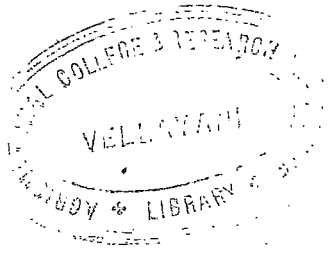
STUDIES ON THE TOXICITY OF INSECTICIDE RESIDUES ON BRINJAL TO *Epilachna vigintioctopunctata* FABRICIUS

By

KUNJAMMA P. MATHEW



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C E R T I F I C A T E

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

(C.K.N.Nair),
Principal and
Additional Director of
Agriculture(Research).

(M.R.G.K.Nair),
Professor of Entomology.

Agricultural College &
Research Institute,
Vellayani, Trivandrum,
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INTRODUCTION.

Brinjal occupies a pride of place among the vegetables in India. Being one which can be cultivated throughout the year, it is also favoured by vegetable growers. Among the various insect pests which attack and damage this crop, Epilachna vigintioctopunctata Fabr. is by far one of the most important which takes a heavy toll of the crop.

Much work has already been done on the use of modern insecticides in controlling Epilachna on brinjal. {Sengupta and Penda (1958) Shi and Satpathy (1960) Shi et.al. (1960) Pradhan et.al. (1962)} . But no effort has been made so far in ascertaining how long the different insecticides persist on the crop after application. This aspect was considered very important because E.vigintioctopunctata has in association with it a number of its parasites. Some of these parasites have been found to exert significant effect in controlling the pest in nature. Thus, Appanna (1948) observed 77% of parasitism among the grubs of the insect during summer months. Puttarudriah and Krishnamurthi (1954) reported that control of this insect in nature was brought about by Pleurotropis foveolatus. Usman and Thontadarya(1957) recorded several useful hymenopterous parasites on this pest. There is also indication that the parasites are adversely affected during the rainy season as a result of which the pest

increases,leading to severe infestation and widespread damage of brinjal crop (Appanna 1948).

The above said facts will emphasise the need of rationalising the use of insecticides against E.vigintioctopunctata with a view to minimise the destruction of parasites by the insecticides. For this, it is necessary to have full knowledge on the residual toxicity of the different insecticides which may be used for controlling this pest on brinjal. This information will interalia help in avoiding toxicity hazards due to insecticide residues. Hence the present investigations were undertaken to ascertain the persistence of insecticides on brinjal crop. These studies have been made with eleven of the modern insecticides, each at its standard dose. The relative toxicity of these eleven insecticides has also been ascertained by observing the toxicity caused by their initial deposit on the brinjal leaves. The results indicate that the different insecticides persist on brinjal leaves for periods varying from 7 to 21 days.

A review of literature on the different species of Epilachna infesting brinjal is presented.

REVIEW OF LITERATURE.

Many members of the subfamily Epilachninae (Coccinellidae:Coleoptera) are destructive to the foliage of vegetables, especially of the solanaceous and cucurbitaceous crops, in various regions of the world. Of these, Epilachna dodecastigma M., E.indica Mule., E.niponica Lew. and E.vigintioctopunctata F are the common species recorded as pests of brinjal. Following is a review of literature on these species of Epilachna occurring as pests of brinjal.

Distribution and importance as pests of brinjal.

Lefroy (1909), Fowler (1912) and Pillai (1922) reported two species of Epilachna viz. E.dodecastigma and E.vigintioctopunctata attacking potato and other solanaceous crops in India. E.dodecastigma and E.vigintioctopunctata were reported to be widely distributed in South East Asia and Australia (Anon.1913). Wimshurst (1919) noted Epilachna spp. on brinjal in Africa. Muramatsu (1919) observed E.niponica feeding on potato and egg plants in Korea. Fletcher (1921) recorded E.dodecastigma as a pest of brinjal in India. Hutson (1921) found E.vigintioctopunctata causing serious damage to egg plants in Ceylon. Corbett (1922) noted E.indica as a pest of brinjal in Malaya.

Later Austin (1925) noticed E.dodecastigma and E.vigintioctopunctata also on brinjal in the same country. Ghosh(1925) pointed out that serious damage was caused by E.vigintioctopunctata in Burma.

Bunting (1930) reported E.indica as a pest feeding on the leaves of various vegetables in Malaya both in the larval and adult stages. Muramatsu (1931) found E.niponica causing serious damage to egg plants in Japan. Krishnamurthi (1932) observed that E.vigintioctopunctata was widely distributed in Mysore and was prevalent in the potato growing areas. Yoshida (1936) reported that E.vigintioctopunctata was common in Formosa where it attacked egg plants. Puttarudriah and Krishnamurthi (1954) considered E.vigintioctopunctata as a serious pest of brinjal, tomato and cucurbits in Mysore. Sengupta and Panda (1958) found E.vigintioctopunctata causing severe damage to brinjal in Orissa.

Jotwani et.al. (1962) recognised E.vigintioctopunctata as a serious pest of brinjal in India and recorded an outbreak of the pest on brinjal near Delhi in August 1962. Pawar (1964) found that Epilachna beetles caused serious damage to solanaceous plants especially brinjal and potato. He reported that the extent of damage at times was 50% or more.

Biology.

Muramatsu (1919) observed that the coccinellid E.niponica had three broods a year in Korea. It was found to pass the winter in the adult stage and become active in the beginning of May, ovipositing towards the end of the month. The adult of the second generation appeared in the middle of June and those of the third, from the end of July. The beetles which would eventually hibernate were found in September.

Cater (1925) recorded that under laboratory conditions the total life cycle lasted 39 days from egg to adult in Malaya. Austin (1925) studied the biology of the Coccinellids E.dodecastigma and E.vigintioctopunctata in Ceylon. Eggs were laid on the lower surface of the leaves and the oviposition period lasted several weeks. The maximum of 800 eggs were laid by one female. The larva hatched in 5-7 days and started feeding slowly on the lower surface of the leaves. The larval period lasted 21 days and the full grown larvae pupated on the leaf. After a pupal period of 5-6 days the adults emerged. The adults like the larvae nibbled away strips of leaf tissue and sometimes caused irregular holes in the leaves.

Temperley (1925) observed the biology of E.vigintioctopunctata in Australia. Eggs were laid in

clusters of 13-45 which hatched in 4 days. The larval stage lasted 17-23 days, the prepupal stage 2 days and the pupal stage 4 days. The adult was found to fly only short distances. The females in the laboratory began to oviposit in about 16-18 days after emergence, laying 125-252 eggs each. The number of eggs laid under natural conditions, however, appeared to be greater.

Chue (1930) described the life history of E.vigintioctopunctata in China. The observations were taken during July and August 1926, the average atmospheric humidity during the period being 80% and the maximum and minimum air temperature 36.1°C. and 22.8°C. respectively. The number of eggs deposited at a time varied from 3 to 78, the average of 18 batches counted being 34. One female kept for a period of 31 days laid, 744 eggs in 21 batches. The egg, larval and pupal stages lasted, 4, 11-15 and 4 days respectively. Overwintering adults appeared by about the middle of April and started ovipositing. The adults of the first generation appeared within 17 days and oviposited after about 9 days. The beetles laid eggs in the laboratory for at least a month.

Tanabe (1931) worked out the biology of E.niponica in Japan. He found that a female laid 284 eggs on an average, in the course of 34 days. In May, the egg, larval and pupal stages lasted about 10, 24 and 6 days respectively and in August, 4, 14 and 5 days respectively. Adults hibernated in

masses under fallen leaves or in other sheltered places which were moist and warm. They became active by about the middle of May and the over wintered adults died in August.

In a subsequent paper, Tanabe, Sekiya and Kumaguya (1934) found the eggs of E.niponica hatch in 3-12 days, the larvae to complete their growth in 13-30 days when fed on potato and much more slowly when fed on tomato or egg plant and the pupae to complete the pupal stage in 5-14 days. Yoshida (1936) noted that E.vigintioctopunctata had 7 generations a year in Japan. The egg, larval and pupal stages of E.dodecastigma and E.vigintioctopunctata lasted for 9, 19 and 9 days respectively in Kumaun. Kapur (1950) described in detail the life history of E.vigintioctopunctata in India.

Pawar (1964) described in detail the life history of Epilachna beetles in Gwalior in India. The female insect laid eggs on the underside of the leaves of the host plant. They were deposited singly and in batches. Each female laid eggs in 10 to 15 batches, each batch consisting of 20 to 60 eggs. On an average a single female laid about 550 to 700 eggs. The eggs were silver yellow in colour when freshly laid and measured about 0.75 x 1.5 mm. The eggs were bomb shaped, pointed at the apex and flat at the base; the side

which is glued to the leaf being flat. The egg period lasted 3 to 4 days.

The grubs emerged by breaking the pointed apical end of the egg and remained inactive for the first few hours. A few hours after emergence the grubs started damaging the plants by feeding on the fleshy matter of the leaf surface leaving the veins and the veinlets. The grub moulted three times and the larval period lasted 20 to 25 days. The full grown grub measured about 5 mm. in length and about 1.5 mm. in breadth. Except the head region, all the segments of the body were found to bear thick hair like structures, the scoli. Each segment bore 6 scoli symmetrically placed, three on each side with black mid-dorsal line running from front to back.

The full grown grub entered the prepupal stage which lasted a day. During this period, the body inside took a convex shape and finally turned into the pupa. The pupa was found sticking to the leaves by its posterior end. The exuvium of the last grub stage along with scoli was retained and this formed a sort of covering to the pupa except for the free anterior portions. The pupal stage lasted 5 to 6 days.

The adult beetles emerged out of the puparium by bursting the anterior end. The freshly emerged adult

beetle appeared pale brown and the elytra were without any markings. Gradually the body of the beetle dried and hardened. A few hours after emergence, the beetle started feeding on the leaf surface. The adults became ready to lay eggs within a week or ten days.

The duration of life cycle, in the absence of hibernation, was found to be 30 to 40 days. In the case of those which underwent hibernation, the life period extended from five to six months.

Alternate hosts.

Jones (1913) pointed out that in addition to brinjal considerable damage was caused to tomato by E.vigintioctopunctata in Philippines. Wimshurst (1919) found Epilachna spp. attacking cucurbits in Africa. Gater (1925) noted E.indica on Datura spp., French beans, cucurbits and rubber. Austin (1925) observed E.vigintioctopunctata feeding on brinjal and Momordica charantia (bitter gourd). Temperley (1928) found that in Australia E.vigintioctopunctata commonly attacked potatoes, pumpkins, cucumbers, cotton and rock melons. Solanum nigrum and Datura stramonium were the two most common weeds on which it fed. Kuijper (1928) observed E.dodecastigma on tobacco. Chopra (1928) recorded Epilachna beetles on a wide range of host plants like potato, tomato, Solanum nigrum, Datura and Solanum xanthocarpum.

Krishnamurthi (1932) found that the food plants of E.vigintioctopunctata included cucurbits and few wild solanaceous plants. Yoshida (1936) found it feeding on tomatoes in Formosa. Nakayama (1939) stated that the preferred food plants of E.vigintioctopunctata were potato and Solanum nigrum. Lever (1944) and Cohic (1950) noticed severe damage to potatoes by the beetles. Puttarudriah and Krishnamurthi (1954) described E.vigintioctopunctata as a serious pest of tomato and cucurbits in Mysore. The grubs and adults of Epilachna beetles attacked the foliage of potatoes, tomatoes, melons and pumpkins (Anon. 1948).

Krishnamoorthy (1956) pointed out that E.vigintioctopunctata fed on Lycopersicum esculentum, Solanum nigrum, Datura fastuosa, Solanum xanthocarpum and bitter gourd. Epilachna beetles were found to attack the foliage of cucumber, marrow, pumpkins and other related vine plants, potatoes, tomatoes, and sometimes beans. In addition they also developed upon a number of weeds including the false nightshade, flase castor and paddy melons. Pawar (1964) observed that Epilachna beetle is a serious enemy of solanaceous vegetables like potato and tomato.

Control.

Natural:- According to Vandergoot (1924) bad weather was the chief controlling factor of E.vigintioctopunctata

in Java. Observations showed that no eggs were laid in the hill districts during a certain period of the dry season. For this reason fields planted in the full dry season were rarely infested. Remedial measures were therefore necessary usually only from May to June. European growers resorted to collection of the adults, but this was not worthwhile and nor was the collection of the egg masses much better. The collection of the larvae, when the plants were 7-8 weeks old was advisible, as the larvae were not then more than 3 weeks old and had not entered the voracious 4th stage.

Austin (1925) found E.dodecastigma and E.vigintioctopunctata to be parasitised by hymenopterous parasites. In heavy infestations hand picking of all the stages of the pest seemed to be the only practicable measure. It was observed in Kumaun in April 1935 that the eulophid parasite Tetrastichus ovulorum Ferriere attacked the eggs of E.vigintioctopunctata and E.dodecastigma in one district, but did not give much control. No natural enemies of the larvae and adults were observed. Handpicking of adults and egg masses in early spring was of considerable value in controlling the pest (Anon.1943).

According to Appanna (1948) the percentage of parasitisation reached as high as 77 during March and July, the average being 40. It was further reported that the degree of parasitisation might be 68% in July. The parasites

appeared to build up their numbers greatly in the summer months. During this period due to the high parasitic activity there was little necessity for resorting to chemical control. The extent of parasite decrease depended on the density of the host population and ecological factors. There was a reduction in the field incidence of the parasite if there was continuous heavy rain fall. In the absence of the parasites the pest increased causing severe infestation and destroying the plants completely. Puttarudriah and Krishnamurthi (1954) found that E.vigintioctopunctata could be controlled to a varying extent, by the parasite Pleurotropis foveolatus C. Paterson (1956) found that the pupae of E.philippinensis Dieke, a serious pest of egg plant in Philippines was parasitised by the eulophid Pediobius epilachnae.

Usman and Thontadarya (1957) reported seven species of hymenopterous parasites from Mysore of which Pleurotropis foveolatus, P.epilachnae and Tetrastichus spp. were most important. Lall (1961) observed Pediobius foveolatus, a eulophid, parasitising the larvae of Epilachna spp., infesting vegetables in Bihar. The female parasite oviposited in the lateral region of the host larva. In the laboratory 3rd to 4th instar larvae were preferred. Development was completed inside the host, the life cycle ranging from 28.5 days in December to 11 days in March.

Upto eight hosts were attacked by a single female and the number of progeny per female was 11 to 50. Parasitism was highest (37.8%) in November and lowest (9.03%) in April.

Chemical control:- Jones (1913) recommended spraying of arsenate of lead which afforded sufficient control of E.vigintioctopunctata Knowles (1918) also showed that this insect could be controlled by spraying lead arsenate or by dusting Paris green. Vandergoot (1924) recommended a spray containing 2% lead arsenate and 2 per mille soap as an effective control. But this was found to be costly. Austin (1925) too found spraying or dusting with arsenicals like Paris green and lead arsenate as an effective remedy. Bunting (1930) noted that both the larval and adult stages could be controlled by lead arsenate sprays mixed with soap. Krishnamurthi (1932) tried a number of insecticides against the beetles and the most effective one was a spray of 1 lb. lead arsenate in 50-60 gallons of water with 5 lbs. of lime and 10 lbs. of jaggery which gave over 90% control. All plants in the crop were sprayed 20-30 days after transplanting. Special attention was given in covering the lower surface of the leaves. A second spray also was given but more lightly, 3-4 weeks later, to kill any beetle that might have migrated from unsprayed areas. In cases of severe infestation a thorough spraying later ie. 1½ or 2 months after planting, gave good results. 4 to 6 lbs. of lead arsenate

was used in one acre, the amount varying with the extent of infestation, the number of sprays, the time of application and type of equipment available.

Subramanian (1932) recommended that water extract of powdered bark of Mundulea suberosa (1 oz.in 1 pint) with soap water secured 100% mortality under laboratory conditions and 70% mortality in the field.

Tanabe et.al. (1934) reported that E.nipponica in Japan could be controlled by spraying lead arsenate in bordeaux mixture. According to Yoshida (1936) the beetles were killed by pyrethrum with soap as a spray or with ash as a dust; sprays of derris or nicotine being much less effective. Bhatta and Narayana (1938) reported that alcoholic extract of seeds of Tephrosia candida and bark of Mundulea suberosa were both toxic to epilachna.

Lever (1939) found that these beetles could be controlled by spraying lead or calcium arsenate at fortnightly intervals. Dusting the plants with a mixture of one part by weight of lead arsenate (or calcium arsenate) powder and 3 parts by weight of a filler such as Kaolin (or hydrated lime) or spraying with lead arsenate powder at the rate of 1 lb. in 20 gallons of water was found to give good control of the pest, but the spray appeared less effective than the dust. As some injury was caused by the use of lead arsenate

on young plants, they were protected by the use of tobacco dust mixed with an equal quantity of hydrated lime (Anon.1940). It was also reported that E.vigintioctopunctata could be controlled by 2 applications of a dust of pyrethrum powder and Kaolin or flour in the ratio of of 1:4 at intervals of 10 days (Anon.1942).

Among a number of insecticides tested, lime sulphur alone was found to kill larvae but not the adults. This material was recommended to be applied thoroughly, particularly to the lower side of the leaves, at fortnightly intervals, from the first appearance of the beetle, at a concentration of 9 to 16 gallons per 100 gallons spray depending on its specific gravity (Anon.1943).

Cohic (1950) found that copper arsenate could control these beetles to some extent. DDT. 0.1% spray and 2% dust were found to be adequate to destroy the adults. HETP also destroyed the adults and larvae of this ladybird beetle (Anon.1950). Krishnaswami (1954) studied the use of DDT. and BHC. as 5% dust (applied at 20 lbs. per acre) and 0.1% and 0.05% sprays (applied at 100 gallons per acre) in controlling the pests of brinjal. He found that the incidence of E.dodecastigma was fairly severe in the beginning when the first round of treatments was given but soon dwindled down before the second round became due. It may be observed that the initial grub population was practically

wiped out in all the treatments within 24 hours. DDT. 5% dust was found to be somewhat effective against adults. Deleterious effects were seen on brinjal plants following the first round of BHC. application and this was found to be aggravated by the second round. The leaves began to turn yellow slowly and wilted away. There was also sufficient evidence to indicate that there existed a correlation between the degree of phytotoxicity and the weather, the former being more pronounced in relatively hotter weather. But on theother hand DDT. gave slight stimulation to the growth of the plants. Both dusts and sprays of DDT. and BHC. gave high mortality of the grubs of Epilachna on brinjal.

Puttarudriah and Krishnamurthi (1954) reported that E.vigintioctopunctata could be controlled by calcium arsenate or lead arsenate spray mixture containing 1:2:3:5 of calcium or lead arsenate, lime, jaggery and water. Modern chlorinated hydrocarbons like DDT., BHC. and Toxaphene were also found effective against this pest. In the case of chemical methods of control, repeated operations were always necessary to keep the pest under check.

Sengupta and Panda (1958) found that endrin 20% E.C. sprayed at a dose of 1.5 lbs. per acre was most effective in controlling E.vigintioctopunctata. A dose of

2.5 lbs. of malathion 25% w.p. per acre also was effective. Spraying with DDT. 50% wettable powder at the rate of 1.25 lbs. per acre gave some control but it was inferior to endrin and malathion. BHC. 50% wettable powder sprayed at 1.5 lbs. per acre proved to be of little value for the control of the Epilachna grubs.

Shi et.al. (1960) studied the relative toxicity of ten insecticides to Epilachna beetles. Parathion was found to be the most toxic insecticide, followed in the descending order by diazinon, malathion, endrin, phosdrin, DDT., dieldrin, lindane, aldrin, and chlordane.

Shi and Satpathy (1960) conducted some experiments to find out the relative effectiveness of parathion (0.025%), endrin (0.04%), malathion (0.2%), BHC. (0.25%) and toxaphene (0.2%) against E.vigintioctopunctata. The statistical analysis of the data on population of Epilachna grubs showed significant reduction, 48 hours after application. BHC proved to be the least effective. One week after application parathion gave excellent protection of the crop from the pest. The percentage reduction of grub population in parathion treated plots was significantly higher than in plots treated with endrin, malathion, toxaphne and BHC. There was no significant difference among the treatments of endrin, malathion, toxaphene and BHC, though endrin gave slightly better result.

Srinivasan and Narayanaswamy (1961) found that some of the modern organo-chloride and organo-phosphatic compounds were effective in controlling Epilachna beetles. Four insecticides namely lindane 0.1%, endrin 0.02%, dieldrin 0.1% and DDT. 0.1% were tested. DDT. 0.1% and endrin 0.02% sprayed twice at fortnightly intervals, commencing a month after transplanting, brought down the percentage of Epilachna infestation on plants to 0 and 1.4% respectively compared with 12.9% in the untreated control. The results were 5.4% in the dieldrin and 7.2% in the lindane treated plots. These observations were made a fortnight after the second round of treatments. Observations were again made after giving two more rounds of treatments ie. a total of four rounds with the above mentioned insecticides. The percentage of infestation was cent percent in the untreated plots. In the DDT. and endrin treated plots none of the plants were infested. In the lindane and dieldrin treated plots the percentage of infestation remained constant. DDT. had given the highest yield followed by endrin. Lindane and dieldrin also compared favourably with DDT. and endrin, in respect of gross yield.

Jotwani et.al. (1962) used emulsion sprays of various insecticides to determine their relative toxicities to E.vigintioctopunctata. The insects were treated under a spray tower and then transferred to clean dishes

containing leaves and observed for mortality after 48 hours at about 27°C. Against the larvae the toxicity of carbaryl was 138 times than that of p'p'DDT. Against the adults parathion, mevinphos (phosdrin) and carbaryl were respectively over 86, 58 and 25 times as toxic as p'p' DDT., while malathion, BHC, dieldrin and endrin were respectively 0.979, 0.334, 0.131 and 0.138 times as toxic as DDT. Toxaphene was ineffective.

David (1963) conducted experiments on brinjal for the control of E.vigintioctopunctata with sprays of thiometon (Ekatin) 0.1%, methyl demeton (Metasystox) 0.1%, methyl naphthyl carbamate (Sevin) 0.1% and dust of heptechlor 30%. The insecticides were applied three times at intervals of about 2 to 3 weeks. The results were highly significant, with sevin proving the best and methyl demeton and thiometon coming next in the order of efficacy. Sevin was not phytotoxic.

To control adults and larvae of Epilachna beetles, dusting with 2% DDT. dust or spraying with 4 fluid oz. of 20% DDT emulsion, or 1½ oz. of 50% dispersible DDT powder in 5 gallons of water were recommended. A dust consisting of one part of derris to 8 parts of either Kaolin or talc (by weight) also could protect the plants, but a number of application was found to be necessary to keep the leaf surfaces covered during their early growth. Malathion at a

concentration of 0.05% of the active ingridient gave satisfactory control of this pest and could be safely used on any of the plants likely to be attacked. Other insecticides which were effective against this pest were malathion 5% dust, methoxychlor 0.1% spray and carbaryl (Sevin) 0.1% (Anon. 1963).

Pawar (1964) found that in large fields Epilachna could be controlled by chemical measures. Insecticides of plant origin, viz., rotenone, nicotnine, and pyrethrum were found to be effective in addition to the organic synthetic insecticides. Rotenone 1% at 15 to 20 lbs. per acre sprayed at weekly intervals or 2 to 2.5 lbs. of 4.4% rotenone in 50 gallons of water gave effective control. Spraying with 0.25% DDT. at 40 to 50 gallons or 15 to 20 oz. of 20% endrin in 50 to 60 gallons of water per acre gave successful control of this beetle pest. Similarly dusting of 3 to 5% DDT. at 10 to 15 lbs. or 5% BHC dust at 15 to 20 lbs. per acre could control the beetle effectively. Parathion (0.03%) spraying also gave good control of this pest. Parathion was recommended to be used before the plants bore fruits.

MATERIAL AND METHODS.

MATERIAL

Test insect. Adults and 3rd instar grubs of *E.vigintioctopunctata* were used as test insects in all the experiments. The adults and grubs were reared in the laboratory on brinjal leaves.

Insecticides. Details of the 11 insecticides used in the studies are given in the following tabulation.

Sl. No.	Common name.	Active ingredient.	Formulation	Source.
1	2	3	4	5
1.	p'p' DDT.	1,1,1-trichloro-2-2 bis (P-chlorophenyl ethane)	25% E.C.	The Mysore Insecticides Company.
2.	BHC.	Benzene hexa chloride.	20% E.C.	Imperial Chemical Industries (India) Ltd.
3.	Endrin.	1,2,3,4,10,10, hexa chloro 6,7 epoxy, 1,4,4a,5, 6,7,8,8a, Octa hydro-1,4,5,8 endo, endodi-methano naphthalene.	Technical.	M/s. Shell Chemical Corporation, Burma Shell Ltd., Bombay.

1	2	3	4	5
4.	Ethyl parathion.	0,0,diethyl-0,P-nitrophenyl thiophosphate.	46.7% E.C.	M/s. Chika Ltd., Bombay.
5.	Malathion.	0,0,dimethyl dithio phosphate of diethyl mercapto succinate.	50% E.C.	M/s. American Cyanamid Co., New York.
6.	Dimecron	2-Chloro, 2 diethyl Carbamyl 1-methyl vinyl dimethyl phosphate.	Technical	Ciba Pesticides, Bombay.
7.	Nuvan.	0,0,dimethyl 2,2-dichloro vinyl phosphate.	100% E.C.	Ciba Pesticides, Bombay.
8.	Imidan 3.E.V.	Pthalimido methyl 0,0 dimethyl phosphoro-dithioate.	30% E.C.	Stauffer Chemical Company, California.
9.	Trithion.	0,0-Diethyl,S-P Chlorophenyl thiomethyl phosphorodi-thioate.	20% E.C.	Mysore Insecticides, Company.

1	2	3	4	5
10.	Dipterex S.P.	dimethyl trichloro, hydroxy ethyl phosphamate.	80% S.P.	Bayer and Company, Bombay.
11.	Sevin.	1-naphthyl N-methyl carbamate.	50% W.P.	Union Carbide India Ltd.

Emulsifier. 'Teepol' supplied by Messrs. Burma Shell was used as emulsifier in the preparation of endrin emulsion from technical material.

Brinjal plants. Brinjal plants of a local variety were used for the experiments. They were raised in 12" x 15" flower pots. Each pot contained a single plant. A bulk cultivation was also maintained for use in the rearing of the test insects. The plants were transplanted in pots 20 days after sowing. One month after transplantation they were used for the experiments. The plants raised in flower pots were subjected to the same cultural practices to ensure uniformity in growth and stand.

Cloth bags. Cloth bags were used to confine the liberated insects on the plants. These bags were made of muslin cloth and measured 30" x 18".

Rearing cages. The mass rearing of insects in the laboratory was done in teak wood cages (12" x 12") with glass on all four sides. The top of the cage was covered with muslin cloth.

METHODS.

Rearing of test insects.

A bulk culture of *E.vigintioctopunctata* was maintained in the laboratory for the experiments as described below:

The adults collected from brinjal plants in the field are confined in the rearing cages and provided with fresh brinjal leaves. The quick drying up of the leaves are prevented by keeping the brinjal branches dipped in water contained in 50 cc. conical flasks. The mouth of the flask is plugged with cotton wool to prevent the insects from falling into the water. This arrangement reduces the chances of the leaves getting contaminated with faecal matter in the rearing cages. The cages are cleaned frequently and the leaves changed as and when found necessary.

When the adults lay eggs they are collected and transferred into hurricane chimneys closed at either ends with muslin cloth, for easy observation of emergence of

grubs. Grubs emerging each day are kept in separate cages with the date of emergence noted. The grubs are fed with fresh leaves collected from the field. Each day the cages are examined to ascertain the instar of the grubs. The adults obtained from the culture are used for raising the next generation.

Preparation of brinjal plants for spraying.

Before spraying, the older leaves of the potted brinjal plants are removed leaving only the fully developed and succulent leaves on the plants. White sand is applied at the base of the plants to fill up the crevices in the soil and thus to prevent the insects from entering into these crevices in the soil. After filling up the crevices with sand, the plants are watered.

Preparation of insecticide formulations.

All the insecticides were used as sprays. The spray fluids were suspensions prepared from wettable powders or emulsions prepared from emulsifiable concentrates, or solutions prepared from soluble or miscible materials. Following were the proportions in which the different insecticide concentrates were diluted with water to prepare the sprays.

1. DDT. 0.2% emulsion: 1 cc. DDT. 25% E.C. + 124 cc. water.

2. BHC. 0.2% emulsion: 1 cc. BHC. 20% E.C. + 99 cc. water.

3. Endrin 0.025% emulsion: This was prepared from Technical endrin as detailed below:

0.5 g. Endrin Technical + 10 cc. Benzene— 5% Stock solution.

1 cc. Stock solution + 9 cc. Benzene + 190 cc. 1% solution of Teepol in water=0.025% emulsion containing 5% benzene.

4. Parathion 0.025% emulsion: 0.25 cc. Folidol (Parathion 46.7% E.C.) + 467 cc. water.

5. Malathion 0.1% emulsion: 0.25 cc. Malathion 50% E.C. + 125 cc. water.

6. Dimecron 0.03% solution: 0.25% cc. Dimecron 100% concentrate + 833 cc. water.

7. Nuvan 0.05% emulsion: 0.25 cc. Nuvan 100% E.C. + 495 cc. water.

8. Imidan 0.1% emulsion: 1 cc. Imidan 30% E.C. + 299 cc. water.

9. Trithion 0.1% emulsion: 1 cc. Trithion 20% E.C. + 199 cc. water.

10. Dipterex 0.1% solution: 0.25 g. Dipterex 80% S.P. + 200 cc. water.

11. Sevin 0.1% suspension: 0.25 g. Sevin 50% W.W.P. + 124 cc. water.

Spraying of plants.

The spraying was done using an atomizer connected to a pressure pump (Plate I). Each plant is sprayed with 30 cc. of the insecticide spray concerned. For this, the spray fluid is taken in a small bottle and is sprayed on each plant so as to cover both sides of the leaves as well as the rest of the plant parts.

Confining the insects on the sprayed plants.

One hour after spraying, by which time the spray fluid has dried on the leaves, four sticks are planted in each pot at four corners along its periphery (Plate II). The cloth bag is then put over the plant and the free end of it tied around the edge of the pot (Plate III). The four sticks help in keeping the bag stretched and thus provide enough space for the plant within to stand without being smothered by the bag. Ten numbers each of adults and 3rd instar grubs of E.vigintio-octopunctata are confined on each sprayed plant. The bag is secured around the edge of the flower pot only after liberating the beetles and grubs on the plants. The beetles and grubs used for confinement on the sprayed plants are starved for the previous 24 hours. This procedure is resorted to, to minimise variations in subsequent feeding among the individual insects.

Assessment of results.

Results are assessed by counting the number of the beetles and grubs dead and surviving, 24 and 48 hours after liberation on the treated plants. For this the cloth bag covering the plant is untied from the edge of the flower pot and carefully lifted. Firstly the dead insects lying on the white sand, spread at the base of the plant are counted. Then each leaf is examined to see if any dead insects are sticking on to it. The cloth bags are also carefully examined.

DETAILS OF EXPERIMENTS AND RESULTS.

A series of eleven experiments were conducted to ascertain the residual toxicity of eleven modern synthetic insecticides, when applied on brinjal leaves. Adults and grubs of E.vigintioctopunctata were used as test insects. Following are the details of the experiments and their results.

Experiment No.1

Toxicity of residues of DDT. on brinjal leaves to the adults and grubs of E.vigintioctopunctata at different intervals after application.

Experimental details.

Test insecticide:	DDT. was used as 0.2% emulsion. This was prepared by diluting DDT 25% E.C. with water.
Number of replications:	3 each.
Number of adults and grubs in each replication:	10
Test insect:	The beetles and 3rd instar grubs obtained from the culture, reared in the laboratory were used for the experiment.

Date of starting the experiment:	8--9--1964
Date of completing the experiment:	1-10--1964
Temperature during the period:	Maximum: 86°F. Minimum: 78°F.
Relative humidity during the period:	90-92%

Procedure: Beetles and grubs were released on potted brinjal plants sprayed with 0.2% DDT. emulsion, at 1 hour, 7 days, 14 days and 21 days after application of the insecticide. Survival of these beetles and grubs were observed 24 and 48 hours after their release on the sprayed plants.

Results.

Results of the experiments are shown in Table I, which gives the percentage survival of the adults and grubs of the beetle, when exposed to the sprayed brinjal plants. The same results are represented in Fig.1. It is observed that DDT. is relatively more toxic to the grubs than to the adults. The residual toxicity of the insecticide appears to be not

TABLE I.

Percent survival of adults and grubs of E.vigintioctopunctata exposed to brinjal plants at varying intervals after spraying with DDT 0.2% emulsion.

Intervals of exposure after spraying.	Adults		Grubs	
	Percent survival		Percent survival	
	24 hours	48 hours	24 hours	48 hours
1 hour	30.0	15.0	20.0	3.4
7 days	33.4	29.6	40.0	18.6
14 days	70.0	51.6	63.4	33.4
21 days	93.4	88.9	86.7	80.0

appreciably reduced in the course of first week as there is only 29.6% survival among adults and 18.6% survival among grubs after 48 hours of exposure. But at the end of 14 days the survival of the adults rises to 51.6% after 48 hours of contact, while that of the grubs is only 33.4%. Beyond two weeks there appears to be a drastic reduction in the toxicity of the residues and it is seen that 21 days after the application there is 88.9% and 80% survival respectively among the adults and grubs after 48 hours of exposure.

Experiment No.2.

Toxicity of residues of BHC on brinjal leaves to the adults and grubs of E.vigintioctopunctata at different intervals after application.

Experimental details.

Test insecticide: BHC. was used as 0.2% emulsion. This was prepared by diluting BHC. 20% E.C. with water. Other details as in Experiment No.1.

Results.

Results of the experiment are shown in Table II and represented in Fig.2.

TABLE II.

Percent survival of adults and grubs of E.vigintioctopuncta exposed to brinjal plants at varying intervals after spraying with BHC. 0.2% emulsion.

Intervals of exposure after spraying.	Adults		Grubs	
	Percent survival		Percent survival	
	24 hours	48 hours	24 hours	48 hours
1 hour	73.4	36.7	56.7	23.4
7 days	100.0	100.0	90.0	81.6
14 days	100.0	100.0	100.0	100.0
21 days	100.0	100.0	100.0	100.0

Fig. 2 Graph showing percentage survival of adults and grubs of E.vigintioctopunctata observed at the end of 24 and 48 hours of exposure to brinjal leaves at various intervals after spraying with BHC 0.2% emulsion.

Fig. 1 Graph showing percentage survival of adults and grubs of E.vigintioctopunctata observed at the end of 24 and 48 hours of exposure to brinjal leaves at various intervals after spraying with DDT. 0.2% emulsion.

FIG. 1

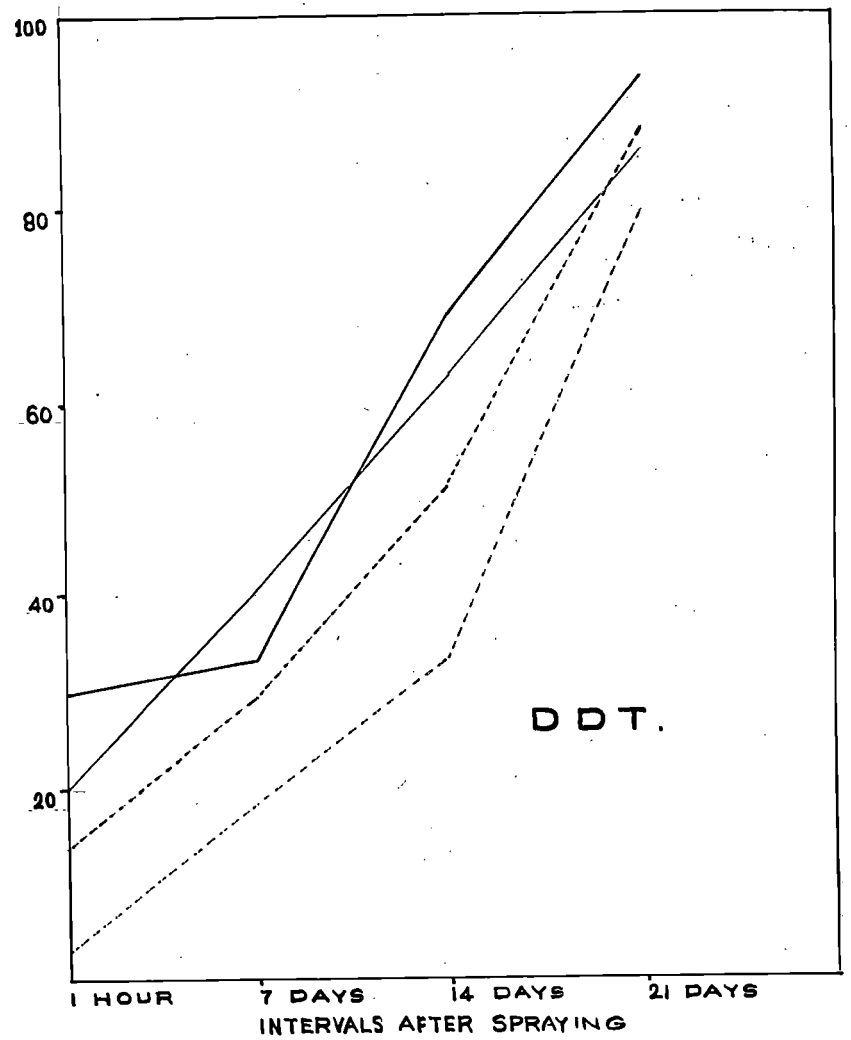
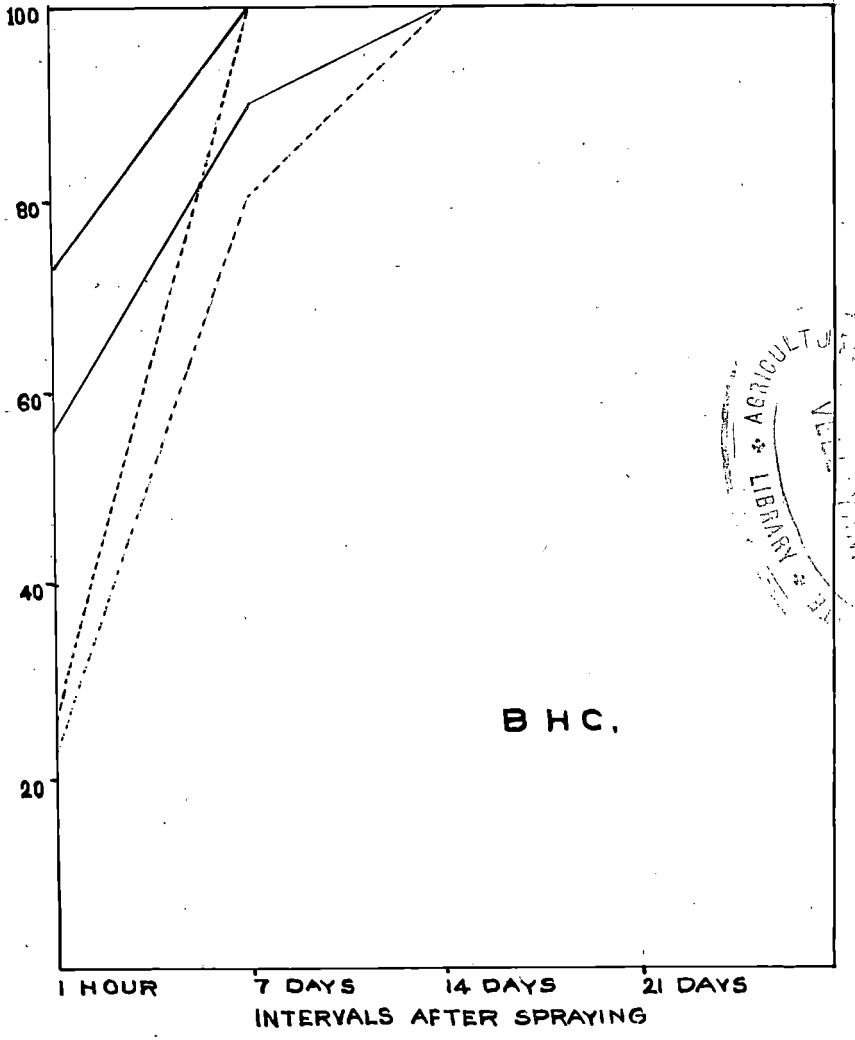
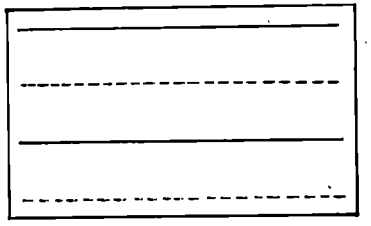


FIG. 2



PERCENT SURVIVAL



ADULTS 24 HOURS EXPOSURE

ADULTS 48 HOURS EXPOSURE

GRUBS 24 HOURS EXPOSURE

GRUBS 48 HOURS EXPOSURE

It is observed that BHC. is relatively more toxic to the grubs than to the adults, but even the initial toxicity of the deposit of BHC. 0.2% on the leaves does not appear to be very high as there is 36.7% and 23.4% survival of the adults and grubs respectively when exposed to the initial deposits for 48 hours. There is 100% survival of the adults when exposed to the sprayed plants 7 days after spraying, indicating that the residue becomes non-toxic to them during that period. To the grubs, however, the residue becomes completely non-toxic only within 14 days.

Experiment No.3.

Toxicity of the residues of 0.025% endrin on brinjal leaves to adults and grubs of E.vigintioctopunctata at different intervals after application.

Experimental details.

Test insecticide: Endrin was applied as 0.025% emulsion which was prepared from Technical endrin. Rest of the details as in Experiment No.1.

Results.

Results of the experiment are given in Table III and graphically represented in Fig.3. Endrin appears to be more toxic to the adults than to the grubs. A gradual reduction in the toxicity of the residue as time elapses is evident.

TABLE III.

Percent survival of adults and grubs of E.vigintioctopunctata exposed to brinjal plants at varying intervals after spraying with endrin 0.025% emulsion.

Intervals of exposure after spraying.	Adults		Grubs	
	Percent survival		Percent survival	
	24 hours	48 hours	24 hours	48 hours
1 hour	63.4	10.0	70.0	17.7
7 days	76.7	36.7	80.0	50.0
14 days	93.4	86.7	100.0	93.4
21 days	100.0	100.0	100.0	100.0

This reduction appears to be more rapid after one week and at the end of 14 days there is 86.7% survival among adults and 93.4% survival among the grubs when exposed to the sprayed leaves. The residue appears to be completely lost at the end of 21 days as no mortality is seen in the beetles and their grubs when exposed to the plants 21 days after spraying.

Experiment No.4.

Toxicity of residues of 0.025% parathion on brinjal leaves to adult and grubs of E.vigintioctopunctata at different intervals after spraying.

Experimental details.

Test insecticide: Parathion 0.025% emulsion was used and this was prepared by diluting parathion 46.7% E.C. (Folidol) with water.

Date of starting the experiment:	4—10—1964
Date of completing the experiment:	27—10—1964
Temperature during the period.	Maximum: 86°F. Minimum: 76°F.
Relative humidity during the period:	89-92%

Other details as in Experiment No.1.

Results.

Table IV gives the results of the experiment which are also represented in Fig.4.

TABLE IV.

Percent survival of adults and grubs of E.vigintioctopunctata exposed to brinjal plants at varying intervals after spraying with parathion 0.025% emulsion.

Intervals of exposure after spraying	Adults		Grubs	
	Percent survival		Percent survival	
	24 hours	48 hours	24 hours	48 hours
1 hour	0.0	0.0	10.0	3.4
7 days	93.4	63.4	63.4	44.7
14 days	100.0	100.0	100.0	100.0
21 days	100.0	100.0	100.0	100.0

It will be observed that the toxicity of the initial deposit of the insecticide is very high giving nearly absolute mortality in adults and grubs in 48 hours when exposed to the deposit. At the end of 7 days after spraying 63.4% of the adults and 44.7% of the grubs survived when exposed to the treated plants for 48 hours, thus indicating a severe reduction in the toxicity of the residue during one week. By the end of 14 days no residue of parathion appears to be left on the plants as no mortality is observed in the insects when exposed to the treated plants after 14 days of treatment.

Fig. 4 Graph showing percentage survival of adults and grubs of E.vigintioctopunctata observed at the end of 24 and 48 hours of exposure to brinjal leaves at various intervals after spraying with parathion 0.025% emulsion.

Fig. 3 Graph showing percentage survival of adults and grubs of E.vigintioctopunctata observed at the end of 24 and 48 hours of exposure to brinjal leaves at various intervals after spraying with endrin 0.025% emulsion.

FIG. 3

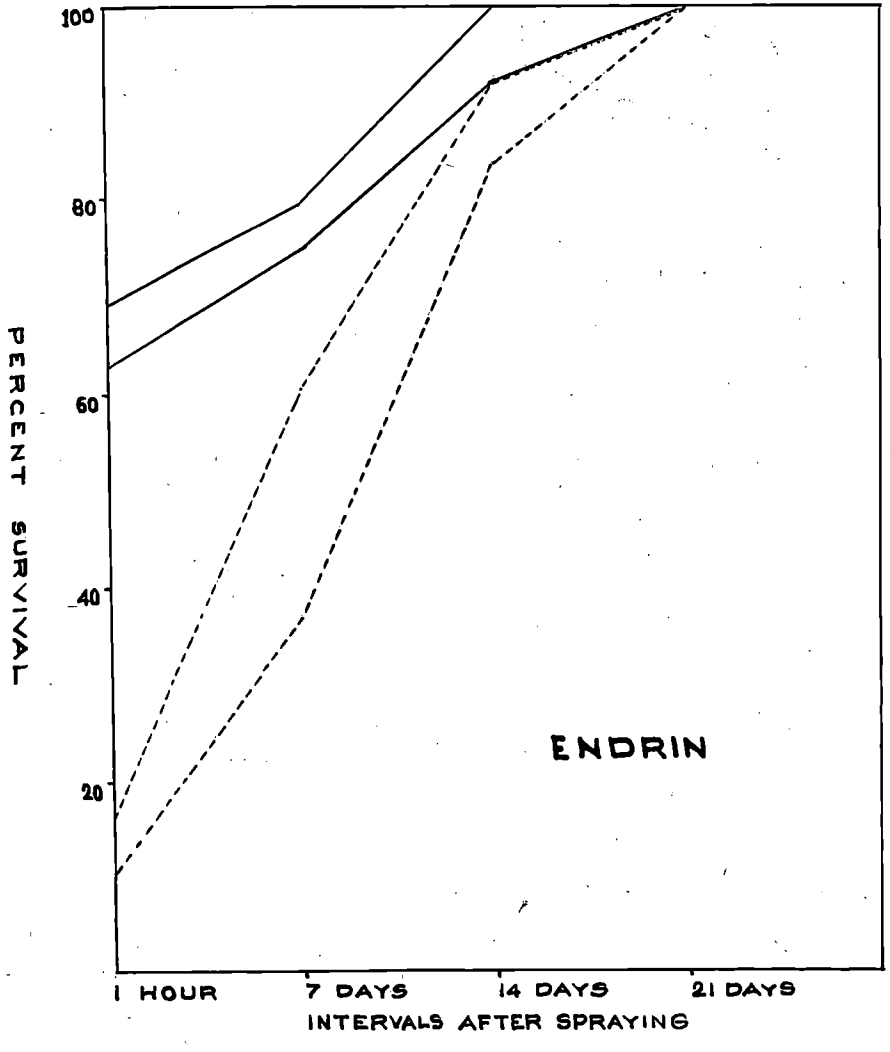
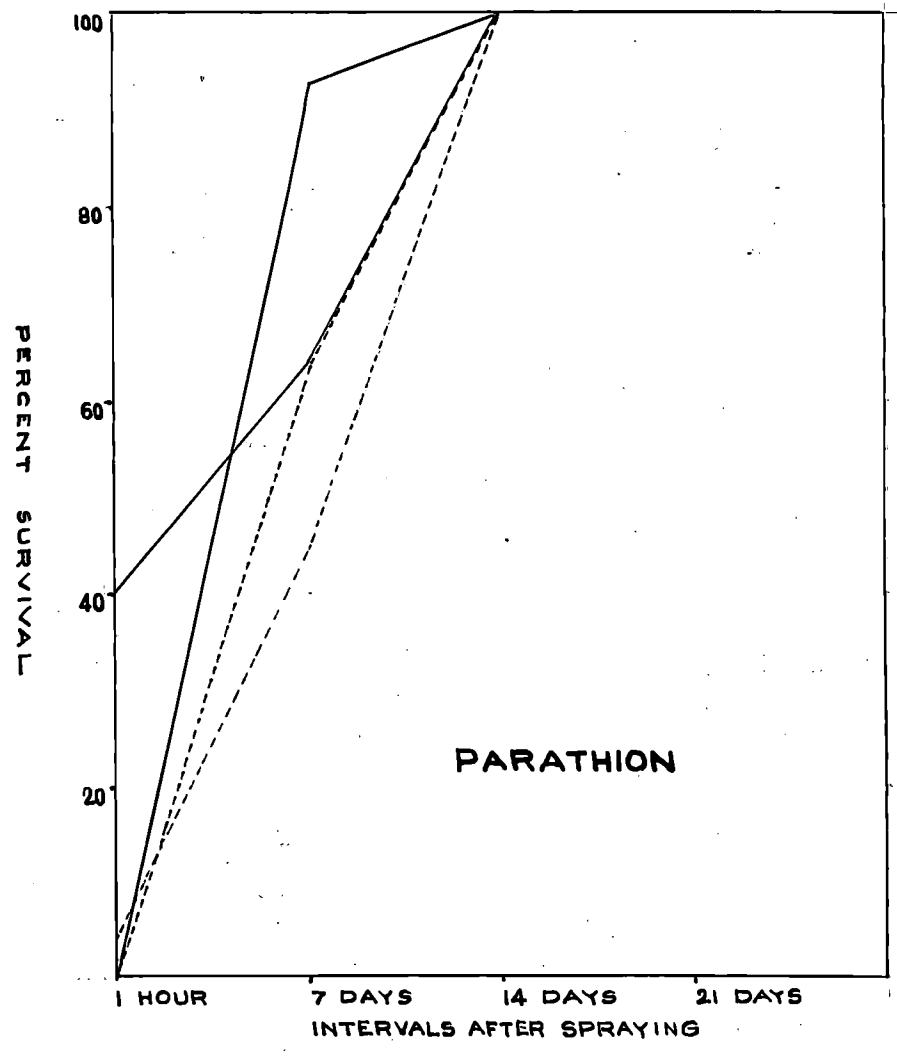
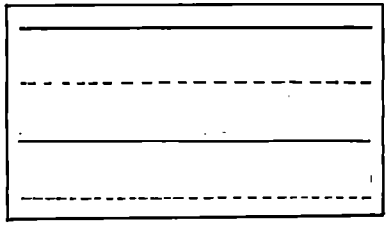


FIG. 4





ADULTS 24 HOURS EXPOSURE

ADULTS 48 HOURS EXPOSURE

GRUBS 24 HOURS EXPOSURE

GRUBS 48 HOURS EXPOSURE

Experiment No.5.

Toxicity of residues of 0.1% Malathion on brinjal leaves to the adults and grubs of E.vigintioctopunctata at different intervals after application.

Experimental details.

Test insecticide: Malathion was used as 0.1% emulsion. This was prepared by diluting malathion 50% E.C. with water. Rest of the details as in Experiment 4.

Results.

Results of the experiment are given in Table V and graphically represented in Fig.5.

TABLE V.

Percent survival of adults and grubs of E.vigintioctopunctata exposed to brinjal plants at varying intervals after spraying malathion 0.1% emulsion.

Intervals of exposure after spraying.	Adults		Grubs	
	Percent survival		Percent survival	
	24 hours	48 hours	24 hours	48 hours
1 hour	30.0	3.7	30.0	6.7
7 days	100.0	100.0	83.4	77.7
14 days	100.0	100.0	100.0	100.0
21 days	100.0	100.0	100.0	100.0

It will be seen that when exposed to the initial deposit of malathion 1 hour after spraying, for a period of 48 hours, only 3.7% of the adults and 6.7% of the grubs survive indicating the high toxicity of the deposit. When the insects are similarly exposed to the plants 7 days after spraying there is 100% survival in adults and 77.7% survival in the grubs indicating a drastic reduction in the residual toxicity of the insecticide. The residue becomes non-toxic to the grubs by the end of 14 days of application.

Experiment No.6.

Toxicity of the residues of 0.03% dimecron on brinjal leaves to adults and grubs of E.vigintioctonunctata at different intervals after application.

Experimental details.

Test insecticide: Dimecron was used as a 0.1% solution which was prepared by mixing 100% technical material in water. Rest of the details as in experiment 4.

Results.

Results of the experiment are shown in Table VI and Fig.6. It will be observed that when exposed to the deposit one hour after spraying the survival of the adults and grubs is 3.4 and 20% respectively at the end of 48 hours of continuous exposure. Similar survivals among the adults

and grubs when exposed to the sprayed leaves at the end of 7 days are seen to be 70% and 77.8 respectively, indicating a severe reduction in the toxicity of the residue during that period. By the end of 14 days, the toxicity of the residue appears to be completely lost.

TABLE VI.

Percent survival of adults and grubs of E.vigintioctopunctata exposed to brinjal plants at varying intervals after spraying with dimecron 0.03% solution

Intervals of exposure after spraying.	Adults		Grubs	
	Percent survival		Percent survival	
	24 hours	48 hours	24 hours	48 houre
1 hour	13.4	3.4	53.4	20.0
7 days	96.7	70.0	93.4	77.8
14 days	100.0	100.0	100.0	100.0
21 days	100.0	100.0	100.0	100.0

Experiment No.7.

Toxicity of the residue of nuvan on brinjal leaves to the adults and grubs of E.vigintioctopunctata at different intervals after application.

Experimental details.

Test insecticide: Nuvan was applied as 0.05% emulsion. This was prepared by diluting nuvan 100% E.C. with water.

Fig. 6 Graph showing percentage survival of adults and grubs of E.vigintioctopunctata observed at the end of 24 and 48 hours of exposure to brinjal leaves at various intervals after spraying with dimecron 0.03% solution.

Fig. 5 Graph showing percentage survival of adults and grubs of E.vigintioctopunctata observed at the end of 24 and 48 hours of exposure to brinjal leaves at various intervals after spraying with malathion 0.1% emulsion.

FIG. 5

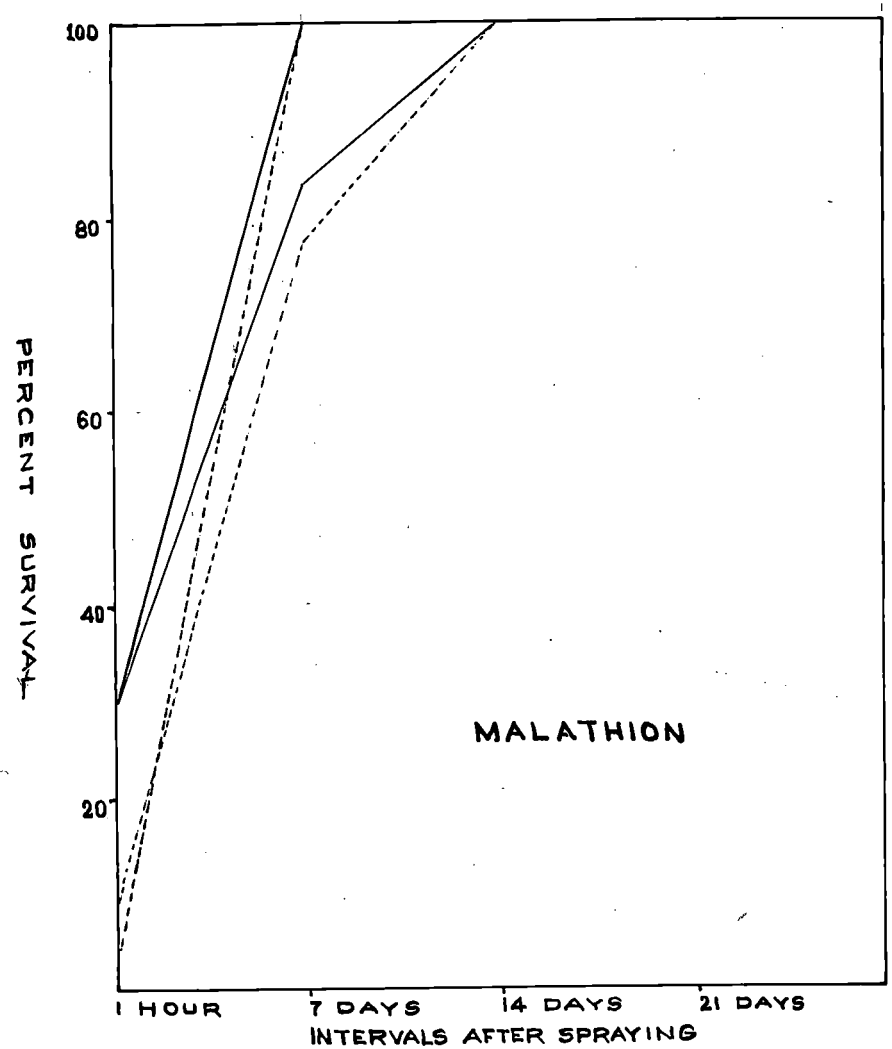
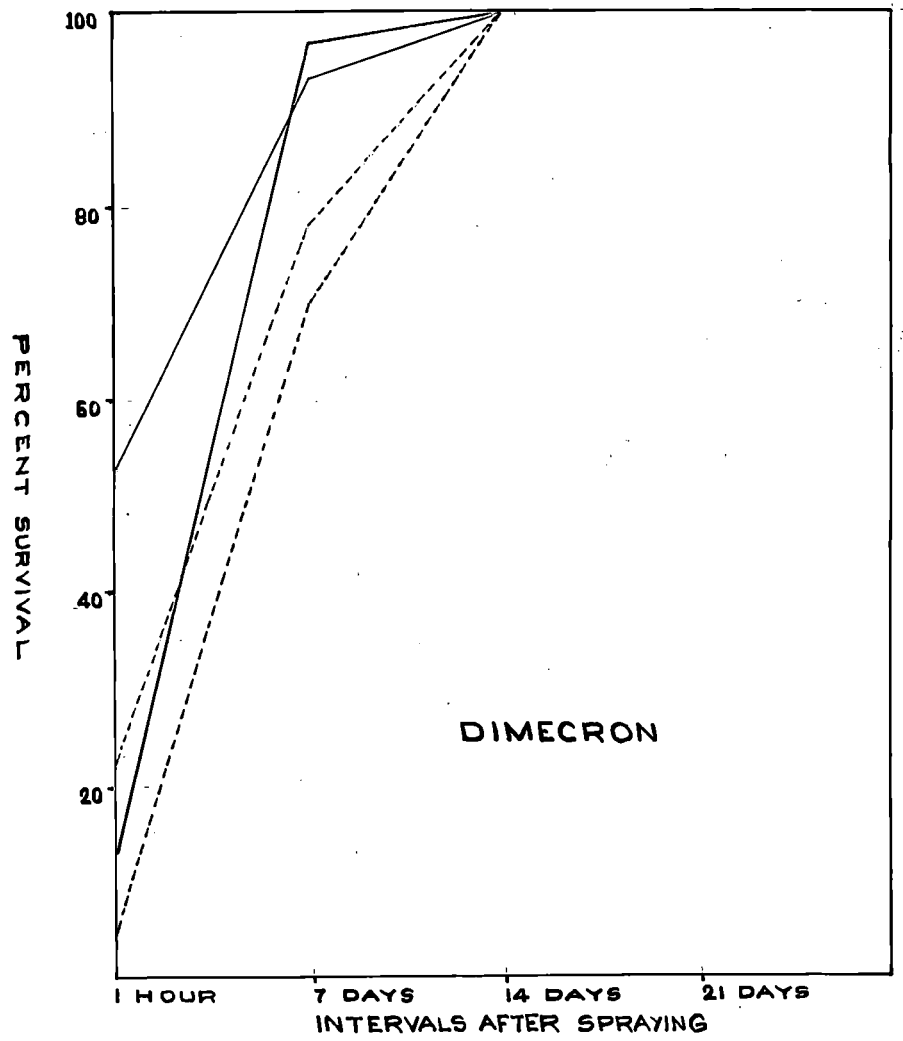
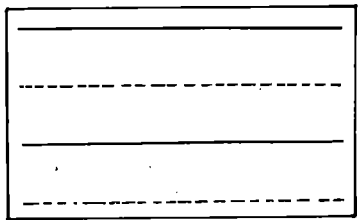


FIG. 6





ADULTS 24 HOURS EXPOSURE.

ADULTS 48 HOURS EXPOSURE.

GRUBS 24 HOURS EXPOSURE.

GRUBS 48 HOURS EXPOSURE

Date of starting the Experiment:	6—11—1964
Date of completing the Experiment:	29—11—1964
Temperature during the period:	Maximum: 82°F. Minimum: 74°F.
Relative humidity during the period:	83-90%

Other details as in Experiment No.1.

Results.

Results of the experiment are given in Table VII and represented in Fig.7.

TABLE VII.

Percent survival of adults and grubs of E.vigintioctopunctata exposed to brinjal plants at varying intervals after spraying with nuvan 0.05% emulsion.

Intervals of exposure after spraying.	Adults		Grubs	
	Percent survival		Percent survival	
	24 hours	48 hours	24 hours	48 hours
1 hour	3.4	3.4	46.7	16.7
7 days	100.0	100.0	100.0	100.0
14 days	100.0	100.0	100.0	100.0
21 days	100.0	100.0	100.0	100.0

Nuvan is found to be relatively more toxic to adults than to grubs, when exposed to the sprayed leaves 1 hour after spraying, giving 3.4% and 16.7% survival respectively at the end of 48 hours of exposure. The residual toxicity of the insecticide is completely lost during the first week as shown by 100% survival of the adults and grubs when exposed on sprayed leaves for 48 hours, 7 days after spraying.

Experiment No.8.

Toxicity of the residue of 0.1% imidan on brinjal leaves to the adults and grubs of E.vigintioctopunctata at different intervals after spraying.

Experimental details.

Test insecticide: Imidan was applied as 0.1% emulsion which was prepared by diluting 30% E.C. with water. Rest of the details as in Experiment No.7.

Results.

Results of the experiment are shown in Table VIII and are graphically represented in Fig.8. It is observed that imidan is almost equally toxic to both the adults and grubs, giving 20% survival in 48 hours, when exposed to the sprayed leaves, 1 hour after spraying. Considerable reduction in toxicity of the residue is evident at the end of 7 days' weathering, as the survival among adults and grubs exposed to

TABLE VIII.

Percent survival of adults and grubs of E.vigintioctopunctata exposed to brinjal plants at varying intervals after spraying with imidan 0.1% emulsion.

Intervals of exposure after spraying.	Adults		Grubs	
	Percent survival		Percent Survival	
	24 hours	48 hours	24 hours	48 hours
1 hour	56.7	20.0	46.7	20.0
7 days	76.7	63.4	80.0	59.3
14 days	100.0	100.0	90.0	83.4
21 days	100.0	100.0	100.0	100.0

the sprayed plants are seen to be 63.4% and 59.3% respectively. Total loss of toxicity of the residue to the adults is seen at the end of 14 days and to the grubs at the end of 21 days.

Experiment No.9.

Toxicity of the residue of 0.1% trithion on brinjal leaves to adults and grubs of E.vigintioctopunctata at different intervals after spraying.

Experimental details.

Test insecticide: Trithion was used as 0.1% emulsion by diluting 20% E.C. with water. Other details as in Experiment No.7.

Fig. 8 Graph showing percentage survival of adults and grubs of E.vigintioctopunctata observed at the end of 24 and 48 hours of exposure to brinjal leaves at various intervals after spraying with imidan 0.1% emulsion.

Fig.7 Graph showing percentage survival of adults and grubs of E.vigintioctopunctata observed at the end of 24 and 48 hours of exposure to brinjal leaves at various intervals after spraying with nuvan 0.05% emulsion.

FIG.7

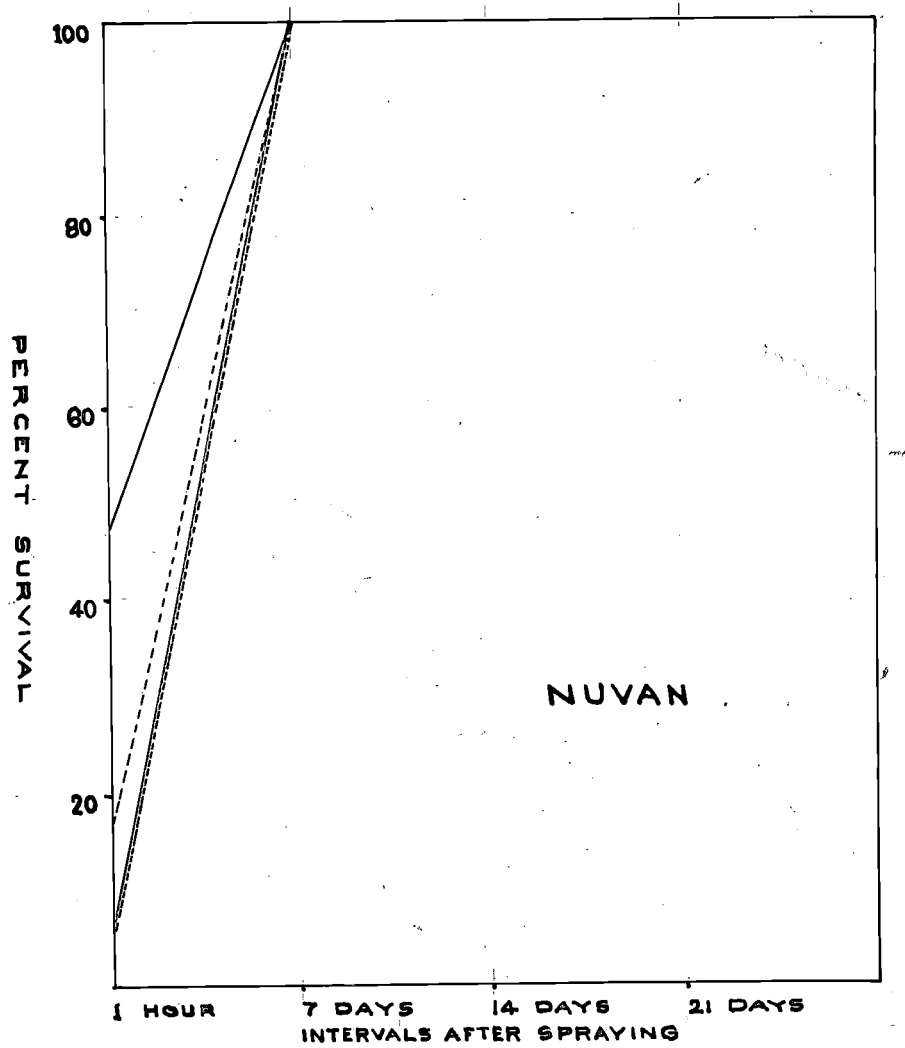
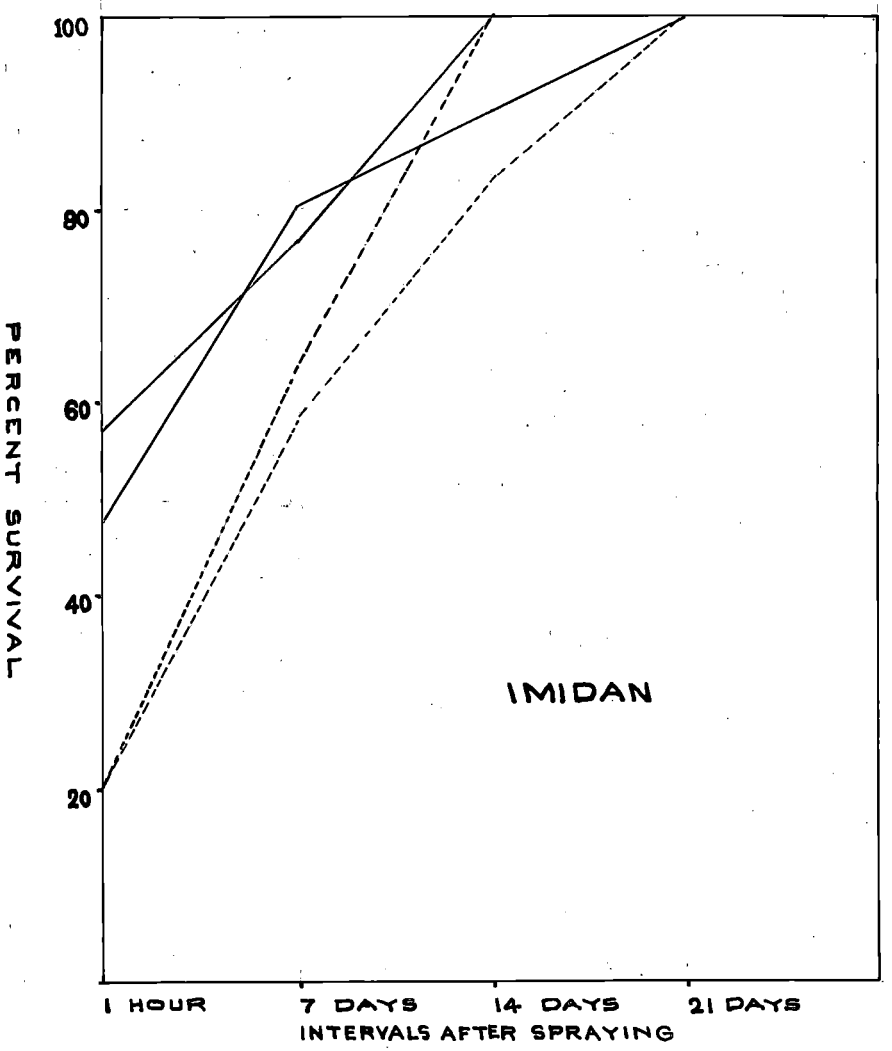
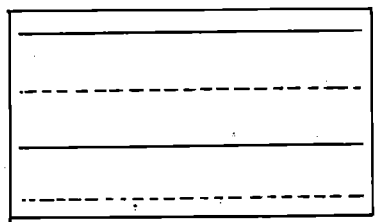


FIG.8





ADULTS 24 HOURS EXPOSURE

ADULTS 48 HOURS EXPOSURE

GRUBS 24 HOURS EXPOSURE

GRUBS 48 HOURS EXPOSURE

Results.

Table IX gives the results of the experiment which are also represented in Fig.9

TABLE IX.

Percent survival of adults and grubs of E.vigintioctopunctata exposed to brinjal plants at varying intervals after spraying with trithion 0.1% emulsion.

Intervals of exposure after spraying.	Adults		Grubs	
	Percent survival		Percent survival	
	24 hours	48 hours	24 hours	48 hours
1 hour	30.0	3.4	25.0	3.4
7 days	46.7	29.7	53.4	22.3
14 days	76.7	53.4	70.0	56.7
21 days	90.0	76.7	80.0	76.7

In general, the residues of trithion appear to be equitoxic to both adults and grubs. The initial toxicity of the deposit is seen to be very high with only 3.4% survival of the insects in 48 hours of exposure to the sprayed leaves. The loss of toxicity of the residue appears to be gradual and slow. Thus at the end of 7 days of spraying the survival of the exposed adults and grubs are only 29.7 and 22.3% respectively. By the end of 14 days, the survival of the exposed insects are

slightly more than 50%. The residue appears to remain still active at the end of 21 days, eventhough to a considerably reduced extent, with 76.7% survival of both adults and grubs in 48 hours of exposure.

Experiment No.10.

Toxicity of the residues of 0.1% dipterex on brinjal leaves to the adults and grubs of E.vigintioctopunctata at different intervals after application.

Experimental details.

Test insecticide:	Dipterex 0.1% was used as solution by dissolving 80% S.P. in water.
Date of starting the experiment:	1--1--1965
Date of completing the experiment:	24--1--1965
Temperature during the period:	Maximum: 88°F. Minimum: 80°F.
Relative humidity during the period:	91-96%

Other details as in Experiment No.1.

Results.

Results of the experiment are given in Table X and represented in Fig.10.

TABLE X.

Percent survival of adults and grubs of E.vigintioctopunctata exposed to brinjal plants at varying intervals after spraying with dipterex 0.1% solution.

Intervals of exposure after spraying.	Adults		Grubs	
	Percent survival		Percent survival	
	24 hours	48 hours	24 hours	48 hours
1 hour	33.4	3.4	46.7	26.7
7 days	76.7	59.3	86.7	85.1
14 days	70.0	66.7	100.0	100.0
21 days	100.0	100.0	100.0	100.0

The residue of the insecticide appears to be far more toxic to the adults than to the grubs. In the case of the adults when exposed to 48 hours on sprayed leaves 7 days, 14 days, and 21 days after spraying there is 59.3, 66.7 and 100% survival respectively while in the case of grubs the survivals are 85.1, 100.0 and 100% respectively. Thus the residues of dipterex remain toxic for a longer period to the adults than to the grubs.

Fig. 10 Graph showing percentage survival of adults and grubs of E.vigintioctopunctata observed at the end of 24 and 48 hours of exposure to brinjal leaves at various intervals after spraying with dipterex 0.1% solution.

Fig.9 Graph showing percentage survival of adults and grubs of E.vigintioctopunctata observed at the end of 24 and 48 hours of exposure to brinjal leaves at various intervals after spraying with trithion 0.1% emulsion.

FIG. 9

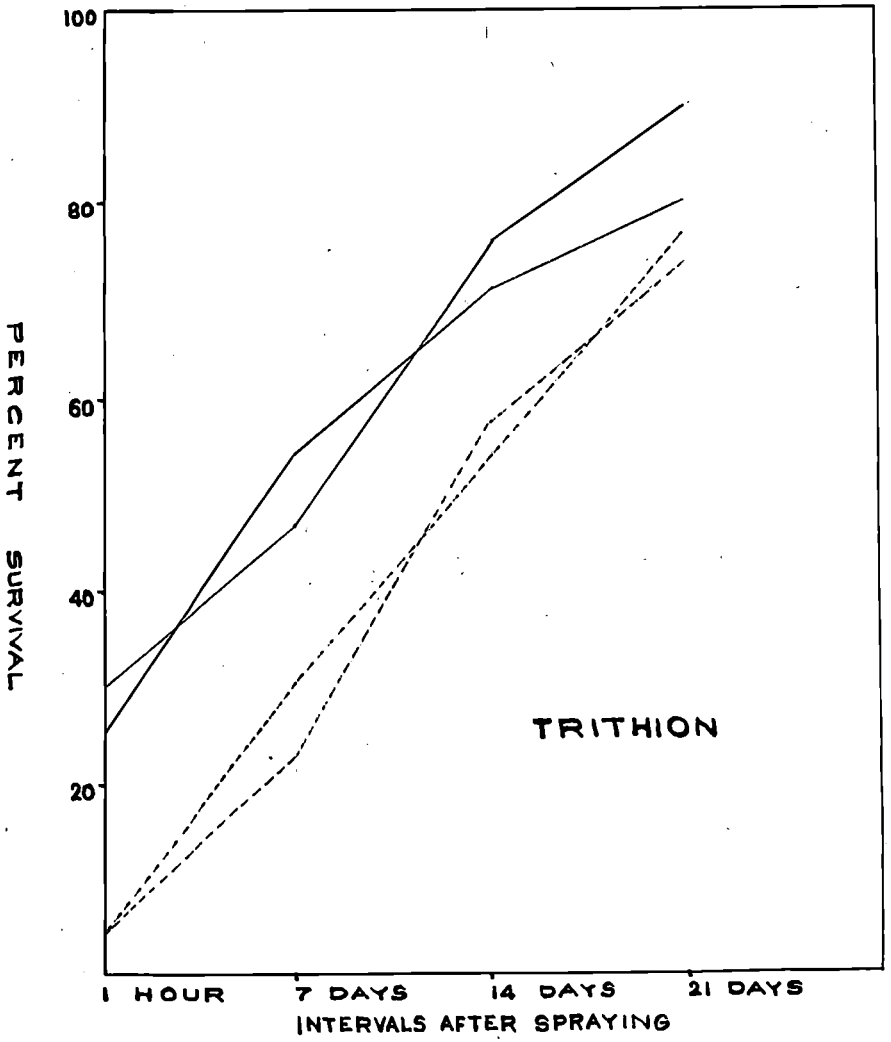
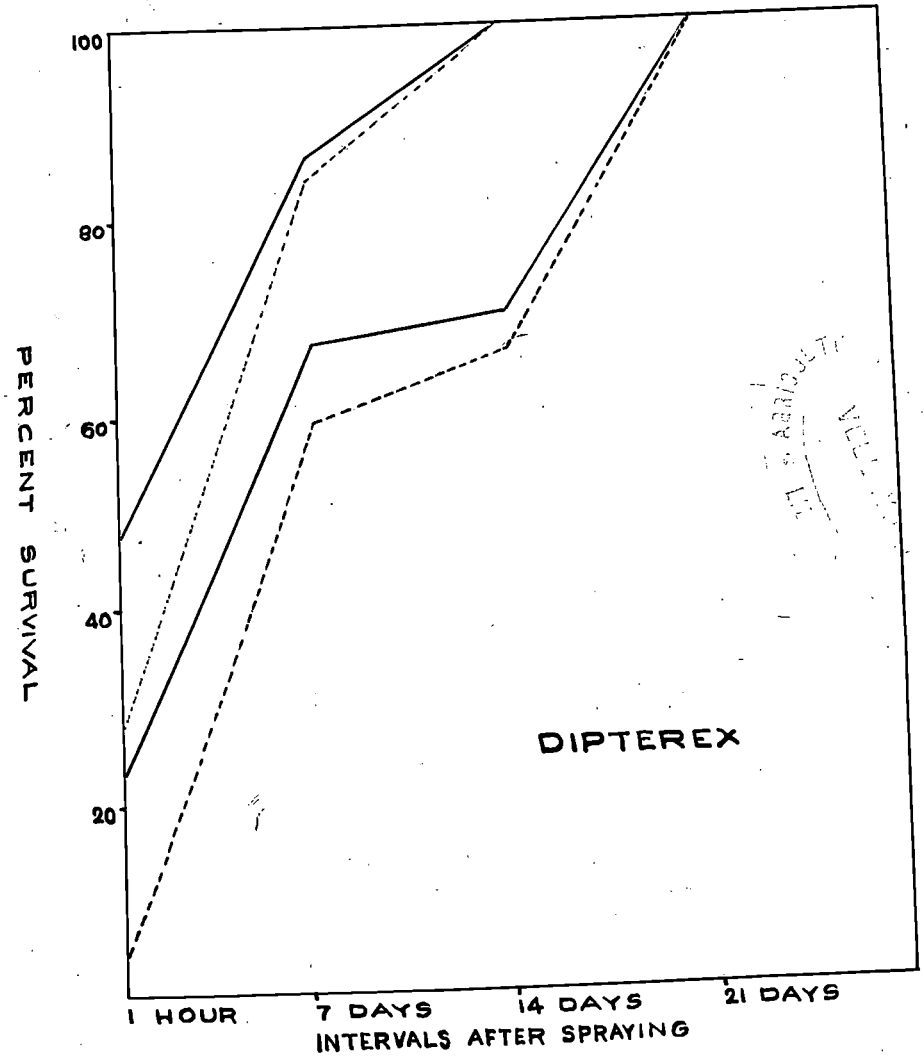
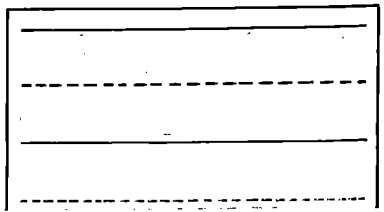


FIG. 10





ADULTS 24 HOURS EXPOSURE

ADULTS 48 HOURS EXPOSURE

GRUBS 24 HOURS EXPOSURE

GRUBS 48 HOURS EXPOSURE

Experiment No.11.

Toxicity of the residues of 0.1% sevin on brinjal leaves to the adults and grubs of E.vigintioctopunctata at different intervals after spraying.

Experimental details.

Test insecticide: Sevin was applied as 0.1% suspension by suspending 50% water wettable powder in water.

Rest as in Experiment No.10.

Results.

Results of the experiment are shown in Table XI and Fig.11. It will be seen that the adults are far more susceptible to the residues of sevin than the grubs. It is also seen that the survival of adults when exposed for 48 hours on sprayed plants at 1 hour, 7 days, 14 days and 21 days after spraying are 0, 0, 3.4 and 6.7% respectively; while the similar survivals of grubs are 6.7, 15, 36.7 and 46.7% respectively. Thus the residue of sevin appears to remain very highly toxic to the adults even at the end of 21 days after application and moderately toxic to the grubs at the end of the same period.

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Toxicity of the residues of 0.1% sevin on brinjal leaves to the adults and grubs of E.vigintioctopunctata at different intervals after spraying.

Experimental details.

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Rest as in Experiment No.10.

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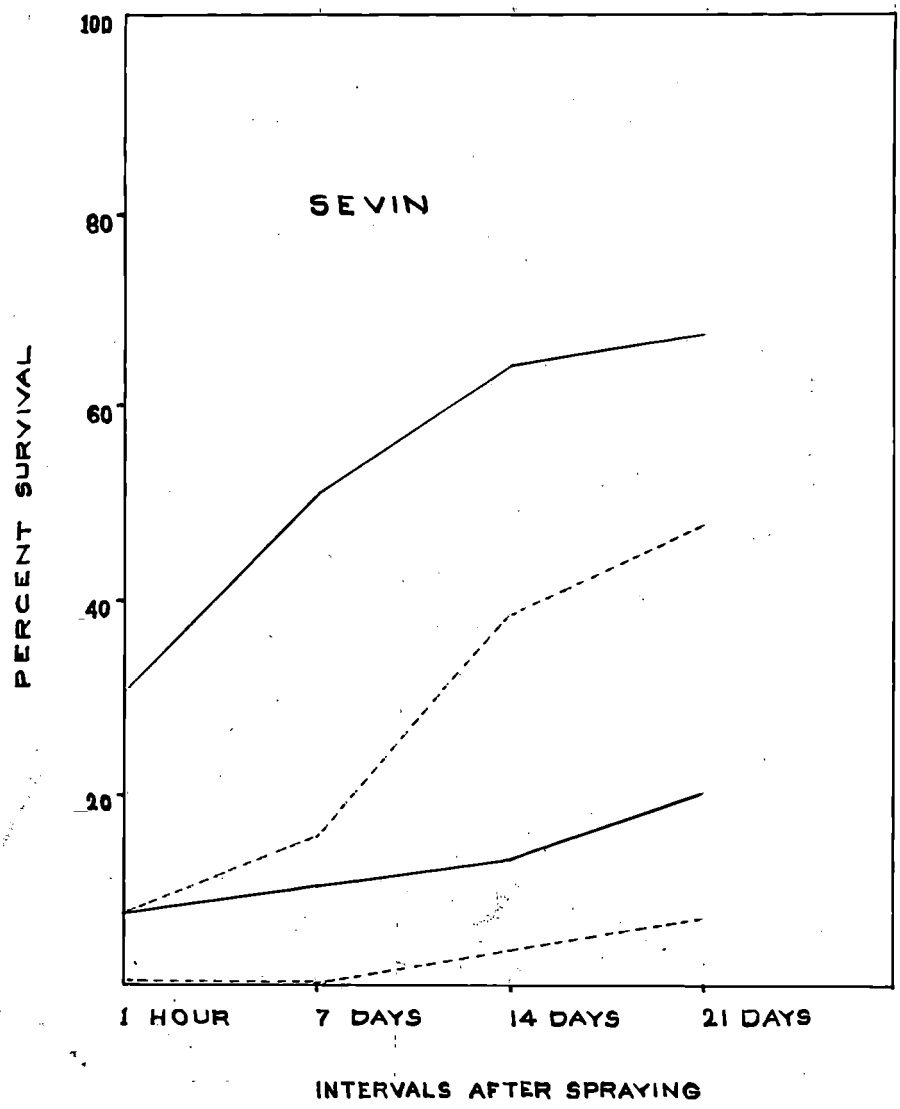
TABLE XI.

Percent survival of adults and grubs of E.vigintioctopunctata exposed to brinjal plants at varying intervals after spraying with sevin 0.1% suspension.

Intervals of exposure after spraying.	Adults		Grubs	
	Percent survival		Percent survival	
	24 hours	48 hours	24 hours	48 hours
1 hour	7.7	0.0	30.0	6.7
7 days	10.0	0.0	50.0	15.0
14 days	13.4	3.4	63.4	36.7
21 days	20.0	6.7	76.7	46.7

Fig.11 Graph showing percentage survival of adults and grubs of E.vigintioctopunctata observed at the end of 24 and 48 hours of exposure to brinjal leaves at various intervals after spraying with sevin 0.1% suspension.

FIG 11



ADULTS 24 HOURS EXPOSURE

ADULTS 48 HOURS EXPOSURE

GRUBS 24 HOURS EXPOSURE

GRUBS 48 HOURS EXPOSURE

DISCUSSION.

The present investigations were primarily aimed at determining, the persistence of different insecticides on brinjal leaves when the insecticides were applied as sprays. In general, studies on problems of persistence of insecticides on crops are important from three different view points. Firstly on crops like brinjal, parts of which are consumed by human beings, the problem of persistance of insecticides has significance in relation to poisonous hazards. Secondly from the view point of insect control, a long persisting insecticide is perhaps more advantageous and economical. Thirdly if the welfare of the biological and natural enemy complex of the pest is the concern and the desirability of maintaining a proper balance is felt, a non-persistent insecticide alone has to be preferred. It was with these considerations in view that the present study was undertaken. Brinjal was taken as test plant and adults and grubs of E.vigintioctopunctata were used as test insects. This particular insect was chosen as the test insect not only because it is a convenient insect which can be easily reared in the laboratory but also because this is a very important pest of brinjal.

For these studies, the brinjal plants raised in flower pots were sprayed with the insecticides and the test insects liberated on them at intervals of 1 hour, 7 days,

14 days and 21 days after insecticide application. The mortality observed after 24 and 48 hours of continuous exposure to the sprayed leaves was taken as a measure of residue left on the leaves. Apart from yielding information on the fate of the toxicity of the residues of insecticides applied on brinjal leaves, these experiments also have indicated the relative toxicity of the different insecticides under study to adults and grubs of E.vigintioctopunctata, when applied at their standard doses. Altogether eleven insecticides were tried, each at a standard concentration and the results obtained are discussed below.

Relative toxicity of different insecticides to adults and grubs of E.vigintioctopunctata.

In Fig. 14 and Table XII is represented the initial toxicity of the deposits of 11 insecticide emulsions on brinjal leaves to the beetles and their grubs. The bars show the mortality of the insects caused by the different insecticide preparations observed after 48 hours of continuous exposure on the brinjal leaves 1 hour after application of the insecticides. It will be seen that parathion 0.025% and sevin 0.1% are the most highly toxic to the adults showing cent percent mortality. Dipterex 0.1%, trithion 0.1% dimecron 0.03%, and nuvan 0.05% come next in position, giving over 95% mortality and are equitoxic among themselves. Malathion 0.1% also comes upto this standard giving about 94% mortality. Endrin 0.025% ranks next giving 90% mortality, while DDT. 0.2%, imidan 0.1% and

TABLE XII.

Consolidated statement showing the percentage mortality of adults and grubs of E.vigintioctopunctata when exposed for 48 hours to brinjal plants 1 hour after spraying with eleven different insecticides.

Sl. No.	Insecticides.	Adults.	Grubs.
1.	DDT. 0.2% emulsion	85.0	96.6
2.	BHC. 0.2% emulsion	63.7	76.6
3.	Endrin 0.025% emulsion	90.0	82.3
4.	Parathion 0.025% emulsion	100.0	96.6
5.	Malathion 0.1% emulsion	96.7	93.3
6.	Dimecron 0.03% solution	96.6	80.0
7.	Nuvan 0.05% emulsion	96.6	83.3
8.	Imidan 0.1% emulsion	80.0	80.0
9.	Trithion 0.1% emulsion	96.6	96.6
10.	Dipterex 0.1% solution	96.0	73.3
11.	Sevin 0.1% suspension	100.0	96.3

BHC 0.2% give lesser mortalities. BHC. 0.2% is the least toxic producing only 64% kill in the adult beetles. Thus it will be seen that except DDT, imidan and BHC which appear relatively less toxic to the beetles, all the rest of the insecticides are quite efficient in killing the adults.

It may be pointed out in this connection, that under field conditions sprays of contact insecticides applied to control E.vigintioctopunctata will exert their action in three ways, namely, (1) direct contact effect of the insecticide particles falling on the insect body (2) residual contact action of that factor which is picked up by the insect from the deposit (3) stomach action of insecticides when the deposit or the residue is taken within the stomach of the insect together with the leaf tissue on which it feeds. In the present studies only two of the above actions are involved, which are the second and third mentioned above. So under field conditions, mortalities obtained may be more than what are observed in the laboratory studies. Thus, even DDT, imidan and BHC which appear less toxic in the present studies also may prove highly effective in killing the beetle when applied in the field.

In the case of grubs, the order of initial toxicity of the different insecticide formulations under test is seem to be different from what is seen in the case of adults.

Thus DDT 0.2%, parathion 0.025% and trithion 0.1% appear to be the most highly toxic to the grubs, they themselves being equitoxic. Sevin 0.1% and malathion 0.1% are themselves equitoxic and are slightly less toxic than the former three insecticides. Endrin 0.025% and nuvan 0.05% are much less toxic than sevin and malathion and are between themselves equally toxic to the grubs. Next in the descending sequence are imidan 0.1% and dimecron 0.03%. They are followed by BHC 0.2% and dipterex 0.1%. Considering the overall picture of the toxicity of the different insecticides to the grubs it is thus observed that all the insecticide formulations excepting BHC. and dipterex give mortalities of 80% and above.

Relative susceptibility of adults and grubs of E.vigintioctopunctata to the different insecticides.

Variations occur in the relative susceptibility of the adults and grubs of E.vigintioctopunctata to the different insecticides under test as is seen from Table XII. Thus, the adults have been found to be relatively more susceptible than the grubs to endrin 0.025%, parathion 0.025%, malathion 0.1%, dimecron 0.03%, nuvan 0.05%, dipterex 0.1% and sevin 0.1%. On the other hand the grubs have been found to be more susceptible than the adults, to the insecticides, DDT. and BHC. Both the adults and grubs show equal susceptibility to imidan 0.1% and trithion 0.1%.

Persistence of the different insecticides on brinjal leaves.

Figs. 12 and 13 and Table XIII illustrate the toxicity of the residues of the different insecticides to the adults and grubs of E.virgintioctopunctata at various intervals after their application. These figures show the survival of the insects. The toxicity of the residues of different insecticides appear to be different in the adults and grubs. Thus in the case of adults, the toxicity of the residues of BHC 0.2%, malathion 0.1% and nuvan 0.05% is completely lost at the end of 7 days. In the case of grubs on the other hand their residual effect is lost in 14 days. Residues of BHC and malathion continue to remain toxic to some extent 7 days after their application, while the toxicity of the residues of nuvan 0.05% is completely lost within that period. The residues of dimecron 0.03%, parathion 0.025%, and imidan 0.1% become completely ineffective to adults by the end of 14 days, while in the case of the grubs, residues of imidan continues to be toxic even at the end of 14 days and its residual effect is completely lost at the end of 21 days. Residual effect of dipterex 0.1% to the adults survives upto 14 days and is totally lost by the end of 21 days. To the grubs, however the residues of dipterex become completely ineffective by 14 days.

The course of the residual toxicity of endrin 0.025% is more or less similar for adults and grubs, its

TABLE XIII.

Consolidated statement showing the percentage survival of adults and grubs of E.vigintioctopunctata exposed to brinjal plants, sprayed with various insecticides, for 48 hours at varying intervals after spraying.

Insecticides	Adults				Grubs			
	1 hour	7 days	14 days	21 days	1 hour	7 days	14 days	21 days
1. DDT. 0.2%	15.0	29.6	51.6	88.9	3.4	18.6	33.4	80.0
2. BHC. 0.2%	36.7	100.0	100.0	100.0	23.4	81.6	100.0	100.0
3. Endrin 0.025% emulsion	10.0	36.7	86.7	100.0	17.7	50.0	93.4	100.0
4. Parathion 0.025%	0.0	63.4	100.0	100.0	3.4	44.7	100.0	100.0
5. Malathion 0.1%	3.7	100.0	100.0	100.0	6.7	77.7	100.0	100.0
6. Dimecron 0.03%	3.4	70.0	100.0	100.0	20.0	77.8	100.0	100.0
7. Nuvan 0.05%	3.4	100.0	100.0	100.0	16.7	100.0	100.0	100.0
8. Imidan 0.1%	20.0	63.4	100.0	100.0	20.0	59.3	83.4	100.0
9. Trithion 0.1%	3.4	29.7	53.4	76.7	3.4	22.3	56.7	76.7
10. Dipterex 0.1%	3.4	59.3	66.7	100.0	26.7	85.1	100.0	100.0
11. Sevin 0.1%	0.0	0.0	3.4	6.7	6.7	15.0	36.7	46.7

Fig. 12 Graph showing percentage survival of adults of E.vigintioctopunctata observed at the end of 48 hours of exposure to brinjal leaves at various intervals after spraying with different insecticide preprations.

FIG.12

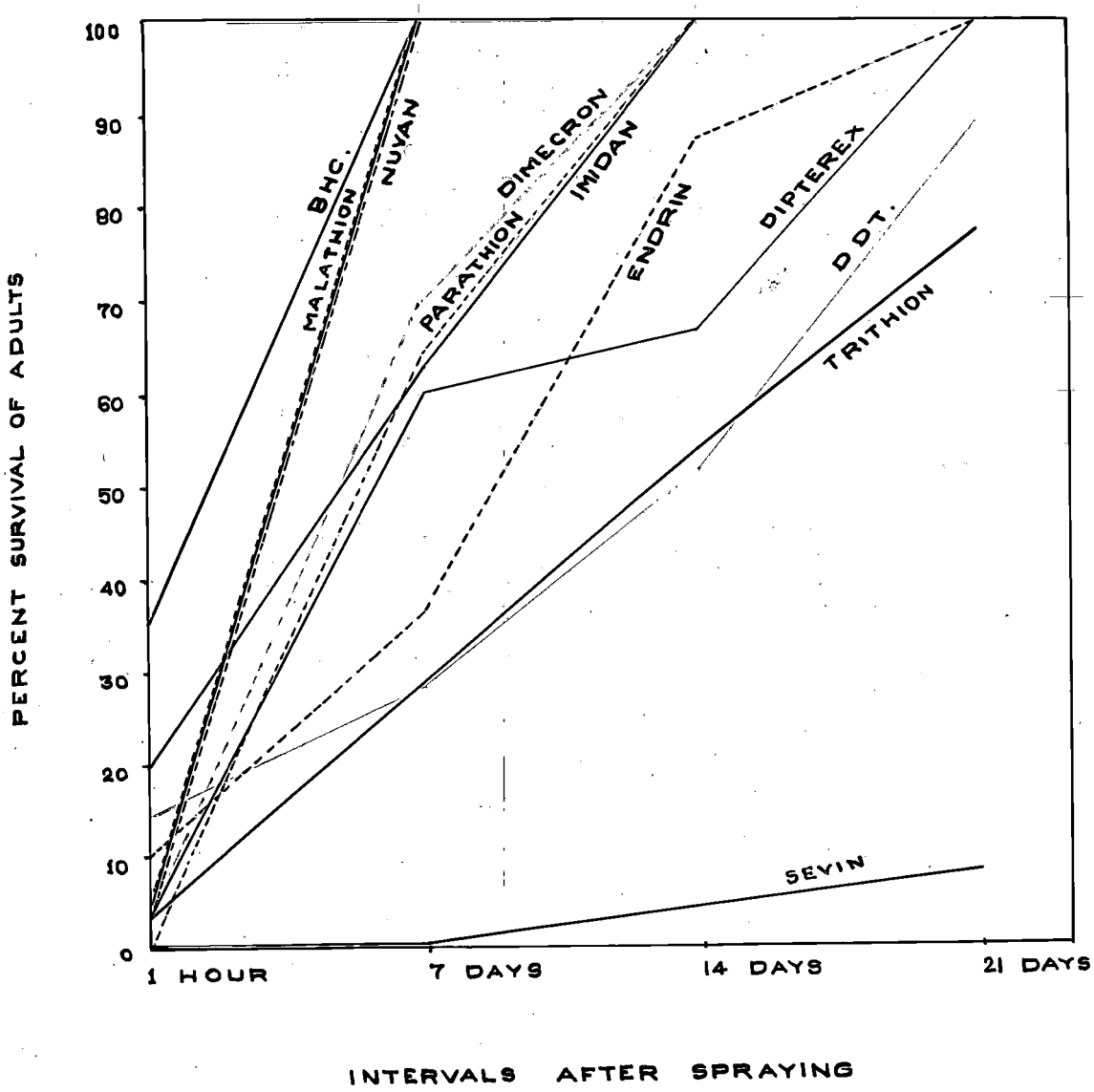
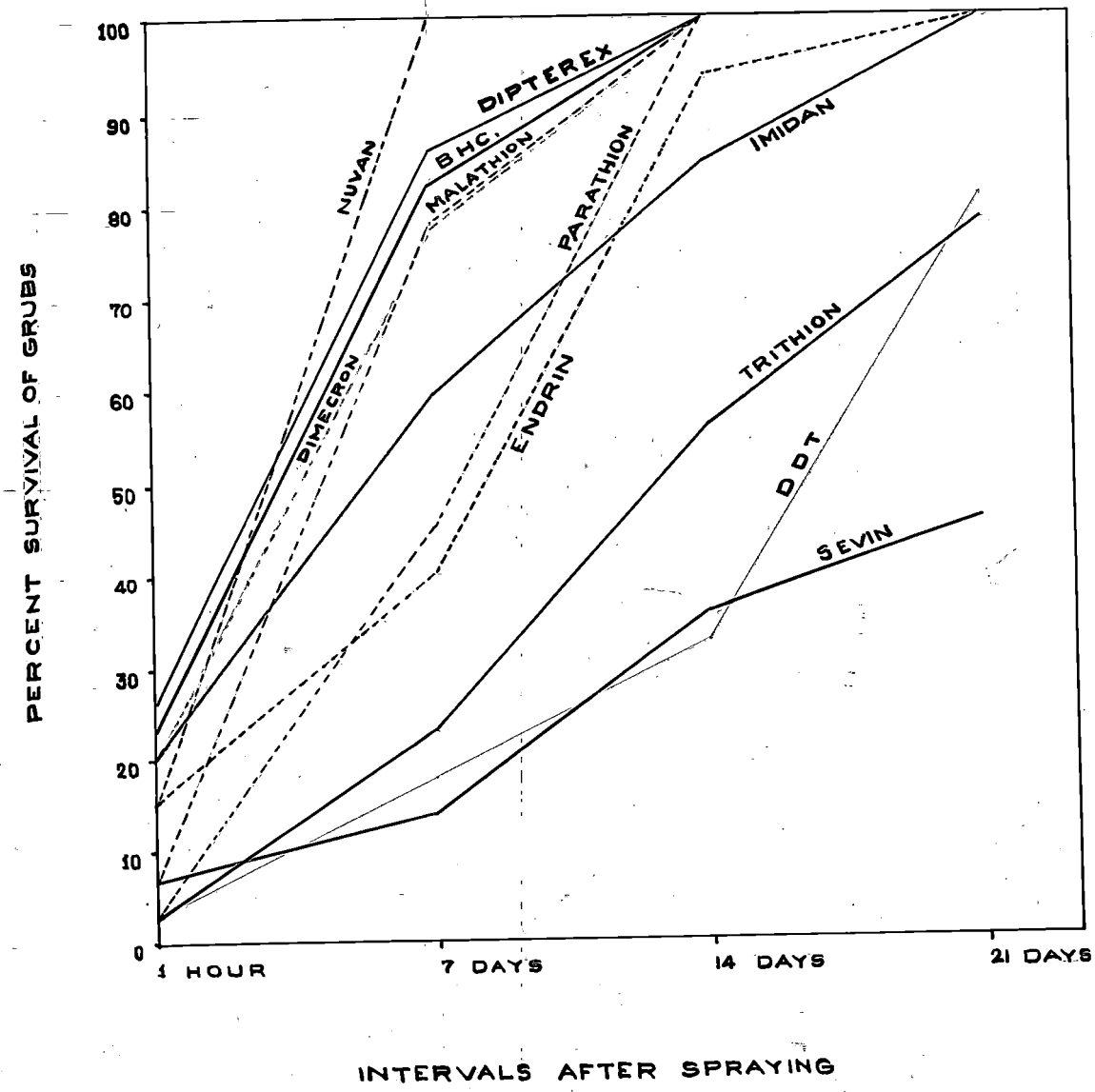

PERCENT SURVIVAL OF ADULTS
100
90
80
70
60
50
40
30
20
10
0
1 HOUR
7 DAYS
14 DAYS
21 DAYS
INTERVALS AFTER SPRAYING
BHC.
MALATHION
NUVAN
PARATHION
DIMECRON
IMIDAN
ENDRIN
DIPTEREX
D.D.T.
TRITHION
SEVIN

Fig.13 Graph showing percentage survival of grubs of E. vigintioctopunctata observed at the end of 48 hours of exposure to brinjal leaves at various intervals after spraying with different insecticide preparations.

FIG.13



toxicity being completely lost by the end of 21 days. DDT 0.2% trithion 0.1% and sevin 0.1% show maximum residual toxicity to both adults and grubs, their residues remaining actively toxic to the insects even after 21 days after their application. Sevin appears to show remarkably high residual action to the adults, there being only 6.7% survival of the adults when exposed to the sprayed leaves 21 days after the application. Against adults DDT 0.2% and trithion 0.1% show nearly equal residual toxicity which of course is considerably less than that shownby sevin. To grubs, on the other hand residual action shown by sevin is far less than that shown to adults and is nearly equal to that of DDT.

Overall findings.

From the discussion of the results given above it is clear that all the insecticides under test excepting probably BHC are quite effective in controlling E.vigintioctopunctata on brinjal, by killing their adults, grubs or both. A comparison of the order of relative toxicity of various insecticides to E.vigintioctopunctata observed by various workers is given below:-

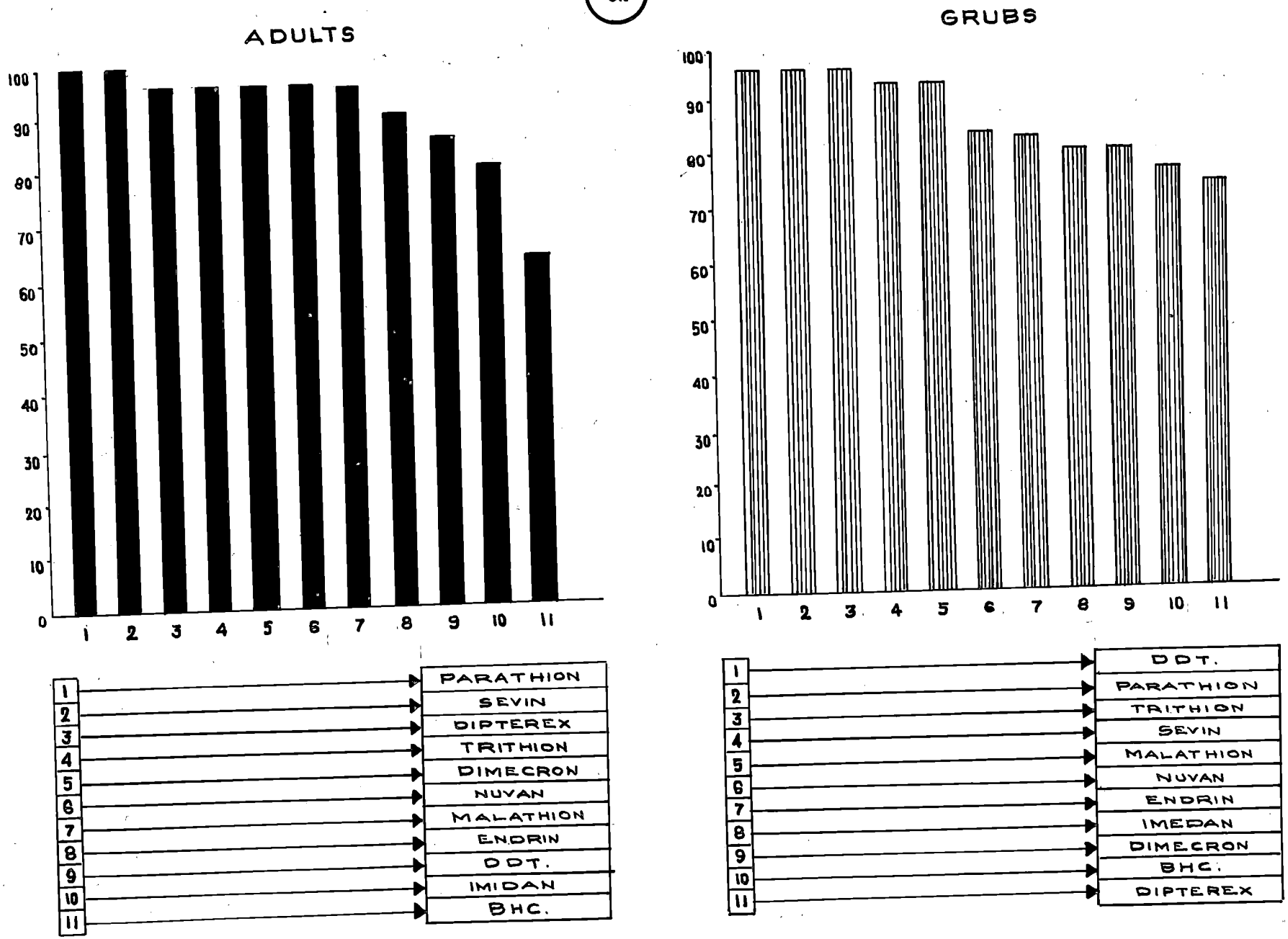
Order of relative toxicity of different insecticides to E.vigintioctopunctata observed by various workers.

Sl. No.	Adult or grub.	Method of application.	Order of relative toxicity.	Basis of comparison.	Reference.
1	2	3	4	5	6
1.	Grub	Applied on grubs on plants.	Endrin > Malathion > DDT > BHC.	Standard doses.	Sengupta and Panda (1958)
2.	Grub	Applied as spray on plant.	Parathion > Endrin > Malathion > Toxaphne. BHC	Standard doses.	Shi and Satpathy (1960)
3.	Grub	Direct spray on grubs in Petri dishes	Parathion > Diazinon > Malathion > Endrin > Phosdrin > p'p'DDT. > Dieldrin > Lindane > Aldrin > Chlordane.	LD 50	Shi, Sengupta and Satpathy (1960)
4.	Adult	Applied as spray on plant.	DDT > Endrin > Lindane > Dieldrin.	Standard doses	Srinivasan and Narayana Swami (1961)
5.	Grub	Direct spray on grubs in Petri dishes.	Sevin > DDT.	LD 50	Jotwani, Sarup and Pradhan (1962)
6.	Adult	Direct spray on grubs in Petri dishes.	Parathion > Phosdrin > Sevin > DDT > Malathion > BHC > Dieldrin > Endrin > Toxaphne.	LD 50	Jotwani, Sarup and Pradhan (1962)

1	2	3	4	5	6
7.	Adult	Applied as spray on plant.	Sevin > Metasystox > Ekatin.	Standard doses	Leela David (1963)
8.	Adult	Exposed to sprayed plants	Parathion=Sevin > Dipterex=Trithion=Dimecron= Nuvan > Malathion > Endrin > DDT > Imidan > BHC.	Standard doses	Present investigation.
9.	Grub	Exposed to sprayed plants	DDT=Parathion > Trithion > Sevin=Malathion > Endrin= Nuvan > Imidan=Dimecron > BHC > Dipterex.	Standard doses.	Present investigation.

Fig. 14 Bar diagram showing the mortality of adults and grubs of E.vigintioctopunctata in 48 hours when exposed to the initial deposit of different insecticides on brinjal leaves.

FIG.14


ADULTS
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11
1 PARATHION
2 SEVIN
3 DIPTEREX
4 TRITHION
5 DIMECRON
6 NUVAN
7 MALATHION
8 ENDRIN
9 DDT.
10 IMIDAN
11 BHC.
GRUBS
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11
1 DDT.
2 PARATHION
3 TRITHION
4 SEVIN
5 MALATHION
6 NUVAN
7 ENDRIN
8 IMEDAN
9 DIMECRON
10 BHC.
11 DIPTEREX

The contents of the table shows that there exists considerable variation in the order of relative toxicity of the insecticides observed by various workers. It is not possible to give a satisfactory explanation for these apparent variations as the conditions at which these experiments were conducted, as well as the modes of application and the criteria of interpretation were different in the different experiments. However, certain observations have shown a good amount of consistency. Thus, the fact that the adults and grubs have varying susceptibilities to different insecticides is a constant feature in all the experiments. It is also seen that the insecticides like parathion, malathion and sevin appear consistently better than other insecticides in killing both the adults and the grubs. Among the other common insecticides DDT. and endrin occupy varying positions in the order of relative toxicity in the different experiments. BHC. appears to be one insecticide which is consistent in showing the least effect. Among the newer insecticides which were tried for the first time in the present investigation trithion, dimecron, and nuvan have proved themselves very effective in controlling the beetles and their grubs.

The present studies appear to be the first of its kind in which an effort is made to understand the fate of residues of various insecticides on brinjal plants. It is seen that insecticides like BHC, nuvan, dimecron and malathion

have the least residual action on the insect. Among these, BHC. has been seen to be not as effective in killing the insects as others. So malathion, dimecron or nuvan appear to be ideal insecticides for the immediate control of the insect and for the maximum preservation of their natural enemies like Chrysocharis sp. (Eulophidae) which is a very common parasite on the grubs. On the other hand insecticides like sevin, DDT and trithion have been seen to have the maximum residual action which in the case of sevin is remarkably high to the adults. So during seasons which are adverse for the natural enemies, highly residual insecticides can be advantageously used for keeping down the pest population for prolonged periods.

SUMMARY.

Relative toxicity of residues of 11 modern synthetic insecticides sprayed on brinjal leaves, to the adults and grubs of Epilachna vigintioctopunctata has been ascertained.

Relative toxicity of different insecticides to the grubs of E.vigintioctopunctata as indicated by the mortality of the grubs when exposed to the insecticide deposit 1 hour after application of the insecticide, is in the order:- DDT (0.2%)=Parathion (0.025%) > Trithion (0.1%) > Sevin (0.1%)=Malathion (0.1%) > Endrin (0.025%)=Nuvan (0.05%) > Imidan (0.1%)=Dimecron (0.03%) > BHC (0.2%) > Dipterex (0.1%).

The relative toxicity of the different insecticides to adults is in the order:- Parathion (0.025%)= Sevin (0.1%) > Dipterex (0.1%)=Trithion (0.1%)=Dimecron (0.03%)=Nuvan (0.05%) > Malathion (0.1%) > Endrin (0.025%) > DDT (0.2%) > Imidan (0.1%) > BHC (0.2%).

The adults of E.vigintioctopunctata are more susceptible than the grubs to endrin, parathion, malathion, dimecron, nuvan, dipterex and sevin at the concentrations under trial. The grubs are more susceptible than the adults to DDT. and BHC. Both adults and grubs are equally susceptible to imidan and trithion.

The orders of relative residual toxicity of the different insecticides to the adults and grubs of E.vigintioctopunctata 1 week, 2 weeks and 3 weeks after application are as indicated below:-

One week after application:-

Grub: Sevin > DDT > Trithion > Parathion > Endrin > Imidan > Malathion > Dimecron > BHC > Dipterex > Nuvan.

Adult: Sevin > DDT > Trithion > Endrin > Dipterex > Parathion > Imidan > Dimecron > Nuvan=Imidan=BHC.

Two weeks after application:-

Grub: DDT > Sevin > Trithion > Imidan > Endrin > Parathion=Malathion=Nuvan=Dimecron=Dipterex=BHC.

Adult: Sevin > DDT > Trithion > Dipterex > Endrin > Parathion=Malathion=Dimecron=Imidan=Nuvan=BHC.

Three weeks after application:-

Grub: Sevin > Trithion > DDT > BHC=Endrin=Parathion=Malathion=Dimecron=Nuvan=Imidan=Dipterex.

Adult: Sevin > Trithion > DDT > Endrin=BHC=Parathion=Malathion=Dimecron=Nuvan=Imidan=Dipterex.

The following conclusions have been made:-

(1) All the insecticides under test excepting BHC are highly effective in killing adults and grubs of E.vigintioctonunctata.

(2) BHC, nuvan, dimecron and malathion have the least residual toxicity and hence these can be used when no residues are desired on the plants ie. during the period when the parasites of the pest are in abundance.

(3) DDT, trithion and sevin have the maximum residual effect and these can be used when long standing persistence is required ie. when the population of the parasite is low and the pest is increasing.

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PLATE I. Spraying apparatus.

A. Pressure pump.

B. Atomizer with bottle containing the spray fluid.

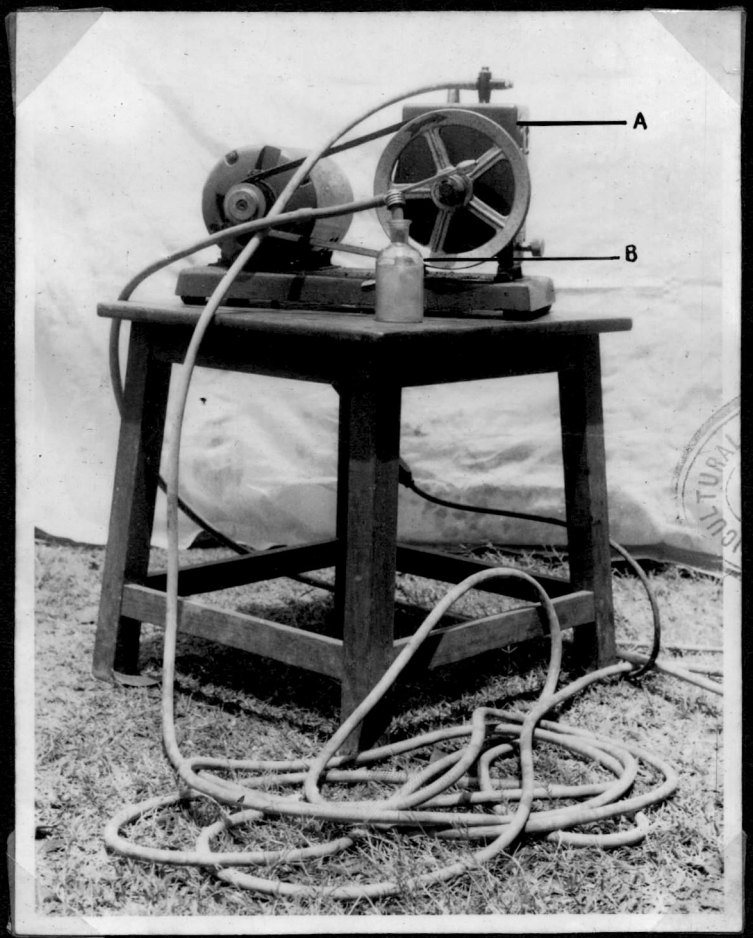

PLATE.I.

PLATE II. Pots with brinjal plants and four supports each for supporting the cloth bag.

PLATE III. Pots showing the cloth bag enclosing the brinjal plants.

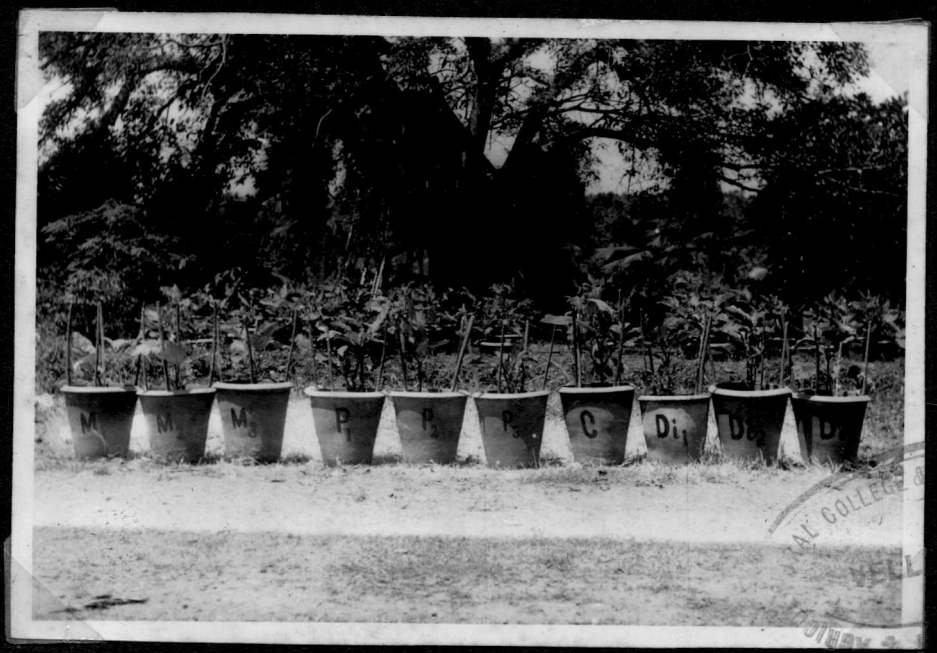

PLATE.II.

PLATE.III.

PLATE IV. Brinjal plants sprayed with sevin 0.1% and exposed to feeding by 10 adults and 10 grubs each on four occasions (at an intervals of 1 hour, 7 days, 14 days and 21 days after liberation).

PLATE V. Brinjal plant unsprayed and exposed to feeding by 10 adults and 10 grubs each on four occasions (at an intervals of 1 hour, 7 days 14 days and 21 days after liberation).

PLATE.IV.