4 ± 0.1 motiles and 0.4 ± 0.1 eggs per leaflet on 25 March and then declined slightly by 30 March.

Yield. In the 2003–2004 season, the mean total marketable yield from the *P. persimilis* treatment was not significantly different from the control (Table 1). The total marketable yield for the *N. californicus* treatment averaged significantly higher than the *P. persimilis* and control treatments ($F = 3.36$; df = 3, 15; $P = 0.0376$). The total marketable yield for the Acramite treatment was not significantly different from the other three treatments.

In contrast, in the 2004–2005 season, there were no significant differences in mean total marketable yield between the four treatments ($F = 2.6$; df = 3, 15; $P = 0.0907$) (Table 1). Mean total marketable yield per treatment was much lower than the previous season. Marketable yields averaged between 35 and 40 kg per treatment compared with 85–90 kg per treatment in the 2003–2004 field season.

Discussion

Greenhouse Experiment. Our results indicate that both species of predatory mites significantly reduced twospotted spider mite numbers below those found in the control. *N. californicus* suppressed twospotted spider mite populations for a longer time period and its population remained relatively constant throughout the experiment. However, these predators initially took longer (1 wk) than *P. persimilis* to reduce twospotted spider mite numbers below the control. This was not surprising because *P. persimilis* is known to quickly knock down twospotted spider mite populations under controlled conditions (Gilstrap and Friese 1985). In our studies, *P. persimilis* seems to be unable to sustain suppression of twospotted spider mite beyond 3 wk in the greenhouse. The twospotted spider mite population increased at week 4, whereas the *P. persimiils* population declined. The reason for this may be related to its biology. As a type I specialist, *P. persimilis* cannot survive in areas where its food supplies are low. Therefore, once the twospotted spider mite population has been greatly reduced, *P. persimilis* must disperse to a new location to find food (McMurtry and Croft 1997). Both species of predatory mites laid very few eggs. We do not know why this occurred, but we speculate that there was not enough twospotted spider mite prey for either species to produce large numbers of eggs.

Field Experiment. In both field seasons, there were fewer twospotted spider mites in the *N. californicus* treated plots compared with the *P. persimilis*-treated plots, although the difference in the 2004–2005 season was not significant. This suggests that *N. californicus* may be better at reducing or regulating field populations of twospotted spider mite than *P. persimilis.* In this study, we do not think that environmental conditions contributed to the better performance of *N. californicus* because similar results were obtained in the greenhouse under controlled conditions.

Acramite was highly effective in the 2003–2004 season, but did not adequately control twospotted spider mite populations in the 2004–2005 season. This was primarily a result of timing. In the 2003–2004 season, the first spray knocked down the twospotted spider mite population and the second spray in early February kept the numbers low. During the 2004–2005 season, in contrast, there were no detectable twospotted spider mite populations when Acramite was first sprayed. By the time twospotted spider mite populations began to increase, there was little residual activity left in the Acramite plots. We delayed the second application of all treatments until March during the 2004–2005 field season so that twospotted spider mite populations could have a chance to increase. Because the Acramite plots were essentially controls (because of delayed application), the twospotted spider mite population in these plots exploded and was so high that the second application of Acramite could not significantly reduce twospotted spider mite levels. This illustrates the importance of properly timing Acramite applications for growers. Using Acramite in combination with other management tactics (predatory mites) to control twospotted spider mites might avoid such problems, although further research would be needed to demonstrate this possibility.

There were several differences in the twospotted spider mite populations between the two field seasons. In the 2003–2004 season, twospotted spider mites were present in the plots from the start of the experiment, they began to increase when the temperature began to increase, and then declined by the last few weeks of the season. In contrast, no detectable numbers of twospotted spider mites were found in the 2004–2005 season until mid-January, and the numbers of twospotted spider mite did not increase greatly until late February. Overall, both twospotted spider mite and predatory mite numbers were much lower in the 2004–2005 season. White and Liburd (2005) found that twospotted spider mites prefer hot, dry conditions, and the late summer and fall 2004 were incredibly wet because of hurricanes Francis and Jeanne. This may have knocked back the surrounding population of twospotted spider mites, leaving smaller numbers to disperse into the strawberries when they were planted.

Another difference in the twospotted spider mite populations between seasons was that the presence of the green form of twospotted spider mite was much more prevalent than the red form in 2003–2004. This trend reversed itself in 2004–2005. The red and green forms were considered separate species until Hinomoto et al. (2001) showed that reproductive incompatibility between the two forms is incomplete. Using cytochrome oxidase subunit I sequences, Hinomoto et al. (2001) demonstrated that the two forms belong to the same species from a phylogenetic standpoint. We do not know why the green form predominated in 2003–2004 and the red predominated in 2004–2005. This would be an interesting topic to research further.

Predatory mite population trends also differed greatly between seasons. In 2003–2004, both species were abundant when twospotted spider mite populations were high, declining when prey populations diminished. In 2004–2005, predatory mites also were present when twospotted spider mite populations were high (compared with the rest of the season). However, overall predatory mite populations were much lower than those in the previous season. This was probably because of the overall much lower twospotted spider mite population in the 2004–2005 season.

Yield. During the 2003–2004 field season, the *N. californicus* treatment had a significantly higher mean total marketable yield than both the control and *P. persimilis* treatments. However, during the 2004–2005 field season, there were no significant differences among treatments. The difference in twospotted spider mite population trends between the two seasons may partially explain why there were significant differences between treatments in 2003–2004 but not in 2004–2005. Sances et al. (1981) found that higher numbers of twospotted spider mites are needed to cause a similar level of damage when infestation occurs later in the season. That the twospotted spider mite population in 2004–2005 was so low and twospotted spider mites occurred so late in the season suggested that the numbers of twospotted spider mites were not high enough to affect the quantity of strawberries produced during the 2004–2005 field season. Other factors that may have contributed to the lack of significant differences in the 2004–2005 field season were a greater amount of fungal problems, including

Anthracnose fruit rot, *Colletotrichum acutatum* Simmonds, and gray, mold *Botrytis cinerea* Pers; bird damage; and weed infestation in 2004–2005. These factors also may have lead to the overall lower marketable yields in 2004–2005 compared with 2003–2004.

Overall, releases of *N. californicus* seem to be a viable tactic for north Florida strawberry growers. Acramite is very effective if applications are timed and applied properly. Application of Acramite followed by the release of an effective predatory mite such as *N. californicus* may be an effective management tactic for strawberry growers in north Florida. Further research on combination treatments is needed before definite conclusions can be drawn.

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