BRAZILIAN CITRUS INTEGRATED INSECT AND MITE PEST MANAGEMENT OVERVIEW

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Os 800 mil ha de cultura cítrica produzem aproximadamente 16,8 milhões de toneladas de frutas, destinadas à indústria (variedades Valência e Natal) e ao mercado de frutas frescas (variedade Pera). Deste montante, quase 30% está voltado para consumo interno. O Manejo Integrado de Pragas (MIP) está sendo adotado em cerda de 25% da área de cultivo. A principal tática é o monitoramento de pragas-chaves, existindo, para a cultura cítrica, dificuldade no controle do ácaro *Brevipalpus phoenicics* Geijskes, o qual é associado ao vírus da leprose. Este ácaro causou cerca de 10% de perda no ano de 1995; fato que pode se repetir em função dos períodos de estiagem que favorecem esta praga. Cerca de 50 milhões de dólares foram gastos entre 1995-96 pelos citricultores para o controle deste ácaro. Pode-se estimar que já existam mais de 1000 unidades de monitoramento de pragas na área de *citrus* do Estado de São Paulo. Este número pode aumentar para 2500 quando o MIP for estendido às demais áreas. Outras pragas monitoradas com interesse são a cigarrinha *Cicadellinae*, vetor da bactéria *Xylella fastidiosa* e a cochonilha de escama, *Selenaspidus articulatus* Morgan. A implementação do MIP está sendo feita pelo Governo do Estado, pelas associações de citricultores e pelas empresas privadas de treinamento, consultoria e pesquisa. As outras táticas que estão sendo adotadas pelos citricultores e pesquisadores são: a manipulação ambiental de pragas, o controle biológico natural e o controle de pragas por métodos nutricionais. Os controles biológico artificial e clássico estão ainda em desenvolvimento no Brasil mas já estão incluídos nos programas institucionais do Governo.

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1 INTRODUCTION

The Integrated Pest Management (IPM) strategies for citrus in Brazil and their tactics have extensively been reported since 1977 when the outlines were shown at the citrus meeting in Boquim, Sergipe, Brazil. The review was based on two citrus research centers: California and Florida (9).

There are three main varieties explored in Brazilian citriculture, being two for processing purposes ('Valencia' and 'Natal') and one for both processing and fresh market ('Pera'). The actual 800.000 hectares of citrus, produced ca. 1,280 million tons of fruits in 1995/96. From this amount about 30% was destined for local consume. The IPM is nowadays being applied in ca. 25% of citrus area and is separated in two fruit destinies: for industry and for fresh market.

The key-pests selected for IPM purposes were the leprosis mite *Brevipalpus phoenicis* (Geijskes) (Acariformes: Tenuipalpidae) and the citrus rust mite *Phyllocoptruta oleivora* (Ashmead) (Acariformes: Eriophyidae). The first one, in spite of its characteristic of low population density, transmits the disease named leprosis that is known by recent studies as a non-systemic virus, which may injury fruits and promote twig-die back. This mite caused about 10% of loss last year (1995) and can repeat the in present year(1996) again due to the long dry weather period that favors the mite. About 50 million U$ was spent in 1995/96 by citrus growers to control this mite.

The second one, usually in high densities, can depreciate fruits for fresh market, by the general bronzing observed on the peel but it does not affect the next season production. These pests are responsible for higher costs to the growers. They represent 35.63% and 41.69% in Campinas and S.J. Rio Preto, SP counties, respectively (1).

The main goals of the IPM in Brazil have been the preservation and augmentation of natural enemies through cover crops into the orchards providing alternative food and habitat for them besides better application of the selective ways for pesticide use. With improved techniques of monitoring procedures to apply the concepts of economic injury levels and the resistance management, being in a continuos effort to use by the citrus growers, the costs of citrus production can be lower and the unique way to maintain the citrus plantations in Brazil prospering, profitable, and more competitive in world prices.

2 ACTUAL PROBLEMS OF THE CITRUS IPM

Usually, citrus orchards under IPM on which fruits are harvested for processing, the number of sprays/year for leprosis mite is only one in average but citrus rust mite takes 3 or 4 times more than the former. But

during the last two seasons the numbers were reversed because of not normal drought weather during spring and early summer in São Paulo State. These conditions are favorable for Citrus Leprosis Mite (CLM) and unfavorable for Citrus Rust Mite (CRM). By the normalization of the weather that we expect for the following years the number of sprays for each pest will return to the initial values. The goal of the IPM is to reduce increasingly more such sprays as only once a year for both pests.

New pests and diseases have had outbreaks, making difficult the IPM in Brazil. A disease caused by *Xyllella fastidiosa*, which is found in the xylem vases and transmitted by sharpshooters belonging to the subfamily Cicadellinae. These are widespread into the field and there is the risk of the growers to abandon the IPM tactics, such as the selective pesticides and the environmental management. Many growers may spray non-selective pesticides trying to exterminate the vector of *X. fastidiosa*. Some of them are applying broad spectrum insecticides by air plane to control adult sharpshooters. Otherwise, the second problem is the total weeds elimination in the grove which may be hosts for the sharpshooters vectors and the disease. The wide use of these cultural practices may fail the IPM program in Brazil.

Researches have been developed by Gravena-ManEcol Co., sponsored by Montecitrus and Fundecitrus, to understand the sharpshooters biology, behavior, selective chemical control, and biological control. It is already known two groups of sharpshooters. The arboreous sharpshooters which preferentially feed on new citrus leaves and are led in abundance by *Dilobopterus costalimai*, *Acrogonia terminalis* and *Oncometopia facialis,* and the grass sharpshooters, which are led by *Hortensia similis*, *Farrariana trivittata* and *Plesiommata corniculata*.

There is a third recent problem. The Citrus Leafminer, *Phyllocnistis citrella* Stainton, that was found attacking citrus for the first time in March 6, 1996. To protect the new flushes against this pest many citrus growers will try to apply again broad spectrum insecticides. Fortunately, there are some selective products that can be used in IPM such as abamectin, lufenuron, diflubenzuron, etc in spraying and imidachloprid on the citrus trunk with good efficacy. Before these two problems, the sharpshooters associated with *Xylella* and the leafminer attacking the flushes, no insecticide was necessary for pest control being the citrus IPM in Brazil much easier to conduct. Now, we need to face the possible outbreaks that can come up with insecticides applied with no environmental criteria by many citrus growers.

3 THE ACTUAL CITRUS KEY PESTS

- **Citrus Rust Mite (CRM)**

The citrus rust mite (*P. oleivora*) has ever been considered the most important citrus key pest in the Brazilian citriculture from the point of view of IPM. Nowadays, after the Brazilian citrus industry had reached international markets, the CRM remains in this same condition, even under the low international prices of orange juice and the higher value of Real (new Brazilian money) practically becoming equal to the U.S. Dollar in currency.

The high spray treatment costs against CRM, especially in the rainy summer, represents 80% of the mitecides bought by the growers. Likewise the mitecides respond by 50% of costs with chemical products and fertilizers. For this reason, IPM is becoming more and more important to the growers. However, in the early 80's, the threshold level for decision make was just one mite per fruit in 5% of sampled fruits. In spite of the many sprayings, 4 to 10 per year, covering all the plants of the orchard, just one product was used: the sulfur. Some studies have demonstrated that the massive use of sulfur sprayings could affect scale insect parasitoids and beneficial fungus, as *Hirsutella thompsonii*. Therefore, outbreaks of citrus rust mite and scales can be expected.

The CRM can be found through all over the year (24). It always occurs in higher density peaks in December/January and in May/June. By the first period the fruits are still small and the sprays are done more frequently. The CRM may injury leaves, twigs and fruits. Green fruits offer the best conditions to its development. Several hundreds can be found per cm^2, wasting the fruit to fresh market. However, it can subsist through the season on leaves.

In order to attempt to reduce the CRM spraying, it was established that the threshold level for CRM spraying is 10 or 20% of fruits exibiting 30 mites per square centimiter (16) and was also showed that the threshold level based on 20% of fruits was as safe as the 10% level against bronzing (17). Some growers have already been using this level reducing their sprays to 1 or 2 per year, while those ones that are out of IPM programs frequently spray 4-7 times/year. The mitecide spraying reduction can reach between 71% and 75% with the adoption of IPM system by the growers.

- **Citrus Leprosis Mite (CLM)**

The leprosis mite *(B. phoenicis)* (CLM) was one of the most important key pest during the 70's and 80's. It is still being important for the transmission of leprosis virus to fruits and twigs, but it is concerned as

the second key pest in terms of economy in IPM systems, except from late 1994 to early 1996 that was favored by long drought weather periods, reaching high levels of mite infestation and virus infection .

The development of IPM programs, since 70's, brought the sampling methodology to CRM and leprosis mite. The risk of leprosis contamination has reduced since then. These studies were supported by 3 basic aspects as the following:

1- Biology and behavior of the mite;
2- Disease etiology;
3- Development of pragmatic threshold action levels.

The first matter was reported in (3) and in (4). Then, it was possible to improve the sampling methodology reported in (10, 12) presented forward. By the second listed aspect, we just found that the virus agent was definitely confirmed (19) but the disease etiology remains a mystery. It was reported that the virus development, after the transmission, last between 14 and 60 days, before the symptoms appear (2). Finally, by the third aspect the threshold action level was improved from 1% to 10-15%. Blocks with the disease already present might be used 10%, and without it, the level could be 15% of fruits and/or twigs with presence of mites.

Studies of biology and behavior of the mite helped the sampling unit selection either to the conventional or to the sequential plan systems(11, 12). Generally, fruits affected by Scab disease are preferable to be sampled, but now we know that twigs might also be sampled by certain periods of the year. Young trees without a well-defined canopy which bear at outer twigs, and for that, have few fruits infected with scab or even trees with no fruits after harvesting might be sampled using twigs picked up from inside the canopy.

One fact also important was concerned to the larval stage. It was found to be the best potential transmitter, while young forms are less efficient (2). But recently, it was found that there is no difference among larva, nymph and adult in capacity of virus transmission (5). The mite can just get the virus in the period between the previous inoculation and the development of the symptoms. The necrotic tissues became less favorable as food for the mites. The result is a slow development of the disease because the leprosis mite density heavily increases in the winter, in spite of the suitable time to its reproduction in the dry period. Then the disease dissemination could be by mites carried by the wind.

4 THE KEY PESTS SAMPLING AND DECISION MAKE

There are two methodologies available to the growers: **Gravena's standard** or conventional sampling, and the **sequential plans**. The last one was developed following the binomial theory (16, 28). The conventional sampling takes 60 fruits or leaves (young plants and nurseries) to the Citrus Rust Mite and also 60 fruits and/or twigs to citrus leprosis mite, making 120 samples per block of about 2,000 trees. It means that it is needed one scouter for each 60,000 trees for pest monitoring. This program has saved 50% of the spraying costs, or may save about 8 times the cost spent by citrus growers to hire a pest scouter.

The sequential sampling takes from 20 to 90 samples per block of 2,000 trees, for both key mites. Generally 28 samples are enough to make a decision plan for each mite. The results are safe and the methodology is suitable and cheap. A scouter can cover around 120,000 trees. One observed problem is related to the different densities of the pests. It is possible to make a decision with 10 samples to one mite if it is in high density. Otherwise, under low density, maximum of 45 samples might be needed to the other mite. For instance, if with only 10 samples could be decided to spray for CRM and for CLM it is taken 45 samples without any decision, the first sampling loose time by waiting to finish the second one.

To solve this problem there are 3 possibilities:

1 - Knowing the mites biology, the environment conditions, and the farm organization, it is possible to sample to CRM only during the rainy period and to CLM only during the dry period.

2 - Defining one scouter to CRM and others to leprosis mite.

3 - Reducing the sampling frequency through the period which it is not favorable for each mite. Then it is possible to increase the interval between sampling from 10 days to 20 days for CRM in the winter and the same changing for citrus leprosis mite in the summer.

5 BIOLOGICAL CONTROL OF KEY PESTS

The principal predators of citrus pests in the Brazilian citriculture are Phytoseiidae, Ascidae, Stigmaeidae, Tydeidae, Cheyletidae, Cunaxidae and Eupalopsellidae mites (3). Also Phytoseiidae, Stigmaeidae and Cunaxidae were reported as predatory mites, being the first one as the most important family (22).

In the Phytoseiidae family there are more than 1500 species in the world, which more than 50 have already been reported in Brazil (21). The main species are: *Amblyseius largoensis* (Muma), *Euseius vivax* (Chant & Baker), *E. concordis* (Chant), *E. citrifolius* Denmark & Muma and *Iphiseiodes zuluagai* Denmark & Muma (3).

The biological control of key mite pests by the predators *E. citrifolius* and *I. zuluagai* is only effective when the pest population levels are low, below 5% of fruits or leaves infested (23). Some exclusion tests to show the importance of the predatory mites are shown in Figures 1, 2, and 3. In the absence of predators where was made their exclusion, the leprosis mite population was higher in comparison to the natural situation, especially in June, July and September. These results confirm the predators efficiency.

P. oleivora had a higher population peak in July and November when the predator exclusion was done, Figure 2. Probably this happened because of environment conditions and the presence of green fruits.

So, if the mitecide spray frequency is lower as a result of the sampling efficacy and the pesticide selectivity is correct used, the predation can be preserved and the need of CRM and CLM control will be reduced. Weeds can supply the predators with other food as pollen or secondary pests as Tetranychidae mites and scales insects.

The observed differences between the natural condition and the predator exclusion situation were evident. However, they were not higher because the predator exclusion was not 100% efficient. Some Phytoseiidae were not exterminated by the malathion spraying.

In the Figure 3 it is possible to observe an antagonism between the predators: Phytoseiidae and Stigmaeidae. Under the predatory mite exclusion condition, the low population of Phytoseiidae allows the growth of Stigmaeidae, and then, contributed to avoid pest population outbreak. The antagonism between Phytoseiidae (*Metaseiulus occidentalis* Nesbitt and *Typhlodromus pyri* Schenten) and the Stigmaeide (*Zetzellia mali* Ewing) can either be beneficial or not (7).

The results from Figures 1 and 2 demonstrate that the biological control is efficient when the densities of key mites, CRM and CLM, are low and the predator population is high. It still can be improved by adopting the IPM tactics. The native Phytoseiidae may consume alternative food, as pollen and other insects and mites. In addition, selective pesticides contribute to increase the predator population which may keep pests at lower levels, as the Broad mite *Polyphagotarsonemus latus* in Florida (26), and the CRM in Australia (27).

FIGURE 1 - SEASONAL ABUNDANCE OF PHYTOSEIIDAE (*Euseius citrifolius*) AND CITRUS LEPROSIS MITE UNDER PREDATOR PRESENT" AND "PREDATOR FREE" PLOTS (23)

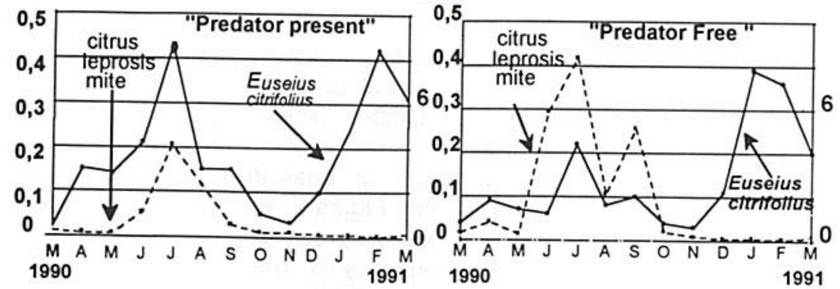
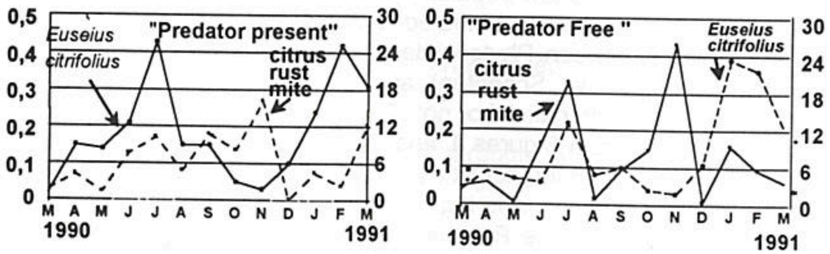


FIGURE 2 - SEASONAL ABUNDANCE OF PHYTOSEIIDAE (*Euseius citrifolius*) AND CITRUS RUST MITE UNDER "PREDATOR PRESENT" AND "PREDATOR FREE" PLOTS (23)



Laboratory biological tests demonstrated that the predator *E. citrifolius* feeds on leprosis mite (14). Larvae are preferable followed by nymphs, eggs and lately adult (Figure 4). As the adult is bigger, a small amount of them is enough to feed the predator. The female predators were the hungriest. The leprosis mite larvae consume are very important because they could be the best transmitter of leprosis disease (2).

FIGURA 3 - SEASONAL ABUNDANCE OF PHYTOSEIIDAE AND STIGMAEID PREDATORY MITES UNDER PREDATOR PRESENT AND PREDATOR FREE" PLOT (Adapted from MOREIRA (23))

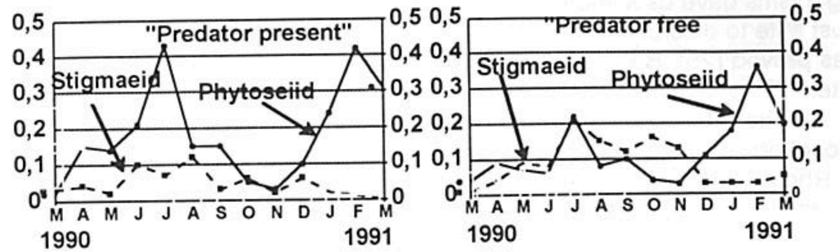
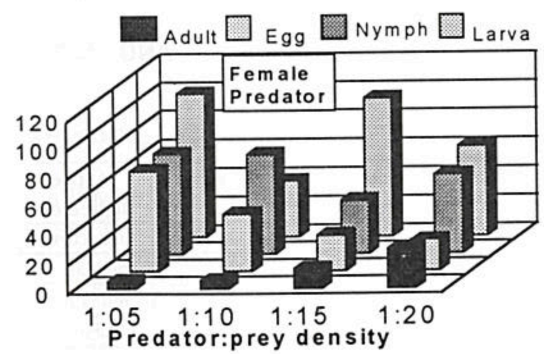


FIGURE 4 - PERCENT MORTALITY OF DIFFERENT PHASES OF LEPROSIS MITE BY THE *E. citrifoius* ADULT FEMALE



In Brazil, as in Florida, there is the *Hirsutella thompsonii* Fisher fungus (6). Favorable environments, as humidity and heat, besides a good amount of citrus rust mite can determine the efficiency of this entomopathogenic fungus. This condition was considered when the threshold of 30 mites/cm² was established.

5 THE PESTICIDE SELECTIVITY AND THE PEST RESISTANCE MANAGEMENT

All key and secondary pests are able to gain resistance to single insecticide or group of similar products. The selecting process of organisms gave us some examples of resistance. The resistance of Citrus Rust Mite to dicofol in Florida, USA, when it is sprayed many times a year was proved (25). But the resistance is more evident for the citrus leprosis mite.

The relationship between resistance and selectivity was studied for difocol on citrus leprosis mite by some recherchers (13, 8) and sponsored by Rhom & Haas in 1991. The frequency to spray pesticides was defined as once a year, reflecting lower risks to appear resistance (13). The rotation must be among the different pesticide groups. Some mitecides as abamectin, aldicarb, azocyclotin, bromo-propylate, cyhexatin, hexythiazox, mancozeb, mineral oil, fenbutatin oxide and propargite have shown between moderate and low toxicity to predator mites being suitable to IPM programs (Table 1).

The mitecides are not totally safe to the predatory mites as the Table 2 shows. By field tests only hexythiazox is considered of low toxicity for phytoseiid mites. So, in IPM it is recommended that the first step to manage the leprosis mite is through small plots within the IPM plot (2,000 plants).

TABLE 1 - TOXICITY OF INSECTICIDES AND MITECIDES FOR PHYTOSEIIDAE MITE (30)

Active Ingredient	Toxicity	Active Ingredient	Toxicity	Active Ingredient	Toxicity
abamectin	L	diazinon	M-H	mancozeb	S
aldicarb(G)	L	dicofol	M-H	metidathion	H
azinphos ethyl	H	dimethoate	H	mineral oil	S-L
azocyclotin	M	sulfur	M-H	fenbutatin	L-H
bifenthrin	H	ethion	H	m. parathion	H
buprofrezin	S	fenpropathrin	H	propargite	L-M
bromopropylate	L-M-H	flufenoxuron	M-H	oxythioquinox	M-H
carbaryl	H	formetenate	H	teflubenzuron	M
carbosulfan	H	hexythiazox	L-M	tetradifon +dicofol	M-H
cyhexatin	L-M-H	malathion	M-H	trichlorfon	L-M

S = safe; L = low; M = moderate and H = high predator mites.

TABLE 2 - DEGREE RANGE OF TOXICITY OF USUAL PESTICIDES AGAINST THE KEY PREDATORS OF CITRUS PESTS

range of toxicity % of mortality	predatory mite field testts	adult coccinellid *Pentilia egena* field tests	larvae coccinellid *Pentilia egena* field tests	adult coccinellid *Coccidophilus citricola* lab tests	larvae chrysopid field tests
< 25	NONE	abamectin fenbutatin cyhexatin dicofol pyridaben chlorfenapyr	abamectin enxofre	abamectin bromopropilate hexythiazox dicofol sulfur fenbutatin pyridaben(CE) fenpyroximate	pyridaben abamectin cyhexatin fenbutatin
25-50%	hexythiazox	enxofre fenpyroximate	cyhexatin(SC) dicofol chlorfenapyr pyridaben fenpyroximate fenbutatin	cyhexatin(SC) pyridaben(PM) oxythioquinox	dicofol propargite
50-75%	fenbutatin(30)	acrinathrin cyhexatin propargite piridafenthion	propargite pyridaben(CE)	cyhexatin(PM) azocyclotin acrinathrin propargite	azocyclotin oxythioquinox
>75%	acrinathrin bifenthrin cyhexatin bromopropylate fenpyroximate carbosulfan fenbutatin(40) azocyclotin piridafenthion oxythioquinox pyridaben	azocyclotin bifenthrin carbosulfan fenpropathrin oxythioquinox	acrinathrin bifenthrin azocyclotin oxythioquinox cyhexatin(EC) fenpropathrin piridafenthion carbosulfan	bifenthrin carbosulfan	fenpropathrin carbosulfan bifenthrin cyhexatin piridafenthion

6 FINAL REMARKS

The citrus IPM program in Brazil is now in process of adjustments and consolidation. It is mainly conducted toward to protect non-target organisms. Consequently, the pesticides must be avoided for frequent use, otherwise the resistance may become evident.

Pesticides with high toxicity might only be used in restrictive blocks and with low pest density, which is characterized by several steps such as: the judicious use of chemicals in order to preserve the natural enemies; the resistance management of key and secondary pests; the rationale and harmonious management of inter-row cover weeds, seeking for alternative food and habitat source for natural enemies, which can maintain the key and secondary pests below the economic level densities.

The improvement of the citrus IPM system pass throughout four distinct aspects:

1- Reorganization of the IPM tactics after the dissemination of diseases, as the one caused by *Xylella fastidiosa* and transmitted by sharpshooters (*Cicadellinae*), and the Post Bloom fruit drop (*Colletotrichum gloesporioides*).

2- Pest and disease control by reducing the influence of pesticides in the tree metabolism and by one better equilibrium at the groves fertilization, using both organic and chemical means.

3- Research to understand the plant-pest-native natural enemies relationships to better improve their potencial benefits.

4- Imports of exotic natural enemies to improve the biological control of key and secondary pests.

Finally, the Brazilian citriculture must receive more attention from growers, researchers and private associations and so, taking them together, promoting the stability of this important industry.

There is the opportunity for reducing costs and risks adopting the Integrated Pest Management, and it must be taken to gain quality in fruits and juice through the next century, when ISO 14000 Total Environment Quality Program will be celebrated.

Abstract

The 800,000 hectares of citrus produced ca. 16.8 million tons of fruits, destined to the industry (varieties *Valência* and *Natal*) and to the market of fresh fruits (variety *Pera*). Of this amount, about 30% was destined for local consumption. The Integrated Pest Management (IPM) is being applied in ca. 25% of citrus. The main tactic is the key-pest monitoring, existing, for the citriculture, difficulty in the control of the acaridae, *Brevipalpus phoenicis* Geijskes, which is associated to the virus of the leprosis. This acaridae caused about 10% of loss in the year of 1995; facts that can repeat in function of the dry weather periods that favor this plague. About U$ 50 million was spent between 1995/96 by the citrus growers to control this mite. It can be considered that already exist more than 1000 units of scouters in the citrus area of the State of São Paulo. This number may increase to 2500 when IPM be found extended to the other areas. Other plagues monitored with interest are the xylem feeders *Cicadellinae*, vectors of the xylem living bacteria *Xylella fastidiosa*, and the armored scale insect, *Selenaspidus articulatus* Morgan. The implementation of IPM is being made by the Government of the State, for the citriculture growers associations, and for private companies of training, consulting and research. Besides the IMP, others activities that are being developed by the growers and researchers are: the environmental pest manipulation, the natural biological control studies, and the pest-control by nutrition management. Artificial and classical biological controls are still undeveloped in Brazil, but are already included in the Government Institutional programs.

REFERENCES

1 ANDIA, L.H., BARROS, S.S. and NEVES, E.M. Minimização de custo na citricultura: análise comparativa de defensivos agrícolas para controle de pragas e doenças. **Laranja**, v. 13, n. 1, p. 101-122, 1992.

2 CHAGAS, C.M. Leprose dos citros; eficiência do transmissor. **Laranja**, Cordeirópolis, SP, v. 4, p. 221-225, 1983.

3 CHIAVEGATO, L.G. Ácaros da cultura de citros. In**:** RODRIGUEZ, O., VIÉGAS, F. **Citricultura brasileira.** 2. ed. Campinas : Fundação Cargil, 1991. p. 601-641.

4 CHIAVEGATO, L.G. and KHARFAN, P.P. Comportamento do ácaro da leprose *Brevipalpus phoenicis* (G.) (Acari: Tenupalpidae) em citros. **An. Soc. Entomol. Bras.,** Itabuna, v. 22, n. 2, 1993.

5 CHIAVEGATO, L. G. Avaliação da potencialidade de *Brevipalpus phoenicis* (Geijskes, 1939) (ACARI: TENUIPALPIDAE) na transmissão da leprosse em plantas cítricas. Proc. Congr. Bras. Entomologia, 15°, March 12-17, 1995, Caxambu, MG, Brazil.

6 CORREIA, A.C.B., GRAVENA, S. and KREBSKY, E.O. Primeira citação do fungo *Hirsutella thompsonii* var. *thompsonii* parasitando *Phyllocoptruta oleivora* (ashm.) (Acari: Erciphyiidae) no Brasil. **Laranja**, Cordeirópolis, v. 13, n. 2, p. 552-558, 1992.

7 CROFT, P.A. and McRAE. I.V. Persistence of *Thyphlodromus pyri* and *Metaseiulus occidentalis* (Acari: Phytoseiidae) on apple after inoculative release and competition with *Zetzellia mali* (Acari: Stigmaeidae). **Environ. Entomol.**, v. 21, n. 5, p. 1168-1177, 1992.

8 DENNEHY, T.J. and MARTINSON, T.E.. Pesticide resistance management: principles and application. **Proc. Pacific Nortwest Fruit School.,** Elizabeth Beers, 1991. 10 p. (Manuscrito).

9 GRAVENA, S. Controle integrado de pragas dos citros. In: RODRIGUES, O., VIEGAS, F. **Citricultura brasileira.** Campinas : Fundação Cargil, 1977. p. 601-641.

10 GRAVENA, S. **Guia de MIP-Citros.** Jaboticabal : CEMIP-UNESP, 1986. (Folder).

11 GRAVENA, S. Manejo ecológico de pragas no pomar. **Laranja**, Cordeirópolis, v. 11, p. 205-225, 1990.

12 GRAVENA, S. MIP-citros: avanços e inovações na citricultura brasileira. **Laranja**, Cordeirópolis, v. 13, n. 2, p. 635-691, 1992.

13 GRAVENA, S. Rotação de acaricidas no MIP-Citros: menos desequilíbrio e reistência. **Laranja**, Cordeirópolis, v. 15, p. 375-395, 1994.

14 GRAVENA, S., BENETOLI, I., MOREIRA, P.H.R. and YAMAMOTO, P.T. *Euseius citrifolius* Denmark & Muma predation on citrus leprosis mite *Brevipalpus phoenicis* (Geiyskes) (Acari: Phytoseidae, Tenurpalpidae). **An. Soc. Entomol. Brasil**, Itabuna, v. 23, n. 2, 1994b.

15 GRAVENA, S., FERNANDES, O.A. and PAZINI, W.C. Amostragem seqüencial para os ácaros da falsa ferrugem Phyllocoptruta oleivora (Ashm.) e da leprose *Brevipalpus phoenicis* (Geiiskes) no manejo integrado de pragas dos citros. **Laranja**, Cordeirópolis, v. 9, p. 147-159, 1990.

16 GRAVENA, S. et al. Conventional and sequental sampling for mites in citrus: options for the IPM pratice in Brasil. Integrated control in citrus fruit crops. In: ANTIBES, France, 26-28 de outubro, 1994c.

17 GRAVENA, S., YAMAMOTO, P. T. & SILVA, J. L. Uso de bropropilato para controle do ácaro da ferrugem em manejo integrado de pragas dos citros. **Laranja**, Cordeirópolis, v.14, p. 421-444, 1993.

18 GRAVENA, S. and TREVIZOLI, D. Injury levels for the citrus rust mite *Phyllocoptruca oleivora* (Ashm.). **Proc. Int. Soc. Citriculture**, v. 2, p. 475-459, 1974.

19 KITAGIMA, E.W., MULLER, G.W. and COSTA, A.S. Partículas baciliformes associadas à leprose dos citros. In: CONGRESSO BRASILEIRO DE FRUTICULTURA, 1., 1971, Campinas. **Anais...** Campinas : Soc. Bras. de Fruticultura, 1971. v. 2, p. 419-438.

20 McCOY, C.W. et al. Management of arthropod pest and plant diseases in greecosystem. **Proc. Tall Tembers. Conf. Ecol. Anim. Control Habitat. Managem.**, Tallahasse, v. 6, p. 1-18, 1974.

21 MORAES, G.J. de. Perspectivas para o uso de predadores no controle de ácaros fitófagos no Brasil. **Pesq. Agropec. Bras.**, v. 27, n. 1, p. 263-270, 1992.

22 MORAES, G.J. de and GESTALDO Jr., I. Uso de inimigos naturais para controle de ácaros pragas dos citros. In: SIMPÓSIO DE CONTROLE BIOLÓGICO, 3., Águas de Lindóia. **Resumos...** Águas de Lindóia, 1992. p. 111-115.

23 MOREIRA, P.H.R. **Ocorrência, dinâmica populacional de ácaros predadores em citros e biologia de *Euseius citrifolius* (Acari: Phytoseiidae).** Jaboticabal, 1993. Dissertação (Mestrado) - Faculdade de Ciências Agrárias e Veterinárias, UNESP.

24 OLIVEIRA, C.A.L. Ácaros da ferrugem, branco e purpúreo dos citros. In: FERNANDES et al. **Manejo integrado de pragas e nematóides.** Jaboticabal : FUNEP, 1991. v. 2, p. 185-203.

25 OMOTO, C., McCOY, C.W., DENNEHY, T.J., CRANE, S.E. and LONG, J.W. Citrus growers chemical industry and university scientists work together to define a resistance management program for Kelthane miticide. **Citrus ind.**, Bartow, v. 75, n. 5, p. 22-27, 1994.

26 PEÑA, J.E. Predator-prey interaction between *Thyphlodromalus peregrinus* and *Polyphagotarsonemus latus*: effects of alternative prey and other food resources. **Fla. Entomol.**, v. 75, n. 2, p. 241-248, 1992.

27 SMITH, D. and PAPACEK, D.F. Studies of the predatory *mite Amblyseius wictoriensis* (Acarina: Phytoseiidae) in citrus orchards in south-east Queensland: control of *Tegolophys australis* and *Phyllocoptruta oleivora* (Acarina: Eriophyidae), effect of pesticides, alternative host plants and augmentative release. **Exp. Appl. Acarol.**, v. 12, p. 195-217, 1991.

28 STERLING, W.L. **Sequential sampling plans developed for use in pest manegement systems.** [S.l.] : Dep. Agric. Integrated Pest Mgt. Unit. Res., 1976. 14 p. (Paper, 1).

29 WEKANE, E., CASTILHO, L.A., VICTOR, N.C., GRAVENA, S. Resultados de testes de manejo integrado de pragas de citros em 1984/85 em Santa Adélia, Jaboticabal e Taiaçu, SP. **Laranja**, Cordeirópolis, SP, v. 7, n. 1, p. 59-69, 1986.

30 YAMAMOTO, P.T., PINTO, A. de S., PAIVA, P.E.B. and GRAVENA, S. Seletividade de agrotóxicos aos inimigos naturais de pragas dos citros. **Laranja**, Cordeirópolis, SP, v. 13, n. 2, p. 709-755, 1992.