Bulletin of Insectology **57** (2): 103-109, 2004
ISSN 1721-8861

Orius insidiosus as biological control agent of Thrips in greenhouse chrysanthemums in the tropics

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Abstract

The possibility to use native *Orius insidiosus* (Say) (Rhynchota Anthocoridae) for control of thrips (Thysanoptera) on chrysanthemums in tropical Brazilian greenhouses was tested. First, thrips infested potted chrysanthemums in cages, cultivars "White Reagan" (WR) and "Yellow Snowdon" (YS), were exposed to the predator *O. insidiosus*. The number of thrips/plant increased from 2.0 to 7.0 thrips after six weeks on control plants in the absence of *O. insidiosus*, while thrips numbers decreased from 2.0 to 0.2 thrips/plant in the presence of the predator on YS. Similar results were obtained for the chrysanthemum cultivar WR. Next, an experiment was carried out in a commercial chrysanthemum greenhouse with the same two cultivars and with a natural infestation of thrips. The predator was introduced five times at rates of 1.5 or 2.0 *Orius*/m^2 (in total 9.5 *Orius*/m^2). Thrips sampling was done by tapping two plants per flower bed per week, and by then counting thrips and predators. The average number of thrips decreased from 4.7 to 2.5 thrips/plant on YS and from 2.8 for 1.1 thrips/plant on WR after the first release. *O. insidiosus* reached a population peak in the sixth week after planting, with 0.5 *Orius*/plant on YS and 0.7 *Orius*/plant on WR, respectively. Thrips numbers decreased to 0.3 thrips/plant on YS and to 0.4 thrips/plant on WR seven weeks after planting. At this time no injury of thrips was found on chrysanthemum. Nine weeks after planting (chrysanthemum flowering period) the insecticide delthamethrin was sprayed for general pest control, and predatory bugs were eliminated from the greenhouse, resulting in a strong population increase of thrips. We conclude that thrips can be controlled effectively in tropical Brazilian chrysanthemum greenhouses with the native predator *O. insidiosus*, but that the selection of insecticides for control of other pests needs to be done carefully. Only those pesticides that are compatible with the use of the predator should be used to make commercial thrips biological control in greenhouses possible.

Key words: Predator, *Orius insidiosus*, seasonal inoculative release, beneficial insect, biological crop protection, thrips, *Frankliniella occidentalis*, *Caliothrips phaseoli*.

Introduction

Biological control and integrated pest management (IPM) are reliable crop protection strategies and are economically profitable endeavours for growers of greenhouse crops, mainly in Europe, Asia and North America (van Lenteren, 2000a). Recently, studies were initiated to use IPM in greenhouses with ornamentals in the tropics (Bueno, 1999, 2000; Bueno *et al*., 2003). In tropical ornamental greenhouses, the favourable climate for growing ornamentals also provides an optimal climate for the development of pests, which usually appear earlier and develop more quickly than under the field conditions. This is a particular problem for intensive greenhouse monocultures with minimal interference of negative climatic factors (Parrella *et al*., 1999). Thus, until recent, frequent sprays were needed for pest control in greenhouses, which resulted in pesticide resistance. Pesticide resistance makes pest control difficult and pesticides create other problems such as the presence of residues in the crops, contamination of the environment, and risks for the growers and consumers. In Brazil, the negative effects related to chemical control in commercial flower crops are increasing both the scientific community's interest and the grower's motivation for development of biological control of pests in ornamental greenhouses. The Brazilian work is based on the great international progress in use of biological control in ornamentals, such as in poinsettia (Hoddle *et al*., 1997), gerbera (Fransen, 1992; van Lenteren, 2000), chrysanthemum and roses (Parrella *et al*., 1999).

The most important pests in greenhouse chrysanthemum crops in Brazil are species of thrips (Thysanoptera). Of the nine species of thrips that develop to pest status in Brazilian greenhouses, *Frankliniella occidentalis* (Pergande), *Frankliniella schultzei* (Trybom) and *Thrips palmi* Karny are among the most important in flowers crops, in addition these species also create very serious problems in other horticultural crops (Bueno, 1999; Monteiro *et al*., 1999; Monteiro *et al*., 2001a, 2001b).

The main natural enemy of thrips found in Brazilian greenhouses is *Orius insidiosus* (Say) (Silveira, 2003). Its characteristics make it a very efficient predator, because it frequently inhabits the same sites as thrips, can survive some time without the presence of prey and is relatively easy to mass produce. *O. insidiosus* it is commonest *Orius* species in Brazil, and several studies of its behaviour and biological characteristics have been conducted under Brazilian greenhouse conditions (e.g. Bueno, 2000; Argolo *et al*., 2002; Mendes *et al*., 2002; Silveira, 2003).

Orius predators have been released in several crops at variable rates and the rates depend, among others, on the type of crop and the level of thrips infestation. In horticulture, release rates between 1 and 2 predators/m^2

per release usually are used, resulting at the end of the crop cycle in a release of 3 to 6 *Orius*/m^2 for a satisfactory control (Van den Meiracker and Ramakers, 1991; Jacobson, 1993; Ramakers and Rabasse, 1995; Sánchez *et al*., 2000; Tavella *et al*., 2000; Tommasini, 2003). In chrysanthemums, the release rates of *O. insidiosus* ranged from 0.9 to 2 *Orius*/m^2 per release, totaling between 3 and 12 *Orius*/m^2 (Del Bene, 1994; Parrella and Murphy, 1996; Reinhart, 1999).

The objectives of the research described in this paper were to determine if an *O. insidiosus* strain native to Brazil (1) was able to significantly reduce the numbers of *Caliothrips phaseoli* Hood (Thysanoptera Thripidae) in the laboratory, and (2) could be used for thrips control in cut chrysanthemums in commercial greenhouses under tropical conditions in Brazil.

Materials and methods

Laboratory predation experiment with *O. insidiosus*

An experiment to verify the potential control effect of *O. insidiosus* was done in the laboratory (25 ± 2ºC, 70 ± 10% RH, and 12 hours photofase). Two-weeks old chrysanthemum plants cv. "Yellow Snowdon" (YS, yellow flowers) and "White Reagan" (WR, white flowers) were used. These plants were kept in acrylic cages (dimensions 30 x 30 x 60 cm), and were infested with the pest thrips *C. phaseoli*. To mimic conditions of commercial chrysanthemum production, each cage contained four pots with one plant/per pot of WR, and four pots with two plants/pot of YS. Six cages were prepared for each cultivar. Chrysanthemum plants were infested with twelve adult thrips. After one week one mated female of *O. insidiosus* was introduced in three cages for each cultivar, and in the other three cages per cultivar no predator was released. The release of one mated female of *O. insidiosus* was repeated after two weeks. So, the treatments were: (a) "White Reagan" with thrips, 3 cages; (b) "White Reagan" with thrips and *O. insidiosus,* 3 cages; (c) "Yellow Snowdon" with thrips, 3 cages; and (d) "Yellow Snowdon" with thrips and *O. insidiosus,* 3 cages. The number of thrips/plant was counted on two plants placed in the opposite corners of each cage, alternating corners were used at each successive count. Counting was done weekly during six weeks. Visual observations about injury caused by thrips to the plants were done throughout the experiment.

Commercial greenhouse predation experiment with *O. insidiosus*

The release and evaluation of effectiveness of *O. insidiosus* as biological agent for thrips control was done in a commercial greenhouse of 600 m^2 with a cut chrysanthemum crop, at Fazenda Terra Viva - Group Schoenmaker, Santo Antonio de Posse, SP, Brazil. The experiment was carried out from March 28 to June 20, 2002. The growing season of chrysanthemum plants from transplanting to harvest was 12 weeks in this greenhouse. The temperature in the greenhouse ranged from 20 to 33ºC, with a general average of 24.7ºC, and the RH was from 30 to 77%, with an average of 56.6%.

In the greenhouse, 24 chrysanthemum beds (12 on each side of a corridor) of 13 x 1.3 m (17 m^2 each) were planted, consisting of 15 beds with YS and nine with WR. The choice for these cultivars was based (1) on their commercial importance and (2) on previous observations of the growers that YS is stronger infested by thrips than WR. Transplant of seedlings was on March 28. The planting densities were 63 plants/m^2 for YS and 36 plants/m^2 for WR. All the normal culture measures were applied including fertilization and fungicide application between April 15 and June 15 for control of white rust, *Puccinia horiana* P. Hennings, alternating sprays of the fungicides mancozeb (Persist SC, 500 mL/100 L water), chlorothalonil (Mancozeb, 500 mL/100 L water) and azoxystrobin (Amistar, 30 mL/100 L water). Also, two treatments of the insecticide deltamethrin (Decis 25 CE, 50 mL/100 L water) was applied at the flowering stage. Thrips sampling was done weekly during the whole growing season. Sampling consisted of tapping plants above white trays and immediate counting of the insects; counted individuals were then collected and stored to determine the species names later. Two plants per week per cultivar per flower bed were sampled, beginning two weeks after transplant of seedlings, so from April 11 to June 20. Sampling was always done immediately before the releases of predators. Plants were regularly visually inspected to evaluate thrips injury.

Individuals of *O. insidiosus* were obtained from the Biological Control Laboratory of the Department of Entomology, Federal University of Lavras, MG, Brazil. Individual predators were transported to the greenhouse area in glass vials mixed with the inert medium vermiculite inside an icebox. Releases were made by walking along the corridors between the chrysanthemum beds and applying the contents of the vials in an homogeneous way over the plants. Adults (males and females) and nymphs were introduced in a proportion of 8 adults:2 nymphs. In total five releases of *O. insidiosus* were made during the chrysanthemum crop cycle (figure 1). Similar release rates (1.5 or 2.0 *Orius*/m^2) were used as those proposed by Gilkeson *et al*. (1990), Tellier and Steiner (1990), Jacobson (1993), Del Bene (1994), Parrella and Murphy (1996), Rubin *et al*. (1996) and Reinhart (1999).

Data analyses

The developments of populations of thrips and *O. insidiosus* in the laboratory were evaluated by simple comparison of the graphs representing the population dynamics; no statistical tests were applied as differences were very obvious. For the greenhouse experiment, data were analyzed (after tests of homogeneity of variance and normality) with ANOVA (F tests) with a 10% significance threshold.

Results

Laboratory predation experiment with *O. insidiosus*

The experiment in the laboratory showed the capability of *O. insidiosus* to dramatically reduce populations

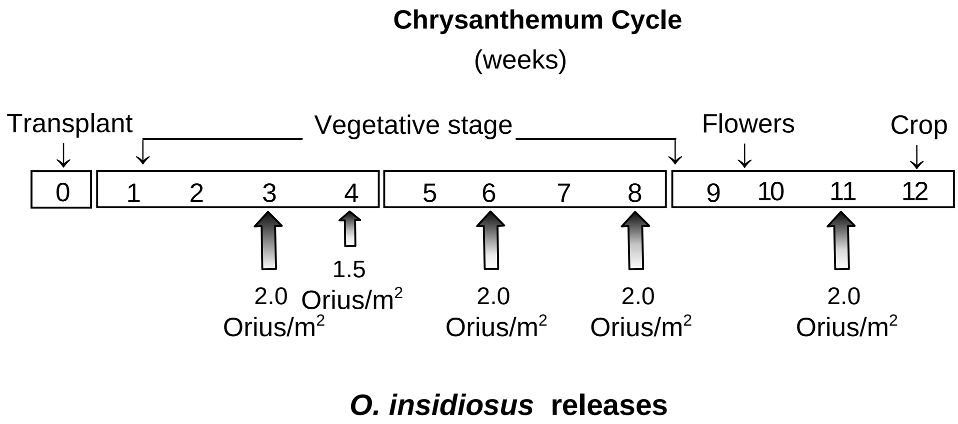

Figure 1. Production cycle of chrysanthemum and release rates of *O. insidiosus*. Fazenda Terra Viva, Santo Antonio de Posse (SP). March 28 to June 20, 2002.

of the pest thrips species *C. phaseoli*. The number of thrips per plant increased more than 3 fold (from 2.0 to 7.0 thrips/plant) in YS (figure 2A) in the absence of the predator between the first and the fifth week, whereas the numbers decreased more than 10 fold (from 2.0 to less than 0.2 thrips/plant) in the presence of *O. insidiosus* (figure 2A). Concerning damage, the plants of YS maintained in cages without *O. insidiosus* showed extensive injuries, such as silvery lesions on the leaves, branches and sprouts, and also contained feces of thrips, while these symptoms were much lower or absent in the presence of the predators.

The thrips population was generally lower on WR than on YS, but that is suppposed to be the result of the lower thrips infestation early in the experiment (figure 2B). The thrips numbers on WR in the presence of *O. insidiosus* were similar as observed on YS (figure 2B). The number of thrips, initially around 1.0 thrips/plant, reached a maximum of 4.5 thrips/plant in WR in the absence of *O. insidiosus*, whereas the number decreased to less than 0.2 thrips/plant in the presence of the predators. However, the WR plants did not show the same injuries as YS, not even in the absence of *O. insidiosus*. This result confirms the observations of the commercial growers that WR generally shows less injury as a result of thrips infestation than YS does. Based on these results and the experience of growers, we suppose that WR is both partly resistant and tolerant to thrips.

Commercial greenhouse predation experiment with *O. insidiosus*

A higher number of thrips was found on cultivar YS in the first six weeks (1.5 to 4.7 thrips/plant) when compared to WR (0.7 to 2.8 thrips/plant), and these numbers were significantly different in the second, third, fourth and 11th week after planting (figure 3). The finding that thrips numbers are lower on WR is in accordance with the laboratory experiment and with experience of the growers. With the development of the plants, the difference in the number of thrips/plant decreased between YS and WR ,and in the seventh week after planting the WR showed significantly more thrips/plant (1.7) compared to YS (1.3).

No significant differences in the number of *Orius* per plant between cultivars were found (figure 3). The largest numbers of *O. insidiosus* per plant on WR were found between the fifth and eighth week after planting (0.2 to 0.7 *Orius*/plant). In the same period, YS had somewhat lower numbers of *Orius* (0.06 to 0.4/plant). The same quantities of *Orius*/m^2 were released, but the density of plants/m^2 in WR (36/m^2) was lower than in YS (63 plants/m^2), and this might have resulted in the somewhat higher density of *O. insidiosus* per plant on cultivar WR.

After the first release of predators (2 *Orius*/m^2, or 0.03 *Orius*/plant, Fig. 3A), a strong reduction of the thrips population was found on YS three weeks after planting (from 4.7 thrips/plant to 2.5 thrips/plant). After the second, third and fourth releases of the predator, the thrips population decreased to 0.3 thrips/plant in YS in the ninth week after planting. The predator population reached a maximum number of 0.5 *Orius*/plant on this cultivar six weeks after planting, and we found on average 29 *Orius*/m2/bed. Since until that week 3.5 *Orius*/m^2 (figures 1 and 3A) had been released, we may conclude that the predators had multiplied to about eight times their original number between the second and the sixth week after planting in the chrysanthemum beds of YS.

The number of thrips/plant decreased from 2.8 to 1.1 after the first release of *O. insidiosus* on WR (figure 3B), and had decreased to 0.4 thrips/plant nine weeks after planting. The number of *O. insidiosus* reached 0.7 *Orius*/plant six weeks after planting, or 26 *Orius*/m^2. So on WR, *O. insidiosus* increased more than seven times in population size between the third and the sixth week after planting.

At the end of growing season, during the flowering period of chrysanthemum (figures 1 and 3), two sprays with the insecticide deltamethrin were applied, one in the ninth and the other in the 11th week after planting. These sprays were necessary because other pests attacked the crop, e.g. the coleopterans *Diabrotica speciosa* (Germar), *Cerotoma* sp., *Astylus variegatus*

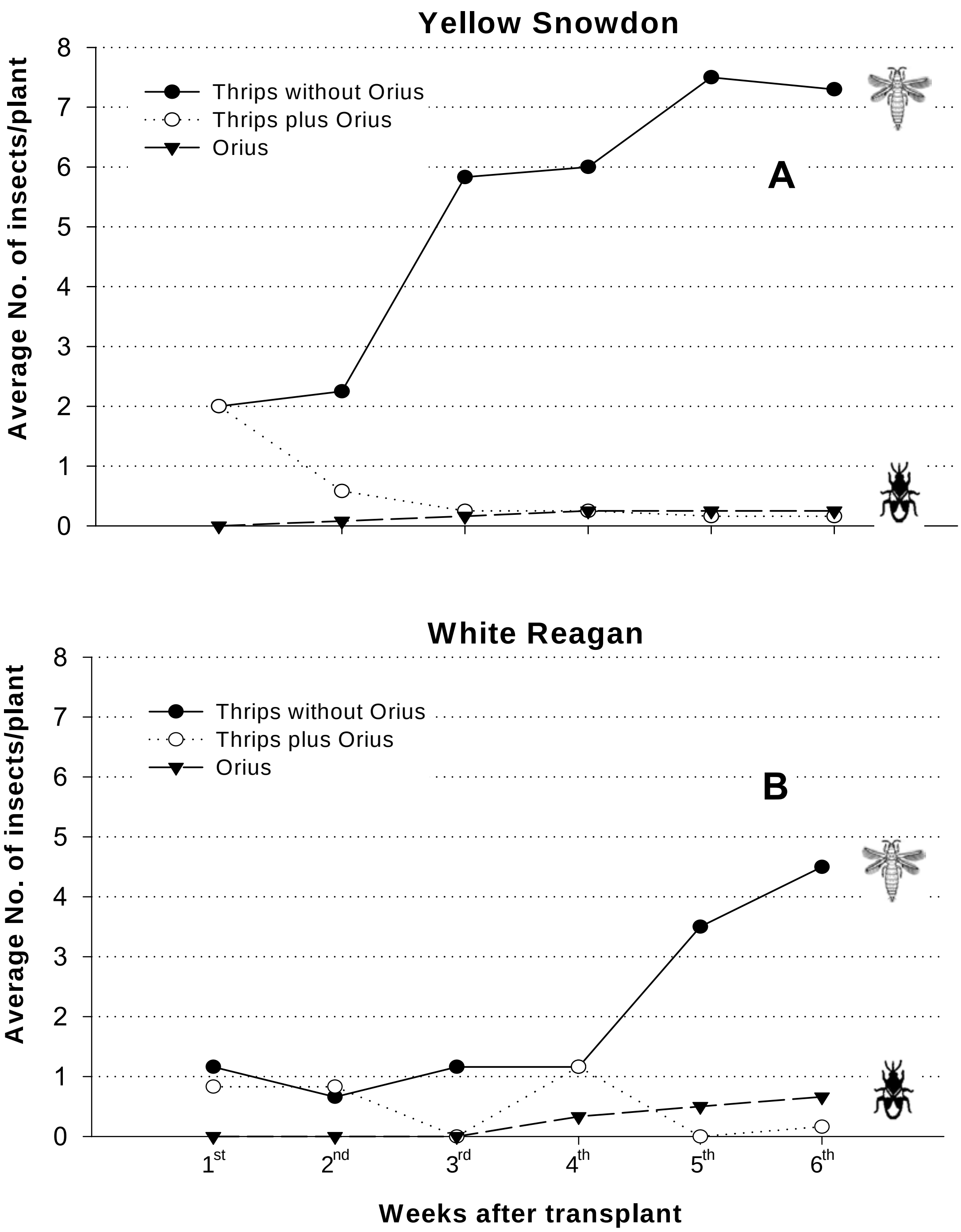

Figure 2. Average number of *O. insidiosus* and thrips per chrysanthemum plant in presence and absence of predators, in YS (A) and WR (B) in the laboratory. Temperature 25 ± 2 ºC, RH 70 ± 10%, 12 hours photophase.

(Germar) and *Lagria villosa* (F.). These insects cause severe direct damage to the flowers, which makes them unmarketable. Although these coleopteran pests were controlled by the sprays, the negative result was that also the beneficial predators disappeared from the greenhouse after the first insecticide application on both cultivars (figure 3). The insecticide sprays affected biological control negatively, and still present thrips were strongly attracted to the opening flowers of chrysanthemum at that time. As a result of the elimination of the predators, the pesticide resistant thrips populations grew fast after the ninth week of planting (figure 3).

The weekly spray of different fungicides for control of the white rust disease in the crop did not appear to affect biological control, since the predators increased in population size and controlled the pest (figure 3). The fungicides mancozeb, chlorothalonil and azoxystrobin are known to be selective to adults and nymphs of *O. insidiosus* under field tests and can be characterized as class 1 (causing less than 25% death of a natural enemy,

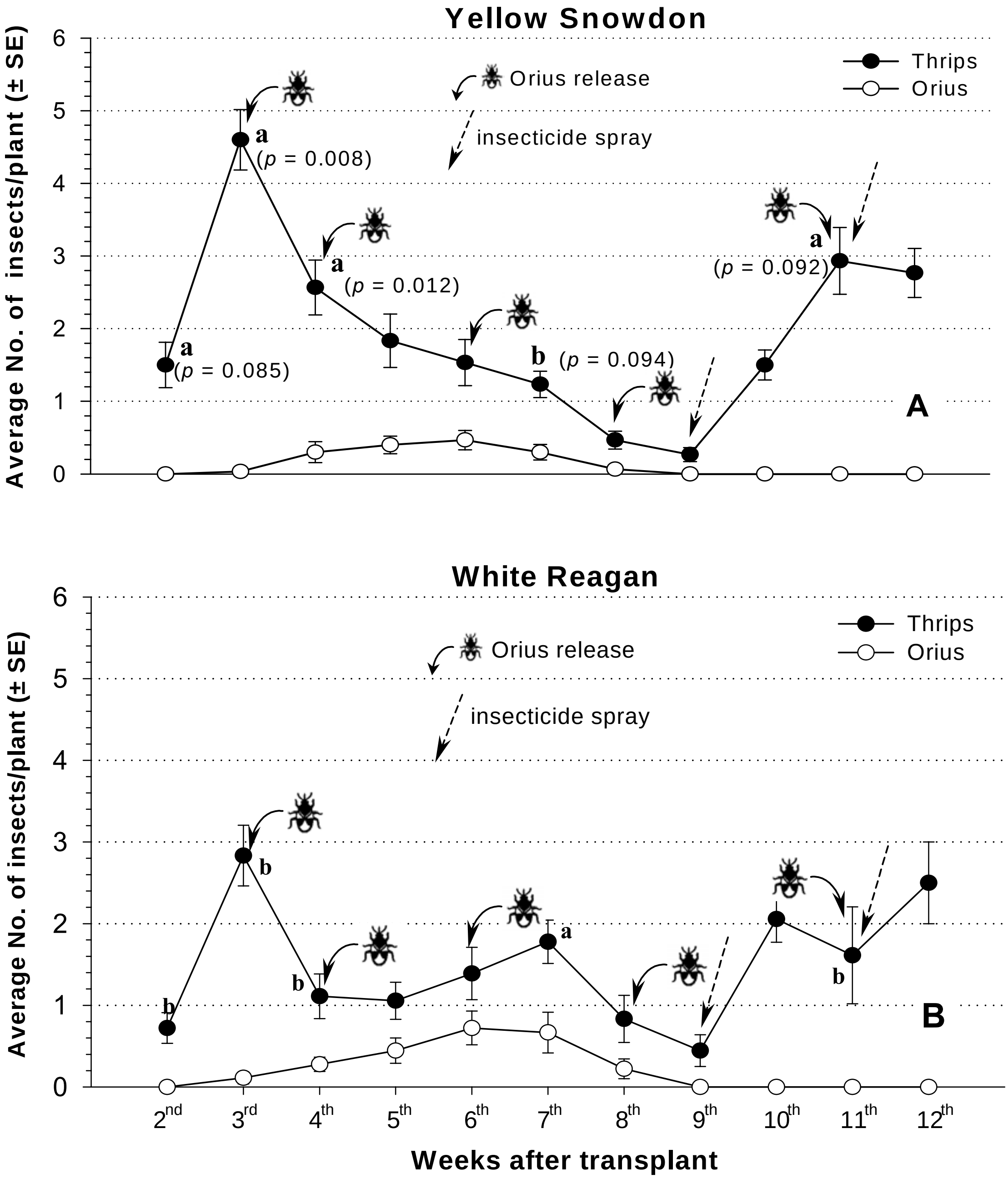

Figure 3. Population dynamics of thrips and *O. insidiosus* in chrysanthemum cultivars YS (A) and WR (B). Small letters indicate weeks when significant differences were observed among cultivars (F Test).

Biobest, 2001, 2004), or non-toxic for these predators. The only exception is the effect of mancozeb on nymphs of *Orius*, which is classified as risk class 2 (slightly toxic, causing between 25-50% death, Biobest, 2001, 2004).

Finally, our results showed that a certain amount of thrips can be tolerated in the crop, because injury was not observed on the leaves or on the flowers until two weeks before the harvest, and this injury was the result of the application of insecticides that killed the predators. In general terms, injury was due to the unbalance between pest and natural enemy caused by chemical control. Our finding that a certain amount of thrips can be tolerated in the crop is in agreement with results obtained by Del Bene (1994), who obtained good plant quality with a control level of three thrips per chrysanthemum branch.

Discussion and conclusion

Based on the results from the laboratory experiments, the observations in the commercial greenhouses and growers experiences, we suppose that the chrysanthemum cultivars YS and WR differently influence thrips development because of differences in plant resistance and or tolerance; WR is more resistant and/or tolerant to thrips than YR. Jager *et al*. (1995) stated that antibiosis represents 60% of the resistance found in chrysanthemum plants, and that the other 40% was due to other resistance sources.

In the greenhouse, *O. insidiosus* populations increased, both as the effect of releases we made, as well as by spontaneous immigration into the greenhouse and as result of reproduction. Before the first release there were already *Orius* individuals in the greenhouse (figure 3). Multiplication of *O. insidiosus* in chrysanthemum occurred quickly, and the offspring suppressed thrips populations already during the first weeks after their release. Based on an estimate of already present and immigrating *Orius*, the numbers to be released can be adjusted (i.e., often lower numbers can be released than we have done in this experiment). Tommasini (2003) came to the same conclusion concerning *Orius* releases in eggplant and sweet pepper crops in Italy. Further, results of weekly sampling of thrips and natural enemy populations by the tapping method could prevent unnecessary releases of predators as well as insecticide spraying. In addition, according to van Lenteren (2000b), the amounts of insects used are established based on previous experience in programs with seasonal inoculative releases. It is very well possible that the number of *O. insidiosus* used for thrips control in chrysanthemum under Brazilian conditions can be reduced, and this would result in lower cost of biological control without influencing its success.

Insecticide applications with deltamethrin (not selective to *O. insidiosus*, causing more than 75% mortality, according to Biobest, 2001, 2004) eradicated the *Orius* population. The same negative effect of broad-spectrum pesticides on *Orius* populations were found by Tommasini (2003). The absence of *Orius*, and the presence of flowers (highly preferred by thrips, according to Beekman *et al*. 1991) lead to a strong increase of the thrips population from the ninth to the 11th week (figure 3). It is clear that this insecticide should not be used in IPM programmes for control of pests in chrysanthemums if biological control with *O. insidiosus* is in use. However, an important problem is that growers are more or less forced to apply pesticides some weeks before harvest, to eliminate all insects from the plants in order to meet zero tolerance regulations enforced by the market (Parrella *et al*., 1999). The presence of insects and or visible insecticide residues on leaves and flowers are the main problem currently in the standardisation of chrysanthemum production in São Paulo State, Brazil according to Silveira (1998). These visible insects or insecticide residues disqualify the final product, as ornamentals have a high esthetical value and a damaged plants are unsaleable.

A very positive conclusion resulting from our research is that, contrary to the experience with the insecticide deltamethrin, the use of selective fungicides could be combined very well with biological control of thrips in chrysanthemums. This is a key positive point in the adoption of the biological control of thrips, since white rust, the major disease of chrysanthemum, needs intensive control with fungicide sprays.

One of the main problems for adoption of biological control in ornamental horticulture is its cost. According to Lambert *et al*. (2002), the cost of the biological control for ornamentals is larger than chemical control. Specifically related to thrips pests, Murphy (2002) stated that cost for thrips control is the largest amount spent to control any pest in ornamentals. In our experiment, the release of 7.5 *Orius*/m^2 (not taking the last release into account, because it was unnecessary) would cost US$ 3,000/ha, based on prices presented by van Lenteren *et al*. (1997) (US$ 0.0404 for each individual of *O. insidiosus*). Even in spite of the high potential value of the crop, this is a high cost for Brazilian growers. We expect, however, that costs of mass producing *O. insidiosus* will be lower in Brazil than in The Netherlands because of much lower labour costs, but more work is needed before a reliable cost estimate can be made. When looking to the future of crop protection in ornamentals, one should realise (1) the increasing occurrence of resistance of thrips to insecticides, (2) the non-existence of appropriate pesticides for control of an increasing number of pests in greenhouses, (3) the larger costs of modern insecticides (van Lenteren, 1995), and also (4) the potential risks for labourers and the environment when recommending chemical control in urbanisation areas close to greenhouses. These are problems that biological control could solve and, with this point of view, the problem of cost should be considered in a global way.

O. insidiosus showed to be a good natural enemy for biological control of thrips in a commercial chrysanthemum greenhouse. However, this control method will only be successfully applied under practical conditions if a complete IPM programme (including chemical pesticides that are safe for natural enemies) will be developed for chrysanthemums (van Lenteren, 1995). We are currently developing elements of such an IPM programme (Bueno *et al*., 2003).

Acknowledgements

The authors would like to thanks CNPq for research grants, and the Schoenmaker Group, for providing greenhouses and plants.

References

ARGOLO V. M., BUENO V. H. P., SILVEIRA L. C. P., 2002.- Influencia do fotoperíodo na reprodução e longevidade de *Orius insidiosus* (Say) (Hemiptera: Anthocoridae).- *Neotropical Entomology*, 31: 257-261.

BEEKMAN M., FRANSEN J. J., OETTING R. D., SABELIS M. W., 1991.- Differential arrestment of the minute pirate bug, *Orius insidiosus* (Say) (Hemiptera: Anthocoridae), on two plant species.- *Mededelingen Faculteit Landbouwwetenschappen Rijksuniversiteit Gent*, 56: 273-276.

BIOBEST, 2001.- *Side effects manual.* Biobest, 3rd edition.

BIOBEST, 2004.- *Side effects manual.* Biobest, 4th edition.

BUENO V. H. P., 1999.- Protected cultivation and research on biological control of pests in greenhouses in Brazil.- *IOBC/WPRS Bulletin* 22 (1): 21-24.

BUENO V. H. P., 2000.- *Controle biológico de pragas: produção massal e controle de qualidade*.- Ed. UFLA, Lavras.

BUENO V. H. P., VAN LENTEREN J. C., SILVEIRA L. C. P., RODRIGUES S. M. M., 2003.- An overview of biological control in greenhouse chrysanthemums in Brazil.- *IOBC/WPRS Bulletin* 26 (10): 1-5.

DE JAGER C. M., BUTÔT R. P. T., KLINKHAMER P. G. L., VAN DER MEIJDEN E., 1995.- Chemical characteristics of chrysanthemum cause resistance to *Frankliniella occidentalis* (Thysanoptera: Thripidae).- *Journal of Economic Entomology*, 88: 1746-1753.

DEL BENE G. 1994.- Possible applications of integrated pest control methods in the greenhouse chrysanthemum.- *IOBC/WPRS Bulletin,* 17(5): 1-4.

FRANSEN J. J., 1992.- Development of integrated protection in glasshouse ornamentals.- *Pesticide Science*, 36: 329-333.

GILKESON L. A., MOREWOOD W. D., ELLIOTT D. E., 1990.- Current status of thrips control in Canadian greenhouses with *Amblyseius cucumeris* and *Orius tristicolor*.- *IOBC/WPRS Bulletin*, 13(5): 71-75.

HODDLE M. S., VAN DRIESCHE R. V., ROY S., SIMTH T., MAZZOLA M., LOPES P., SANDERSON J., 1997.- *A grower´s guide to using biological control for silverleaf whitefly on poinsettias in the Northeast United States*.- Floral Facts, UMASS Extension, Massachussets.

JACOBSON R., 1993.- Control of *Frankliniella occidentalis* with *Orius majusculus*: Experiences during the first full season of commercial use in U. K..- *IOBC/WPRS Bulletin*, 16(2): 81-84.

LAMBERT L., CÉCYRE A., CHOUFFOT T., JOHNSON S., ROY A., 2002.- An overview of biological control in ornamental greenhouses in Québec, Canada.- *IOBC/WPRS Bulletin*, 25 (1): 135-138.

VAN LENTEREN J. C., 1995.- Integrated pest management in protected crops, pp. 311-343. In: *Integrated pest management* (DENT D., Ed.).- Chapman & Hall, London.

VAN LENTEREN J. C., 2000a.- A greenhouse without pesticides: fact or fantasy?.- *Crop Protection*, 19: 375-384.

VAN LENTEREN J. C., 2000b.- Success of biological control of arthopods by augmentation of natural enemies pp. 77-103. In: *Biological control: measures of success* (GURR G., WRATTEN S., Eds). Kluwer Academic, Dordrecht.

VAN LENTEREN J. C., ROSKAM M. M., TIMMER R., 1997.- Commercial mass production and pricing of organisms for biological control of pests in Europe.- *Biological Control*, 10: 143-149.

MENDES S. M., BUENO V. H. P., ARGOLO V. M., SILVEIRA L. C. P., 2002.- Type of prey influences biology and consumption rate of *Orius insidiosus* (Say) (Hemiptera: Anthocoridae).- *Revista Brasileira de Entomologia*, 46: 99-103.

MONTEIRO R. C., MOUND L. A., ZUCCHI R. A., 1999.- Thrips (Thysanoptera) as pests of plant production in Brazil.- *Revista Brasileira de Entomologia*, 43: 163-171.

MONTEIRO R. C., MOUND L. A., ZUCCHI R. A., 2001a.- Espécies de *Frankliniella* (Thysanoptera: Thripidae) de importância agrícola no Brasil.- *Neotropical Entomology*, 1: 65-72.

MONTEIRO R. C., MOUND L. A., ZUCCHI R. A., 2001b.- Espécies de *Thrips* (Thysanoptera: Thripidae) no Brasil.- *Neotropical Entomology*, 1: 61-63.

MURPHY G. D., 2002.- Biological and integrated control in ornamentals in North America: successes and challenges.- *IOBC/WPRS Bulletin*, 25(1): 197-200.

PARRELLA M. P., MURPHY B., 1996.- Western flower thrips: identification, biology and research on the development of control strategies.- *IOBC/WPRS Bulletin*, 19(1): 115-118.

PARRELLA M. P., HANSEN L. S., VAN LENTEREN J., 1999.- Glasshouse environments, pp. 819-839. In: *Handbook of Biological Control - Principles and Applications of Biological Control* (BELLOWS T. S., FISHER T. W., CALTAGIRONE L. E., DAHLSTEN D. L., HUFFAKER C., GARDH G., Eds).- Academic Press, New York.

RAMAKERS P. M. J., RABASSE J. M., 1995.- Integrated pest management in protected cultivation, pp. 199-229. In: *Novel approaches to integrated pest management* (REUVENI R., Ed.).- CRC Press, Boca Raton.

REINHART A., 1999.- Integrated pest management in *Dendranthema indicum*.- *IOBC/WPRS Bulletin*, 22(1): 1-4.

RUBIN A., UCKO O., OFFENBACH R., 1996.- Efficacy of natural enemies of the western flower thrips *Frankliniella occidentalis* in pepper flowers in the Araya Valley, Israel.- *IOBC/WPRS Bulletin*, 19(1): 139-142.

SÁNCHEZ J. A., ALCÁZAR A., LACASA A., LLAMAS A., BIELZA P., 2000.- Integrated pest management in sweet pepper plastic houses in the southeast of Spain.- *IOBC/WPRS Bulletin*, 23(1): 21-30.

SILVEIRA L. C. P., 2003.- Registro e associação de espécies de *Orius* Wolff com tripes, influência do fotoperíodo na reprodução e avaliação de *Orius insidiosus* (Say, 1832) (Hemiptera: Anthocoridae) no controle biológico de tripes (Thysanoptera) em casa-de-vegetação. 104 p., *Thesis* - UFLA, Lavras, MG.

SILVEIRA R. B. de A., 1998.- Avaliação da qualidade de crisântemos (*Dendranthema grandiflora* Tzvelev) produzidos em diferentes regiões do Estado de são Paulo. 114 p. *Thesis* - ESALQ/USP, Piracicaba, SP.

SOGLIA M. C. de M., BUENO V. H. P., SAMPAIO M. V., 2002.- Desenvolvimento e sobrevivência de *Aphis gossypii* Glover (Hemiptera: Aphididae) em diferentes temperaturas e cultivares comerciais de crisântemo.- *Neotropical Entomology*, 31: 211-216.

TAVELLA L., TEDESCHI R., ARZONE A., ALMA A., 2000.- Predatory activity of two *Orius* species on the western flower thrips in protected pepper crops (Ligurian Riviera, Italy).- *IOBC/WPRS Bulletin*, 23(1): 231-240.

TELLIER A. J., STEINER M. Y., 1990.- Control of the western flower thrips, *Frankliniella occidentalis* (Pergande), with a native predator *Orius tristicolor* (White) in greenhouse cucumbers and peppers in Alberta, Canada.- *IOBC/WPRS Bulletin*, 13(5): 209-211.

TOMMASINI M. G., 2003.- Evaluation of *Orius* species for biological control of *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae). 215 p., *Thesis* - Wageningen University, Wageningen, The Netherlands.

VAN DEN MEIRACKER R. A. F., RAMAKERS P. M. J., 1991.- Biological control of the western flower thrips, *Frankliniella occidentalis*, in sweet pepper, with the anthocorid predator *Orius insidiosus*.- *Mededelingen Faculteit Landbouwwetenschappen Rijksuniversiteit Gent*, 56: 241-249.

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Received September 4, 2003. Accepted September 14, 2004.