NOTE: Ovicidal and Nymphicidal Effects of Some Fungicides on the Greenhouse Whitefly *Trialeurodes vaporariorum*

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Eggs and L1 nymphs of the greenhouse whitefly *Trialeurodes vaporariorum* (Westwood) (Hem.: Aleyrodidae) on bean leaves were directly sprayed with the fungicides maneb and mancozeb at recommended rates for practical use. Strong ovicidal and nymphicidal effects were observed. These fungicides may prove to have practical use for integration in IPM programs for whitefly control, as they also exert low or no toxicity to the whitefly parasitoid *Encarsia formosa*.

KEY WORDS: *Trialeurodes vaporariorum*; maneb; mancozeb; contact toxicity; ovicidal effect; nymphicidal effect; side-effects on *Encarsia formosa*.

In the 1960's, the greenhouse whitefly *Trialeurodes vaporariorum* (Westwood) (Hem.: Aleyrodidae) was successfully controlled with broad-spectrum pesticides; however, in the early 1970's growers were confronted with serious resistance problems (2). These problems were solved mainly by the introduction of the parasitic wasp *Encarsia formosa* Gahan (Hym.: Aphelinidae). However, biocontrol with *Encarsia* was not always successful, especially at lower ($<16^{\circ}$C) and higher ($>30^{\circ}$C) temperatures, thus requiring additional control measures (chemicals, other biocontrol agents).

Today, biological control with *E. formosa* is often supported by either selective chemicals such as buprofezin (2), pyriproxyfen, pymetrozine (3) or other biocontrol agents, *e.g.* the predatory bug *Macrolophus caliginosus* Wagner (Hem.: Miridae), the predatory beetle *Delphastus pusillus* (Le Conte) (Col.: Coccinellidae), the parasitic wasp *Eretmocerus eremicus* Rose & Zolnerowich (Hym.: Aphelinidae) and the entomopathogenic fungus *Paecilomyces fumosoroseus* Wize (Brown and Smith) (Fungi: Hyphomycetes) (*PFR*) (1).

Although this wide range of control methods is available to control the greenhouse whitefly, any alternative selective chemical or biological control (that can support *E. formosa*) must be considered, keeping in mind that the number of chemicals compatible with biological control is small.

In a semi-field test carried out to assess the effect of two bisdithiocarbamate fungicides (maneb and mancozeb) on the entomopathogenic fungus *PFR*, we noticed that these compounds had a possible ovicidal and nymphicidal effect on the greenhouse whitefly. In these tests, *PFR* was cultivated on multiple whitefly stages (eggs, nymphs, pupae) on tomato leaves. Maneb and mancozeb are used in Belgium in greenhouse tomatoes to control the causal agent of potato late blight, *Phytophthora infestans*, which can occur under conditions of high humidity, especially in soil cultures.

The ovicidal and nymphicidal effects of maneb and mancozeb were studied under controlled laboratory conditions, by spraying bean leaves containing eggs and L1-nymphs of *T. vaporariorum* with the fungicides.

Potted beans (*Phaseolus vulgaris*) with two leaves were placed in a Plexiglas cage

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(50×50×70 cm), at 20–25°C, 60–80% r.h., 16:8 L:D. They were infested with adult *T. vaporariorum* (>50 per leaf), which were removed after 3 days. Then the leaves, containing a high number of white and lilac whitefly eggs, were cut from the plants in such a way that they could be grown further in moist vermiculite. This was done by cutting the stem of the bean plant 2 cm below the place where the two leaves grow. The 2-cm stem was cut lengthwise and each leaf was put in very damp vermiculite in plastic pots.

To evaluate the ovicidal activity of the compounds, the leaves and eggs were sprayed in a spray chamber. Two concentrations of the fungicides were used: the recommended rate and double the recommended rate for practical use in Belgium, respectively 1500 and 3000 mg a.i. l^{-1} for both maneb (Tricarbamix extra, 75%) and mancozeb (Dithane WG 75%). To evaluate the nymphicidal activity of the compounds, cut leaves containing a high number of L1 whitefly nymphs were sprayed in a spray chamber with the recommended rate of maneb and mancozeb (1500 mg a.i. l^{-1} for each compound). One ml of formulated product was evenly sprayed all over each leaf, at 1 bar pressure. Five leaves were sprayed (five replicates) per compound and per concentration. Untreated bean leaves infested with *T. vaporariorum* eggs and L1 nymphs were used as a control. After treatments, the bean leaves were placed in the Plexiglas cage under the same abiotic conditions as described above.

Ten to 13 days after the treatments, the leaves were examined under a stereomicroscope and unhatched and hatched whitefly eggs and larval instars (L1, L2) were counted.

The toxicity of the fungicides to *T. vaporariorum* eggs is given in Tables 1 and 2.

Both compounds had a strong ovicidal effect. More than 95% of the few hatched eggs (L1 nymphs) were found dead in all treatments. Both compounds also killed all L1 nymphs when applied at the recommended rate. It is unlikely that these effects are caused by the formulation of the products, because we have also tested TMTD (Pomarsol WG 80%) and tolylfluanid (Euparen M 50%) with the same procedure, and they did not have ovicidal and/or nymphicidal effects.

Treatment of the eggs with maneb and mancozeb not only killed most of the eggs but also killed most of the L1 nymphs which hatched from the eggs. These fungicides can thus prove to be of practical use to sustain biological control of the whitefly in greenhouses (*e.g.* tomatoes, at the beginning of the growing season). One or two applications of these compounds, in hot spots, or at the top of the plants, could be sufficient to correct poor biological control more economically than with selective insecticides.

It would be interesting (but was not within the scope of this research) to study the LC_{50} of both compounds on whitefly eggs or nymphs. If the LC_{50} proved to be low, reduced concentrations of the compounds could be applied. Mancozeb (5000 mg a.i. l^{-1}) was tested in 'worst case' laboratory tests on the susceptible (adult) and less susceptible (black scale) stage of *E. formosa*. The compound turned out to be harmless (unpublished data). Maneb (1500 mg a.i. l^{-1}) was tested in semi-field tests and turned out to be harmless to the black scales and moderately harmful to adult *E. formosa* wasps; also, the product proved to be shortlived. If applied at low frequency, maneb and mancozeb are safe to the predatory mites *Amblyseius californicus, A. cucumeris, A. degenerans* and *Phytoseiulus persimilis.* Mancozeb is safe to the predatory bugs *Macrolophus caliginosus* and *Orius laevigatus*, but moderately toxic to *Anthocoris nemoralis* (Biobest NV, technical brochure). Both compounds can thus be used together with the parasitic wasp, concurrently with or in addition to the biological control. It would also be worthwhile to study the effect of both compounds on eggs and nymphs of the sweet potato whitefly *Bemisia tabaci*, which may become a serious threat to sweet peppers and ornamentals in northern Europe.

TABLE 1. Ovi-nymphicidal activity of maneb and mancozeb on *Trialeurodes vaporariorum*

Compound and concentration (mg a.i. l^{-1})	Total no. of deposited eggs	Egg mortality (% ±S.D.)	L1-mortality[z] (% ±S.D.)
Maneb 1500	1740	94.7 (± 4.6)	95.2 (± 8.3)
Maneb 3000	1028	98.0 (± 3.5)	100
Mancozeb 1500	1840	88.4 (± 6.4)	97.7 (± 3.9)
Mancozeb 3000	2512	99.7 (± 0.5)	100
Untreated	1005	4.5 (± 3.7)	7.4 (± 6.8)

[z]Mortality was calculated as dead nymphs/number of nymphs × 100.

TABLE 2. Nymphicidal activity of maneb and mancozeb, each at 1500 mg a.i. l^{-1}, on *Trialeurodes vaporariorum*

Compound	Total no. of L1-L2 nymphs	L1-L2 Mortality (%±S.D.)
Maneb	2850	100
Mancozeb	2605	100
Untreated	3155	12.9 (±1.8)

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