

Impact of chrysanthemum cultivar, fertilization and soil-dwelling predatory mites on *Frankliniella occidentalis*

G.J. Messelink¹ & W.J. de Kogel²

¹Applied Plant Research, Division Glasshouse Horticulture, P.O. Box 8, 2670 AA Naaldwijk, The Netherlands; ²Plant Research International, P.O. Box 16, 6700 AA Wageningen, The Netherlands

Frankliniella occidentalis is a major problem in greenhouse chrysanthemum. The effects of plant resistance and fertilization on thrips, and the effect of soil-dwelling predatory mites on thrips pupae were studied in order to find alternative methods for controlling this pest. A greenhouse experiment was set up with four chrysanthemum cultivars and two fertilization levels. Thrips performance was analysed in the laboratory on leaf discs. Thrips reproduction among the four cultivars varied with 70%. Extra nitrogen resulted in a mean reproduction increase of 35%. Predation of thrips pupae in the soil was achieved by adding compost. The most dominant predatory mites were *Macrochelus robustulus* and *Macrochelus subbadius*. In small containers in a climate chamber, these mites could reduce a thrips population with 80%. Possibilities for using these results in the control of thrips are discussed.

Keywords: *Frankliniella occidentalis*, *Macrochelus robustulus*, *Macrochelus subbadius*, chrysanthemum, plant resistance, nitrogen, pest control

Chrysanthemum (*Dendranthema grandiflora*) is the second largest crop in Dutch greenhouse floriculture with an area of 750 ha in 2004. The many pest species that occur in this crop are in general controlled with pesticides. Western flower thrips (WFT), *Frankliniella occidentalis* Pergande (Thysanoptera: Thripidae), is one of the main pest species in chrysanthemum and many other greenhouse crops in Europe and North America (Lewis 1997). Chemical control strongly depends on a few active substances and risks for resistance to these substances are high. This risk can be reduced in a system with less intensive use of chemicals by alternative control methods.

The objective of the present study was to find alternative methods that help suppress thrips in chrysanthemum cut flowers. One of these methods can be the resistance of plants itself. Chrysanthemum cultivars show a large genetic variation in thrips resistance (de Jager *et al.* 1995). Selecting cultivars with high levels of resistance against thrips will enable growers to suppress thrips to a certain level. Thrips feeding on chrysanthemum can result in two types of damage: silver damage and growth damage. Thrips feeding on young developing tissues cause growth damage, whereas thrips feeding on older expanded leaves cause 'silver damage' (de Jager *et al.* 1995). Breeders consider 'growth damage' as the

most important type of thrips damage (M. Uiterdijk, pers. comm.). However, silver damage is more related to thrips population levels. In this study we investigated thrips performance on a number of chrysanthemum cultivars.

A second method for suppressing thrips in chrysanthemum might be possible by changing the amount of certain plant nutrients. Schuch *et al.* (1998) showed that fewer adults and immatures of WFT were found on chrysanthemums with lower nitrogen levels. Crop yield however, was also much lower as a result of these lower nitrogen levels. For practical use it is necessary to minimise nitrogen gift without consequences for production.

Use of soil-dwelling predatory mites for thrips control is a third less common method with potential. The soil-dwelling mites *Hypoaspis miles* (Berlese) and *Hypoaspis aculeifer* (Canestrini) (Acari: Laelapidae) are commercially available and do predate on soil-dwelling thrips stages (Gillespie & Quiring 1990, Berndt *et al.* 2004). These mites however do not always establish when released in greenhouse soils (Messelink & Slooten 2004). Soil fauna, including a whole complex of predatory mite species, can be enriched by adding compost and might be able to suppress thrips populations. In this study we investigated the impact of cultivar, fertilization levels and soil-swelling predatory mites on *F. occidentalis* in greenhouse chrysanthemums.

MATERIAL AND METHODS

Greenhouse experiment

An experiment with chrysanthemum was set up in a greenhouse of 240 m², to which a 4 cm layer of bio-waste compost was added. The compost contained high numbers of Collembola, oribatic mites and soil-dwelling predatory mites (Mesostigmata). Species present in this compost were: *Macrochelus robustulus* (Berlese), *Macrochelus subbadius* (Berlese), *Macrochelus vagabundus* (Berlese), *Parasitus* sp., *Arctoseius cetratus* (Sellnick) and *Rhodacarus* sp. More than 13 thousand predatory mites were added per m² with this compost. The greenhouse was divided in four blocks of equal size. Two of these blocks were steamed after adding the compost. Extra nitrogen was added in the same blocks by scattering 'Monterra N⁺' and calcium nitrogen (Ca(NO₃)₂). Nitrogen was lowered in the other two blocks by adding wood shavings of coniferous wood. Four chrysanthemum cultivars were planted in separate rows in every block. The cultivars 'Panther', 'Vesuvio Green', 'Universe' and 'Euro Pink' were planted in week 18 of 2004. 2000 rooted cuttings were planted per cultivar in a plant density of 64 plants/m². Thrips were introduced two weeks after planting by releasing 400 female thrips in the middle of each chrysanthemum cultivar row. These female thrips were collected with an aspirator from a culture on chrysanthemum. Thrips population in the crop was followed each week by hanging yellow sticky traps in every cultivar-fertilization combination (16 traps/week). 250 ml soil samples were taken from these plots in week 19, 24 and 30. Soil micro-arthropods

present in samples were extracted by heat using Tullgren funnels. These organisms were collected in 70% ethanol, filtrated on a paper filter and identified under a microscope. Extracted soil predatory mites were mounted in glass slides in order to determinate species names. Plants were harvested in week 29 and 80 cm stem sections of 40 plants per plot were weighed.

Thrips performance

Thrips performance on chrysanthemum was investigated on plants taken from the greenhouse experiment. Plants were harvested during the vegetative stage, eight weeks after planting (week 26). In total 32 plants were harvested; four plants per cultivar-fertilization level combination. Plants were moved to the laboratory and kept in a cold store at 5°C. Leaves discs (ø 28 mm) from these plants were put in Petri dishes with 1.5% agar, just before the agar was solidified. Female thrips of unknown age were randomly collected with an aspirator from a culture on chrysanthemum. Five female thrips, shortly anaesthetized with CO₂, were put in each Petri dish, after which these were sealed with plastic foil and stored in a climate chamber (T=25°C, L16:D8). Thrips mortality was recorded after a number of days and surviving thrips adults were moved to 'fresh' leaf discs in new Petri dishes. Reproduction was analysed by counting thrips larvae in all Petri dishes after about a week. Leaf analysis from plants used in this experiment was done by a commercial laboratory.

Soil-dwelling predatory mites

Effects of soil-dwelling predatory mites on thrips were investigated in a climate chamber at 20°C and L16:D8. Steamed and unsteamed soil was collected from the greenhouse experiment in week 34. Part of this soil was sterilized for 20 minutes at 120°C. Plastic containers of 30 × 40 × 50 cm were filled with 4 l steamed, unsteamed or sterilized soil in four replicates. Each container was filled with a flowering pot chrysanthemum cultivar Miramar, after which 50 thrips larvae were added. These larvae were collected with an aspirator from a culture on chrysanthemum. Containers were closed with yellow sticky traps on the top, to catch all thrips adults. Thrips numbers on these traps were counted under a microscope after four weeks. Soil samples of 250 ml were collected from each container. Soil micro-arthropods present in these samples were extracted by heat using Tullgren funnels. These organisms were collected in 70% ethanol, filtrated on a paper filter and identified under a microscope. Extracted soil predatory mites were mounted in glass slides in order to determinate species names.

Statistical analyses

Numbers of thrips and soil-dwelling predatory mites were transformed on a log scale and analysed by ANOVA using GenStat Release 6.1, followed by mean comparisons by the least significant difference method.

RESULTS

Cumulative numbers of thrips on yellow sticky traps did not differ significantly among chrysanthemum cultivars. However, there is a trend visible from effects of cultivars and fertilization (Table 1). The laboratory experiment showed significant effects of cultivars and fertilization on thrips performance (Fig. 1). These results correspond to the results from the sticky traps (Table 1). Cultivar Vesuvio Green gave the lowest thrips reproduction on leaves and cultivar Panther the highest. Fertilization with extra nitrogen resulted for all cultivars in 20-45% higher

Table 1. Mean cumulative number of thrips adults on yellow sticky traps during the vegetative period of chrysanthemum (week 18-23).

Cultivar	Unsteamed + standard fertilization	Steamed + extra nitrogen
Panther	47	53.5
Vesuvio Green	40	38.5
Euro Pink	34.5	53
Universe	42	43

Table 2. Mean number of soil organisms (\pm se) per 250 ml soil in steamed and unsteamed soil on three sample dates in 2004.

Week	Collembolan		Oribatic mites		Predatory mites >500 μ m	
	Steamed	Unsteamed	Steamed	Unsteamed	Steamed	Unsteamed
19	50 \pm 15	29 \pm 7	76 \pm 27	939 \pm 221	37 \pm 6	22 \pm 2
24	87 \pm 21	103 \pm 21	750 \pm 152	331 \pm 42	18 \pm 3	21 \pm 2
30	47 \pm 11	9 \pm 2	220 \pm 41	299 \pm 37	6 \pm 1	5 \pm 1

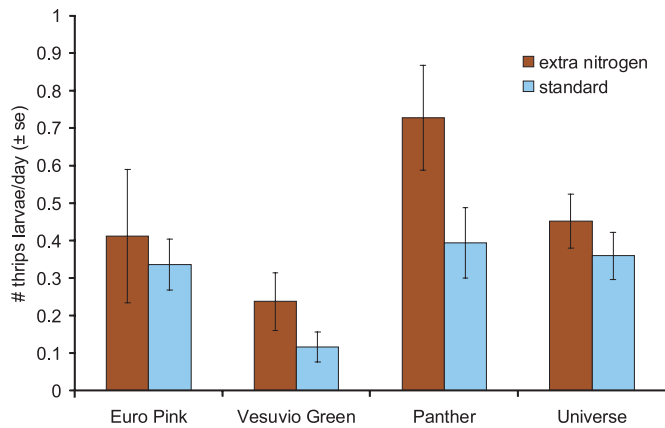


Figure 1. Thrips reproduction in the laboratory on four chrysanthemum cultivars with two levels of fertilization.

thrips reproduction (Fig. 1). There was no significant interaction with cultivar type. Nutrient analyses of plants used in this experiment, showed higher nitrogen and manganese levels in plants from steamed soil with extra fertilization.

Soil-dwelling predatory mites (>500 μm) were slightly more abundant in steamed plots during the first weeks of the experiment, whereas oribatic mites were in much higher numbers present in unsteamed soil (Table 2). Differences in numbers of soil micro-arthropods diminished during the experiment. Dominant soil-dwelling predatory mites were *M. robustulus* and *M. subbadius*. The mean weight of 80 cm stem sections was 9% lower in soil with standard fertilization than in steamed soil with extra nitrogen.

Soil-dwelling predatory mites

There were significantly more thrips on sticky plates from containers with sterilized soil without soil-dwelling predatory mites, than in containers with unsteamed soil (Table 3). The total number of thrips was reduced by about 80%. The more predatory mites were present, the less thrips were found (Fig. 2). All predatory mite species were identified as *M. robustulus* and *M. subbadius*. Smaller predatory mite species as *Rhodacarus* spp. were occasionally found.

Table 3. Mean (\pm se) number of thrips adults on yellow sticky traps and soil-dwelling predatory mites per 250 ml soil in containers with different soil treatments.

Treatment	Thrips	<i>M. robustulus</i>	<i>M. subbadius</i>
Sterilized soil	37.75 \pm 14.79 a*	0.25 \pm 0.25 a	0.00 \pm 0.00 a
Steamed soil	16.00 \pm 5.90 ab	1.25 \pm 1.25 a	1.25 \pm 0.95 a
Unsteamed soil	7.25 \pm 4.09 b	10.75 \pm 5.44 b	9.75 \pm 7.88 a

*Means within a column are significantly different ($p < 0.05$) if they are not followed by the same letter.

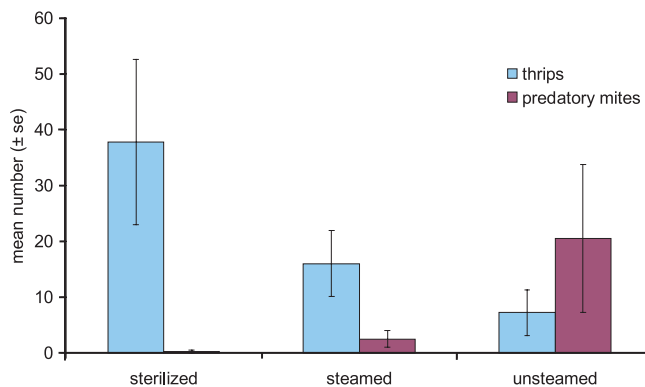


Figure 2. Mean number of thrips adults on sticky plates and soil-dwelling predatory mites (*M. robustulus* and *M. subbadius*) per 250 ml soil in boxes with different soil treatments.

DISCUSSION

This study investigated a number of alternative methods for thrips control in greenhouse chrysanthemum. Significant differences in the thrips population were observed among four chrysanthemum cultivars. Cultivating the more resistant cultivar 'Vesuvio Green' instead of the more sensitive cultivar 'Panther', can in theory lower thrips reproduction with 70%. Additionally, thrips reproduction could be decreased with an average of 35% when nitrogen levels in the plant were lowered. In practice it is more complicated to apply these results for the control of thrips. The choice for cultivating a certain cultivar is normally based on market demand. It is also a fact that breeders are more interested in selection to minimize growth damage rather than silver leaf damage (although the latter is more related to resistance against thrips).

Plant nutrients are generally available in more than sufficient levels so the cuttings have the maximum weight, essential for a good market price. However, during the last years more attention has been paid to the reduction of fertilizers because of the environmental risks of drainage. A lower nitrogen standard and lower nitrogen levels in the plant might help to slow down population growth of thrips.

Biological control of thrips in greenhouse chrysanthemum is hardly practised. Some growers use the Phytoseiid predator *Neoseiulus cucumeris*, for control of thrips larvae on the plant, with moderate success. The majority of a thrips population leave the plant for pupation in the soil (Berndt *et al.* 2004). This offers the opportunity for use of soil-dwelling predators for thrips control. Most growers and researchers are very focused on the two commercial available species *H. miles* and *H. aculeifer*. However, predation on thrips pupae is probably possible using a wider range of predatory mites, which are in general very polyphagous (Karg 1971). Predation of thrips pupae was also observed for the soil-dwelling predatory mite *Lasioseius fimetorum* Karg (Enkegaard & Brødsgaard 2000). In this study thrips control was achieved with a mixture of *M. robustulus* and *M. subbadius*. These mites are abundant in composted manure, where they feed upon nematodes, Enchytraeidae and eggs of flies (Halliday & Holm 1987, Karg 1971). Control of thrips using these predators has not been mentioned before. Applying compost to a greenhouse crop can be a simple method to add high numbers of soil-dwelling predatory mites. In this study we added more than 13 thousand mites per square meter with compost. Adding the same densities with commercial reared predatory mites is economically not feasible.

Acknowledgements This study was supported by the Ministry of Agriculture, Nature and Food Quality.

REFERENCES

Berndt, O., Meyhöfer, R. & Poehling, H.M. 2004. The edaphic phase in the ontogenesis of *Frankliniella occidentalis* and comparison of *Hypoaspis miles* and *Hypoaspis aculeifer*

- as predators of soil-dwelling thrips stages. *Biol. Contr.* 30: 17-24.
- Enkegaard, A. & Brødsgaard, H.F. 2000. *Lasioseius fimetorum*: a soil-dwelling predator of glasshouse pests? *BioControl* 45: 285-293.
- Gillespie, D.R. & Quiring, M.J.D. 1990. Biological control of fungus gnats, *Bradysia* spp. (Diptera: Sciaridae), and western flower thrips, *Frankliniella occidentalis* (Pergande) (Tysanoptera: Thripidae), in greenhouses using a soil-dwelling predatory mite, *Geolaelaps* sp. nr. *aculeifer* (Canestrini) (Acari: Laelapidae). *Can. Ent.* 122: 975-983.
- Halliday, R.B. & Holm, E. 1987. Mites of the family Macrochelidae as predators of two species of dung-breeding pest flies. *Entomophaga* 32: 333-338.
- Jager, de C.M., Butôt, R.P.T., Klinkhamer, P.G.L., Jong, de T.J., Wolff, K. & Meijden, van der E. 1995. Genetic variation in chrysanthemum for resistance to *Frankliniella occidentalis*. *Entomol. Exp. Appl.* 77: 277-287.
- Karg, W. 1971. Die Tierwelt Deutschlands. Teil 59. *Die freilebenden Gamasina (Gamasides), Raubmilben*. VEB Gustav Fischer Verlag, pp. 1-475.
- Lewis, T. 1997. Pest thrips in perspective. In: Thrips as crop pests (ed. T. Lewis), p. 740. CAB International, Wallingford, UK.
- Messelink, G. & Slooten, M. van. 2004. Effects of soil-dwelling predators and organic treatments on the cabbage root fly *Delia radicum* (Diptera: Anthomyiidae) in greenhouse radish. *Proc. Neth. Entomol. Soc. Meet.* 15: 87-91.
- Schuch, U.K., Redak, R.A. & Bethke, J.A. 1998. Cultivar, fertilizer and irrigation affect vegetative growth and susceptibility of chrysanthemum to western flower thrips. *J. Am. Soc. Horticul. Sci.* 123: 727-733.