Residual Toxicity of some of the Commonly Recommended Insecticides against Spotted bollworm, Potato tuber moth, Cabbage aphid and Mango hopper

A Thesis

submitted to the

Maharashtra Krishi Vidyapeeth

in partial fulfilment of the

requirements for the Degree of

MASTER OF SCIENCE (Agriculture)

IN

AGRICULTURAL ENTOMOLOGY

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May, 1969

ACKNOWLEDGEMENTS

The author wishes to take this opportunity to express his deep sense of gratitude to Prof. R.N. Pokharkar, M.Sc.(Agri.), Asst. Professor of Agricultural Entomology, College of Agriculture, Poona for invaluable guidance, keen interest in the problem, prompt suggestions, constant encouragement and help in preparing the manuscript.

The author is also greatly indebted to Prof.G.M.Talgeri, M.Sc.(Agri.), F.E.S.I., Agricultural Entomologist, Department of Agriculture, Maharashtra State, Poona 5 and Head of Division of Agricultural Entomology, College of Agriculture, Poona for providing all the facilities for carrying out the studies. Similarly, he is grateful to Sarvashri R.G.Tilekar and A.G.Tilekar from Dehugaon (Dist: Poona), S.G.Bhandalkar Naik from Manjri (Dist:Poona) and N.B.Varkad from Khed (Dist: Poona) for providing land and other requirements for conducting the field experiments.

Lastly, the author wishes to extend his sincere thanks to all the staff members of the Entomology Division, College of Agriculture, Poona for their kind co-operation.

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Date: 19 APR 1969

C O N T E N T S

CHAPTER I

INTRODUCTION

Owing to the quick and effective control of the pests obtained by the use of pesticides, they have become extremely popular in human warfare against pests. In fact, their use has become a routine feature in the cultivation of many crops. However, due to the intensive and indiscriminate use of pesticides, several problems associated with their use have cropped in, important amongst which is the toxicity hazards due to pesticidal residues persisting on the treated commodities.

It is a common practice with the cultivators to use persistent insecticides against crop pests as it economises the treatment, However, such use particularly on edible crops poses a great problem of toxicity hazards due to their residues on treated commodities. Several instances of poisoning in human beings and other domestic animals due to the consumption of commodities treated with insecticides are reported every year from different parts of the world. It is therefore, needless to emphasize the necessity of having knowledge about the persistence of atleast those insecticides which are used in plant protection on different commodities under varying environmental conditions so as to utilize them successfully in pest control work.

Besides helping in reducing the toxicity hazards due to the insecticidal residues on treated surfaces, such knowledge on the persistence of insecticides also helps in fixing the interval between the two succeeding applications which in turn is useful in formulating an effective and economic pest control schedules.

Several workers in different countries of the world are engaged in this important aspect of plant protection chemicals. In fact, the advanced countries like U.S.A. have gone a step ahead in this line and have fixed tolerance limits in case of different insecticides which are regulated by a special legislature. Although in India unfortunately no such legal provision has yet been made, it is absolutely essential to find out the persistence of atleast commonly used insecticides on different crops. No doubt, some work has been carried out at the Indian Agricultural Research Institute, New Delhi and elsewhere, however, it seems that the problem has not received adequate attention.

In the State of Maharashtra also several insecticides are used in combating the pest menaces regardless of their consequences. In view of the importance and seriousness of the problem, it was felt necessary to undertake studies on the persistence of commonly used insecticides on at least

the crops of economic importance with the prime object of finding out an interval between two succeeding applications which will also help in formulating pest control schedules. Further such knowledge may also help in reducing the toxicity hazards due to their residues by avoiding the application of persistent insecticides on crops just prior to harvest.

During the course of present investigations (1967-69), the persistence of as many as 18 commonly used insecticides on cabbage, potato, bhendi and mango was studied both under laboratory and field conditions by bioassay method using Brevicoryne brassicae (L.), Gnorimoschema operculella (Zell.), Earias fabia (Stoll.) and Idiscopus atkinsoni (Leth.) as test species.

CHAPTER II

REVIEW OF LITERATURE

Although the use of chemicals in plant protection was started as early as 1865, it seems that very little attention was given to the problem of residual toxicity till the development of organic synthetic compounds for pest control. Berton (1944) was probably the first man to explain the technique of studying the residual toxicities of organic insecticides against different pests and considerable literature has been added thereafter. Recent literature contains many reports on persistence of insecticides on treated surfaces. Efforts have been made to review the available literature on the residual toxicity of insecticides and a review pertaining to the factors affecting the residual toxicity of insecticides against different crop pests and cabbage aphids, potato tuber moth, bhendi shoot and fruit borer and mango hoppers in particular is presented in this Chapter.

Of the two methods followed to determine the residual toxicity viz. biological assay and chemical analysis of the treated surfaces, the former was used during the present investigation and therefore the review presented here is mostly confined to the literature on biological assay.

According to Berton (1944) many organic insecticides although initially effective loose their toxicity in a few days or even in few hours due to weathering and other factors.

Burt and Ward (1955, 1956) grouped the factors affecting the residual toxicities as chemical, mechanical and physical. Losses due to chemical factors include decomposition caused by ultra-violet light, exposure to air and moisture and catalytic agents. High temperature accelerated the rate of loss of DDT applied to various surfaces are determined by using Tribolium castaneum(Hbst.) as a test insect. DDT sprayed glass plates kept at 18° C showed non significant reduction in toxicity while these stored at 43° C reduced the toxicity rapidly which was negligible after 26 days. Teotia and Dahm (1950) reported that residual toxicity of dieldrin, chlordane, parathion and lindane against Musca domestica F. was considerably reduced with high temperature and low humidity as compared to low temperature and high humidity. This loss was more rapid with aldrin, chlordane and lindane than dieldrin and para-thion. Dustan (1949) studied the effect of temperature on toxi-city of DDT against the larvae of Plutella maculipennis (Curt.)and observed that the toxicity steadily increased with rise in tempe-rature between 60° - 95° F.

The work carried out by Wright (1945) and then confirmed by Hadaway and Barlow (1949) suggested that direct sunlight deteriorated DDT deposits more rapidly. Treated plates when exposed to sunlight gave 10 per cent kill whereas the unexposed ones gave 95.00 per cent mortality of Glossina palpalis (R.D.) after the same period. Robert and Hoffman (1956) observed that temperature was the most important factor in deciding the insecticidal residues on treated surfaces.

It was further pointed out that the residual toxicity depends on the speed and extent to which poison is absorbed by the insect and how it acts on insect tissues; the speed and the extent at which the poison is eliminated.

Rains appeared to be the most important factor in reducing the DDT dust deposits on foliage during the 1st week after the treatment. It was further observed that even light showers received during the 1st week caused more reduction in residues than heavy rains received some time after 7-10 days. Reduction in the residues of parathion sprayed at the rate of 0.75 lb. and DDT at 1 lb. per acre on lettuce crop was to the tune of 91.5 and 77.0 per cent respectively due to 0.57" rain received one day after the spray (Hopkins et al. 1952).

Wind and rainfall has been reported to cause sufficient reduction in the residual toxicity of insecticides. Fennah (1945) exposed DDT deposits on slides to 1.6" intermittent rains for two days and observed that there was progressive reduction of DDT residues. Mistric and Gaines (1953) and Hopkins et al. (1952) studied the effect of wind on the residual toxicity of BHC and parathion. Wind with a velocity 6.2 mph caused 60 per cent reduction during the 1st week after treatment and 80 percent at the end of 24 days. This was practically equal to the losses caused by rainfall during the same period.

Loss of residues due to increase in the area of the treated surfaces by growth was studied by several workers. Sloan et al.(1951) reported that DDT residues on lettuce were reduced to 94.00 per cent per unit area of the leaves 14 days after the treatment. The losses only due to growth, were upto 73.00 per cent. The reduction in residues was reported to be more pronounced in case of crop like alfalfa which grows more rapidly. The growth of crop was a limit to the period of effectiveness of single application of insecticide. In case of crop which is actively growing and rapidly producing shoots, the period may be only 1-2 weeks (Hopkins et al. 1952).

Carter (1948) opined that the amount of residues on crops depended on weight of crop per unit urea, quantity of insecticides applied to the area, time between sampling and the last treatment, the total effect of growth and weathering factors. The decline in DDT deposits per unit area on alfalfa was 54 and 95 per cent 2 and 18 days after the treatment, while in case of parathion it was 66 and 100 per cent after the same period, thus showing that DDT was more persistent than parathion (Arant, 1948).

Nature of leaf surface also determines the amount of residues, Rogaff and Metcalf (1951) reported that glass plates sprayed with 3 ml. of DDT lost the toxicity more rapidly compared to avacado leaves treated in similar manner.

Burt and Ward (1956) studied comparative residual toxicities of insecticides on glass plates and different leaf surfaces and observed that deposits of insecticides were more toxic on leaves than on glass plates. These results were similar to those reported by Hogoff and Metcalf (1951).

The toxicity in case of leaves is more because of the presence of humidity in leaves which resulted in higher toxicity. Pradhan (1949) while working on the effects of humidity on the toxicity, reported that glass plates and waxy surfaces were less toxic than other surfaces. Batia (1957) compared the leaf surfaces of different plants with glass plates and reported that the later remained toxic for longer compared to plant leaf surfaces tested. He further observed that dieldrin was persistent for longer period than aldrin. The pots kept in laboratory showed less reduction in deposits compared to those kept outside. Wallis et al. (1957) while studying the residues of malathion on leafy and fleshy vegetables reported that residues were heavier and persisted longer on leafy vegetables than fleshy. Deposits with emulsions reduced faster than those from wettable powder sprays and dusts. Carbaryl at 1 lb. per acre was reported to remain toxic for longer time on cotton plants than the cole crops (Shovey and Reynolds 1962).

The residual toxicity of carbaryl, endrin and malathion against cereal leaf beetle Oulema melanopa L. was more on wheat plant than oat, (Ruppel and Yun 1965). Vail et al. (1967) studied the performance and persistence of different

insecticides and observed that the insecticides like parathion, endosulfan and dimethoate persisted longer on leafy vegetables than on cabbage.

Murti (1968) while working on the residual toxicity of carbaryl, endrin and malathion on cotton and bean leaves using Musca nebula F. as test insects reported that endrin was more persistent giving 26.15 and 59.65 per cent mortality after 10 days on cotton at 0.1 and 0.2 concentration respectively. Carbaryl at the same concentrations gave 14.85 and 46.30 per cent mortality after 7 days.

Burt and Ward (1956) reported that lower the rate of deposition of DDT more will be the percentage of loss. DDT was applied at the rate of 2 micro grams per sq. cm. on leaves and losses were assessed by bioassay with Tribolium castaneum (Hbst.) and chemical analysis. Losses assessed by both the methods were observed to be similar. DDT deposits at the rate of 2 and 4 micrograms per sq. cm. on foliage lost the toxicity after 16 and 30 days respectively, indicating that higher concentrations remained more persistent than lower (Hopkins 1952 and Burt and Ward 1955).

Sloan et al. (1951) noticed that samples of lettuce sprayed 4-6 times with DDT at the rate of 1 lb. per acre and analysed after 4th application gave 9.1 - 68.3 ppm. initial deposits which decreased to 0.37 ppm. on market

heads and 0.38-3.62 ppm on lower leaves after 14-25 days. Initial residues after 5th application were 572 ppm. which after 11-17 days decreased to 0.07 - 0.39 ppm. on heads and 2.34-38.5 ppm. on lower leaves, thus loosing 94-95 per cent DDT deposits within two weeks. Chemical analysis of deposits of parathion, lindane and DDT suspensions sprayed on peach and apple leaves at the rate of 0.15, 0.025 and 1 lb. per acre respectively gave 28.6, 173.4 and 490.9 ppm. initial residues on apple and 25.1, 461.5 and 92.50 on peach leaves. These residues were reduced to 0.0, 5.1 and 115.0 ppm. on apple leaves and 0.0, 76.1 and 0.0 ppm. on peach leaves respectively 21 days after the treatments (Decker et al. 1950).

Brown and Green (1958) reported that spraying with 0.16 per cent chlordane or dusting either with DDT or BHC were initially as effective as 0.2 per cent DDT against Brontispa longissima (Gestro) the later remained to be equally effective upto 3-4 weeks, while former treatments showed signs of diminishing the efficacy in fourth week. Dominiek (1949) tested efficacy of 1 per cent parathion dust against Myzus persicae (Sul.) on tobacco under laboratory conditions and observed that the treatment was effective upto 7 days but gave 41 per cent mortality on 9th day and 4 per cent on the 11th day indicating that the parathion residues deteriorated rapidly one week after the treatment. Singh and Sindu (1958) also reported that parathion had short

residual effect and recommended its applications at 10 days interval against Lipaphis erysimi (Kalt.) on mustard. Raut and Senapati (1967) tested the efficacy of 0.1 per cent methyl demeton, 0.05 per cent menazon, 0.02 per cent phosphamidon, 0.025 per cent parathion and 0.1 per cent dimethoate against mustard aphid under laboratory conditions and observed that methyl demeton, menazon and dimethoate had longer residual toxicity compared to phosphamidon and parathion. Phosphamidon and dimethoate at the rate of 0.5 and 2 lb. per acre gave high percentage of mortality of (M. persicae Sul.) on tobacco upto a month and remained very effective till harvest (Savage and Harrison 1962). Menzer and Ditman (1963) however, observed that phosphamidon residues practically disappeared from lucerne, tobacco, most of the vegetables and fruits within 4 days, though it could be detected for 8 days on spinach and 9 to 16 days on peas. Spray deposits of dimethoate at the rate of 0.25 and 0.5 lb. per acre on lucerne were 8.09 and 34.7 ppm. respectively immediately after treatment which reduced to 1.88 and 7.74 ppm. after 3 days, 0.1 and 0.66 ppm. after 8 days respectively and less than 0.5 ppm. at both the rates at the end of 34th day (Shaw and Ziener 1964).

Maier and Bode (1968) studied the residual toxicity of endosulfan, DDT and other chlorinated hydrocarbons by using gas chromatography and concluded that endosulfan was less

persistant than DDT and other chlorinated hydrocarbons. While Donnie M. Powell (1966) showed that spraying with endrin and endosulfan at 1 lb. per acre at 10 days interval were equally effective against Green peach aphids on potatoes.

1. Cabbage aphids (Brevicoryne brassicae L.) :

Aphids are the important pests of cabbage all over the world and several workers have studied the efficacy and residual toxicity of different insecticides against the pest.

Wene and White (1952) showed that parathion at the rate of 0.25 and 0.13 lb. per acre had good residual toxicity for 14 days against the pest. It was however, found ineffective 3 weeks after the treatment. 0.025 per cent parathion although, gave high initial mortality, fresh colonies persisted in heart of the plant 7 days after the treatment. The aphid colonies were, however, not seen until 3 weeks after spraying(Wright and Wheatley 1953). Kasting and Harcourt (1952) could not detect any residues of parathion on cauliflower at harvest even though the crop was sprayed at the rate of 1 lb. (15% wettable powder) in 100 gallons of water per acre at weekly interval and the last application given at fortnight before the harvest. Liang et al.(1964) observed that residues of parathion at the rate of 0.67 lb. per acre required 7 days to reach less than one ppm. level and 16 days when applied at 2.02 lb. per acre, indicating that the insecticides at high concentrations left larger

amount of residues than those applied in more dilute forms. Hoelscher et al. (1968) studied the residues of parathion spray at the rate of 1-3 lb. per acre on cabbage and reported that the residues in cabbage were above the tolerance level of 1 ppm. at 4 and 7 days after the application, whereas, it was below tolerance limit 14 days after the treatment.

Wene (1957) showed that demeton reduced population of cabbage aphids for a period of 3 weeks when applied at 0.5 lb. per acre but 43 per cent of the plants showed aphid colonies two weeks after the treatment. Phosdrin, malathion and demeton gave excellent control of cabbage aphids, when sprayed twice at 9 days interval. Promising results were also obtained with diazinon, endrin and carbaryl. Demeton, dimethoate, phosphamidon and endosulfan at the rate of 0.31, 0.19, 0.27, and 0.25 lb. per acre respectively were reported to be more toxic against the pest. Shovey (1962), Mattick et al. (1963) studied the residues of endrin on cabbage sprayed at the rate of 0.8, 0.5 and 0.25 lb. per acre and observed that the residues were 0.13 ppm. or less in all the levels of application, 21 days after the treatment.

Dimethoate has been reported to disappear within 14 days after treatment on cabbage and 21 days in case of lima beans, snap beans and soyabeans (Katherine et al. 1966). Yamauchi (1966) studied the malathion residues on chinese cabbage and reported that more than 75 per cent of initial deposits were

lost within 6 days after the treatment. The residues disappeared more rapidly at higher temperatures.

The Maharashtra State Department of Agriculture has recommended spraying with 0.05 per cent malathion, pyrocalloid (1:600), 0.02 per cent endrin, thiometon, diazinon or parathion for the control of cabbage aphids (Ananymous, 1967).

2. Potato tuber moth (Gnorimoschema operculella Zell.):

Tuber moth has been considered to be the most serious pest of stored potatoes. Nevertheless, it is equally important in the field. The control of the pest therefore is to be started from the field itself. Several insecticides have been reported to be effective against the pest.

Michelbacher et al.(1950) reported that the application of lindane, toxaphene, DDT and chlordane dusts at the rate of 40 lb. per acre gave 100, 98.5, 97.8, 97.1 and 69 per cent respectively, reduction in mines of tuber moth larvae, observed on 5th day after application. Spraying of 0.2 per cent DDT at fortnightly interval was reported to be effective against the pest (Cannon and Cald Well 1946). Cannon (1948) however, observed that 0.1 per cent DDT spray applied at an interval of not exceeding 3 weeks kept the crop free from foliage infestation. Spraying with 0.05 per cent endrin, dieldrin and 0.1 per cent DDT proved to be effective against the potato tuber moth (Smith 1954).

Button and Koch (1959) reported that four applications of 0.2 per cent Trichlorophon, 0.05 per cent endrin, 0.09 per cent dieldrin and 0.1 per cent DDT at the rate of 50 gallons of water per acre at 9 days interval were equally effective in controlling tuber worm infestation and gave significantly higher yields. Bacon (1960) however, reported that four sprays of endrin and azinphos methyl at the rate of 0.4 and 1 lb. per acre respectively, at 15 days interval gave significant reduction in damage to foliage and tubers, whereas DDT at the rate of 2 lb. per acre had little effect on the pest.

Four foliage applications with DDT, endrin, azinphos methyl or endosulfan at 1, 0.375, 0.5 and 0.5-1 lb. per acre respectively at 10 days interval were recommended by U.S. Department of Agriculture (Anonymous 1963). Isobenzan and endrin at the rate of 0.28 Kg. per hectare applied at 15 days interval reported to be more effective compared to parathion and malathion. The infestation of the pest in tubers after harvest was 9.8, 13.9, 14.9 and 21.3 per cent in case of treatment with isobenzan, endrin azinphos methyl and parathion sprayed at the rate of 0.95 Kg. per hectare (Anonymous, 1964). Malathion, isobenzan, endosulfan and azinphos methyl at the rate of 0.75 lb. per acre was reported to be the best insecticides for control of the pest. Spraying azinphos and phosphamidon at 14 days interval was found to be less effective and therefore 10 days interval was recommended,

Shevey et al.(1967). Dusting with 5 per cent or 0.65 per cent lindane at 20 -25 lb. per acre or spraying with 0.03 per cent lindane or 0.2 per cent DDT was reported to check the initial field infestation(Anonymous 1967). Mahajan (1968) obtained 87.08, 81.34, 80.67 and 77.87 per cent control of the pest in foliage with 0.03 per cent azinphos, 0.05 per cent parathion, malathion and 0.03 per cent isobenzan respectively.

3. Bhendi shoot and Fruit Borer (Spotted boll worm)Barias fabia (Stoll) :

Spotted boll worm, although an important pest of bhendi has not been extensively worked out especially for its chemical control. Very little information is available on its control on bhendi crop. Considerable literature however, is available on chemical control of spotted boll worm on cotton. A review presented here therefore narrates the literature on the chemical control of the pest both on cotton and bhendi.

Hanna and Mistric (1953) observed no difference in yields of cotton by spraying aldrin, DDT and toxaphene at 4 and 8 days interval for the control of boll worm. Eight applications of endrin at the rate of 1.5 or 2 lb. per acre gave excellent control of spiny boll worm on cotton and was significantly better than dieldrin (Walker and Haidari 1954). In the laboratory and field experiments for the control of (Earias insulana Stoll.) Gomez et al. (1955) observed that

0.15 per cent parathion gave 100 per cent mortality in 24 hours, while 0,5 per cent lindane, 0.4 per cent dieldrin, aldrin gave 93, 87 and 83 per cent mortality respectively in 72 hours. When the larvae were released to bolls and leaves sprayed 4 days previously, the mortality after 72 hours was 60 per cent for 0.25 per cent dieldrin, 70 per cent for 0.15 per cent parathion and 10 per cent in case of 0.3 per cent lindane, 1-3 applications of 5% DDT or DHC dusts or 0.1 and 0.05% sprays at weekly interval gave no control of spotted bollworms on bhendi fruits (Krishnaswami 1954). Patel and Kulkarni (1954) reported that 8 applications with 0.2 per cent DDT at weekly interval found ineffective for controlling the spotted bollworm on cotton, while 0.2 per cent toxaphene reduced the infestation from 62.9 to 58.2 per cent, but treatment had no effect on yield. Seven applications at weekly interval with 0.05% endrin, 0.4 per cent toxaphene and a mixture of 0.4% toxaphene, 0.2 DDT (2:1) reduced the infestation to 33.3, 41.3 and 40.3 per cent respectively as against 60.3 per cent in case of untreated plots. Perimmer et al. (1960) while studying several insecticidal sprays against cotton boll worm observed that the residual effect of azinphos methyl + DDT was considerably more than that of endosulfan and carbaryl. 0.04 per cent or 0.1 per cent carbaryl sprayed at every 7th day gave excellent control of spotted boll worm on cotton in Taiwan (Tsai and You 1962).

Experiments on the control of (Earias fabia Stoll.) and E. insulana Boisd.) on cotton were conducted with sprays of endrin, parathion, diazinon, malathion, thiometon and a mixture of DDT + BHC and dust containing toxaphene and heptachlor applied at 12 days interval from the first appearance of the moths in the field and it was reported that 0.15 per cent thiometon applied twice was the most effective treatment giving a reduction of 80.44 per cent in the number of infestated boll and also gave the highest yields(Srivastava et al. 1964).

Rattan Lal and Dhall (1965) carried out tests with different insecticides for assessing the spray residues on the leaves and their toxicity to the first instar larvae of spotted boll worm on bhendi. Spray with 0.095 - 0.38 per cent Malathion, 0.0125-0.05 per cent parathion or endrin and 0.05-0.2 per cent dieldrin gave 94 to 100 per cent mortality after an hour, while 0.198-0.594 per cent lindane gave 69 to 93 per cent mortality. The deposit gradually lost their toxicities during the next 7 days. DDT at 0.2 - 0.6 per cent concentration gave 41.8 to 54.8 per cent mortality after one hour but 71.07 to 80.8 per cent after one day, 60.5 to 93.5 after 3 days and 46.8 to 81.2 after seven days. The deposits of DDT remained appreciably toxic for longer time, although it appeared to be less toxic initially.

Matthews (1966) suggested that the most effective insecticides for control of Earias spp. were methyl parathion,

carbaryl, methyl demeton, parathion, methiocarb, Zectran, isobenzan BHC, endrin and phosphamidon.

Spraying with 0.03 per cent endrin + sulphur (1:1) or 0.2 per cent carbaryl + sulphur (1:1) or 0.1 per cent malathion was reported to be effective in reducing the boll worm incidence on bhendi, (Anonymous 1967).

Dorge et al (1968) reported that the treatment with 6 sprays of 0.02 - 0.04 per cent endrin given at 15 days interval was the most effective in reducing boll worm infestation on cotton. The next best treatment was 0.1 - 0.2 per cent carbaryl. The Maharashtra State Department of Agriculture recommended six sprays of 0.02 - 0.04 per cent endrin or 0.1 - 0.2 per cent carbaryl for the control of boll worm on irrigated cotton and for dry cotton, 3 dustings with 10 per cent carbaryl are recommended.

4. Mango hoppers (Idioscopus Spp.) :

Hoppers being the serious pests of mango, the work on their chemical control started as early as 1944. In the State of Maharashtra Uppal and Wagle (1944) recommended 3-4 sulphur dusting at 10 days interval for controlling the pest effectively. Vevai and Talgeri (1948) however, recommended two spraying with 0.15 per cent DDT + sulphur (1:1) or three dusting with 5 per cent DDT + Sulphur (1:1) at an interval of 15 days. Threhan (1948) observed that dusting

with 5 per cent DDT or toxaphene with equal or double quantity of sulphur was the most effective and economic treatment for controlling mango hoppers, mites and mildews. Patel and Hadli (1953) recommended spraying with 0.16 - 0.25 per cent DDT or dusting 5 per cent DDT at 15 days interval for the control of hoppers. They further observed that DDT + sulphur in (1:1) and (1:2) proportion and 5 per cent toxaphene + sulphur (1:1), were equally effective while chlordane and DDD were observed to be inferior. Sen and Prasad (1954) reported that DDT was better than BHC, dieldrin, aldrin, parathion or pyrocolloid.

Schradan at 0.4 per cent concentration was found to be the most effective treatment as against the pest as the pesticide had advantage of being quickly translocated and thus free from being washed away by rains (De R.K. and Dutta D.K. 1955).

Srivastava and Singh (1956) however, reported that spraying with 0.05 per cent malathion or mixture of 0.05 per cent malathion and chlordane, 0.02 per cent ethyl parathion or endrin were quite effective and cheaper as compared to DDT.

In field trials on chemical control of mango hoppers in two seasons Sham Sunder and Ali (1961) observed that 0.56 per cent DDT and 0.156 per cent lindane comparatively

ineffective. Spraying with 0.1 per cent DDT or 0.05 per cent parathion was found to be equally effective against the pest in Madras State but parathion being hazardous 0.1% DDT was recommended. Field trials conducted by Khaire (1965) showed that 0.1 per cent carbaryl was the most effective treatment.

Chikkerur (1967) reported that although spraying with DDT, endrin or malathion was effective against mango hoppers. They were however, ineffective against mites. And therefore, insecticides like thiometon, phosphamidon and parathion effective in controlling both the pests. The State Department of Agriculture recommended three sprayings with 0.2 per cent carbaryl + sulphur or 0.2 per cent DDT + sulphur at interval of 2-3 weeks, starting from the 1st flush of flowering, or three dustings with 10 per cent carbaryl + sulphur or 10 per cent DDT + Sulphur is also included in the schedule (Anonymous 1968).

CHAPTER III

MATERIAL AND METHODS

Investigation on the residual toxicities of different insecticides against cabbage aphids, potato tuber moth, bhendi shoot and fruit borer and mango hoppers were carried out under laboratory conditions and the results were confirmed by conducting field experiments. The methods employed for these studies are given below.

I. Cabbage aphids (Brevicoryne brassicae L.) :

(A) Laboratory studies : A culture of B. brassicae was obtained from infested leaves of cabbage plants and was maintained on the potted plants under laboratory conditions. Healthy cabbage seedlings were transplanted in pots and these pots were kept in glasshouse for 1½ months. Plants having approximately uniform size and equal number of leaves were selected for the further studies. A single plant in a pot was taken as a treatment and these were replicated three times. The following insecticides which are commonly used for the control of cabbage aphids were selected to determine their residual toxicity against cabbage aphids. These insecticides were used at the concentration usually suggested for the control of the pest. These are given along the insecticides together with their source of supply.

(1) 0.02 per cent phosphamidon (100% E.C.)
(Dimethyl 2 -chloro-2-diethylcarbamoyl-1-methyl vinyl phosphate, Messrs Ciba of India Ltd., Bombay 1).

(2) 0.02% Dimethoate (35% E.C.)
(O.O-Dimethyl S-(N-methylcarbamoylmethyl) phosphorodithioate, Messrs Rallis India Ltd., Bombay)

(3) 0.02% Thiometon (25% E.C.)
(0,0-Dimethyl S-2(ethylthio)-ethyl phosphorodithioate, Messrs Sandoz India Ltd. Bombay)

(4) 0.02% methyl demeton (25% E.C.)
(0,0-Dimethyl O-2(ethylthio)-ethyl phosphorothioate, Messrs. Bayer India Ltd., Bombay)

(5) 0.02% Parathion (50% E.C.)
(0,0-Diethyl O-P-nitrophenyl phosphorothioate, Messrs. Sandoz India Ltd., Bombay)

(6) 0.02% Endrin (20% E.C.)
(1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo-1,4-endo-5,8- dimethanonaphthalene, Messrs National Organic Chemical Industries Ltd., Bombay).

(7) 0.02% Diazinon (20% E.C.)
(0,0-Diethyl O-(2-isopropyl-4-methyl-6-pyrimidinyl) phosphorothioate, Messrs. Rallis India Ltd.,Bombay.

(8) 0.04 Endosulfan (35% E.C.)
(6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4, 3-benzodixathiepn-3-oxide, Messrs.Hoechst Pharmaceutical Ltd., Bombay)

(9) 0.05% malathion (50% E.C.)
(O-O-Dimethyl S-1, 2-di(ethoxycarbamoyl) ethyl phosphorodithioate, Messrs. Bharat Pulverising Mills,Ltd., Bombay.

Before spraying these insecticides the quantity of the spray material required for one plant was calibrated by spraying water with the help of hand operated compressor sprayer having conventional cone type nozzle maintaining the pressure at 30 lb. per sq. inch. The pots were arranged treatmentwise and sprayed with the insecticides

taking care that all the plants get uniform quantity of spray. The temperature, relative humidity and rain fall were recorded throughout the period of the experiment. The sprayed plants were arranged replicationwise in open space outside the glass house.

Second and third instar nymphs were selected for releasing on treated plants after complete drying of the insecticidal film on the treated leaves. A batch of 20 nymphs was released with the help of fine camel hair brush on lower surface of the treated leaves. A similar batch of 20 was also released on plants sprayed with water. Counts of living aphids were taken 48 hours after the treatment. Morbid individuals were treated as dead.

Similar batch of 20 nymphs was released on each plant 5, 10 and 15 days after the treatment and observations on their mortality were recorded. The mortality percentage was calculated and it was corrected by using Abbott's formula (1925). The insecticides was treated to have lost its residual toxicity when the corrected mortality was observed to reach less than 50 per cent. In the field experiments the interval between two spraying was determined on the basis of the mortality obtained in the laboratory studies. The time for subsequent spraying was fixed when the insecticide had given less than 50% mortality.

(B) Field Experiments : Statistically designed field experiment was laid out on a cultivator's field at Dehugaon (Poona) with randomized block design, replicated three times. The details are given below :

1. Plot Size : a) Gross 30' X 15'
   b) Net 28' X 13'
2. Variety :Early drum head
3. Date of transplanting : 25-12-1968.
4. Date of 1st spraying : 7- 2-1969.
5. Treatments :

   a) 0.02% Phosphamidon at 15 days interval.

   b) 0.02% Dimethoate at 15 days interval.

   c) 0.02% Thiometon at 10 days interval.

   d) 0.02% Methyl demeton at 10 days interval.

   e) 0.02% Parathion at 10 days interval.

   f) 0.02% Endrin at 10 days interval.

   g) 0.02% Diazinon at 5 days interval.

   h) 0.04% Endosulfan at 10 days interval.

   i) 0.05% Malathion at 5 days interval.

   j) 0.02% Endrin (as standard treatment) at 15 days interval.

   k) Water spray.

Spraying was done with the help of hand operated compressor sprayer maintaining the pressure at 30 lb. per sq. inch.

Method of recording observations :

Five plants were selected at random for recording observations. Population count was taken on three leaves on each plant prior to spraying and 48 hours after the treatment. The percentage mortality worked out and data was statistically analysed.

II. Potato tuber moth : (Gnorimoschema operculella Zell.)

(A) Laboratory studies : A culture of G. operculella was procured from the infested tubers and was multiplied on potatoes in the laboratory at room temperature.

Estimation of time required for entrance of 1st instar larvae in leaf :

Just hatched larvae were released on leaves to study their preference of spots for entry in the leaf tissues. It was observed that there was no special preference for any definite spot on the leaf. Most of the larvae entered in the leaf either near the mid-drib or at marginal portion. There was also no preference for upper or lower leaf surface. The information on the estimation of time required by the 1st instar larvae to enter into the leaf tissues is practically scanty. Ten fresh twigs with three leaves were collected from the potted plants and the stalk of which was immersed in water in glass vial in order to prevent them from drying.

Before proceeding with the laboratory studies it was felt necessary to work out the time required for the larvae to enter in leaf tissues for this purpose. A batch of 5 larvae was released on each twig and observations were recorded on the time required by them to enter in leaves.

Potato plants of upto-date variety were grown in pots and were kept in the glass house. 30 days after planting the plants of equal vigour were selected for the experiment. The insecticides which are usually recommended for the control of tuber moth were selected for the test. Selected insecticides together with their concentrations and source of supply are listed below :

1. 0.2 % Carbaryl (50% W.P.)
   (1-Naphthyl N-methylcarbamate, Messrs. Union Carbide India Ltd., Bombay).

2. 0.03% Azinphos (40% E.C.)
   (0,0 - Dimethyl S-4-oxobenzotriazino-3- methyl-phosphorodithioate, Messrs Bayer India Ltd.,Bombay).

3. 0.03% Lindane (20% E.C.)
   (Gamma-1,2,3,4,5,6 Hexachloro- cyclohexane, Messrs.Rallis India Ltd., Bombay).

4. 0.05% Malathion (50% E.C.).

5. 0.05% Parathion (50% E.C.).

6. 0.03% Endrin (20% E.C.).

7. 0.2% DDT (50% W.P.)
   (2,2-Bis (P-chlorophenyl)-1,1,1-trichloroethane, Messrs. Sandoz India Ltd., Bombay).

8. Water spray.

The selected potted plants were arranged treatmentwise and sprayed with the insecticides at the concentration mentioned above by using hand operated compressor sprayer. The dose per plant required was also calibrated as prescribed under cabbage. Each treatment was replicated three times. Soon after drying of insecticidal films, two leaves from each treatment were collected in separate petri dishes and a batch of 20 just hatched caterpillars was exposed for 15 minutes. Although the time observed for the caterpillar to penetrate into the leaf was in range of 30 - 195 minutes, an exposure of 15 minutes was given so that the larvae should be killed before any of them is able to enter in the leaf. After 15 minutes the larvae were transferred on fresh potato leaves for feeding. In order to prevent these leaves from drying the stalk of the twigs was kept immersed in vials containing water.

The observations on the mortality of the larvae were recorded 48 and 72 hours after the treatment. The larvae which mined the leaf were observed under bionocular so as to determine whether they are living or dead. On the basis of living caterpillars the mortality percentage was calculated. Two middle leaves from each of the treated plant were collected 5,10 and 15 days after treatment and a batch of 20 larvae was released on these leaves for 15 minutes and these larvae were transferred on fresh potato leaves and observations recorded as mentioned earlier. The observed mortalities were

corrected by applying Abbott's formula. The time for subsequent spraying of an insecticide was fixed when it was given less than 50% mortality.

(B) Field experiments : A field experiment was conducted at Khed (Poona), the details of which are given below :

I. Plot size : 1. Gross 35' X 15'
2. Net 33' X 13'

II. Variety : Upto-date

III. Date of planting: 25-12-1968

IV. Date of first spraying : 29-1-1969

V. Date of harvesting : 23-2-1969

VI. Treatments :

1. 0.2% Carbaryl at 15 days interval.
2. 0.2% DDT at 10 days interval.
3. 0.03% Azinphos at 15 days interval.
4. 0.03% Lindane at 10 days interval.
5. 0.05% Malathion at 10 days interval.
6. 0.05% Parathion at 15 days interval.
7. 0.03% Endrin at 15 days interval.
8. 0.2% DDT (as standard treatment) at 15 days interval.
9. Water spray.

The spraying was done with the help of hand operated compressor sprayer.

Methods of recording observations : The number of mines on all the leaves of 10 randomly selected plants were counted just before the first application and at an interval of five days. Further observations on number of fresh mines were recorded at an interval of five days and total number of fresh mines were calculated and statistically analysed. At harvest, the total number of tubers and the infested tubers of the selected 10 plants were recorded in each treatment and the percentage of infestation was worked out and data was utilised for further analysis.

III. Bhendi shoot and fruit borer : (Earias fabia Stoll.)

(A) Laboratory studies : A culture of E. fabia was maintained in the laboratory by the method suggested by Rattan Lal and Dhall (1965). The larvae were kept in glass jars (10" X 6") covered with black paper and fed on cut pieces of bhendi fruits. The pupae were removed from the jars and kept in petri-dishes. The moth emerged out were transferred in wooden cage with the help of glass tube and fed with 5 per cent sugar solution. Fresh bhendi fruits were kept in wooden cage for oviposition. The eggs from bhendi fruits were collected and kept in conical flask so as to facilitate easy picking of newly hatched larvae.

Estimation of time required for entrance of 1st instar larvae in shoot : Before starting the laboratory experiment it was felt necessary to know the time required for the first instar larvae to enter in shoot so as to fix the time

for exposure. A careful observation was made about the spots preferred by the larvae for their entrance in shoots. From the continuous observations made for 8 hours, it was found that the larvae preferred succulent apical leaves for entrance in shoot.

In order to know the time required for the entrance in shoot 50 just hatched larvae of E. fabia were exposed on succulent shoots and observations were recorded. From these observations minimum time required for 1st instar larvae to enter in the shoots was noted. Rattan Lal and Dhall (1965) reported that the time required by the 1st instar larvae for entrance in shoots varied from 45 - 226 minutes.

Four seeds of Pusa sawani variety were dibbled in earthen pots filled with soil mixed with well rotted compost. These pots were kept in the glass house and regularly watered. Thinning was done 15 days after germination, keeping only one healthy seedling in each pot. These plants were selected for experiment 50 days after sowing.

The insecticides which are usually recommended for the control of E.fabia were taken up for the residual toxicity studies. These are listed below together with their concentration and sources of their supply.

1. 0.2% Carbaryl (50% W.P.)
2. 0.04% Endrin (20% E.C.)
3. 0.1% Malathion (50% E.C.)

4. 2% Parathion
   (Messrs. Bharat Pulverising Mills Pvt.Ltd., Bombay).

5. 10% Carbaryl
   (Messrs. Bharat Pulverising Mills Pvt.Ltd., Bombay).

6. 1% Endrin
   (Mysore Insecticides Co., Madras).

7. 5% Malathion
   (Imperial Chemical Industries Ltd., Bombay).

8. 0.2% DDT + BHC (50% W.P.)
   (BHC-1,2,3,4,5,6-Hexachloro cyclohexane or Benzene hexachloride, Messrs. Sandoz India Ltd., Bombay).

9. 10% DDT + BHC
   (Messrs. Sandoz India Ltd., Bombay).

Potted plants were sprayed with the help of hand compressor sprayer and in case of dust formulations application was made by baby duster and pots were arranged replicationwise. Soon after the drying of the film of the treated plant two leaves from each treated plant were collected in separate petri dishes and 20 just hatched larvae were exposed on these leaves for a period of 20 minutes. Although the minimum time required for penetration of the larvae was observed to be 40 minutes a period of 20 minutes was fixed for exposure so that the larvae exposed to treated surface should be killed before any of them is able to bore into the plant tissue. This technique was suggested by Rattan Lal and Dhall (1965). A similar batch of 20 larvae was exposed to the leaves from plants sprayed with water.

After the prescribed time of 20 minutes the larvae were transferred to petri dishes containing fresh pieces of bhendi

fruits. Observations about mortality of the larvae were recorded 48 and 72 hours after the treatment. The observed mortalities in each treatment were corrected by applying Abbott's formula. On 5th, 10th and 15th day after the treatment two middle leaves were collected from each treatment in separate petri dishes and a batch of 20 larvae were exposed for 20 minutes as mentioned above. These larvae after 20 minutes were transferred to separate petri-dishes containing fresh pieces of bhendi fruit. Observations were recorded in similar manner and corrected mortalities were worked out.

The temperature, relative humidity and rainfall were recorded during the entire period of experiment. Intervals between the two spraying of the insecticides under test were fixed on the basis of the corrected mortalities. It was felt necessary to give 2nd spray when mortality was observed to be less than 50 per cent.

(B) Field Experiment : Statistically designed field experiment was conducted at Manjri (Poona) the details of which are given below :

I. Variety : Pusa sawani.

II. Date of sowing: 5-12-1968.

III. Plot size : a) Gross: 35' X 15'
b) Net : 33' X 13'

IV. Replications : Three.

V. Date of first application : 9-1-1969.

VI. Treatments :

1. 0.2% Carbaryl at 15 days interval.
2. 0.2% DDT + BHC (1:1) at 10 days interval.
3. 0.04% Endrin at 10 days interval.
4. 0.1% Malathion at 10 days interval.
5. 2% Parathion dust at 10 days interval.
6. 10% Carbaryl dust at 15 days interval.
7. 1% Endrin dust at 10 days interval.
8. 5% Malathion dust at 10 days interval.
9. 10% DDT + BHC dust (1:1) at 10 days interval.
10. 0.04% Endrin (as standard treatment) at 15 days interval.
11. Water spray.

The spraying and dusting was done at 10 and 15 days interval according to the treatment with the help of hand operated compressor sprayer and rotatory type dust gun respectively.

Method of recording observations : 100 plants were selected at random in each plot and observations were recorded on number of shoots infested prior to each application. At each picking bhendi fruits from selected 100 plants were collected and the infested fruits were counted and the percentage of infestation was worked out and data was statistically analysed.

IV. Mango hoppers : (Idioscopus atkinsoni Leth.)

(A) Laboratory studies : A culture of I.atkinsoni was obtained from untreated infested blossoms. Second and third instar nymphs were collected with the help of aspirator for the experimental purpose. As it was not possible to keep the mango bloosoms healthy under laboratory conditions for the entire period of the experiment. These studies were conducted on mango trees in the field.

A single tree was selected for each treatment and the treatments were replicated three times. One tree was kept untreated in between the two treated trees. The insecticides selected for the experiment are as under :

1. 0.1% Carbaryl + Sulphur (1:1) (50% W.P.)
2. 0.2% DDT + Sulphur (1:1) (50% W.P.)
3. 0.02% Endrin + Sulphur (1:1) (20% E.C.)
4. 0.02% Phosphamidon + Sulphur (100% E.C.)
5. 10% Carbaryl + Sulphur (1:1).
6. 5% DDT + Sulphur (1:1).
7. 2% Parathion + Sulphur (1:1).

Trees were treated just after the inflorescences started appearing. Each tree was sprayed or dusted with equal amount of sulphur at the rate of 5 litres spray material and ½ kg dusts per tree respectively. Two inflorescences were selected on each treated tree and were caged

with wire cage covered with muslin cloth (6" X 14"). 20 nymphs were released just after the drying of the insecticidal film on inflorescence. Observations on the mortality were recorded 48 hours after the treatment and percentage mortality was worked out.

A batch of 20 nymphs was similarly released in each cage 5,10,15 and 21 days after the treatment. Observations on mortality were recorded 48 hours after the treatment and percentage mortalities were calculated and these were corrected by Abbott's formula. On the basis of laboratory data the interval in between two applications was fixed. The application of an insecticides was repeated when it gave less than 50 per cent mortality.

(b) Field experiment : Statistically designed field experiment was conducted at Dehugaon (Poona) the details of which are given below :

I. Number of trees for each treatment : Three

II. Date of application : 5-2-1969

III. Replications : Three.

IV. Treatments :

1. 0.1% Carbaryl + Sulphur (1:1) at 21 days interval.
2. 0.2% DDT + Sulphur (1:1) at 15 days interval.
3. 0.02% Endrin + Sulphur (1:1) at 15 days interval.
4. 0.02% Phosphamidon + Sulphur (1:1) at 15 days interval.

5. 10% Carbaryl + Sulphur (1:1) at 21 days interval.
6. 5% DDT + Sulphur (1:1) at 15 days interval.
7. 2% Parathion + Sulphur (1:1) at 15 days interval.
*8. 10% Carbaryl + Sulphur (1:1) at 15 days interval.
*9. 5% DDT + Sulphur (1:1) at 15 days interval.
*10. 0.1% Carbaryl + Sulphur (1:1) at 15 days interval.
11. Water spray.

(* As standard treatments).

Spraying and dusting was done according to the treatment with hand operated compressor sprayer and rotatory type dust gun.

Method of recording observation : Six inflorescences were selected on each tree for recording observations. Total number of nymphs were counted on each inflorescence just before the first application and 48 hours after the treatment. Further observations on total number of nymphs were recorded at an interval of 5 days and percentage mortalities were worked out and the data was statistically analysed.

CHAPTER IV.

RESULTS AND ANALYSIS

Results of the laboratory and field experiments on the residual toxicity of various insecticides against cabbage aphids, potato tuber moth, bhendi shoot and fruit borer and mango hoppers are presented in this Chapter.

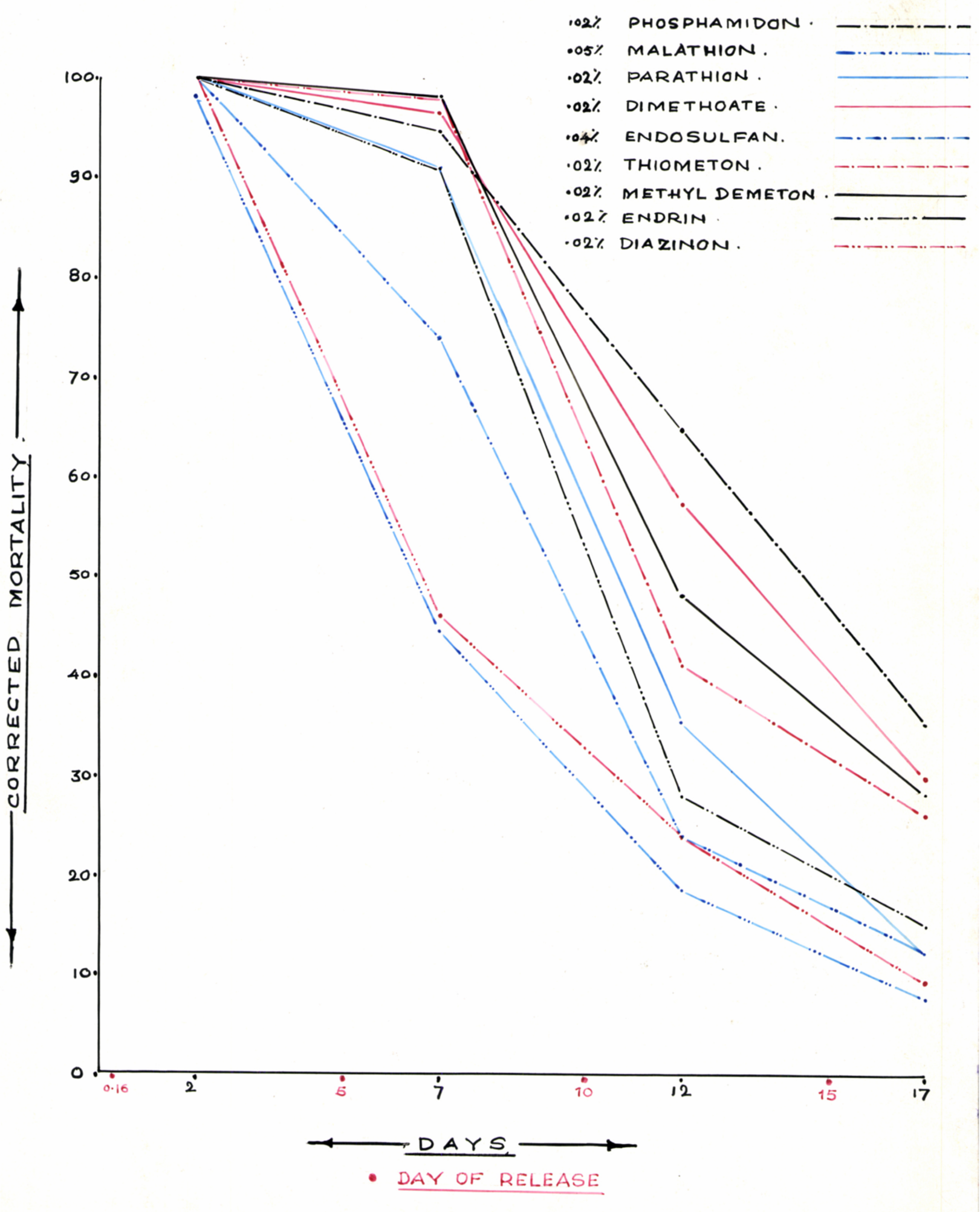
I. Cabbage aphids (Brevicoryne brassicae L.) :

(A) Laboratory studies : As mentioned earlier labbratory experiments were conducted using second and third instar nymphs of B. brassicae. The data is presented in table 1 in Appendix. From the table 1(I) it will be seen that most of the treatments gave cent per cent mortality immediately after the treatment. Malathion, however, gave 98.25 per cent mortality. The data on mortalities of aphids released 5 days after the spraying which is presented in table 1(II) indicated that all the treatments gave more than 90 per cent mortality except malathion and diazinon which gave less than 50 per cent mortality. When aphids were released 10 days after spraying, phosphamidon gave the highest mortality (64.63%), while rest of the insecticides except dimethoate gave less than 50 per cent mortality.

From the data recorded on the mortality of the aphids released 15 days after spraying showed that none of the insecticides gave more than 50 per cent mortality. The

FIG:1.

RESIDUAL TOXICITY OF INSECTICIDES AGAINST THE *BREVICORYNE BRASSICAE* L. ON CABBAGE.



residual toxicities of different insecticides were plotted on graph which is given in Figure 1. On the basis of this data, it was decided to repeat the spray of malathion and diazinon at an interval of 5 days, methyl demeton, thimeton, parathion, endrin and endosulfan at 10 days; phosphamidon and dimethoate at 15 days interval in the field experiments as it was observed that these insecticides gave less than 50 per cent mortality of aphids when released after 5, 10 and 15 days after spraying respectively.

(B) Field experiment : The residual toxicities of insecticides tested in laboratory were studied under field conditions and compared with standard treatment recommended by the State Department of Agriculture.

The data on the pest decline immediately after spraying are presented in Table 2(I). It was observed that all the insecticidal treatments gave significant reduction in pest population. Thiometon gave the highest mortality and was on par with dimethoate, parathion, phosphamidon and endosulfan. It was significantly superior to methyl demeton, diazinon and endrin. Diazinon and malathion were again sprayed 5 days after the first application and the data on pest decline is given in Table 2(II). Malathion and diazinon although gave the highest mortality, it was however, not significantly superior as compared with dimethoate, phosphamidon, methyl demeton and thiometon. Endosulfan gave the least mortality and was found to be significantly inferior to rest of the insecticides except endrin.

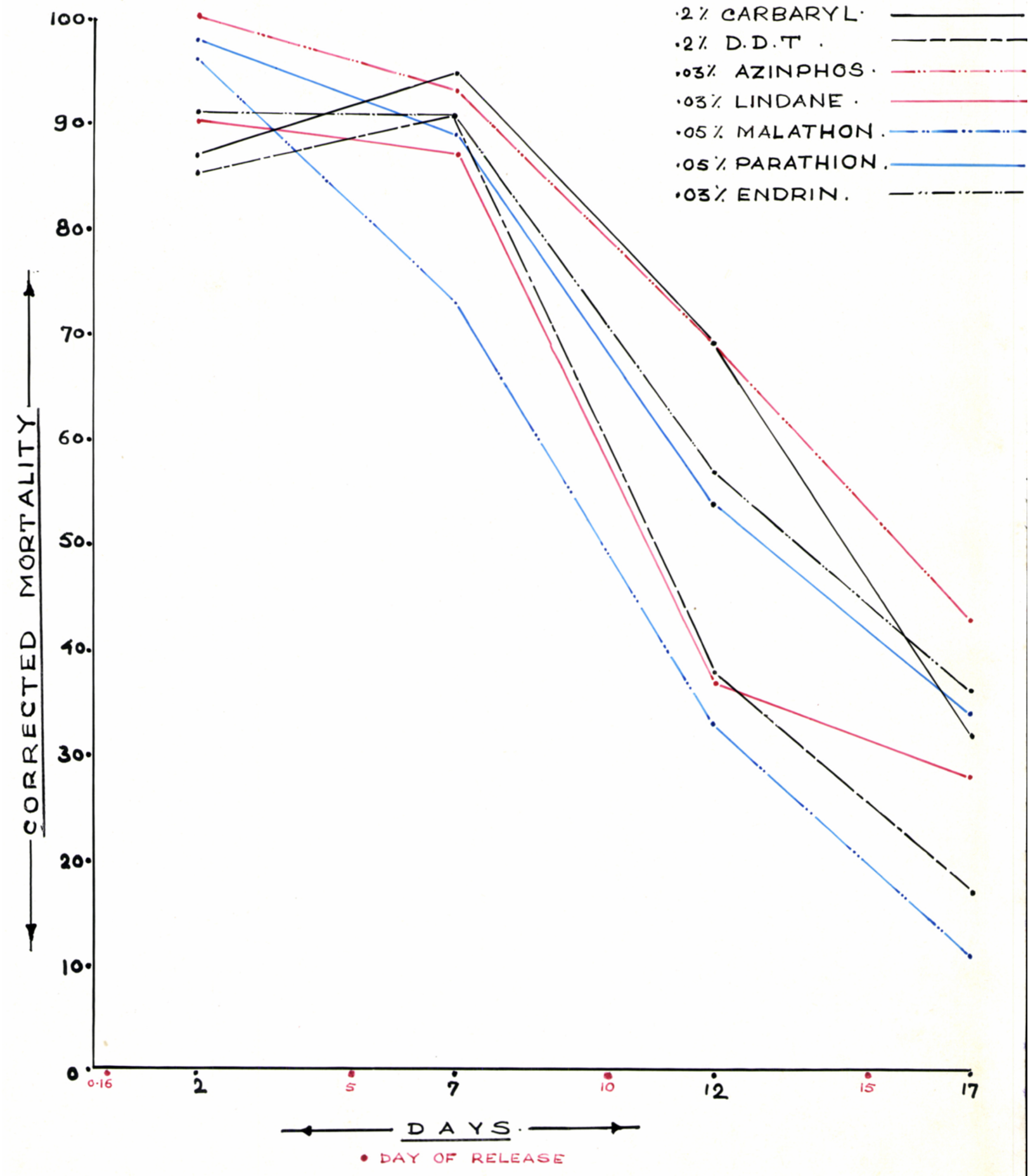
The application of all the insecticides except phosphamidon, dimethoate and endrin as standard treatment was given 10 days after the first application. The data of percentage decline in the pest population 48 hours after the treatment is presented in table 2(III). From the data it will be seen that the mortality was the highest in treatment with thiometon which was on par with methyl demeton, diazinon, parathion, endosulfan and malathion. All the insecticides sprayed on the 10th day proved to be significantly superior to the unsprayed treatments. The standard treatment with endrin was significantly inferior to all other treatments. On the 15th day after the first application phosphamidon, dimethoate, diazinon, malathion and endrin as standard treatment were sprayed and the data regarding decline in pest population is presented in table 2(IV). Treatment with phosphamidon gave the highest mortality. It was however, on par with rest of the treatments except endrin and endosulfan sprayed 5 days prior to the 15 days' application.

II. Potato tuber moth (Gnorimoschema operculella Zell.):

(A) Laboratory studies: The time required for the entrance of the first instar larvae in leaf tissues was recorded on 50 individuals and the observations are given in Table 3 in Appendix. The time required for complete entrance was observed to range from 30 - 195 minutes, with an average of 107.12 minutes.

FIG : 2

RESIDUAL TOXICITY OF INSECTICIDES AGAINST THE FIRST INSTAR LARVAE OF *GNORIMOSCHEMA OPERCULELLA* ZELL. ON POTATO PLANT.



As mentioned earlier the first instar larvae were released on the leaves treated with different insecticides and observations on mortality were recorded. The data of experiments are given in table 4 in Appendix. The data on the mortality obtained in respect of the larvae released just after spraying is given in table 4(I). From the data it will be observed that azinphos gave cent per cent mortality while DDT gave the minimum mortality (85.37). The observations on the mortalities of the first instar larvae released on leaves 5 days after spraying is given in table 4(II). The treatments with carbaryl, azinphos, endrin and DDT gave more than 90 per cent mortality and malathion proved to be inferior giving only 73.1 per cent mortality. On the 10th day, the mortality of the larvae was highest in azinphos and carbaryl treatments and it was less than 50 per cent, in case of DDT, lindane and malathion (Table 4 III). The mortality of the larvae released on the leaves 15 days after spraying was observed to be less than 50 per cent in case of all the insecticides Table 4 (IV). The residual toxicities of different insecticides is graphically presented in Figure 2. On the basis of data recorded in the laboratory experiment, the interval of spraying with DDT, lindane and malathion was fixed at 10 days and in case of rest of the insecticides it was decided to be 15 days.

(B) Field studies : The residual toxicities of insecticides tested in laboratory were studied under field conditions

and compared with standard treatment of spraying with 0.2 per cent DDT at 15 days interval. The details of the observations are given in Table 5 in Appendix. The data on number of fresh mines observed 5 days after spraying on foliage are presented in table 5(I). It was observed that all the treatments were significantly superior to water spray. The treatment with azinphos, carbaryl, parathion and endrin were on par and significantly superior to rest of the insecticides. Observations on the number of fresh mines increased on 10 days after first spraying are presented in table 5(II). Treatments with azinphos, carbaryl, parathion and endrin were significantly superior to rest. Endrin however, was on par with malathion and lindane. Treatments with DDT and lindane were observed to be ineffective in reducing the pest infestation.

Spraying of lindane, malathion and DDT was given 10 days after the first application and the data on fresh mines recorded 5 days after the 2nd treatment is given in table 5(III). From the table it will be seen that the treatments with lindane, malathion and DDT were significantly superior to all the treatments. Treatments with azinphos and carbaryl were however, significantly superior to endrin and DDT as a standard treatment. Spraying of the remaining insecticides except lindane, malathion and DDT was given 15 days after the first application. DDT as standard treatment was also applied at the same time.

The data on fresh mines are given in Table 5(IV). Treatments with azinphos, carbaryl and parathion were on par and significantly superior to rest of the treatments. Lindane, malathion and DDT were inferior to all above insecticides but significantly superior to untreated.

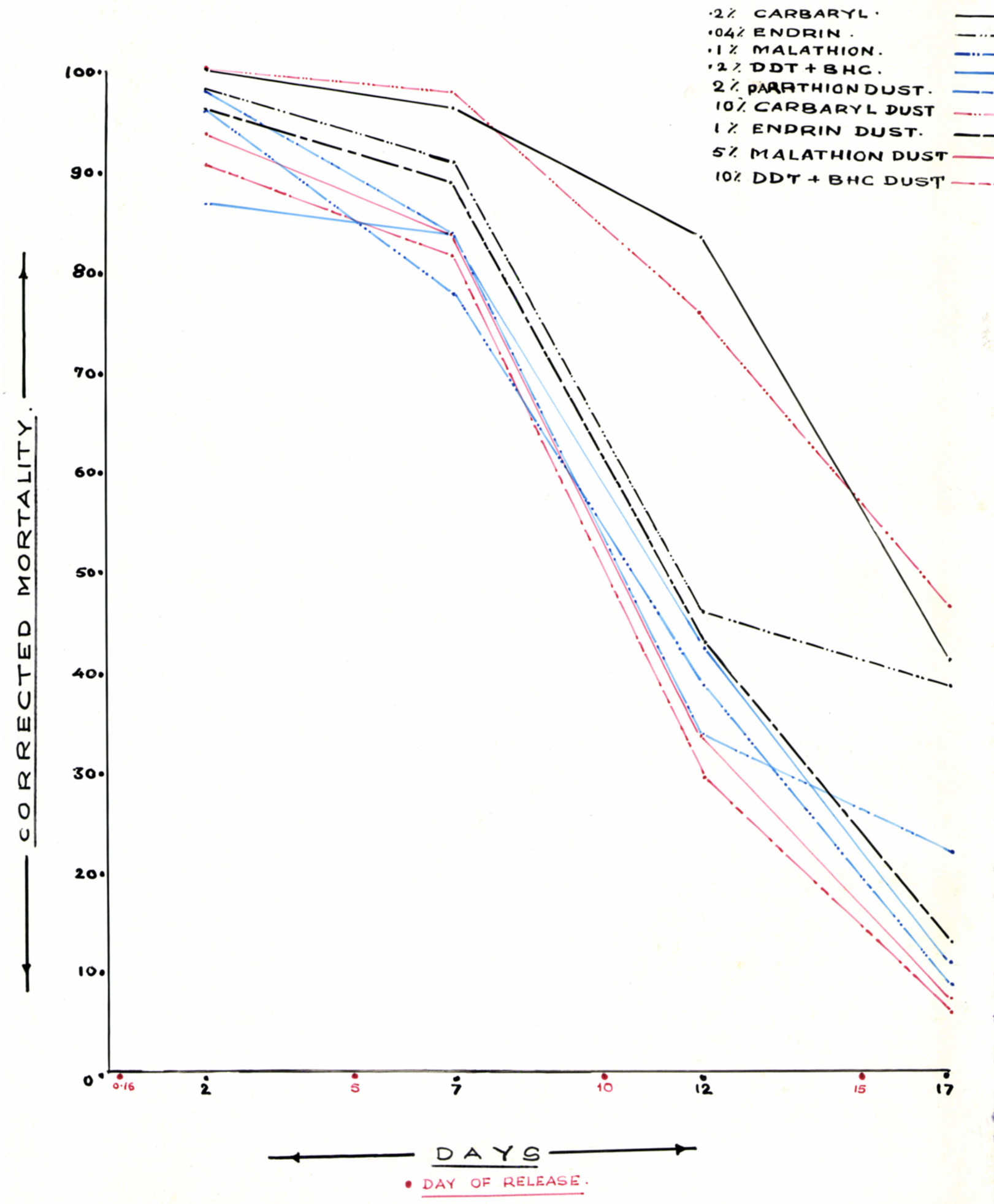
The crop was harvested 10 days after the last spray and the data on percentage tuber infestation recorded at harvest are given in table 5 (V). It was observed that the treatment with azinphos, carbaryl and parathion were significantly superior to rest of the treatments except endrin in reducing percentage infestation of tubers. The standard treatment of DDT was found to be inferior of all the insecticides in reducing the infestation of G.operculella in tubers.

III. Bhendi shoot and fruit borer (Earias fabia Stoll.):

(A) Laboratory studies : The time required for the entrance of the first instar larvae in shoots was recorded on 50 individuals and the observations are given in table 6. The time required for entrance was observed to range from 40-250 minutes. On an average they required 131.02 minutes for complete entry in shoots. As stated earlier the first instar larvae were released on the leaves treated with different insecticides and observations on mortality were recorded 48 hours after application, these are given in table 7(I). From the data it will be seen that carbaryl

FIG:3.

RESIDUAL TOXICITY OF INSECTICIDES AGAINST THE FIRST INSTAR LARVAE OF *EARIAS FABIA* STOLL. ON BHENDI PLANT.



both as spray and dust gave cent per cent mortality while the mixture DDT + BHC dusts gave the least mortality, (84.21). The observations on the mortalities of the first instar caterpillars released on leaves 5 days after the application are given in table 7(ii). The treatments with 0.2 per cent carbaryl, 0.04 per cent endrin and 10 per cent carbaryl dust gave more than 90 per cent mortality and 0.1 per cent malathion proved to be inferior giving 77.97 per cent mortality.

The mortality percentage of the larvae released 10 days after application of insecticides are given in table 7(III). Spraying with 0.2 per cent carbaryl and dusting with 10 per cent carbaryl gave the 83.51 and 75.97 Per cent mortalities respectively. All the rest treatments gave less than 50 per cent mortality. The observations on the mortality of larvae released 15 days after spraying are given in table 7(IV).It was observed that all the treatments gave less than 50 per cent mortality.

On the basis of results of the laboratory experiments the interval of application of insecticides with carbaryl spray and dust, endrin spray as a standard treatment was fixed at 15 days and in case of rest of the insecticides it was decided to be 10 days. The residual toxicity of all the insecticides tested is presented graphically appearing in Figure 3.

(B) Field experiment : The residual toxicities of insecticides were studied under field conditions and compared

with that of standard treatment. As the infestation of pest was very much negligible on shoots, observations recorded on shoot infestation are not given here. The percentage decline in fruit infestation were recorded at each picking are presented in table 8. The observations recorded at first picking indicated that treatments with carbaryl spray and dust applied at 15 days interval were significantly superior in reducing the infestation as compared to the rest of the treatments except spraying with 0.04 per cent endrin at 10 days interval. Dusting with 10 per cent DDT + BHC and 1 per cent endrin at 10 days were observed to be the least effective (Table 8,I). At second picking treatments with carbaryl spraying and dusting were proved to be the most effective, but were on par with rest of the treatment except spraying with 0.2 per cent DDT + BHC (Table 8,II). At third picking spraying with 0.2 per cent carbaryl and 0.04 per cent endrin were significantly superior to the rest of the treatments. The dusting with 2 per cent parathion and 10 per cent DDT + BHC proved to be the least effective (Table 8,III). At the fourth and fifth picking treatments with 0.2 carbaryl and 0.04 per cent endrin were found to be the most promising in reducing the pest infestation. Dusting with 10 per cent DDT + BHC was the least effective treatment (Table 8, IV & V).

IV. Mango hoppers (Idioscopus atkinsoni Leth.) :

(A) Laboratory studies : As stated earlier laboratory experiments were conducted on mango inflorescences using

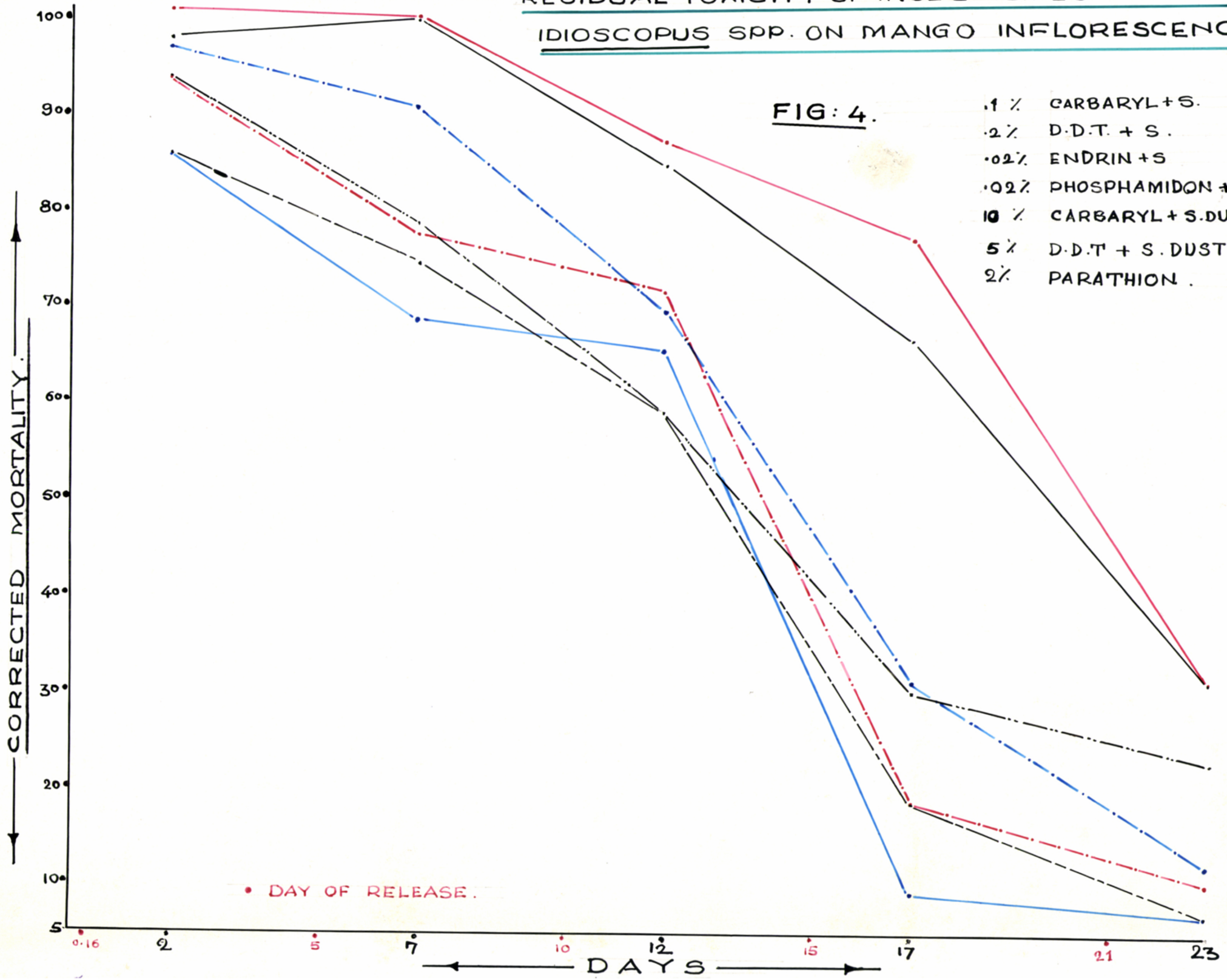
second and third instar nymphs of I. atkinsoni. The data are presented in table 9. The data on the mortality obtained in respect of nymphs released just after spraying is given in table 9(I). From the data it will be observed that 10 per cent carbaryl + sulphur gave the highest mortality (99.14 per cent), while 0.2 per cent DDT+Sulphur and 5 per cent DDT + Sulphur gave 84.80 per cent mortality 48 hours after the treatment. Rest of the treatments gave more than 90 per cent mortality. The nymphs were released 5 and 10 days after the application of insecticides and the observations recorded on their mortalities are given in table 9 (II & III). All the insecticidal treatments gave more than 50 per cent mortality. Carbaryl spraying or dusting was observed to be the most effective treatment. The observations recorded on the mortality, 15 days after application are presented in table 9 (II). It was observed that all the insecticides gave less than 50 per cent mortality except spraying with 0.1 per cent carbaryl + sulphur and dusting with 10 per cent carbaryl + sulphur. The mortality percentages released 21 days of the nymphs after the application of insecticides are given in table 9(V). From the data it will be seen that all the insecticides gave less than 50 per cent mortality.

The residual toxicities of different insecticides were plotted on a graph which is given in figure 4. On the basis

RESIDUAL TOXICITY OF INSECTICIDES AGAINST

IDIOSCOPUS SPP. ON MANGO INFLORESCENCE.

FIG: 4.



of laboratory experiments the spraying and dusting intervals were fixed. The carbaryl treatment both as spray or dust was repeated at 21 days interval while all the rest applications were made at 15 days interval.

(B) Field experiment : As mentioned above the applications were made at the interval fixed on the basis of laboratory data and the efficacy was compared with recommendations of the State Department of Agriculture.

The data on the percentage decline on the pest population recorded 48 hours, 5, 10, 15 and 21 days after the treatments are given in table 10.

From the table 10(I) it will be seen that all the insecticidal treatments were effective in reducing the pest population just after the applications. Spraying with 0.1 per cent carbaryl was the most effective treatment. On the 5th day the pest decline was the highest in 0.1 per cent carbaryl spraying. All the dusting treatments were significantly inferior to spraying treatments (Table 10, II).

On the 10th day, treatment with 0.2 per cent phosphamidon was observed to be the most effective but was on par with rest of the treatments except dusting with carbaryl and DDT as standard treatments (Table 10, III). The data on the percentage decline on the pest population recorded after second application of the insecticides are presented in

table 10 (IV). Spraying with carbaryl at 15 days interval was observed to be the most effective and significantly superior to the rest of the treatments. Dusting with 2 per cent parathion at 15 days interval was observed to be the least effective treatment. The data on the pest decline 21 days after the last application are presented in table 10 (V). It will be seen from the table that spraying with carbaryl at 21 days interval was the most effective treatment and on par with spraying 0.02 per cent phosphamidon and 0.1 per cent carbaryl at 15 days interval.

CHAPTER V

D I S C U S S I O N

The results on the residual toxicities of different insecticides tested in laboratory and under field conditions against cabbage aphids, potato tuber moth, bhendi shoot and fruit borer and mango hoppers are presented in earlier Chapter. These results are briefly discussed below.

I. Cabbage aphids : Under laboratory conditions phosphamidon and dimethoate persisted longer as compared to rest of the insecticides. The mortality however, was observed to be less than 50 per cent after 15 days. The mortalities with methyl demeton and thiometon although was less than 50 per cent on 10th day, these were quite comparable with dimethoate and phosphamidon. These observations do not agree with those made by Raut and Senapati (1967) who noted that methyl demeton and dimethoate were more persistant as compared to phosphamidon. Thus the systemic insecticides persisted more longer compared to contact insecticides. The comparison of systemics and non-systemics seems to have not been carried out in the past, Wene and White (1952). Wright and Wheatley (1952) compared the residual toxicity of parathion with BHC and they observed parathion was more persistant. Parathion during the present investigation was found to give less than 50 per cent mortality on 10th day and was observed to be less persistant as compared to systemic insecticides. Parathion has been also reported to deteriorate rapidly one week after the treatment

against M. persicae on tobacco (Dominick, 1949). Singh and Sindu (1958) also observed that parathion had a short residual effect and recommended its spraying at 10 days interval against mustard aphid.

Under the field conditions the systemics proved to be more persistant although the contact insecticides like parathion, diazinon, malathion gave appreciable knockdown of the pest immediately after the treatment. Diazinon and malathion were sprayed at an interval of 5 days as they were found to give less than 50 per cent mortality within these period. But mortality due to these insecticides was not significantly superior with that obtained with systemic insecticides 5 days after spraying. On the 10th day systemics like thiometon, methyl demeton were sprayed along non systemic insecticides and it was observed that these gave higher mortality indicating that two sprayings of thiometon and methyl demeton at 10 days interval were as effective as three sprayings of malathion and diazinon at 5 days interval. Phosphamidon and dimethoate, the other two systemic tested, gave significantly less mortality on the 10th day after spraying indicating that although they gave more than 50 per cent mortality under laboratory conditions on the 10th day, did not give comparable mortality under field conditions. This means that it is necessary to spray the systemics at 10 days interval to obtain comparable results with non-systemic sprayed

at 5 days interval. The standard treatment of spray 0.02 per cent endrin at 15 days interval was found to be inferior even on 5th and 10th days. It is obvious from the above discussion that in order to get effective and economic control of cabbage aphids, the systemic insecticides should be sprayed atleast 10 days interval and if the non-systemics are to be used, they should be sprayed at 5 days interval.

I. Potato tuber moth : Under laboratory conditions azinphos, carbaryl, endrin and parathion were found to be more persistant and gave good results of the pest infesting the foliage upto 15 days. DDT, lindane and malathion gave less than 50 per cent mortality on 10th day, Under field conditions azinphos, carbaryl, parathion and endrin sprayed at 15 days interval gave significantly higher pest decline 5th days after spraying but their efficacy was not comparable with lindane,malathion and DDT sprayed at 10 days interval. The standard treatment of DDT sprayed at 15 days interval was found to be the least effective as compared to other treatments. These observations thus are not agreeable to Cannon (1948) who reported that spraying of 0.1 per cent DDT at 3 weeks interval kept the crop free from foliage infestation of the pest. The observations recorded in tubers showed that spraying of azinphos, carbaryl and endrin at 15 days interval was more effective as compared to a spraying of malathion, endrin and DDT at 10 days interval. Thus the spraying of

insecticides like azinphos, carbaryl, parathion and endrin at 15 days interval will be more economic to give effective control of the pest in foliage and tubers, compared to spraying of malathion, lindane and DDT at 10 days interval. But in order to obtain the effective control of pest, 10 days interval will be more appropriate in case of azinphos, carbaryl, parathion and endrin. Shevey et al.(1967) also recommended the spraying of azinphos at 10 days interval instead of 14 days. Bacon (1960) also reported that four sprays of azinphos methyl and endrin at 15 days interval gave satisfactory control of pest infesting foliage and tubers. He also observed that DDT is to be ineffective.

III. Bhendi shoot and fruit borer : In the laboratory studies spraying or dusting with carbaryl gave longer residual toxicity compared to the other insecticides. Endrin spraying at 15 days interval usually recommended for the control of bollworms was observed to give less than 50 percent mortality on the 10th day. Under the field conditions spraying or dusting with carbaryl was observed to reduce the fruit infestation more effectively as compared to others. The infestation in shoots was negligible and therefore the performance of the insecticides could not be judged for controlling the pest attack on shoots. Spraying or dusting of carbaryl at 15 days interval was observed to be as effective as spraying of endrin at 10 days interval. Therefore it will be advantageous to spray carbaryl at 15 days interval than to spray endrin at 10 days interval.

IV. Mango hoppers : In the laboratory experiments carbaryl spraying or dusting was observed to persist more longer compared to other insecticides. DDT did not give 50 per cent mortality on the 15th day and therefore it was required to be applied at an interval not exceeding 15 days. The mortality due to carbaryl was much higher on 21st days as compared to that of DDT obtained on 15th day.

Under field conditions carbaryl sprayed at 15 days interval gave the highest efficacy compared to the rest of the treatments. The mortality with carbaryl applied at 21 days interval was significantly inferior as compared to carbaryl applied at 21 days interval was significantly inferior as compared to carbaryl applied at 15 days interval, spraying was observed to be more efficacious compared to dusting. Although it was observed that carbaryl gave more than 50 per cent mortality 15 days after treatment. Its application interval of 21 days is not effective and therefore not worthy to follow. In order to obtain effective and economical control of the pest, the treatment of spraying of carbaryl at 15 days interval needs recommendations.

CHAPTER VI

SUMMARY

Due to the spectacular success of pesticides in pest control work, large number of them are available in the market, However, due to their intensive and indiscriminate use, certain problems have cropped in. Amongst these, the toxicity hazards due to the insecticidal residues on or in the treated products is the most important one. It is a common practice to use persistant insecticides in the plant protection work. However, use of such insecticides particularly on edible crops poses a great threat as it is likely to produce deliterious effects on consuming the treated commodities. Very little or practically, no systematic work on the problems seems to have been carried out so far in the State of Maharashtra.

In view of the seriousness of the problems it was felt necessary to undertake studies on residual toxicity of some important insecticides on crops of economic importance such as cabbage, potato, bhendi and mango. During the course of present investigations (1967-69), the residual toxicities of as many as 18 commonly used insecticides was studied by bioassays method using, cabbage aphids (*B. brassicae*), potato tuber moth, (*G. operculella*), bhendi shoot and fruit borer (*E. fabia*) and mango hoppers (*I.atkinsoni*) as test species. The results of these investigations are summarised in this Chapter.

Under the laboratory experiments, the insecticides were sprayed on potted plants of cabbage, potato and bhendi while in case of mango the insecticides were applied on the inflorescence under the field conditions. A known number of insects were released immediately after the treatment and 5, 10 and 15 days thereafter. The mortality percentages were worked out and these were corrected by using Abbott's formula, (1925). On the basis of this, the intervals between two applications were fixed. When the mortality was observed to reach less than 50 per cent, in case of any insecticides, it was decided to spray it again. These laboratory findings were confirmed by conducting field experiments and compared with standard treatments.

In case of cabbage aphids, phosphamidon and dimethoate showed longer residual toxicity in the laboratory experiments and they gave more than 50 per cent mortality on the 10th day. The interval of spraying of these insecticides was therefore, fixed at 15 days. Thiometon, methyl demeton, parathion and endosulfan did not give 50 per cent mortality on the 10th day and therefore their application interval was fixed as 10 days. Malathion and diazinon were however, observed to give less than 50 per cent mortality on the 5th day after application and therefore they were required to be sprayed at 5 days interval.

Under field conditions the insecticides were sprayed at the interval fixed on the basis of the laboratory

experiments and the percentage decline of the pest was recorded. The systemic insecticides like methyl demeton and thiometon sprayed at 10 days interval gave as much mortalities as obtained with diazinon and malathion sprayed at 5 days interval. Phosphamidon and dimethoate sprayed at 15 days interval gave comparable pest control upto 10 days but the mortality was less after 10 days and therefore they also need application at 10 days interval.

In case of potato tuber moth azinphos, carbaryl, parathion and endrin were observed to give 50 per cent mortality of the larvae 10 days after spraying in the laboratory experiments and therefore in the field they were sprayed at 15 days interval. DDT, lindane and malathion were sprayed at 10 days interval as they failed to give 50 per cent mortality on 10th day after the treatment.

In the field experiments, observations were recorded on the number of leaf mines caused by the tuber moth larvae. The data was also recorded on tuber infestation at the harvest. It was observed that treatments with azinphos, carbaryl, parathion sprayed at 15 days interval gave significant reduction in the pest infestation in foliage and also in tubers. The treatments with lindane, malathion and DDT sprayed at 10 days interval, although gave less number of fresh mines 5 days after the treatment, the infestation recorded after 10 days was not comparable with the other

insecticides. The standard treatment of DDT at 15 days interval proved to be inferior to all the insecticides.

In the laboratory experiments on bhendi shoot and fruit borer, carbaryl spray or dusting was observed to persist longer and its application interval was fixed at 15 days. All the rest of the insecticides including endrin gave less than 50 per cent mortality on 10th day and as such they were sprayed at 10 days interval in the field experiments.

The infestation of the pest was recorded on bhendi fruits at each picking. It was observed that the application of 0.2 per cent carbaryl at 15 days interval and 0.04 per cent endrin at 10 days interval were the most promising in reducing the pest infestation. Dusting with 10 per cent DDT + BHC was the least effective treatment.

In case of mango hoppers carbaryl spraying and dusting gave more than 50 per cent mortality of third and fourth instar of nymphs released 15 days after the treatment and therefore the interval of the application of carbaryl spraying or dusting was fixed at 21 days. The mortality of the hoppers was observed to be less than 50 per cent on the 15th day after the treatment in the case of 0.02 per cent endrin, phosphamidon and 0.2 per cent DDT and 2 per cent parathion as such they were applied at 15 days intervals in the field experiments.

The results obtained with spraying of 0.1 per cent carbaryl at 21 days interval although encouraging, the standard treatment of spraying 0.1 per cent carbaryl at 15 days interval was the most effective treatment and gave the highest mortality of the pest and as such carbaryl spraying needs 15 days interval to obtain effective control of the pest.

The results of these investigations will be of immense use for fixing of the interval of the application of insecticides especially when the present trend is to recommend insecticidal schedule for economic and effective control of the pest. It will too early to consider these results as conclusive and they need further confirmation.

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* Original not seen.

Table 1

Laboratory studies on residual toxicities of insecticides against cabbage aphids

(*B. brassicae*)

Design: R.B.D. with 3 replications. Variety - Early drum head. Date of application: 29.12.67.

Weather record (Average of 15 days) : Rainfall - Nil.

Temperature: Min. 17.1° C. Max. 27.6° C. Humidity percentage : Morning - 94.7 Evening - 53.0

I. Toxicity 48 hours after spraying.

Sr. No.	Treatments	Percentage mortality of aphids: 48 hours after spraying				Corrected mortality			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
1.	0.02% Phosphamidon	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2.	0.02% Parathion	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.	0.02% Dimethoate	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
4.	0.04% Endosulfan	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
5.	0.02% Thiometon	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
6.	0.02% Methyldemeton	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
7.	0.02% Endrin	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
8.	0.02% Diazinon	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
9.	0.05% Malathion	100.00	95.00	100.00	98.33	100.00	94.44	100.00	98.25
10.	Control (Water spray)	10.00	5.00	10.00	8.33	-	-	-	-

Continued

Table 1 (Continued)

II. Toxicity five days after spraying.

Sr. No.	Treatments	Percentage mortality of aphids 48 hours after release				Corrected mortality			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
1.	0.02% Methyldemeton	95.00	100.00	100.00	98.33	94.44	100.00	100.00	98.15
2.	0.02% Thiometon	100.00	95.00	100.00	98.33	100.00	94.44	100.00	98.15
3.	0.02% Dimethoate	100.00	95.00	95.00	96.67	100.00	94.44	94.44	96.29
4.	0.02% Phosphamidon	100.00	90.00	95.00	95.00	100.00	88.88	94.44	94.44
5.	0.02% Parathion	100.00	85.00	90.00	91.67	100.00	83.33	88.88	90.74
6.	0.02% Endrin	100.00	85.00	90.00	91.67	100.00	83.33	88.88	90.74
7.	0.04% Endosulfan	85.00	80.00	65.00	76.67	83.33	77.76	61.11	74.07
8.	0.02% Diazinon	50.00	55.00	50.00	51.67	44.44	50.00	44.44	46.29
9.	0.05% Malathion	50.00	55.00	45.00	50.00	44.44	50.50	38.89	44.44
10.	Control(Water spray)	10.00	10.00	10.00	10.00	-	-	-	-

Continued

Table 1 (Continued)

III. Toxicity 10 days after spraying.

Sr. No.	Treatments	Percentage mortality of aphids 48 hours after release				Corrected mortality			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
1.	0.02% Phosphamidon	60.00	65.00	80.00	68.33	52.94	63.16	77.76	64.63
2.	0.02% Dimethoate	60.00	60.00	65.00	61.67	52.94	57.89	61.11	57.31
3.	0.02% Methyldemeton	55.00	50.00	55.00	53.33	47.06	47.37	50.00	48.14
4.	0.02% Thiometon	55.00	40.00	45.00	46.67	47.06	36.84	38.89	40.93
5.	0.02% Parathion	45.00	30.00	50.00	41.67	35.29	26.32	44.44	35.35
6.	0.02% Endrin	45.00	30.00	30.00	35.00	35.29	26.32	22.22	27.94
7.	0.02% Diazinon	40.00	30.00	35.00	31.67	29.41	26.32	16.66	24.13
8.	0.04% Endosulfan	40.00	35.00	20.00	31.67	29.41	31.58	11.11	24.03
9.	0.05% Malathion	35.00	25.00	20.00	26.67	23.53	21.05	11.11	18.56
10.	Control (Water spray)	15.00	5.00	10.00	10.00	-	-	-	-

Continued

Table 1 (continued)

IV. Toxicity 15 days after spraying.

Sr. No.	Treatments	Percentage mortality of aphids 48 hours after release				Corrected mortality			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
1.	0.02% Phosphamidon	35.00	45.00	45.00	41.67	27.78	38.89	38.89	35.19
2.	0.02% Dimethoate	30.00	35.00	45.00	36.67	22.22	27.78	38.89	29.63
3.	0.02% Methyl demeton	30.00	35.00	40.00	35.00	22.22	27.78	33.34	27.78
4.	0.02% Thiometon	30.00	30.00	40.00	33.33	22.22	22.22	33.34	25.93
5.	0.02% Endrin	25.00	20.00	25.00	23.33	16.67	11.11	16.67	14.82
6.	0.04% Endosulfan	25.00	25.00	15.00	21.67	16.67	16.67	5.56	12.97
7.	0.02% Parathion	25.00	20.00	20.00	21.67	16.67	11.11	11.11	12.89
8.	0.02% Diazinon	20.00	15.00	20.00	18.33	11.11	5.56	11.11	9.26
9.	0.05% Malathion	20.00	15.00	15.00	16.67	11.11	5.56	5.56	7.41
10.	Control (Water spray)	10.00	10.00	10.00	10.00	-	-	-	-

Table 2

Studies on residual toxicities of insecticides against cabbage aphids (B.brassicae) under field conditions.

Design: R.B.D. with 3 replications. Variety - Early drum head. Date of first application:7.2.69

Plot size : a. Gross - 30'x 15'
b. Net - 28'x 13'

I. Toxicity immediately after first spraying.

Sr. No.	Treatments	Percentage decline in pest population 48 hours after spraying				Aresin transformation			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
1.	0.02% Thiometon at 10 days interval	98.79	96.46	93.78	96.34	83.71	79.22	75.58	79.50
2.	0.02% Dimethoate at 15 days interval	96.25	94.45	98.24	96.31	78.91	76.44	82,29	79.21
3.	0.02% Parathion at 10 days interval	98.85	90.75	94.15	94.59	83.98	72.34	76.06	77.46
4.	0.02% Phosphamidon at 15 days interval	92.33	94.66	96.28	94.42	73.89	76.69	78.91	76.49
5.	0.04% Endosulfan at 10 days interval	90.75	88.50	95.65	9163	72.34	70.18	78.03	73.52
6.	0.02% Methyl demeton at 10 days interval	89.25	91.35	94.49	91.70	70.91	72.95	76.44	73.43
7.	0.02% Diazinon at 5 days interval	90.41	95.54	88.91	91.62	71.95	77.75	70.54	73.41
8.	0.05% Malathion at 5 days interval	92.18	85.75	93.78	90.57	73.78	67.86	75.58	72.41
9.	0.02% Endrin at 10 days interval	88.75	92.47	87.54	89.92	70.45	74.11	69.30	71.29
10.	0.02% Endrin(as std. treatment)at 15 days interval	89.25	90.21	92.15	90.54	70.91	71.76	73.78	72.15
11.	Control(Water spray)	4.00	6.09	8.68	6.26	11.54	14.30	16.11	13.98

S.E. 2.96. C.D. 6.06.

Continued...

Table 2 (continued)

II. Toxicity 48 hours after the treatment in case of insecticides sprayed at 5 days interval and 5 days after treatment in respect of insecticides sprayed at 10 and 15 days interval

Sr. No.	Treatments	Percentage decline in pest population [illegible] treatment				Aresin transformation			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
1.	0.02% Diamnon at 5 days interval	98.21	93.43	97.45	96.36	82.29	75.11	80.90	79.43
2.	0.05% Malathion at 5 days interval	98.49	95.26	94.75	96.16	88.96	77.48	76.82	79.09
3.	0.02% Dimethoate at 15 days interval	92.41	90.00	95.75	92.72	74.00	71.56	78.17	74.58
4.	0.02% Phosphamidon at 15 days interval	91.42	92.80	93.21	92.48	72.95	74.44	74.88	74.09
5.	0.02% Methyl demeton at 10 days interval	87.88	89.92	92.42	90.73	69.64	71.47	74.00	71.70
6.	0.02% Thiometon at 10 days interval	87.41	89.29	92.47	89.72	69.21	70.91	74.11	71.41
7.	0.02% Parathion at 10 days interval	90.15	88.20	89.25	89.20	71.76	69.91	70.91	70.86
8.	0.02% Endrin at 10 days interval	86.78	83.50	81.49	82.92	67.86	66.03	64.54	66.14
9.	0.04% Endosulfan at 10 days interval	75.85	79.41	73.41	76.22	60.60	63.01	58.95	60.85
10.	0.02% Endrin (as standard treatment) at 15 days interval	85.92	85.75	80.70	84.12	67.94	67.86	63.94	66.55
11.	Control(Water spray)	4.30	6.21	5.15	5.22	10.47	14.42	13.18	12.69
						S.E. 2.77.		C.D. 8.16	

Continued ...

Table 2 (continued)

III. Toxicity 10 days after spraying in case of insecticides sprayed at 15 days interval and 48 hours in respect of insecticides sprayed at 5 and 10 days interval.

Sr. No.	Treatments	Percentage decline in pest population				Arcsin transformation			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
1.	0.02% Thiometon at 10 days interval	99.50	94.75	93.41	95.89	84.41	76.82	75.11	78.75
2.	0.02% Methyl demeton at 10 days interval	98.58	95.78	92.75	95.80	83.20	78.17	73.36	78.24
3.	0.02% Diazinon at 5 days interval.	95.59	91.28	98.00	94.96	77.89	72.64	81.87	77.53
4.	0.02% Parathion at 10 days interval.	95.58	96.25	93.25	95.03	77.89	78.91	75.00	77.27
5.	0.04% Endosulfan at 10 days interval	92.05	89.59	96.80	92.81	73.68	71.19	81.47	75.45
6.	0.05% Malathion at 5 days interval	94.58	90.50	95.30	93.46	76.56	72.05	77.48	75.36
7.	0.02% Endrin at 10 days interval	92.41	89.68	85.49	87.19	74.00	71.28	67.62	70.97
8.	0.02% Dimethoate at 15 days interval	81.15	78.30	79.80	73.75	64.30	62.24	63.29	63.28
9.	0.02% Phosphamidon at 15 days interval	80.32	79.45	76.21	75.33	63.65	65.08	60.80	62.51
10.	0.02% Endrin(as standard treatment)at 15 days interval.	55.40	48.85	60.00	54.75	48.10	44.37	50.77	47.75
11.	Control (Water spray)	7.50	3.75	4.15	5.13	15.89	11.24	11.83	12.99

S.E. 1.91. C.D. 5.62

Continued....

Table 2 (continued)

IV. Toxicity 48 hours after spraying in case of insecticides sprayed at 5 and 15 days interval and 5 days after the treatment in respect of insecticides sprayed at 10 days interval.

Sr. No.	Treatments	Percentage decline in pest population				Arcsin transformation			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
1.	0.02% Phosphamidon at 15 days interval	92.31	98.20	96.89	95.80	73.89	82.29	79.86	78.67
2.	0.02% Dimethoate at 15 days interval.	99.25	97.50	92.87	96.54	84.35	80.90	75.46	78.57
3.	0.02% Diazinon at 5 days interval	95.63	97.40	93.75	95.59	77.89	80.72	75.58	78.06
4.	0.02% Thiometon at 10 days interval	82.55	90.35	94.30	89.67	65.35	84.38	76.19	75.31
5.	0.05% Malathion at 5 days interval	95.50	85.40	94.81	91.90	77.75	67.54	76.82	74.04
6.	0.02% Methyl demeton at 10 days interval.	89.77	91.47	88.83	90.02	71.37	73.05	70.45	71.62
7.	0.02% Parathion at 10 days interval	91.25	87.70	88.65	89.20	72.84	69.47	70.36	70.89
8.	0.02% Endrin at 10 days interval	79.50	83.98	80.85	81.44	63.09	66.42	64.08	64.53
9.	0.04% Endosulfan at 10 days interval.	74.95	70.91	85.00	76.95	60.00	57.35	67.21	61.52
10.	0.02% Endrin (as standard treatment)at 15 days interval	85.82	95.55	94.00	91.79	67.86	77.89	75.82	73.86
11.	Control (Water spray)	7.80	8.50	9.78	8.69	16.22	16.95	18.24	17.14

S.E. 2.743. C.D. 8.07

continued....

Table 3

Time required for the first instar larvae of Potato tuber moth for entrance in leaf tissues.

Temperature: Min. 5.7° C. Max.26.4° C. Humidity percentage: Morn. 87 Even. 35

Sr. No.:	Time required in minutes	Sr. No.:	Time required in minutes.
1.	115	26.	99
2.	87	27.	100
3.	108	28.	84
4.	69	29.	181
5.	72	30.	114
6.	103	31.	100
7.	128	32.	85
8.	72	33.	92
9.	74	34.	147
10.	73	35.	133
11.	98	36.	95
12.	70	37.	88
13.	42	38.	92
14.	130	39.	97
15.	33	40.	123
16.	100	41.	140
17.	190	42.	135
18.	165	43.	98
19.	137	44.	195
20.	159	45.	155
21.	158	46.	48
22.	40	47.	90
23.	55	48.	40
24.	180	49.	30
25.	185	50.	105

Average in minutes 107.12.

Table 4

Laboratory studies on residual toxicities of insecticides against Potato tuber moth (*G. operculella*)

Design : R.B.D. with 3 replications. Variety - Upto - date. Date of application: 4.1.69
Weather record (average of 15 days) : Rainfall - Nil

Temperature : Min. 10.07° C. Max. 30.00° C.
Humidity percentage: Morning - 81.00 Evening- 28.33

I. Toxicity 48 hours after spraying.

Sr. No.	Treatments	Percentage mortality of larvae 48 hours after spraying				Corrected mortality			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
1.	0.03% Azinphos	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2.	0.05% Parathion	100.00	100.00	95.00	99.33	100.00	100.00	94.11	98.04
3.	0.05% Malathion	100.00	95.00	95.00	96.67	100.00	94.44	94.11	96.18
4.	0.03% Endrin	85.00	100.00	90.00	91.67	84.21	100.00	88.33	90.81
5.	0.03% Lindane	100.00	90.00	85.00	90.00	100.00	88.89	82.35	90.41
6.	0.2% Carbaryl	95.00	80.00	90.00	88.33	94.73	77.78	88.23	86.91
7.	0.2% DDT.	85.00	80.00	95.00	86.67	84.21	77.78	94.11	85.37
8.	Control (Water spray)	5.00	10.00	15.00	10.00	-	-	-	-

Continued ....

Table 4 (continued)

II. Toxicity 5 days after spraying.

Sr. No.	Treatments	Percentage mortality of larvae 48 hours after release				Corrected mortality			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
1.	0.2% Carbaryl	100.00	95.00	90.00	95.00	100.00	94.56	88.89	94.48
2.	0.03% Azinphos	100.00	85.00	95.00	93.33	100.00	83.69	94.44	92.71
3.	0.03% Endrin	85.00	100.00	90.00	91.67	84.21	100.00	88.89	91.03
4.	0.2% DDT	85.00	100.00	90.00	91.67	84.21	100.00	88.89	91.03
5.	0.05% Parathion	85.00	95.00	90.00	90.00	84.21	94.56	88.99	89.22
6.	0.03% Lindane	95.00	85.00	85.00	88.33	94.73	83.69	83.33	87.25
7.	0.05% Malathion	65.00	75.00	85.00	75.00	63.15	72.82	83.33	73.10
8.	Control (Water spray)	5.00	8.00	10.00	7.67	-	-	-	-

Continued .....

Table 4 (continued)

III. Toxicity 10 days after spraying.

Sr. No.	Treatments	Percentage mortality of larvae 48 hours after release				Corrected mortality.			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
1.	0.03% Azinphos	60.00	65.00	55.00	73.33	76.47	83.33	47.06	68.95
2.	0.2% Carbaryl	65.00	75.00	80.00	73.33	58.82	72.22	76.47	68.95
3.	0.03% Endrin	75.00	65.00	45.00	56.67	70.59	61.11	35.29	57.33
4.	0.05% Parathion	65.00	60.00	55.00	53.33	58.82	55.56	47.06	53.81
5.	0.2% DDT	45.00	40.00	55.00	46.67	35.29	33.33	47.06	38.56
6.	0.03% Lindane	60.00	40.00	35.00	45.00	52.94	33.33	33.53	36.60
7.	0.05% Malathion	35.00	40.00	50.00	41.67	23.53	33.33	41.18	32.68
8.	Control (Water spray)	15.00	10.00	15.00	13.33	-	-	-	-

Continued ....

Table 4 (continued)

IV. Toxicity 15 days after spraying.

Sr. No.	Treatments	Percentage mortality of larvae: 48 hours after release				Corrected mortality			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
1.	0.03% Azinphos	50.00	45.00	55.00	50.00	41.18	38.89	50.00	43.36
2.	0.03% Endrin	35.00	40.00	55.00	43.33	23.52	33.33	50.00	35.62
3.	0.05% Parathion	55.00	40.00	30.00	41.67	47.06	33.33	22.22	34.20
4.	0.2% Carbaryl	35.00	30.00	55.00	40.00	23.53	22.22	50.00	31.92
5.	0.03% Lindane	35.00	40.00	35.00	36.67	23.53	33.33	27.78	28.21
6.	0.2% DDT	25.00	35.00	20.00	26.67	11.76	27.78	11.11	16.88
7.	0.05% Malathion	30.00	20.00	15.00	21.67	17.65	11.11	5.56	11.44
8.	Control (Water spray)	15.00	10.00	10.00	11.67	-	-	-	-

Table 5

Studies on residual toxicities of insecticides against potato tuber moth under field conditions.

Design: R.B.D. with 3 replications. Variety - Upto-date. Date of Application:29.1.69

Plot size : A. Gross - 35' x 15'
b. Net - 33' x 13'

Date of last application:13.2.69
Date of Planting : 25.11.68
Date of harvesting:23.2. 69

I. Number of fresh mines 5 days after the treatment.

Sr. No.	Treatments	Number of fresh mines 5 days after first application.			
		RI	RII	RIII	Mean
1.	0.03% Azinphos at 15 days interval	5.00	4.00	8.00	5.67
2.	0.2% Carbaryl at 15 days interval	8.00	10.00	3.00	7.00
3.	0.05% Parathion at 15 days interval	9.00	5.00	11.00	8.33
4.	0.03% Endrine at 15 days interval	12.00	8.00	9.00	9.67
5.	0.05% Malathion at 10 days interval	15.00	18.00	13.00	15.33
6.	0.03% Lindane at 10 days interval	13.00	20.00	18.00	17.00
7.	0.2% DDT at 10 days interval	23.00	14.00	18.00	18.33
8.	0.2% DDT (as standard treatment) at 15 days interval	10.00	25.00	23.00	19.33
9.	Control (Water spray)	35.00	48.00	30.00	37.67

S.E. 2.94. C.D. 8.79.

continued ...

Table 5 (continued)

II. Number of fresh mines 5 days after first observation.

Sr. No.	Treatments	Number of fresh mines 10 days after first application			
		RI	RII	RIII	Mean
1.	0.03% Azinphos at 15 days interval	9.00	20.00	14.00	14.33
2.	0.2% Carbaryl at 15 days interval	23.00	15.00	19.00	19.00
3.	0.05% Parathion at 15 days interval	15.00	23.00	29.00	22.33
4.	0.03% Endrin at 15 days interval	30.00	21.00	19.00	23.33
5.	0.2% DDT at 10 days interval	40.00	28.00	43.00	37.00
6.	0.05% Malathion at 10 days interval	32.00	31.00	38.00	33.67
7.	0.03% Lindane at 10 days interval	42.00	32.00	31.00	35.00
8.	0.2% DDT (as standard treatment) at 15 days interval	25.00	46.00	46.00	39.00
9.	Control (Water spray)	55.00	40.00	48.00	47.67

S.E. 4.19. C.D. 12.52.

Continued .....

Table 5 (continued)

III. Number of fresh mines 10 days after first observation.

Sr. No.	Treatments	Number of fresh mines 15 days after first application			
		RI	RII	RIII	Mean
1.	0.03% Lindane at 10 days interval	16.00	12.00	14.00	14.67
2.	0.05% Malathion at 10 days interval	20.00	11.00	14.00	15.00
3.	0.2% DDT at 10 days interval	20.00	15.00	14.00	13.33
4.	0.03% Azinphos at 15 days interval	28.00	26.00	22.00	25.33
5.	0.2% Carbaryl at 15 days interval	31.00	38.00	21.00	30.00
6.	0.05% Parathion at 15 days interval	35.00	42.00	33.00	36.67
7.	0.03% Endrin at 15 days interval	48.00	32.00	38.00	39.33
8.	0.2% DDT (as standard treatment) at 15 days interval	52.00	47.00	42.00	47.00
9.	Control (Water spray)	61.00	49.00	55.00	55.00

S.E. 2.64. C.D. 7.90.

Continued ....

Table 5 (continued)

IV. Number of fresh mines 15 days after first observation.

Sr. No.	Treatments	Number of fresh mines 20 days after first application.			
		RI	RII	RIII	MeAn
1.	0.03% Azinphos at 15 days interval	9.00	11.00	5.00	8.33
2.	0.2% Carbaryl at 15 days interval	11.00	13.00	8.00	10.67
3.	0.05% Parathion at 15 days interval	20.00	9.00	13.00	14.00
4.	0.03% Endrin at 15 days interval	18.00	20.00	10.00	16.00
5.	0.03% Lindane at 10 days interval	39.00	34.00	27.00	33.33
6.	0.05% Malathion at 10 days interval	40.00	31.00	35.00	35.33
7.	0.2% DDT at 10 days interval	33.00	45.00	40.00	39.33
8.	0.2% DDT (as standard treatment) at 15 days interval	21.00	18.00	17.00	18.67
9.	Control (Water spray)	51.00	47.00	53.00	50.33

S.E. 2.36 C.D. 7.04.

Continued .....

Table 5 (continued)

V. Percentage tuber infestation at harvesting.

Sr. No.	Treatments	Percentage tuber Infestation:				Arcsin transformation			
		RI	RII	RIII	Mean:	RI	RII	RIII	Mean
1.	0.03% Asinphos at 15 days interval	13.73	14.78	12.75	13.75	21.72	22.63	20.96	21.77
2.	0.2% Carbaryl at 15 days interval	12.25	13.78	16.27	14.10	20.53	21.81	23.81	22.05
3.	0.05% Parathion at 15 days interval	13.24	15.73	14.75	14.57	21.30	23.34	22.63	22.42
4.	0.03% Endrin at 15 days interval	15.28	16.75	14.28	15.44	23.03	24.20	22.22	23.15
5.	0.05% Malathion at 10 days interval	17.26	16.00	19.27	17.51	24.58	23.58	26.06	24.74
6.	0.03% Lindane at 10 days interval	18.78	21.22	16.75	18.92	25.70	27.44	24.20	25.77
7.	0.2% DDT at 10 days interval	19.74	23.00	17.29	20.01	26.35	28.66	24.58	26.53
8.	0.2% DDT (as standard treatment) at 15 days interval	21.76	25.00	19.50	22.09	27.63	30.00	26.21	28.01
9.	Control (Water spray)	26.50	23.00	25.50	31.67	30.98	28.66	30.33	29.99

S.E. 0.814. C.D. 2.43.

Table 6

Time required for the first instar larvae of bhendi shoot and fruit borer (E. fabia)

Temperature : Min. 12.8° C Max. 29.2° C Humidity percentage: Morn: 86 Even. 36

Sr. No.	Time required in minutes	Sr. No.	Time required in minutes.
1.	70	26.	120
2.	85	27.	122
3.	63	28.	92
4.	131	29.	65
5.	87	30.	79
6.	139	31.	198
7.	95	32.	242
8.	150	33.	205
9.	125	34.	79
10.	138	35.	55
11.	135	36.	148
12.	110	37.	189
13.	250	38.	209
14.	55	39.	125
15.	148	40.	115
16.	178	41.	110
17.	195.	42.	185
18.	68	43.	198
19.	201	44.	243
20.	105	45.	78
21.	45	46.	128
22.	220	47.	58
23.	217	48.	40
24.	245	49.	80
25.	85	50.	48

Average in minutes : 131.02.

Table 7

Laboratory studies on residual toxicities of insecticides against bhendi shoot and fruit borer (E. fabia)

Design: R.B.D.with 3 replications. Variety - Pusa sawani. Date of application: 6.12.68

Weather record (Average of 15 days) : Rainfall - Nil.

Temperature : Min. 9.93° C. Max.30.27° C

Humidity percentage : Morning - 87.33 Evening - 30.00

I. Toxicity immediately after the treatment.

Sr. No.	Treatments	Percentage mortality of larvae 48 hours after application				Corrected mortality			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.2% Carbaryl	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2.	0.04% Endrin	100.00	95.00	100.00	98.33	100.00	94.44	100.00	98.15
3.	0.1% Malathion	100.00	95.00	95.00	96.67	100.00	94.44	94.12	96.19
4.	0.2% DDT + BHC	95.00	80.00	90.00	88.33	94.44	77.76	88.24	86.88
	b. Dusts								
5.	10% Carbaryl	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
6.	2% Parathion	100.00	95.00	100.00	98.33	100.00	94.44	100.00	98.15
7.	1% Endrin	100.00	90.00	100.00	96.67	100.00	88.89	100.00	96.30
8.	5% Malathion	100.00	100.00	85.00	95.00	100.00	100.00	82.35	94.12
9.	10% DDT + BHC	100.00	80.00	95.00	91.67	100.00	77.76	94.12	94.21
10.	Control (Water spray)	5.00	10.00	15.00	10.00	-	-	-	-

Continued ....

Table 7 (continued)

II. Toxicity 5 days after the treatment.

Sr. No.	Treatments	Percentage mortality of larvae: 48 hours after release				Corrected mortality			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.2% Carbaryl	100.00	95.00	95.00	96.67	100.00	94.44	94.44	96.29
2.	0.04% Endrin	95.00	85.00	95.00	91.67	94.74	83.33	94.44	90.84
3.	0.2% DDT + BHC	80.00	85.00	90.00	85.00	78.95	83.33	88.89	83.72
4.	0.1% Malathion	90.00	70.00	80.00	80.00	89.47	66.67	77.76	77.97
	b. Dusts								
5.	10% Carbaryl	100.00	95.00	100.00	98.33	100.00	94.44	100.00	98.15
6.	1% Endrin	95.00	80.00	95.00	90.00	94.44	77.76	94.44	88.98
7.	2% Parathion	95.00	75.00	85.00	85.00	94.74	72.22	83.33	83.43
8.	5% Malathion	70.00	90.00	95.00	85.00	68.42	88.89	94.44	83.92
9.	10% DDT + BHC	85.00	85.00	80.00	83.33	84.21	83.33	77.76	81.77
10.	Control (Water spray)	5.00	10.00	10.00	8.33	-	-	-	-

Continued...

Table 7 (continued)

III. Toxicity 10 days after the treatment.

Sr. No.	Treatments	Percentage mortality of larvae 48 hours after release				Corrected mortality			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.2% Carbaryl	85.00	80.00	90.00	85.00	83.33	78.95	88.24	83.51
2.	0.04% Endrin	60.00	50.00	45.00	51.67	55.56	47.37	35.29	46.07
3.	0.2% DDT + BHC	50.00	45.00	50.00	48.33	44.45	42.11	41.18	42.58
4.	0.1% Malathion	60.00	40.00	35.00	45.00	55.56	36.84	23.53	38.64
	b. Dusts								
5.	10% Carbaryl	80.00	75.00	80.00	78.33	77.76	73.68	76.47	75.97
6.	1% Endrin	55.00	40.00	50.00	48.33	50.00	36.84	41.18	42.67
7.	2% Parathion	35.00	30.00	55.00	40.00	27.78	26.32	47.06	33.72
8.	5% Malathion	25.00	55.00	40.00	40.00	16.67	52.63	29.41	32.90
9.	10% DDT + BHC	30.00	40.00	40.00	36.67	22.22	36.84	29.41	29.39
10.	Control (Water spray)	10.00	5.00	15.00	10.00	-	-	-	-

Continued .....

Table 7 (continued)

IV. Toxicity 15 days after the treatment.

Sr. No.	Treatments	Percentage mortality of larvae 48 hours after release				Corrected mortality.			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.2% Carbaryl	45.00	50.00	45.00	46.67	42.11	41.18	38.89	40.73
2.	0.04% Endrin	55.00	45.00	35.00	45.00	52.63	35.29	27.78	38.57
3.	0.2% DDT + BHC	15.00	25.00	20.00	20.00	10.53	11.76	11.11	11.13
4.	0.1% Malathion	15.00	20.00	20.00	18.33	10.53	5.88	11.11	9.17
	b. Dusts								
5.	10% Carbaryl	40.00	60.00	55.00	51.67	36.84	52.94	50.00	46.59
6.	2% Parathion	45.00	25.00	20.00	30.00	42.11	11.76	11.11	21.66
7.	1% Endrin	15.00	30.00	20.00	21.67	10.53	17.65	11.11	13.10
8.	5% Malathion	15.00	20.00	15.00	16.67	10.53	5.88	5.56	7.32
9.	10% DDT + BHC	10.00	20.00	15.00	15.00	5.26	5.88	5.56	5.90
10.	Control (Water spray)	5.00	15.00	10.00	10.00	-	-	-	-

Table 8

Studies on residual toxicities of insecticides against bhendi shoot and fruit borer under field conditions.

Design: R.B.D. with 3 replications. Variety - Pusa savani. Date of Ist application: 9.1.69

Plot size : a. Gross - 35' x 15' Date of sowing : 20.12.68

b. Net - 33' x 13'

I. Percentage of fruit infestation at first picking(24.1.69).

Sr. No.	Treatments	Percentage fruit infestation				Arcsin transformation.			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.2% Carbaryl at 15 days interval	8.59	12.50	13.33	11.47	17.05	20.70	21.39	19.71
2.	0.04% Endrin at 10 days interval	23.33	16.00	18.15	19.16	28.86	23.58	25.25	25.90
3.	0.1% Malathion at 10 days interval	50.00	43.75	47.22	46.92	45.00	41.44	43.39	43.28
4.	0.2% DDT + BHC at 10 days interval	53.33	59.14	55.55	56.01	46.89	50.24	48.22	48.45
5.	0.04% Endrin(as std. treatment)at 15 days int.	35.00	12.00	22.22	23.07	36.27	20.27	28.11	28.22
	b. Dusts								
6.	10% Carbaryl at 15 days interval	17.35	15.00	16.28	16.21	24.65	22.79	23.81	23.75
7.	5% Malathion at 10 days interval	40.00	32.18	45.45	39.21	39.23	34.57	42.42	38.74
8.	2% Parathion at 10 days interval	34.61	56.52	55.00	48.71	36.09	48.73	47.87	44.23
9.	10% DDT + BHC at 10 days interval	58.33	55.55	59.14	57.67	49.78	48.22	50.24	49.41
10.	1% Endrin at 10 days interval	60.00	64.00	66.67	63.56	50.77	53.13	54.76	52.89
11.	Control (Water spray)	83.33	80.00	75.00	76.11	65.88	56.89	60.00	60.89

S.E. 2.31. C.D. 6.79.

Continued ...

Table 8 (continued)

II. Percentage of fruit infestation at second picking (1.2.69)

Sr. No.	Treatments	Percentage fruit infestation				Arcsin transformation			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.2% Carbaryl at 15 days interval	11.76	8.00	10.00	9.92	20.09	16.43	18.44	18.32
2.	0.04% Endrin at 10 days interval	11.11	11.66	10.67	11.15	19.46	20.00	19.09	19.52
3.	0.1% Malathion at 10 days interval	18.18	23.19	20.96	20.78	25.25	28.89	27.28	27.11
4.	0.2% DDT + BHC at 10 days interval	28.57	36.36	39.65	34.76	32.33	37.11	39.06	36.17
5.	0.04% Endrin(as std. treatment)at 15 days int.	14.00	20.45	10.64	15.03	21.97	26.92	19.00	22.63
	b. Dusts								
6.	10% Carbaryl at 15 days interval	7.88	11.67	17.46	12.34	16.32	20.00	24.73	20.35
7.	1% Endrin at 10 days interval	12.08	20.27	15.13	15.83	20.36	26.78	22.87	23.34
8.	2% Parathion at 10 days interval	29.31	20.96	26.06	25.77	32.77	27.28	30.72	30.26
9.	5% Malathion at 10 days interval	18.00	28.57	53.45	33.34	25.10	32.33	47.01	34.81
10.	0.2% DDT + BHC at 10 days interval	45.16	30.76	27.67	34.53	42.25	33.71	31.76	35.91
11.	Control (Water spray)	90.00	85.71	88.23	87.98	71.56	67.78	69.91	69.75
						S.E. 6.12.		C.D. 17.09	

Continued ...

Table 8 (continued)

III. Percentage of fruit infestation at third picking (5.2.69)

Sr. No.	Treatments	Percentage fruit infestation				Arcsin transformation			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.2% Carbaryl at 15 days interval	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.	0.04% Endrin at 10 days interval	7.14	3.22	5.51	5.29	15.45	10.31	13.56	13.11
3.	0.2% DDT + BHC at 10 days interval	6.06	5.00	15.62	8.89	14.30	12.92	23.26	16.83
4.	0.1% Malathion at 10 days interval	18.75	8.33	20.00	15.69	25.70	16.74	26.56	23.00
5.	0.04% Endrin(as Std. treatment)at 15 days int.	9.52	0.0	5.88	5.13	17.95	0.0	14.06	10.67
	b. Dusts								
6.	10% Carbaryl at 15 days interval	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.	1% Endrin at 10 days interval	5.26	5.26	6.67	5.73	13.31	13.31	15.00	13.54
8.	5% Malathion at 10 days interval	13.34	7.40	4.76	8.50	31.05	15.79	12.66	19.83
9.	2% Parathion at 10 days interval	14.28	7.14	15.00	12.14	22.22	15.45	22.39	20.15
10.	10% DDT + BHC at 10 days interval	9.37	11.11	16.00	12.16	17.85	19.46	23.58	20.26
11.	Control (Water spray)	64.28	33.33	80.00	59.20	53.31	35.24	63.44	50.66
						S.E. 3.26. C.D. 9.58.			

Continued ...

Table 8 (continued)

IV. Percentage of fruit infestation at fourth picking (11.2.69)

Sr. No.	Treatments	Percentage fruit infestation				Arcsin transformation			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.2% Carbaryl at 15 days interval	2.56	6.25	0.0	2.94	9.28	14.54	0.0	7.94
2.	0.04% Endrin at 10 days interval	2.00	6.24	5.00	4.42	8.13	14.54	12.92	11.86
3.	0.2% DDT + BHC at 10 days interval	5.26	2.43	6.00	4.58	13.31	8.91	14.18	12.13
4.	0.1% Malathion at 10 days interval	9.37	3.57	2.56	5.17	17.85	10.94	9.28	12.69
5.	0.04% Endrin(as std. treatment)at 15 days int.	0.00	8.10	4.33	4.14	0.00	16.54	11.97	9.50
	b. Dusts								
6.	10% Carbaryl at 15 days interval	2.50	5.88	1.37	3.25	9.10	14.06	6.80	9.99
7.	1% Endrin at 10 days interval	2.00	7.69	2.70	4.13	8.13	6.11	9.46	11.23
8.	2% Parathion at 10 days interval	5.41	4.44	4.44	4.76	13.44	12.11	12.11	12.55
9.	5% Malathion at 10 days interval	11.11	2.78	4.87	6.25	19.46	9.63	12.79	13.63
10.	10% DDT + BHC at 10 days interval	14.28	3.70	6.90	8.30	22.22	11.09	15.23	16.18
11.	Control (Water spray)	26.87	62.50	44.44	44.60	31.24	52.24	41.78	41.42

S.E. 3.35. C.D. 9.86

Continued ...

Table 8 (continued)

V. Percentage of fruit infestation at fifth picking (15.2.69)

Sr. No.	Treatments	Percentage fruit infestation				Arcsin transformation			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.2% Carbaryl at 15 days interval	4.00	2.50	12.50	6.33	11.54	9.10	20.70	13.78
2.	0.04% Endrin at 10 days interval	12.00	8.25	6.20	8.82	20.27	16.74	14.42	17.14
3.	0.1% Malathion at 10 days interval	23.08	8.69	5.55	12.44	28.73	17.16	13.56	19.82
4.	0.2% DDT + BHC at 10 days interval	21.42	7.69	12.50	13.87	27.56	16.11	20.70	21.46
5.	0.04% Endrin(as std. treatment)at 15 days int.	16.13	12.00	14.31	14.15	23.66	20.27	22.22	22.05
	b. Dusts								
6.	1% Endrin at 10 days interval	9.37	4.17	7.14	6.89	17.85	11.83	15.45	15.04
7.	10% Carbaryl at 15 days interval	9.09	10.71	4.00	7.93	17.56	19.09	11.54	16.06
8.	2% Parathion at 10 days interval	12.93	7.32	13.88	11.37	21.05	15.68	21.89	19.54
9.	5% Malathion at 10 days interval	11.11	6.67	20.83	12.87	19.46	15.00	27.13	20.53
10.	10% DDT + BHC at 10 days interval	19.04	11.62	18.75	16.47	25.84	19.91	25.70	23.82
11.	Control (Water spray)	40.00	30.00	53.33	41.33	39.23	23.21	46.89	39.78

S.E. 2.52. C.D. 7.41.

Table 9

Laboratory studies on residual toxicities of insecticides against mango hoppers (*I. atkinsoni*)

Design: R.B.D. with 3 replications. Variety - Hapus. Date of 1st application: 9.3.68

Weather record (average of 21 days) : Rainfall - Nil.

Temperature : Min. 15.75° C, Max. 33.6° C Humidity percentage: Morning - 68.50, Evening - 37.50

I. Toxicity immediately after the treatment.

Sr. No.	Treatments	Percentage mortality of hoppers 48 hours after application				Corrected mortality			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.1% Carbaryl+Sulphur (1:1)	97.50	95.00	100.00	97.50	97.06	94.44	100.00	97.17
2.	0.02% Phosphamidon + (1:1) Sulphur	92.50	100.00	97.50	96.67	91.18	100.00	97.22	96.12
3.	0.02% Endrin + Sulphur (1:1)	92.50	92.50	97.50	94.67	91.18	91.57	97.22	93.32
4.	0.2% DDT + Sulphur (1:1)	82.50	85.00	92.50	86.67	79.41	83.33	91.67	84.80
	b. Dusts								
5.	10% Carbaryl+Sulphur (1:1)	100.00	100.00	97.50	99.15	100.00	100.00	97.22	99.14
6.	5% DDT + Sulphur (1:1)	92.50	97.00	92.50	94.00	91.18	96.67	91.67	93.17
7.	2% Parathion	82.50	85.00	92.50	86.67	79.41	83.33	91.67	84.80
8.	Control(Water spray)	15.00	10.00	10.00	11.67	-	-	-	-

Continued ....

Table 9 (continued)

II. Toxicity 5 days after the treatment.

Sr. No.	Treatments	Percentage mortality of hoppers 48 hours after release				Corrected mortality			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.1% Carbaryl+Sulphur (1:1)	97.50	100.00	100.00	99.17	97.22	100.00	100.00	99.07
2.	0.02% Phosphamidon + Sulphur (1:1)	97.50	82.50	92.50	90.83	97.22	80.56	91.18	89.65
3.	0.02% Endrin + Sulphur (1:1)	72.25	77.50	90.00	76.92	69.70	75.00	88.24	77.65
4.	0.2% DDT + Sulphur (1:1)	75.00	62.50	92.50	76.67	72.22	58.33	91.18	73.91
	b. Dusts								
5.	10% Carbaryl+Sulphur (1:1)	100.00	100.00	97.50	99.17	100.00	100.00	97.06	99.02
6.	5% DDT + Sulphur(1:1)	85.00	80.00	75.00	80.00	83.33	77.78	70.59	77.23
7.	2% Parathion	71.67	82.50	62.50	72.22	68.52	80.56	55.88	68.32
8.	Control(Water spray)	10.00	10.00	15.00	11.67	-	-	-	-

Continued ...

Table 9 (continued)

III. Toxicity 10 days after the treatment.

Sr. No.	Treatments	Percentage mortality of hoppers 48 hours after release				Corrected mortality			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.1% Carbaryl+Sulphur (1:1)	85.00	82.50	90.00	85.83	83.33	79.41	88.24	83.66
2,	0.02% Phosphamidon + Sulphur (1:1)	75.00	82.50	62.50	73.33	72.22	79.41	55.88	69.17
3.	0.2% DDT + Sulphur (1:1)	88.33	50.00	55.00	64.44	87.03	41.18	47.06	58.42
4.	0.02% Endrin+Sulphur (1:1)	52.33	62.50	76.67	63.83	47.03	55.88	72.55	58.39
	b. Dusts								
5.	10% Carbaryl+Sulphur (1:1)	92.50	97.50	75.00	88.33	91.67	97.06	70.59	86.44
6.	5% DDT + Sulphur(1:1)	82.50	62.50	79.91	81.63	80.56	55.88	76.36	70.93
7.	2% Parathion	80.00	55.00	75.00	70.00	77.78	47.06	70.59	65.14
8.	Control(Water spray)	10.00	15.00	15.00	13.33	-	-	-	-

Continued ...

Table 9 (continued)

IV. Toxicity 15 days after the treatment.

Sr. No.	Treatments	Percentage mortality of hoppers 48 hours after release				Corrected mortality			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.1% Carbaryl+Sulphur (1:1)	76.67	62.50	70.00	69.72	72.55	58.33	66.67	65.85
2.	0.02% Phosphamidon + Sulphur (1:1)	35.00	40.00	42.49	39.17	23.53	33.33	36.11	30.99
3.	0.02% Endrin + Sulphur (1:1)	37.50	42.50	34.50	38.17	26.47	36.11	27.22	29.93
4.	0.2% DDT + Sulphur (1:1)	22.50	34.50	27.50	24.83	8.82	27.22	19.44	18.49
	b. Dusts								
5.	10% Carbaryl+Sulphur (1:1)	82.50	70.00	85.00	79.17	79.41	66.67	83.33	76.47
6.	5% DDT + Sulphur(1:1)	27.50	22.50	34.50	28.17	14.71	13.89	27.22	16.60
7.	2% Parathion	20.00	22.50	17.50	20.00	5.88	13.89	8.33	9.37
8.	Control (Water spray)	15.00	10.00	10.00	11.67	-	-	-	-

Continued ...

Table 9 (continued)

V. Toxicity 21 days after the treatment.

Sr. No.	Treatments	Percentage mortality of hoppers 48 hours after release				Corrected mortality			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.1% Carbaryl + Sulphur (1:1)	37.50	52.50	27.50	39.17	30.56	47.22	14.71	30.83
2.	0.02% Endrin + Sulphur (1:1)	32.50	35.00	27.50	31.67	25.00	27.78	14.71	22.50
3.	0.02% Phosphamidon + Sulphur (1:1)	20.00	22.50	25.00	22.50	11.11	13.89	11.76	12.25
4.	0.2% DDT + Sulphur (1:1)	12.50	22.50	20.00	18.33	2.78	13.89	5.88	7.52
	b. Dusts								
5.	10% Carbaryl+Sulphur (1:1)	34.50	42.50	40.00	39.00	27.22	36.11	29.42	30.92
6.	2% Parathion	17.50	12.50	22.50	17.50	8.33	2.78	8.82	6.64
7.	5% DDT + Sulphur(1:1)	27.50	17.50	18.00	16.67	19.44	8.33	3.53	10.10
8.	Control (Water spray)	10.00	10.00	15.00	11.67	-	-	-	-

Table 10

Studies on residual toxicities of insecticides against mango hoppers (*I.atkinsoni*) under field conditions.

Design: R.B.D. with 3 replications. Variety - Hapus. Date of first application: 5.2.69

I. Toxicity 48 hours after application.

Sr. No.	Treatments	Percentage decline in pest population				Arcsin transformation			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.1% Carbaryl+Sulphur(1:1) at 21 days interval	95.34	52.50	91.00	78.61	77.48	46.44	72.34	65.42
2.	0.2% DDT+Sulphur (1:1)at 15 days interval	86,69	89.77	85.73	87,39	68.61	71.37	67.78	69.25
3.	0.02% Phosphamidon+Sulphur (1:1)at 15 days interval	85.10	84.48	87.13	85.57	67.29	66.81	68,95	67.68
4.	0.02% Endrin+Sulphur(1:1) at 15 days interval	83.68	80.34	77.13	80.38	66.19	63.65	61.41	63.75
5.	0.1% Carbaryl+Sulphur(1:1) as std.treatment)at 15 days interval	96.76	95,65	88.34	93.58	79.69	78.03	70.00	75,90
	b. Dusts								
6.	5% DDT + Sulphur(1:1) at 15 days interval	84.57	90.34	87.13	87.35	66.89	71.85	68.95	69.23
7.	2% Parathion at 15 days interval	73.94	85.45	82.58	80.66	59.28	67.62	63.63	64.08
8.	10% Carbaryl + Sulphur (1:1)at 21 days interval	87.68	91.25	90.34	89.76	69.47	72.84	71.85	61.38
9.	10% Carbaryl+Sulphur(1:1) (as std.treatment)at 15 days interval	88.78	89.59	92.26	90.21	70.45	71.19	73.89	71.84
10.	5% DDT + Sulphur (1:1)at 15 days interval(as std. treatment.	84.00	91.72	89.28	88.23	66.42	73.26	70.91	70.19
11.	Control (Water spray)	5.68	7.83	9.84	7.78	13.81	16.22	18.24	16.09

S.E. 3.70. C.D. 10.92.

continued...

Table 10 (continued)

II. Toxicity 5 days after the treatment.

Sr. No.	Treatments	Percentage decline in pest population				Arcsin transformation			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.1% Carbaryl+Sulphur (1:1)at 21 days interval	92.68	91.48	90.34	91.50	74.32	73.05	71.85	73.07
2.	0.2% DDT+Sulphur(1:1)at 15 days interval	80.49	82.78	78.47	80.58	63.79	65.50	62.37	63.88
3.	0.02% Phosphamidon+Sulphur (1:1)at 15 days interval	75.10	81.48	82.78	79.79	60.07	64.52	65.50	63.36
4.	0.02% Endrin+Sulphur(1:1) at 15 days interval	80.42	79.98	76.67	79.03	63.72	63.44	61.14	62.76
5.	0.1% Carbaryl+Sulphur(1:1) (as std.treatment)at 15 days interval	94.58	93.68	87.95	92.07	76.56	75.46	69.73	73.91
	b. Dusts								
6.	10% Carbaryl+Sulphur(1:1) at 21 days interval	83.68	85.65	90.84	86.72	66.19	67.78	72.34	68.77
7.	5% DDT + Sulphur(1:1)at 15 days interval	77.13	86.62	81.23	81.66	61.41	68.53	64.30	64.74
8.	2% Parathion at 15 days interval	71.46	80.78	79.58	77.27	57.73	64.01	63.15	61.63
9.	0.1% Carbaryl+Sulphur(1:1) (as std.treatment) at 15 days interval	83.23	83.88	89.39	85.50	65.80	66.34	71.00	67.71
10.	5% DDT + Sulphur(1:1)(as std.treatment)at 15 days interval	78.02	85.15	80.00	81.06	62.03	67.37	63.44	64.28
11.	Control (Water spray)	5.00	8.10	2.58	5.23	12.92	16.54	9.28	12.91
						S.E. 1.56.		C.D. 4.59.	

Continued....

Table 10 (continued)

III. Toxicity 10 days after the treatment.

Sr. No.	Treatments	Percentage decline in pest population				Aresin transformation			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.02% Phosphamidon+Sulphur (1:1)at 15 days interval	86.27	95.56	91.62	91.22	68.28	77.89	73.36	73.18
2.	0.2% DDT + Sulphur(1:1) at 15 days interval	87.34	92.04	85.87	88.42	69.12	73.57	67.94	70.21
3.	0.1% Carbaryl+Sulphur(1:1) at 21 days interval	89.78	85.24	88.34	87.75	71.37	67.37	70.00	69.58
4.	0.02% Endrin+Sulphur(1:1) at 15 days interval	89.34	92.76	79.25	87.12	70.91	74.44	62.94	69.43
5.	0.1% Carbaryl+Sulphur(1:1) (as std.treatment)at 15 days interval	91.24	84.76	82.98	86.33	72.74	67.05	65.65	68.48
	b. Dusts								
6.	5% DDT+Sulphur(1:1)at 15 days interval	88.54	83.00	91.45	87.66	70.18	65.65	73.05	69.63
7.	2% Parathion at 15 days interval	78.28	84.54	85.35	82.72	62.24	66.81	67.54	65.53
8.	10% Carbaryl+Sulphur(1:1) at 21 days interval	84.51	78.45	79.35	80.77	66.81	62.31	63.01	64.06
9.	5% DDT+Sulphur(1:1)(as std.treatment)at 15 days interval.	62.39	45.00	35.83	47.74	52.18	42.13	36.75	43.67
10.	10% Carbaryl+Sulphur at 15 days interval(as std. treatment)	83.67	80.45	77.62	80.58	66.19	63.79	61.75	63.91
11.	Control (Water spray)	0.0	9.82	2.89	4.24	0.0	18.24	9.81	9.35

S.E. 2.97. C.D. 8.74.

Continued ....

Table 10 (continued)

IV. Toxicity 15 days after application of insecticides applied at 21 days interval and 48 hours after application in case of insecticides with 15 days interval.

Sr. No.	Treatments	Percentage decline in pest population				Arcsin transformation			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.02% Endrin+Sulphur (1:1)at 15 days interval.	86.81	86.89	78.54	84.08	68.70	68.78	62.37	66.62
2.	0.2% DDT+Sulphur(1:1) at 15 days interval	83.68	88.58	78.92	83.73	66.19	70.27	62.65	66.37
3.	0.02% Phosphamidon+Sulphur(1:1)at 15 days int.	79.35	86.62	82.89	82.95	63.01	68.53	65.59	65.71
4.	0.1% Carbaryl+Sulphur (1:1)at 21 days interv.	64.69	53.98	58.35	59.01	53.55	47.29	49.84	50.23
5.	0.1% Carbaryl+Sulphur (1:1)(as std.treatment) at 15 days interval	98.08	91.76	99.62	96.49	82.08	73.36	84.44	79.96
	b. Dusts								
6.	5% DDT+Sulphur(1:1)at 15 days interval	78.13	81.76	84.68	81.52	62.10	64.75	66.97	64.67
7.	2% Parathion at 15 days interval	69.51	76.38	81.67	75.52	56.46	68.14	64.67	60.69
8.	0.1% Carbaryl+Sulphur (1:1)at 21 days interval.	62.76	50.62	55.82	56.40	52.42	45.34	48.33	48.69
9.	0.1% Carbaryl+Sulphur (1:1)(as std.treatment) at 15 days interval	95.52	88,02	91.78	91.76	77.75	69.75	73.26	73.58
10.	5% DDT+Sulphur(1:1)as std.treatment at 15 days interval	89.76	81.68	92.76	88.67	71.37	64.67	74.44	70.16
11.	Control(Water spray)	0.0	3.48	4.52	2.67	0.0	10.78	12.25	7.68

S.E. 1.97. C.D. 5.79.

Continued ...

Table 10 (continued)

V. Toxicity 48 hours after application in case of insecticides with 21 days interval and 5 days after in respect of insecticides applied at 15 days interval.

Sr. No.	Treatments	Percentage decline in pest population				Arcsin transformation			
		RI	RII	RIII	Mean	RI	RII	RIII	Mean
	a. Sprays								
1.	0.1% Carbaryl+Sulphur(1:1)at 21 days interval	100.00	98.15	96.43	98.19	90.00	82.29	79.06	82.78
2.	0.02% Phosphamidon+Sulphur (1:1)at 15 days interval	100.00	85.62	87.51	91.04	90.00	67.70	69.30	75.67
3.	0.02% Endrin+Sulphur(1:1)at 15 days interval	96.04	79.92	95.43	90.46	78.46	63.36	77.61	73.14
4.	0.2% DDT+Sulphur(1:1)at 15 days interval	89.20	83.95	91.43	88.19	70.81	66.42	72.95	70.06
5.	0.1% Carbaryl+Sulphur(1:1) (as std.treatment)at 15 days interval	95.08	87.94	91.59	91.54	77.21	69.64	73.15	73.33
	b. Dusts								
6.	10% Carbaryl+Sulphur(1:1)at 21 days interval	99.87	89.45	98.72	96.01	84.53	71.09	83.45	79.69
7.	5% DDT+Sulphur (1:1)at 15 days interval	89.70	74.64	92.85	85.73	71.28	59.74	74.55	68.52
8.	2% Parathion at 15 days interval	79.13	81.58	91.15	83.95	62.80	64.60	72.74	66.71
9.	10% Carbaryl +Sulphur (1:1)(as std.treatment)at 15 days interval.	89.27	81.72	90.32	87.14	70.91	64.67	71.85	69.14
10.	5% DDT+Sulphur (1:1)(as std. treatment)at 15 days interval.	83.64	76.20	84.15	81.33	66.11	60.80	66.58	64.46
11.	Control (Water spray)	0.0	0.0	4.37	1.46	0.0	0.0	12.11	4.04

S.E. 3.12. C.D. 9.19.