BIOEFFICIENCY PERSISTENCE AND RESIDUE DYNAMICS OF CARBOFURAN IN BITTERGOURD (*Momordica charantia* L.)

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled 'Bioefficiency, persistence and residue dynamics of carbofuran in bittergourd (Momordica charantia L.)' is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship or other similar title, of any other University or Society.

Vellanikkara,
28-9-1989.

CHERIAN THOMAS

CERTIFICATE

Certified that this thesis entitled 'Bioefficiency, persistence and residue dynamics of carbofuran in bitter-gourd (*Momordica charantia* L.)' is a record of research work done independently by Sri.Cherian Thomas under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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We, the undersigned members of Advisory Committee of Sri.Cherian Thomas, a candidate for the degree of Master of Science in Agriculture with major in Agricultural Entomology, agree that the thesis entitled 'Bioefficiency, persistence and residue dynamics of carbofuran in bittergourd (Momordica charantia L.)' may be submitted by Sri.Cherian Thomas in partial fulfilment of the requirements of the degree.

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Introduction

INTRODUCTION

Bittergourd (*Momordica charantia* L.) is a native of Indo-Burma and it is one of the most important cucurbitaceous vegetables grown throughout India. The importance of this vegetable has been recognised due to its high nutritive value and valuable medicinal properties. Though the fruits are bitter, they are wholesome and are much relished as a vegetable. Bittergourd fruit is used widely in the preparations of pickles, curries and fries. In Kerala, bittergourd ranks first among the cucurbitaceous vegetables in terms of popularity and is cultivated commercially under both rainfed and irrigated situations.

The bittergourd crop is subject to infestation by numerous pests right from germination up to harvesting stage. Among the pest complex infesting the crop, the melon fruit fly *Dacus cucurbitae* Coq. is the most serious one causing substantial losses to the fruit. The fruit flies bore into the fruit and cause losses ranging from 50 to 72 per cent (Lal and Sinha, 1959; Narayanan and Batra, 1960 and Kushwaha *et al*., 1973). The epilachna beetles *Henosepilachna 28 punctata* Fab. occur throughout the growth stages skeletonising the leaves and causing great debilitation to the crop. The red pumpkin beetles (Raphidopalpa foveicollis Lucus.) attacking the crop mainly at the seedling stage (Hussain and Shah, 1926) also cause damage to the leaves during the later period of the crop growth. The crop is also infested by the aphids (Aphis gossypii Glover (Ayyar, 1940). Protection of crop from pests right from the seedling stage to harvest is of great importance in the successful cultivation of this crop.

Various insecticides have been reported to control the pests infesting the bittergourd crop. Spraying with carbaryl against pumpkin beetles was found to be quite effective by several workers (Kavadia et al., 1974; Singh and Misra, 1977; Butani and Verma, 1977a; Noor and Pareek, 1978; Krishnaiah et al., 1979 and Pareek and Kavadia, 1988). For the control of fruit fly, endrin (Sinha and Lall, 1975), parathion (Pali, 1963), malathion (Mann et al., 1976), carbaryl (Kavadia et al., 1974, 1977; Mote, 1975; Pareek and Kavadia, 1988) and fenitrothion (Yadav and Kathpal, 1983) have been recommended.

The application of carbofuran granules right from sowing till harvest to afford protection from the various pests infesting bittergourd has somehow become a very popular practice with the farmers of Kerala without giving due care for controlling the hazards from its terminal residues in fruit. Practically no work has been reported on the residue dynamics of carbofuran in bittergourd crop, following soil application of carbofuran at graded doses. Unless carbofuran is applied at optimum doses at the proper stages of the growth, to ensure reduction of the terminal residues well below the tolerance limit, there will be considerable toxic hazards to the consumers. In view of the possible hazards involved in the wide spread practice of applying carbofuran without caring for the residues, the present investigation was carried out with the following objectives;

i) to evaluate the bioefficacy of carbofuran against the major pests infesting bittergourd,

ii) to study the persistence and residues of carbofuran in bittergourd,

iii) to assess the effects of culinary processes on the residues of carbofuran in fruit and

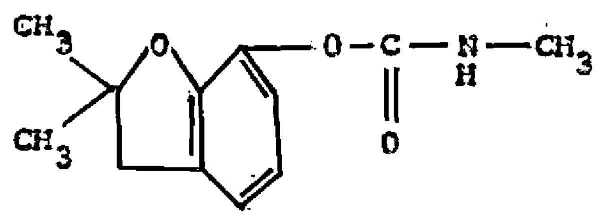
iv) to study the economics of insecticide application.

Review of Literature

2. REVIEW OF LITERATURE

Carbofuran is a systemic insecticide cum nematicide effective against sucking and soil inhabiting pests. Some properties of carbofuran are given in Table 1.

Table 1. Some properties of Carbofuran

Common name	:	Carbofuran
Trade name	:	Furadan
Formulation	:	3 G
Chemical name	:	2,3 - dihydro - 2,2 - dimethyl - 7 - benzofuranyl methyl carbamate
Structural formula	:	
Empirical formula	:	$C_{12}H_{15}NO_3$
LD_{50} Dermal	:	10200
LD_{50} Oral	:	14.1
Tolerance limit	:	0.2 ppm for vegetables

The important information pertaining to the investigations carried out is reviewed under the following heads.

2.1. Biological efficiency of carbofuran on vegetable crops.

2.2. Dissipation of insecticide residues on crops.

2.3. Decontamination of crop products.

2.1. Bioefficacy of carbofuran on vegetable crops

No work has been reported on the bioefficiency of carbofuran against pests of bittergourd. Therefore, other vegetable crops were also included for the review of literature.

2.1.1. Cucurbits

Sinha and Chakrabarti (1983) reported that soil application of carbofuran 3 G at 0.5 kg ai/ha proved to be very effective in controlling the red pumpkin beetle in the cucurbitaceous crops like Muskmelon, var. Pusa Sharbathi, Pusa Mudhuras and the bottle gourd var. Pusa Summer prolific long. Besides soil application, seed treatment with carbofuran wettable or flowable at 3 to 4 per cent ai on a w/w basis was also equally effective in controlling red pumpkin beetle.

Wen and Lee (1983) found that carbofuran 3% granules was effective against *Aphis gossypii* Glover. and *Thrips flavus* Schrank. in water melon.

Singh *et al*. (1984) indicated that a single soil application of carbofuran granules at 200-500 g ai/ha at the time of germination was as effective as 4 to 5 sprays of carbaryl at 250 g ai/ha against the red pumpkin beetle *Raphidopalpa foveicollis* Lucas. on melon. He has further stated that higher dosage of carbofuran granules resulted in better plant growth and yield. Additional advantages of carbofuran treatments were reduced cost, ease of application, safety to pollinators and longer protection against the pest under adverse weather conditions.

2.1.2. Brinjal (*Solanum melongena* L.)

Nath and Chakraborty (1978) reported that carbofuran at the rate of 6 kg ai/ha has effectively reduced the shoot and fruit borer incidence at all stages of brinjal crop. At this dosage an yield of 49.2 ton/ha was obtained which was about 73 per cent more than the untreated control. Carbofuran at 3 kg ai/ha did control the shoot borer, but its effects lasted only up to 30 days. Phorate and disulfoton did not reduce the borer population even when they were used at the rate of 6 kg ai/ha.

According to Deka and Sabaria (1981) carbofuran was effective against the fruit borer infesting brinjal fruit, but not the shoot.

Yazdoni *et al.* (1981) observed that split application of carbofuran to the soil at 0.5 kg ai/ha at the time of transplanting and again 40 days after transplanting of brinjal was more effective against the brinjal shoot and fruit borer *Leucinodes orbonalis* Guen. than when applied at transplanting only and followed by sprays containing carbaryl, endosulfan, fenitrothion or malathion applied at 0.25 kg ai/ha 40, 60 and 80 days after transplanting.

2.1.3. Okra (*Abelmoschus esculentus* Moench.)

Egwuatu (1982) reported that carbofuran applied in the seeding hole at the rate of 1.5 kg ai/ha reduced the number of leaf eating flea beetle *Podagrica* spp. on okra, but this treatment was initially phytotoxic to young plants. The yield was found to be the highest in carbofuran-treated plots.

Seed treatment with a flowable paste formulation of carbofuran (Furadan 40F) at 5% before sowing controlled the population of *Amrasca devastans* Distant. on okra for three weeks and the seed treatment with the soluble powder formulation of carbofuran (Furadan 50 SP) at 5% gave protection against the jassids for four weeks during the vegetative period (Mohan *et al.*, 1983).

Srinivasan and Krishnakumar (1983) indicated that carbofuran or disulfoton granules at the rate of 1 kg ai/ha at the time of sowing of okra seeds, followed by an application of 0.1% carbaryl 40, 50 and 65 days after germination during the rainy and late summer season and 0.035 per cent phosalone during the winter season effectively controlled the fruit borer *Earias vittella* Fabricius, and gave the maximum crop yield and net income. But, the application of granular insecticide such as carbofuran and disulfoton without additional control of fruit borer did not increase the marketable value of the crop over the cost of control.

2.1.4. Chilli (*Capsicum annuum* L.)

Rajukkannu *et al.* (1978) found that carbofuran and aldicarb applied at the rate of 1.5 kg ai/ha as a band at the time of fruit set, effectively controlled sap feeding pests like thrips, mites, aphids etc. in the chilli crop (var. K-1).

2.1.5. Onions (*Allium cepa* L.)

According to Kisha (1979), a single application of carbofuran granules at the rate of 0.025 g ai/plant was found to be most effective in controlling thrips *Thrips tabaci* Lind. infesting the late transplanted onions throughout the period of infestation.

Mogal *et al.* (1982) indicated that carbofuran 3 G at 0.75 kg ai/ha, effectively controlled the onion thrips *T. tabaci* Lind., when applied 15, 45 and 75 days after transplanting. It was also found that carbofuran at 0.75 kg ai/ha was as effective as phorate 1.5 kg ai/ha. When carbofuran was applied at 0.75 kg ai/ha, the increase in yield, over control was observed to be 45.49 q/ha.

Sinha *et al.* (1984) reported that carbofuran granules @ 1 kg ai/ha was most effective in controlling *T. tabaci* infesting onions. Carbofuran thus applied persisted in plants upto 23 days after application.

2.1.6. Pea (*Pisum sativum* L.)

Sharma *et al.* (1981) obtained very effective control of the pea shoot fly *Melanagromyza phaseoli* Coq. in pea when carbofuran 3% granules were placed at seeding at the rate of 1 kg ai/ha.

Seed treatment with 4% granules of carbofuran at 0.5 kg ai/ha was found to be effective in reducing the leaf miner *Phytomyza horticola* Gourcau attacking pea for upto 14 weeks (Vyas and Saxena, 1982).

2.1.7. Potato (*Solanum tuberosum* L.)

Zehnder (1986) reported that carbofuran 4F + oxamyl 2L each at 0.55 kg ai/ha was very effective in controlling all life stages of the Colorado potato beetle, *Leptinotarsa decemlineata* (Say.).

A granular formulation containing 5% carbofuran incorporated into the soil before planting at 40, 60, 80 and 100 kg/ha and a second application of 40 and 60 kg/ha given on 40 days after planting and the plots which received 40 kg and 60 kg/ha protected the potato crop from *Myzus persicae* (Sulz.) and *Microsiphum euphorbiae* (Thos.) upto 51 days. The best result was obtained from the single application of 100 kg/ha at the time of planting (Rocha et al., 1982).

Awate and Pokharkar (1977) observed that carbofuran granules at the rate of 1.87 kg ai/ha applied to the soil at planting was very effective in controlling aphids, jassids, thrips and mites throughout the season.

2.2. Dissipation of carbofuran residues on crops

Habeebullah and Balasubramanian (1981) reported that carbofuran 3 G, when applied at the rate of 1 kg ai/ha in the cowpea variety C-152 at the time of sowing resulted in terminal residue of 0.2 ppm at harvest, 90 days after application. The presence of 0.2 ppm as the terminal residue proved to be toxic since the EPA tolerance for allied crops (tomato, beans) is 0.2 ppm.

Krishnamoorthy et al. (1978) found that there was 0.33 ppm of carbofuran residues in okra fruit at 50 days after soil application of carbofuran at the rate of 1.0 kg ai/ha.

Nanda et al. (1980) reported that application of carbofuran 3 G @ 1.5 kg ai/m row at the time of sowing of mustard resulted in 2.04, 3.34, 1.60 and 0.84 ppm of residues 15, 30, 45 and 60 days, respectively, after sowing. But the residues came below detectable limit on 75th day.

According to Coble et al. (1972) no detectable residues of carbofuran were obtained, when the granules were applied on cabbage and cauliflower crop, but on radish the residue exceeded 0.1 ppm at harvest.

Kalberer and Vogel (1978) reported that when carbofuran granules @ 1 g ai/m^2 was applied to mushrooms, the residues were found to be 0.13, 0.28 and 0.13 ppm after 15, 30 and 48 days, respectively, of application.

Mithyantha et al. (1977a) observed that when carbofuran was applied to brinjal crop @ 0.26, 0.78 and 2.61 kg ai/acre the residues in fruit ranged from 0.088 to 0.171 ppm on 7th day which was decreased to 0.027 ppm after 75 days.

Rajukkannu *et al.* (1978) indicated that carbofuran applied at 1.25 kg ai/ha in soil as band at the time of fruit set, when the pest incidence was high in chilli var. K-1, the accumulation of the insecticide was so high that the green chillies harvested upto 45 days of application exceeded the tolerance limit of 0.2 ppm. The residue levels on 15th, 30th and 45th day were 2.8, 0.65 and 0.28 ppm, respectively. However, the residues dissipated to very low levels or non-detectable level after 60 days.

Rajukkannu and Sree Ramulu (1983) observed that when bhindi seeds were treated with carbofuran by coating at 12% w/w, or when seeds were soaked in 3% carbofuran 50 SP or when carbofuran 3 G was applied at 1.5 kg ai/ha at the time of sowing, there was accumulation of the toxicant in the fruit upto 55 days of application. But, the residue levels were generally low and did not exceed 0.105, 0.087 and 0.085 ppm in respective treatments. Further, it was observed that the residues in the fruit dissipated to ND level after 60 or 65 days.

2.3. Decontamination of crop products

2.3.1. Washing

Kalberer and Vogel (1978) reported that there was considerable amount of reduction in the residue by washing mushrooms treated with carbofuran 1 g ai/m^2. He reported that by washing mushrooms in water on 15th and 30th days, the residues dissipated from 0.13 ppm to 0.05 ppm and 0.28 ppm to 0.09 ppm, the extent of reduction being 61.5% and 67.85%, respectively.

2.3.2. Cooking

Rajukkannu and Sree Ramulu (1983) observed that when carbofuran was applied at the rate of 1 and 1.5 kg ai/ha at the time of sowing of okra seeds in furrows resulted in 0.105, 0.087 and 0.085 ppm of residues which was dissipated from 64.5 to 100 per cent by cooking the fruit.

Nithyantha *et al*. (1977a) found that boiling the brinjal fruit in salt water removed large portions of residues of carbofuran.

2.4. Yield

Singh *et al*. (1985) reported that granular application of carbofuran @ 1.5 kg ai/ha at sowing time effectively controlled the shoot fly (*Atherigona* spp.) for 42 days and the percentage of increase in yield was 88.5.

Egwuatu (1982) observed highest yield in okra when carbofuran was applied at 1.5 kg ai/ha in the seeding hole. Carbofuran granules @ 0.025 g ai/plant in onions against thrips *T. tabaci* Lind. resulted in higher yields (Kisha, 1978).

Seed treatment with 5% carbofuran on seed weight basis effectively controlled *Earias vittella* Fab. on okra. The number of leaves per plant and the yield were greatest in plots treated with carbofuran (Narke and Suryawanshi, 1987).

Materials and Methods

3. MATERIALS AND METHODS

3.1. Field experiment

The field experiment was undertaken at the Instructional Farm of the Horticultural College, Vellanikkara, Trichur, Kerala. from October to December, 1987 with the variety Priya of bittergourd. The experiment was laid out in Randomised block design with three replications of plot size 16 m^2 and spacing of 2 x 2 m^2 between pits. The treatment details are given in Table 2.

Table 2. Treatment details of the experiment

Treatment	Dosage	Time of application
T_1 Carbofuran	0.75 kg ai/ha	Sowing
T_2 Carbofuran	1.5 kg ai/ha	Sowing
T_3 Carbofuran	0.75 kg ai/ha	Vining
T_4 Carbofuran	1.5 kg ai/ha	Vining
T_5 Carbofuran	0.75 kg ai/ha	Flowering
T_6 Carbofuran	1.5 kg ai/ha	Flowering
T_7 Carbofuran	0.75 kg ai/ha	Sowing, Vining and again at Flowering
T_8 Carbofuran	1.5 kg ai/ha	Sowing, Vining and again at Flowering
T_9 Absolute Control		

Carbofuran was applied in the form of Furadan 3 G obtained from M/s.Rallis India Ltd. Carbofuran granules were applied along with the basal dose of fertilisers and along with urea in top dressings in the respective treatments. In the treatments T_1, T_2, T_7 and T_8 carbofuran was applied at 0.75 kg ai/ha and 1.5 kg ai/ha, respectively, around the seed at the time of sowing. In the treatments T_3, T_4, T_7 and T_8 the two dosages of carbofuran granules were given on the 30th day of sowing and at the vining stage of the plants. In the treatments T_5, T_6, T_7 and T_8 carbofuran granules were applied at 0.75 kg ai/ha and 1.5 kg ai/ha after 45 days of sowing at the blooming stage of the plants. The treatment T_9 served as absolute control without any insecticide application.

Farm yard manure at the rate of 20 tonnes per hectare was applied in the field while taking the pits. Four pits were taken in each plot with five seeds sown per pit. On germination, only two healthy seedlings were retained. Fertilisers were applied as per Kerala Agricultural University package of practice recommendations (1986) at the rate of 70 - 25 - 25 kg N, P_2O_5 and K_2O per hectare as urea, super phosphate and muriate of potash. Out of these, half of nitrogen and full dose of phosphorus and potash were applied basally at the time of sowing. The remaining quantity of nitrogen was given in three equal split doses at intervals of 15 days up to blooming.

Harvesting of fruits

Harvesting was done thrice at intervals of 10 days on attainment of maturity.

3.2. Bio-efficiency of carbofuran against the major pests of bittergourd

With a view to assessing the level of protection given to the crop from pests by insecticidal treatments, persistence of residual toxicity of carbofuran to major pests of bittergourd, both in field and laboratory, was investigated.

3.2.1. Field studies

Field studies were carried out at different intervals of treatment to study the efficiency of carbofuran against the epilachna beetle *Henosepilachna 28 punctata* Fab. the red pumpkin beetle *Raphidopalpa foveicollis* Lucus. and the fruit fly *Dacus cucurbitae* Coq.

3.2.1.a. <u>The Epilachna beetle</u> (<u>H.</u> <u>28</u> <u>punctata</u> Fab.)

Three plants were selected at random from each replication of the treatments including control and the epilachna grubs were counted from the whole plant. The study was carried out at 10 days' interval to assess the persistence of carbofuran.

3.2.1.b. <u>The Red pumpkin beetle</u> (<u>R.</u> <u>foveicollis</u> Lucus.)

The persistence of carbofuran was assessed by counting the adult beetles from three randomly selected vines from each replication of the treatment including control at 10 days' interval.

3.2.1.c. <u>The Fruit fly</u> (<u>D.</u> <u>cucurbitae</u> Coq.)

The number and weight of infested fruits were recorded at the time of harvesting from each treatment.

3.2.2. <u>Laboratory studies</u>

A laboratory study was carried out to investigate the persistence of residual toxicity of carbofuran to the epilachna beetle.

Third instar grubs of the epilachna beetle were collected from the stock culture and pre-conditioned for five hours. Carbofuran-treated leaves of bitter-gourd along with petiole were collected from the field and brought to the laboratory. They were put in petri dishes of 15 cm diameter with the petiole ends wrapped with moistened cotton. The treatment was replicated thrice and ten epilachna grubs were released in each petri dish. A control was kept by using leaves from untreated plants. Mortality data were taken after 72 hours of exposure. Moribund insects were also counted as dead. The experiment was carried out at different intervals of treatment.

3.3. <u>Estimation of carbofuran residues in bittergourd</u>

Residues of carbofuran were estimated by the colorimetric method developed by Gupta and Dewan (1971). The method was based on the coupling of diazonium salt (P-nitro benzene diazonium tetra fluoro borate) with the products of alkaline hydrolysis of carbofuran. The pink colour formed was measured at 500 mμ.

3.3.1. Preparation of calibration graph

Technical grade material of carbofuran weighing 100 mg was transferred to a 100 ml volumetric flask and diluted with acetone (Solution A, 1 ml-1000 μg). From the solution A, 4 ml was transferred to a 100 ml volumetric flask and diluted to the mark with acetone (Solution B, 1 ml-40 μg). Similarly 10 ml of solution A was transferred to 100 ml volumetric flask and diluted to the mark with acetone (Solution C, 1 ml-100 μg). From the solution B, 0.0, 0.25, 0.5, 1.0, 1.5, 2.0, 2.5 and 3 ml representing 0, 10, 20, 40, 60, 80, 100, 120 μg) and 1.6 ml from solution C (representing 160 μg) were taken in separate glass stoppered test tubes by using micro burette. The volume in each test tube was then made to 3 ml by adding distilled acetone. Then 7 ml of freshly prepared coagulating solution (one gram ammonium chloride mixed with 400 ml glass-distilled water and 2 ml orthophosphoric acid) was added to each tube and was shaken well and allowed to stand for 10 minutes with occasional shaking. Five ml of the aliquot from each of these solutions (representing 0, 5, 10, 20, 30, 40, 50, 60 and 80 μg) were pipetted into stoppered test tubes and they were placed in an ice bath (below 4°C). Two ml of alcoholic KOH was added to the solution and mixed well.

After 5 minutes, 1 ml of cold chromogenic reagent (prepared by saturating a cold mixture of 25 ml ethanol and 2 ml glacial acetic acid with about 25 mg para nitrobenzene diazonium tetrafluoroborate which was filtered through Whatman No.1 filter paper and kept cool) was added and was shaken immediately. The mixture was allowed to stand for two minutes and the absorbance was determined in a Spectronic-20 spectrophotometer at 550 mμ. (wave length observed to give maximum absorbance) against a blank prepared by starting with 3 ml of acetone.

3.3.2. Residue estimation from sample extract

3.3.2.1. Sampling

On harvesting, bittergourd fruits were collected from all replications and pooled treatment-wise. A representative sample was analysed for residues.

3.3.2.2. Extraction

Thirty grams of the fruit sample ~~was~~ were transferred to a waring blender and 90 ml of acetone and 30 g of anhydrous sodium sulphate were added. It was blended for two minutes and filtered with suction through a Buchner funnel. The residues from the filter were returned to the blender and repeated the extraction with 60 ml of acetone again for 2 minutes. After filtration, the third and the final extractions with 60 ml of acetone were carried out for two minutes. The combined extract was transferred to a Kuderna flask and two drops of propylene glycol were added which acts as a fixer. The contents were concentrated to about 10 ml. The concentrated extract was diluted with about 200 ml of distilled water and was transferred to a 500 ml separating funnel. About 45 ml of dichloromethane was added and shaken for two minutes. A pinch of sodium chloride was added to check the formation of emulsion. The lower layer of the methylene chloride was separated by passing it through a funnel containing sodium sulphate over cotton in a 100 ml cylinder. Two more separations were performed by using 25 ml of methylene chloride each time, the shaking time again in each case was two minutes. The three extracts were collected in methylene chloride in the same cylinder. The volume was made to 100 ml.

3.3.2.3. <u>Clean-up</u>

From the extract 25 ml of aliquot was taken and shaken with activated charcoal in a test tube and filtered.

3.3.2.4. Estimation

Fifteen ml of the cleaned filtrate was taken in a test tube and evaporated the solvent on a manifold dry air evaporator to almost dryness. The sides of the test tube were rinsed with 3 ml of acetone from a pipette and swirled to dissolve the residues. Seven ml of the coagulating solution was added and shaken well and allowed to stand for 10 minutes with occasional shaking. It was filtered through Whatman No.42 filter paper with suction.

Five ml of the filtrate obtained above was pipetted into a stoppered test tube and placed the tube in an ice bath (below 4°C). Further procedure was the same as described for making the calibration graph.

The residues were calculated from the specific regression equation. The absorbance obtained after converting to optical density was referred to the standard curve and the total amount of insecticide (μg) was found out. It was done by calculating the value of 'X' by putting the value of 'Y' in the regression equation. Residues in ppm were calculated by working out the μg of insecticide per gram of plant material by applying the following formula:

$$\text{Residue in ppm} = \frac{\text{Amount of insecticide calculated from the regression equation} \times \text{Total volume of extract}}{\text{Volume of extract taken for analysis} \times \text{Weight of sample in gram}}$$

3.4. Decontamination of insecticide treated fruit samples

Different home processing methods were carried out to study their effect on the reduction of residues.

3.4.1. Water Washing

The fruit sample was sliced into small pieces and taken in a tray containing tap water. The material was gently rubbed by hands for about one minute and the water was decanted. Washing was repeated twice and the sample was then analysed for residues.

3.4.2. Cooking

Sample of chopped bittergourd fruit was washed in tap water and boiled for five minutes. The water was decanted and the fruit sample was allowed to cool and residue analysis was carried out.

3.4.3. Dehydration

The sliced and water washed fruit sample was dehydrated in the sun at temperatures ranging from 27 to 35°C for eight hours. The fruit sample was analysed for residues of carbofuran.

3.5. Yield

The yield of quality fruit per plant in terms of number and weight was taken at each harvest.

3.6. Interpretation of data

Theoretically residues should decrease logarithmically, since the amount lost per unit time should be proportional to the total amount present at any time, provided all are equally exposed to weathering, metabolism or degradation reactions (Hoskins, 1961). Accordingly, he showed that when log of residues (ppm) was plotted against the days elapsed, it gave a straight line that followed general statistical equation Y = a+bx, where Y is the log of residues (ppm) 'a' is the expected initial deposit, 'b' is the slope of the regression line and 'x' is the time in days.

The experimental data (log-residues vs days) were, therefore, subjected to simple regression analysis and the regression equation was calculated.

3.7. Calculation of lower level of detectability or sensitivity

Sensitivity refers to the lowest amount of insecticide (in ppm) which would be determined by the method employed with high degree of certainty.

The procedure given above in the preparation of calibration graph was followed to find out the lower level of detectability.

3.8. Recovery experiment

Thirty g of bittergourd fruit sample was taken in a beaker and fortification was done with 5, 10 and 15 ppm of carbofuran. These fortified samples were analysed for carbofuran residues. From the ppm of carbofuran residues obtained, percentage recovered has been worked out.

3.9. Calculation of PT indices

The persistent toxicity of carbofuran to *H. 28 punctata* Fab. was calculated in terms of PT indices following the methods of Pradhan (1967), where P is the period upto which the toxicity persisted and T is the average toxicity.

$$\text{Average toxicity (T)} = \frac{\text{the sum of percentage mortality}}{\text{number of observations}}$$

The various laboratory experiments were carried out at ambient temperature and relative humidity conditions as indicated in Appendix I.

Results & Discussion

4. RESULTS AND DISCUSSION

The results of the present investigations are presented as follows:

4.1. Standardisation of colorimetric method

4.1.1. Preparation of standard curve for carbofuran

The regression equation was worked out and presented in Table 3 and graphically depicted in Fig.1.

4.1.2. Recovery experiment

Recovery tests with fortified samples of bitter-gourd fruit were carried out to examine the efficiency of the method. The recovery data is presented in Table 4.

4.1.3. Sensitivity experiment

The sensitivity of the method with respect to carbofuran is given in Table 5. It was found that sensitivity values ranged from 0.15 to 0.2 ppm.

Table 3. Standard calibration curve for carbofuran by colorimetric method

ppm of carbofuran	Optical density	Regression equation
0	0.0	
5	0.055	
10	0.105	
20	0.210	
30	0.320	Y = 0.011x - 0.011
40	0.425	
50	0.530	
60	0.645	
80	0.870	

FIG. 1

STANDARD CALIBRATION CURVE FOR CARBOFURAN BY COLORIMETRIC METHOD.

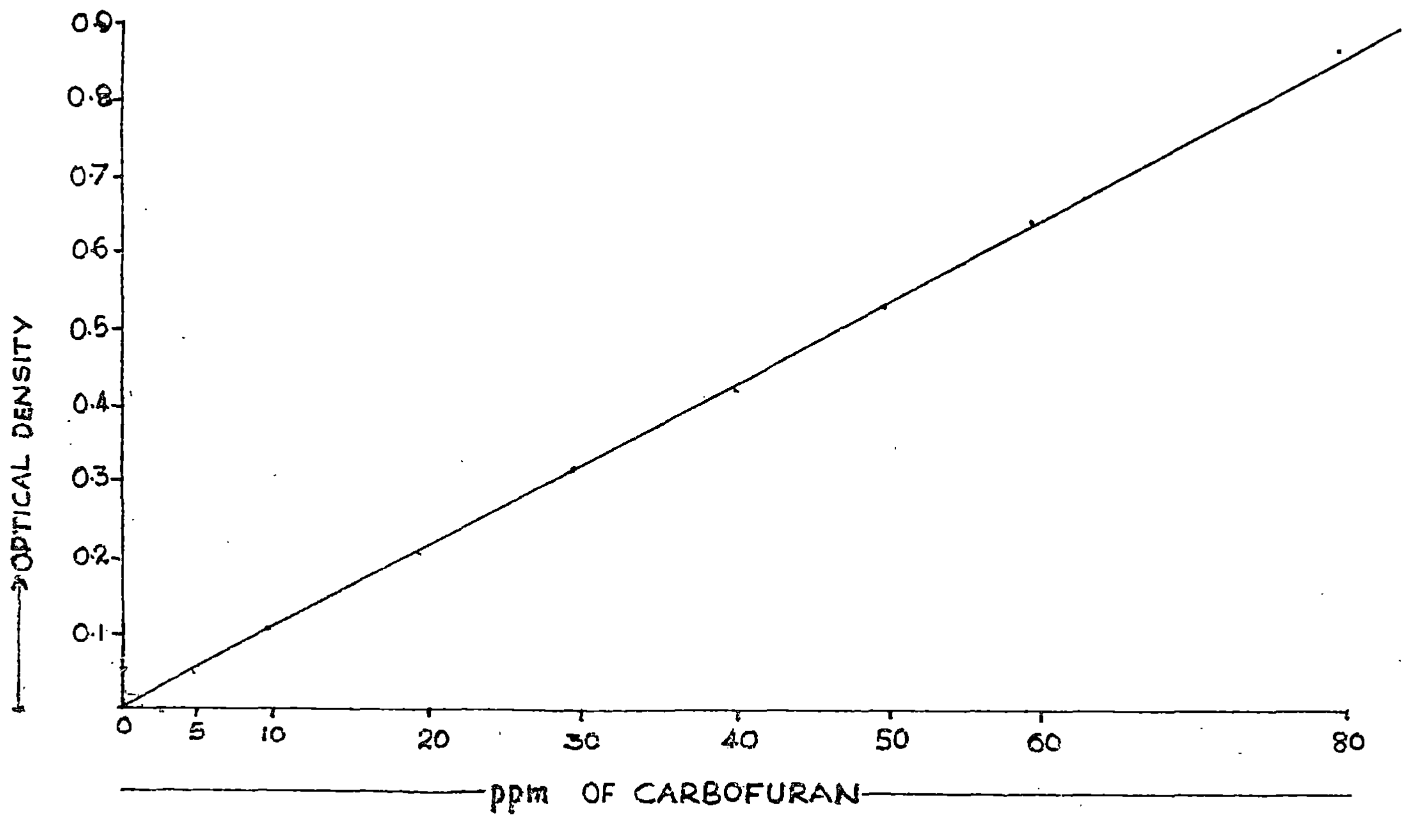


Table 4. Percentage recovery of carbofuran from the fortified samples

Carbofuran added (ppm)	Quantity recovered (ppm)	Recovery percentage	Average recovery
5	4.33	86.66	
10	8.20	82.36	80.83
20	16.40	82.00	
30	21.68	72.28	

Table 5. Lower level of detectability of carbofuran

Carbofuran added (ppm)	Optical Density	Range of lower level of sensitivity (ppm)
0.05	100	
0.10	100	
0.15	99	
0.20	99	0.15 to 0.20
0.15	99	
0.10	100	
0.15	99	

4.2. Bioefficiency of carbofuran on the field population of the key pests of bittergourd

4.2.1. Effect of carbofuran on the field population of *Henosepilachna 28 punctata* Fab. on bittergourd

It is seen from Table 6 that the treatments which received carbofuran @ 0.75 kg ai/ha and 1.5 kg ai/ha at the time of sowing, vining and combinations of sowing, vining and flowering were completely free of epilachna attack after 20 days of sowing (Table 6).

After 30 days of sowing, it is observed that the vines that received carbofuran @ 1.5 kg ai/ha at all the three stages of sowing, vining and flowering (T_8) had the lowest epilachna population (Table 7), followed by T_2, wherein carbofuran @ 1.5 kg ai/ha applied only at the time of sowing. The treatments T_1, T_7, T_2 and T_8 were found to be on par. No significant difference was observed among the treatments T_3, T_4, T_5 and T_6.

The epilachna beetles were not present at 40 days after sowing in plants treated with 1.5 kg ai/ha of carbofuran at vining stage of the crop (Table 7). The plants that received carbofuran @ 1.5 kg ai/ha and 0.75 kg ai/ha at all the three stages of sowing, vining and

Table 6. Effect of carbofuran on the field populations of epilachna beetle

Treatments	Stage of application	Dose kg ai/ha	Population mean/plant at 20 days after sowing
T_1	Sowing	0.75	0.00
T_2	Sowing	1.50	0.00
T_3	Vining	0.75	0.00
T_4	Vining	1.50	0.00
T_5	Flowering	0.75	2.66
T_6	Flowering	1.50	2.33
T_7	Combination of $T_1 + T_3 + T_5$	0.75	0.00
T_8	Combination of $T_2 + T_4 + T_6$	1.50	0.00
T_9	Control	-	2.66

Table 7. Effect of carbofuran granules on the field populations of epilachna beetle <u>Henosepilachna 28 punctata</u> Fab. occurring in bittergourd crop

Treat-ments	Stage of application	Dose kg ai/ha	Population mean of epilachna beetle/plant					
			Days after sowing					
			30	40	50	60	70	80
T_1	Sowing	0.75	4.6(2.139)	18.6(4.316)	30.0(5.467)	27.6(5.250)	30.3(5.505)	49.0(6.998)
T_2	Sowing	1.50	2.6(1.609)	14.6(3.826)	23.3(4.815)	19.0(4.355)	18.6(4.314)	45.3(6.730)
T_3	Vining	0.75	17.6(4.190)	2.6(1.626)	4.3(2.061)	9.0(3.0)	12.3(3.488)	32.3(5.685)
T_4	Vining	1.50	17.6(4.190)	0.0(0.707)	2.3(1.520)	5.0(2.215)	7.3(2.644)	14.0(3.370)
T_5	Flowering	0.75	14.3(3.744)	29.3(5.371)	3.3(1.794)	4.6(2.157)	5.3(2.307)	10.0(3.160)
T_6	Flowering	1.50	14.0(3.735)	30.6(5.531)	0.6(0.902)	2.3(1.520)	4.0(2.000)	4.3(2.079)
T_7	Combination of $T_1 + T_3 + T_5$	0.75	3.0(1.732)	2.0(1.414)	1.6(1.284)	3.0(1.715)	4.0(2.000)	7.0(2.627)
T_8	Combination of $T_2 + T_4 + T_6$	1.50	2.3(1.517)	0.3(0.548)	0.0(0.707)	1.0(1.0)	2 (1.414)	3.0(1.732)
T_9	Control	-	13.0(3.598)	30.3(5.506)	33.5(5.798)	34.0(5.822)	55 (7.407)	71.3(8.445)
	CD at 5%		0.7644	0.5960	0.5650	0.4845	0.6568	0.4612

Figures in parenthesis are values obtained on square root transformations flowering were found to control epilachna beetles very effectively with 99 and 93.3 per cent reduction over control (Table 7a). But all other treatments were found to be significantly superior to control (Table 7).

After 50 days of sowing, carbofuran @ 1.5 kg ai/ha applied at all the three stages of sowing, vining and flowering was found to control the epilachna beetle very effectively, closely followed by the application of the same dose at flowering stage only (Table 7a). This low incidence of epilachna beetle population in treatments T_6 and T_8 may be due to the application of carbofuran during the flowering stages of the crop after 45 days of sowing. Sowing stage application of carbofuran @ 1.5 kg ai/ha brought about a reduction of 30.6 per cent over control. But, no significant difference was observed between the application of 0.75 kg ai/ha at sowing and control indicating the decreasing effect of carbofuran as the days after application increases. The treatments T_8 and T_6, T_7, T_4 and T_5 were found to be on par, but significantly superior to control.

After 60 days of seeding also, maximum reduction (97%) of epilachna population was noted in vines treated with carbofuran @ 1.5 kg ai/ha at all the three stages

Table 7a. Percentage reduction in the populations of epilachna beetles (*Henosepilachna 28 punctata* Fab.) infesting bittergourd consequent on treatment with carbofuran at graded doses

Days after sowing	Percentage reduction over control							
	Treatments kg ai/ha							
	Sowing		Vining		Flowering		Combination of	
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
	0.75	1.5	0.75	1.5	0.75	1.5	$T_1 + T_3 + T_5$ 0.75 kg ai/ha	$T_2 + T_4 + T_6$ 1.5 kg ai/ha
30	64.61	80.00	-35.38	-35.38	-10.0	-7.69	76.92	82.30
40	38.61	51.81	91.41	100.00	3.3	-0.99	93.39	99.0
50	10.71	30.65	87.20	93.15	90.17	98.21	95.23	100.00
60	18.82	44.11	73.52	85.29	86.47	93.23	91.17	97.05
70	44.90	66.18	77.63	86.72	90.36	92.72	92.72	96.36
80	31.27	36.45	54.46	80.36	85.97	93.96	90.18	95.79

sowing, vining and flowering followed by flowering stage application with a reduction of 93.23 per cent over control (Table 7a). The lower dosage of 0.75 kg ai/ha at the above stages did not differ significantly, but all the treatments were found to be significantly superior over control.

After 70 days of sowing also the treatment T_8 was consistently found to be the most effective one (Table 7). The lower dose of carbofuran at 0.75 kg ai/ha applied at all the three stages of sowing, vining and flowering (T_7) was found to be on par with lower and higher doses applications at flowering stage only. The lower dose of 0.75 kg ai/ha at flowering and higher dose of 1.5 kg ai/ha at vining stage also did not differ significantly. All the treatments were found to be significantly superior to control.

After 80 days of sowing, the treatment T_8 which was on par with T_6 was found to be the most effective one in reducing the population of epilachna followed by treatment T_7 with 95.79, 93.96 and 90.18 per cent reductions respectively. The treatment T_5 which was on par with T_4 recorded a reduction of 85.9 per cent over control. No significant difference was observed between the higher and lower doses of carbofuran applied at sowing time in controlling the epilachna population. But they were found to be significantly superior to control.

In general, the treatment T_8 wherein carbofuran @ 1.5 kg ai/ha applied at all the three stages of sowing, vining and flowering was found to be the most effective one in controlling the epilachna beetles with 95.79 per cent reduction over control after 80 days of sowing. Carbofuran @ 0.75 kg ai/ha applied at the time of sowing was least effective in controlling the epilachna beetles giving only 31.27 per cent reduction over control after 80 days of sowing. Carbofuran @ 0.75 kg ai/ha applied at flowering time could bring about 85.97 per cent reduction of population after 80 days of sowing.

It is found that carbofuran applied at 0.75 kg ai/ha during various stages of crop growth viz. sowing, vining, flowering and in all these three stages could bring about 31.27, 54.69, 85.97 and 90.18 per cent reduction of epilachna beetle population, respectively, after 80 days of sowing. With the higher dose of 1.5 kg ai/ha the per cent reductions of epilachna beetle population recorded were 36.45, 80.36, 93.96 and 95.79 respectively after 80 days of sowing during the same stages of application.

4.2.2. Effect of carbofuran on the field populations of red pumpkin beetle (*Raphidopalpa foveicollis* Lucus.) on bittergourd

The results of the field study are given in Tables 8 and 9. Red pumpkin beetle infestation was not noticed after 20 days of sowing in the treatments wherein carbofuran was applied at the time of sowing. But when carbofuran was applied @ 0.75 kg and 1.5 kg ai/ha at vining and flowering stages, red pumpkin beetle infestation was reduced by 13.04 and 6.52 per cent. Carbofuran application @ 0.75 kg ai/ha and 1.5 kg ai/ha at the time of flowering brought about 13.04 and 23.91 per cent reduction of red pumpkin beetles after 20 days of sowing.

Carbofuran @ 1.5 kg ai/ha applied at the time of seeding was found to be the most effective treatment with 85.7 per cent reduction in the population of red pumpkin beetle over control after 30 days of sowing followed by treatment T_9 (Table 9a). No significant difference in the field population was observed between the treatments T_2 and T_8. The highest mean population was noted in the treatment T_6 ie. 1.5 kg ai carbofuran per hectare applied at the time of flowering. But the treatments T_6, T_5, T_4 and T_3 were found to be on par.

Table 8. Effect of carbofuran on the field populations of red pumpkin beetle *Raphidopalpa foveicollis* Lucus

Treatments	Stage of application	Dose kg ai/ha	Adult beetle population mean/plant 20 days after sowing
T_1	Sowing	0.75	0
T_2	Sowing	1.5	0
T_3	Vining	0.75	4
T_4	Vining	1.5	4.3
T_5	Flowering	0.75	4
T_6	Flowering	1.5	3.5
T_7	Combination $T_1 + T_3 + T_5$	0.75	0
T_8	Combination $T_2 + T_4 + T_6$	1.5	0
T_9	Control	-	4.6

Table 9. Effect of carbofuran granules on the populations of red pumpkin beetle <u>Raphidopalpa foveicollis</u> Lucus infesting bittergourd crop

Treatments	Stage of application	Dose kg ai/ha	Population mean of red pumpkin beetle/plant					
			Days after sowing					
			30	40	50	60	70	80
T_1	Sowing	0.75	1.75(1.321)	2.0(1.414)	3.0(1.715)	6.0(2.444)	5.6 (2.378)	7.6(2.768)
T_2	Sowing	1.5	0.8(0.911)	1.1(1.079)	2.0(1.414)	4.3(2.079)	4.3 (2.079)	6.3(2.509)
T_3	Vining	0.75	4.6(2.154)	0.0(0.707)	1.3(1.138)	2.3(1.520)	3.6 (1.911)	4.6(2.157)
T_4	Vining	1.5	4.6(2.154)	0.0(0.707)	1.0(1.000)	1.6(1.276)	2.3(1.520)	3.3(1.821)
T_5	Flowering	0.75	4.6(2.154)	5.6(2.378)	0.0(0.707)	1.0(1.000)	1.6 (1.276)	3.6(1.911)
T_6	Flowering	1.5	5.6(2.365)	6.3(2.515)	0.0(0.707)	0.0(0.707)	1.0 (1.000)	3.1(1.778)
T_7	Combination of $T_1 + T_3 + T_5$	0.75	1.6(1.276)	0.0(0.707)	0.3(0.805)	0.6(0.902)	1.3 (1.138)	3.0(1.715)
T_8	Combination of $T_2 + T_4 + T_6$	1.5	1.0(1.000)	0.0(0.707)	0.0(0.707)	0.0(0.707)	0.0 (0.707)	2.6(1.609)
T_9	Control	-	5.6(2.378)	6.6(2.580)	7.6(2.768)	9.0(3.00)	15.3 (3.914)	16.6(4.081)
	CD at 5%		0.2988	0.1623	0.2396	0.2673	0.2816	0.3642

Figures in parentheses are values obtained on square root transformation

Table 9a. Percentage reduction in the populations of Red pumpkin beetle (<u>Raphidopalpa foveicollis</u> Lucus.) infesting bittergourd consequent on treatment with carbofuran at graded doses

Days after sowing	Percentage reduction over control							
	Treatments kg ai/ha							
	Sowing		Vining		Flowering		Combination of treatments of	
							$T_1 + T_3 + T_5$	$T_2 + T_4 + T_6$
	T_1 0.75	T_2 1.5	T_3 0.75	T_4 1.5	T_5 0.75	T_6 1.5	T_7 0.75	T_8 1.5
30	68.75	85.71	17.85	17.85	17.85	0.00	71.42	82.14
40	69.69	83.33	100.00	100.00	15.15	4.50	100.00	100.00
50	60.52	73.68	82.89	86.84	100.00	100.00	96.05	100.00
60	33.33	52.22	74.44	82.22	88.88	100.00	93.33	100.00
70	63.39	71.89	76.47	84.96	89.54	93.46	91.50	100.00
80	54.21	62.04	72.28	80.12	78.31	81.32	81.92	84.33

After 40 days of sowing, the treatments T_3 and T_4 wherein carbofuran @ 0.75 and 1.5 kg ai/ha applied at the time of vining and treatments T_7 and T_8 wherein carbofuran @ 0.75 and 1.5 kg ai/ha applied in all the three stages of sowing, vining and flowering were found to be free of red pumpkin beetle. The highest mean population was observed in treatment T_6 as the insecticide was applied only at the time of flowering after 45 days of sowing.

It is seen from Table 9 that red pumpkin beetles were not present due to the application of carbofuran in treatments T_5, T_6 and T_8 after 50 days of sowing and all the treatments were found to be significantly superior to control. Vining stage application of carbofuran @ 0.75 kg ai/ha and 1.5 kg ai/ha brought about 82.89 and 88.84 per cent reduction of red pumpkin beetle population over control after 50 days of sowing.

After 60 days of sowing red pumpkin beetles were not observed in the treatment where carbofuran at 1.5 kg ai/ha was applied at the time of flowering and during the stages of sowing, vining and flowering. This is due to the application of carbofuran at the time of flowering after 45 days of sowing. No significant difference in the pest population was observed between the treatments T_8, T_6 and T_7.

Carbofuran at 1.5 kg ai/ha applied during the stages of sowing, vining and flowering was found to be the most effective treatment after 70 days of sowing followed by the plants which received carbofuran at 1.5 kg ai/ha at the time of flowering. Highest red pumpkin beetle population was noted in treatment T_1 wherein carbofuran at 0.75 kg ai/ha was applied at the time of sowing only.

After 80 days of sowing also the treatment T_8 recorded the lowest population of red pumpkin beetles with a reduction of 84.3 per cent over control followed by treatment T_7 and T_6. The highest population was recorded in treatment T_1 wherein carbofuran @ 0.75 kg ai/ha was applied at seeding. The treatment T_8 was found to be significantly superior to all other treatments.

In general, the treatment T_8 wherein carbofuran @ 1.5 kg ai/ha applied at all the three stages of sowing, vining and flowering was found to be the most effective treatment. The treatment T_1 wherein carbofuran @ 0.75 kg ai/ha applied at the time of sowing only was found to be the least effective treatment. Sinha and Chakrabarti (1983) reported that carbofuran at 0.5 kg ai/ha was very effective in controlling red pumpkin beetle Raphidopalpa foveicollis Lucus. on muskmelon. Similarly Singh et al. (1984) indicated that a single soil application of carbofuran granules at 200 to 500 g ai/ha at the time of germination was as effective as 4 to 5 sprays of carbaryl at 250 g ai/ha against Raphidopalpa foveicollis Lucus. on melon.

4.2.3. Effect of carbofuran on the field populations of melon fruit fly (Dacus cucurbitae Coq.)

The percentage infestation of Dacus cucurbitae Coq. based on the number and weight of the fruit was worked out and the results are presented in Table 10.

Carbofuran at 1.5 kg ai/ha applied in all the three stages of sowing, vining and flowering was found to be the most effective treatment for controlling the fruit fly with the infestation of 16.21 per cent by number (Table 10). But, when carbofuran was applied at 1.5 kg ai/ha at the time of sowing only, the bittergourd fruit showed 51.39 per cent infestation. The same dose of chemical, when applied at vining stage, showed an infestation of 26.93 per cent. The flowering stage application of carbofuran @ 1.5 kg ai/ha still reduced the infestation to 20.25 per cent. Thus it is quite clear from Table 10

Table 10. Effect of carbofuran granules on the populations of melon fruit fly - <u>Dacus cucurbitae</u> Coq. infesting bittergourd fruit

Treatments	Stage of application	Dosage kg ai/ha	Mean per cent of infested fruits/plant		Per cent of protection over control	
			Number of infested fruits	Weight of infested fruits	Number	Weight
T_1	Sowing	0.75	56.55(7.519)	45.75(6.764)	29.26	23.25
T_2	Sowing	1.50	51.39(7.169)	33.39(5.779)	35.71	43.98
T_3	Vining	0.75	52.84(7.269)	38.04(6.617)	33.90	36.18
T_4	Vining	1.50	26.93(5.189)	16.76(4.094)	66.31	71.88
T_5	Flowering	0.75	37.00(6.082)	28.22(5.312)	53.72	52.65
T_6	Flowering	1.50	20.25(4.497)	11.97(3.459)	74.66	79.91
T_7	Combination of $T_1 + T_3 + T_5$	0.75	32.61(5.708)	19.82(4.451)	49.20	66.75
T_8	Combination of $T_2 + T_4 + T_6$	1.50	16.21(4.024)	9.92(3.148)	79.72	83.35
T_9	Control	-	79.94(8.941)	59.61(7.721)		
	CD at 5%		0.2854	0.1060		

Figures in parentheses are values obtained on square root transformation

that carbofuran @ 1.5 kg ai/ha applied at sowing, vining, flowering stages and also in all the three stages could reduce the fruit fly infestation from 51.39 to 16.21 per cent, when the infestation was calculated on the basis of number of infested fruits. The same trend was noticed when the infestation was calculated based on the weight of infested fruit (Table 10).

4.3. Persistent toxicity of carbofuran to epilachna beetle (*Henosepilachna 28 punctata* Fab.)

The results of the study conducted on persistent toxicity of carbofuran to epilachna beetle in the laboratory are given in Table 11.

It is clear from Table 11 that the application of carbofuran @ 0.75 kg ai/ha at the time of sowing resulted in 100 per cent mortality of epilachna beetle after 14 days of application. While the higher dose of 1.5 kg ai/ha resulted in 100 per cent mortality up to 21 days of application and the PT values were found to be 2461.2 and 4277.7 for the two dosages.

It is indicated that there was 100 per cent mortality of epilachna after 14 days of application of carbofuran at 1.5 kg ai/ha at the time of sowing, vining,

Table 11. Persistent toxicity of carbofuran to the epilachna beetle *Henosepilachna 28 punctata* Fab.

Treatments/ stages of application	Dose kg ai/ha	Percentage mortality: Days after application 7	14	21	28	35	42	49	56	63	70	77	84	P	T	PT	ORE
T_1 Sowing	0.75		100	80	58	40	15							42	58.6	2461.2	7
T_2 Sowing	1.5		100	100	90	80	80	56.6	30	6.6				63	67.9	4277.7	3
T_3 Vining	0.75	100	80	69	51	44	18							42	60.33	2533.9	6
T_4 Vining	1.5	100	100	80	60	56	51	50	27	3				63	58.55	3688.9	5
T_5 Flowering	0.75	100	70	53.3	40	19								35	56.46	1976.1	8
T_6 Flowering	1.5	100	100	90	75	63	50	40	21	4				63	60.33	3800.9	4
T_7 Combination of $T_1 + T_3 + T_5$	0.75		70	53.3	40	69	90	70	100	42				70	61.47	4303.4	2
T_8 Combination of $T_2 + T_4 + T_6$	1.5		100	90	75	63	100	90	100	80	72	61	33	84	78.5	6597.8	1

P = Period
T = Average toxicity
PT = Index based on persistent toxicity
ORE = Order of relative efficacy based on PT indices

flowering and in the combinations of all the three stages of application and subsequently mortalities decreased. Comparing the PT indices, it is observed that persistent toxicity was highest when the granules were applied at 1.5 kg ai/ha at all the three stages of sowing, vining and flowering followed by the application of 0.75 kg ai/ha at the same above stages.

The field efficacy study of carbofuran on epilachna also proved that the treatment T_8 wherein carbofuran @ 1.5 kg ai/ha applied at all the three stages of sowing, vining and flowering was found to be the most effective one and gave 95.79 per cent reduction over control.

The bioefficacy studies conducted in the field as well as in the laboratory revealed that carbofuran application @ 1.5 kg ai/ha at all the three stages of sowing, vining and flowering of the vines could effectively control the key pests of bittergourd.

4.4. Residues in bittergourd fruit

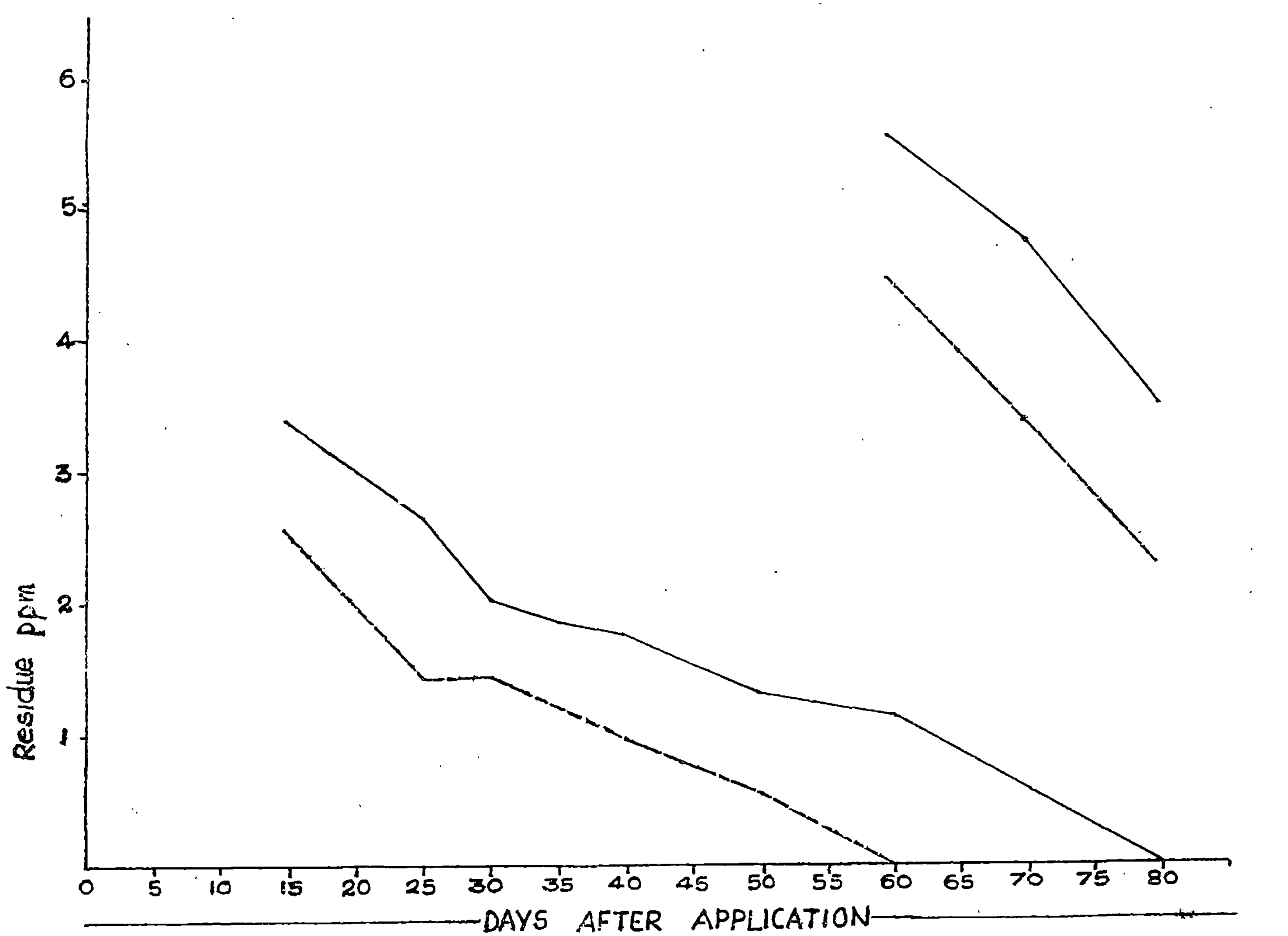
The residues of carbofuran in bittergourd fruit estimated at different intervals are presented in Table 12 and dissipation rate is depicted in Fig. 2. When

Table 12. Residues of carbofuran (ppm) in bittergourd fruit

Treatment numbers	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
Time of application	Sowing	Sowing	Vining	Vining	Flowering	Flowering	Combination of $T_1 + T_3 + T_5$	Combination of $T_2 + T_4 + T_6$
Dosage (kg ai/ha)	0.75	1.5	0.75	1.5	0.75	1.5	0.75	1.5
Residues (ppm) at								
15 DAA*					2.515	3.351		
25 "					1.444	2.630		
30 "			1.444	2.070				
35 "					1.244	1.856		
40 "			0.953	1.751				
50 "			0.579	1.343				
60 "	BDL	1.147						
70 "	BDL	0.579						
80 "	BDL	BDL						
15, 30, 60 "							4.416	5.466
25, 40, 70 "							3.351	4.703
35, 50, 80 "							2.290	3.478

*DAA - Days after application

FIG. 2 RESIDUES OF CARBOFURAN (ppm) IN BITTERGOURD FRUIT



carbofuran was applied at 0.75 kg ai/ha at the time of seeding, the residues in bittergourd fruit were found to be below detectable limit after 60 days of application. But with the higher dosage of 1.5 kg ai/ha the residue levels after 60 and 70 days of applications were 1.147 and 0.579 ppm which were well above the Maximum Residue Limit of 0.2 ppm fixed by FAO/WHO (1980). However, the residues dissipated to non-detectable limit after 80 days of application. Habeebullah and Balasubramanian (1981) reported that when carbofuran was applied at the rate of 1 kg ai/ha at the time of sowing in cowpea resulted in 0.2 ppm of residue. But Krishnamoorthy et al. (1978) reported 0.33 ppm of carbofuran residue in okra after 50 days of application at 1 kg ai/ha at the time of sowing. The application of carbofuran at the vining stage of the crop at 0.75 kg ai/ha resulted in a higher level of residue of 1.44 ppm in the bittergourd fruit harvested 30 days after application. Similar results were reported by Faleiro et al. (1985), who have detected high residues of carbofuran in cowpea plant 35 days after sowing. Even after 50 days of application the fruits were found to contain 0.579 ppm of carbofuran residues which is well above the Maximum Residue Limit of 0.2 ppm. After 30 days of application of carbofuran at 1.5 kg ai/ha the harvested fruit showed a residue level of 2.07 ppm which was dissipated to 1.343 ppm after 50 days of application during the vining stage of the crop.

The application of carbofuran at 0.75 kg ai/ha during flowering stage resulted in a high residue of 2.515 ppm in bittergourd fruit harvested 15 days after application. The residues came to 1.244 ppm after 35 days of application which is also quite above the Maximum Residue Limit. With the higher dosage of 1.5 kg ai/ha applied at the flowering stage, the fruit showed a higher residue of 1.856 ppm 35 days after application.

When carbofuran was applied at 0.75 kg ai/ha in all the three stages of seeding, vining and flowering, the residues in the fruit of the three harvests were 4.416, 3.351 and 2.290 ppm, respectively. With the higher dosage of 1.5 kg ai/ha the residues dissipated from 5.446 ppm to 3.478 ppm in the fruit.

It is evident from the above results that carbofuran at 0.75 kg ai/ha can be applied to bittergourd only at the seeding stage, as the residues came below detectable level 60 days after application. This is in consonance with Rajukkannu et al. (1978) who reported that carbofuran residues dissipated to non-detectable level after 60 days of application in green chillies. But, when 1.5 kg ai/ha of carbofuran was applied at the sowing time, residues in the bittergourd fruit exceeded the Maximum Residue Limit of 0.2 ppm after 60 days of application. However, after 80 days of application the residues came below the detectable level. It is quite clear from the above results that the application of carbofuran to bittergourd at vining stage and thereafter is not desirable due to the high level of terminal residues persisting in the bittergourd fruit. It is also observed from the above data that the dissipation rate of carbofuran in later stages of the plant growth is so slow that the residue level is not coming down to safe limit. Therefore, carbofuran can be applied to bittergourd only at the time of sowing of the seed.

4.5. Decontamination of treated bittergourd fruit

Various home processing methods such as washing of fruit in tap water, cooking and dehydration were undertaken to study the effectiveness or practicability of those methods to reduce the residues from the insecticide treated bittergourd fruit.

4.5.1. Effect of washing in water on the reduction of carbofuran residues in bittergourd

Residue data after water washing are presented in Table 13. The residues were well above the Maximum Residue

Table 13. Effect of washing on the reduction of carbofuran residues in bittergourd

Treatments	Stage of application of carbofuran	Dose kg ai/ha	Days after application	Residues in ppm		Percentage of reduction
				Un-washed fruit	Washed fruit	
T_1	Sowing	0.75	60	BDL	-	
			70	BDL	-	
			80	BDL	-	
T_2	Sowing	1.5	60	1.147	0.953	16.90
			70	0.579	0.4	30.85
			80	BDL	-	
T_3	Vining	0.75	30	1.444	1.244	13.85
			40	.953	0.858	9.96
			50	.579	0.4	30.85
T_4	Vining	1.5	30	2.070	1.856	10.33
			40	1.751	1.545	11.76
			50	1.343	1.147	14.59
T_5	Flowering	0.75	15	2.515	2.171	13.67
			25	1.444	1.244	13.85
			35	1.244	1.050	15.59
T_6	Flowering	1.5	15	3.351	2.983	10.96
			25	2.630	2.402	8.66
			35	1.856	1.648	11.20
T_7	Combination of $T_1 + T_3 + T_5$	0.75	15,30,60	4.416	4.002	9.37
			25,40,70	3.351	2.983	10.96
			35,50,80	2.290	2.070	9.60
T_8	Combination of $T_2 + T_4 + T_6$	1.5	15,30,60	5.466	4.850	11.26
			25,40,70	4.706	4.137	12.03
			35,50,80	3.478	3.105	10.72

Limit in all the stages of application of carbofuran due to the poor dissipation of carbofuran, except at the sowing stage. Therefore, it is advisable to apply carbofuran only at the time of sowing at 0.75 kg ai/ha and not beyond that stage. Washing the bittergourd fruit treated with carbofuran at 1.5 kg ai/ha at the time of sowing reduced the residues from 1.147 to 0.953 ppm at 60 days after application, showing a reduction of 16.9 per cent.

When 0.75 kg ai/ha of carbofuran was applied at vining stage, washing of the fruit resulted in a reduction of residues ranging from 9.96 to 30.85 per cent for 30, 40, 50 days after application. With the higher dosage of 1.5 kg ai/ha application, washing the fruit with tap water brought about 10.33 to 14.59 per cent reduction of residues in bittergourd fruit harvested 30, 40 and 50 days after application of insecticide.

Washing brought about a reduction of residues from 8.66 to 15.59 per cent in fruit harvested from vines treated with 0.75 and 1.5 kg ai/ha at the flowering stage.

The residues of carbofuran were reduced to a lesser extent with a range of 9.37 to 12.03 per cent by washing the fruit of first harvest taken from the vines treated with 0.75 and 1.5 kg ai/ha at sowing, vining and flowering stages of the plants.

In general, it was observed that washing of fruit had little effect on the reduction of residues. To bring down the residue below Maximum Residue Limit this method was found to be quite ineffective. Being a systemic insecticide, carbofuran is absorbed and translocated within the plant system including the fruit. The residues present on the peripheral region of the fruit may be less and the low levels of reduction of residues by washing from the treated fruit could be explained on this basis.

4.5.2. Effect of cooking on the reduction of carbofuran residues in bittergourd

The residues of carbofuran in bittergourd fruit after cooking are given in Table 14. Cooking of the fruit harvested after 60 and 70 days of carbofuran application at 1.5 kg ai/ha at the time of seeding brought the residues below detectable level.

Cooking reduced the residues to 72.29 per cent in bittergourd fruit harvested 30 days after application of carbofuran at the vining of the plants @ 0.75 kg ai/ha. But the residues came below detectable level

Table 14. Effect of cooking on the reduction of carbofuran residues in bittergourd

Treatments	Stage of application of carbofuran	Dose kg ai/ha	Days after application	Residue in ppm		Percentage of reduction
				Uncooked fruit	Cooked fruit	
T_1	Sowing	0.75	60	BDL	-	
			70	BDL	-	
			80	BDL	-	
T_2	Sowing	1.5	60	1.147	BDL	
			70	0.579	BDL	
			80	BDL		
T_3	Vining	0.75	30	1.444	0.4	72.29
			40	0.953	BDL	-
			50	0.579	BDL	-
T_4	Vining	1.5	30	2.070	0.858	58.55
			40	1.751	0.765	56.30
			50	1.343	0.579	56.88
T_5	Flowering	0.75	15	2.515	1.343	46.60
			25	1.444	0.579	59.90
			35	1.244	.311	75.0
T_6	Flowering	1.5	15	3.351	1.963	41.42
			25	2.630	1.444	45.09
			35	1.856	0.765	58.78
T_7	Combination of $T_1 + T_3 + T_5$	0.75	15,30,60	4.416	2.515	43.04
			25,40,70	3.351	1.963	41.42
			35,50,80	2.290	1.050	54.14
T_8	Combination of $T_2 + T_4 + T_6$	1.5	15,30,60	5.466	3.351	38.69
			25,40,70	4.703	2.745	41.63
			35,50,80	3.478	1.963	43.55

by cooking after 40 days of application. With the higher dosage of 1.5 kg ai/ha the residues in bittergourd fruit were reduced by 56.3 to 58.55 per cent by cooking.

Carbofuran residues were reduced by cooking to 46.6 and 41.2 per cent after 15 days of treatment with 0.75 and 1.5 kg ai/ha at the time of flowering. After 25 days of application, the residues were reduced to an extent of 59.9 and 45.09 per cent by cooking the fruit. After 35 days of application @ 0.75 kg ai/ha, cooking the fruit brought about 75 per cent reduction of residues. At the higher dosage of 1.5 kg ai/ha the extent of reduction of residues was 58.78 per cent.

In the T_7 treatment of 0.75 kg ai/ha, carbofuran residues were reduced from 43.04 to 54.14 per cent by cooking. With the higher dosage of 1.5 kg ai/ha of the T_8 treatment, cooking could bring about a reduction of residues from 38.69 to 43.55 per cent.

It is evident from the above results that cooking has got great influence in reducing the residues. Carbofuran can be applied up to 1.5 kg ai/ha at sowing time since cooking of fruit was found to bring down the residues below detectable level after 60 days of application. Similar results were reported by Rajukkannu and

Sree Ramulu (1983) in okra wherein carbofuran applied at 1 and 1.5 kg ai/ha at sowing time dissipated from 64.5 to 100 per cent by cooking. A dosage of 0.75 kg ai/ha can be given to bittergourd even during vining stage of plant as the residues came to non detectable limit after 40 days of application by cooking of the fruit. Studies by several investigators on green leaves, tomato spinach and bhindi indicated that washing, peeling and cooking were very effective in removing 50 to 99 per cent of DDT, malathion, parathion, carbaryl and quinalphos (Elkins _et al._, 1968; Farrow _et al._, 1968; Rajukkannu _et al._, 1976 and Jacob and Verma, 1985). Therefore, carbofuran @ 0.75 kg ai/ha can be recommended for application up to the vining stage of bittergourd safely and the fruit can be consumed by cooking without any residue hazard.

4.5.3. Effect of dehydration on the reduction of carbofuran residues in bittergourd

The data is presented in Table 15. Dehydration of bittergourd fruit resulted in the reduction of carbofuran residues from 25.19 to 46.28 per cent after 60 and 70 days of application of carbofuran @ 1.5 kg ai/ha.

Table 15. Effect of dehydration on reduction of residues of carbofuran in bittergourd fruit

Treatments	Stage of application of carbofuran	Dose kg ai/ha	Days after application	Residue in ppm		Percentage of reduction
				Unproceeded fruits	Dehydrated fruits	
T_1	Sowing	0.75	60	BDL	-	
			70	BDL	-	
			80	BDL	-	
T_2	Sowing	1.5	60	1.147	0.858	25.19
			70	0.579	0.311	46.28
			80	BDL	-	-
T_3	Vining	0.75	30	1.444	0.953	34.00
			40	0.953	0.672	29.48
			50	0.579	0.4	30.9
T_4	Vining	1.5	30	2.070	1.545	25.36
			40	1.751	1.244	28.95
			50	1.343	0.953	29.03
T_5	Flowering	0.75	15	2.515	1.963	21.94
			25	1.444	1.050	27.28
			35	1.244	0.858	30.02
T_6	Flowering	1.5	15	3.351	2.745	18.08
			25	2.630	2.070	21.29
			35	1.856	1.444	22.19
T_7	Combination of $T_1 + T_3 + T_5$	0.75	15,30,60	4.416	3.606	18.34
			25,40,70	3.351	2.745	18.08
			35,50,80	2.290	1.751	23.53
T_8	Combination of $T_2 + T_4 + T_6$	1.5	15,30,60	5.466	4.703	13.95
			25,40,70	4.703	3.868	17.75
			35,50,80	3.478	2.864	17.65

Dehydration reduced the residues to a range of 34.01 to 30.9 per cent in bittergourd fruit harvested 30 to 50 days after application of the insecticide at the time of vining of the plants @ 0.75 kg ai/ha. With the higher dosage of 1.5 kg ai/ha the residues in bittergourd fruit were reduced by 25.36 to 29.03 per cent by dehydration.

Carbofuran residues were reduced by dehydration to 21.94 and 18.08 per cent after 15 days of treatment when applied @ 0.75 kg and 1.5 kg ai/ha at the time of flowering.

In the T_7 treatment consisting of 0.75 kg ai/ha carbofuran residues were reduced to the extent of 18.34 to 23.53 per cent by dehydration. With the higher dosage of 1.5 kg ai/ha of the T_8 treatment, dehydration could bring about a reduction of residues from 13.95 to 17.65 per cent.

It is observed from the above results that dehydration of fruit brought about little reduction of residues and is not of much use to bring down the residues below the Maximum Residue Limit. Dehydration in sun entailed exposure to temperature ranging from 27 to 35°C and at these temperatures carbofuran is chemically stable and the above results are explicable on this basis.

Out of the three processes of decontamination treatments namely, washing, cooking and dehydration, cooking of the fruit was found to bring about maximum reduction of terminal residues. Carbofuran residues came to non-detectable levels after 40 days of application at 0.75 kg ai/ha during the vining stage of the crop. Thus, cooking was found to be the best method whereas the other two methods of washing and dehydration were of little use in reducing the residues. Rajukkannu and Sree Ramulu (1983) also reported that carbofuran residues of 0.105, 0.087 and 0.085 ppm contained in okra fruit dissipated from 64.5 to 100 per cent by cooking.

4.6. Fruit yield

Vines started flowering uniformly from 45th day of sowing. After 15 days of flowering first harvest was taken. Two more harvests were taken at 10 days interval. Fruit yield in terms of weight and number are given in Table 16.

It is clear from Table 16 that the vines which received carbofuran at the rate of 1.5 kg ai/ha at the stages of sowing, vining and flowering produced the highest yield of 2729.67 g/plant which was 81.95 per cent over control. In terms of number of fruit per plant also

Table 16. Effect of carbofuran on the yield of bittergourd fruit

Treatments	Stage of application	Dose kg ai/ha	Healthy fruit yield per plant	
			Weight (g)	Number
T_1	Sowing	0.75	764.00 (0.874)	10.00
T_2	Sowing	1.5	1185.33 (1.089)	12.67
T_3	Vining	0.75	1041.00 (1.020)	13.00
T_4	Vining	1.5	2302.30 (1.517)	19.00
T_5	Flowering	0.75	1512.67 (1.230)	15.30
T_6	Flowering	1.5	2437.00 (1.561)	14.30
T_7	Combination of $T_1 + T_3 + T_5$	0.75	2085.67 (1.444)	19.30
T_8	Combination of $T_2 + T_4 + T_6$	1.5	2729.67 (1.652)	22.30
T_9	Control	-	492.67 (0.702)	5.00
	CD at 5%		0.0219	1.63

Figures in parentheses are values obtained on square root transformation

the treatment T_8 was found to be the best one, the yield being 22.3 fruit per plant followed by treatment T_7. All the treatments were found to be significantly superior to control. The highest yield was produced by the treatment T_8, wherein 1.5 kg ai/ha was applied at all the three stages of sowing, vining and flowering.

The significant increase in fruit yield in carbofuran treatments, particularly at 1.5 kg ai/ha is explicable on the basis of effective control of the key pests Henosepilachna 28 punctata (Table 7) and the fruit flies Dacus cucurbitae (Table 10). Among the various timings for application of the granules at 1.5 kg ai/ha the application at flowering showed remarkable reduction in fruit fly incidence (Table 10) and the yield increase could, therefore, be ascribed mainly to the suppression of fruit fly incidence at the formative stage of the fruit, thereby preventing any impairment to the normal fruit development upto maturity. The phytotonic effects of carbofuran have been very well documented (Kisha, 1978; Egwuatu, 1982; Singh et al., 1984). Such influence in increasing fruit production cannot, therefore, be ruled out, but the better control of key pests appears to be relatively more important. Raju and Rao (1984) observed that mesta (Hibiscus cannabinus) seeds treated with carbofuran granules@5 g/100 g seed decreased the jassid attack by 98% and increased the fibre yield to 2.53 tonnes/ha from 1.91 ton without seed treatment and the efficiency of carbofuran increased with increasing rates.

4.7. Economics of insecticidal treatment

The increase in yield and net profit resulting from a pest control programme are the main considerations in recommending an insecticide subject to the condition that the terminal residues in fruit do not exceed permissible levels. The data presented in Table 17 reveal that the highest net profit of Rs.19641.20/ha was obtained from plots which received carbofuran @ 1.5 kg ai/ha at the time of flowering, followed by the treatment T_8 wherein carbofuran was applied at the rate of 1.5 kg ai/ha at all the three stages of sowing, vining and flowering which earned a profit of Rs.18468.75/ha. Application of carbofuran @ 1.5 kg ai/ha at the time of vining could provide a profit of Rs.18125.8/ha. The highest benefit-cost ratio of 8.79:1 was observed in carbofuran treatment @ 1.5 kg ai/ha at flowering stage followed by carbofuran application 1.5 kg ai/ha at vining stage of the crop.

The combination of high net profit (Rs.18468.75/ha) and low benefit-cost ratio (2.76 : 1) with treatment 8

Table 17. Economics in carbofuran application in bittergourd crop

Treat-ments	Stage of application	Dosage kg ai/ha	Mean yield of healthy fruit kg/ha	Increased yield over control kg/ha	Value of increased yield at Rs.225/q (Rs.)	Cost of labour & insecticide used/ha (Rs.)	Net profit (Rs.)	Benefit-cost ratio
T_1	Sowing	0.75	3820	1356.65	3052.45	1432.50	1619.95	1.13 : 1
T_2	Sowing	1.5	5926.65	3463.30	7792.40	2232.50	5559.9	2.49 : 1
T_3	Vining	0.75	5205.00	2741.65	6168.70	1432.50	4736.20	3.30 : 1
T_4	Vining	1.5	11511.50	9048.15	20358.30	2232.50	18125.8	8.12 : 1
T_5	Flowering	0.75	7563.35	5100.00	11475.00	1432.50	10042.50	7.01 : 1
T_6	Flowering	1.5	12185.00	9721.65	21873.70	2232.50	19641.20	8.79 : 1
T_7	Combination of $T_1 + T_3 + T_5$	0.75	10428.35	7965.00	17921.25	4297.50	13623.75	3.17 : 1
T_8	Combination of $T_2 + T_4 + T_6$	1.5	13648.35	11185.0	25166.25	6697.50	18468.75	2.76 : 1
T_9	Control	-	2463.35					

wherein carbofuran was applied @ 1.5 kg ai/ha at the time of sowing, vining and flowering, may be attributed to the high cost of insecticide and labour involved in the application of the insecticide thrice. Kisha (1978) indicated higher yields in onions with carbofuran application. Singh et al. (1984) also reported better plant growth and yield with higher doses of carbofuran in melon.

In the light of the benefit-cost analysis the most effective treatment is application of carbofuran granules at 1.5 kg ai/ha at flowering stage, the ratio being 8.79: 1.00. In terms of fruit yield, the application of carbofuran granules at 1.5 kg ai/ha at seeding, vining and also at flowering is the best but since the B/C ratio in this treatment is far lower than in the treatment of applying at flowering alone, the latter treatment is certainly more desirable on ground of economy. It is to be noted that when carbofuran was applied at 1.5 kg ai/ha at flowering the terminal residues far exceeded the MRL for upto 35 days after application and as such for commercial cultivation of bittergourd this treatment cannot be recommended. However, for seed multiplication plots, it could be very desirable to recommend application of carbofuran 3 G at 1.5 kg ai/ha at the flowering time for ensuring better output of fruit/seed.

Summary

SUMMARY

Bittergourd (*Momordica charantia* Linn.) is the most widely cultivated cucurbitaceous vegetable in Kerala. Among the key pests of the crop, the melon fruit fly *Dacus cucurbitae* Coq., the red pumpkin beetle *Raphidopalpa foveicollis* Lucus., the epilachna beetle *Henosepilachna 28 punctata* Fab. are more important. The crop has to be effectively protected against these pests right from seedling stage to harvest to realise the production potential in full. Indiscriminate use of carbofuran granules to protect the crop from these pests has become a common practice among the farmers of Kerala. Misuse of the insecticide without any consideration to the terminal residues of the toxicant will cause several hazards to the consumers. Therefore, a study was carried out with the following objectives:

i) To evaluate the bioefficiency of carbofuran granules against the key pests infesting bittergourd,

ii) to study the persistence and residue dynamics of carbofuran in bittergourd,

iii) to assess the effects of common culinary processes on the residues of carbofuran in fruit, and

iv) to study the economics of insecticide application.

A field experiment was conducted from October to December 1987 using the bittergourd variety Priya in a Randomised block design with three replication. Carbofuran granules were applied in soil @ 0.75 and 1.5 kg ai/ha at different stages of crop growth namely, sowing (T_1, T_2), vining (T_3, T_4) and flowering (T_5, T_6). The same dosages were given at all the above three stages of seeding, vining and at flowering (T_7, T_8).

In the bioefficiency study, it was found that the treatment with carbofuran applied @ 1.5 kg ai/ha at all the three stages of sowing, vining and flowering excelled others in controlling the epilachna beetle with 95.79 per cent reduction over control at 80 days after sowing. Carbofuran @ 0.75 kg ai/ha applied at the time of sowing alone was least effective giving only 31.27 per cent reduction in pest incidence over control at 80 DAS. When carbofuran was applied at 0.75 kg ai/ha at sowing, vining, flowering, the extent of reduction of the epilachna beetle was 31.27, 54.69, and 85.97 per cent, respectively, after 80 days of sowing. With the higher dose of 1.5 kg ai/ha, the percentage of reduction of the epilachna beetle population was 36.46, 80.36 and 93.96 respectively after 80 days of sowing for the above three stages of application.

In controlling the red pumpkin beetle Raphidopalpa foveicollis Lucus. also the trend in population reduction following treatments was quite similar. The treatment T_8 wherein carbofuran was applied @ 1.5 kg ai/ha at all the three stages, namely, sowing, vining and flowering was the most effective treatment with 84.3 per cent reduction over control after 80 days of sowing. The treatment T_1 wherein carbofuran was applied @ 0.75 kg ai/ha at the time of sowing was found to be the least effective in controlling the red pumpkin beetle population.

The treatment consisting of application of carbofuran at 1.5 kg ai/ha at sowing, vining and also at flowering was found to be the best treatment in reducing the infestation of the melon fruit fly Dacus cucurbitae Coq., the percentage reduction in incidence being of the order of 79.72 over control in terms of fruit damage by number and 83.35 by weight. The fruit fly infestation was 51.39, 26.93, 20.25 and 16.21 per cent by number of fruit.

The study conducted in the laboratory on the persistent toxicity of carbofuran to the epilachna beetle Henosepilachna 28 punctata Fab. indicated that the persistent toxicity was the highest when the carbofuran granules were applied @ 1.5 kg ai/ha at all the three stages of sowing, vining and flowering. The order of persistent toxicity based on PT value is $T_8 > T_7 > T_2 > T_6 > T_4 > T_3 > T_1 > T_5$.

The results of the studies clearly showed that carbofuran can be safely applied to the bittergourd crop @ 0.75 kg ai/ha only at the time of sowing if the residues in fruit are to be kept below detectable level. The higher dose of the insecticide at 1.5 kg ai/ha given at the time of sowing caused terminal residues in fruit well above the Maximum Residue Limit even after 70 days of application. All other treatments were also found to have high residues of carbofuran. The practice of applying carbofuran granules at doses above 0.75 kg ai/ha beyond sowing is thus found to be hazardous to the consumers in view of the terminal residues above tolerance limit.

The results of various home processings such as washing of fruit in tap water, cooking and dehydration showed that except in cooking there was no substantial reduction in the residue of carbofuran present in the bittergourd fruit. The percentage of reduction of residues due to washing varied from 8.66 to 30.85, while due to dehydration the reduction ranged from 13.95 to 46.28 per cent. But cooking of the fruit showed maximum influence in reducing residues. The reduction of carbofuran residues due to cooking was 38.69 to 75 per cent. In the treatments with carbofuran at 0.75 kg ai/ha at vining and at 1.5 kg ai/ha at sowing the residues on the 60th and 60 days after sowing were above the Maximum Residue Limit, but on cooking the residues could be brought down to below detectable levels.

The benefit-cost analysis of the various treatments showed that application of carbofuran at 1.5 kg ai/ha at flowering stage was the best, the ratio being 8.79 : 1.00. For commercial cultivation of bittergourd meant for the production of fruit for consumption, this treatment cannot be recommended in view of toxic hazards to consumers due to terminal residues. For seed multiplication plots, this treatment is very much desirable in view of cost-effectiveness and lack of hazards due to terminal residues.

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*Originals are not seen

Appendix

APPENDIX-I

Ambient temperature and relative humidity conditions for the laboratory studies for the period from 28-10-1987 to 19-1-1988 (recorded at Vellanikkara)

Week	Temperature (°C)		Mean relative humidity (%)
	Maximum	Minimum	
28-10-87 to 3-11-87	31.35	23.51	81.28
4-11-87 to 10-11-87	31.51	23.42	82.85
11-11-87 to 17-11-87	31.22	21.84	76.28
18-11-87 to 24-11-87	31.87	23.72	79.5
25-11-87 to 1-12-87	31.54	21.97	59.28
2-12-87 to 8-12-87	31.32	23.68	73.35
9-12-87 to 15-12-87	31.77	24.31	77.71
16-12-87 to 22-12-87	32.01	21.92	65.85
23-12-87 to 29-12-87	31.3	23.6	66.21
30-12-87 to 5-1-88	31.02	21.3	59.92
6-1-88 to 12-1-88	31.8	22.34	58.0
13-1-88 to 19-1-88	32.87	22.32	60.62

BIOEFFICIENCY PERSISTENCE AND RESIDUE DYNAMICS OF CARBOFURAN IN BITTERGOURD (*Momordica charantia* L.)

By

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ABSTRACT OF A THESIS

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ABSTRACT

Studies were undertaken to assess the bioefficiency, persistence and residue dynamics of carbofuran in bittergourd (*Momordica charantia* L.). Carbofuran was applied at two doses, 0.75 and 1.5 kg ai/ha at different growth stages, namely sowing, vining, flowering and at all the above three stages of the bittergourd crop. An untreated control was also maintained to compare the effects of various treatments.

All the treatments recorded lower population of epilachna beetle (*Henosepilachna 28 punctata* Fab.) than control. But the treatment wherein carbofuran @ 1.5 kg ai/ha applied at the time of sowing, vining and flowering was found to be the most effective one in controlling the epilachna beetles with 95.79 per cent reduction over control 80 days after sowing. In controlling the red pumpkin beetle *Raphidopalpa foveicollis* Lucus. and melon fruit fly *Dacus cucurbitae* Coq. also the same above treatment was found to be the most effective one. The percentage of reduction in incidence of fruit fly was of the order of 79.72 over control in terms of fruit damage by number and 83.35 by weight. The treatment in which carbofuran @ 0.75 kg ai/ha applied at the time of sowing was found to be least effective in controlling the above pests.

The study conducted in the laboratory on the persistent toxicity of carbofuran on H. 28 punctata Fab. indicated that the PT value of carbofuran treatment at the stages of sowing, vining and flowering @ 1.5 kg ai/ha was found to be the highest (6597.8) among all the treatments.

Studies on the residue dynamics of carbofuran in bittergourd fruit showed that the residues were below detectable limit when it was applied @ 0.75 kg ai/ha only at the time of sowing of seeds. But the residues were found to be well above the Maximum Residue Limit when carbofuran was applied to soil at other stages of crop growth namely vining and flowering.

The residues in bittergourd fruit were observed to be reduced from 8.66 to 30.85 per cent by washing and 13.95 to 46.28 per cent by dehydration. But cooking of fruit indicated a still higher reduction of residues from 38.69 to 75 per cent. In the treatments of carbofuran at 0.75 kg ai/ha at vining and 1.5 kg ai/ha at sowing, the residues on the 50th and 60th days after sowing were above the Maximum Residue Limit but on cooking the residue could be brought down to BDL.

The benefit cost analysis of various treatments of carbofuran showed that application of carbofuran at 1.5 kg ai/ha at flowering stage was the best treatment with a ratio of 6.79:1. For commercial cultivation for the production of fruit for consumption, this method cannot be recommended in view of toxic hazards to consumers due to terminal residues. For seed multiplication plots, this treatment is very desirable in view of cost effectiveness and lack of hazards due to terminal residues.