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**CENTRALIZED CONTROL METHODS AGAINST THE MEDITERRANEAN  
FRUIT FLY *C. capitata* (Trypetidae Dip.) IN CITRUS GROVES IN ISRAEL**

**(Based on annual reports 1958-1966 by I. Cohen & J. Cohen, the  
Citrus Marketing Board.)**

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**ABSTRACT**

The collective treatment of the citrus groves with bait sprays, applied both from the air and with land equipment, proved to be successful in keeping the fruit fly below economic levels. The bait was yeast hydrolysate, and the insecticide was malathion.

After the initial applications early in the season, the necessity and timing of further applications is indicated by trappings of the fly. The attractant used first was siglure then medlure and finally "trimedlure"; this last was used in an improved jar, a description of which is given.

The bait treatments were extended also into the summer, which helped to keep the fly from building up a dense population towards the end of the summer.

The annihilation of male flies was initiated in limited areas with the aim of reducing the number of bait applications.

The release of sterile *flies* in a limited area did not result, in a reduction in the fly population.

Endeavours to reduce the fly population in the northern parts of the country by combined measures are described.

A decade has passed since the bait method was adopted in Israel against the Mediterranean fruit fly on citrus, and about eight years since applications have been done collectively. The aim of this paper is to sum up the accomplishments and benefits obtained so far from this enterprise, and also to point out the difficulties of this method of control, and the Steps that were and should be taken to overcome them. A better evaluation will be obtained if we consider the situation as it existed prior to the adoption of the collective bait method in the control of the fly.

Cover sprays were introduced in the early fifties, primarily to protect the late Valencia fruit from the fly. (Prior to this, a high percentage of the fruit dropped before harvest.) They also reduced the hazards of repacking the fruit in the ports of consignment. The ill effects of this method became apparent about two years after it was introduced. The insecticides employed in the cover sprays were DDT, methoxychlor and dieldrin, which killed also the beneficial fauna in the citrus groves, and upset the natural balance. Outbreaks of the Egyptian black scale Chrysomphalus aonidum and the Florida wax scale Ceroplastes floridensis were particularly outstanding; outbreaks of Coccus hesperidum and Saissetia oleae were also common, but of a more local nature. The cost of controlling these pests was enormous.

To ensure that the fruit was free from live fruit fly maggots, it was put through treatment with ethylene dibromide (EDB). Fumigations of the citrus fruit with EDB was practised for some time. At the suggestion of J. Cohen, of the Citrus Marketing Board (CMB), Rivnay carried out tests of dipping the fruit in an emulsion containing 0.4% EDB. The successful results brought about a series of trials by the Citrus Marketing Board, with the aim of incorporating this treatment in the general practice of washing and packing the fruit in the packing houses. These trials resulted in the general adoption of EDB treatments in the packing houses.

The first trials by members of the Agricultural Experiment Station in Rehovot were based on the experience and recommendations of American entomologists in Hawaii (Steiner, 1952, 1955, etc.). After a series of trials in small plots, treatments on a large scale were undertaken by the agricultural division of the Citrus Market Board. In 1957/58, one thousand dunams \* were treated by the spot method, in which the bait material (100 ml per tree) was applied by means of a brush or a knapsack sprayer; this treatment proved to be a great success. As a result of this, organized collective applications were carried out in 1958/59, with entire citrus areas being treated from airplanes. The applications were at regular intervals, until the end of the fly "season". When the fruit from these groves was compared with that from groves that had not been treated, or from groves which had been treated only twice, it became evident that control applications must be done at regular intervals, thoroughly and to the end of the fly season.

\* 1 dunam = 1000 m<sup>2</sup>

The success of these localized treatments encouraged the CMB to extend this system of fly control to larger areas, and in 1959/60 178,000 dunams were treated. Some of the groves were treated four times, others five times, a few with ground equipment, but the great majority from the air. The results of this system were outstanding, and even better than localized treatments of the previous year. The bait control system as recommended by Steiner (1959, 1957b) was thus adopted as the standard system for treating citrus groves in Israel.

Table 1. shows the total area treated annually from 1959/60 to 1965/66. During these years several improvements were introduced, some difficulties were overcome, and some new problems arose.

Table 1. Summary of Seven Years of Bait Treatments against the Mediterranean Fruit Fly in Israel.

	Number of Dunams						
	1959/60	1960/61	1961/62	1962/63	1963/64	1964/65	1965/66
Month							
May-August	-	-	-	27,000	107,137	53,289	9,900
September	17,150	180,070	106,450	204,925	183,127	156,824	138,151
October	371,229	348,720	274,150	261,935	127,879	306,810	235,787
November	224,762	169,150	259,300	302,456	193,881	174,813	299,483
December	129,525	179,550	85,350	41,110	57,753	52,364	149,661
January	10,200	63,400	5,100	23,550	1,419	2,839	56,602
February	-	6,300	-	-	-	-	12,004
March	-	25,500	11,700	10,224	3,312	30,812	38,028
April	-	5,000	4,890	8,990	12,962	16,424	22,265
Total air application	752,866	977,690	746,940	880,890	687,470	794,175	961,881
Total ground application	103,134	97,980	270,793	356,000	236,226	252,596	305,000
Total dunams treated	856,000	1,075,670	1,017,633	1,236,890	923,696	1,046,771	1,226,881
Area of groves treated	178,300	206,000	250,000	300,000	330,000	360,000	400,000
Average number of applications applications per dunam	4.80	5.22	4.07	4.12	2.80	2.91	3.17
Cost of single application per dunam (L.)	0.906	0.768	0.770	1.039*	1.306	1.360	1.364
Total collective expenditure(L.)	775,536	826,115	783,577	1,285,128	1,206,150	1,434,449	1,727,682

\* The considerable increase, beginning in 1962/63, was due to devaluation of the Israel pound.

### The Bait.

The experiments began with a local brewers' yeast hydrolysate, containing 6% active ingredient of malathion W. P. The whole was diluted four times its volume before being sprayed on the tree. In the course of use, it became evident that the bait was not standardized and it was replaced by Staley's yeast hydrolysate S. I. B. 7. In 1964, this was replaced by a local product, Naziman, used at the rate of 200 cc per dunam, to which 100 cc malathion 50% E. C. was added. With the last two mentioned baits, it was possible to apply them at low volume, viz. 2 lit./dunam.

### The Insecticide.

The insecticide applied was malathion 25% W. P. In 1961, the same insecticide was used as an emulsifiable concentrate at the rate of 50% S. I. B. 7 and 50% malathion 50% E. C. This change enabled a reduction in the volume of spray. Malathion was chosen because it proved to be less toxic than other materials to warm-blooded animals.

### EDB Treatments.

As a result of the efficiency of the bait treatments in controlling the fly in the grove, the general practice in packing houses of dipping the fruit in a solution of ethylene dibromide became superfluous; this practice was reduced, but not abolished. It was felt that in case of a failure in the control of the fly in the grove for one reason or another, provisions should be maintained to enable dipping of the fruit in case of emergency. Furthermore, the quarantine authorities of some consumer countries conditioned purchase of our fruit on its treatment with EDB, regardless of the bait control. Thus, in 1960, only 905,000 cases were dipped in EDB in certain packing houses. After re-examining the procedure of dipping the fruit and the difficulties it involved, it was decided to return to fumigation with EDB rather than dipping. In the ports of Yafa and Haifa, and in some packing houses, fumigation cells were built and provided with facilities for quick diffusion of the gas. The fruit treated with EDB has not exceeded 10% of the total fruit exported.

### Prolongation of the Valencia Season.

Valencia fruit is subject to the spring attack of the fruit fly. It matures just when the fly is awakening from its winter quiescence, and is growing stronger as the temperature rises (Rivnay 1956). In the past, in order to escape damage, early picking was practised, but the subsequent cold storage of the fruit proved to be too expensive. In view of this, spring bait treatments were tried.

In 1962, three 10-dunam groves situated in different areas were treated, and in 1963 four 15-dunam groves were treated. In each, about 10-11 applications were carried out at 7-10 day intervals from April to June. The results showed that where the applications were made according to plan, no infestation occurred. The experimental fruit was shipped to England in June or July and was, according to reports received from there, "of fine texture, proper lustre, good taste, with no decay and no fruit fly maggots".

#### Phytotoxicity of Combined Treatments.

Workers from South Africa reported that bait of S. I. B. 7, when sprayed upon trees which had been treated with copper fungicides, caused injury to the fruit. To ascertain this, experiments were carried out in this direction in 1959. It was found that when copper preparations were applied over the bait spray, no injury was caused; but when the bait was mixed with the fungicide, slight scorching of the fruit occurred in the form of spots or stripes about one week after application.

#### Ground vs. Air Application of Spray Material.

Some citrus experts claimed that, as far as the maintenance of the biological balance is concerned, air applications are just as bad as cover sprays, and that the spot-treating system was the more advantageous. In view of this, an experiment sponsored by the CMB was carried out by entomologists at the Faculty of Agriculture to clarify this question. It was found that the mortality of the parasite Aphytis holoxanthus DeBach was about the same in ground-treated and air-treated groves (Avidov and Rosen, 1964).

#### Traps as Indicators.

Current practice in the citrus groves consists of two total applications at the beginning of the season; further applications and their timing depend upon the information obtained from fly traps. At the beginning of the collective treatments all the groves were treated at regular intervals. It soon became evident that the applications might be superfluous in some groves, and insufficient in others. Groves closer to summer fruit orchards, for instance, required more applications than others. In view of this, traps were set up in various groves as observation sites. However, it became clear that these sites, due to the vagabond nature of the fly, were insufficient, so traps were set in every grove or even in every section of each grove.

Special traps were developed. At first the trap constructed by Steiner (1957a) was adopted, but in the course of use, some improvements were made in it. The cover was abolished, the cage was made of two halves, the rim of one fitting into that of the other. In order to prevent them from sticking together, due to drops of "trimedlure", they were made of different substances. Instead of the hole in the body of the cage, in which the wire by which the cage was hung was inserted, an external "ear" was made with a hole for the wire, thus preventing excessive evaporation. Instead of the wick, a small 10-ml plastic bottle was introduced into the cage. The 2-3 ml of "trimedlure" which were dropped into it lasted six months - thus saving the labour of moistening the wick with "trimedlure" every 3 weeks. The bottle could be shoved in and out over two ridges when emptying the flies, thus increasing the efficiency by 25%. At first "siglure" was used as a bait for the males, then "medlure", and finally "trimedlure".

#### Summer Treatments.

Although the population of the fly at the end of the citrus season has been greatly reduced, the warm summer and the continual existence of host fruit enable it to build up the population anew. It was felt that, unless drastic measures were taken, the cost of citrus treatments would remain unjustifiably high.

According to Rivnay (1950b, 1953), the citrus groves are populated with Med. flies throughout the summer. In 1963, summer applications were initiated in the citrus groves. As seen from Table 1, summer applications began in 1963, since then the average number of applications in the citrus groves dropped from over four to less than three per dunam. (The cost per dunam was also reduced, when considering the devaluation of the Israel pound in 1962). The summer application also included treatments of built areas in which many summer fruits are grown on small holdings.

#### Sterile Male Technique.

In the Biological Control Laboratory of the CMB, facilities for mass rearing of the fly were developed. There, the sterile male technique was tested with the aim of eradicating the fly in certain limited areas. This work of rearing the flies, their sterilization, tagging and liberation, was conducted by D. Nadel.

In 1963, over three million irradiated individuals, tagged with Calco blue and/or P<sup>32</sup>, were released in the groves. The release was

first in the pupal stage and then as adults; the former method was soon abandoned as ants devoured the pupae before the flies could emerge.

In 1965, 90-100 million irradiated flies were released in experimental groves; no subsequent reduction in the fly population could be observed.

#### Male Annihilation.

In connection with the summer treatments, the elimination of the applications over inhabited areas, and their replacement by other methods was tried. The male annihilation system is now being tested with the hope of reducing the fruit fly population.

In 1964, 1400 trap-jars containing the male fly attractant "trimedlure" were hung in the town area of Rehovot. Every yard or house garden containing fruit trees was supplied with one or more trap-jars. During that summer 100,000 male flies were caught. The citrus fruit in the town area remained uninfested during the 1964/65 season. Furthermore, the citrus fruit in the groves around the town of Rehovot received one bait application less than other groves around which no male annihilation was practised.

Male trapping was resumed also during the summer of 1965. The infestation of summer fruit was investigated, but it became evident that this method was not successful with it, for summer fruit became totally infested. However, the success with citrus fruit stimulated the extension of this method to other areas on a larger scale. (If these further experiments will substantiate the results described above, the difficulties of spraying over inhabited areas will be overcome, and a reduction in the number of bait applications may be attained.)

#### Combined Treatments in Border Areas.

In upper Galilee, the part of the country bordering on Lebanon, Syria and Jordan, efforts are now being made in cooperation with the Fruit Growers' Association, to reduce the fly population to a minimum, by three combined methods:- 1) continuous applications of bait and cover sprays; 2) male annihilation; and 3) liberation of parasites. For the third method, *Dirhinus giffardi* Silv. is being reared in large numbers at Rehovot and is being released there, and *Syntomosphyrus indicus* has been reintroduced from Puerto Rico for the same purpose.

Whether a fly population can be eradicated as a result of these combined measures, and whether influx of flies from beyond the boundaries of the country can be prevented, remains to be seen.

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