IMPACT OF *n*C24 HORTICULTURAL MINERAL OIL DEPOSITS ON THE BEHAVIOUR OF *FRANKLINIELLA SCHULTZEI* (TRYBOM) (THYSANOPTERA: THRIPIDAE)

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Summary

The impact of *n*C24 horticultural mineral oil deposits on oviposition by tomato thrips (*Frankliniella schultzei*) on French bean pods and tomato seedlings was determined in four laboratory experiments. The results showed that deposits on dipped bean pods repelled adult tomato thrips and significantly reduced oviposition. The impact of the deposits was similar for aqueous emulsions with oil concentrations ranging from 2.5 to 15 mL of oil/L of water. The effect of deposits did not decline significantly as the oil deposits aged over the 5 day period. On tomato seedlings, sprays containing 10 mL of oil/L of water significantly reduced oviposition but 5 mL/L sprays had no significant effect. The results for 15 and 20 mL/L sprays were affected by unexpected oil induced phytotoxicity.

Keywords: tomato thrips, horticultural mineral oil, behaviour, oviposition, repellency

INTRODUCTION

Tomato thrips *Frankliniella schultzei* (Trybom) (Thysanoptera: Thripidae) is a polyphagous pest of plants ranging from ornamentals and fruit trees to vegetables and cotton. Its hosts, distribution, and economic importance were briefly reviewed by Vierbergen and Mantel (1991). In addition to being phytophagous it is also a facultative predator of spider mites (Acari: Tetranychidae) (Wilson *et al*. 1996; Milne and Walter 1997). It is a vector of tomato spotted wilt tospovirus (TSWV), a serious disease of tomatoes and other crops in Australia and elsewhere (Tesoriero *et al*. 1995; Latham and Jones 1998; Clift *et al*. 2002). A range of toxic pesticides has been used and evaluated for its control (Murthy *et al*. 1988; Peter and Sundararajan 1991; Latha *et al*. 1993; Jacobs 1995; Branco 1996). Recent studies have shown that *F. schultzei* and spread of TSWV can be controlled with biorational horticultural mineral oils (Singh *et al*. 2000; Clift *et al*. 2002). We report the effects of horticultural mineral oil deposits on the oviposition behaviour of *F. schultzei* on tomato seedlings and French bean pods in choice and no-choice experiments.

MATERIALS AND METHODS

Thrips and plants

Tomato thrips were obtained from NSW Agriculture, Gosford (Drs Steven Goodwin and Marilyn Steiner). Cultures of tomato thrips were maintained on French bean pods using methods similar to those described by Steiner and Goodwin (1998).

Horticultural mineral oil

The horticultural mineral oil (HMO) used in the experiments was *n*C24 Ampol D-C-Tron Plus (Ampol Limited, now Caltex Australia Pty Ltd, Sydney). Its specifications are given by Rae *et al*. (1996).

Oviposition on bean pods with aged HMO deposits: no-choice test

Adult thrips were exposed to a range of dried oil deposits on about 12 cm long bean pods. A factorial design with five treatments (distilled water, and aqueous emulsions of 2.5, 5, 10 and 15 mL of oil/L of water), three deposit ages (2 h, 3 d and 7 d) and four replicates (= bean pod) per treatment/time combination, was used. Pods were dipped in water or freshly prepared emulsion for 5 s in a 1 L beaker with a magnetic stirrer, allowed to dry and then placed in separate test-tubes (1.7 cm x 15 cm). A length of spiralled 1.5 mm wire was placed in each tube to prevent pods touching the sides of the tubes. Ten adult thrips were released into each test-tube at the allotted times, and each tube was covered with fine cloth mesh. The thrips were removed from the test-tubes 24 h after they were released and the number of nymphs on each pod was recorded 7 d later. Data were subjected to analysis of variance. Data were approximately normally distributed (visual assessment of normal probability plots) and variances were homogeneous (Levene's test: $F_{14, 45} = 0.711$, ns).

Repellency of HMO deposits on bean pods to adults: choice test

Two bean pods, each approximately 12 cm long, were suspended in each of 16 jars (9 cm x 18 cm). One pod was randomly selected as the control and dipped in distilled water for 5 s. The other was deemed the treatment pod and was dipped in aqueous emulsions containing 2.5, 5, 10 or 15 mL of oil/L of water for 5 s. Four jars (= replicates) were used for each oil treatment. Twenty adult thrips were released into each jar after the water and oil emulsion deposits dried (about 2 h). Three hours after release the number of thrips on the control and treatment pods in each jar was counted. The extent of repellency was the difference in the number between the control and treatment pods divided by the number on both pods: (a – b)/(a + b) where a = number of adults on the control pod, b = number of adults on the treatment pod. Data were subjected to one-way analysis of variance. Untransformed data were approximately normally distributed and had homogenous variances (Levene's test: $F_{3,12} = 3.216$, $p = 0.062$).

Repellency of HMO deposits on bean pods to adults and impact of deposits on oviposition: choice test

The experiment was a factorial design with five treatments (distilled water, and aqueous emulsions of 2.5, 5, 10 and 15 mL of oil/L of water, and three deposit ages (2 h, 3 d and 5 d). There were four replicates (= bean pods) per treatment/time combination. Pods were dipped in water or freshly prepared emulsions for 5 s in a 1 L beaker with a magnetic stirrer, allowed to dry (2 h) and then arranged vertically in a 40 x 30 x 23 cm clear plastic storage container. The base of the container was lined with lengths of paper towel and the container was covered with fine white cloth and a loosely fitted lid (to reduce moisture loss from pods) before and after the release of thrips. The beans were supported by two layers of 12 mm x 12 mm wire mesh, supported 4 cm and 7 cm respectively above the base of the container. On the fifth day, after the last of the pods were dipped, all pods were arranged randomly and equidistantly in the grid formed by the mesh and 200 adult thrips were then released into the container. After the thrips were released the container was placed in a constant environment chamber (Thermoline Pty Ltd, South Melbourne, Victoria, Australia) at 23 ± 2°C and 65% RH 12:12 L:D cycle. Adult thrips on each pod were counted and were removed from the container 24 h after they were released. The number of nymphs on each pod was recorded 7 d later. Data were subjected to analysis of variance. To better approximate a normal distribution, adult counts were ln (y + 1) transformed and nymph counts were $(y + 0.5)^{0.5}$ transformed. Transformed data were approximately normally distributed (visual assessment of normal probability plots) and variances were homogeneous (Levene's test: adults: $F_{14, 45} = 0.735$, ns; nymphs: $F_{14, 45} = 0.296$, ns).

Repellency of HMO deposits on tomato seedlings to adults and impact of deposits on oviposition: choice test

The experimental design was a completely randomised split plot. The whole plot factor 'cage' was assumed to be a random effect. The subplot factor was oil concentration at five levels (distilled water, and aqueous emulsions of 2.5, 5, 10 and 20 mL of oil/L of water) and there were three replicates (= tomato seedling) of each oil concentration in each cage (50 x 35 x 30 cm). Each seedling had three small leaves and was about 15 cm high. Spray treatments (2 mL of agitated emulsion) were applied with a paint airbrush sprayer (Paasche Airbrush Company, Harwood Heights, Illinois, United States of America) operating at 138 kPa, from a distance of 10 cm from each seedling. The seedlings were gently and evenly rotated as the sprays were applied and the leaves allowed to dry before 225 adult thrips were released into each cage. After 2 d, the number of adult thrips on each seedling was counted. After 7 d the number of nymphs was also counted. Checks of the data for normality and variance homogeneity were conducted prior to the analysis to determine if a transformation was appropriate. Counts of adults did not require transformation but the number of nymphs was $(y + 0.5)^{0.5}$ transformed to better approximate a normal distribution. Data were subjected to analysis of variance.

All statistical analyses were performed using SPSS (1999).

RESULTS

Oviposition on bean pods with aged HMO deposits: no-choice test

The number of nymphs on beans differed significantly between levels of oil concentration ($F_{4, 45} = 12.28$, $p < 0.001$) and deposit age ($F_{2, 45} = 34.33$, $p < 0.001$) (Figure 1). There was no significant interaction between these two factors ($F_{8, 45} = 1.380$, $p = 0.23$). However, the data suggest that suppression of oviposition was similar for concentrations of oil between 2.5 and 15 mL of oil/L of water, a result supported by a test of differences among treatments in which oil was applied ($F_{3, 45} = 2.167$, $p = 0.105$). About 87% of the variation in the treatment effect was due to the difference between the control and the treatments in which oil was applied.

The number of nymphs was significantly lower in the

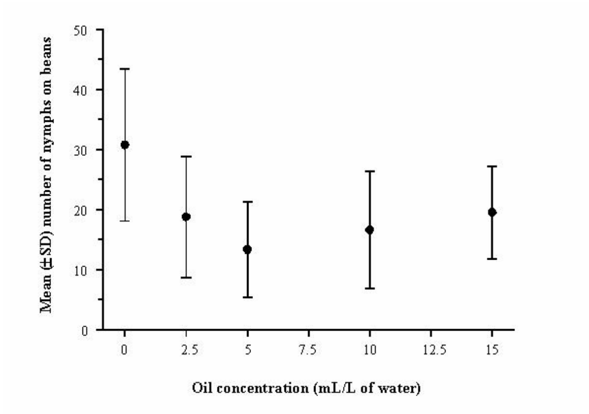

Figure 1. Relationship between oil concentration and the number of nymphs counted on bean pods in a no-choice experiment.

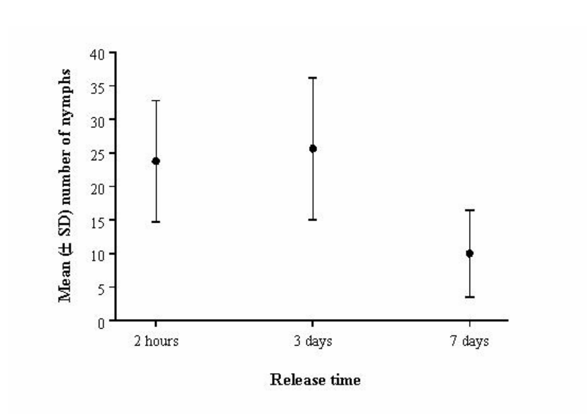

Figure 2. Effect of release time after spray application of the number of thrips nymphs on bean pods in a no-choice experiment.

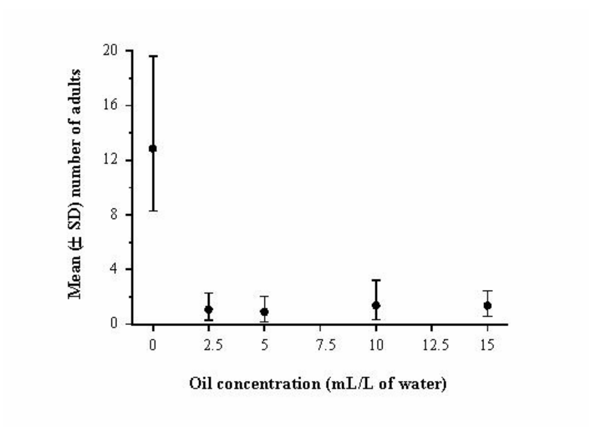

Figure 3. The effect of oil concentration on the number of adults on bean pods in a choice experiment. Data are the back-transformed means and 95% confidence intervals of ln (y + 1) data.

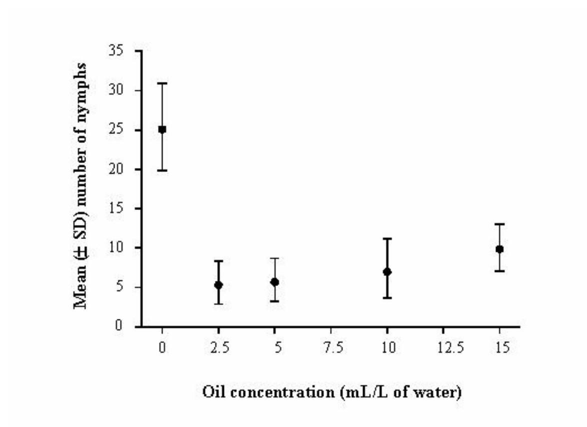

Figure 4. The effect of oil concentration on the number of nymphs on bean pods in a choice experiment. Data are the back-transformed means and 95% confidence intervals of $(y + 1)^{0.5}$ data.

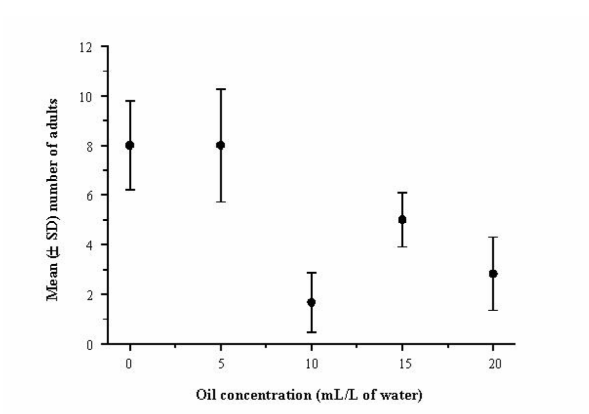

Figure 5. Relationship between the number of adult thrips on tomato seedlings and oil concentration applied to the seedlings.

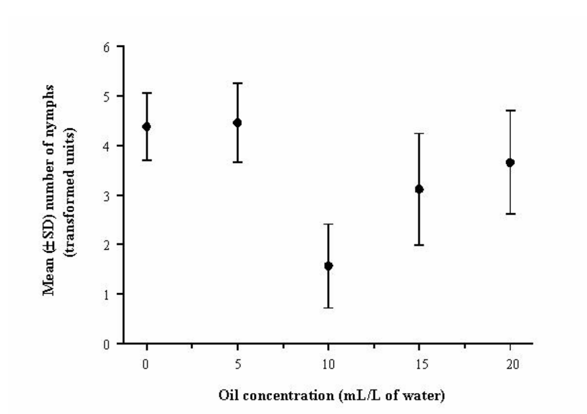

Figure 6. Relationship between the number of nymphs on tomato seedlings $[(y + 0.5)^{0.5}$ transformed] and oil concentration.

7 d release times than in either the 2 h or 3 d release times ($F_{1, 45}$ = 67.86, $p < 0.001$) (Figure 2). This difference accounted for about 99% of the variation in the release time effect. There was no difference between the 2 h and 3 d counts ($F_{1, 45}$ = 0.808). Few nymphs were found in the 7 d release data probably because the beans dried and became poorer oviposition substrates for the thrips.

Repellency of HMO deposits on bean pods to adults: choice test

The impact of deposits on the number of adult thrips was significant ($F_{1,12}$ = 9.53; $p < 0.009$). An average of 66.6% of thrips chose the undipped pod. There was no significant difference in the numbers observed on pods dipped in the four concentrations of HMO.

Repellency of HMO deposits on bean pods to adults and impact of deposits on oviposition: choice test

The concentration of oil significantly affected the number of adults on beans ($F_{4, 45}$ = 17.19, $p < 0.001$) but deposit age ($F_{2, 45}$ = 2.077, p = 0.137) and the interaction between deposit age and oil concentration ($F_{8, 45}$ = 1.428, p = 0.211) were not significant. The results in Figure 3 suggest that any quantity of oil repelled adult thrips, and indeed no significant difference was found among treatments in which oil was applied ($F_{3, 45}$ = 0.275, p = 0.84) with 99% of the variation among oil concentrations being due to the difference between the control and the other treatments.

Nymphs were affected in a way very similar to the adults. The number of nymphs differed significantly between treatments ($F_{4, 45}$ = 17.67, $p < 0.001$) (Figure 4) but not between deposit ages ($F_{2, 45}$ = 2.107, p = 0.133) or for the deposit age by oil concentration interaction ($F_{8, 45}$ = 0.423, p = 0.52). There was no significant difference between oil treatments ($F_{3, 45}$ = 1.961, p = 0.133) with about 92% of the variation between treatments due to the difference between the control and the other treatments.

Repellency of HMO deposits on tomato seedlings to adults and impact of deposits on oviposition: choice test

The 15 and 20 mL of oil/L of water sprays caused phytotoxicity. Plants wilted and leaves curled and the impact of 20 mL/L sprays was more obvious than the effect of 15 mL/L sprays. There were significant differences in the number of adult thrips between concentrations of oil ($F_{4,4}$ = 7.307, p = 0.04) (Figure 5). A significant result was also obtained for nymph counts ($F_{4, 4}$ = 7.032, p = 0.043) (Figure 6). The relationship between adult numbers on tomato seedlings and oil concentration was linear (linearity: $F_{1, 4}$ = 14.841, p = 0.012; deviation from linearity: $F_{3, 4}$ = 4.446, p = 0.092) (Figure 5). However, numbers of adults on seedlings treated with 10 mL of oil/L of water appeared to be relatively low. For the nymph data, the relationship between counts (transformed) and oil concentration was more complex. As for the results for adult thrips, the number of nymphs in the 10 mL/L oil treatment appeared to be relatively low compared to the 5 and 15 mL/L treatments.

DISCUSSION

The results of three experiments showed that HMO deposits on dipped bean pods repelled adult tomato thrips and significantly reduced oviposition. The impact of the deposits was similar for aqueous emulsions with oil concentrations ranging from 2.5 to 15 mL of oil/L of water. The effect of deposits did not decline significantly as oil deposits aged over the period of 5 days in the ‘choice’ experiment on bean pods. The oviposition response observed in the ‘choice’ experiment on beans was similar to the response recorded by Liu *et al*. (2002) for greenhouse thrips *Heliothrips haemorrhoidalis* (Bouché) (Thysanoptera: Thripidae) oviposition on Valencia orange fruit and mango leaves sprayed with the same *n*C24 horticultural mineral oil. On tomato seedlings in this study, 10 mL of oil/L of water sprays significantly reduced oviposition but 5 mL/L sprays had no significant effect, and the results for 15 and 20 mL/L sprays were affected by oil induced phytotoxicity. This phytotoxicity was unexpected and may have been related, in this instance, to the use of excised leaves, as phytotoxicity was not observed in related experiments using similar procedures (Xue *et al*. 2002). In five recent field studies in New South Wales, Singh *et al*. (2000) only observed oil-induced phytotoxicity on tomatoes when 20 mL/L sprays were applied with a knapsack sprayer to trellised plants 11 times at weekly intervals. Reduced growth was observed after 8-9 sprays. There were no other symptoms and normal growth occurred in treatments containing 5, 10 and 15 mL of HMO/L. No phytotoxicity was observed in the other experiments, even when 10 mL/L sprays were applied 13 times over season to trellised fresh tomatoes at an average volume of 2,150 L/ha (Singh *et al*. 2000).

In anoxia bioassays, Kallianpur *et al*. (2002) derived LD_{95}s of 236 μg and 127 μg oil cm^{-2} for *n*C21 HMO and *n*C23 HMOs respectively for *F. schultzei*. These values are higher than those derived for several pests for which HMOs have been used historically at 10 to 20 mL of oil/L of water (Hely *et al*. 1982; Davidson *et al*. 1991; Herron *et al*. 1995) and would suggest limited potential for using HMOs in tomato thrips management programs. However, our results indicate that HMOs may have potential for managing tomato thrips through effects on mortality and behaviour. This view is supported by recent field studies (Singh *et al*. 2000; Clift *et al*. 2002) in which HMO was used to control a range of tomato pests, including tomato thrips and plague thrips *Thrips imaginis* Bagnall, and to reduce the TSWV infection, in most instances as effectively or more effectively than conventional pesticides.

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