COMPARATIVE OVICIDAL AND LARVICIDAL EFFECTS OF PESTICIDES ON *Ceratitis Capitata* Wied. IN CITRUS FRUITS

by

Sami I. Musa

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DIPPING CITRUS FRUITS AGAINST MEDITERRANEAN FLY

Musa

ABSTRACT

The present study is an attempt to introduce to the citrus industry in Lebanon a new and simple improvement of fruit fly control in connection with the dip-tank method of treatment of citrus. The effectiveness of seven pesticides against eggs and larvae of the fruit fly, Ceratitis capitata in the citrus fruits, was tested in the laboratory.

Fruits of the Mediterranean mandarin were exposed to laboratory bred fruit flies. The number of living larvae, after exposed fruits were dipped in different insecticidal solutions, was recorded and data were analyzed statistically. Results showed that there was significant difference among the insecticides as to their efficiency.

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INTRODUCTION

The Mediterranean fruit fly--Ceratitis capitata Wied. is one of the world's most destructive fruit pests. It belongs to the family Trypetidae of the order Diptera. In some countries this insect has made commercial fruit production difficult or impossible.

This insect is well established in all the countries bordering the Mediterranean Sea and on the islands of Cyprus, Malta and Sicily. In Central Europe, it is found in Germany, Austria, Hungary and Switzerland; in South America, in Argentina, Brazil and Uruguay; in Africa, in Eritrea, the Gold Coast, Kenya, Tangenika, Uganda, the Union of South Africa, and the Canary Islands; in Australia, it is found in the western section (C.I.E. 1951). It was observed for the first time in Belgium in 1952 (Van den Brande, 1953), in Costa Rica in March 1955 (Morales, 1955) and in Holland in 1955 (FAO, 1956). Only twice has this pest gained a foothold in continental United States--in 1929 and in 1956. The 1929 infestation, which involved 20 counties in Central Florida, was eradicated by late 1930 at a cost of seven and a half million dollars. The 1956 infestation, which was discovered in April in greater Miami, Flrorida, and nearby areas, was opposed by strict and immediate measures, and by the end of 1956 almost complete eradication was achieved (U.S.D.A. 1956).

The wide host spectrum and the wide distribution of C. capitata in the world makes it an insect of great importance in the field of plant protection and a threat to the economy of the large fruit-exporting countries.

The fly may attack any one of more than 200 fruits and vegetables but it does have a preference for a few. Citrus fruits, except lemons and sour limes, are among the preferred hosts (U.S.D.A. 1956).

Peaches and apricots are the most preferred hosts in all countries where C. capitata exists. The fruits of these two species are not only the most susceptible ones to the attack of the fly, but also help to increase the Ceratitis population considerably, even when, only a few trees are present. Plums are relatively resistant to fruit fly attack. There are many other plants that serve as hosts for this insect such as - apples, quinces, pomegranates, mangos, guavas, avocado, bananas, papaya, persimon, sour sap, dates, grapes, Oberia caffra (hedge plant), and Solanum coagulans (hedge plant). With regard to vegetables, infestation was reported on tomatoes, egg plants and green pepper in years of heavy infestation (Bodenheimer 1951).

The economic losses resulting from the attack of C. capitata can be very high especially in years where the climatic conditions are favourable for the rapid development of the fly. The exact amount of damage done by this pest each year over the world has never been determined. In Greece, up to half of the citrus crop has been lost to this insect in some years; damage to summer fruit is even greater. In Sardinia in 1950, at least 80% of the peach crops was lost, and apple, pear, and orange crops were seriously damaged. In some areas of Africa and South America the pest has made commercial fruit production difficult or impossible. In North America, in coastal and irrigated areas of high humidity, the insect is particularly damaging to peaches, pears, and apricots. In Brazil, oranges and other fruits,

as well as coffee and many other cultivated and wild plants are frequently attacked (U.S.D.A. 1956).

The population of the Mediterranean fruit fly in Lebanon is subject to considerable yearly fluctuation. This fluctuation is due to changes in climatic conditions and cultural practices. The degree of damage caused to citrus, peaches, apricots and other crops changes accordingly. In the last few years the citrus industry has suffered heavy losses from fruit attack. Hundreds of cases of fruit were disqualified for shipping,* and very large quantities decay in the groves. In addition, the oviposition scar can be often the point of entry for saprophytic fungi, mainly of the genus Pennicillium, that cause decay in otherwise sound fruits. Furthermore, the pest is a limiting factor in the case of establishing new orchards of late varieties, such as Valencia, which are fairly susceptible.

Ceratitis capitata. without question, is the most damaging insect pest to citrus fruits and most troublesome to market experts. The world consumer desires choice produce, free from injury. Importing countries insist, for their own protection, that fresh fruits be free from specific dangerous insect pests and plant diseases.

The Lebanese Fruit Board is facing much difficulties with some importing European and Arab countries, mainly because the control measures used in Lebanon against the Mediterranean fruit fly on citrus are not efficient. The inefficiency of these is due, amongst other things, to the lack of local scientific and technical data on the ecology and biology of this fly.

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*Oral communication by the chairman of the Lebanese Fruit Board.

The inadequacy of the control measures used necessitates the development of additional methods for destruction of eggs and larvae. The need of shipping the fruits to world markets in good condition free from fruit-fly larvae and secondary decay, in accordance with international standards, suggests dipping the fruits in an insecticidal solution.

The present study is an attempt to introduce to the Lebanese citrus industry a new method of fruit fly control, namely the dipping tank method. The comparative ovicidal and larvicidal effect of seven insecticides were evaluated on infested fruits of late-maturing Mediterranean mandarin. The dipping tank method to control larvae and eggs of this fly, in case positive results are obtained, would be a useful supplement to the field measures already practiced to ensure clean, healthy and sound fruits for export.

REVIEW OF LITERATURE

Different investigators have studied the susceptibility of citrus varieties to the attack of the Mediterranean fruit fly, and the causes of successful development of the maggots in the different varieties. The results of these investigations point out to chemical as well as to physical or anatomical causes in the different fruits.

The susceptibility of the different citrus fruits to the attack of this fly differs greatly. The degree of susceptibility is determined by (a) the absence of oil glands that secrete etheric oils which kill the eggs and young maggots, (b) variation in thickness and elasticity of the rind of different citrus varieties, (c) the amount of gum secretions in the rind that kills both eggs and maggots, (d) late maturing varieties are also more susceptible to attack than early-maturing ones. Sour orange and citron are immune to the attack due to their thick and rough rinds. The infestation of oranges and grapefruit depends on the variety, those with a thin rind when over ripe, are more susceptible. Sour oranges are as severely attacked as the sweet oranges but on account of the looseness of the rind and rag, their pulp becomes infested more easily. Clementines are among the first citrus fruits liable to be infested and the Mediterranean mandarin are only slightly infested (Bodenheimer 1951).

Hanna (1948) studied the possible factors that reduce the successful attack of the fruit-fly in citrus fruits. He classified them into:

1. Physical factors such as the thickness of the rind, and the mechanical resistance of the rind to the puncture of the ovipositor.

2. Chemical factors such as a) presence of essential oils, b) presence of glucosides, and c) presence of pectins. His studies showed no correlation between the physical factors and chemical factors and the percentage of attack, except for the presence of pectins, that reduced or prevented successful infestation by this fly. He concluded that the main factors limiting the infestation of Citrus fruits are (i) the percentage of the total pectins in the fresh peel, (ii) the percentage of the water content of the peel, (iii) the saturation deficiency of the air, (iv) the incubation period of the eggs.

Delanoue (1962) in addition to the factors mentioned above, found out that the secretion of gum of mucilaginous nature by the cells of the rind, especially in immature fruits would increase the mortality of the eggs. The solidification of the egg-laying cavity after being exposed to air reduces the hatchability of the eggs and stops the larvae from further penetration. He further states that the nutritional factors are as important in promoting growth and development of the small larvae in the fruit. When the fruits become physiologically mature they produce indispensable materials, particularly yeasts for the evolution of the maggots.

The use of toxic chemicals to kill eggs and larvae of the fruit flies inside the fruits has been on the plant protection stage only for about ten years. Ethylene dibromide was the first successful fumigant used for this purpose. Balock (1951) reported ethylene

dibromide to be very effective for destroying fruit fly infestations in fruits and vegetables. In the course of screening various materials as fumigants on naked eggs and larvae of the oriental fruit fly, it was found that ethylene dibromide was the most toxic of 53 compounds tested. The LD 95 at 70°F were 0.43 mg/liter for eggs and 0.95 mg/liter for third instar larvae. In large scale tests ethylene dibromide was used successfully as fumigant to destroy the immature stages of the oriental fruit fly in papaya and guava and the melon fly in cucumbers and tomatoes.

Lindgren and Sinclair (1953) summed up the results obtained with ethylene dibromide and ethylene chlorobromide. The work of these authors showed that ethylene dibromide was very active in destroying eggs and larvae of the oriental fruit fly; indeed it was shown to be more effective than any other fumigant tested by them. A concentration of 0.5 lb. per 1,000 cu. ft. at 70°F and exposure of 2 1/2 hours was found to give satisfactory control. No fruit injury or change in aroma, and no off-flavor of the fruit was noticed. The possibility of storage was not significantly affected. The bromine absorption and retention in the peel and pulp of the fruit were examined and the concentration was found to be so low that the fumigated fruit was considered safe for human consumption.

Grunberg, et al. (1956) performed experiments on citrus fruit by fumigation with ethylene dibromide for the control of the Mediterranean fruit fly larvae inside citrus fruits during the 1951-52 and 1952-53 seasons. A 75% kill of the larvae of Ceratitis inside the

citrus fruits was obtained by exposure of 2 1/2 hours at a concentration of 15 gm/m^3. Fumigation of fruit for export, in batches of 3,000 cases at one time, showed that 6 gm/m^3 for ethylene dibromide killed up to 98.5% of Ceratitis larvae, provided no gas leakage occured in fumigation chamber. This concentration did not cause injury to Jaffa and Valencia oranges.

Research in California, confirmed that ethylene dibromide used in the washing tank to control the eggs and larvae of the Mediterranean fruit fly is a great saving in time and labor over the fumigation method, but somewhat more EDB is used in this tank method. (anonymous, 1959).

Hubert (1960) stated that one of the latest and very promising methods of treatment which has been investigated intensively in Mexico, Hawaii and Israel is a tank-dip using ethylene dibromide (EDB) with a light oil and an emulsifier so that it will readily mix in a washing tank.

Cohen and Nadel (1958) published their instructions for using EDB tank-dip method to control the eggs and larvae of the Mediterranean fruit fly in the citrus fruit. For proper results, they say the EDB concentration in the tank should remain between the limits of 1.5-2.0 grams per liter, with the fruit three minutes in the tank. In order of decreasing sensitivity to EDB, and this may vary from season to season, the following was established: grapefruit; shamouti; valencia; lemons.

The degree of sensitivity to ethylene dibromide of the following fruits, however, is unknown; Washington Navel, Blood Oranges, Tangerines. In general the treatment is very delicate, needs high technicality, cooperation and complicated equipment.

Burditt, et al. (1963) reported that when infested papayas were submerged for 20 minutes in a solution containing 108 or 120 mg. of EDB per liter of water at temperatures of 115° or 110°F., respectively, the mortality of fruit flies exceeded 99.9968%. The added EDB was lost rapidly from the dip mixture during use. Under average conditions at 110°F. only 79.9% of the applied amount could be recovered by chemical analysis immediately after preparation of the dip, and only 73.4% after 20 minutes. Comparable figures for recovery of EDB from mixtures at 115°F. were 82.2% and 69.2% and at 120°F. they were 83.2 and 73.2% respectively. Because of this rapid loss, some booster dosages of 15 ml. and 3.9 ml. every 20 minutes maintained concentrations at required levels in the conveyer belt and commercial tanks, respectively. The loss rates may vary considerably with design of tank, circulation of the dip, air temperature, and method of dipping fruit.

The advantages in using EDB outweight the disadvantages. Hubert (1960) says "as it is a toxic chemical, due care must be exercised in its use." Polacek (1958) added that the leaf hopper injury to the fruit becomes more apparent after ethylene dibromide fumigation.

Myburgh (1961) reported that observations made on individual trees sprayed with 0.05% Lebaycid(R) in home gardens showed that this insecticide killed larvae of Ceratitis capitata and Pterandrus rosa inside such fruit within one week. Newly hatched larvae were killed by residual toxicity of Lebaycid(R) within the fruit for four weeks after spraying.

MATERIALS AND METHODS

A. Rearing Ceratitis capitata for laboratory infestation of citrus.

A fortified fresh carrot medium developed by the University of California Agricultural Experiment Station (Finney 1953) has been used by the U.S.D.A. Fruit Fly Laboratory in Honolulu, for rearing nearly 50 million experimental flies.

In experiments conducted by Christenson, Maeda and Holloway (1956) at the Entomology Research Branch of the Agricultural Research Service, U.S.D.A., dehydrated milled carrot was substituted for the fresh carrots used to prepare the fruit rearing medium.

Rearing and breeding the Ceratitis fly, in the laboratory at the Faculty of Agricultural Sciences, American University of Beirut was practiced very successfully. The temperature was around 22°-26°C and the relative humidity ranged between 70-75%. The procedure which was used, is a modified process of Finney's, which for the time being is applied in Antibes, France, by Delanoue and co-workers, and was observed and studied by the advisor of the writer in the summer of the year 1961.

The parent stock, about 18,000 pupae were received from France and Germany. About 300 pupae were placed in each of 24 Zwolfer humidity chambers over a saturated solution of NaCl to provide about 75% R.H. in the chambers. The chambers were then placed in an incubator at a temperature of 28°C. After about five days, adults started to appear. Immediately afterwards, the humidity chambers were removed

from the incubators, and the flies from any three chambers were placed in a 40 x 30 x 30 cms. wooden cage. Two sides and the top of the cage were made of transparent plastic sheet and the other two sides of nylon cloth for aeration. Light was provided by means of two 20 W fluorescent desk lamps placed 20 cms. over the cages. Every morning and late afternoon, a light mist of water was sprayed into the cages containing the adults destined for egg laying. The flies in the cages were given the following food mixture:

banana	400 gr.
beer yeast	10 gr.
benzoic acid 0.2%	60 gr.
honey	30 gr.

The food mixture was spread evenly over a frame of nylon cloth (15 x 5 cm.), hung in the top of the cage. A vial full of water, plugged by a piece of absorbant cotton provided drinking water for the flies.

Four days, after emergence, a small hemispherical box with fine holes was provided per cage for egg laying. The inside of the box was smeared with an egg-laying mixture composed of:

beer yeast	40 gr.
benzoic acid 0.2%	400 cc.
carrot powder	200 gr.
HCl 1N	16 cc.

A sponge imbided with water was placed inside the cover of each laying box to provide the necessary humidity. One egg-laying box was hung, in each of the eight cages and left for a period of one day for

the collection of eggs. The egg-laying mixture from each two boxes, was removed together with the eggs by a small spatula and spread carefully and evenly over the rearing medium for the maggots. The maggot rearing medium was composed as follows:

beer yeast	20 gr.
benzoic acid 0.2%	400 cc.
carrot powder	100 gr.
HCl 1N	10 cc.

From this medium, a layer one centimeter thick was spread on the bottom of a rectangular box (25 x 10 x 10 cms.) and was kept at room temperature. The eggs hatched on the third day. Six days after the transfer of eggs into these rectangular boxes, the rearing medium was watered with 75 cc. of the following nutritive solution:

beer yeast	70 gr.
benzoic acid 0.2%	500 cc.
HCl 1N	20 cc.
sugar	150 gr.

and covered by about 20 gr. of thoroughly washed and dried bran, without mixing. The following day, another 275 cc. of the same nutritive solution and 45 grs. of bran were added to the contents of the box and mixed thoroughly to aerate the medium and to render it homogenous. Following this, the contents of the box were divided into three shallow-bottomed cups, which were placed in a cardboard box, whose bottom was covered with three centimeters of sand. By that time the larvae have had attained full growth. The full grown larvae jumped from the cups

to the sand where they pupated. The sand was later sieved, and the pupae were collected for further breeding of Ceratitis. Only two cages out of eight, were used for continuing the breeding, and the remaining six cages were used for fruit infestation as described later.

B. Dipping Technique

Fruits of the Mediterranean mandarin were obtained from an orchard in Damour, Southern Lebanon. The orchard was sprayed with a heavy grade white oil in October, that is, 5 months before the fruits were used in the laboratory. All fruits used were thoroughly checked for freedom from fruit-fly infestation before they were exposed to the fruit flies for oviposition.

Whenever the flies started laying eggs heavily in the egg-laying boxes, ten of these fruits were placed in each cage containing approximately one thousand two hundred flies. The fruits were exposed to the flies for 16 hours, to ensure adequate egg-laying. They were then collected from the cages and allocated at random to the different treatments. There were six treatments and the control, each replicated eight times. Every treatment consisted of three concentrations of the chemical to test the ovicidal effect. The same concentrations were repeated for their larvicidal effect.

Fruits destined for ovicidal tests, were directly dipped in the solutions with the appropriate concentrations as mentioned below. The fruits were kept in the solution for a period of three minutes. Then they were placed on a tray exposed to an air current generated

by two fans for one hour. Afterwards, the fruits were placed on trays in conventional rearing cages (80 x 45 x 45 cms. with very fine wire mesh sides) to permit any surviving eggs or larvae to complete their development. Ten days later, each fruit was opened, the larvae when found were counted, their numbers recorded, and the data were analyzed by the analysis of variance method.

Fruits destined for larvicidal tests, were dipped in the insecticidal solutions with the appropriate concentrations, four days after exposure to the flies, just to allow eggs to hatch. Then the same procedure mentioned above was followed, that is ten days after exposure, the surviving larvae were counted. Their numbers were recorded and the data analyzed.

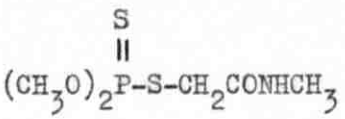
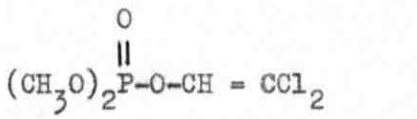
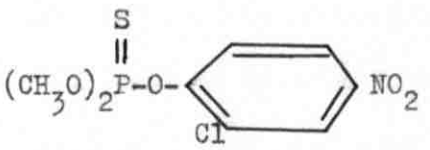
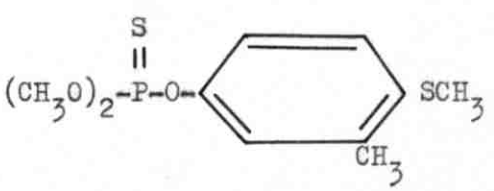
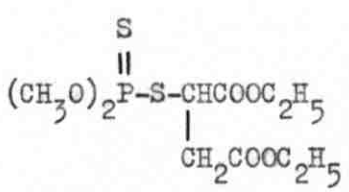
The untreated check fruits were dipped in water and afterwards received the same treatment as the chemically treated fruits. Observations on "control" were made twice in each experiment and were recorded in the table of observations.

This work was carried out during March, April and May of the year 1964.

C. Insecticides Used

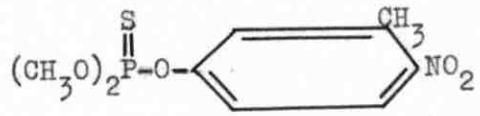
The effectiveness of seven insecticides against eggs and larvae of C. capitata inside the citrus fruits was tested in the laboratory, by counting the number of larvae living after exposed fruits were dipped.

The insecticides used in these tests were the following:

Material	Composition
Cygon 2-E	 O,O-Dimethyl S-(N-methylcarbamoylmethyl) phosphorodithioate.
DDVP	 O-2,2-Dichlorovinyl O,O-dimethyl phosphate
Dicapthon	 O-(2-chloro-4-nitro-phenyl) O,O-dimethyl phosphorothioate
Ethylene dibromide	$BrCH_2CH_2Br$ 1, 2-Dibromoethane
Lebaycid	 O,O-dimethyl l(4-(methylthio)-m-tolyl) phosphorothioate.
Malathion[1] + DDVP + Chlorowax[1]	 O,O-dimethyl phosphorodithioate of diethyl mercapto succinate.(malathion)

[1]This pesticide contains 25% Malathion + 3% DDVP + Chlorowax.

47300



0,0-dimethyl O-(3-methyl-4-nitrophenyl) phosphorothioate.

Each insecticide was tested at three different concentrations. The concentrations were termed "low", "medium" and "high"; containing, 0.25%, 0.50% and 1% of actual ingredient respectively, for Cygon-2E, Dicapthon, Malathion + DDVP + Chlorowax and 47300. The following percentages by weight, 0.0125, 0.0250% and 0.05% formed the analogous concentrations of Lebaycid. Only two concentrations of DDVP were used, 0.1% and 0.2% by weight. The concentrations were prepared by diluting the insecticide in tap water, and were calculated on the basis of percentage by weight.

Material	Concentration % (actual)
Cygon 2-E (Dimethoate)	1
	0.50
	0.25
DDVP	0.2
	0.1
Dicapthon	1
	0.50
	0.25
EDB	0.4

Material	Concentration % (actual)
Lebaycid	0.05
	0.025
	0.0125
Malathion + DDVP + Chlorowax	1
	0.50
	0.25
47300	1
	0.50
	0.25

Ethylene dibromide was tried only at one concentration, namely 0.4% (actual). This is the standard concentration used in the countries where EDB constitutes the dip-tank method for the control of eggs and larvae of C. capitata on a commercial scale. Our main purpose in using EDB in these trials, was to compare its effect with that of the other insecticides.

RESULTS AND DISCUSSION

Tables 1-6 show the data obtained on dipped infested fruits in the different insecticidal concentrations to control eggs and maggots of C. capitata. The data were recorded and analyzed by the analysis of variance method. The analysis of variance test, being intended to detect differences in effect among the insecticides, does not use the "control" observations. In any case, the number of living larvae in the "control" was much higher than in the treated batches, as seen in the different tables.

At any concentration, whether in ovicidal trials or larvicidal trials, it is sometimes apparent that fluctuation in the observations within one single treatment existed. This fluctuation of observations within a treatment is in the nature of the experiment. The initial number of eggs and larvae in each replication varies from one replication to the other, within the same treatment. When the fruits were exposed to the flies, it is beyond control to make an equal number of flies lay their eggs in each fruit. Moreover, it is impossible, to make each fly deposit the same number of eggs in each exposed fruit. Usually the fly lays its eggs in batches and with a different number of eggs in each batch. Nevertheless this variation was reduced as much as possible, by increasing the number of replications and by using the randomized block design.

The variation in the number of living larvae within the replication of each treatment is more observed at the "low" and "medium" concentrations. In Table 1, the population in each observation for DDVP treatment varied from 28 - 41, for Lebaycid from 12 - 22, for Malathion + DDVP + Chlorowax from 28 - 40. In Table 4, the population in the observations of DDVP treatment also varied from 61 - 85, for 47300 from 35 - 57. But such fluctuations in observations within treatments become very reduced at the "medium" and "high" concentrations. One may conclude that as long as the concentration of the insecticide is below the lethal dose, the variation is to be expected since the number of eggs deposited varies from one fruit to another. Once the concentration is close to the lethal dose, the variation is liable to be reduced to a minimum. This was the case in most of the observations at the "medium" and "high" concentrations. In Table 1, the number of living larvae in each replication for each of Lebaycid and 47300 varied from 12 - 22 and 48 - 63 respectively. In Table 2, when the concentrations of each of these two insecticides were increased from 0.0125% to 0.0250% in case of Lebaycid and from 0.25% to 0.50% in case of 47300, the number of living larvae was reduced to zero in both treatments. In Tables 4 and 5, Dicapthon and 47300 showed the same reduction. While as in the other treatments the number of living larvae was reduced in proportion to the increase in concentration until it reached zero for the comparatively "high" concentration.

Table 1. Ovicidal Effect of the Insecticides at Comparatively "Low" Concentration

Insecticides	Percent Concentration by wt.	Number of living larvae in each replication								
		1	2	3	4	5	6	7	8	Mean+
Cygon 2-E	0.25	0	0	0	0	0	0	0	0	0
DDVP	0.1	41	35	32	28	33	40	35	38	35.25
Dicapthon	0.25	30	28	35	30	28	34	30	30	30.62
Lebaycid	0.0125	18	15	22	12	14	14	14	14	15.87
Malthion + DDVP + Chlorowax	0.25	35	28	41	38	28	40	36	32	34.75
47300	0.25	56	60	63	48	50	55	49	53	54.25
Control		116					112			114

+ L.S.D. at P = 0.05 = 3.35

Table 2. Ovicidal Effect of Insecticides at Comparatively "Medium" Concentration

Insecticides	Percent concentration by wt.	Number of living larvae in each replication								
		1	2	3	4	5	6	7	8	Mean+
Cygon 2-E	0.50	0	0	0	0	0	0	0	0	0
Dicapthon	0.50	25	19	10	18	20	18	24	17	18.87
Lebaycid	0.025	0	0	0	0	0	0	0	0	0
Malathion + DDVP + Chlorowax	0.50	9	6	5	7	9	10	11	6	7.87
47300	0.50	0	0	0	0	0	0	0	0	0
Control		103					115		109	

+ L.S.D. at P = 0.05 = 2.15

Table 3. Ovicidal Effect of the Insecticides at Comparatively "High" Concentration

Insecticides	Percent concentration by wt.	Number of living larvae in each replication								
		1	2	3	4	5	6	7	8	Mean+
Cygon 2-E	1	0	0	0	0	0	0	0	0	0
DDVP	0.2	22	13	10	18	15	15	21	14	16.25
Dicapthon	1	0	6	0	4	0	0	0	0	1.25
Lebaycid	0.05	0	0	2	0	0	0	0	0	0.25
Malathion + DDVP + Chlorowax	1	0	0	0	0	0	0	0	0	0
47300	1	0	0	0	0	0	0	0	0	0
Control		126				118			122	

+ L.S.D. at P = 0.05 = 1.48

Table 4. Larvicidal Effect of the Insecticides at Comparatively "Low" Concentration

Insecticides	Percent concentration by wt.	Number of living larvae in each replication								
		1	2	3	4	5	6	7	8	Mean+
Cygon 2-E	0.25	0	0	0	0	0	0	0	0	0
DDVP	0.1	85	68	61	78	78	67	70	81	73.50
Dicapton	0.25	8	9	11	14	10	14	9	8	10.37
Lebaycid	0.0125	11	12	16	10	10	11	7	8	10.62
Malathion + DDVP + Chlorowax	0.25	15	10	10	13	8	10	12	13	11.37
47300	0.25	40	32	35	41	57	50	48	53	44.50
Control				132				126		129

+ L.S.D. at P = 0.05 = 5.14

Table 5. Larvicidal Effect of Insecticides at Comparatively "Medium" Concentration

Insecticides	Percent concentration by wt.	Number of living larvae in each replication								
		1	2	3	4	5	6	7	8	Mean+
Cygon 2-E	0.50	0	0	0	0	0	0	0	0	0
Dicapthon	0.50	0	9	0	0	0	0	0	0	1.12
Lebaycid	0.025	0	27	12	13	12	20	21	24	16.12
Malathion + DDVP + Chlorowax	0.50	8	4	3	0	2	4	6	3	3.75
47300	0.50	16	0	0	0	0	0	0	0	2
Control				96				104		100

+ L.S.D. at P = 0.05 = 5.28

Table 6. Larvicidal Effect of the Insecticides at the Comparatively "High" Concentration

Insecticides	Percent concentration by wt.	Number of living larvae in each replication								
		1	2	3	4	5	6	7	8	Mean+
Cygon 2-E	1	0	0	0	0	0	0	0	0	0
DDVP	0.2	32	31	25	28	26	31	24	30	28.37
Dicapthon	1	0	0	0	0	0	0	0	0	0
Lebaycid	0.05	0	2	3	0	0	0	0	0	0.625
Malathion + DDVP + Chlorowax	1	0	0	0	0	0	0	0	0	0
47300	1	0	0	0	0	0	0	0	0	0
Control				127				124		126

+L.S.D. at P = 0.05 = 1.27

Table 7. Effect of Ethylene Dibromide on the Eggs and Larvae of C. capitata

Stage	Acute oral LD50 to rats mg/kg	Percent concentration by wt.	Number of living larvae in each replication								
			1	2	3	4	5	6	7	8	Control
Eggs	117-146	0.4	0	0	0	0	0	0	0	0	103
Larvae			0	0	0	0	0	0	0	0	111

Table 8. Comparative Toxicity of the Insecticides Used

Insecticide	Cygon 2-E	DDVP	Dicapthon	Lebaycid	Malathion	47300	EDB
Acute oral LD50 to rats mg/kg	245	56-80	500(in oil)	230-250	4000	870	117-146

The variation in the means of treatments was found to be significant at the 5% level of significance, as was concluded from the analysis of variance. The significant difference is probably due to the differential potency and the differential power of penetration of each insecticide into the fruit. Naturally, both of these characteristics for every insecticide differ from those of the other according to their chemical composition.

Figures 1 and 2, derived from the tables of analysis of variance show the different categories of treatment means; those compounds with the smallest means being the most efficient. As the concentration increases, the means of treatments group themselves in lesser categories. In other words, there would be no significant difference among the different insecticides. At the "high" concentration, in either the ovicidal or the larvicidal trials, all insecticides fell into two categories, DDVP was in one, and the other five constituted the second. This may be due to the fact that at "high" concentration, the insecticides that grouped themselves in one category, were fully lethal to the population.

The insecticide Cygon 2-E, in all of the three concentrations used, was the only insecticide that reduced the population to 0%; both in the ovicidal and larvicidal trials. The high effectiveness of this insecticide may be due to its known systemic action.

DDVP, on the other hand, was the least effective. It is a volatile insecticide, and since dipping was done in an open container, possibly part of it was lost during the preparation of the solution.

Figure 1. Categories of Treatment Means for Ovicidal Trials at "Low", "Medium" and "High" Concentrations Respectively, at the 5% Level of Significance[+]

"Low" L.S.D. 3.35

Cygon 2-E	Lebaycid	Dicapthon	Malathion+DDVP + Chlorowax	DDVP	47300
0	15.87	30.62	34.75	35.25	54.25

"Medium" L.S.D. 2.15

Cygon 2-E	Lebaycid	47300	Malathion+DDVP + Chlorowax	Dicapthon
0	0	0	7.87	18.87

"High" L.S.D. 1.48

Cygon 2-E	Malathion+DDVP + Chlorowax	47300	Lebaycid	Dicapthon	DDVP
0	0	0	0.25	1.25	16.25

[+]The treatments joined by the same line do not differ significantly from each other.

Figure 2. Categories of Treatment Means for Larvicidal Trials at "Low", "Medium" and"High" Concentrations Respectively, at the 5% Level of Significance[+]

"Low" L.S.D. 5.14

Cygon 2-E	Dicapthon	Lebaycid	Malathion+DDVP + Chlorowax	47300	DDVP
0	10.37	10.63	11.37	44.50	73.50

"Medium" L.S.D. 5.28

Cygon 2-E	Dicapthon	47300	Malathion+DDVP + Chlorowax	Lebaycid
0	1.12	2	3.75	16.12

"High" L.S.D. 1.27

Cygon 2-E	Dicapthon	47300	Malathion+DDVP + Chlorowax	Lebaycid	DDVP
0	0	0	0	0.625	28.37

+ The treatments joined by the same line do not differ significantly from each other.

Another possible reason that reduced the efficiency of DDVP, was the pH of dilution water, that was 7.4. Alkalinity enhances the dissociation of DDVP[+].

In Figure 2, Lebaycid at the "low" concentration ranked in the second category with a mean of 10.62, while as at the "medium" concentration also it ranked in the second category but with a mean of 16.12. However, at the "high" concentration its effectiveness was increased. A possible reason for this fluctuation in means or in efficiency of Lebaycid, may be either due to experimental error or some of the fruits that were used in the replications were already imperceptibly infested by the fly in the field, without being discovered.

Dicapthon and Lebaycid caused slight burning when used at the "high" concentration. The burning was most conspicuous at the calyx of the fruits and at the stung area. No serious burning was observed on fruits treated with other insecticides.

Table 7, shows that ethylene dibromide at 0.4% by weight reduced the population of both of the eggs and living larvae to zero. This agrees with the results of the research already done on controlling the eggs and larvae of C. capitata by ethylene dibromide tank-dip method. Most of the insecticides, in this work, at the "high" concentration gave similar results to ethylene dibromide, except Cygon - 2E gave complete control at the three concentrations.

[+]As communicated to us by Pflanzenschutz Abtlg. Farbenfabriken Bayer in their letter of November 11, 1963.

For a maximum outcome of this technique, controlling the eggs and larvae of C. capitata by the tank-dip method, this work should be carried on other citrus varieties which are shipped to a greater extent to the foreign markets.

SUMMARY AND CONCLUSIONS

The Mediterranean fruit fly, Ceratitis capitata Wied., is one of the world's most destructive fruit pests. It is a problem to the fruit producer, exporter, importer and consumer. The problem becomes more acute because of the steadily increasing demand on high quality fruit by the international markets.

The present work attempts to introduce to citrus industry a new and simple improvement of fruit fly control in connection with the dip-tank method of treatment of citrus. The following insecticides were tested against the eggs and the larvae of C. capitata: Cygon 2-E, Dicapthon, DDVP, Ethylene dibromide, Lebaycid, Malathion + DDVP + Chlorowax and 47300. All these insecticides were tested at three concentrations except DDVP and Ethylene dibromide at two and one concentration respectively.

Late-maturing Mediterranean mandarins were exposed to sexually mature, and laboratory bred adults of the fruit fly for oviposition. The fruits destined for ovicidal trials were dipped for three minutes in the insecticidal solution at the appropriate concentration right after exposing the fruits to the flies. The fruits destined for larvicidal trials were dipped four days after exposure. Ten days later, the fruits were dissected, the living larvae were counted and the data were analyzed by the analysis of variance method. There were six treatments

and the control, each replicated eight times. Every treatment consisted of three concentrations to test the ovicidal effect. The same concentrations were repeated for their larvicidal effect.

The results of this work show that all insecticides at the "low" concentration varied significantly in reducing the population of living larvae inside the fruits. As the concentration was increased, the insecticides grouped themselves in lesser number of categories, and the significant difference among the treatments was greatly reduced. Most of the insecticides reduced the number of living larvae in each replication at the "high" concentration to zero. Cygon 2-E was the only insecticide that showed 100% control at all three concentrations.

The recommendations to be made, based on this study, are conditioned by the results of the residual analysis of fruits treated with these different insecticides. For this purpose, large batches of dipped fruits were sent to the laboratories of Bayer in Germany and the American Cyanamid Company in the United States of America, for the residue analysis. The results will be published as soon as they are received. The insecticides that give 100% reduction of the population, and leave the minimum possible residues on the fruits, below the tolerance limit, would be recommended to be used on a commercial scale.

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