Israel Journal of Entomology

Vol. XXIX (1995) pp. 271-276

THINNING POPULATIONS OF THE FLORIDA WAX SCALE, *CEROPLASTES FLORIDENSIS* COMSTOCK (COCCIDAE), BY USE OF POTASSIUM NITRATE AND SPRAY OIL, AS AN OPTION IN IPM OF CITRUS GROVES IN ISRAEL

AHARON YARDENI[1] AND ELYAKIM SHAPIRA[2]

[1]*Extension Service, Ministry of Agriculture, Rehovot 76120, Israel*

[2]*Moshav Yesodot 76810, Israel*

ABSTRACT

The Florida wax scale (FWS), *Ceroplastes floridensis* Comstock (Homoptera: Coccidae), is a major pest of citrus groves in Israel and is usually controlled by non-selective insecticides. The pest has an advantage over its natural enemies in the build-up of its population in a "clean" grove, following pesticidal control, due to the ability of its wind-dispersed crawlers to invade the grove and the tremendous rate of increase of its population. Thinning the invading generation of FWS larvae at low population densities by a combination of a nutritional spray of 4% potassium nitrate with 2% spray oil, once a year, obviated the necessity to control the pest by any other means during 7 years, in a citrus grove at Yesodot (southern coastal plain, Israel) maintained under Integrated Pest Management (IPM). Thinning the population of a pest might be an additional option in IPM.

KEY WORDS: Coccidae, *Ceroplastes floridensis*, Florida wax scale, citrus, thinning, population, potassium nitrate, nutritional spray, selective insecticide, Israel.

INTRODUCTION

The Florida wax scale (FWS), *Ceroplastes floridensis* Comstock (Homoptera: Coccidae), is a major pest of citrus in Israel, requiring recurrent control measures. Clean citrus groves often become heavily infested within a short period and may be rapidly reinfested subsequent to effective chemical control. This situation led to efforts to find a better solution for the control of FWS. Insect populations have a characteristic pattern of increase (the logistic curve) when invading an unoccupied area. Population growth is slow at first (establishment phase), then becomes rapid (logarithmic phase), and finally slows down as it reaches the 'carrying capacity' of the environment (Crombie, 1945; Odum, 1969; Varley, 1973). Agro-ecosystems are rather unstable environments (Chant, 1966; Smith and Reynolds, 1966), and pest outbreak is often regarded as a general consequence of reducing diversity through monoculture (Van Emden and Williams, 1974). FWS infestation of a citrus grove following pesticidal control with non-selective insecticides is often initiated by wind-dispersed crawlers invading the grove (Yardeni, 1987). This establishment phase of the FWS population build-up is followed by a tremendous rate of increase in the next generation. FWS is usually controlled with broad-spectrum pesticides in the second damaging generation. This initiates a vicious circle of infestation and control, since broad-spectrum pesticides decimate both the pest and its natural

enemies and thus enable an undisturbed invasion of the next establishment generation, which produces another damaging generation, and so on. In order to prevent this sequence of events, it was suggested to control the larvae of the establishment generation with a selective insecticide, for the following reasons. First, young larvae are more sensitive to control measures than older instars. Second, the population density of the invading generation is rather low. Cressman (1936), who examined the efficiency of spray oils in control of the armored scale insect *Pseudaonidia duplex* (Cockerell) at different population densities, concluded that oil is inversely density efficient: the lower the population density, the higher the percentage of control. Third, satisfactory natural control could be expected at low population density of FWS, since the number of attacks per parasite, as host density changes, i.e. the 'functional response' (Solomon, 1949), is inversely density dependent (Holling, 1959; Varley et al., 1973). Thus, the establishment phase of FWS may be considered a weak phase in the build-up of the pest population in the grove and may be utilized to develop a control strategy different from the use of broad-spectrum pesticides.

Following the results of a preliminary experiment (Yardeni, 1984) in which 80% control of FWS larvae was achieved by a nutritional spray of potassium nitrate, experiments were conducted at Hazor-Ashdod and at Yesodot.

MATERIALS AND METHODS

Experiment at Hazor-Ashdod. This field experiment was conducted in the Hazor-Ashdod grove (situated in the southern coastal plain of Israel) in the summer of 1985. In a 20-year-old grove of Valencia grafted on sour orange, with trees planted at 6×4 m intervals, a completely randomized experiment with 4 treatments, each of 4 replicates and an untreated control, was conducted. A plot contained 6 adjacent rows and samples were taken from 2 fixed trees in the middle rows of each plot. A sample contained 10 twigs from each sampled tree, and live and dead FWS scale insects were counted with a stereoscopic microscope by $\times 20$ magnification. Treatments consisted of (i) 4% potassium nitrate and 0.05% surfactant (Triton B-1956); (ii) 13 litre/ha of 40% EC methidathion; (iii) 3% medium spray oil; and (iv) untreated control. All treatments were sprayed with a speedet air blast sprayer in a volume of 3500 litre water/ha; only methidathion was also sprayed diluted with only 1000 litre/ha water. Pre-spray live FWS larvae were counted on 1 June 1985; treatments were sprayed on 3 June and the number of surviving live adult female scale insects of the first and second annual generations was counted on 17 August 1985 and 30 January 1986, respectively; mean numbers per twig were calculated.

Experiment at Yesodot. At Yesodot (coastal plain of Israel), the grove with an area of about 34 ha is divided into 19 plots, from each of which 30 twigs were sampled randomly from 10 trees per plot. In 1993 population density was evaluated as infestation rate, based on the number of live scale insects per twig, as follows: 1, no scale insects; 2, 1 to 10 scale insects; 3, over 10 scale insects per twig; a twig being a young shoot with 10 leaves. Samples of larvae were taken in June before the treatment, and surviving live adult female scales of the first and second annual generations were counted on 30 August and 7 December 1993, respectively. A spray with 4% potassium nitrate + 2% spray oil in 4000 litre water/ha was conducted once a year at the beginning of June, from 1988 to 1993.

RESULTS

The results of the experiment at Hazor-Ashdod are presented in Table 1. The values in the table are the mean number of live FWS larvae per twig before treatments (June 1985), whereas the mean number of surviving live adult female scale insects per twig of the first and second annual generations is presented for August 1985 and January 1986, respectively.

TABLE 1
Control of FWS by potassium nitrate in comparison with insecticides, Hazor-Ashdod grove, 1985–1986 (the spray was conducted on 3 June 1985)

	Mean number of live FWS per twig*		
	Larvae	Adult females	
Treatment	1.vi.85	17.viii.85	30.i.86
13 litre 40% EC methidathion in 1000 l water/ha	2.88 A	0 C	1.1 C
13 litre 40% EC methidathion in 3500 l water/ha	2.30 A	0.23 C	1.64 C
3% summer oil in 3500 l/ha	2.78 A	1.01 B	6.66 B
4% potassium nitrate + 0.05% surfactant in 3500 l/ha	2.32 A	1.26 B	4.99 B
Untreated control	3.45 A	2.53 A	11.83 A

*Square root transformed values of mean live FWS per twig.
Figures within a column followed by the same letter are not significantly different at P = 0.05.

Although methidathion treatments gave the best control, the FWS population was significantly reduced ('thinned') by the potassium nitrate and the spray oil treatments. These results agree with preliminary experiments (Yardeni, 1984), in which 80% of FWS larvae were controlled by the potassium nitrate treatment. In a subsequent experiment (Yardeni, 1990), it was found that better control of FWS larvae was achieved with a mixture of 4% potassium nitrate and 2% medium spray oil than by applying each separately. Since FWS has an advantage over its natural enemies in the build-up of its population in a "clean" grove following pesticidal control, an attempt was made at thinning the larvae of the invading generation of FWS at low population densities during the establishment phase. In the Yesodot grove, a nutritional spray of 4% potassium nitrate and 2% spray oil in a volume of 3500 litre/ha was given during 1988–1993 once a year in June, to control the invading spring generation. This procedure was used instead of the control with broad-spectrum pesticides at the economic threshold in the second generation, when population growth is in the logarithmic phase. In order to demonstrate the differences between the two control strategies it may be useful to see how FWS had been controlled in the years before the thinning began. Table 2 shows the control of FWS population during the years 1983–1986 by the usual recommended procedure that preceded the thinning strategy. It was necessary to control FWS yearly despite the use of broad-spectrum pesticides. This situation is characteristic of many citrus groves in the coastal plain of Israel.

At the beginning of 1987 it was decided to change the method of FWS control in the Yesodot grove from the use of broad-spectrum pesticides to thinning the population of spring generation

TABLE 2
FWS control at the Yesodot grove (1983–1986) prior to the application of the thinning strategy

Year	Date	Area controlled in ha	Pesticides
1983	July	7.0	chlorpyrifos + carbaryl
	August	6.5	chlorpyrifos + carbaryl
	October	8.5	medium oil
	November	2.0	methoate + carbaryl
1984	June	15.4	methidathion, ethion, carbaryl, carbosulfan
1985	June	20.0	chlorpyrifos + carbaryl
	September	10.0	chlorpyrifos + carbaryl
1986	June	30.0	chlorpyrifos + carbaryl

larvae by a nutritional spray of potassium nitrate and spray oil. Results in Table 3 show a reduction in the use of non-selective insecticides during subsequent years. During these years, the population density of FWS remained below the economic threshold and no other control measures for FWS were needed. A general reduction in the severity of other scale pests was noticed and almost no control measures against them were required in these years. In the same years, other groves in the surrounding area were treated yearly against FWS with broad-spectrum pesticides.

TABLE 3
Data on the thinning strategy of FWS (1987–1993) at the Yesodot citrus grove, Israel, by a nutritional spray of 4% potassium nitrate + 2% medium spray oil in 4000 litre water per ha

Year	Date	Area controlled in ha	Pesticide
1987	–	–	no control measures applied
1988	June	20.0	potassium nitrate + medium oil
	October	16.0	2% medium oil
1989	June	20.0	potassium nitrate + medium oil
	June	10.0	2% medium oil (full volume) (FWS + California red scale)
1990	June	26.0	potassium nitrate + medium oil
	June	4.0	chlorpyrifos + carbaryl (mealybug control)
1991	June	30.0	potassium nitrate + medium oil
	September	6.0	potassium nitrate + medium oil
1992	June	30.0	potassium nitrate + medium oil
1993	June	30.0	potassium nitrate + medium oil
	July	4.0	potassium nitrate + medium oil

An example of the thinning effect on the annual change of FWS population density in the summer of 1993 is presented in Table 4. Numbers in the table are the weighted means of the FWS infestation rate in each plot on three dates. It can be seen that the population density at the beginning of June was quite high and was reduced to an economically low level as expressed by the rate of infestation in December 1993.

TABLE 4
Weighted mean of FWS infestation rate, during the application of the thinning strategy at the Yesodot grove, Israel 1993

	Weighted means of FWS infestation rate		
Plot	6.vi.93	30.viii.93	7.xii.93
1	3.0	1.2	1.0
2	2.5	1.2	1.0
3	2.7	1.8	1.1
4	2.7	1.8	1.0
5	2.6	1.5	1.1
6	2.6	1.6	1.7
7	2.9	1.5	1.4
8	3.0	1.4	1.3
9	3.0	1.2	1.0
10	3.0	1.2	1.0
11	2.3	1.2	1.0
12	2.0	1.5	1.2
13	3.0	1.2	1.4
14	1.9	1.3	1.0
15	2.0	1.1	1.1
16	3.0	1.8	1.2
17	3.0	1.5	1.4
18	3.0	1.6	1.2
19	3.0	1.8	1.2
Average	2.69	1.44	1.17

DISCUSSION

One result of the thinning procedure is the reduction in the use of broad-spectrum pesticides, which is believed to enable the build-up of stable populations of natural enemies, reduce the build-up of resistance in pest populations, and, moreover, is welcomed by the market, which seeks products with low pesticide residues. A question arising from these results is, why does the thinning strategy work at all? How is it possible that a nutritional spray (combined with a small amount of spray oil), which in itself cannot be considered a pesticide and which controls no more than 80% of young FWS larvae, is able to solve a problem to which commercial insecticides supply only a partial answer? In the thinning procedure, control measures are aimed at a weak stage in the build-up of the FWS population, namely at the larvae of the establishment phase, which have rather low population densities. This causes a reduction in the tremendous

rate of increase of the next FWS generation, leaves natural enemies undisturbed to build up their populations, and allows them a longer time to act at low population densities of the pest. Indeed, surveys of natural enemies in groves maintained under this strategy confirm the presence of higher population densities of natural enemies than in groves controlled by the conventional way (Yardeni, 1990). Thus, thinning is quite different from control with broad-spectrum pesticides which aims to reduce the population density of the pest from the economic threshold to zero, destroys natural enemies at the same time, and thus causes a vicious circle of infestations and control. Thinning dampens the oscillation of pest populations densities in comparison with usual control measures, keeps the populations at moderate levels, and avoids the necessity to apply control measures only when the economic threshold has been reached. The thinning procedure has kept the Yesodot grove free of FWS damage during 7 years and was also applied in several other groves, with satisfying results. We, therefore, regard these results as an indication that this strategy may be considered an additional option in IPM in citrus groves. Moreover, a spray of 4% potassium nitrate + 2% medium oil is recommended by the Extension Service of the Ministry of Agriculture of Israel as a means of FWS control. This control measure is also recommended by the Citrus Marketing Board of Israel and the Extension Service for the production of 'Jaffa Environment Friendly' citrus fruit.

REFERENCES

Chant, D.A. 1966. Integrated control systems. In: Scientific Aspects of Pest Control (A Symposium). National Academy of Sciences, Washington, D.C. Publication 1402:193–218.

Cressman, A.W. 1936. The comparative insecticidal efficiency against the camphor scale of spray oils with different unsulphonatable residues. *Journal of Agricultural Research* 52:865–878.

Crombie, A.C. 1945. On competition between different species of graminivorous insects. *Proceedings of the Royal Society (B)* 132:362–395.

Holling, C.S. 1959. Some characteristics of simple types of predation and parasitism. *Canadian Entomologist* 91:385–398.

Odum, E.P. 1969. Fundamentals of Ecology. W.B. Saunders, Philadelphia. 546 pp.

Smith, R.F. and Reynolds, H.T. 1966. Principles definitions and scope of Integrated Pest Control. In: Proceedings of the FAO Symposium on Integrated Pest Control. Food and Agricultural Organization, Rome. 129 pp.

Solomon, M.E. 1949. The natural control of animal populations. *Journal of Animal Ecology* 18:1–35.

Van Emden, H.F. and Williams, G.F. 1974. Insect stability and diversity in agro-ecosystems. *Annual Review of Entomology* 19:455–476.

Varley, G.C., Gradwell, G.R. and Hassell, M.P. 1973. Insect Population Ecology. Blackwell Scientific Publication, Oxford. 212 pp.

Yardeni, A. 1984. The effect of foliar sprays with potassium nitrate or Nutricol, on the Florida wax scale, *Ceroplastes floridensis* Comstock. *Alon Hanotea* 39:698–701 (in Hebrew).

Yardeni, A. 1987. Evaluation of wind dispersed soft scale crawlers (Homoptera: Coccidae) in the infestation of a citrus grove in Israel. *Israel Journal of Entomology* 21:25–31.

Yardeni, A. 1990. Pattern of colonization and damage development caused by the Florida wax scale *Ceroplastes floridensis* Comstock, on citrus in Israel. Ph.D. Thesis, The Hebrew University of Jerusalem. 89 pp. (in Hebrew).