EFFECT OF FUNGICIDES ON THE MITE FAUNA OF *PRUNUS PERSICA* L. CULTIVARS IN PRESIDENTE PRUDENTE, SP, BRAZIL

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Abstract: The objective of this study was to characterize the diversity of phytophagous and predatory mites on peach cultivars either with or without fungicide treatment, in the city of Presidente Prudente, State of São Paulo, Brazil. In order to evaluate the effect of fungicides, leaf samples were colleted at random from treated and untreated plants of the Tropical, Aurora 1 and Aurora 2 cultivars, from June 2004 to February 2006. From the results obtained it can be concluded that: plants with or without treatment showed high populations of predatory mites, indicating that the treatments were innocuous on the mite populations. A diversified composition of the mite community was observed. The Phytoseiidae family had the highest richness in numbers and species of mites. *Euseius citrifolius* and *E. concordis* were the most abundant species. Plants with or without treatment had high abundances of predatory mites, with a predominance of *E. citrifolius*.

Key words: *Prunus persica*, dynamics, diversity, fungicide, pest control, mites

INTRODUCTION

Brazil ranks 11th as a global temperate fruit producer (FAO 2007). Production is mainly concentrated in the states of Rio Grande Sul, São Paulo, Santa Catarina, Minas Gerais and Paraná. Approximately 22,453 ha of peaches for processing or fresh consumption, are grown in Brazil. In 2006, the yield was 199,719 tons. Yield in the State of São Paulo during the same year was 44,379 tons from 2,101 ha (IBGE 2006).

Mites are small organisms that remove the surface leaf tissues and cause sap losses on the upper layers of the leaf tissue in peach plants. Infestations by mites cause yellowing on the sides and along the midrib. In more severe infestations leaf bronzing may occur, with qualitative and quantitative reductions in fruit yield (Salles 1998).

In Brazil, pest mite species that attack peach trees are the two-spotted spider mite (*Tetranychus urticae* Koch, 1836) (Tetranychidae), the red mite (*Panonychus ulmi* Koch, 1836) (Tetranychidae), and the peach silver mite (*Aculus cornutus* Banks, 1905) (Eriophyidae) (Flechtmann 1976; Santa-Cecília and Souza 1997).

In a study on the population of predatory mites in peach, especially mites from the Phytoseiidae family, Moraes *et al*. (1986) referred to the occurrence of *Euseius concordis* (Chant 1959), *Iphiseiodes zuluagai* Denmark and Muma 1972, *Phytoseiulus macropilis* (Banks 1904), and *Ricoseius loxocheles* (De Leo 1965).

Some mites in the Tetranychidae family are important pests of fruits trees and generally only reach economically damaging levels when their natural enemies are not very abundant or are not present. Mites in the Phytoseiidae family are important natural enemies of the tetranychids, and their predatory activity is affected by the use of non-selective agrochemicals (Altieri *et al*. 2003). Another problem that stems from the intensive use of agrochemicals is the appearance of mite resistance cases to those products, as verified by Sato *et al.* (2000) in peach trees in the Paranapanema region, State of São Paulo.

This study aimed to evaluate the mite fauna composition and the effect of fungicide application on the mite populations in peach cultivars in the city of Presidente Prudente, SP. The evaluation was done in order to support pest management in the crop.

MATERIALS AND METHODS

The experiment was conducted in a peach orchard installed at the Farm headquarters of Pólo Regional da Alta Sorocabana, Agência Paulista de Tecnologia dos Agronegócios, State of São Paulo's Secretaria Agricultura e Abastecimento, located in the city of Presidente Pru-

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dente, UTM 7545288.76 m N, 459930.31 m E and 424.29 m elevation. The study was conducted in the period of June 2004 to February 2006, in a five-year-old orchard installed at a row spacing of 6.0x3.0 m. Peach cultivars Tropical, Aurora 2, and Aurora 1, which require less than 100 hours of cold temperatures, were used. The management practices adopted during the study were the conventional practices indicate for the crop (Pereira *et al.* 2002), such as: artificial dormancy-breaking treatment with hydrogen cyanamide (0.5%) + mineral oil (1%), fruit thinning, fertilizations, control of spontaneous plants (Glyphosate at 0.5% active substance), green and dry pruning, and micro-sprinkler irrigation.

We evaluated the occurrence of phytophagous and predatory mites in the peach trees under the effect of fungicides employed to control peach rust [*Tranzschelia discolor* (Fuckel) Tranzschel e Litv.]. Mancozeb (Dithane WP) was applied at a dose of 200g of commercial product (c.p.)/100 l water in alternation with azoxystrobin (Amistar) at a dose of 20 g c.p./100 l water. The application was compared against a control (no application), at 21-day intervals. Six plants of each cultivar were used, three with the application of fungicides and three without, in a completely randomized statistical design.

Samplings were performed every fifteen days by colleting 12 leaves/plant from different positions, that is, from the upper, middle and lower thirds of the plant (internal and external parts), for a total of 72 leaves. The samples were placed in paper bags kept in polystyrene boxes containing ice, to decrease mite activity. Mite extractions were performed at the Plant Health and Quality Laboratory. To accomplish the extractions, the samples were placed individually in plastic containers and immersed for 5 minutes in a 70% alcohol solution and then stirred to displace the mites. The leaves were discarded and the solution was passed through a 0.038 mm sieve and then collected in 30 ml capacity glass vials for later screening and identification. The mites thus collected, were mounted in Hoyer's medium for identification, except for the eriophids, which were mounted in modified Berlese medium (Krantz 1978). A representative sample of the species found was deposited at the Geraldo Calcagnolo mite reference collection, Economic Entomology Laboratory, Instituto Biológico.

A faunistic analysis of results was conducted and mite occurrence (accidental, assessory and constant) and dominance indices (accidental, assessory and dominant) were obtained, based on the method proposed by Palma (1975). The combination between the occurrence and dominance indices allows a general classification or status for the species to be obtained as follows: common species (constant + dominant) [C], intermediate species (accidental + dominant; accidental + assessory; assessory + assessory; assessory + dominant) [I]; and rare species (accidental + accidental) [R]. Morisita-Horn's similarity index (C_{MH}) (Magurran 1988) was used to analyse the composition of mite species in the various peach cultivars. The index was used to establish the mite diversity degree of similarity, between the various cultivars of plants with or without treatment.

In order to determine the rust control treatment effect with the use of fungicides, on the population of the predatory mite *Euseius citrifolius* Denmark and Muma 1970, the data were submitted to analysis of variance and compared using Duncan's test. This analysis was run on SAS. The significance level adopted in this statistical test was 5% ($p < 0.05$). The original data were transformed in $\sqrt{x}$.

RESULTS AND DISCUSSION

Mite diversity in peach cultivars

The occurrence of 34 mites species in 17 families was recorded in the period from June/2004 to February/2006 (Table 1). In all, 1.208 mite specimens were identified in the Tropical, Aurora 2 and Aurora 1 cultivars, of which 54.6% (660 mites) were collected in plants treated with fungicides and 45.36% (548 mites) were collected in the control plants. In plants without fungicide treatment, 76 phytophagous individuals were identified representing 13.87%, 436 predators (79.56%), and 36 individuals with other feeding habits representing 6.57% of the total. In treated plants, 176 phytophagous individuals were identified (26.67%), 445 predators (67.42%), and 39 with other feeding habits (5.91%) (Figs. 1, 2). *Parapronematus acaciae* Baker, *Neoseiulus* sp., *Neoseiulus idaeus* Denmark and Muma, *Fungitarsonemus* sp., and *Iphiseiodes zuluagai* Denmark and Muma were only obtained in cv. Tropical; *Homeopronematus* sp., *Tyrophagus* sp., *Typhlodromus transvaalensis* (Nesbit) were collected exclusively in cv. Aurora 1, while *Grallacheles* sp., *Czenspinski*a sp., *Oligonychus mcgregory*, Ixodida, Erythraeidae, *Lasioseius helvetius* Chant, *Haplochthonius* sp. 2, and Tarsonemid*ae* were restricted to cv. Aurora 2.

Some species occurred in more than one cultivar, like *Oligonychus* sp. and *Catarhynus* sp. in cvs. Tropical and Aurora 2; *Brevipalpus phoenicis* (Geijskes), *Lorryia* sp., *Mononychellus planki* (McGregor), *Tetranychus urticae* Koch, *Euseius citrifolius, Euseius concordis* (Chant), and *Aculus fockeui* (Nalepa and Trouessart) in cvs. Aurora 1, Aurora 2, and Tropical.

In the analysis of mites collected from plants either treated or non treated with fungicides, high diversity and abundance of mites were observed in cvs. Tropical and Aurora 2, corresponding to 36.26% and 36.75% of the total, respectively. Among the phytoseiids, *E. citrifolius* and *E. concordis* were the most frequent, corresponding to 19% of the total in cv. Tropical, 26% in cv. Aurora 2 and 19% in cv. Aurora 1.

In plants of cultivars treated with fungicides, a higher abundance of phytophagous mite species (46.67% of the total) was observed, but the population size (26.67%) was smaller in relation to the total. These results indicate little interference of the product on the mite population (Fig. 1).

In studies dealing with the residual effect of copper oxychloride on the reproduction of the southern red mite, *Oligonychus ilicis* (McGregor), Reis and Teodoro (2000) reported a positive effect on reproduction and increased oviposition, and new mite outbreaks in coffee plantations.

Table 1. Mite species obtained from peach trees, Presidente Prudente, SP, Brazil. Jun 2004 to February 2006

Order	Family	Genus/Species	Food habit
Astigmata	Acaridae Latreille, 1802	*Tyrophagus* sp.	Mycophagous
	Winterschmidtiidae Oudemans, 1923	*Czenspinskia* sp.	Mycophagous
Cryptostigmata	Cosmochthoniidae Grandjean, 1947	*Cosmochthonius* sp.	Saprophagous
	Haplochthoniidae van der Hammen, 1959	*Haplochthonius* sp.	Saprophagous
Mesostigmata	Ascidae Oudemans, 1905	*Asca* sp.	Predatory
		Lasioseius helvetius Chant, 1958	Predatory
		Proctolaelaps sp.	Predatory
	Phytoseiidae Berlese, 1913	*Amblyseius herbicolus* (Chant, 1959)	Predatory
		Euseius citrifolius Denmark & Muma, 1970	Predatory
		Euseius concordis (Chant, 1959)	Predatory
		Iphiseiodes zuluagai Denmark & Muma, 1972	Predatory
		Neoseiulus californicus (McGregor, 1954)	Predatory
		Neoseiulus idaeus Denmark & Muma, 1973	Predatory
		Neoseiulus aff. mumai	Predatory
		Neoseiulus sp.	Predatory
		Phytoseiulus fragariae Denmark & Schicha, 1983	Predatory
		Proprioseiopsis sp.	Predatory
		Typhlodromus transvaalensis (Nesbit, 1951)	Predatory
Metastigmata	Ixodida		Haematophagous
Prostigmata	Bdellidae Dugès, 1834	*Spinibdella* sp.	Predatory
	Cheyletidae Leach, 1815	*Hemicheyletia* sp.	Predatory
		Grallacheles sp.	Predatory
	Diptilomiopidae Keifer, 1944	*Catarhynus* sp.	Phytophagous
	Eriophyidae Nalepa, 1898	*Aculus fockeui* (Nalepa & Trouessart, 1891)	Phytophagous
	Erythraeidae Oudemans, 1902	sp. 1	Predatory
	Tarsonemidae Kramer, 1877	*Fungitarsonemus* sp.	Phytophagous
		Tarsonemus sp.	Phytophagous
	Tenuipalpidae Berlese, 1913	*Brevipalpus phoenicis* (Geijskes, 1939)	Phytophagous
	Tetranychidae Donnadieu, 1875	*Eutetranychus* sp.	Phytophagous
		Mononychellus planki (McGregor, 1950)	Phytophagous
		Oligonychus mcgregori (Baker & Pritchard, 1953)	Phytophagous
		Oligonychus sp.	Phytophagous
		Tetranychus urticae Koch, 1836	Phytophagous
	Tydeidae Kramer, 1877	*Lorryia* sp.	Mycophagous
	Iolinidae	*Homeopronematus* sp.	Mycophagous
		Parapronematus acaciae Baker	Pollenophagous

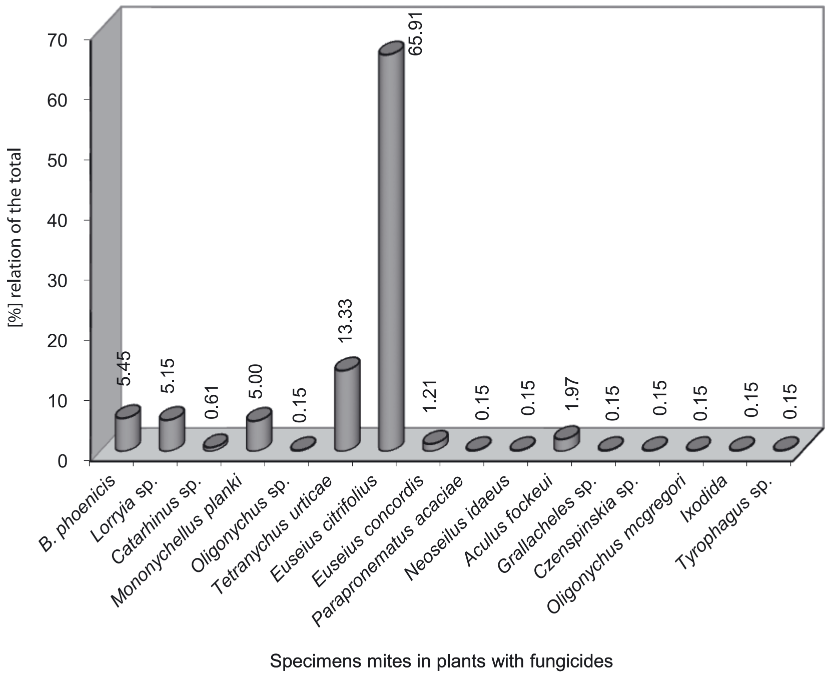

Fig. 1. Frequency of mite specimens on leaves of peach cultivars under application of fungicide in Presidente Prudente, SP, Brazil. 2004/2006

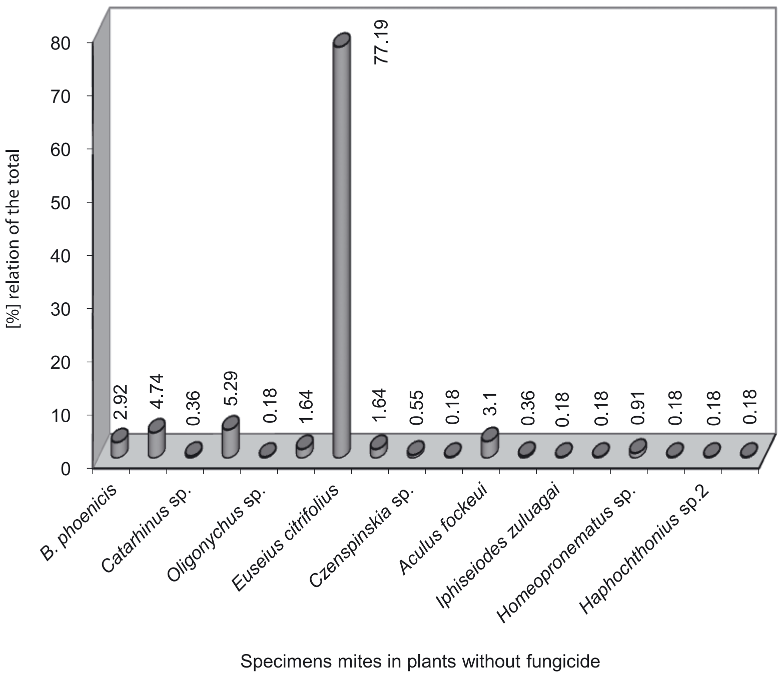

Fig. 2. Frequency of mite specimens on leaves of peach cultivars without application of fungicide in Presidente Prudente, SP, Brazil. 2004/2006

Faunistic analysis of mite species on leaves of peach cultivars with or without aplication of fungicides

In the faunistic analysis performed according to Palma's classification (1975), plants form the Tropical cv. treated with fungicides, had 45% of the collected mites with a rare species status, while 55% were intermediate species (Table 2). Among phytophagous species, which corresponded to 55% of the occurrences, *B. phoenicis, M. planki and T. urticae* received the status of intermediate species; however, *A. fockeui* was considered rare. A little different behavior was observed in plants without the effect of fungicides, in which phytophagous mites corresponded to 45%; *T. urticae* received rare species status, while *A. fockeui* was an intermediate species. *E. citrifolius* is considered common in plants with or without the effect of fungicides. Due to the fact that fungicide applied on the species was innocuous,

Table 2. Faunistic analysis of mite species on leaves of peach cv.Tropical, with or without the effect of fungicides in Presidente Prudente, SP, Brazil (2004/2006)

Species	Effect of fungicides on mite populations			
	with effect		without effect	
	N	Status	N	Status
Tenuipalpidae				
Brevipalpus phoenicis	13	I	7	I
Tydeidae				
Lorryia sp.	11	I	6	I
Iolinidae				
Parapronematus acaciae	1	R	0	–
Homeopronematus sp.	0	–	4	R
Diptilomiopidae				
Catarhinus sp.	2	R	0	–
Tetranychidae				
Mononychellus planki	7	I	9	I
Oligonychus sp.	1	R	0	–
Tetranychus urticae	19	I	3	R
Phytoseiidae				
Euseius citrifolius	160	I	166	C
Euseius concordis	6	I	2	R
Iphiseiodes zuluagai	0	–	1	R
Neoseiulus sp.	0	–	1	R
Neoseiulus idaeus	1	R	0	–
Eriophyidae				
Aculus fockeui	2	R	8	I
Tarsonemidae				
Fungitarsonemus sp.	0	–	2	R

N – mites total; S – species status; C – common; I – intermediate; R – rare

Table 3. Faunistic analysis of mite species on leaves of peach cv. Aurora 1, with or without the effect of fungicides in Presidente Prudente, SP, Brazil (2004/2006)

Species	effect of the fungicide on mites populations			
	with effect		without effect	
	N	S	N	S
Tenuipalpidae				
Brevipalpus phoenicis	7	I	4	I
Tydeidae				
Lorryia sp.	5	R	0	–
Tetranychidae				
Mononychellus planki	7	I	19	I
Tetranychus urticae	45	I	2	R
Phytoseiidae				
Euseius citrifolius	131	I	93	C
Typhlodromus transvaalensis	0	–	1	R
Euseius concordis	1	R	3	R
Eriophyidae				
Aculus fockeui	6	I	1	R
Acaridae				
Tyrophagus sp.	1	R	0	–

N – mites total; S – species status; C – common; I – intermediate; R – rare

E. citrifolius received the status of a constant species in plants without the fungicide effect, and intermediate in plants with the fungicide effect. A higher diversity of phytoseiid was observed in plants without the effect of fungicides.

In the Aurora 1 cv. (Table 3), 37.50% of the mite occurrences received the status of rare, and 62.50% were intermediate. Among the phytophagous species, which corresponded to 50% of the occurrences, the phytophagous species

B. phoenicis, *M. planki*, *A. fockeui* and *T. urticae* were classified as intermediate. A similar behavior was observed in plants without the effect of fungicides, in which phytophagous mites corresponded to 57%. *T. urticae* and *A. fockeui*, however, received the status of rare species. *Euseius citrifolius* received the status of intermediate species in plants with fungicides, and constant in plants without fungicides. A lower species diversity was observed in the Aurora 1 cv. in relation to the cvs. Tropical and Aurora 2.

In the cv. Aurora 2 (Table 4), in plants that received fungicide treatment, 61.5% of the mite occurrences received a rare status, while 38.5% were intermediate. Among phytophagous species, which corresponded to 46% of the species, *B. phoenicis, M. planki and T. urticae* received the status of intermediate species. However, *A. fockeui* was considered rare, in the Tropical cv. though it showed the same behavior. A similar behavior was observed in plants without the effect of fungicides, in which phytophagous mites corresponded to 43%, but the species received the status of rare. The phytoseiids species *E. citrifolius* considered common in plants with or without the effect of fungicides, received the status of intermediate species.

Table 4. Faunistic analysis of mite species of peach cv. Aurora 2, with or without the effect of fungicides in Presidente Prudente, SP, Brazil (2004/2006)

Species	Effect of fungicide on population mites			
	with effect		without effect	
	N	S	N	S
Tenuipalpidae				
Brevipalpus phoenicis	16	I	5	R
Tydeidae				
Lorryia sp.	18	I	20	I
Iolinidae				
Homeopronematus sp.	0	–	1	R
Diptilomiopidae				
Catarhinus sp.	2	R	2	R
Tetranychidae				
Mononychellus planki	13	I	1	R
Oligonychus sp.	0	–	1	R
Oligonychus mcgregori	1	R	0	–
Tetranychus urticae	24	I	4	R
Phytoseiidae				
Euseius citrifolius	144	I	164	I
Euseius concordis	1	R	4	R
Eriophyidae				
Aculus fockeui	5	R	8	R
Cheyletidae				
Grallacheles sp.	1	R	0	–
Winterschmidtiidae				
Czenspinskia sp.	1	R	3	R
Ixodida				
sp. 1	1	R	0	–
Erythraeidae				
sp. 1	1	R	0	–
Blattisociidae				
Lasioseius helvetius	0	–	1	R
Haplochtoniidae				
Haplochthonius sp. 2	0	–	1	R
Tarsonemidae				
sp. 2	0	–	1	R

N – mites total; S – species status; C – common; I – intermediate; R – rare

The results obtained in this work differ from those reported for peach by Rodrigues *et al*. (2005) in Portugal; those authors observed high mancozeb toxicity on the phytoseiids *Euseius stipulatus* (Athias-Henriot) and *Euseius finlandicus* (Oudemans). In Australia, James (1989) tested the effect of 18 pesticides on the survival of the predator *Euseius victorienses* (Womersley) and observed that mancozeb, dicofol, and oxythioquinox differed from malathion, azinphos-ethil, carbaryl, and pirimicarb, which erradicated the predator's population.

Similarity of mite species composition in peach cultivars with or without application of fungicides

The observed similarity index (above 97%) indicated that the mite species composition in peach trees with or without treatment with fungicides were very close to one another for all cultivars observed. Such a similarity index demonstrates that the fungicide did not interfere with species composition. A slightly smaller index (87%) was observed between cvs. Tropical and Aurora 2, in plants without application of fungicides (Table 5).

Table 5. Similarity Index (Morisita-Horn) for mite species composition on peach leaves, Presidente Prudente, SP, Brazil (2004/2006)

Peaches leaves with application of fungicides					
	number of species	number of individuals	similarity index		
			Tropical	Aurora 2	Aurora 1
Tropical	11	229	–	0–99	0–97
Aurora 2	13	228	–	–	0–98
Aurora 1	8	203	–	–	–
Peaches leaves without application of fungicides					
	number of species	number of individuals	similarity index		
			Tropical	Aurora 2	Aurora 1
Tropical	11	209	–	0–87	0–99
Aurora 2	14	216	–	–	0–97
Aurora 1	7	123	–	–	–

C – cultivar; F – test F; T – treatment; C.V. – coefficient variation

Occurrence of predatory mites in peach cultivars with or without effect of fungicides

No significant differences were observed between the predatory mite populations in plants with or without effect of the fungicides mancozeb and azoxystrobin. Since there were no differences, it indicates that the treatments were innocuous on the populations of important phytophagous mite predators (Table 6).

Table 6. Occurrence of *E. citrifolius* under orchard conditions, either treated or untreated with fungicide. Presidente Prudente, SP, Brazil (2004/2006)

Cultivar (c)	Mite infestation
	No.
Aurora 1	44.8
Aurora 2	51.33
Tropical	54.33
Test F (cultivar)	1.28 ns
Test F (cultivar vs treatment)	0.02 ns
Treatment (T)	
with	48.33
without	52.88
Test F (treatment)	0.18 ns
Coefficient variation (a) [%]	9.6
Coefficient variation (b) [%]	16.97

ns – non significant at the 5% probability level by Duncan's test; No. – to $\sqrt{x}$ mites number transformed

The products used in this work proved effective for the control of peach rust throughout the study period. The only exception was in the year 2005, when it was difficult to comply with the spraying schedule due to high precipitation indices.

Many studies have been conducted on the selectivity of chemical products against predatory mites and other natural enemies present in citrus orchards (Yamamoto *et al*. 1992; Sato *et al*. 1994, 1995a, 1995b, 1996) and in coffee plantations (Reis *et al*. 1998, 2004). However, studies on the selectivity of fungicides in peach orchards are scarce in Brazil.

Rodrigues *et al.* (2005) evaluated the secondary effects of pesticides on predatory mites associated with apple and grape in Portugal. They observed a toxic effect of mancozeb after the third application on *E. stipulatus*, *E. finlandicus*, *Typhlodromus pyri* Scheuten, *T. phialatus* Athias-Henriot, and *Kampimodromus aberrans* (Oudemans).

CONCLUSION

In the conditions under which the study was performed, it can be concluded that:

– plants with or without fungicide treatments had a high percentage of predatory mites in relation to the total collected, which indicates a non-significant interference of mancozeb and azoxystrobin on the composition of predatory mites,
– the family Phytoseiidae, within a much diversified mite fauna on peach cultivars, had the highest incidence and species richness, with *E. citrifolius* and *E. concordis* as the most abundance predators,
– there was a predominance of *E. citrifolius* on plants of the Tropical, Aurora 2, and Aurora 1 cvs. with or without the application of fungicides.

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POLISH SUMMARY

WPŁYW FUNGICYDÓW NA FAUNĘ ROZTOCZY WYSTĘPUJĄCYCH NA ODMIANACH BRZOSKWINI ZWYCZAJNEJ (*PRUNUS PERSICA* L.) W PRESIDENTE PRUDENTE, SP, BRAZYLIA

Celem badań było określenie różnorodności fitofagicznych oraz drapieżnych roztoczy występujących na odmianach brzoskwini zwyczajnej, opryskiwanych i nie opryskiwanych fungicydami, w mieście Presidente Prudente w Stanie São Paulo w Brazylii. W celu oceny wpływu fungicydów na roztocze, pobierano losowo próby liści z drzew opryskiwanych i nie objętych ochroną w okresie od czerwca 2004 do lutego 2006. W badaniach uwzględniono odmiany brzoskwini: Tropical, Aurora 1 i Aurora 2. Na podstawie uzyskanych wyników badań stwierdzono występowanie licznych populacji roztoczy i zróżnicowany skład gatunkowy owadów w obydwóch obiektach, traktowanych i kontrolnych, co świadczyło, że zabiegi fungicydami nie miały szkodliwego działania na roztocze. Najliczniej reprezentowana była rodzina Phytoseiidae, zarówno pod względem liczebności populacji, jak też poszczególnych gatunków. Najczęściej spotykanymi gatunkami roztoczy były *Euseius citrifolius* i *E. concordis*. W obiektach doświadczalnych (traktowanych i kontrolnych) stwierdzono duże nasilenie występowania drapieżnych roztoczy wraz z dominującym gatunkiem *E. citrifolius*.