Israel Journal of Entomology
Vol. XXV-XXVI (1991-1992) pp.67-71

EFFECT OF BUPROFEZIN ON CALIFORNIA RED SCALE, *AONIDIELLA AURANTII* (MASKELL), IN A CITRUS ORCHARD*

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ABSTRACT

The effectiveness of wettable powder (WP) and emulsifiable concentrate (EC) of buprofezin on *Aonidiella auranlii* (Maskell) was studied in a citrus grove. When applied once at the rate of 125 mg active ingredient a.i./l or twice at the rate of 62.5 mg a.i./l, WP was considerably less potent than the EC for controlling *A. auranlii.* Addition of 0.5% light medium grade mineral oil increased the potency of the WP to a greater extent than that of the EC. The infestation rate of fruits by *A. aurantii* recorded 75 days after application resembled, in general, that of twigs and leaves. The rate of parasitism by *Comperiella bifasciata* Howard (Encyrtidae) and *Aphylis* spp. (Aphelinidae) measured as rate of parasitism did not differ among treatments.

KEY WORDS: *Buprofezin, mineral oil, California red scale, Aonidiella auranlii, Comperiella bifas- ciata, Aphylis.*

INTRODUCTION

The California red scale, *Aonidiella aurantii* (Maskell), is a major pest in most citrus-growing areas of the world (Talhouk, 1975). It attacks all parts of the tree, causing yellowing of leaves, dropping of foliage and fruits, and dieback of twigs and limbs (Anon., 1985; Rosen and DeBach, 1978). Biological control of the scale is not always sufficiently effective to reduce the pest population to below the economic threshold (Rivnay, 1968; Luck, 1981). The use of nonselective insecticides such as organophosphates and pyrethroids may interfere with the activity of natural enemies, it may cause severe outbreaks of *A. aurantii* and other pests, and lead to formation of resistant strains (Bedford and Grobler, 1981). Hence, an integrated pest management program including selective chemical control along with biological control is needed to protect citrus groves from the scale pests.

Buprofezin (2-tert-butylimino-3-isopropyl-5-phenyl-3,4,5,6-tetrahydro-thiadiazine-4-one), an insect growth regulator, Nihon Nohyaku Company, Japan (Kanno et al., 1981; Uchida et al., 1985), acts on whiteflies (Yasui et al., 1985; Ishaaya et al., 1988; Ishaaya, 1990), planthoppers (Izawa et al., 1985; Nagata, 1986) and the citrus scales: *Unaspis yanonensis* (Kuwana) (Kanno et al., 1981), *A. aurantii* and *Saissetia oleae* (Olivier) (Yarom et al., 1988; Ishaaya et al., 1989). Buprofezin is harmless to aphelinid parasitoids (Garrido et al., 1984; Martin and Workman, 1986) and predacious mites (Anon., 1985) and may, therefore, be considered an important component in integrated pest management.

This study investigates the potency of the emulsion concentrate and wettable powder of buprofezin, applied alone or together with mineral oil in a citrus grove for control of A. *aurantii.*

*Contribution from the Agricultural Research Organization, The Volcani Center, Bet Dagan, Israel. No. 3146-E, 1990 Series.

MATERIALS AND METHODS

Chemicals

Two formulations of buprofezin, wettable powder (WP) 25% and emulsifiable concentrate (EC) 10% (Nihon Nohyaku Co., Ltd., Tokyo), were applied at various concentrations to control *A. aurantii* under field conditions. Addition of 0.5% light-medium-grade mineral oil (Tarsis, Tel Aviv) was used to evaluate possible synergism for the tested formulations.

Field trials

Field trials were carried out in a grapefruit orchard at Kibbutz Yif'at in the Yizre'el Valley. The grove was divided into 12 plots of 0.15 ha each. Each plot consisted of three rows of 15 trees sprayed until runoff with 1300 l/0.1 ha of each formulation, using a tractor-mounted boom sprayer (Rundell). The central row of each treatment was used for testing. The first treatment was applied during the early stage of crawler settlement on May 16 and the second on June 14. The layout of the experimental plots was as follows: (1) Control — no treatment. (2) Two treatments of 62.5 mg a.i./l buprofezin (WP); (3) As No. 2, but with 0.5% mineral oil; (4) One treatment of 125 mg a.i./l buprofezin (WP); (5) As No. 4, but with 0.5% mineral oil; (6) Two treatments of 62.5 mg a.i./l buprofezin (EC); (7) As No. 6, but with 0.5% mineral oil; (8) One treatment of 125 mg a.i./l buprofezin (EC); (9) As No. 8, but with 0.5% mineral oil; (10) One treatment of 0.5% mineral oil; (11) Two treatments of 0.5% mineral oil; (12) Control — no treatment.

TABLE 1
Effect of buprofezin WP 25% and EC 10% applied alone or together with 0.5% mineral oil, on twigs and leaves of grapefruit trees infested with *Aonidiella aurantii*

	Treatment			Mean number ± SE of scales (per 20-cm twig with 10 leaves) at various periods after first treatment*		
Plot no.	Buprofezin (mg a.i./l)	Mineral oil	Date of application	Prior to application	43 days	75 days
1 & 12	Controls	–	–	3.9 ± 0.5b	9.3 ± 1.9a	3.2 ± 0.4ab
2	62.5 WP (×2)	–	16.v, 13.vi	3.9 ± 0.6b	3.8 ± 0.5b	4.1 ± 0.4a
3	62.5 WP (×2)	+	16.v, 13.vi	4.3 ± 0.1b	0.2 ± 0.1d	0.4 ± 0.1d
4	125 WP	–	16.v	4.6 ± 0.9b	5.2 ± 0.5b	1.4 ± 0.4bc
5	125 WP	+	16.v	5.0 ± 1.0b	0.7 ± 0.2cd	0.5 ± 0.1d
6	62.5 EC (×2)	–	16.v, 13.vi	4.7 ±1.1b	1.9 ± 0.6c	1.0 ± 0.1c
7	62.5 EC (×2)	+	16.v, 13.vi	5.3 ± 1.0b	1.2 ± 0.3c	0.5 ± 0.2cd
8	125 EC	–	16.v	4.5 ± 1.0b	2.9 ± 0.4b	0.7 ± 0.3cd
9	125 EC	+	16.v	7.8 ± 3.4ab	0.5 ± 0.2cd	1.0 ± 0.3c
10	–	+	16.v	8.3 ± 0.8a	8.9 ± 1.2a	2.0 ± 0.3b
11	–	(×2)+	16.v, 13.vi	3.5 ± 0.8b	16.7 ± 6.6abc	2.2 ± 0.6b

*Means followed by the same letter within vertical rows are not significantly different at P = 0.05 (S.N.K. multiple range test).

Infestation rate of *A. aurantii* was expressed as scale density per 20 cm length of twig with 20 leaves at three periods: prior to treatment, and 43 and 75 days after the first application. Fruit infestation with *A. aurantii* was determined as 50 fruits of each treatment 75 days after the first application. Percentage parasitism of *A. aurantii* by *Comperiella bifasciata* Howard (Hym., Encyrtidae) and *Aphytis* spp. (Hym., Aphelinidae) was determined for each group of treatments: 1 and 12, no treatment; 2–5, buprofezin WP 25%; 6–9, buprofezin EC 10%; and 10–11, mineral oil. The percentage parasitism was calculated by the formula $P/(P+T) \cdot 100$, whereas P = number of parasitized scales and T = number of live scales (excluding 1st instar larvae). Statistical analysis was carried out by ANOVA.

RESULTS AND DISCUSSION

WP was considerably less potent than EC for controlling *A. aurantii* in all the counts carried out 43 and 75 days after the first application of buprofezin (Tables 1 and 2). Infestation rates on twigs and leaves 43 days after application showed that two sprays of 62.5 mg a.i./l of WP gave better results than one spray of 125 mg a.i./l (Table 1). Addition of 0.5% mineral oil increased considerably the potency of WP applied either once or twice. Addition of 0.5% mineral oil increased the potency of EC, but to a lesser extent than that of the WP (Table 1). Mineral oil may improve the performance of buprofezin on *A. aurantii* through contact and penetration into the insect body. The strong decline in infestation rate in the untreated plots observed 75 days after insecticide application in the treated plots (Table 1) resulted probably from the high activity of natural enemies.

The rate of infestation of fruits (Table 2) 75 days after the first buprofezin application resembled that of twigs and leaves (Table 1). Best results were observed when the EC was applied

TABLE 2
Effect of buprofezin WP 25% and EC 10%, applied alone or together with 0.5% mineral oil, on fruits infested with *Aonidiella aurantii*

Plot no.	Treatment: Buprofezin (mg a.i./l)	Treatment: Mineral oil	Treatment: Date	Mean number ± SE of scales/fruit, 75 days after first treatment*	% infested fruits: >2 scales	% infested fruits: >5 scales
1 & 12	Controls	–	–	6.5 ± 1.0b*	62	35
2	62.5 WP (×2)	–	16.v, 13.vi	12.0 ± 1.8a	92	60
3	62.5 WP (×2)	+	16.v, 13.vi	2.1 ± 0.3d	28	10
4	125 WP	–	16.v	5.5 ± 1.0bc	68	32
5	125 WP	+	16.v	2.2 ± 0.4d	32	8
6	62.5 EC (×2)	–	16.v, 13.vi	2.3 ± 0.3d	38	10
7	62.5 EC (×2)	+	16.v, 13.vi	0.6 ± 0.1d	4	0
8	125 EC	–	16.v	1.6 ± 0.2d	24	2
9	125 EC	+	16.v	1.0 ± 0.1d	12	2
10	–	+	16.v	5.4 ± 1.3bc	54	26
11	–	(×2)+	16.v, 13.vi	3.3 ± 0.6cd	46	20

*Means followed by the same letter do not differ significantly (P = 0.05, two-way ANOVA, SAS Institute 1982).

together with 0.5% mineral oil. In this case the percentage of sampled fruits infested with >5 scales was 2% and 0% after one and two applications, respectively (Table 2). When the results of the treatments were arranged into four groups, the mean rate of parasitism by *C. bifasciata* and *Aphytis* spp. increased significantly from 2.0–3.2% one day before the first application to 14.6–19.2% 75 days later, with no significant differences among buprofezin formulations, mineral oil, and controls (Table 3). Thus, our results indicate a high activity of hymenopterous parasites in citrus groves even in the presence of buprofezin.

The conclusions of our study are as follows:

1. WP applied as a single spray of 125 mg a.i./l or as two sprays of 62.5 mg a.i./l each gave insufficient control of *A. aurantii*.

2. Addition of 0.5% mineral oil increased considerably the potency of WP.

3. EC was more potent than WP and gave good control of *A. aurantii*. Addition of 0.5% mineral oil further increased the performance of EC.

4. According to the infestation rate of fruits, best results were obtained with two sprays of EC of 62.5 mg a.i./l each with addition of 0.5% mineral oil.

5. Buprofezin showed no harmful effect on the parasitoid populations attacking *A. aurantii*.

6. Light medium-grade mineral oil applied alone at the rate of 0.5%, had no appreciable effect on *A. aurantii*.

TABLE 3
Effect of buprofezin WP 25%, EC 10%, and of mineral oil on percentage of parasitism by *Compriella bifasciata* and *Aphytis* spp. of *Aonidiella aurantii* on twigs and leaves

Treatment group	Prior to application	75 days after first application
Buprofezin (WP)	3.2*	19.2
Buprofezin (EC)	2.3	12.8
Mineral oil (alone)	2.0	14.6
No treatment	2.1	14.7

*Means within vertical rows are not significantly different; means within each line differ significantly (P = 0.05, two-way ANOVA, SAS Institute 1982).

ACKNOWLEDGEMENTS

The authors wish to thank Z. Mendelson, S. Goldenberg and S. Tam, The Volcani Center, ARO, for technical assistance, and the Nihon Nohyaku Company, Tokyo, Japan and the Citrus Marketing Board of Israel for financial support and encouragement.

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