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THE BIOLOGICAL CONTROL SITUATION IN DUTCH GLASSHOUSES: PROBLEMS WITH *TRIALEURODES VAPORARIORUM* (WESTWOOD), *LIRIOMYZA BRYONIAE* KALT. AND *MYZUS PERSICAE* SULZ.

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Summary

Recent developments in Dutch glasshouses will make the future of application of biological control uncertain. These developments are:

- *Breeding of new tomato varieties that produce a normal quantity of fruit if grown at low glasshouse temperatures. Varieties become available that can be grown at about 5°C lower than usual. Encarsia formosa is not able to control the whitefly at this lower temperature. New parasites have to be looked for.*
- *Tomato-leafminer pests occur more frequent than before. Chemical control of this pest interferes with biological control of the whitefly, so either a selective insecticide or a natural enemy has to be found. Several parasites are being tested.*
- *Biological control of the greenhouse whitefly in cucumber is still not possible. If the varieties with smooth leaves instead of hairy leaves do not increase the parasitization efficiency of Encarsia sufficiently, it will be necessary to check whether there are cucumber varieties that are less suitable for the whitefly.*
- *Records become available about resistance of Myzus persicae against the selective chemical pirimicarb. The two natural enemies being studied up til now, Aphidius matricariae and Aphidoletus aphidimyza, showed good control possibilities during part of the growing season; a reliable control program is not yet ready.*

1. Importance of crop production in glasshouses in The Netherlands and the place of biological control

Glasshouses in The Netherlands cover an acreage of 8100 ha, 4600 ha are used for the production of vegetables (including 1000 ha non-heated houses), 3400 ha for ornamentals and 100 ha are planted with fruit trees (data for 1978).

Vegetable growing in intensively heated houses occurs during two cropping periods: the main one starts in winter and lasts about 6 to 8 months, the other one - the fall cropping period - lasts 2 to 3 months. A common scheme is that tomatoes (*Lycopersicum esculentum* L.) are grown as the main crop and cucumbers (*Cucumis sativus* L.) in fall, or the other way around. Another common glasshouse crop is sweet pepper (*Capsicum annuum* L.) with a cropping period from January to November.

Gherkin (*Cucumis sativus* L.) is cultured in less strongly heated glasshouses from March to September. Together these four crops comprise 80% of the economic value of Dutch glasshouse food crops.

Our research on biological control and guidance to extension officers is, at this moment, limited to tomato, cucumber, sweet pepper and gherkin crops during the main cropping period, from January to September. The crop areas and the acreage on which biological control is applied are given in the table below.

Table. Acreage (in ha) of the three most important glasshouse food crops in The Netherlands in which biological control is applied (non--heated houses excluded). Total acreage in the main cropping period, the acreage and percentage of successful biological control of the whitefly by *Encarsia formosa* (in tomato) and of the twospotted spider mite by *Phytoseiulus persimilis* (in cucumber and sweet pepper).

	TOMATO			CUCUMBER			SWEET PEPPER		
	total	*Enc.*	%	total	*Phyt.*	%	total	*Phyt.*	%
1969	2200	-	-	860	25	3	-	-	-
1970	2380	-	-	870	200	23	-	-	-
1971	2430	4	2	750	75	10	70	-	-
1972	2290	20	1	840	100	12	75	-	-
1973	2040	120	6	790	150	19	150	10	7
1974	2090	400	19	785	150	19	160	12	8
1975	2060	500	24	780	200	26	160	15	9
1976	2040	600	29	720	300	42	160	20	13
1977	2090	550	26	770	350	45	175	30	17
1978	2000	530	27	750	400	53	180	40	22

Biological control in lettuce (*Lactuca sativa* L.), the third important glasshouse crop, with its dominating fungus problems and a short cropping period, is not feasible.

Our aim is to develop as many biological control methods as possible against glasshouse pests, mainly to prevent and overcome problems because of resistance against insecticides. We concentrate our efforts on developing complete biological control schemes per crop, because if control of one pest remains dependent on the use of pesticides, the future of biological control of any pest in that crop remains uncertain. This uncertainty is caused by the rapid change of pesticides used in vegetable crops: a relatively harmless chemical may be replaced by a broad spectrum pesticide on a very short term.

The positive attitude of the growers towards the use of biological control methods is important for our continuation in this field, because the problems at the administrative level are quite discouraging. Although sufficient evidence is available that biological control is at least as reliable and cheap as chemical control, the government did not develop an active policy to support research and extension (Van Lenteren *et al.*, 1979).

Beside these problems, recent developments in crop production in glasshouses in Holland make the future of application of biological control uncertain. These developments are:

- Breeding of new tomato varieties that produce a normal quantity of fruit at low glasshouse temperatures. *Encarsia formosa* is not able to control the whitefly at these lower temperatures.
- Tomato-leafminer pests occur more frequently than before. Chemical control of this pest interferes with biological control of the whitefly.
- Biological control of the whitefly in cucumber crops is still impossible.
- *Myzus persicae* is becoming resistant against the selective chemical pirimicarb. Use of other insecticides interferes with the biological control of twospotted spider mite.

2. <u>Tomato - whitefly</u> (*Trialeurodes vaporariorum* (Westwood))

Biological control of whitefly with *Encarsia formosa* Gahan in tomato crops was and still is easy (see table). The parasite-introduction scheme developed by Woets (described by him in 1978) is reliable, it has been successfully applied for 6 years now.

Because of high energy consumption (natural gas) of glasshouse crop production, much research is being done by plant breeders to develop varieties that develop at lower glasshouse temperatures than used now (De Ponti, pers. comm.). Tomato varieties will soon be available that develop as fast and produce as much as the usual varieties, but that are grown at a temperature of about 5 degrees lower than normal. *Encarsia formosa* will not be able to keep the whitefly at low population levels at this lower temperature. At temperatures lower than 18°C whitefly develops faster than *E. formosa*. Average glasshouse temperatures (in spring) are now 15°C at night and 22°C at day. A decrease of 5°C will result in too low average temperatures for *E. formosa*.

To cope with this problem new parasite species and strains of *E. formosa* are collected and their parasitization efficiency will be compared. Although biological control has a history of almost a century, we could not find any simple evaluation test in handbooks or articles. Many authors theorethesize about possible tests, others describe time- or space-consuming experiments. We decided to collect new parasites and to carry out some simple laboratory tests in which the lifespan, mortality of developmental stages, developmental time and reproduction capacity of the possible candidates are tested. In this way we can at least determine which parasites are certainly not suitable for biological control, that is those species that have a lower capacity of increase than the pest species. The remaining species will then be tested in small glasshouses to find out whether their host-finding and migration capacity is sufficient. When a good parasite is found, we finally have to develop a mass-rearing and introduction method.

A complication might be that a parasite that is active at low temperatures might be less active during the warmer part of the season. Perhaps introduction of a mixture of species will then be necessary.

3. Tomato - tomato leafminer (*Liriomyza bryoniae* Kalt.)

Hendrikse *et al.* (1979) and Zucchi & van Lenteren (1978) describe the tomato-leafminer problem in full detail. At present there is no good biological control method and chemical control of this pest makes biological control of the whitefly impossible. Sanitary measures will diminish the probability that a leafminer pest occurs. In the same way as we compare whitefly parasites also tomato-leafminer parasites are being studied. We think that there is a good chance to solve this problem within one or two years.

4. Cucumber - whitefly (*Trialeurodes vaporariorum*)

On cucumber whitefly pests develop faster than on tomato. The adult flies live longer and lay more eggs (Van Boxtel *et al.* , 1978) . Further, mortality of developmental stages is lower (Van de Merendonk & Van Lenteren, 1978). Additionally, large hairs and honeydew attached to these hairs on cucumber leaves hamper the parasite seriously in searching for hosts. The end result is that biocontrol of whitefly on cucumber is difficult and fails frequently.

Three possible solutions were studied, being:

- searching for a new parasite that does not search in the same way as *Encarsia formosa*,
- selection of a whitefly-resistant cucumber variety, and
- selection of a less hairy cucumber variety.

The first possibility - a new parasite that searches differently - gave no solution. All parasites known to oviposit in the whitefly search in a similar way. As soon as they land on a leaf with hosts they start drumming the leaf surface with their antennae, so their parasitization efficiency will be impaired by hairs and honeydew.

The second possibility was not successful either, but only a limited number of varieties was tested. (Experiments to test (partial) resistance are very time consuming).

The third possibility - selection of less hairy varieties - turned out to be successful. De Ponti (Institute for Horticultural Plant Breeding, Wageningen) examined about 200 cucumber varieties but none of these appeared to be definitely less hairy. However, he found a literature reference about a hairless cucumber and we obtained seeds of this mutant. Studies by one of our students (Hulspas-Jordaan, 1978, Hulspas-Jordaan & Van Lenteren, 1978) showed that walking speed and walking behaviour of *Encarsia* differed dramatically on a hairless and hairy cucumber variety. The results of this study support the hypothesis that the structure of the leaf surface of the host plant influences the walking speed of the wasps and therefore may affect their parasitization efficiency.

A test in which hairy and hairless cucumbers were cultured in separate glasshouses and in which whiteflies and parasites were released was unsuccessful up till now because it was not possible to grow the hairless mutant under normal glasshouse conditions. New selection lines became available and a glasshouse test to compare the parasitization efficiency on hairy and hairless plants is in progress.

If it appears from these experiments that 'smooth' leaves alone do not increase the parasitization efficiency on cucumber sufficiently to obtain reliable control, it will be necessary to check again whether there are (partially) resistant varieties. The solution of this problem will make biological control of whitefly possible in the second largest glasshouse crop.

5. Sweet pepper - green peach aphid (*Myzus persicae* Sulz.)

In sweet pepper crops relatively many pests occur compared with tomato and cucumber crops (Van Lenteren *et al.*, 1977). It will therefore be difficult to develop a biological control program for all pests on this crop. *Myzus persicae* is the most important aphid pest in sweet pepper and records about increasing resistance of the aphids against the selective chemical pirimicarb are available. The very intensive use of this chemical might increase this problem and can cause the loss of one of the best pesticides in integrated control. In the literature several natural enemies are advised for biological control of this aphid in glasshouses. Two of them were tested for their long-term effect.

The Braconid *Aphidius matricariae* Hal. is frequently observed as a parasite of *Myzus persicae* in heated glasshouses throughout the year. Mass rearing and cold storage are possible. The parasite completes its larval development faster than other known parasites of *M. persicae*, and has a shorter average generation time than this aphid. Adult parasites oviposit very rapidly; they prevent egg wastage by discriminating parasitized from unparasitized aphids ('t Hart *et al.* 1978). Besides killing aphids by parasitization, the parasite causes an important loss of aphids probably by disturbance. We found that when at a certain moment about 5% of the aphid population is parasitized, the aphid population stops to increase and within a few weeks the majority of the population is destroyed. The parasite is able to control the aphid until the end of spring, when the balance may be upset by hyperparasites. The possible use of this parasite might therefore be restricted to winter and spring.

Aphidoletus aphidimyza (Rond.) preys on glasshouse aphids from June (immigrating adults from outdoor populations) until October (start of diapause, induced by short photoperiod). After artificial introduction this predator can be used from March onwards, and with prolonged photoperiod during the entire year. Methods for mass rearing are developed and applied in Russia and Finland.

In glasshouse experiments a quick destruction of the aphids was obtained, but no permanent control. Quality of control at low aphid densities is being studied at this moment. Aphids with a clustered distribution pattern like *Aphis gossypii* are probably the most suitable hosts for this predator.

6. Conclusion

The starting position for the application of biological control in glasshouses in The Netherlands (about 10 years ago) was rather good because data about natural enemies of two important glasshouse pests (whitefly and two-spotted spider mite) were already available. The problems that we have to solve now ask more effort before success can be obtained. Research facilities and governmental support are - to put it gently - not optimal. The enthusiasm of research students and growers for research and application of biological control is a solid backing for us.

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Zusammenfassung

Die Lage der biologischen Schädlingsbekämpfung in den Niederlanden: Probleme mit Trialeurodes vaporariorum (Westwood), Liriomyza bryoniae Kalt. und Myzus persicae Sulz.

Rezente Entwicklungen in den niederländischen Gewächshausbau haben die Zukunft der Anwendung biologischer Bekämpfung sehr unsicher gemacht.
a. Die Anzahl neuerer Tomatenvarietäten die bei niedriger Gewächshaustemperatur eine normale Ernte liefern.
Es gibt schon Varietäten die diesen Anforderungen entsprechen und die schon bei einer $5^{o}C$ *niedriger Temperatur als üblich gezuchtet werden können. Encarsia formosa ist bei dieser niedrigen Temperatur nicht imstande die Weisse Fliege genügend zu bekämpfen. Neue natürliche Feinde werden gesucht.*

b. Die Tomatenminierfliege tritt immer häufiger als Schädling auf. Chemische Bekämpfung dieser Fliege macht biologische Bekämpfung der Weissen Fliege unmöglich. Zur Lösung dieses Problems soll entweder ein selektives

chemisches Bekämpfungsmittel oder eine wirksame natürliche Feind gefunden werden müssen. Es werden im Augenblick einige mögliche Feinde studiert.

c. Biologische Bekämpfung der Weissen Fliege auf Gurken ist noch immer nicht möglich. Wenn auf die neuen haarlosen Varietäten die Effektivität der Parasitierung nicht ausreichend zunimmt, in Vergleich zur Effektivität auf härigen Gurken, wird es notwendig sein neue Gurkenrassen zu züchten auf denen die Weisse Fliege sich nicht so schnell entwickeln kann.

d. Daten sind zur Verfügung gekommen über die Resistenz von Myzus persicae gegen das selektive Insekticide pirimicarb. Zwei natürliche Feinde sind studiert worden: Aphidius matricariae und Aphidoletus aphidimyza. Beide sind wahrscheinlich ausreichend wirksam. Ein gutes biologisches Bekämpfungprogramm steht jedoch noch nicht zur Verfügung.