STUDIES ON THE RELATIVE TOXICITY OF SOME INSECTICIDES TO ADULTS OF *Dacus cucurbitae* (COQUILLETT) WHEN USED IN BAIT SPRAYS

BY

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THESIS

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CERTIFICATE

This is to certify that the thesis herewith submitted contains the results of bonafide research work carried out by Shri D.Dale under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

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INTRODUCTION

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Among the various insect pests which attack cucurbitaceous crops in India, the melon fly, *Dacus cucurbitae* (Coquillett) is by far the most common and the most destructive. In Kerala the damage it causes to the crops like snake gourd, bitter gourd and cucumbers is considerable. Often it becomes absolutely difficult to obtain fruits which do not show blemishes caused by this insect.

Being a boring insect, it is very difficult to obtain a satisfactory control of it. Various methods have been in use from early days. These include using baits with arsenicals as poisons, application of contact insecticides and application of bait sprays. Bait sprays have proved themselves as efficient weapons for the control of fruit flies in other countries. The bait sprays which are liquid baits are either sprayed on the foliage of the crop or on the foliage of the surrounding vegetation. The only work done in India on this line is that of Gupta (1960), who made a bait spray with 0.75 oz. of protein hydrolysate, 0.75 oz. of brown sugar and 0.25 oz. of 60% malathion EC in one gallon of water. His tests showed that this bait spray was effective against *D. dorsalis* and *D. cucurbitae*.

Several insecticides have been found useful as the poisonous factor in the bait sprays. These include lead arsenate, sodium arsenite, sodium fluosilicate, tartar emetic, DDT, dieldrin, toxaphene, parathion, dipterex and malathion. But all of these, with the exception of malathion, have been tested against fruit flies other than D.cucurbitae. Further, no effort has been made so far to ascertain the residual effect of the bait sprays on fruit flies. Hence the present studies were undertaken with a view to compare the effectiveness of DDT, BHC, parathion, malathion, dipterex and sevin when used in bait sprays, against D.cucurbitae. The residual toxicity of these insecticides to the flies also has been ascertained.

A comprehensive review of the literature on chemical control of fruit flies is also presented.

REVIEW OF LITERATURE

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A perusal of the literature has shown that the chemical control of fruit flies can be grouped under four main heads viz.

(a) The use of bait sprays.

(b) Bait trapping of the adult flies by means of chemical attractants which is based on the principle of chemotropism.

(c) Cover sprays with insecticides and

(d) Soil treatment.

BAIT SPRAYS.

The first published record of the use of foliage bait sprays for the control of fruit flies appears to be that of Mally(1904) of South Africa, who suggested a coarse 'hit or miss' spray, leaving small globules of an attractive substance containing poison on the leaves and stated that the Mediterranean fruit fly, *Ceratitis capitata* succumbed readily to treacle containing an arsenical poison. Berlese(1909) conducted some trials with foliage bait sprays for the control of olive fruit fly, *Dacus oleae* Rossi with the attractant medium consisting of a mixture of molases 2 parts, honey 1 part and a small quantity of glycerine. Following these pioneer investigations experiments with bait sprays have been reported from various parts of the world against many species of fruit flies. Marsh(1910) in Hawaii found that a bait spray of ½ oz. of paris green or lead arsenate added to a solution of 1 quart of molasses and 1½ gallons of water was not effective against D.cucurbitae.

Severin et. al.(1914) recommended a bait spray containing brown sugar 2½ lbs., lead arsenate 5 oz. and water 4 gallons against D.cucurbitae. De Charmoy (1915) claimed success using his bait of sugar 2 lbs., Glycerine 2 oz., lead arsenate 2 oz. and water 17½ pints and found that this amount was sufficient for 3000 sq.ft. foliage against D.cucurbitae and D.ferrugineus.

Newman(1921) recommended a bait containing the juice of 1 dozen average sized ripe oranges, 4 lbs. of molasses, 4-5 oz.of lead arsenate paste and sufficient water to make up to 4 gallons. The bait proposed by Minangoin (1922) against Ceratitis capitata included a small amount of preserved figs boiled in water until reduced to pulp and water containing sodium arsenite at the rate of about 1/3 oz. to 1¾ pints. It was also stated that the bait containing 10 gallons water, 5 oz. sodium arsenite and 15 lbs. molasses was popular among the orchardists for a very long time and this was based on the original Berlese formula. Trinchieri(1924) suggested that this spray could be efficienty used against D.oleae by spraying only a part of the olive tree, which was exposed to the east getting more sunshine. Poutiers and Lardat (1925) suggested another bait formula against Dacus oleae which consisted of 1000 parts water, 100 parts molasses and 2 parts sodium arsenite by weight and they claimed this to be very effective against mediterranean fruit fly. Silvela (1925) suggested a poison bait containing 4½ lbs.molasses, lead arsenate 5 lbs. and water to make 60 gallons. From the spraying experiments against mediterranean fruit fly, Newman(1925) concluded that a bait spray consisting of 5 oz. lead arsenate paste(or 2½ oz.dry lead arsenate), 4 lbs. molasses, 1 gallon fruit syrup and 3 gallons of water at the rate of not less than 1 gallon for 80 trees, would be effective. Mc Carthy(1925) showed that majority of the flies fed on lead arsenate solution took from 65 to 90 hours to die in the laboratory and would most probably take longer time in the field. Jarvis(1926), recommended a bait spray consisting of 4 lbs. molasses, 2½ oz. lead arsenate powder and 4 gallons of water against the Queensland fruit fly D.tryoni. Allen and Brereton(1926) suggested a formula with the juice of 12 oranges or 18 peaches, 4 lbs. molasses, 8 oz. lead arsenite paste (or 5 oz.powder) and water to make 4 gallons.

Poutiers(1927) found that a solution of sodium arsenate proved best among various other chemicals tried when used with a bait base of 10 percent molasses. Best results were obtained by Newman(1927) with a bait of pollard and borax at the rate of ½ lb. each to 1 gallon of water. In the olive fly-control experiments in Syria, Hallage(1928) demonstrated the efficiency of a bait spray containing 88 parts of molasses, 2 parts of lead arsenate, and 9 parts of water. One part by weight of this solution was diluted with 9 parts of water and used for spraying. Constantino(1929) recommended a bait spray in water containing 20-25 percent of vine vinegar or 10 percent of beet molasses from which the sugar has been removed, against C.capitata. Miller and Mc Brudge(1931) found that the mean length of life of mediterranean fruit flies fed on a mixture of 8 lbs. lead arsenate, 50 lbs. sugar, 10 US gallons molasses and 190 US gallons water was 3.69± 0.034 days. Copper carbonate used at the same strength gave a mean survival period of 4.43± 0.050 days. Against D.ferrugineus, a bait containing 1/8 fl.oz. vanilla and ½ oz. household ammonia diluted in 26 fl.oz. water was successfully used.

In 1934, Ripley and Hepburn came to the conclusion that treacle and brown sugar should not be substituted for white sugar in any formulae which included fluosilicates or arsenates as there was possibility of the insecticide losing its toxicity. Silvestri (1934) recommended a bait spray against D. oleae containing beet molasses 95 gallons, sodium arsenite 30 lbs., and water 2 gallons. Just before application, 1 gallon of this mixture was diluted with 9 gallons of water with the addition of 1 lb. of ammonium sulphate or ammonium nitrate. Smit (1934) proved the effectiveness of a bait spray of sodium fluosilicate and sugar which did not affect the flavour of citrus fruits in South Africa. Bishop's (1934) bait spray made up of 1 oz. sodium fluosilicate, 2 lbs. white sugar and 4 gallons water proved effective against melon flies.

Morris(1935) recommended a bait spray schedule against mediterranean fruit fly Ceratitis capitata which consisted of the application of 1 lb. of sodium fluosilicate, 24 lbs. granulated sugar and 40 gallons of water at about 8 days interval from early September until mid December. Another recommendation by Ritchie(1935) included the weekly application of a bait spray containing 20 gm. sodium arsenite and 5 lbs. sugar in 4 gallons of water. Melis (1935) found out a formula against C. capitata consisting of 4 parts by weight of powdered quassin, 20 parts of water, and 200 parts of alcohol 90° and 776 parts of syrup of invert sugar. When this was added to branwater at the rate of 1 lb. to 5 gallons and used as a spray, it killed the flies within 3 hours. Newman and Jenkins(1936) found that a bait spray containing 1 oz. sodium fluosilicate, 2½ lbs. sugar and 4 gallons of water was effective against mediterranean fruit fly. Bouhelier and Foury (1936) could get good results in fruit fly control using a mixture of 14 lbs. molasses and 10 gallons water, 0.5 lb. arsenate paste or 0.07 lb. sodium arsenite. Morris(1939) improved on his previous formula (loc.cit.) and suggested a new bait spray consisting of 1 lb. sodium fluosilicate, 30 lbs. sugar and 60 gallons water. Under field conditions this spray was not so effective, probably because over-ripe figs on the ground were more attractive than the spray. The formula recommended in Palestine against mediterranean fruit fly included 10 lbs. lead arsenate, 2.7 lbs. copper carbonate, 35 lbs.sugar and 8 oz. Agral spreader in 100 gallons water, which was to be applied at intervals of 2 weeks at the beginning of the season and 10 days during the peak period of fly activity. But the citrus growers in that country were asked to use bait sprays containing 4 oz. lead arsenate, 3 oz.sodium fluosilicate or 6 oz. copper carbonate each with 100 oz. sugar in 50 pints of water applied at the rate of about ½ pint per tree on the eastern and southern sides of citrus trees, at 10 days interval till picking season ended. Eventhough this application reduced the infestation, scorching was noted on leaves.

Allman(1940) found that against D.tryoni the effective formula was tartar emetic 1 oz. and sugar 2½ lbs. in 4 gallons of water. Holdaway et.al. (1942) showed that mixing tartar emetic bait spray with fungicides reduced its toxicity. A mixture of basic copper arsenate and nicotine sulphate was as toxic to Dacus cucurbitae as tartar emetic. DDT was also found ineffective against it in baits, and DDT dusts lost their high initial toxicity in short time when the cages treated with them were exposed to outdoor conditions and frequent light rains. Various other workers like Waterston(1942), May and Caldwell(1944) suggested various formulae for bait sprays against fruit flies using lead arsenate or sodium fluosilicate as the toxicant, sugar as the base and water in different proportions.

When DDT was tested in a bait spray, Holdaway (1945) found that its action was much slower than that of tartar emetic. But Friend and Pasfield (1945) could show that DDT was as effective as tartar emetic. Wason (1947) used nicotine sulphate as the toxicant in the bait spray formulation and satisfactory results were obtained in gardens with his bait spray of 1 fl.oz. nicotine sulphate and 2 lbs. sugar in 3 gallons water applied to the foliage every 2-3 days. It did not kill all the flies that fed, but caused them to fall to the ground where they died subsequently. By his elaborate trials Hanna(1945) could formulate a bait mixture similar in composition to that of the fallen citrus fruits. He also found (1947) that the best bait base consisted of a mixture of 2 gallons molasses containing 55 percent sugar and 8 lbs. fine wheat bran (or 1 lb. casein) in 20 gallons of water fermented for 12 hours in summer or 16 hours in winter. Among the various poisons tested,barium chloride, the tartrates of antimony and potassium , sodium nitrite, sodium fluoride, and sodium arsenate were equally toxic. A concentration of 2 percent of these killed the flies in 24 hours, but flies fed on a bait containing sodium fluosilicate which was less soluble in water required 2-3 days to accumulate a lethal dose. Allman and Friend (1948) compared the value of cover sprays of DDT, BHC and chlordane with that of tartar emetic for the control of D. tryoni. The first 3 insecticides were used at 0.2 percent in the form of emulsified solutions and applied at fortnightly intervals at the rate of about 1 gallon spray per tree. The results indicated that tartar emetic and DDT gave an appreciable degree of control.

Friend(1949) based on his experiments showed that (a) baits of tartar emetic (2 oz. with 2 oz. sugar in 4 gallons of water) were more efficient than the cover sprays of 0.2 percent DDT or 0.2 percent parathion in preventing the flies from stinging plum fruits in the field (b) of the bait sprays, tartar emetic gave greater freedom from stings but not of statistical significance and (c) in respect of maggoty fruits, there was no significant difference between the results obtained with parathion bait and cover spray. Melis(1949) reported the infectiveness of a BHC bait spray for the control of Dacus oleae in the coast of Tuscany.

Hepburn and Bishop(1950) observed that the sodium fluosilicate bait spray was less toxic to melon flies than BHC or parathion in sugar solution. DDT was found to be slower in its action than either BHC or parathion and the latter was found very rapid in its action when used at a concentration as low as 0.005 percent. Both BHC and parathion caused an early paralysis from which there was no recovery. But in the case of sprays with sodium fluosilicate and lead arsenate the flies could lay eggs before the poison took effect. Parathion 0.005 percent and BHC 0.01 percent in solution of white sugar were found to be attractive and highly toxic to melon flies, if applied as a coarse spray.

Gomez Clemente and Bellod(1951) found that in general, bait sprays were no less efficient than bait pan, bait traps and combination of bait trap and bait spray.

Steiner(1952) found that protein hydrolysates of soyabean or yeast greatly increased the attractiveness of bait sprays containing sugar and parathion or metacid to Dacus dorsalis and C.capitata. Wettable powder formulations of EPN and lindane and an emulsifiable formulation of 'Compound 22008' were also very effective as bait sprays, when supplemented with protein hydrolysate. Deposits from slow-acting poisons such as DDT, dieldrin, aldrin, chlorodane and nicotine bentonite, failed to kill flies rapidly. Peretz and Plant (1953) experimented with wettable powder sprays containing 0.5 percent DDT or methoxychlor or 0.3 percent dieldrin, all with 2 percent sugar beet molasses as attractant. At harvest, the percentage of uninfested fruits exceeded 90 as compared with 46 for no treatment. In their experiments for the control of C.capitata, Puzzi et.al. (1955) tried emulsion sprays of 0.135 percent gamma BHC, 0.5 percent toxaphene, 0.046 percent parathion and 0.0925 percent dieldrin, 3 percent sugar being added to all sprays as attractant. Dieldrin and toxaphene gave significantly good results. Steiner(1955) observed that a poisoned bait spray containing malathion and hydrolysed or partially hydrolysed protein could give good control of the oriental fruit fly for one to three weeks.

Georghiou(1956) applied a bait spray of 1 percent malathion in 10 percent sugar solution in several orchards to a patch of foliage on each tree 2-3 times at intervals of about 10 days and this resulted in the total prevention of fruit fly infestation. Steiner(1957) could get 93-100 percent reduction in infestation by bait sprays containing wettable parathion or malathion and protein hydrolysate applied at intervals of two weeks. Bait spray of 2-4 lbs. 25 percent wettable parathion or malathion with 1 lb. protein hydrolysate in 3-150 US gallons of water at intervals of 2-3 weeks was recommended by him. Nishida *et. al.* (1957) compared the effectiveness of malathion and malathion-yeast hydrolysate sprays for the control of melon fly. But the results were inconsistent. Planes Gracia (1957) could get good control of mediterranean fruit flies using bait spray with either malathion, chlorthion or dipterex and sugar. Neither DDT nor diazinon proved effective in bait sprays.

Nishida(1958) observed that the response of the melon fly to the yeast hydrolysate was greatest when applied to plants favoured by the adult flies. Puzzi and Orlando(1958) found that protein hydrolysates were powerful attractants while sugarcane molasses were the best among the cheap products available. In orchard tests 0.1 percent dieldrin, 0.2 percent malathion or

0.2 percent parathion each with 5 percent molasses applied fortnightly at an average of 22.5 gallons per acre gave 97 percent reduction of adult population.

Frezal(1960) sprayed an orchard with a bait spray containing 5 lbs. malathion and 9 lbs. protein hydrolysate in 10 gallons water at 0.9 gallons per acre by helicopter, 4 times. The results showed that the percentages of fruits punctured were 0-0.08 in the experimental area which was commercially satisfactory. Gupta(1960) made a bait spray with 0.75 oz. protein hydrolysate, 0.75 oz. of brown sugar, 0.25 oz. 60 percent malathion EC in one gallon of water. Tests showed that this spray was quite effective against the fruit flies D.dorsalis and D.cucurbitae.

BAIT TRAPS

Frogatt(1909) recorded that citronella oil attracted only the male flies of D.ferrugineus. Mally (1909) found that paraffin oil attracted C.capitata and later on Lounsbury(1910) observed that both sexes of the fruit fly were attracted to paraffin oil, the males predominating. Howlett (1912) reported that oil of citronella was attractive to males of D.diversus and D.zonatus in India and reasoned that since two species were involved, possibly two separate ingredients were the attractants. Later Howlett(1915) found that methyl eugenol, presumably a constituent of the oil of citronella, attracted D.zonatus, whereas D.diversus was strongly attracted by iso-eugenol. D.ferrugineus was attracted by both methyl and iso-eugenol.

Harvey(1914) could successfully lure both sexes of D.tryoni and C.capitata with a combination of imitation vanilla essence, ammonia and water. Pemberton (1914) demonstrated in Hawaii that many oils derived from crude petroleum and also certain vegetable oils attracted the males of D.cucurbitae and C.capitata.

Newman(1923) was successful in trapping large number of both sexes of the flies of C.capitata in Western Australia with a pollard and water bait. Later on he(1926) recommended a bait trap containing 8 oz.bran and 8 oz. powdered borax added to 1 gallon water.

Chopra(1928) found eugenol as a highly effective attractant for D.zonatus. For D.cucurbitae, citronella and eucalyptus oils were the best. Batra(1937), however, failed to obtain parallel results with citronella. Hussain (1927) proved that on the whole, trapping the flies with the help of ammoniated materil was the most effective remedy for the control of fruit flies.

Newman(1928) in his trapping and luring experiments found that kerosene attracted male C.capitata. A bait containing pollard 8 oz., 8 oz. powdered borax, ¼ oz. sodium arsenate and 1 gallon water, was found to be more attractive for the females. Coiute(1930) found that the liquid obtained from olive after the oil was separated attracted D.oleae. Gomez Clemente(1930) found a fermenting mixture of bran and water or simply the water in which bran(2-2½ oz. in 35 fl.oz.) had been steeped until the fermentation began, to be good baits.

Newman and O' Connor(1931) found out that 'Clensel' 1 part in 30 parts of water attracted C.capitata, while 'Dachicida F' attracted D.oleae. Bua(1932) from his trapping experiments in Cyprus found that bran and borax(8 oz. of each to 1 gallon of water) or 'Clensel' (1 to 20-40 parts of water) were attractive to C.capitata. Again he (Bua, 1934) tried 'Dacivore D.F.O'. containing 1 percent ammonium flouride and olive oil. Solutions of ammonium hydrate or ammonium nitrate alone, though initially much less attractive, remained attractive for a longer period than baits containing molasses.

Ripley and Hepburn(1935) reported that terpinyl acetate was very effective in attracting female fruit flies. Bua(1935) prepared a bait for C.capitata by stirring 10 lbs. bran and 10 lbs. borax with 4 gallons water, allowing it to stand for 15 hours and then supernating the liquid and diluting with water to a total of 20 gallons. Constantino(1935) stated that a decoction of dried figs made by boiling 1 lb. figs in 1 gallon of water for ½ an hour was more attractive than any other baits. Newman(1935) observed that largest catches of flies were obtained with 'Clensel' (1:30) followed by 'Lura Daw' and 'Beeco' (1:40). But in May-June, an improved type of 'Beeco' caught more flies than 'Clensel'. Bouhelier et.al.(1935) tested 'Clensel' solution, a solution of molasses containing ammonium flouride or biflouride, and a bait prepared by steeping 11 lbs. coarse flour and 11 lbs. borax in 20 gallons water for 24-48 hours and straining the water for use. All of them proved effective against C.capitata.

Isaakides(1936) found that against C.capitata among the substances, molasses, an infusion prepared by steeping 8 parts bran in 100 parts water for 24 hours, a 5 percent solution of ammonia and a solution of 'Clensel' (1:30), 'Clensel' was considerably the most effective bait attractant. Gomez Clemente(1936) also got good results with 'Clensel'. Benlloch and Dominguez(1936) found that in cool wet weather 6 percent ammonia proved the best bait, while in hot weather and in situations exposed to the sun, a 2 percent solution of 'Clensel' was effective. Simmonds(1937) could increase the efficiency of the ammonia bait by the addition of synthetic vanilla essence. Morris (1937) reported that the most attractive baits in order of efficiency were ammonium sulphate alone, ammonium sulphate with molasses, and grape juice. Ponce(1937) found that white arsenic was slower in action in brown sugar bait than sodium arsenite and took 53 hours for the complete mortality of the flies. 'Clensel' (1:20) traps were reported to successfully control C.capitata which was a serious pest of stone fruits and citrus in Malta(Anon.1937). Hutson(1938), however, observed that 'Clensel' was a failure against D.dorsalis in Ceylon.

Ruffo et.al.(1938) recommended a trapjar containing water in which bran was fermented. Morris (1938) showed that bait traps with molasses and 1 percent ammonium sulphate worked better than those with molasses, fig extract, 'Clensel' and bran and borax against C.capitata and D.oleae.

Pruthi and Bhatia(1938) observed that 'Clensel' in the ratio of 1:20 was more effective than the weaker dilutions. Batra(1938) observed that the effectiveness of 'Clensel' depended upon the climatic conditions to a certain extent. The adult flies were attracted to 'Clensel' only in summer. During the monsoon in Kurrum valley(6000 ft.) no flies were found attracted. Bua(1938) found a 10 percent dilution of 'Dachicida F' most attractive for C.capitata, but in summer, it was inferior to ammonium salts. Monzon(1938) recommended a bait of a 10 percent sugar solution containing 5 percent amyl alcohol against D.dorsalis. Mc Phail(1939) found proteins in the presence of sodium hydroxide solution were very attractive to Anastrepha striata. Experiments of the US Bureau of Entomology showed that C.capitata and D.cucurbitae resembled A.striata in this respect. In Kualalampur it was found that a solution of formaldehyde and sugar was found to be best against D.ferrugineus. It was equally attractive to males and females and remained effective for several weeks (Anon.1939).

Ruiz Castro(1940) found 'Clensel' consistently better than orange juice and peach juice for baiting C.capitata. Bohorquez(1940) reported that the largest number of flies were attracted with 5 percent ammonium phosphate, and appeared to retain its attractiveness for a fortnight. Yashiro(1940) recommended two baits:

one containing honey and water(1:20) and another with wine, brown sugar and water(1:2:40). Both baits attracted more females than males of D.cucurbitae. Miwa and Moriyama (1940) got good results using a mixture of soap solution, methyl eugenol, lemongrass oil and water, but most of the flies attracted were males. Against C.capitata, Hayward(1941) found that orange juice bait was the most effective followed by pollard bait. Moreno Marquez(1942) observed that 2-4 percent solutions of ammonium phosphate were more effective against olive fly than those solutions of 6,8 or 10 percent. Marlowe(1942) showed that C.capitata and D.cucurbitae preferred invert sugar syrup, white maize syrup, laevulose, dextrose and sucrose to a solution of Hawaiian sugarcane molasses at equivalent concentrations.

Mc Phail(1943) found out a new lure for melon fly namely linseed oil soap which acted as a strong attractant for both sexes of D.cucurbitae. Cotton seed oil soap and maize oil soap were also found to be good attractants. Caldwell and May(1943) observed that mixtures of ammonia with pollard, bran or orris roots were more attractive and that the addition of vanilla was unnecessary or even detrimental. Gomez Clemente and Mellod(1945) studied the duration of attraction for D.oleae, of solutions of ammonium phosphate and it was found that the liquid had to be renewed frequently owing to loss by evaporation. Trehan and Pingale(1946) found 'Clensel A'(1:30) as an effective attractant in the cucurbit fields and practically all the species of fruit flies were trapped. However trapping did not appear to reduce appreciably the damage caused even when used on a large scale. Donato and Aramayo(1947) noted that of 16 different baits, the most effective was a 25 percent solution of molasses with 50 percent ground kumquats in water and undiluted orange juice the next best. Grape fruit juice alone or diluted was fairly effective, and better than wine vinegar or beer. All these attracted both sexes of C.capitata and Anastrepha sp. Gomez Clemente (1949) found that the ammonium phosphate traps with a narrow-sealed neck retarded evaporation and these proved very satisfactory.

Rivnay(1950) observed that ecological surroundings of 'Clensel' traps had a considerable influence on the catch. In the summer, a jar in the shade took more flies than a jar exposed to the sun. Steiner(1952) noted that methyl eugenol was one of the most effective baits for males of D.ferrugineus in Hawaii. Emulsions of methyl eugenol or citronella oil were very effective when first exposed, but absorption of the aromatics by large catches of flies or overflowing caused by rain resulted in a rapid loss of effectiveness. There was strong evidence that males could be attracted for half a mile or more against a wind blowing at 8 miles per hour.

Rosillo(1953) found that bait traps containing a mixture of 25 percent wine venegar and 10 percent molasses hung on citrus and other fruit trees was very effective against fruit flies. Gow(1954) found that attractiveness of the proteinaceous materials might be due chiefly to products of micro-biological action. Of 14 strains of micro-organisms isolated from effective baits, a species of Proteus consistently showed high attractiveness. He concluded that the isolation of attractants and elimination of any repe-llents present might lead to more effective and useful material. Lizer Trelles and Yergani(1955) found that bait traps with 2 percent commercial ammonia were not effective.

Steiner et.al.(1957) reported that oils from the seeds and roots of angelica(Archangelica officinalis) were outstanding attractants for the males of C.capitata. Lall and Sinha(1959) reported that a bait containing fermented palm juice 1 pt.,saturated sugar solution 1 pt. and malathion WP 50 percent 5 gm. at the rate of 100 ml. gave the maximum catch of both sexes of D.cucurbitae. Beroza et.al.(1961) proved the officacy and longlasting effect of 'Medlure' over 'Siglure' which was previously considered the best synthetic lure.

Frandino et.al.(1961) found that the hydrolysates of flax seed oil and soyabean meal were very effective particularly in attracting the females of C.capitata and that it remained so for 8-10 days at an average temperature of 28°C. They also confirmed the efficacy of angelica oil as an attractant and showed that it remained attractive for 15 days. Dipterex - soyabean hydrolysate mixture gave better results than dipterex - sugar combination. Alexander et.al.(1962) found that cue-lure was most effective in trapping D.cucurbitae.

COVER SPRAYS

Nonell Comas(1926) considered that spraying of bordeaux mixture on olive trees could repel the fly D.oleae. Jarvis(1935) reported that a spray consisting of ½ pint nicotine sulphate, ½ gallon white oil and 40 gallons water gave promising results. Another two sprays, viz. ½ gallon white oil in 40 gallons water and 1 oz.of colloidal sulphur in 4 gallons water did not give conclusive results. For cover sprays, Strong(1935) found that tartar emetic was more toxic than nicotine compounds, copper arsenite, copper tartrate, copper sucrate, cadmium salts and lead arsenate. Voitch(1935) advocated the use of a mixed spray of nicotine sulphate and white oil and found it to give better protection of the fruits than sprays containing white oil or colloidal sulphur only. Russo (1938) postulated a spraying pattern against D.oleae with a mixture of 3 parts lime-sulphur, 1 part soft soap, 0.5 part copper sulphate, 0.5 part powdered lead arsenate and 3-5 parts clay in 100 parts water and then dusting them immediately with sulphur containing 1 percent naphthalene. Ayyar(1940) recommended nicotine sulphate as the one in vogue at that time. Allman(1940) reported the inefficiency of sodium fluosilicate to control fruit flies in the presence of an abundant alternative food supply. Tartar emetic, which maintained its effectiveness under these conditions, produced a more conspicuous deposit that appeared to be hygroscopic and more attractive to the flies.

Holdaway et.al.(1942) got excellent control of D.cucurbitae by using a spray containing 2 lbs. DDT per 100 US gallons of water and it was as effective as 2 percent dust and retained its effectiveness longer.

The use of systematically sprayed barrier crops showed promise. Cherian(1942) contented that spraying with a dilute solution of crude oil emulsion would repel the ovipositing melon flies. Martelli(1942) reported promising results by spraying olive trees with a mixture consisting of 25 lbs. iron sulphate, 4 gallons lime-sulphur, 5 lbs. solid creoline and 5 gallons milk of lime in 100 gallons of water at 15-20 gallons per tree. Baptista (1943) confirmed the value of clay and sulphur for repelling the ovipositing females of D.oleae from olives. Application of a spray mixture containing 50 lbs. clay, 5 lbs.copper sulphate and 5 lbs. lead arsenate per 100 gallons of water followed immediately afterwards by dusting with sulphur gave excellent control of the flies. Ayoutantis(1946) used DDT aerosols applied from aeroplanes with a 20 percent solution of DDT in velsicol at a rate equivalent to about 1 mgm. DDT per square foot, and found it effective and economical than bait sprays to control D.oleae. Grandori(1947) reported DDT 'Guesarol' dust effective for the control of D.oleae. Holdaway et.al.(1947) reduced the percentage of infested tomatoes to about 32 percent by eight treatments of the crop field with DDT dusts; this was in a field where prior to treatments, the flies were so numerous that complete crop failure seemed likely.

Allman and Friend(1948) compared the value of cover sprays of DDT, BHC and chlordane with that of bait sprays of tartar emetic for the control of D.*ferrugineus*. The results indicated that tartar emetic bait spray and DDT cover spray gave an appreciable degree of control. The laboratory studies of Martin(1948) showed that a suspension containing 0.15 percent BHC gave poor results and that one of 0.5 percent DDT and an emulsion spray of 0.15 percent DDT gave complete mortality for nearly two months. The addition of bordeaux mixture had little effect. A further test indicated that bordeaux mixture had no toxicity to flies but reduced oviposition by rendering the fruits less attractive.

Armitage(1949) reported DDT as the most effective of the newer organic insecticides, but it had no residual effects. In their preliminary tests,Nishida and Bess (1950) found that an oil emulsion containing 10-12 percent DDT applied to the vegetation immediately outside melon and tomato fields with a mist blower before or soon after sunrise or late in the evening, eliminated practically all flies within 50-100 ft. of the blower. Ciampolini (1950) found that both parathion spray and dust gave rapid and complete mortality of D.*oleae* in the laboratory.

Ryan(1950) made trials with newer insecticides for fruit fly control and got promising results using DDT, BHC and HETP. Tominic(1951) observed that an aerosol containing 16 percent DDT when applied from an aeroplane at an average rate of 1.8 lb. per acre to about 2 square miles of olive groves against D.oleae was affected by the high prevailing temperature. Santoro(1951) observed that colloidal DDT paste and 3 emulsion concentrates containing respectively, 50 percent chlordane, 25 percent each of DDT and BHC, and a mixture of 32 percent chlordane and 18 percent DDT, all at 4 lbs. per 10 gallons water killed the adults of D.oleae. But fruits from trees sprayed with 0.04 percent parathion showed that only the larvae, and consequently those nearest the surface of the fruits had been killed, while those further in continued to develop normally. Martin(1952) found DDT spray better than 5 percent pyrolan. Russo and Santoro(1952), in a comprehensive study on the control of D.oleae found that:(a) repellent sprays mainly of bentonite and sulphur separately and together, and usually with the addition of an adhesive or bordeaux mixture at the normal concentration or with an increased lime content gave fairly good protection (b)chlordane alone gave little or no protection and the mixture of chlordane and DDT was only slightly better, but the mixture of 25 percent technical DDT and 25 percent gamma-BHC and 50 percent colloidal DDT gave good control. (c)Parathion 0.03 percent spray and 2 percent dust killed larvae in their early stages of development. (d) Dieldrin in emulsion sprays prepared from a concentrate of unspecified strength gave good results.

Ciampolini(1952) indicated that parathion penetrated into the fruits and then it acted mainly as a stomach poison. Alessandrini and Sacca(1953) observed that adult olive flies confined in gauze bags on branches which had been copiously sprayed with suspensions of DDT 5 percent or chlordane 5 percent were killed completely in 5 and 6 hours respectively. Rivnay(1954) contented, after laboratory studies of deposits on leaves, that the insecticides proved most effective in wettable powder sprays. Of the insecticides tested as wettable powders, BHC gave the best initial control but was less persistent than methoxychlor or dieldrin. Roselli(1954) got excellent control of C.capitata using 0.5 percent wettable DDT, 0.015 percent wettable parathion followed by 0.3 percent DDT in an emulsion spray.

Ebeling(1953) conducted extensive laboratory experiments for the control of 3 species of fruit flies namely D.oleae, D.cucurbitae and C.capitata. He found that the relative effectiveness of the insecticides varied with the different formulations. The most toxic insecticides in emulsifiable concentrates, kerosene solutions, wettable powders and dusts were respectively paraoxon, pyrethrins, parathion and heptachlor. Among the different formulations, the kerosene solutions were the most efficient both as space sprays and as residues. Emulsifiable concentrates were superior to the wettable powders as space sprays, but inferior as residues. The dusts were the least efficient.

Ebeling et.al.(1953) suggested sprays containing 0.027, 0.025, 0.1 and 0.2 lb. in 10 gallons of EPN, parathion, dieldrin and DDT respectively for spraying a corn border to control melon flies. Laboratory evaluation showed that the effectiveness of parathion was more adversely affected by rain than that of the other insecticides mentioned. Nishida(1953) could control melon flies effectively by treating border vegetation with parathion at a concentration of 1 lb. of a 25 percent wettable powder per 100 gallons of water by means of conventional type power sprayers.

Narayanan *et.al.*(1955) found endrin 0.03 percent to be the most effective insecticide for controlling the melon fruit fly. Vasseur and Schvester(1955) tried many insecticides against *C.capitata*. They found that gamma-BHC as wettable powers was very rapid in action giving 50-60 percent knock-down in 4 hours but rapidly lost its toxicity. Wettable parathion proved unusually persistent and its toxicity as emulsions to larvae inside the fruits was notable. Menezes Mariconi and Iba(1955) got excellent control of *C.capitata* using 0.2 percent toxaphene, 0.03 percent gamma-BHC or 0.25 percent DDT, whereas sprays of 0.02 percent parathion or 0.008 percent parathion and 0.16 percent toxaphene gave poor results. For the control of *C.capitata*, Genduso(1955) found that 0.25% DDT spray and 0.04 percent wettable dieldrin were not sufficiently effective. Melis (1956) found that low-volume sprays of diazinon and malathion gave good results in the control programme of *D.oleae* in Italy. Nishida and Bess(1957) reported that spraying border plants favoured by the adults with DDT or parathion afforded good protection of tomato and cucumber. Watermelon fields were found protected by treating border plants with 0.5 to 4 percent malathion in an emulsion spray, applied with a mist blower. Planes Gracia(1957) showed that the best control of *C.capitata* was given by spraying the whole tree with DDT at 0.25 percent which was slightly superior to the bait sprays containing malathion, chlorthion or dipterex. Melis(1957) applied 0,0 dimethyl S-methyl phosphorodithioate at 0.06 percent for the control of D.oleae. All treatments gave complete kill of the larvae within the olives. The second International Conference on mediterranean fruit fly(Anon.,1957) concluded that DDT sprays gave good control which might be due to their prolonged residual action or a repellent effect on the adults. Wettable powders were superior to emulsion sprays. Methoxychlor, dieldrin and parathion also gave very good control.

Orphanidis et.al.(1958) showed the effectiveness of dimethoate(Rogor) spray 0.03 or 0.06 percent for the control of D.oleae. Tominic(1959) studied the toxicity of different insecticide deposits against adult flies. In cage tests, diazinon gave the best results and dieldrin was nearly as good as diazinon. But in field trials the dieldrin deposit did not kill the females rapidly enough to prevent oviposition. Spraying with 0.2 percent diazinon resulted in complete mortality of larvae in the fruit and 0.2 percent dimethoate killed eggs laid 6 days later.

Sreenivasan and Narayanaswamy(1960) concluded that nicotine sulphate 0.1 percent, endrin 0.02 percent and parathion 0.025 percent reduced the bitter gourd fruit fly incidence effectively and the latter two gave higher yield. They recommended application of DDT 0.1 percent three times with a fourth round of endrin 0.02 percent or parathion 0.025 percent. Chen(1960) used a 25 percent malathion WP for the control of D.cucurbitae and got excellent results. There was no scorching at a dilution of 1:800 for young leaves and 1:400 for old foliage. Russo(1960) reported that the most effective materials for the control of D.oleae were dimethoate, bopard oil and parathion with copper sulphate.

Myburgh(1961) observed that lebaycid could kill adults and larvae of fruit fly by penetrating into the fruit. Sreenivasan and Basheer(1961) recommended the use of ribbed gourd sprayed with DDT 0.1 percent as a trap crop.

Sreenivasan and Narayanaswamy(1962)recommended treatment of snake gourd plants with parathion 0.025 percent or endrin 0.02 percent four times at intervals of 10 days commencing from the time of flowering and stopping two to three weeks in advance of bulk or large scale harvest. Leela David(1965) found that the systemic insecticides thiometon, methyl-demeton and dimethoate could effect good control of D.cucurbitae. The carbamate insecticide carbaryl appeared promising and treatment with carbaryl 0.1 percent applied 3 times at intervals of a fortnight from the time of flowering of the crop was recommended to control the fruit fly infestation.

SOIL APPLICATION

Borg(1933) reported the efficacy of injecting carbon bisulphide into the soil to kill pupae of C.capitata.

Martelli(1950) treated the soil with dusts of DDT and BHC 5 percent against C.capitata and D.oleae. When larvae of C.capitata were allowed to drop from peaches on to the soil dusted with DDT, a mortality of 25.2 percent was obtained as against 4.7 percent in control. When tubes containing puparia were placed upright in soil which was dusted with the two insecticides, the mortality among emerging adults was 72.5 percent for DDT and 44.3 percent for BHC and zero in the control. Ryan(1950) observed that the adults died soon after emerging from soil, the surface of which had been dusted with BHC at rates of 0.13 to 2.08 lb.gamma-BHC per acre. When gamma-BHC at 0.26 lb. per acre was applied as a dust to the soil in a field trial, it had no effect on fruit flies emerging from it, though in one test, the average survival period of the adults that emerged a few days after the application was reduced from 25-30 days to 7-8 days. This was attributed to a fumigant action of BHC. When fully fed larvae were exposed in the laboratory on moist or dry mixtures of 3 parts of sand and 1 part of dust containing 2 percent p'p'-DDT or 0.26 lb. gamma-BHC, DDT did not prevent pupation but killed the adults as they emerged from the surface, while BHC killed larvae and its effect was shown not to be due to fumigation. Carter(1952) found that dieldrin and aldrin acted as contact as well as fumigants for several days after soil application.

Constantino(1957) controlled fullfed larvae and pupae in the soil by scattering 6 percent heptachlor dust on the surface of soil in pots, or mixing with it at the rate of about 1 oz. per sq.yard. Steiner (1957) reported that the treatment of the soil under infested plants, with 5-10 lbs. dieldrin, aldrin,parathion or lindane per acre gave valuable supplementary control.

Sherman(1958) studying the latent toxicity of different insecticides on C.capitata and D.cucurbitae observed that with D.cucurbitae aldrin, dieldrin, chlordane, endrin and isodrin exhibited latent toxicity but less than that seen with C.capitata.

Chen(1960) recommended that dieldrin should be used only for soil application in view of its less immediate toxicity and longlasting effect and considering the danger of residue it may leave on fruits, if used as cover sprays.

MATERIAL AND METHODS

MATERIAL AND METHODS

A. MATERIAL

Insecticides used: The efficacy of the following insecticides in bait sprays was assessed against adults of *D. cucurbitae*.

Sl. No.	Insecticide	Active ingredient	Formulation	Source
1	DDT	1,1,1-trichloro- 2-2 bis (p-chloro phenyl)ethane	Technical	Mysore Insecticides Company.
2	BHC	Benzene hexachloride	Technical	Imperial Chemical Industries (India) Ltd., New Delhi.
3	Parathion	0,0 diethyl - 0,p-nitrophenyl thiophosphate	Folidol E 605	M/s Chika Limited, Bombay.
4	Malathion	0,0 dimethyl dithio phosphate of diethyl mercaptosuccinate	Technical	Cyanamid India Ltd., Bombay.
5	Diptorex	Dimethyl trichloro hydroxy phosphamate	80% SP	Bayer(India) Ltd., Bombay.
6	Sevin	1 - naphthyl N - methyl carbamate	50% WP	Union Carbide India Ltd.

<u>Attractant used</u>: The attractant base used in all the bait sprays was 'Bacto-Yeast Extract' manufactured by DIFCO Laboratories, Detroit-1, Michigan, U.S.A.

<u>Emulsifier used</u>: 'Teepol' supplied by M/s Shell Chemicals was used as emulsifier wherever necessary.

<u>Spraying equipments</u>: A Potter's spraying tower was used for spraying in the laboratory. For field spraying a knapsack sprayer fitted with an atomizing nozzle was used.

<u>Glasswares</u>: The glasswares consisted of specimen tubes (7.5 cm. x 2.5 cm.), glass vials, conical flasks, pipettes of 1 cc. 2 cc. and 5 cc. capacity, petri-dishes(9.5 cm. diameter), measuring cylinder 100 cc. capacity, glass rods, beakers 50 cc., 100 cc. and 200 cc. capacity and glass-stoppered bottles.

<u>Rearing equipments</u>: Rearing cages with wooden bottom, glass sides and open top, measuring 26 cm. x 20 cm. x 15 cm. were used to rear the fruit flies in the laboratory. Muslin cloth was used to cover and close the open top(see plate 2.).

<u>Testing cages</u>: Cylinders made of fly screen of 15 meshes, 4 inches high and closed at both ends with petri-dishes were used for confining the flies on sprayed leaf surface (see plate 1).

Test insect used: Adults of *Dacus cucurbitae* Coq. (Tephritidae) were used in the present studies. They were reared out in the laboratory from maggots collected from the field.

B. METHODS

Raising fruit flies in the laboratory: Snake gourd fruits attacked by *D. cucurbitae* are collected from the field. They are then placed in rearing cages on a 1 inch layer of clean sand which has been previously placed there. This sand is kept moist. When the maggots are full grown, they get into the moist sand and pupate. The fruits or parts of fruits which have become rotton beyond use for feeding by the maggots are removed and fresh broken fruits supplied if necessary. When puparia have been formed, they are collected and lots of 10-12 put within the petri-dishes of the testing cages. The emerging flies come to remain within the cages ready for experimentation.

Conditioning of the test flies: Only healthy and active flies are used for the experiment. The flies tested are one or two days old and are selected at random without regard to sex. They are starved for 12 hours before being offered leaves sprayed with the bait sprays.

<u>Preparation of the bait sprays</u>: Five graded concentrations of each insecticide were used to determine the relative toxicity of the different insecticides to *D. cucurbitae* in bait sprays. The different concentrations were prepared as follows:-

The dilutions of the insecticides from the concentrates are made using 1 percent solution of the yeast extract in water as under:-

1. <u>DDT and BHC</u> (Technical)

295 cc. water + 2.0 gm. Teepol + 3.0 gm. Yeast
= 300 cc. Emulsifiable water (EW)

0.5 gm. DDT or BHC + 9.5 cc. Benzene
= 5 percent solution (S)

0.4 cc. S + 0.1 cc. Benzene + 9.5 cc. EW = 0.2 percent (E)
0.2 cc. S + 0.3 cc. Benzene + 9.5 cc. EW = 0.1 percent (D)
0.2 cc. S + 0.8 cc. Benzene + 19.0 cc. EW = 0.05 percent (C)
0.2 cc. S + 1.8 cc. Benzene + 38.0 cc. EW = 0.025 percent (B)
0.2 cc. S + 3.8 cc. Benzene + 76.0 cc. EW = 0.0125 percent (A)

2. <u>Parathion</u> (Folidol E605)

1 gm. of Yeast + 99 cc. water = 1 percent yeast solu
1 cc. Folidol in 1,827 cc. yeastwater = 0.025 percent (E)
1 cc. Folidol in 3,654 cc. yeastwater = 0.0125 percent (D)

1 cc. Folidol in 7,308 cc. yeastwater	=0.00625 percent(C)
1 cc. Folidol in 14,616 cc.yeast water	=0.003125 percent(B)
1 cc. Folidol in 29,232 cc.yeastwater	=0.0015625 percent(A)

3.Malathion(Technical)

0.5 gm.Malathion + 9.5 cc. Benzene	=5 percent S
0.2 cc.S+ 0.3 cc.Benzene+9.5 cc.EW	=0.1 percent(E)
0.2 cc.S+ 0.8 cc.Benzene+19.0 cc.EW	=0.05 percent(D)
0.2 cc.S+ 1.8 cc.Benzene+38.0 cc.EW	=0.025 percent(C)
0.2 cc.S+ 3.8 cc.Benzene+76.0 cc.EW	=0.0125 percent(B)
0.2 cc.S+ 7.8 cc.Benzene+152.0 cc.EW	=0.00625 percent(A)

4.Dipterex(80% SP)

1 gm.in 400 cc.yeastwater	=0.2 percent(E)
1 cc.E + 3 cc. yeastwater	=0.05 percent(D)
1 cc.D + 3 cc. yeastwater	=0.0125 percent(C)
1 cc.C + 3 cc. yeastwater	=0.003125 percent(B)
1 cc.B + 3 cc. yeastwater	=0.0007 percent(A)

5.Sevin (50% WP)

1 gm. in 500 cc.yeastwater	=0.1 percent(E)
1 gm. in 1,000 cc.yeastwater	=0.05 percent(D)
1 gm. in 2,000 cc.yeastwater	=0.025 percent(C)
1 gm. in 4,000 cc.yeastwater	=0.0125 percent(B)
1 gm. in 8,000 cc.yeastwater	=0.00625 percent(A)

<u>Exposing the fruit flies to the bait sprays:</u> The fruit flies were exposed to the bait sprays applied on leaves of snake gourd. Two methods used for this were as follows:-

<u>Method.1.</u> The snake gourd leaves are sprayed on their under surface with 2 cc. of the bait fluid under a Potter's spraying tower in the laboratory. The sprayed leaf is then immediately placed on the top opening of the wire-gauze testing cage containing the adult flies, with the sprayed leaf surface facing inwards. The leaf is kept in position by pressing a petri-dish over it(see plate.1).

<u>Method.2.</u> Twenty uniform-sized drops of the bait spray are put inside a clean petri-dish. These drops are those which collect in falling drops at the tip of a sterile glass rod which has been dipped in the bait fluid and taken out. The size of the drops are such that they do not drop down when inverted. Each drop is put not touching each other. After the drops are put, the petri-dish is inverted over the top opening of the test cage containing the flies.

For assessing the residual effect of the bait sprays under field condition, they are sprayed on snake gourd leaves in the field with an atomizer, giving a thorough coverage of the leaves. The sprayed leaves are periodically collected and sprayed with 1 percent yeast solution in the laboratory and exposed to the fruit flies in the testing cages. The spraying of the leaves again with yeast solution is done to stimulate the flies to feed from the surface of the treated leaves.

NOTE:- In all the experiments, the surface on which the bait sprays are applied is exposed at the top of the testing cages. This is done because the fruit flies have the habit of coming to rest or spending a major part of their time on horizontal planes, away from light.

Assessment of the effect of the various insecticides in bait sprays:

The lethal effect of the insecticides in bait sprays is assessed by counting the number of dead and moribund flies found on the bottom of the test cage. Those flies which do not show any movements are considered as dead and those which show slight movements as moribund. The counts are taken at intervals of six hours from the time of exposure of the flies to the sprayed surface.

Experimental conditions:

All the experiments except the assessment of the residual effect of the bait sprays were conducted under laboratory conditions. Appendix.I gives the monthly temperature and humidity during the experimental period.

EXPERIMENTS AND OBSERVATIONS

DETAILS OF EXPERIMENTS AND OBSERVATIONS

A. Experiments to compare the toxicity of insecticides when used in bait sprays to adults of *Dacus cucurbitae*.

Two series of experiments were conducted to ascertain the relative toxicity of six of the newer synthetic insecticides to adults of *D.cucurbitae* when used in bait sprays. In the first series, the liquid baits were applied as a fine spray and in the second series as droplets. The details of these experiments are given below:-

SERIES.I.

When the liquid bait is applied as spray.

EXPERIMENT:1

Concentration - mortality relation between DDT in bait sprays and adults of D.cucurbitae.

Experimental details:-

Test insect	:	Adults of *D.cucurbitae* obtained from cultures maintained in the laboratory were used for the experiment. The flies were conditioned before being used as described under 'methods'.
Number of replications	:	3 each

Number of flies used in each replication	:	10
Test insecticide	:	DDT. Technical
Concentration of the insecticide used in bait sprays	{	A = 0.0125% B = 0.025% C = 0.05% D = 0.1% E = 0.2%
Control	:	Leaves sprayed with 1% protein solution.
Date of experiment	:	2--9--1964.
Temperature during the experiment	:	Mnm. 74°F. Mxm. 82°F.
Relative humidity during the experiment	:	76%

Procedure : The different concentrations of the bait liquid were prepared as detailed on page 39, sprayed on snake gourd leaves and exposed to the fruit flies as already detailed on page 41. Mortality observations were taken at intervals of 6, 12 and 24 hours after exposure of the flies to the sprayed leaf surfaces.

Results: Results are given in Table I and represented in Fig.1. It will be observed that only 0.2% DDT causes cent per cent mortality to the flies in a period of 24 hours

TABLE.I. Mortality of adults of *D. cucurbitae* exposed to snake gourd leaves sprayed with bait fluid containing different concentrations of DDT.

Percentage of concentration	Percentage mortality after different periods of exposure					
	Observed			Corrected		
	6 hours	12 hours	24 hours	6 hours	12 hours	24 hours
0.0125	13.3	23.3	60.0	13.3	20.6	55.5
0.025	16.6	30.0	83.3	16.6	27.6	81.4
0.05	20.0	46.6	86.6	20.0	44.7	85.1
0.1	33.3	50.0	90.0	33.3	47.2	88.8
0.2	56.1	80.0	100.0	56.1	79.3	100.0
Control	—	3.3	10.0	—	—	—

after exposure to the sprayed leaves. A gradual increase in the percentage of mortality among the flies is evident as the concentrations are increased from 0.0125% to 0.2%. The lowest concentration, viz. 0.0125% appears to have little effect on the flies as it gives only 55.5% mortality even after 24 hours of confinement on the treated leaf surface. Thus 0.2% seems to be the most effective dose of DDT to kill the flies.

EXPERIMENT: 2

Concentration - mortality relation between BHC in bait sprays and adults of D. cucurbitae.

Experimental details:-

Test insecticide : BHC. Technical

Date of experiment : 13--9--1964

Temperature during the experiment : Mnm. 74°F. Mxm. 81°F.

Relative humidity during the experiment : 85%

Rest of the details as in experiment. 1.

Results:- Results of the experiment are given in Table II

TABLE. II. Mortality of adults of D. cucurbitae exposed to snake gourd leaves sprayed with bait fluid containing different concentrations of BHC.

Percentage of concentration	Percentage mortality after different periods of exposure.					
	Observed			Corrected		
	6 hours	12 hours	24 hours	6 hours	12 hours	24 hours
0.0125	50.0	73.3	83.3	50.0	70.3	80.9
0.025	56.7	76.7	90.0	56.7	74.1	88.6
0.05	76.7	86.7	93.3	76.7	85.2	92.2
0.1	83.3	90.0	100.0	83.3	88.8	100.0
0.2	96.7	100.00	100.0	96.7	100.00	100.0
Control	--	10.0	13.3	--	--	--

Fig.(1) Log. concentration - percent mortality relationship between DDT in liquid bait and adults of *D. cucurbitae* observed at 6,12 and 24 hours after exposure to snake gourd leaves sprayed with the bait fluid.

Fig.(2) -do- using BHC in the bait.

Fig.(3) -do- using parathion in the bait.

Fig.(4) -do- using malathion in the bait.

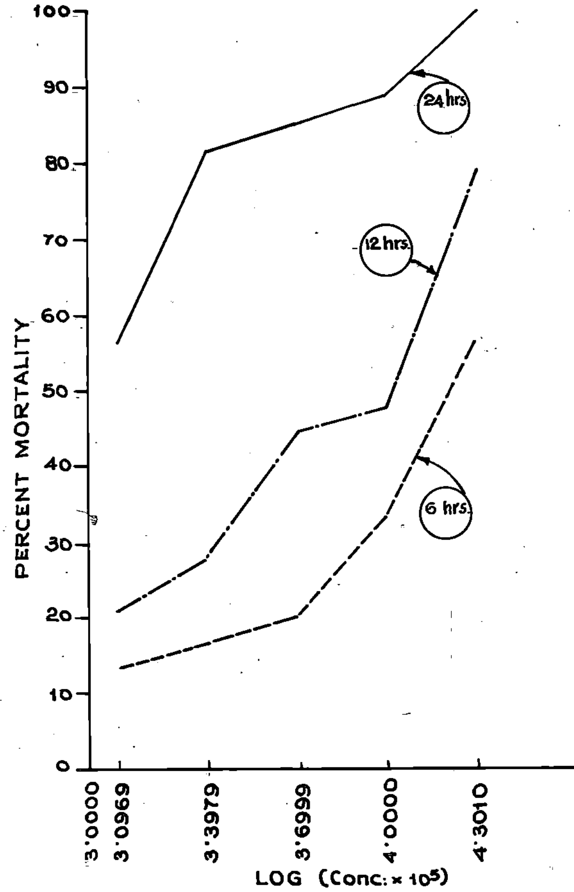

FIG. 1

DDT (Spray)

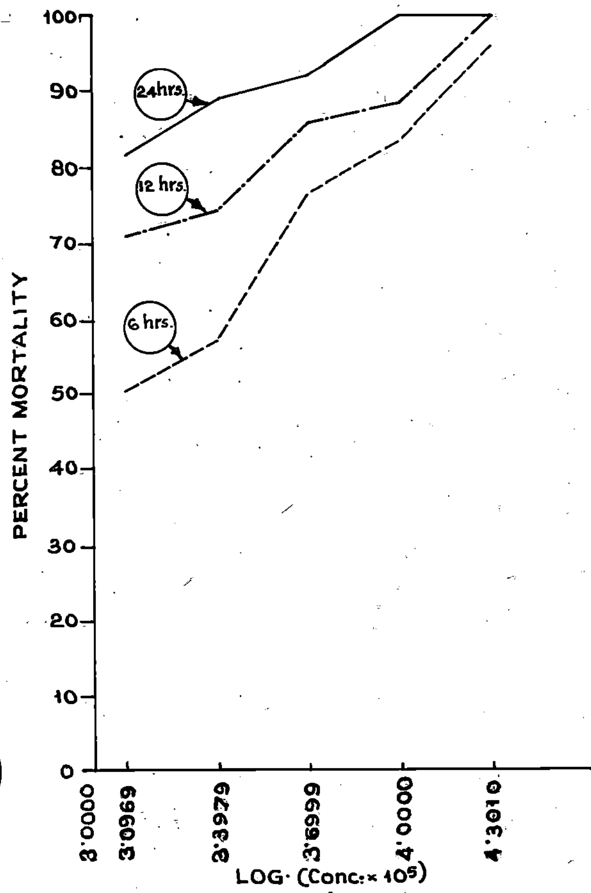

FIG. 2

B H C (Spray)

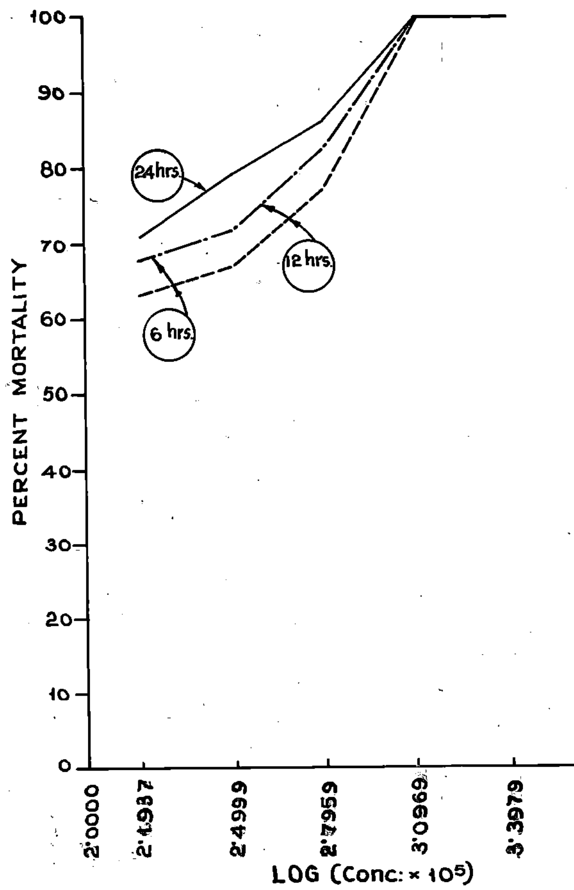

FIG. 3

PARATHION (Spray)

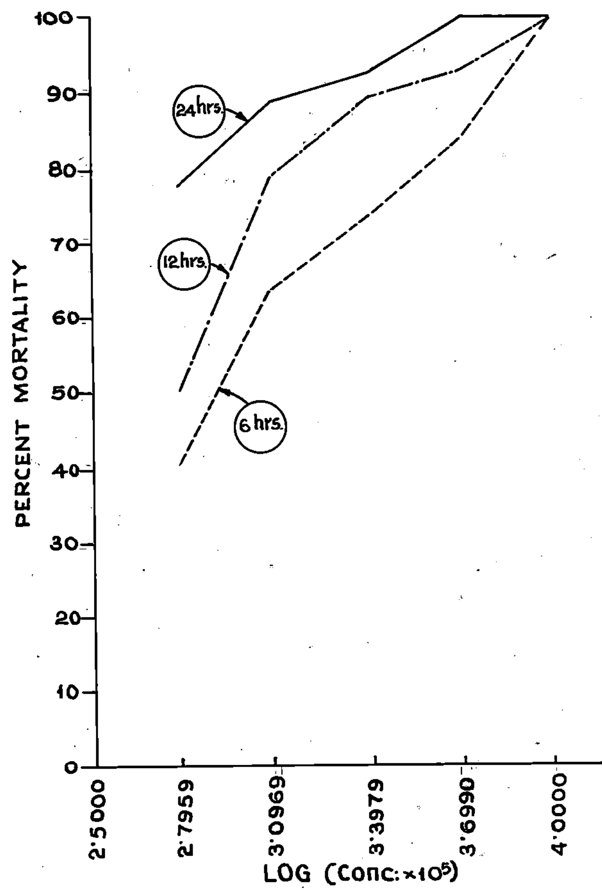

FIG. 4

MALATHION (Spray)

and represented in Fig.2. It is observed that concentrations of 0.1% and 0.2% BHC bring about 100 percent mortality in 24 and 12 hours respectively. Eventhough the other concentrations do not give 100 percent mortality among the flies, they also appear to be fairly effective producing 80.9 to 92.2 percent mortality in 24 hours.

EXPERIMENT.3

Concentration - mortality relation between parathion in bait sprays and adults of *D.cucurbitae*.

Experimental details:-

Test insecticide	:	Folidol E605
Concentrations of the insecticide used in bait sprays.	}	A = 0.0015625% B = 0.003125% C = 0.00625% D = 0.0125% E = 0.025%
Date of experiment	:	27--9--1964
Temperature during the experiment.	:	Mnm. 74°F Mxm. 82°F
Relative humidity during the experiment.	:	83%

Rest of the details as in experiment.1.

Results:- Results of the experiment are presented in Table III. The same results are represented graphically in Fig.3. It is

TABLE. III. Morality of adults of D. cucurbitae exposed to snake gourd leaves sprayed with bait fluid containing different concentrations of parathion.

Percentage of concentration	Percentage mortality after different periods of exposure					
	Observed			Corrected		
	6 hours	12 hours	24 hours	6 hours	12 hours	24 hours
0.0015625	63.3	70.0	73.3	63.3	67.7	70.3
0.003125	66.7	73.3	80.0	66.7	71.3	78.8
0.00625	76.7	83.3	86.7	76.7	82.1	85.2
0.0125	100.0	100.0	100.0	100.0	100.0	100.0
0.025	100.0	100.0	100.0	100.0	100.0	100.0
Control	--	6.7	10.0	--	--	--

obvious from the table that the highest two concentrations viz. 0.0125 percent and 0.025 percent cause cent per cent mortality even within 6 hours after the exposure of the flies on the sprayed leaf surface. It is further observed that the lower concentrations of 0.00625 to 0015 percent also give substantial kill of the flies (70.3 to 85.2%) in 24 hours.

EXPERIMENT:4

Concentration - mortality relation between malathion in bait sprays and adults of *D.cucurbitae*.

Experimental details:-

Test insecticide	:	Malathion. Technical
Concentrations of the insecticide used in bait sprays	{	A = 0.00625%
		B = 0.0125%
		C = 0.025%
		D = 0.05%
		E = 0.1%
Date of the experiment	:	5--10--1964.
Temperature during the experiment.	:	Mnm.76°F. Mxm.81°F.
Relative humidity during the experiment	:	74%

Rest of the details as in experiment.1.

Results:- Table IV shows the results which are also represented in Fig.4. It will be observed that 0.1 percent malathion gives 100% mortality within 6 hours of exposure to the sprayed leaves. Malathion at 0.05 percent concentration shows 100 percent mortality among the flies within 24 hours of exposure. The concentration

TABLE. IV. **Mortality of adults D. cucurbitae exposed to snake gourd leaves sprayed with bait fluid containing different concentrations of malathion.**

Percentage of concentration	Percentage mortality after different periods of exposure.					
	Observed			Corrected		
	6 hours	12 hours	24 hours	6 hours	12 hours	24 hours.
0.00625	40.0	53.3	80.0	40.0	50.0	77.7
0.0125	63.3	80.0	90.0	63.3	78.5	88.8
0.025	73.3	90.0	93.3	73.3	89.3	92.5
0.05	83.3	93.3	100.0	83.3	92.8	100.0
0.1	100.0	100.0	100.0	100.0	100.0	100.0
Control	—	6.6	10.0	—	—	—

of 0.025 percent also gives a substantial kill of the flies (92.5%) within 24 hours.

EXPERIMENT: 5.

Concentration - mortality relation between Dipterex in bait sprays and adults of D. cucurbitae.

Experimental details:-

Test insecticide : Dipterex 80% SP

Concentrations of the insecticide used in bait sprays:
- A = 0.0007%
- B = 0.003125%
- C = 0.0125%
- D = 0.05%
- E = 0. 2%

Date of experiment	:	9--11--1964
Temperature during the experiment.	:	Mnm. 74°F. Mxm. 81°F.
Relative humidity during the experiment	:	86%

Rest of the details as in experiment.1.

Results:- Results of the experiment are presented in Table V and graphically represented in Fig.5 . It is seen

TABLE.V. Mortality of adults of *D.cucurbitae* exposed to snake gourd leaves sprayed with bait fluid containing different concentrations of dipterex.

Percentage of concentration	Percentage mortality after different periods of exposure					
	Observed			Corrected		
	6 hours	12 hours	24 hours	6 hours	12 hours	24 hours
0.0007	16.6	26.6	36.6	16.6	18.4	23.9
0.003125	36.6	83.3	93.3	36.6	81.4	91.9
0.0125	80.0	93.3	96.6	80.0	92.5	95.9
0.05	93.3	100.0	100.0	93.3	100.0	100.0
0.2	100.0	100.0	100.0	100.0	100.0	100.0
Control	---	10.0	16.6	---	---	---

that 0.2 percent dipterex produces 100 percent mortality among the flies within 6 hours of exposure to the sprayed leaves while a concentration of 0.05 percent produces the

same mortality in 12 hours of exposure. The two lower concentrations of 0.0125 and 0.003% also appear very effective giving 95.9 and 91.9 percent mortality respectively in 24 hours of exposure. The concentration of 0.0007% does not show any significant result.

EXPERIMENT.6

Concentration - mortality relation between Sevin in bait sprays and adults of *D. cucurbitae*.

Experimental details:-

Test insecticide	:	Sevin 50 percent WP
Concentrations of the insecticide used in bait sprays	{	A = 0.00625% B = 0.0125% C = 0.025% D = 0.05% E = 0.1 %
Date of experiment	:	5--4--1965
Temperature during the experiment.	:	Mnm. 81°F. Mxm. 88°F.
Relative humidity during the experiment.		91%

Rest of the details as in experiment.1.

<u>Results</u>:- Results are given in Table VI and represented in Fig.6. It will be observed that 0.1% sevin gives complete mortality of the flies within 24 hours of exposure to the sprayed leaves. The immediate two lower concentrations i.e. 0.05 percent and 0.025 percent also give a

TABLE.VI Mortality of adults of *D.cucurbitae* exposed to snake gourd leaves sprayed bait fluid containing different concentrations of sevin.

Percentage of cocentration	Percentage mortality after different periods of exposure					
	Observed			Corrected		
	6 hours	12 hours	24 hours	6 hours	12 hours	24 hours
0.00625	36.6	56.6	63.3	36.6	56.6	59.2
0.0125	46.6	66.6	73.3	46.6	66.6	70.3
0.025	56.6	70.0	83.3	56.6	70.0	81.4
0.05	73.3	80.0	96.7	73.3	80.0	96.2
0.1	90.0	93.3	100.0	90.0	93.3	100.0
Control	—	—	10.0	—	—	—

substantial kill of the flies (96.2 and 81.4 percent respe-ctively) within 24 hours. The remaining two concentrations of 0.0125 and 0.00625 percent do not appear to be very effective as they give only 70.3 and 59.2 percent mortality among the flies in 24 hours of contact with the sprayed leaves

Fig.(5) Log. concentration - percent mortality relationship between dipterex in liquid bait and adults of D.cucurbitae observed at 6,12 and 24 hours after exposure to snake gourd leaves sprayed with the bait fluid.

Fig.(6) -do- using sevin in the bait.

Fig.(7) Log. concentration - percent mortality relationship between DDT in liquid bait and adults of D.cucurbitae observed at 6,12 and 24 hours after exposure to droplets of the bait applied on glass surface.

Fig.(8) -do- using BHC in the bait.

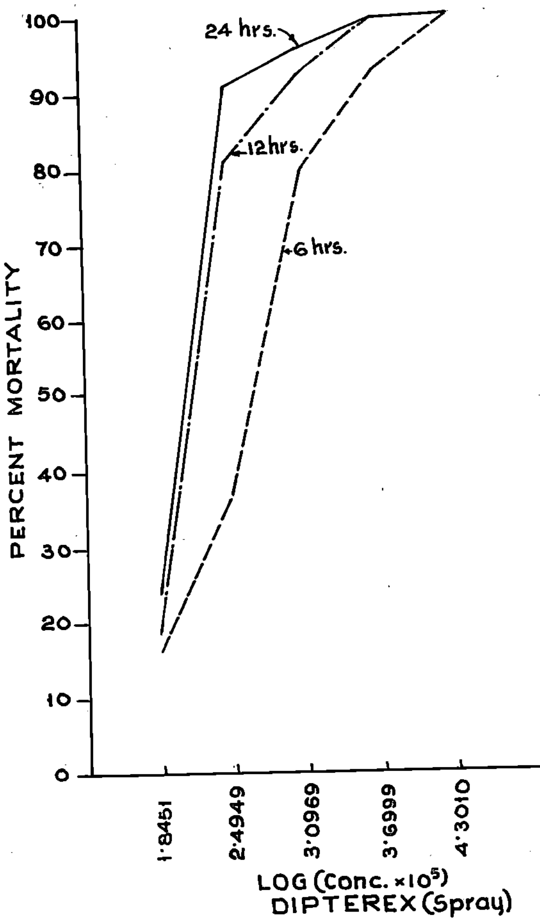

FIG. 5

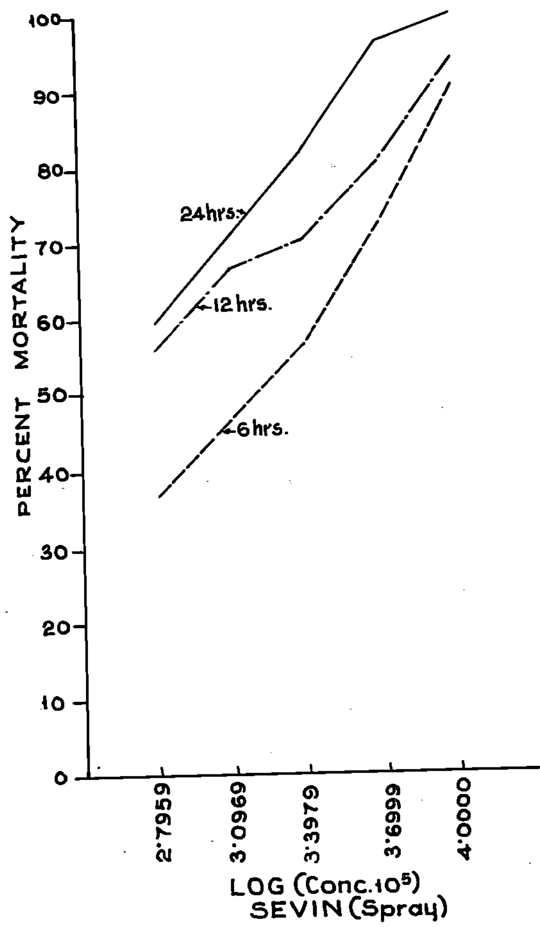

FIG. 6

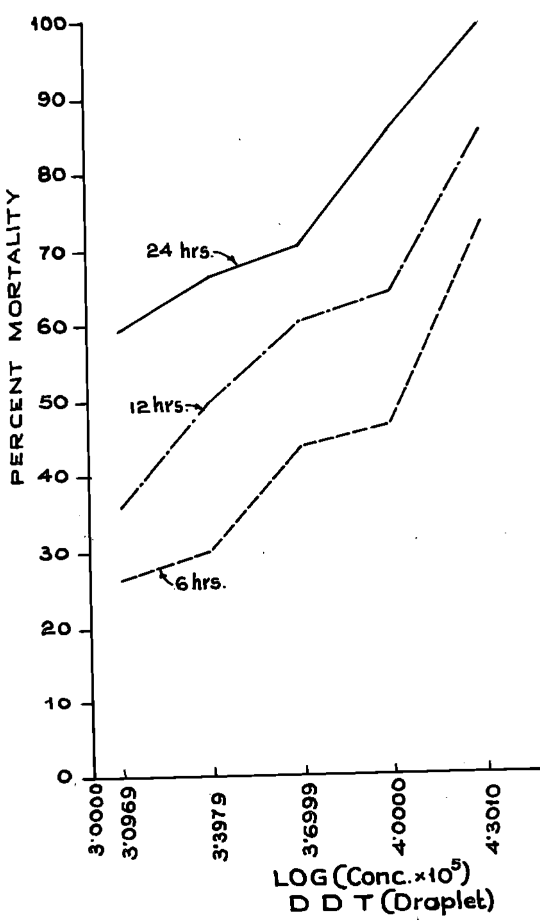

FIG. 7

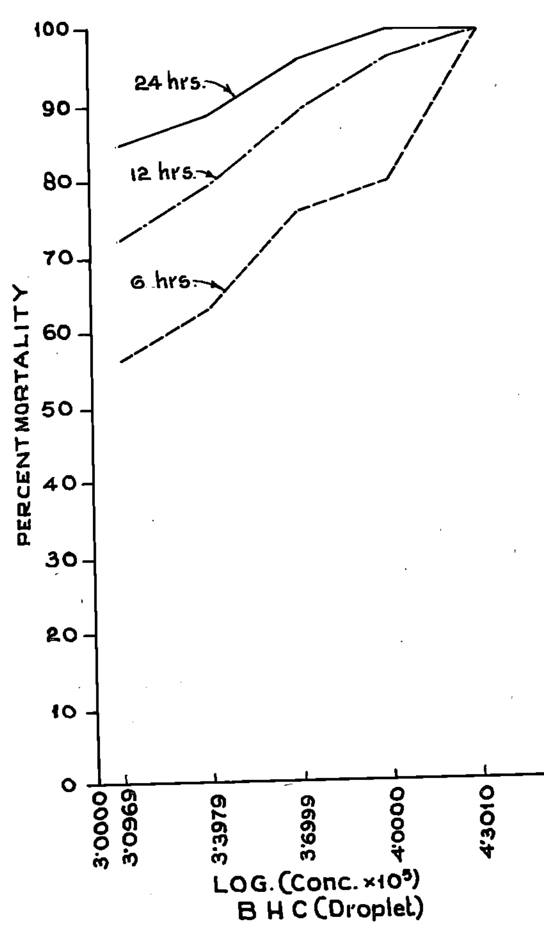

FIG. 8

SERIES.II

When liquid bait is applied as droplets.

EXPERIMENT.7

Concentration - mortality relation between DDT in liquid bait applied as droplets and adults of D.cucurbitae.

Experimental details:-

Date of experiment	:	19--1--1965
Temperature during the experiment	:	Mnm.76°F. Mxm.81°F.
Relative humidity during the experiment	:	86%

Procedure : The bait fluid containing the different concentrations of the insecticide were applied as droplets on the inner side of clean petri-dishes and then exposed to adult fruit flies as described on page 41.

Rest of the details as in experiment.1.

Results:- Results of the experiment are presented in Table VII which gives the percentage mortalities of fruit flies at various intervals after exposure to droplets of bait fluid containing different concentrations of DDT.

TABLE.VII. Mortality of adults of D.cucurbitae exposed to droplets of bait fluid containing different concentrations of DDT.

Percentage of concentration	Percentage mortality after different periods of exposure					
	Observed			Corrected		
	6 hours	12 hours	24 hours	6 hours	12 hours	24 hours
0.0125	26.4	40.0	63.3	26.4	35.7	59.2
0.025	30.0	53.3	70.0	30.0	50.0	66.6
0.05	43.3	63.3	73.3	43.3	60.6	70.3
0.1	46.7	66.6	86.7	46.7	64.2	85.2
0.2	73.3	86.7	100.00	73.3	85.6	100.0
Control	--	6.6	10.0	--	--	--

The same results are depicted in Fig.7. It will be observed that only the highest concentration of DDT under trial i.e. 0.2%, causes cent per cent mortality to the fruit flies within a period of 24 hours of exposure. The next lower concentration of 0.1% also gives a fairly good mortality of 85.2 percent while the other concentrations do not show significant results at all.

EXPERIMENT.8

Concentration - mortality relation between BHC in liquid bait applied as droplets and adults of D.cucurbitae

Experimental details:-

Date of experiment : 11--2--1965

Temperature during the experiment : Mnm.78°F. Mxm.82°F.

Relative humidity during the experiment : 84%

Rest of the details as in experiment.7.

Results:- Results of the experiment are given in Table VIII and represented in Fig.8. It may be observed that

TABLE.VIII **Mortality of adults of D.cucurbitae exposed to droplets of bait fluid containing different concentration of BHC.**

Percentage of concentration	Percentage mortality after different periods of exposure					
	Observed			Corrected		
	6 hours	12 hours	24 hours	6 hours	12 hours	24 hours
0.0125	56.7	73.3	86.7	56.7	72.3	85.2
0.025	63.3	80.0	90.0	63.3	79.3	88.8
0.05	76.7	90.0	96.7	76.7	89.6	96.2
0.1	80.0	96.7	100.0	80.0	96.5	100.0
0.2	100.0	100.0	100.0	100.0	100.0	100.0
Control	--	3.3	10.0	--	--	--

0.2% and 0.1% BHC in the bait causes cent per cent mortality of the flies in 6 hours and 24 hours of exposure respectively to the droplets. BHC at 0.05% also appears to be nearly as effective as the higher concentrations giving 96.2 percent mortality in 24 hours. The lowest two concentrations(0.025 and 0.0125%) also produce high mortality of flies in 24 hours(88.8 and 85.2 percent respectively).

EXPERIMENT.9

Concentration - mortality relation between parathion in liquid bait applied as droplets and adults of D.cucurbitae

Experimental details:-

Test insecticide	:	Folidol E605
Concentrations of the insecticide used in bait sprays		A = 0.0015625% B = 0.003125% C = 0.00625% D = 0.0125% E = 0.025%
Date of experiment		5--4--1965
Temperature during the experiment	:	Mnm.82°F. Mxm.88°F.
Relative humidity during the experiment	:	91%

Rest of the details as in experiment.7

Results:- Results of the experiment are presented in Table IX and are graphically represented in Fig. 9. It is evident that a concentration of 0.0125% of

TABLE. IX Mortality of adults of *D. cucurbitae* exposed to droplets of bait fluid containing different concentrations of parathion

Percentage of concentration	Percentage of mortality after different periods of exposure					
	Observed			Corrected		
	6 hours	12 hours	24 hours	6 hours	12 hours	24 hours
0.0015625	73.3	83.3	86.7	73.3	81.4	85.2
0.003125	83.3	86.7	90.0	83.3	85.2	88.8
0.00625	86.7	90.0	93.3	86.7	88.8	92.5
0.0125	100.0	100.0	100.0	100.0	100.0	100.0
0.025	100.0	100.0	100.0	100.0	100.0	100.0
Control	--	10.0	10.0	--	--	--

parathion in the bait is as effective in killing the flies as 0.025%, both the concentrations giving 100 percent mortality in 6 hours of exposure to the sprayed leaves. The lower three concentrations of 0.00625, 0.003125 and 0.0015% also appear highly effective showing 92.5, 88.8 and 85.2 percent mortality respectively after 6 hours of exposure.

EXPERIMENT.10

Concentration - mortality relation between malathion in liquid bait applied as droplets and adults of D.cucurbitae

Experimental details:-

Test insecticide	:	Malathion. Technical
Concentrations of insecticide used in bait sprays	{	A= 0.00625% B= 0.0125% C= 0.025% D= 0.05% E= 0.1%
Date of experiment	:	3--4--1965
Temperature during the experiment	:	Mnm.82°F. Mxm.86°F.
Relative humidity during the experiment	:	87%

Rest of the details as in experiment.7

Results:- Results of the experiment are presented in Table X and Fig.10. It is seen that 0.1% malathion in the bait causes cent per cent mortality to the flies in 6 hours, 0.05% in 12 hours and 0.025% in

Fig.(9) Log.concentration - percent mortality relationship between parathion in liquid bait and adults of D.cucurbitae observed at 6,12 and 24 hours after exposure to droplets of the bait applied on glass surface.

Fig.(10) -do- using malathion in the bait.

Fig.(11) -do- using dipterex in the bait.

Fig.(12) -do- using sevin in the bait.

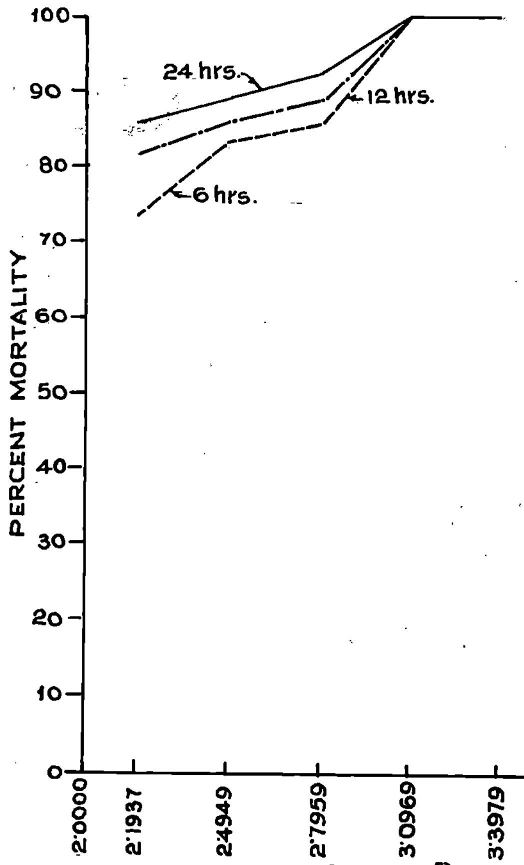

FIG. 9

LOG. (Conc.×10^5)
PARATHION (Droplets)

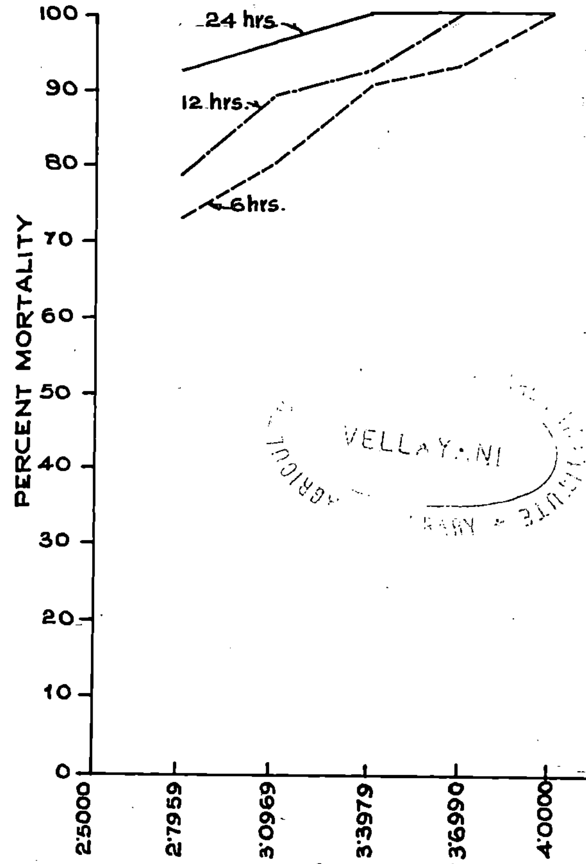

FIG. 10

LOG (Conc.×10^5)
MALATHION (Droplets)

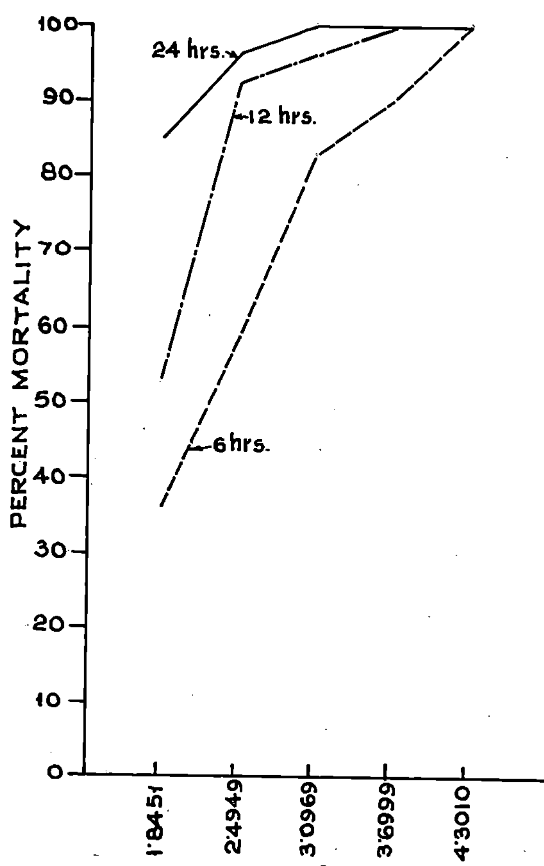

FIG. 11

LOG (Conc.×10^5)
DIPTEREX (Droplets)

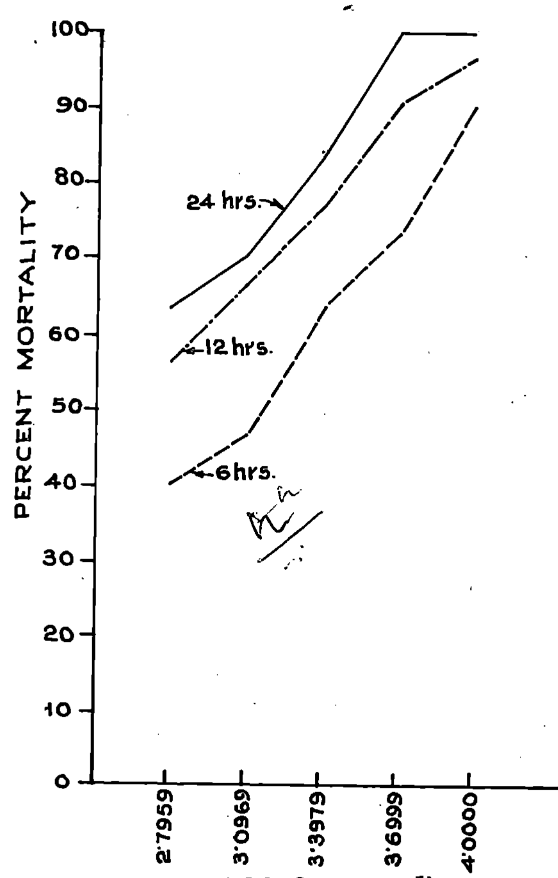

FIG. 12

LOG. (Conc.×10^5)
SEVIN (Droplets)

TABLE.X **Mortality of adults of D.cucurbitae exposed to droplets of bait fluid containing different concentrations of malathion**

Percentage of concentration	Percentage of mortality after different periods of exposure					
	Observed			Corrected		
	6 hours	12 hours	24 hours	6 hours	12 hours	24 hours
0.00625	73.3	80.0	93.3	73.3	78.5	92.8
0.0125	80.0	90.0	96.6	80.0	89.3	96.3
0.025	90.0	93.3	100.0	90.0	92.8	100.0
0.05	93.3	100.0	100.0	93.3	100.0	100.0
0.1	100.0	100.0	100.0	100.0	100.0	100.0
Control	—	6.6	6.6	—	—	—

24 hours. The remaining two lower concentrations of 0.0125 and 0.00625% also appear very highly toxic to the flies giving 96.3 and 92.8 percent kill respectively in 24 hours of exposure.

EXPERIMENT.11

Concentration - mortality relation between dipterex in liquid bait applied as droplets and adults of D.cucurbitae

Experimental details:-

Test insecticide : Dipterex 80% SP

Concentrations of insecticide used in bait sprays		A = 0.0007% B = 0.003125% C = 0.0125% D = 0.05% E = 0.2%
Date of experiment	:	8--2--1965
Temperature during the experiment	:	Mnm. 78°F. Mxm. 82°F.
Relative humidity during the experiment	:	87%

Rest of the details as in experiment.7.

Results:- Table XI and Fig.11 show the results. It is

TABLE.XI Mortality of adults of D.cucurbitae exposed to droplets of bait fluid containing different concentrations of dipterex

Percentage of concentration	Percentage of mortality after different periods of exposure					
	Observed			Corrected		
	6 hours	12 hours	24 hours	6 hours	12 hours	24 hours
0.0007	36.6	56.1	86.6	36.6	53.1	85.1
0.003125	59.4	93.3	96.6	59.4	92.8	96.2
0.0125	83.3	96.6	100.0	83.3	96.3	100.0
0.05	90.0	100.0	100.0	90.0	100.0	100.0
0.2	100.0	100.0	100.0	100.0	100.0	100.0
Control	—	6.6	10.0	—	—	—

seen that cent per cent mortality is caused by 0.2 percent dipterex in 6 hours, by 0.05 percent in 12 hours and by 0.0125 percent in 24 hours of exposure to the droplets. Even the lowest two doses of 0.003 and 0.0007% also are seen to be highly effective producing 96.2 and 85.1 percent mortality respectively in 24 hours of exposure.

EXPERIMENT.12

Concentration - mortality relation between sevin in liquid bait applied as droplets and adults of D.cucurbitae

Experimental details:-

Test insecticide	:	Sevin 50% WP
Concentration of the insecticide used in bait sprays	{	A= 0.00625% B= 0.0125% C= 0.025% D= 0.05% E= 0.1%
Date of experiment	:	5--4--1965
Temperature during the experiment	:	Mnm.82°F. Mxm.88°F.
Relative humidity during the experiment.	:	91%

Rest of the details as in experiment.7

Results:- Results of the experiment are presented in Table XII and Fig.12. It will be observed that 0.1% and 0.05% sevin in the bait cause cent per cent mortality to the flies in 24 hours. The next lower concentration 0.025% also gives a good kill of the flies in 24 hours of exposure, the mortality being 83.3 percent. Concentrations of 0.0125 and 0.00625% do not appear to be significantly effective.

TABLE.XII Mortality of adults of D.cucurbitae exposed to droplets of bait fluid containing different concentrations of sevin

Percentage of concentration	Percentage of mortality after different periods of exposure					
	Observed			Corrected		
	6 hours	12 hours	24 hours	6 hours	12 hours	24 hours
0.00625	40.0	56.6	63.3	40.0	56.6	63.3
0.0125	46.6	66.6	70.0	46.6	66.6	70.0
0.025	63.3	76.6	83.3	63.3	76.6	83.3
0.05	73.3	90.0	100.0	73.3	90.0	100.0
0.1	90.0	96.7	100.0	90.0	96.7	100.0
Control	--	--	--	--	--	--

B. Experiments to compare the residual toxicity of insecticides when used in bait sprays under field conditions

A set of 6 experiments using the 6 insecticides under trial were undertaken to assess their residual toxicity to adults of D.cucurbitae when used in bait sprays under field conditions. Each insecticide was used at a single standard concentration. Following are the details of the experiments and their results:-

EXPERIMENT.13

Residual toxicity of 0.2% DDT to adults of D.cucurbitae when applied in bait sprays on snake gourd leaves

Experimental details:-

Date of experiment	:	11--2--1965
Temperature during the experiment	:	Mnm.78°F. Mxm.82°F.
Relative humidity during the experiment	:	84%

Procedure: The bait fluid containing the insecticide was sprayed on the under surface of snake gourd leaves in the field as described on 'Methods'. To assess the residual toxicity of the insecticide, the sprayed leaves were collected from the field at intervals of

1 hour, 3 days and 10 days. They were then sprayed with 1% yeast-protein solution except those leaves collected 1 hour after spraying and exposed to the flies in the test cages. Mortality counts were taken after 24 hours of exposure.

Results:- Results of the experiment are given in Table XIII and represented in Fig.13. It is observed

TABLE.XIII , Mortality of adults of D.cucurbitae in 24 hours on snake gourd leaves sprayed with 0.2% DDT when exposed at various intervals after spraying

Intervals after spraying	Observed percentage mortality		Corrected mortality
	Treatment	Control	
1 hour	100.0	10.0	100.0
3 days	13.3	0.0	13.3
10 days	10.0	0.0	10.0

that 100 percent mortality is caused to the flies when they are exposed to the leaves 1 hour after spraying. When the flies are exposed to the leaves 3 days and 10 days after spraying, the mortalities are only 13.3 and 10.0 percent respectively.

EXPERIMENT.14

Residual toxicity of 0.2% BHC to adults of D.cucurbitae when applied in bait sprays on snake gourd leaves

Experimental details:-

Date of experiment	:	11--2--1965
Temperature during the experiment	:	Min. 78°F. Max. 82°F.
Relative humidity during the experiment	:	84%

Rest of the details as in experiment.13.

Results:- Table XIV and Fig.13 show the results. It is seen that BHC 0.2% sprayed on leaves in field conditions is sufficient to cause total mortality to the fruit flies when exposed to them 1 hour after the application

TABLE.XIV. **Mortality of adults of D.cucurbitae in 24 hours on snake gourd leaves sprayed with 0.2% BHC when exposed at various intervals after spraying**

Intervals after spraying	Observed percentage mortality		Corrected mortality
	Treatment	Control	
1 hour	100.0	13.3	100.0
3 days	36.6	—	36.6
10 days	16.6	—	16.6

of the insecticide. But the mortality percentage declines to 36.6 percent in 3 days and 16.6 percent in 10 days of weathering of the insecticide deposit in the field.

EXPERIMENT.15

Residual toxicity of 0.025% parathion to adults of D.cucurbitae when applied in bait sprays on snake gourd leaves

Experimental details:-

Date of experiment	:	19—1—1965
Temperature during the experiment	:	Mnm.70°F. Mxm.81°F.
Relative humidity during the experiment	:	86%

Rest of the details as in experiment.13.

Results:- Table XV shows the results of the experiment which are also represented in Fig.13. It is observed

TABLE.XV. Mortality of adults of D.cucurbitae in 24 hours on snake gourd leaves sprayed with 0.025% parathion when exposed at various intervals after spraying

Intervals after spraying	Observed percentage mortality Treatment	Control	Corrected mortality
1 hour	100.0	10.0	100.0
3 days	66.6	3.3	65.4
10 days	10.0	—	10.0

Fig.(13) Histograms showing the percent mortality of adults of *D.cucurbitae* on residues of liquid baits containing different insecticides on snake gourd leaves at 1 hour, 3 days and 10 days after spraying.

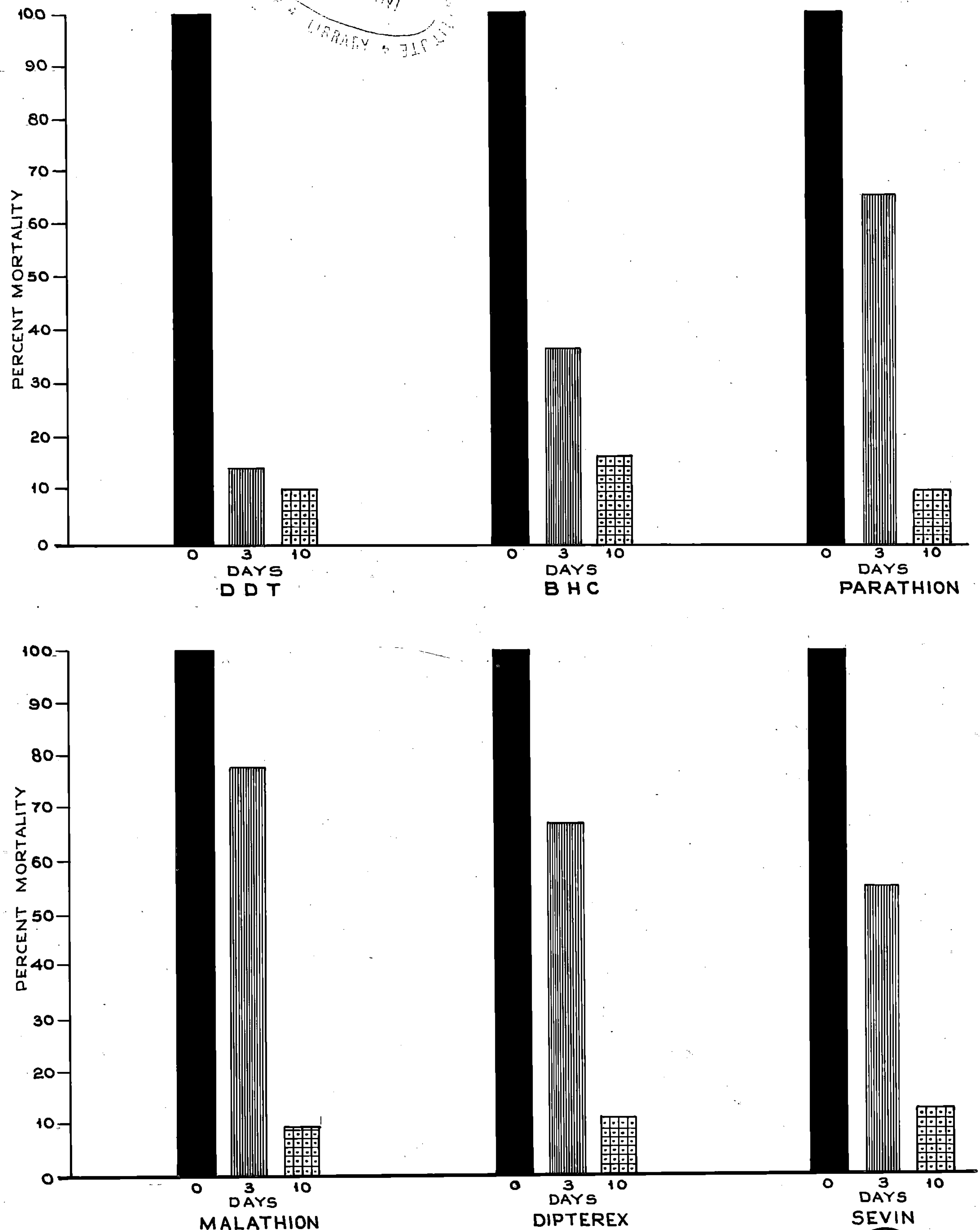
PERCENT MORTALITY
100
90
80
70
60
50
40
30
20
10
0
0 3 10
DAYS
D D T
DAYS
B H C
DAYS
PARATHION
DAYS
MALATHION
DAYS
DIPTEREX
DAYS
SEVIN

FIG:13

that the initial deposit of the insecticide on the leaves is sufficient to cause 100 percent mortality to the fruit flies in 24 hours of exposure. At the end of 3 days of weathering under field conditions, the residue causes 65.4 percent mortality to the flies. But after 10 days, the residue of the bait spray has little effect on the flies as it gives only 10.0 percent mortality after 24 hours of confinement on the treated leaf surface.

EXPERIMENT.16

Residual toxicity of 0.1 percent malathion to adults of *D.cucurbitae* when applied in bait sprays on snake gourd leaves

Experimental details:-

Date of experiment	:	11--2--1965
Temperature during the experiment	:	Mnm.78°F. Mxm.82°F.
Relative humidity during the experiment	:	84%

Rest of the details as in experiment.13

Results:- Results of the experiment are presented in Table XVI. The same results are illustrated in Fig.13. It is obvious from the table that cent per cent mortality of the flies is caused by the initial deposit of 0.1 percent malathion bait spray. After 3 days of

TABLE.XVI **Mortality of adults of D.cucurbitae in 24 hours on snake gourd leaves sprayed with 0.1% malathion when exposed at various intervals after spraying**

Intervals after spraying	Observed percentage mortality		Corrected mortality
	Treatment	Control	
1 hour	100.0	10.0	100.0
3 days	80.0	6.6	78.5
10 days	13.3	3.3	10.3

weathering under field conditions, the insecticide on the sprayed leaf surfaces is seen to be still highly effective producing 78.5 percent mortality. But after 10 days, the bait spray shows only very low residual action with a mortality of 10.3 percent.

EXPERIMENT.17

Residual toxicity of 0.2 percent dipterex to adults of D.cucurbitae when applied in bait sprays on snake gourd leaves

Experimental details:-

Date of experiment	:	19--1--1965
Temperature during the experiment	:	Mnm.76°F. Mxm.81°F.
Relative humidity during the experiment	:	86%

Rest of the details as in experiment.13.

Results:- Results of the experiment are given in Table XVII and the same is depicted in Fig.13. It is observed that the sprayed leaves retain enough deposit of the insecticide in the beginning to cause 100 percent mortality to the exposed flies. A mortality of 66.6 percent is caused to the flies by the insecticide residue remaining on the sprayed leaves 3 days after the spraying. However after 10

TABLE.XVII Mortality of adults of D.cucurbitae in 24 hours on snake gourd leaves sprayed with 0.2% dipterex when exposed at various intervals after spraying

Intervals after spraying	Observed percentage mortality		Corrected mortality
	Treatment	Control	
1 hour	100.0	16.6	100.0
3 days	66.6	—	66.6
10 days	13.3	3.3	10.3

days, the bait spray residue has little effect on the flies as it gives only 10.3 percent mortality to the flies.

EXPERIMENT.18

Residual toxicity of 0.1% sevin to adults of D.cucurbitae when applied in bait sprays on snake gourd leaves

Experimental details:-

Date of experiment	:	5--4--1965
Temperature during the experiment	:	Mnm.82°F. Mxm.88°F.
Relative humidity during the experiment	:	91%

Rest of the details as in experiment.13

Results:- Results of the experiment are presented in Table XVIII. The same results are illustrated in Fig.13.

TABLE.XVIII Mortality of adults of D.cucurbitae in 24 hours on snake gourd leaves sprayed with 0.1% sevin when exposed at various intervals after spraying

Intervals after spraying	Observed percentage mortality		Corrected mortality
	Treatment	Control	
1 hour	100.0	10.0	100.0
3 days	56.6	3.3	55.1
10 days	13.3	--	13.3

It is obvious from the table that 100 percent mortality is caused by the initial deposit of 0.1% sevin bait spray. After 3 days of weathering under field conditions, the insecticide on the sprayed leaf surfaces is seen to be effective to produce 35.2 percent mortality. But after 10 days, the bait spray shows only very low residual action with a mortality of 13.3 percent.

DISCUSSION

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DISCUSSION

In the present investigations, the relative toxicity of six of the newer synthetic insecticides to adults of D.cucurbitae when used in liquid baits was ascertained. The bait base used was yeast extract and the bait contained 1% of it. This material was found to attract the adult flies strongly.

Three sets of experiments were conducted.

They were:

1.Experiments to study toxicity of the insecticides in the bait to the flies when applied as a fine spray.

2.Experiments to study toxicity of the insecticides in baits when applied as droplets.

3.Experiments to determine residual toxicity of the insecticides in baits under field conditions.

In all these experiments, the surface (of leaf or petri-dishes) on which the insecticide bait was applied was exposed to the flies on the horizontal plane at the top of the wire-gauze test cage. This was based on the fact that the flies preferred to rest on horizontal surfaces facing downwards. For example, Eboling(1953) observed that there was a tendency among the melon flies to spend a higher proportion of their time on the underside of horizontal surfaces. In the present case, since the bait

Fig.(14) Log. concentration - probit mortality relationship between the insecticides in liquid bait and adults of *D.cucurbitae* observed at 12 hours after exposure to snake gourd leaves sprayed with the bait fluid.

Fig.(15) Log. concentration - probit mortality relationship between the insecticides in liquid bait and adults of *D.cucurbitae* observed at 12 hours after exposure to droplets of the bait applied on glass surface.

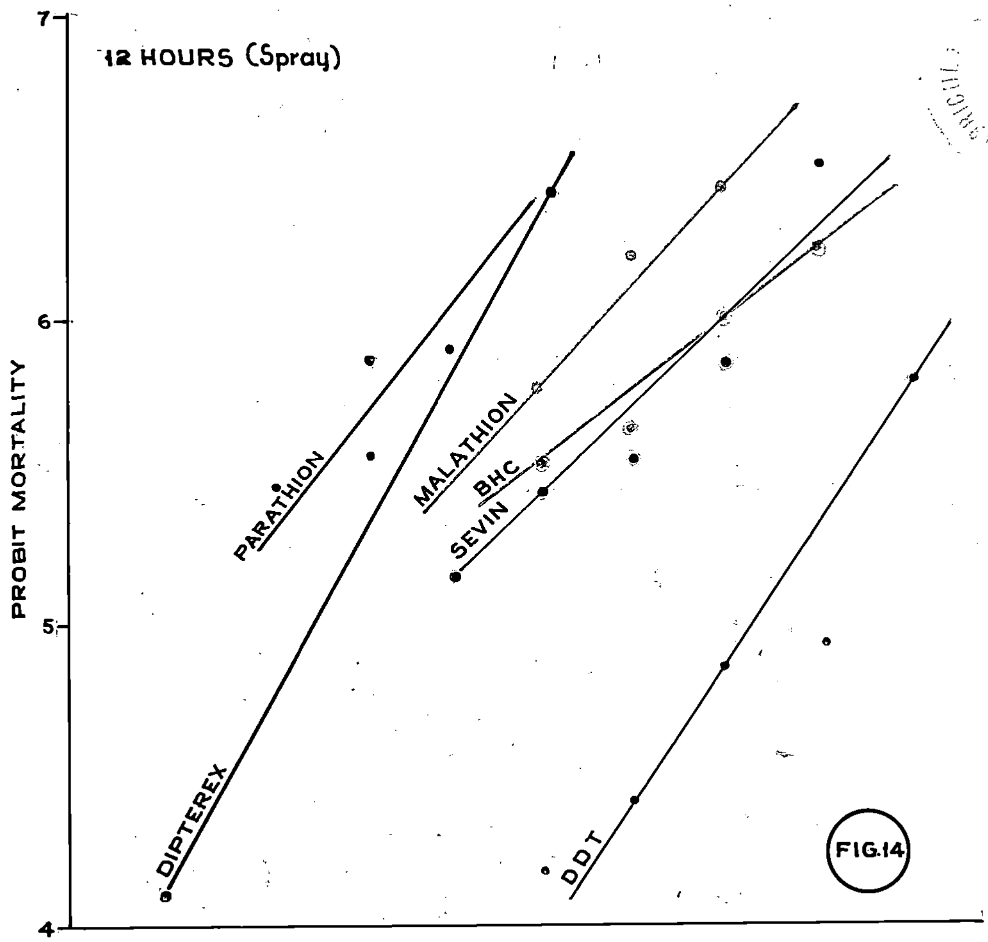
12 HOURS (Spray)
PROBIT MORTALITY
7
6
5
4
PARATHION
DIPTEREX
MALATHION
BHC
SEVIN
DDT

FIG.14

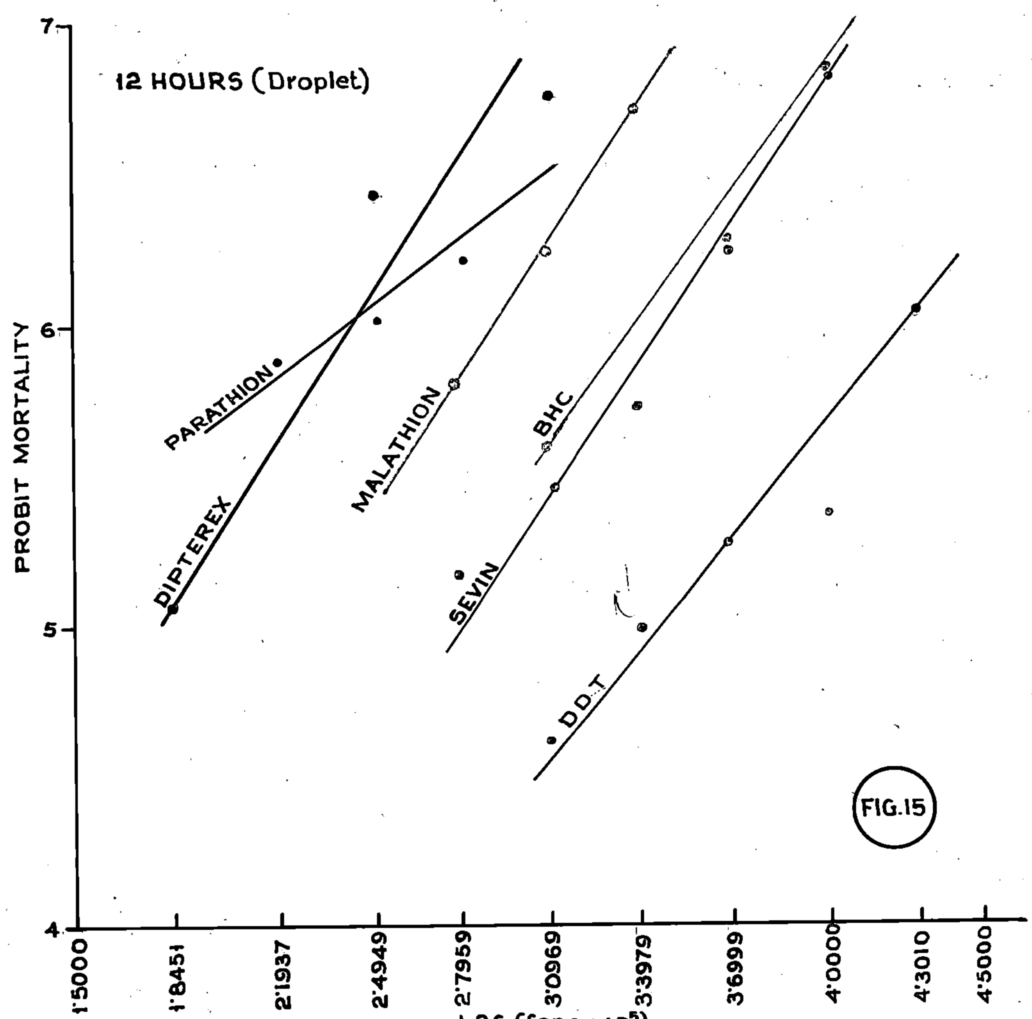
12 HOURS (Droplet)
PROBIT MORTALITY
7
6
5
4
PARATHION
DIPTEREX
MALATHION
BHC
SEVIN
DDT
1·5000
1·8451
2·1937
2·4949
2·7959
3·0969
3·3979
3·6999
4·0000
4·3010
4·5000
LOG (Conc. × 10^5)

FIG.15

contained an attractant, the flies immediately moved on to the exposed surface at the top of the test cages and started moving on them and feeding on the bait deposit. Thus both contact and stomach actions were involved in the overall mortality of the flies exposed to the bait deposits.

<u>Relative toxicity of the different insecticides to adults of *D. cucurbitae*</u>

Fig. 14 represents the log-dose probit mortality relationship between the different insecticides and adults of the fruit flies observed 12 hours after exposure to the bait deposits on snake gourd leaves applied by spraying the bait fluid as a fine spray. It will be observed that parathion and dipterex appear to be the most highly toxic of the insecticides, they themselves being nearly equitoxic. Next in toxicity to the flies ranks malathion. Sevin and BHC show the same toxicity to the flies and rank next to malathion. DDT is the least toxic and occupies a position much below the rest of the insecticides.

In the case of the bait fluid applied as droplets also, the relative toxicity of the different insecticides is of the same pattern as seen in the case of the bait sprays (Fig. 15). Parathion and dipterex have the same

Fig.(16) Log. concentration - probit mortality relationship between DDT in liquid bait applied as spray on snake gourd leaves and as droplets on glass surface on the one hand and adults of *D.cucurbitae* on the other observed 12 hours after exposure.

Fig.(17) Same as (16) but with BHC.

Fig.(18) Same as (16) but with parathion.

Fig.(19) Same as (16) but with malathion.

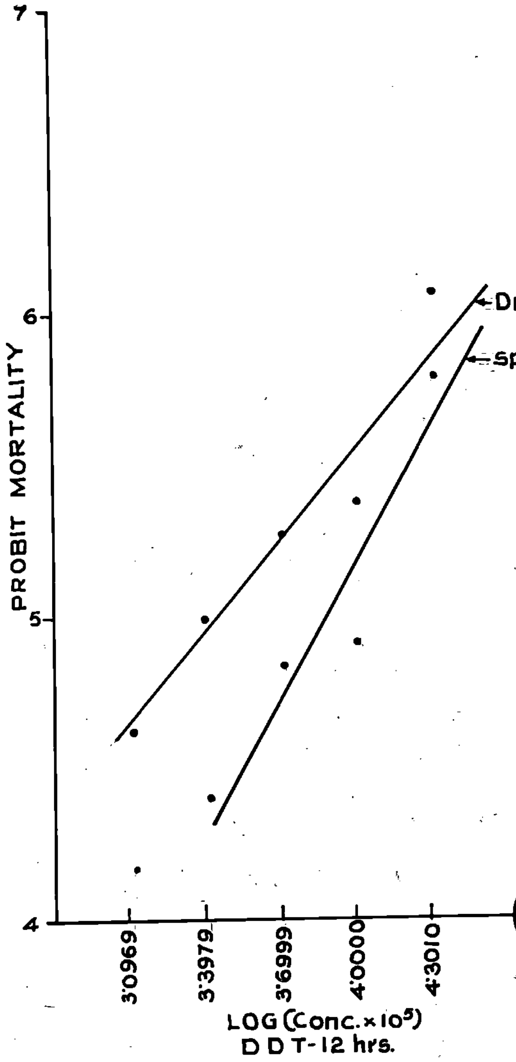

FIG.16

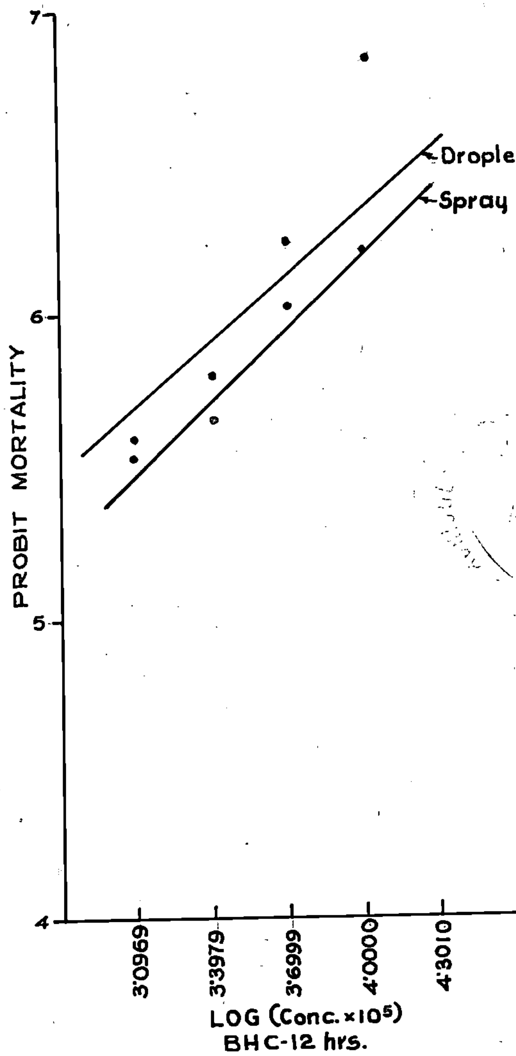

FIG.17

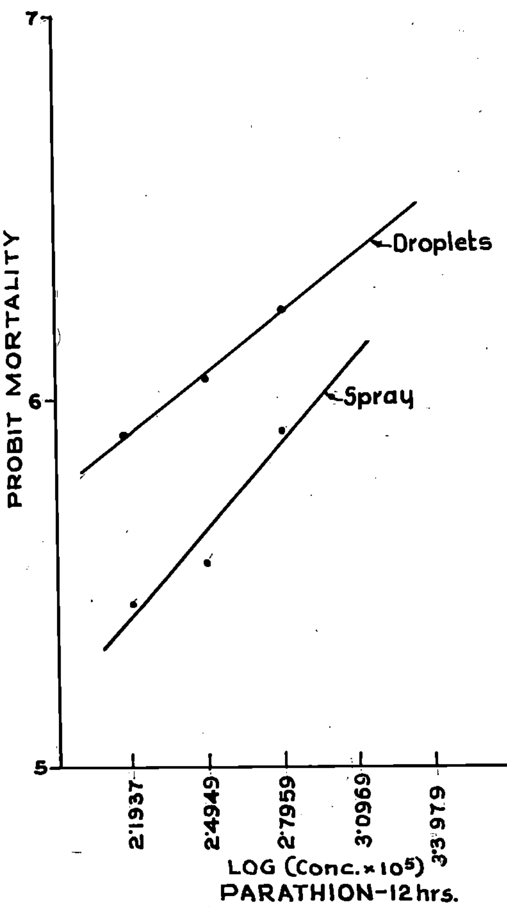

FIG.18

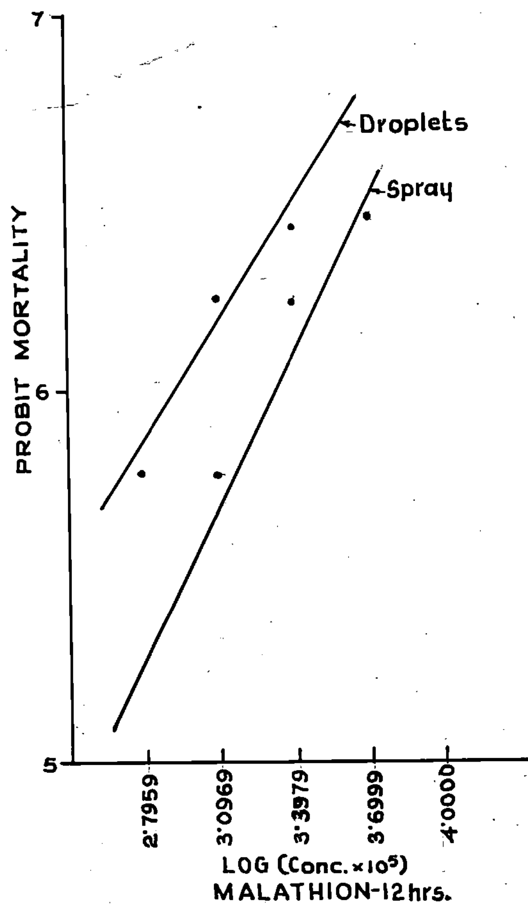

FIG.19

toxicity to the fruit flies and have also the highest toxicity among the toxicants under test. Malathion ranks next and this is followed by BHC and sevin which between themselves are equitoxic. DDT is far less toxic to the flies than all the others.

Fig.16 to 21 compare the toxicity of the different insecticides when applied as bait spray on the one hand and as bait droplets on the other. With every insecticide the droplets appear to be more effective in killing the flies than the residual sprays. This might be because the flies were able to ingest a larger dose of the bait fluid from droplets than from the fluid baits sprayed on the substrate surface as a fine spray. The chances of pick-up of the insecticide on the vulnerable external contact phases are likely to be more from a spray deposit than from a deposit of droplets, because the spray deposit is more uniform and continuous than the droplet deposits. But the toxic effect is more for the droplets. This observation indicates that the toxic effect of the insecticide in bait sprays to the fruit flies may be more due to the ingestion of the poison and the consequent stomach action than due to the contact action. So in practical field control of the flies also, it may be more advantageous to apply the bait liquid as a coarse spray rather than as a fine spray. The coarseness of the bait droplets should then be obviously such that they will remain on the foliage for a long time without being lost by run-off.

Residual toxicity of insecticides to adults of *D. cucurbitae*

This was tested under field conditions. The bait sprays containing the different insecticides were applied on snake gourd leaves and the fruit flies exposed to them 1 hour, 3 days and 10 days after spraying. The leaves with the bait residues collected on 3rd and 10th days were again sprayed with 1 percent yeast extract solution before being exposed to the flies. This was considered necessary to attract the flies to the sprayed leaf surface as well as to bring back the residue on the leaf surface to solution making it easily available to the flies.

Fig.22 represents the comparitive residual action of the six insecticides. Survivals of the flies confined on the leaves are shown in this figure. Each insecticide was used at the standard dose viz. DDT 0.2 percent, BHC 0.2 percent, parathion 0.025 percent, malathion 0.1 percent, dipterex 0.2 percent and sevin 0.1 percent. No flies survived when they were exposed for 24 hours to leaves sprayed with any of these insecticides 1 hour before

Fig. (20) Log. concentration - probit mortality relationship between dipterex in liquid bait applied as spray on snake gourd leaves and as droplets on glass surface on the one hand and adults of D. cucurbitae on the other observed 12 hours after exposure.

Fig. (21) Same as (20) but with sevin.

Fig. (22) Graph showing the survival of adults of D. cucurbitae when exposed to snake gourd leaves sprayed with liquid baits containing different insecticides, 1 hour, 3 days and 10 days after spraying.

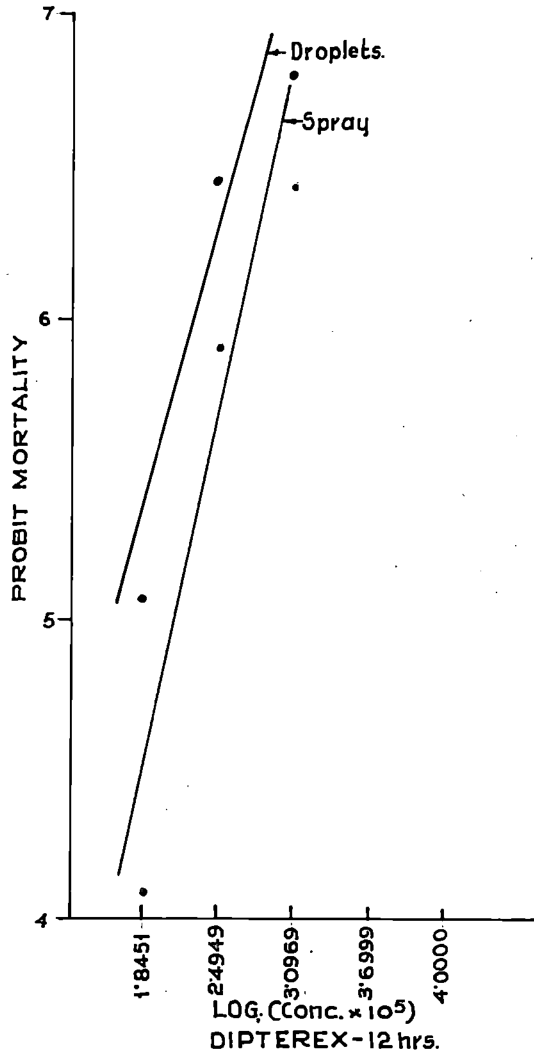

FIG. 20

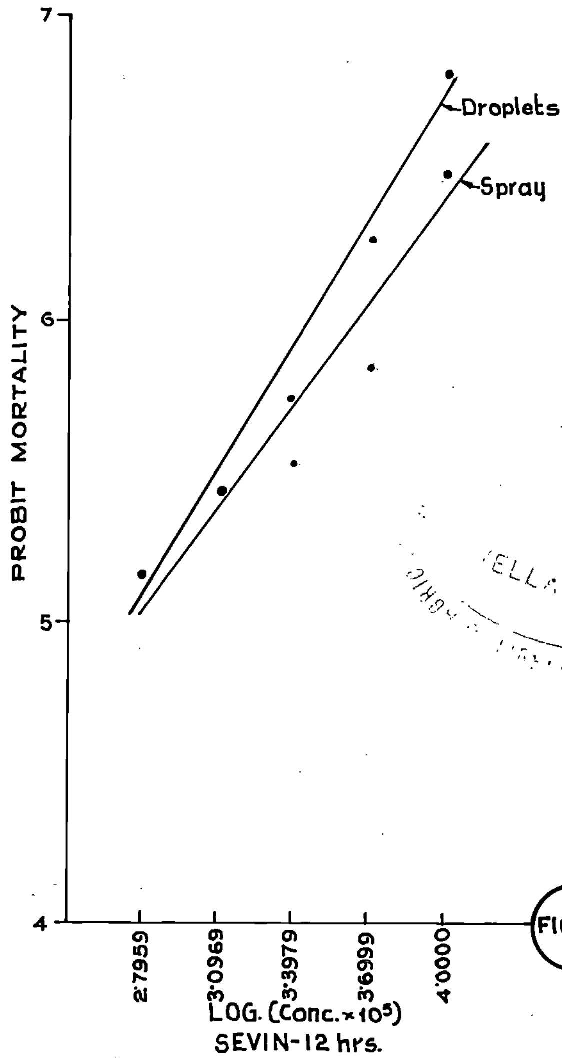

FIG. 21

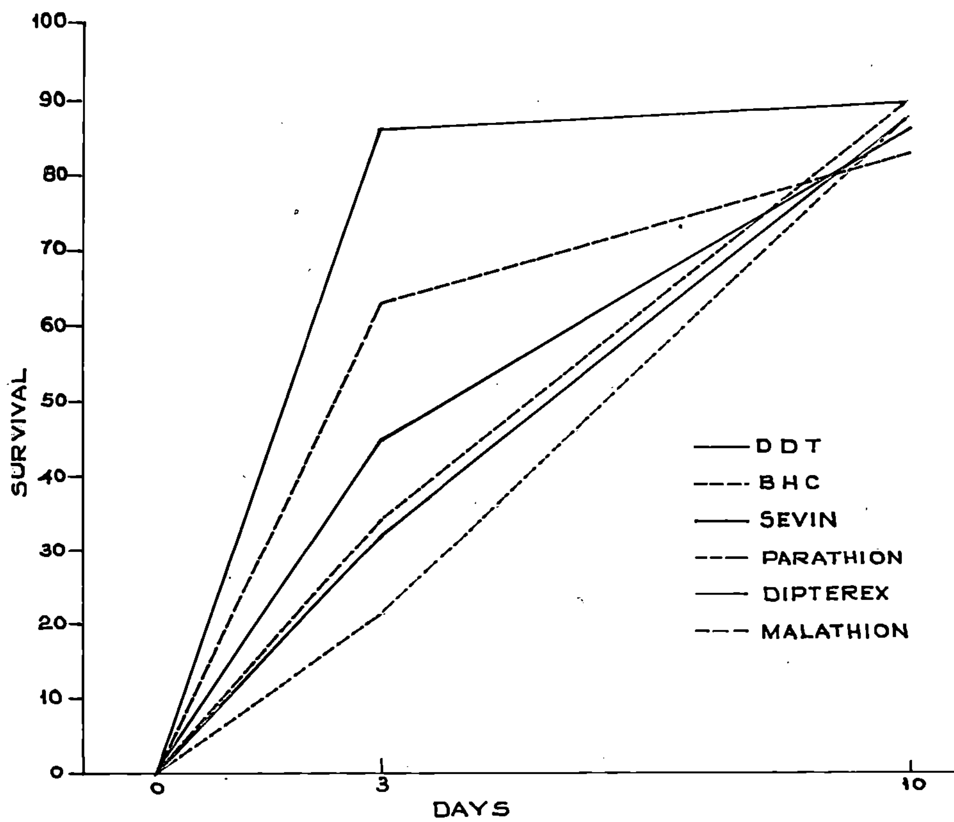

FIG. 22

exposure. But when the flies were confined on the leaves 3 days after application of the bait spray, the least survival(20%) was noted on the leaves with malathion 0.1% and the highest survival(86.7%) on leaves sprayed with DDT 0.2 percent. Less than 50% survival was observed on residues of sevin 0.1 percent(43.4%), parathion 0.025 percent(33.4%) and dipterex 0.2 percent (33.4%). Survival of flies on residue of BHC 0.2 percent was 63.4%. Thus it is interesting to note that DDT which is ordinarily considered more residual than malathion, dipterex, parathion and BHC appeared to be the least residual, the residual action being substantially lost in as short a period as 3 days. This phenomenon may be due to the translocation of the residue away from the leaf surface. It is known that contact insecticides are lipid soluble and are liable to be translocated into the cuticular lipids wherein they may remain as residues for varying periods depending upon the stability of the chemical. When an insecticide residue becomes translocated within the cuticular lipid, it becomes unavailable to be picked up by the insect moving on the leaf surface. DDT is highly lipid-soluble and the cuticle of the snake gourd leaf has a high wax content. So the apparent loss of toxicity of DDT to the flies may be attributed to its being translocated within the cuticular wax. Pradhan(1949) observed a similar phenomenon with marrow leaves(*Cucurbita pepo*).

None of the six insecticides persisted on the leaves to any significant extent upto 10 days after application.

Application of the bait-spray containing DDT and BHC caused scorching of snake gourd leaves and so they do not appear to be suitable for being used in bait sprays.

Conclusions

Among the six insecticides under trial only parathion, dipterex, malathion and sevin are suitable for being used in bait sprays on cucurbits as DDT and BHC cause scorching of leaves. The effectiveness of the four former insecticides is in the order parathion > dipterex > malathion > sevin.

Considering residue hazards, all these four insecticides are equally safe as the residual toxicity is lost rapidly.

Considering application hazards, malathion, dipterex and sevin are preferable to parathion.

Considering residual effect to control the flies, malathion is better than the others.

Thus overall considerations indicate that malathion 0.1% is the most suitable insecticide to be used in bait sprays against fruit flies.

Sprinkling or a coarse spray is a more efficient method of application of bait sprays than applying it as a fine spray.

SUMMARY

S U M M A R Y

The relative toxicity of six new synthetic insecticides namely DDT, BHC, parathion, malathion, dipterex and sevin to adults of D.cucurbitae was ascertained by exposing the flies:(a) to snake gourd leaves sprayed with the bait fluid and:(b) to droplets applied on glass surface.

The order of relative toxicity of the different insecticides was Parathion = Dipterex > Malathion > Sevin = BHC > DDT.

Coarse spray droplets of the baits were found to be more effective in killing the flies than the fine sprays. An explanation for this phenomenon is given. It is concluded that under field conditions for practical control, coarser sprays will be better than fine sprays of the liquid bait.

Residual toxicity of the insecticides under test to adults of D.cucurbitae was ascertained under field conditions. Each insecticide was used at the standard dose namely, DDT 0.2%, BHC 0.2%, parathion 0.025%,malathion 0.1%, dipterex 0.2% and sevin 0.1%. Initial deposit of all these insecticides gave cent per cent mortality to the flies. The relative residual toxicity of the bait sprays 3 days after application on snake gourd leaves was in the order Malathion > Parathion = Dipterex > Sevin > BHC > DDT. None of the six insecticides persisted on the

leaves to any significant extent 10 days after application. DDT, which has ordinarily higher residual action than the other insecticides, appeared to have very poor residual action in the present studies. An explanation is given for this phenomenon.

Application of bait spray containing DDT and BHC caused scorching of snake gourd leaves.

It has been concluded that sprinkling or a coarse spray with a liquid bait containing 1% yeast protein and 0.1% malathion is an effective method to control the melon fly D.cucurbitae without risk of poison hazards or phytotoxicity.

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APPENDIX

APPENDIX

RECORD OF TEMPERATURE AND HUMIDITY

Month	Weeks	Maximum temperature		Minimum temperature		Humidity	
		From	to	From	to	From	to
October	1	81	82	73	79	67	86
	2	80	83	76	78	77	90
	3	80	81	76	77	77	83
	4	80	81	76	78	80	90
November	1	80	81	74	76	85	90
	2	81	81	74	76	85	90
	3	81	81	76	76	85	91
	4	81	82	78	78	80	86
December	1	81	82	76	78	83	87
	2	82	83	76	78	91	92
	3	81	82	74	76	86	91
	4	82	83	74	76	87	91
January	1	81	83	76	78	83	91
	2	82	83	76	78	83	87
	3	81	82	76	78	86	90
	4	81	83	76	78	85	90
February	1	81	82	78	78	86	94
	2	81	82	74	78	83	90
	3	83	84	78	80	80	84
	4	83	84	78	80	80	84
March	1	83	84	76	78	86	90
	2	83	84	76	78	86	91
	3	86	88	78	80	86	91
	4	82	84	78	80	84	91
April	1	86	88	80	82	90	94
	2	86	90	80	82	91	96
	3	86	90	80	82	90	96
	4	86	90	80	82	92	96

PLATES