RELEASE OF NEOSEIULUS CALIFORNICUS ON PEPPER TRANSPLANTS TO PROTECT GREENHOUSE-GROWN CROPS FROM EARLY BROAD MITE (POLYPHAGOTARSONEMUS LATUS) INFESTATIONS

E. Jovicich¹, D.J. Cantliffe², L.S. Osborne³, P.J. Stoffella⁴ & E.H. Simonne⁵

¹Horticultural Sciences Department, University of Florida, Present address: Plant Protection Systems – Tropical, Horticulture & Forestry Sciences, Department of Primary Industries & Fisheries, Ayr Research Station, PO Box 15, Ayr, QLD 4807, Australia, e.jovicich@internode.on.net; ²Horticultural Sciences Department, University of Florida, 1143 Fifield Hall, P.O. Box 110690, Gainesville, FL 32611-0690, U.S.A., djcant@ufl.edu; ³Entomology and Nematology Department, University of Florida, Mid-Florida Research and Education Center, 2725 Binion Road, Apopka, FL 32611-0690, U.S.A., lsosborn@ufl.edu; ⁴Horticultural Sciences Department, University of Florida, Indian River Research and Education Center 2199 South Rock Road, Ft. Pierce, FL 34945-3138, U.S.A., pjs@ufl.edu; ⁵Horticultural Sciences Department, University of Florida, 1143 Fifield Hall, P.O. Box 110690, Gainesville, FL 32611-0690, U.S.A., esimonne@ufl.edu

ABSTRACT.

Broad mites (Polyphagotarsonemus latus) rapidly damage pepper (Capsicum annuum) crops and reduce production in greenhouses in warm climate regions when the minute pest infests at early plant developmental stages. A first study was set to evaluate biological control strategies during seedling development. Timing of release of Neoseiulus californicus, a commercially-reared predatory mite, was investigated in scenarios of pest and predator presence to simulate preventive and curative control strategies. Undamaged seedlings were produced when two predators per seedling were released preventively. Curative control strategies were not effective for producing undamaged or broad mite-free transplants. Further studies were carried to evaluate the effectiveness of N. californicus on pepper seedlings that host a few broad mites and are transplanted into the production greenhouse. N. californicus released at different times and densities, and conventional control methods (micronized-sulfur sprays) were evaluated for pest control, plant damage, and fruit yield. Yields of red fruits from plants with four predators per plant released at any of the release times (six days before, at, or four days after transplanting) or with sulfur sprays were not significantly different from an uninfested control treatment. Releases of two predatory mites per plant led to yields similar to the uninfested control only when introductions were a week before transplanting, while later introductions led to serious plant damage and significantly lower yields. Early broad mite infestations in pepper crops grown in greenhouses might be effectively controlled with N. californicus released at early seedling developmental stages in the nursery and at transplanting in the fruit production greenhouse.

INTRODUCTION.

Infestations of broad mite [Polyphagotarsonemus latus (Banks) (Acari:Tarsonemidae)] initiated at early developmental stages of pepper (Capsicum annuum) can lead to severe plant damage in greenhouses where transplants or fruit are produced (de Coss-Romero & Peña, 1998; Gerson, 1992; Weintraub et al.,
Seedlings will appear undamaged when they become infested with the minuscule mite a few days before transplanting but they carry the pest to crops grown in greenhouses. Biological control programs initiated at early pepper crop stages are disrupted by multiple sprays of commonly used pesticides (e.g., sulfur, abamectin, and dicofol). *Neoseiulus californicus* McGregor (Acari: Phytoseiidae), a predaceous mite that can be released on greenhouse-grown vegetables for biological control of two-spotted spider mite (*Tetranychus urticae* Koch (Acari: Tetranychidae)), has been reported to feed on *P. latus* and reproduce when feeding on this pest as well (Castagnoli & Falchini, 1993; Peña & Osborne, 1996). Preventive releases of *N. californicus* may provide effective pest management as the predator can remain on plants for short periods when prey is absent (de Courcy Williams *et al.*, 2004). Assessments of the effectiveness of releasing *N. californicus* on seedlings or young pepper plants have not evaluated the effects of the pest on fruit production in crops grown in greenhouses. This manuscript presents selected results of research in which we evaluated the use of *N. californicus* as a broad mite management strategy for greenhouse-grown pepper crops when infestations were initiated during seedling development.

**MATERIALS AND METHODS.**

In a first experiment, seedlings of bell pepper cv. ‘Legionnaire’ (Rogers-Syngenta) were grown in commercial nursery flats separated from each other by water barriers, and in a controlled environment (L:16h and D: 8h, with air temperatures 24 ± 1°C and 19 ± 1°C, and air relative humidity 70 ± 10% and 80 ± 10%, respectively, and no air movement over the seedlings). Seedlings were artificially infested with two gravid female *P. latus* at three seedling developmental stages (unfolded cotyledons, two leaves, and four leaves). Two *N. californicus* (reared by Biotactics, Romoland, California) were released on seedlings with a) unfolded cotyledons at either 0, +15, or +24 days from initial infestation (DFI) of *P. latus*, b) two leaves unfolded at either –15, 0, or +9 DFI, and c) four leaves unfolded, at either –24, −9, or 0 DFI. Additionally, separate groups of seedlings remained mite-free (non-infested control), and other groups were either infested with *P. latus* only or had releases of *N. californicus* only at the three seedling developmental stages. From each flat, seedlings were sampled every third day until day 42 after seeding. Mites were recovered using a plant washing procedure and counted under the microscope (Jovicich, 2007). Plant growth variables (leaf area, dry weight, and stem height) were measured on seedlings.

In a second experiment, pepper seedlings with nine unfolded leaves were transplanted into containers and grown in soilless production systems in a passively ventilated greenhouse. Seedlings were transplanted in March, three days after each seedling had been artificially infested with two female broad mites. Treatments included a) release of either 2 or 4 *N. californicus* per plant at either –3, +3, or +7 DFI, b) five weekly micronized-sulfur sprays (80% sulfur at a rate of 3.4 kg·ha⁻¹) initiated at either –3 or +3 DFI, c) infested with no pest management, and d) non-infested control. Within the greenhouse, plots were isolated with vertical polyethylene film barriers. Top plant canopy leaves were sampled weekly for mite recovery, and early marketable yield of red fruit was harvested. Both experiments were arranged as randomized complete block designs.
RESULTS & DISCUSSION.

In the first experiment, undamaged 42-days-old seedlings were produced when two predators per seedling were released preventively (up to 24 d before seedlings were infested with *P. latus*) (Fig. 1). Growth variables in seedlings that had two predators released on the same day of the infestation, or before the day of the infestation, were not significantly different from seedlings that had not been infested with *P. latus*. However, these undamaged seedlings, which still hosted *N. californicus* at 42 d after seeding, also hosted from 3 to 13 *P. latus*, and were at prey:predator ratios < 7:1 in whole seedlings. It is likely that *N. californicus* could maintain the pest at non damaging levels after seedlings from the latter scenario are transplanted in a greenhouse. However, higher predator release densities than two *N. californicus* per seedling may be needed to obtain pest-free seedlings in transplant flats with widespread infestations of *P. latus*.

Releasing two *N. californicus* per seedling as a curative control strategy (within a time as short as 9 days after an initial infestation with two *P. latus*) in nursery trays was not effective for producing undamaged or broad mite-free transplants (Fig. 1). Growth variables in curative releases were up to 60% less than in seedlings that had not been infested with *P. latus*. At 42 d after seeding, severely damaged seedlings averaged up to 5000 *P. latus* cumulative mite-days. Seedlings with preventive releases had generally less than 100 *P. latus* cumulative mite-days for growth variables to be reduced 5% or less with respect to measurements in non-infested seedlings, and showed no visual symptoms of mite damage. Peaks of up to 350 *P. latus* per seedling were measured in pest-predator scenarios where *N. californicus* were released 9 to 24 days after the initial *P. latus* infestation. In these curative releases of the predator, *P. latus* populations decreased by day 42 after seeding and were in a range from 16 to 226 *P. latus* per seedling.

In the second experiment, serious plant damage occurred where broad mites were left uncontrolled, within a month after transplanting infested seedlings into the greenhouse (Fig. 2). No marketable fruit was harvested from plants where *P. latus* was left uncontrolled (Fig. 3). Marketable fruit loss was due to damage caused by *P. latus* to terminal shoots, flowers, and fruits. Yields of red fruits from plants with four predators per plant released at any of the release times (six days before, at, or four days after transplanting), or with sulfur treatments, were not significantly different from the uninfested control treatment (Fig. 4). Releases of two predatory mites per plant led to yields similar to the uninfested control only when introductions were a week before transplanting (Fig. 4), while later introductions led to serious plant damage and significantly lower yields. Pest populations at fruit harvest were nil in all plants treated with *N. californicus*. During the 88-day crop, releases of *N. californicus* that were effective had ≤ 120 *P. latus* cumulative mite-days on the top canopy leaves (averaging 1 mite/leaf-cm²), while top leaves from plants with no *P. latus* control reached up to 1500 *P. latus* cumulative mite-days. With sulfur sprays, broad mite populations on top leaves were kept at low numbers (≤ 2 mites/leaf-cm²) but mite populations resurged after the spray program was interrupted (after fifth spray).
Fig. 1. Damage levels in pepper seedlings 42 d after seeding in selected scenarios where two *Polyphagotarsonemus latus* and two *Neoseiulus californicus* were introduced at different times during seedling development. Developmental stages of non infested seedlings: cotyledons unfolded (Coty), two leaves unfolded (2L), and four leaves unfolded (4L). Days from initial *P. latus* infestation (DFI). Damage scale ranged from 0 (no visual damage) to 4 (necrosis of terminal shoot leaves).
Fig. 2. Pepper plants treated with and without *Neoseiulus californicus* a month after they were transplanted in a greenhouse. (LEFT) Each plant was infested with two *Polyphagotarsonemus latus* 3 d before transplanting but had two *N. californicus* released 6 d before transplanting, and (RIGHT) each plant was infested with two *P. latus* 3 d before transplanting and the pest was left unchecked.

Fig. 3. Fruit on pepper plants treated with and without *Neoseiulus californicus* for an early *Polyphagotarsonemus latus* infestation. Plants (88 days after transplanting) with fruit attached and leaves removed. (LEFT) Plant was infested with two *P. latus* 3 d before transplanting but had two *N. californicus* released 6 d before transplanting, and (RIGHT) Plant was infested with two *P. latus* 3 d before transplanting and the pest was left unchecked (all fruit were damaged and unmarketable). Reference line is 50-cm tall.
Fruit yield relative to non-infested plants (%)

Time from an infestation initiated with 2 *P. latus* per seedling (d)

Fig. 4. Marketable fruit yield (88 days after transplanting, DAT) in greenhouse-grown bell pepper plants that were infested with two *Polyphagotarsonemus latus* (–3 DAT) and had the pest managed with a) *Neoseiulus californicus* (released at either –6, 0, or 4 DAT, at predator release densities of two or four per plant), b) sulfur (5 weekly sprays started at either –6 DAT or 0 DAT). Yield was 100% in non infested plants and 0% in infested plants with no pest management. Letters for comparisons are based on Tukey-Kramer test for mean separation.

In tropical and subtropical regions, *P. latus* infests pepper crops at any time during the crop development. Pepper crops are most vulnerable when early crop infestations occur (de Coss-Romero & Peña, 1998) and pest management is delayed because the pest is unnoticed. In pepper seedlings grown in nursery flats as well as in young plants grown in fruit production greenhouses, a curative release of two *N. californicus* per plant once symptoms were observed on top leaves were not effective for avoiding transplant damage or yield reduction. However, initial broad mite infestations in pepper crops grown in greenhouses could effectively be controlled with *N. californicus* released at early seedling developmental stages in the nursery and at transplanting in the fruit production greenhouse. Both *Neoseiulus cucumeris* (Oudemans) (Acari: Phytoseiidae) (Weintraub et al., 2003) and *N. californicus* are phytoseiids that are commercially reared in many countries and can be used to manage broad mite infestations in greenhouse-grown pepper crops. Released on transplants, *N. californicus* may control early infestations of broad mites and two-spotted spider mites, and become established on the transplanted crop. In production regions where *N. californicus* is available, this predator could be an important pest management tool for growers who intend to produce pesticide-free crops, crops with a minimum use of pesticides, or crops that follow organic production standards.
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REFERENCES.


