EFFECT OF A HORTICULTURAL MINERAL OIL ON OVIPOSITION BY TWO-SPOTTED MITE *TETRANYCHUS URTICAE* KOCH (ACARI: TETRANYCHIDAE)

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Summary

The impact of spray deposits of an *n*C24 horticultural mineral oil on two-spotted mite oviposition on French bean leaf discs was evaluated under laboratory conditions. An unsprayed control was compared with 25, 50, 100 and 150 μg cm^{-2} deposits of oil sprays applied with a Potter spray tower. One day after adult female mites were placed on untreated and treated leaf discs significantly fewer eggs were recorded on discs treated with 100 and 150 μg cm^{-2} deposits. Significant differences between all oil treatments and the untreated control were found 2 d and 6 d after females were placed on the discs, and the number of eggs laid on oil treated discs fell as the concentration of oil in sprays increased. The relationship between the number of eggs per leaf disc and oil concentration on day 6 was a typical negative exponential.

Keywords: two-spotted mite**,** horticultural mineral oil, behaviour, oviposition, repellency

INTRODUCTION

Two-spotted mite *Tetranychus urticae* Koch (TSM) is a serious pest of a wide-range of crops (Helle and Sabelis 1985). Current control measures rely heavily on the use of synthetic pesticides. Many of these chemicals are toxic to mite predators and the natural enemies of other pests, and resistance to them is widespread. These issues are serious impediments to sustainable management of the mite (Herron *et al*. 1993; Clark *et al*. 1995; Beers *et al*. 1998). Horticultural mineral oils (HMOs or narrow-range petroleum spray oils) are biorational products to which arthropod resistance has not been empirically demonstrated (see Beattie *et al*. 2002). Herron *et al*. (1995; 1998) evaluated HMOs as suffocants (the generally accepted primary mode of action is anoxia) and their results indicated that adult TSM were more tolerant to HMOs than other pests for which petroleum-derived oils have traditionally been used for control. The level of tolerance also indicated that HMOs would have relatively low potential for practical control of the pest. However, increasing evidence of significant effects of oil deposits on arthropod behaviour (Beattie *et al*. 1995; Mensah *et al*. 1995; Rae *et al*. 1997; Stansly *et al*. 2002) and the apparent success of concurrent studies on control of TSM and rose powdery mildew on roses (Nicetic *et al*. 1999; 2002) led us to determine the effects of an HMO on TSM oviposition. We report the outcome of these studies and discuss their implications.

MATERIALS AND METHODS

Mites

The source of mites used for the experiments was a TSM culture maintained for commercial production of predatory mites on French bean seedlings in a greenhouse at the Centre for Horticulture and Plant Sciences. Adults used in the evaluations were obtained by placing young mite-free bean seedlings next to older infested plants for 1 d. A fine camel-hair brush was then used to remove all immature mites from the younger plants. The adults were then allowed to feed, mate and oviposit on the plants for 5 d before they were used in the experiment.

Horticultural mineral oil

The 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).

Treatments, spraying and assessments

There were five treatments: an unsprayed control, and 25, 50, 100 and 150 μg cm^{-2} deposits of the HMO, each with 10 single leaf disc replicates. A Potter spray tower (Burkard, Uxbridge, United Kingdom) was used to apply 5 mL sprays of 2.5, 5, 10 and 15 mL of oil/L of water to the abaxial surface of individual 9 mm leaf discs using procedures described by Herron *et al*. (1995). The tower was calibrated to achieve a linear relationship between oil concentration and deposit (Herron *et al*. 1995). After the spray deposits dried, each leaf disc was placed gently on 20 mL of 7 g/L solidifying agar media in a 90 mm Petri dish. The camel-hair brush was then used to transfer single adult female TSM from the bean seedlings to each disc. The number of eggs laid by each female was recorded 1, 2 and 6 d after the females were placed on the leaf discs. A stereomicroscope was used for all assessments.

Statistical analysis.

The variables analysed were the number of eggs per leaf disc at 1, 2 and 6 d after adult female TSM were placed on unsprayed and oil sprayed leaf discs. The number of eggs per disc on day 1 was logarithm transformed (log (x+1)), and the number of eggs per disc on day 6 was square-root transformed (√x+1) to improve variance homogeneity. Day 2 data did not require transformation. To determine the effect of different oil concentrations on the number of mite eggs, variables were analysed using ANOVA (SPSS 1999). When a significant difference was detected, pair-wise comparisons between treatment means were made using the Dunn-Šidák method (Sokal and Rohlf 1981).

RESULTS

There were significant differences between treatments in the number of eggs per leaf disc 1 d after adult female TSM were placed on the discs ($F_{4, 36}=7.61$, $p < 0.001$). At this point females laid significantly fewer eggs on discs with 100 and 150 µg HMO cm^{-2} deposits but there were no significant differences between the 25 and 50 µg HMO cm^{-2} treatments and the unsprayed control (Table 1). Significant differences between all HMO treatments and the untreated control were found 2 d ($F_{4, 36}=23.15$, $p < 0.001$) and 6 d ($F_{4, 36}=65.83$, $p < 0.001$) after the females were placed on the discs. The number of eggs laid on HMO treated discs was significantly lower than in the untreated control and the number of eggs laid on oil treated discs fell as the concentration of oil increased (Table 1).

DISCUSSION

The relationship between the number of eggs per leaf disc and HMO concentration on day 6 was a typical negative exponential, $y = 48.84e^{-3.90x} + 2.36$ ($r^2 = 0.858$), where y is the number of eggs per leaf disc and x the concentration of HMO. Similar relationships have been reported for citrus leafminer *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) (Beattie *et al.* 1995) and greenhouse thrips *Heliothrips haemorrhoidalis* (Bouché) (Thysanoptera: Thripidae) (Liu *et al.* 2002). Herron *et al.* (1995; 1998) determined LD_{95} values ranging from 166 to 207 µg oil cm^{-2} for HMO-induced anoxia against TSM adult females. These relatively high values (see Herron *et al.* 1995) suggested limited scope for controlling TSM in management programs based on the use of 1 to 2 L oil/100 L water sprays applied once or twice annually to kill mites in situations where population densities exceed economic thresholds. This limitation has been demonstrated in field evaluations in apples (Thwaite *et al.* 2002). However, Nicetic *et al.* (2002) showed,

Table 1. Effect of *n*C24 horticultural mineral oil (HMO) deposits on two-spotted mite oviposition 1, 2 and 6 d after adult female mites were placed on bean leaf discs [1].

Treatment	Number eggs per leaf disc (means ± SD) [1]		
	1 d [2]	2 d	6 d [2]
Unsprayed control	2.05 ± 1.87 a	13.30 ± 4.06 a	50.74 ± 0.38 a
25 µg HMO cm^{-2}	2.86 ± 0.56 ab	7.80 ± 4.26 b	18.78 ± 0.47 b
50 µg HMO cm^{-2}	0.85 ± 1.05 ab	3.80 ± 3.79 bc	9.47 ± 0.15 c
100 µg HMO cm^{-2}	0.23 ± 0.40 b	1.60 ± 0.84 c	2.01 ± 0.90 d
150 µg HMO cm^{-2}	0.00 ± 0.00 b	0.80 ± 1.32 c	2.86 ± 0.73 d

[1] Means followed by the same letters within columns were not significantly different at the adjusted significant level ($\alpha = 0.0051$).
[2] Back-transformed data.

in studies conducted after ours, that HMOs can be used weekly at 300 mL of oil/100 L of water, or fortnightly at 500 mL of oil/100 L of water, to control TSM in greenhouse roses. Under these circumstances the sprays control TSM and rose powdery mildew simultaneously, at as little as half the cost of management programs based on the use of synthetic miticides and fungicides, providing TSM populations are below economic thresholds when the first HMO spray is applied at these concentrations (Nicetic *et al*. 1999; 2002).

Our results suggest that the effects of the sprays under these circumstances are largely related to behavioural effects of the oils on adult females. However, further research is required to determine the relative impact of HMOs on the behaviour of TSM adults and nymphs, and egg and nymph mortality. These results and those of Nicetic *et al*. (1999; 2002) indicate significant new potential for using HMOs to control TSM in a range of crops and in the management of acaricide resistance. Our research adds to other recent research that has shown that control of pests through influences on their behaviour, particularly the behavioural effects of HMOs can be more significant than death caused by pesticides. The benefits of using biorational products such as HMOs for this purpose are readily recognised by farmers but may not be appreciated by the pesticide industry or those who believe that the only effective means of controlling pests is through death.

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