CONTROL OF BRINJAL PESTS USING DIFLUBENZURON IN COMBINATION WITH INSECTICIDES

By

REVI D.

THESIS

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DECLARATION

I hereby declare that this thesis entitled "Control of brinjal pests using diflubenzuron in combination with insecticides", is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that the thesis entitled "Control of brinjal pests using diflubenzuron in combination with insecticides" is a record of research work done independently by Sri.D. Revi under my guidance and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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D. REVI

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INTRODUCTION

1. INTRODUCTION

As a reaction to the manifold problems arising from the wide spread use of pesticides, increasing interest was generated in Integrated Pest Management. Here, suitable techniques and methods were utilised in as compatible a manner as possible in maintaining the pest population below economic threshold levels. Inspite of this change in plant protection technology insecticides could not be fully dispensed with and if correctly used it would be an effective tool in Integrated Pest Management practices too. The strategy of using safer chemicals like chitin synthesis inhibitors, antifeedants, hormones etc. along with insecticides is being widely explored for efficient pest management.

The chitin synthesis inhibitors have delayed action and hence crops treated with these chemicals often suffer some inevitable damage. The slow or delayed action could be countered by the addition of contact or systemic insecticides so as to obtain quick and durable control of not only defoliators but also borers and sucking type of insect pests (Gujar, 1987). The high selectivity of chitin synthesis inhibitors may ensure them a prominent role in integrated pest management. Application of combinations of chitin synthesis inhibitors with low concentrations of insecticides has been suggested by Eisa (1978).

The studies of Eisa (1978) have provided considerable insight into the possibility of applying insect growth regulators (IGRs) and classic insecticides for control of insect populations. Since then a number of workers have reported the successful potentiation of IGRs when mixed with low doses of insecticides (Sobeiha et al., 1984; El-Sayed, 1984; Auda and Degheele, 1985; Auda and Degheela, 1986; Espinoza Zuniga et al., 1986). Such combinations helped in reducing the quantity of chemicals and IGRs used for pest control while accomplishing adequate crop protection.

In India, studies on the use of IGRs in general and that of IGRs - insecticides combinations in particular are rather limited. Saradamma et al., 1980; Vivek, 1983; Das et al., 1984 and Reddy and Rao, 1987 a, 1987 b are some of the workers in this field.

Use of chitin synthesis inhibitor, diflubenzuron (Dimilin) for control of vegetable pests has been investigated in the laboratory and field in India also and reported promising against various insect pests of vegetables by Saradamma et al. (1987) and Sekhar and Rao (1987). But detailed studies on joint action of insecticides and chitin synthesis inhibitors are lacking and the present investigations were taken up with a view in collecting information on the following aspects.

1. Bio-efficacy of diflubenzuron and common insecticides applied on vegetables namely carbaryl and deltamethrin independently and in combination against insects with different feeding mechanisms (A. gossypii and H. vigintioctopunctata).

2. Effect of different combinations of diflubenzuron and insecticides on the grubs of H. viginticto-punctata under simultaneous and sequential applications in a pot culture experiment.

3. Evaluation of efficient combinations selected out from the above experiment in controlling the major pests of brinjal under field conditions keeping carbaryl as standard.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

A brief review of literature on areas related to the present investigation are given below.

2.1. Control of crop pests using diflubenzuron

2.1.1. Control of pests of vegetables and fruit crops

2.1.1.1. Control of pests of brinjal using carbaryl, synthetic pyrethroids, diflubenzuron and combinations.

Efficacy of carbaryl against epilachna grubs are well reported by workers like Leela David (1963), Jotwani and Sarup (1963), Jayakumari and Nair (1968), Nair and Nair (1976) & Mathai and Nair (1976). Synthetic pyrethroids decamethrin, cypermethrin, fenvalerate and permethrin were also found effective against this pest (Tewari and Krishna Moorthy, 1983).

Sundaramurthy (1979) observed prevention of pupal transformation in last instar larvae of *Henosepilachna vigintioctopunctata* (F.) when it was fed with 1.25 to 100 ppm of Dimilin. Vivek (1983); Reddy and Rao (1987b) confirmed the effectiveness of this chemical against *H. vigintioctopunctata*.

Against brinjal shoot and fruit borer *Leucinodes orbonalis* Guen. spraying with carbaryl was recommended by Leela David (1963, 1964 & 1966), Gaikwad (1969), Joshi and Sharma (1973), Nair and Nair (1976), Chandurwar (1979) and Chaudhary (1982).

Gangwar and Sachan (1981) & Nimbalkar and Ajri (1981) evaluated the effectiveness of synthetic pyrethroids against this pest and reported that deltamethrin at 15 g/hectare and cypermethrin 0.01 per cent were effective.

But David *et al.* (1986) and Reddy *et al.* (1986) reported that repeated applications of synthetic pyrethroids favoured the build up of population of *Bemisia tabaci* (Gennadius) and *Myzus persicae* Sulzer on brinjal.

Sekhar and Bhaskaran (1976), Bhaskaran and Kumar (1980) studied the effectiveness of Dipel (*Bacillus thuringiensis* var. kurstaki) in combination with reduced doses of quinalphos, carbaryl, endosulfan and DDT and reported that some of these combination sprays were effective in controlling pests of brinjal.

2.1.1.2. Control of pests of other vegetable crops using diflubenzuron

Turnipseed *et al.* (1974) and Lara *et al.* (1977) found that diflubenzuron at doses upto 75 g ai/hectare controlled *Anticarsia gemmatatis* Hebener, the velvet bean caterpillar.

Both *Agrotis segetum* (Schift) and *Memestra brassicae* (L.) were found susceptible to Dimilin at doses ranging from 0.00025 ppm to 25 ppm (Lipa, 1976). Hatching rate of eggs of the cabbage root fly, *Hylemya brassicae* Bouche was reduced to 35.1 per cent (Vande and Delcour, 1976) when Dimilin was applied at 1 µl/insect on its thorax. Arambourg *et al.* (1977) and Albajes & Santiago-Alvarez (1979) found that diflubenzuron caused mortality of *Ceratitis capitata* (Wied) at 2.5 ppm, 25 ppm, 250 ppm and 1000 ppm to the tune of 3.77 per cent, 3.88 per cent, 38.84 per cent and 80.17 per cent respectively.

Mohamad *et al.* (1979) found that 0.007 per cent of the compound was effective against *Plutella xylostella* (L.).

Wellinga *et al.* (1973), Grosscurt (1977, 1978a and 1978b), Grosscurt and Anderson (1980) and Tamaki *et al.* (1984) reported the effectiveness of diflubenzuron against colarado potato beettle, *Leptinotarsa decemlineata* Say.

Tamaki *et al.* (1984) also reported that the treatment of the foliage of potato at 50 mg/litre was not having adverse effect on the survival of its parasite *Doryphorophaga doryphorae* (Ril.)

Mc Whorter *et al.* (1977) reported that the lowest dose of diflubenzuron tested (3 ppm) against *Epilachna verivestis* Muts was injurious to the parasite *Pediobius foveolatus* (Crawford) as it was unable to complete its development.

Zungali *et al.* (1983) reported profound interference on parasite development when diflubenzuron was applied to *E. verivestis* just before or four days after parasite oviposition at concentrations 0.01, 0.10 and 1.00 per cent ai and the chemical was found effective against this pest in the field at 0.018, 0.053 and 0.088 kg ai/ha.

Vivek (1983) reported that diflubenzuron was effective against *Sylepta derogata* Fb., *Amrasca biguttula biguttula* Ishida, *Earias* spp. and *Psara basalis* F. Saradamma *et al.* (1987) reported that diflubenzuron was not effective against *Aphis craccivora* Koch. but it had ovicidal action against *S. derogata*.

Reddy and Rao (1987a) studied the contact toxicity of diflubenzuron to the egg, larval and pupal parasites of *H. vigintioctopunctata* and reported no adverse effect on parasite emergence.

2.1.1.3. Control of pests of fruit trees

Against gypsy moth, *Lymantria dispar* (L.) 0.013 ppm (Granett and Dunbar, 1975) 0.025 and 0.05 per cent ai (Lyanchenko and Andreeva, 1979), 0.056 and 0.067 kg/ha (Forgash *et al.*, 1979) of diflubenzuron gave good results in the laboratory.

Field doses reported effective against gypsy moth, (*L. dispar*) were 0.125 to 0.39 lb ai/10 gal of water (Granett and Dunbar, 1975) and 70 g/ha (Cameron and Waldvogel, 1980).

In field experiments diflubenzuron at doses of 30 g/ha (Audermard *et al.*, 1975), 0.05 per cent (Westigard, 1979) and 150 g/ha (Bower and Kaldor, 1980) was found successful against codling moth, *Cydia pomonella* (L.)

Lecheva (1985) reported that diflubenzuron was most effective when applied before the flowering of apple trees against 2nd and 3rd instar larvae of *Operophtera brumata* (L.) and *Erannis bejaria*. But Reede *et al.* (1985) observed that diflubenzuron was not significantly effective in reducing the population level of leaf folders in apple.

2.1.2. Control of pests of rice

Beevi (1979) & Beevi and Dale (1980) found that application of diflubenzuron at doses of 1 to 1000 ppm resulted in mortality of eggs, larvae, pupae and adults of Spodoptera mauritia (Boisd.) in the laboratory.

The chemical was reported effective against larvae of Cnaphalocrocis medinalis Guen. by Natesan et al. (1980) and Das et al. (1984). Rao et al. (1987a) observed that diflubenzuron was more effective as a larvicide among the chitin synthesis inhibitors tested against C.medinalis. Rao et al. (1987b) reported that diflubenzuron sprayed before folding the rice leaves gave perfect control of the leaf folder.

Pillai et al. (1980) and Das et al. (1984) recorded diflubenzuron effective against Nilaparvata lugens (Stal.).

2.1.3. Control of pests of coconut

Sundaramurthy and Santhanakrishnan(1979) observed inhibition of moulting in larvae of Nephantis serinopa Mayer treated with diflubenzuron 0.20 to 0.40 g/l. Saradamma et al. (1980) found that diflubenzuron was highly effective against Ist instar larvae at 0.20 per cent concentration. Sundaramurthy (1980) also observed that field doses ranging from 2.50 to 20 g ai in 10 l water was effective against N. serinopa.

Diflubenzuron at 0.20, 0.10 and 0.02 per cent concentration was toxic to grubs of rhinoceros beetle (Das et al., 1984).

2.1.4. Control of pests of oil seeds

Against Tobacco caterpillar, *Spodoptera litura* (Fab.) on groundnut 0.02 per cent diflubenzuron was found effective at field level (Natesan and Balasubramanian, 1979).

Winder (1984) reported that diflubenzuron at 15, 20 or 25 g per hectare controlled 80 per cent of the larvae of *Anticarsia gemmatalis* Hb. on soyabeans.

2.1.5. Control of pests of cotton

Many of the research work on diflubenzuron were directed towards its ovicidal activity against cotton leaf worm *Spodoptera littoralis* (Boisd.) (Ascher and Nemny, 1974; Abo-Elghar *et al*. 1976; Salama and El-Din, 1977).

Laboratory tests showed that 0.04 and 0.066 g (Ascher and Nemny, 1976), 0.01 and 0.10 µg of diflubenzuron per larvae (Radwan *et al*., 1978) interfered with normal life functions of the cotton leaf worm.

Diflubenzuron at a dose of 100 to 5 x 100^{-8} µg/pupae (Abo-Elghar *et al*., 1978a) and 0.05 µg/pupae (Abo-Elghar *et al*., 1978b) resulted in the emergence of deformed or dead adults of *S.littoralis*.

In field experiments diflubenzuron at 0.69 and 1.20 g/l (El-Tantawi *et al.*, 1976) or as 5 per cent granules or foliar spray (Radwan *et al.*, 1983a) caused high reduction of larval population of *S.littoralis.*

Dimilin at a dose of 0.10 per cent (Moore and Taft, 1975) 431 and 2797 ppm (Mc Laughlin, 1976) and 0.11 µg/female (Earle *et al.*, 1979) were reported effective in reducing the fertility of *Anthonomus grandis* Boh.

Application of diflubenzuron in the field caused larval-adult mortality and reduced adult emergence of the boll weevil at doses of 141, 282 and 564 g/ha (Ganyard *et al.*, 1977), 0.25 kg ai/acre (Lloyd *et al.*, 1977), 0.14 kg ai/ha (Ganyard *et al.*, 1978), 35 g ai/ha (House *et al.*, 1978), 141.80 g ai/ha (Johnson *et al.*, 1978), 70 g ai/ha (Rummel *et al.*, 1979), 140 g ai/ha (Ables *et al.*, 1980), 52.50 g ai/ha (Rummel, 1980) and 0.10 per cent (Villavaso *et al.*, 1980).

Hopkins *et al.* (1984) found that in a field trial with triflumuron, penfluron and diflubenzuron at 0.07 kg ai/ha controlled the emergence of progeny of *A.grandis*.

Abid *et al.* (1978) reported that application of diflubenzuron to the third instar larvae of shoot borer *Earias insulana* (Boisd.) resulted in abnormal and incomplete development. Doses ranging from 0.005 to 0.10 per cent of diflubenzuron caused 76 to 100 per cent mortality in different instars of *E.insulana* (Ascher *et al.*, 1978).

2.1.6. Control of pests of tobacco

Sundaramurthy (1977) and Sundaramurthy and Balasubramanian (1978) reported that diflubenzuron 0.10 per cent inhibited 46 to 96 per cent transformation of larvae into pupae of *Spodoptera litura* (Fab.). Further, Balasubramanian and Natesan (1979) found that treatment of eggs, different larval instars, pupae and adults of *S.litura* resulted in characteristic malformations. Dipping the pupae of *S.litura* in diflubenzuron caused pupal mortality, partial emergence and malformed adults (Natesan and Balasubramanian, 1980).

In the field, diflubenzuron gave effective control of *S.litura* (Santharam and Balasubramanian, 1980; Ramzan and Singh, 1980).

Wolfenbarget *et al.* (1977) and Condriet and Sen (1979) reported that diflubenzuron was effective against tobacco bud worm *Heliothis virescens* (F.).

2.2. Control of insect pests using combinations of insect growth regulators (IGRs) and insecticides

Eisa (1978) reported joint action of insect growth regulator and classic insecticides when their mixtures were tested as larvicides.

2.2.1. Joint action of IGRs and insecticides as ovicides

Radwan *et al.* (1983b) reported enhanced ovicidal action of diflubenzuron and Bay Sir 8514 when combined at different ratios with chlorpyrifos and carbamate groups of insecticides on eggs of *S.littoralis*. El-Guindy *et al.* (1983b) reported synergistic activity in combinations of fenvalerate and diflubenzuron against 0-1 day old eggs of *S.littoralis*.

Ammar *et al.* (1984) reported ovicidal activity of diflubenzuron and triflumuron against eggs of different ages of colorado potato beetle, *Leptinotarsa decemlineata* (Say) when applied in combination with methoprene.

Radwan *et al.* (1986) reported that the ovicidal action of cypermethrin and deltamethrin was greater in mixtures with triflumuron against *S.littoralis* than when used independently.

2.2.2. Combined effect of IGRs and insecticides on insect larvae

El-Guindy *et al.* (1983a) observed low levels of synergism with diflubenzuron and synergist S,S,S-tributyl phosphoro tri thioate against 4th instar larvae of *S.littoralis*.

Natesan and Balasubramanian (1979) reported that mixture of diflubenzuron and chlorpyrifos was not superior to chlorpyrifos against larvae of *S.littoralis* on groundnut.

Sundaramurthy and Balasubramanian (1978) reported that the insect growth inhibitor methoprene (Altosid) and diflubenzuron inhibited transformation of 6th instar larvae of *S.litura* into pupae. El-Guindy *et al.* (1983d) reported synergistic activity of diflubenzuron with methoprene against fourth instar larvae of *S.litura*.

Under field condition, Saad *et al.* (1981) found that combinations of chlorpyrifos and diflubenzuron and deltamethrin and diflubenzuron were effective against *S.littoralis* on cotton.

Sobeiha *et al.*(1984) reported that the addition of diflubenzuron or bactospaine to synthetic pyrethroids against *S.littoralis* did not result in synergism.

El-sayed (1984) studied the effect of diflubenzuron at different levels with triazophos and reported that all combinations were equally effective against 4th larval stage of S.littoralis.

2.2.3. Effect of combinations of diflubenzuron and insecticides on insect population

According to Saad et al. (1979) a mixture of diflubenzuron with endosulfan was highly effective for controlling field population of E. insulana on cotton.

El-Nawawy et al. (1981) reported that mixtures of cypermethrin and diflubenzuron or methomyl against population of cicadellids, aleyrodids, tetranychids and aphids in cotton fields were not completely effective. Khalil et al.(1983) studied the effectiveness of sprays of diflubenzuron with profenofos (Curacron) and reported effective against Pectinophora gossypiella (Saund.), Aphis gossypii Glover, B.tabaci and Tetranychus urticae Koch on cotton.

While investigating the joint action of chitin synthesis inhibitors with profenofos, monocrotophos or methomyl on laboratory populations of susceptible and resistant strain of S.littoralis Auda and Degheele (1986) also reported that mixtures of pyrethroids and chitin synthesis inhibitors, (chlorfluazuron and diflubenzuron) at LC_{25} levels showed a high degree of synergism.

No effect was observed with combimations of insecticides and insect growth regulators on the biotic potential of susceptible and resistant strains of S.littoralis (El-Guindy et al., 1983c). But Zidan et al. (1984) reported that the mixture of fenvalerate and diflubenzuron at LC_{25} levels exhibited synergistic effect on the oviposition period and average number of eggs laid.

Auda and Degheele (1985) studied the joint action of pyrethroids with chitin synthesis inhibitors and organophosphorus insecticides with carbamates on susceptible and resistant strains of S.littoralis and reported that mixtures of pyrethroids and chitin synthesis inhibitors,chlorfluazuron and diflubenzuron at LC_{50} level in the ratio 1:1 showed high degree of synergism against both resistant and susceptible strain.

Mustafa and El-Sayed (1985) reported that diflubenzuron enhanced the toxicity of chlorpyrifos to S.littoralis.

Auda and Degheele (1986) reported potentiation with combinations of insect growth regulators (chlorfluazuron or diflubenzuron) and insecticides (profenofos, monocrotophos or methomyl) against larvae of S.littoralis resistant and susceptable to monocrotophos.

While diflubenzuron 0.05 per cent applied individually was not effective against jassids and aphids on brinjal it was effective in combination with chlorpyrifos and diflubenzuron (Sekhar and Rao, 1987).

Espinoza Zuniga et al. (1986) reported that against pine shoot moth, Rhyacionia buoliana (Schiff.) aerial spraying with carbaryl, diflubenzuron and a mixture of the two was effective in controlling the pest.

2.2.4. Use of chitin synthesis inhibitors in combination with oils and neem seed kernal suspension

Retnakaran et al. (1982) observed that when diflubenzuron and triflumuron were applied as 1 per cent suspension in sunspray oil to red oak trees in the field, population of Croesia semipurpurana (Kearpott) was reduced significantly.

Against S.litura in tobacco nurseries application of diflubenzuron 0.0035 per cent in combination with 1 per cent neem seed kernal suspension significantly reduced the larval population (Sitaramaiah et al., 1986).

Bull and Coleman (1985) reported that in the absence of crop oil, diflubenzuron had little effect on A.grandis and crop oil had a highly deleterious effect on the parasite Trichogramma pretiosum (Riley).

2.2.5. Use of chitin synthesis inhibitors in combination with microbial agents .

Salama et al.(1984) reported that pyrethroids and most organophosphorus compounds potentiated the activity of B.thuringiensis var. entomocidus and var. gallariae. Carbamates, diflubenzuron and combination of methomyl and diflubenzuron showed additive effect with B.thuringiensis.

Sobeiha et al. (1984) observed that addition of diflubenzuron or bactospaine to pyrethroids did not result in synergism against S.littoralis.

Effective control of S.litura was obtained when 0.04 per cent of chlorpyrifos and dichlorvos were used in combination with NPV at doses $15x10^{11}$ PIB^{s}/ml (250 LE), $7.5x10^{11}$$PIB^{s}$/ml (125 LE) and diflubenzuron gave 30 per cent control 40 hours after application, but it gave good control after one week.(Santharam and Balasubramanian, 1980).

Mohamed et al. (1983) studied the effect of mixtures of microbial agents and chemical pesticides on *H.virescens* and reported that for either 1st or 3rd instar larvae, NPV with methoprene was synergestic and combinations of *B.thuringiensis* with cyhexatin, chlordimeform or fentin hydroxide were antagonistic against one or both larval instars.

Hassan and Chernley (1983) reported that dual application of diflubenzuron and the fungus *Metarhizium anisopliae* (Metsch.) applied separately or simultaneously had sysergistic action against larvae of *Manduca sexta* (Joh.).

2.3. Control of insect pests by using diflubenzuron and irradiation

Adults of cotton boll weevil fed on diet containing diflubenzuron for 5 days after emergence when subjected to either irradiation or fumigation, on the sixth day, 99 per cent sterility was induced. Diflubenzuron reduced sperm transfer from male to female and increased mortality of eggs (Wright *et al.*, 1980).

Mictachell *et al.* (1983) reported that adults of *A.grandis* fed with diet containing 100 ppm of diflubenzuron for 5 days after emergence followed by 10 krd of irradiation produced significant difference in egg hatch and infestation levels.

In a laboratory test in Mississippi State when newly emerged adults were fed on a diet containing 100 ppm diflubenzuron for 6 days and subjected to irradiation at 10 krads, the flight of sterilized males, 3 days and 2 days after treatment, was 48.60 per cent and 22.80 per cent respectively compared to untreated ones (Haynes and Wright, 1984a).

Haynes and Wright (1984b) observed that the treated males of A.grandis were 63.60 per cent as competitive as untreated males only for mating and thereafter 50 per cent reduction in sperm transfer was observed in treatment males than untreated males.

2.4. Residues of diflubenzuron on plants

Schroeder *et al*. (1980) studied the effect of non target pests and beneficial species after application of diflubenzuron to citrus for weevil control and reported that the tesidues in fruit harvested 27 days after the sixth aerial application of diflubenzuron @ 350 g ai/ha were 0.34, in unwashed fruit, and 0.11 in washed fruit. No detectable residue was found in finished pulp, fruit juice, pressed liquor, molasses, pre-washed or after wash water or emulsion water fractions.

Mian and Mulla (1983) studied persistence of residues of triflumuron, diflubenzuron and methoprene in stored wheat grains and reported that diflubenzuron at 1.5 or 10 ppm showed residue loss of 40-50 per cent during 23 months.

Arganer and Cantelo (1984) found no residues of diflubenzuron and triflumuron in mushrooms grown in treated compost.

Cameron _et al_. (1985) reported that carbaryl and trichlorfon at 1.12 kg ai/ha and diflubenzuron at 35 g ai/ha for control of _L.dispar_ reduced population. Pesticide recoveries were recorded with carbaryl in the weeks following application with diflubenzuron results were positive 7 days after application and no residue of trichlorfon was recorded after the day of treatment.

The mean residue of diflubenzuron on harvested worcester fruit was 0.05 mg/kg fresh weight and on harvested cox fruit, residue was 0.02 mg/kg (Austin and Carter, 1986).

Rao _et al_. (1987b) studied the residual toxicity of diflubenzuron, triflumuron (BAY SIR 8514) and buprofezin (NNI 750) and reported that residues of the three chitin synthesis inhibitors were found upto eight days after application.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

3.1. Rearing of test insects

3.1.1. Henosepilachna vigintioctopunctata (Fabracius)

H.vigintioctopunctata was reared in the laboratory in circular glass troughs on fresh leaves of brinjal. Eggs collected from the field were transferred to clean and sterilized chimneys with pieces of muslin cloth and kept on petri dishes. Grubs emerging each day were transferred to such separate chimneys. Duration and moulting of each instar of the grubs were noted. Third instar larvae, one day after the second larval moulting were used for all the experiments.

3.1.2. Aphis gossypii Glover

Colonies of A.gossypii collected from the field were brought to the laboratory. Apterous adults of the same size were transferred without any injury to brinjal shoots of 5 cm length kept on wet blotting paper in petri dishes. First instar nymphs emerged from the eggs laid by the transferred adults were collected daily and released on fresh twigs of brinjal in separate chimneys. Date of emergence and dates of moulting of the nymphs were recorded. Fourth instar nymphs were selected for all the experiments.

Contamination in the culture was minimised by maintaining good sanitation in rearing. Glass wares were sterilised by immersing them in 0.50 per cent sodium hypochlorite solution for one day (Wittig, 1963). They were then washed in distilled water and air dried in a hot air oven. Twigs of brinjal washed thoroughly in running sterile water were used for feeding the aphids.

3.2. Bioassay of insecticides/diflubenzuron

LC_{50} values of deltamethrin (Decis 2.5 EC) carbaryl (Sevin 50 WP), and diflubenzuron (Dimilin 25 WP) were assessed.

3.2.1. Determination of LC_{50} of insecticides and diflubenzuron against 3rd instar larvae of H.vigintioctopunctata

Third instar grubs drawn from the culture maintained in the laboratory were used for the experiment. Ten grubs were transferred into a petri dish of 100 mm diameter and were sprayed directly with 1 ml of the respective concentrations of the chemicals under a Potter's tower. Three such replications were maintained for each treatment. The treated larvae were kept under fan for about 5 minutes. They were then transferred to glass chimneys and provided with fresh brinjal leaves for feeding. The percentage of mortality was recorded 24 hours after the application of insecticide. For diflubenzuron observations were continued till death of the larvae or adult emergence. Malformed insects were also treated as dead in counting the total mortality caused by the chemical. Natural mortality was corrected by applying Abbott's formula (1925) and the data for the mortality - regression lines of insecticides and diflubenzuron were subjected to probit analysis by Finney's method (1971). From the regression equations LC_{50}, LC_{25} and LC_{10} values were computed.

3.2.2. Determination of LC_{50} of insecticides and diflubenzuron against fourth instar nymphs of *A.gossypii*.

Fourth instar apterous forms of *A.gossypii* in the laboratory were used for the experiment. Twenty insects were transferred into a petri dish of 100 mm diameter and were sprayed under a Potter's tower with 1 ml each of the different concentrations of chemicals. Sprayed petri dishes containing the aphids were air dried for five minutes under an electric fan. They were then transferred to separate glass tubes (10x4 cm) containing fresh, untreated leaf bits of brinjal for feeding and were closed using pieces of muslin cloth and rubber bands. The collection of data and analysis of results were done as described in para 3.2.1.

3.3. Evaluation of bio efficacy of the combination of diflubenzuron and insecticides in the laboratory against *H.vigintioctopunctata*

The joint action of diflubenzuron and insecticides was assessed by mixing them at LC_{10}, LC_{25} and LC_{50} levels and assaying their toxicity in the laboratory adopting the methods described in para 3.2.1.

As diflubenzuron did not give any mortality of *A.gossypii* even upto 0.20 per cent concentration in the laboratory, the combination of chitin synthesis inhibitor and insecticides were not tried against the insect.

The degree of potentiation of the different mixtures of insecticides and diflubenzuron were determined by following the method of Mansour *et al*.(1966).

The bioefficacy was assessed in terms of Co-toxicity factor.

Co-toxicity factor = Observed mortality (%) of the test insect - expected mortality percentage of the combinations (eg: expected mortality of combinations at LC_{50} and LC_{10} levels = 60%) x 100/ expected mortality percentage.

This factor was used to separate the results into three categories. The treatments which gave a co-toxicity factor above 20 were considered as potentiating, those having a co-toxicity factor below (-20) were considered as antagonistic & those with co-toxicity factor within the range of (-20) to 20 were considered as additive.

3.4. Assessing the effect of combinations of diflubenzuron and insecticides applied in sequences on grubs of *H.vigintiopunctata* under field conditions

Six combinations of diflubenzuron and delta methrin having potentiation and additive effects were selected for the experiment (Table No.4). In the combinations of diflubenzuron and carbaryl five such combinations were selected (Table No.5).

Combinations of chitin synthesis inhibitor and insecticides in varying doses were applied in a sequence of insecticide followed by chitin synthesis inhibitor and vice versa.

Pot culture experiments replicated thrice were used to evaluate combinations of diflubenzuron and insecticides in the field. For this brinjal seedling raised in the nursery were transplanted in flower pots (30x30 cm), when the seedlings attained 8-10 cm height.

Manures and fertilizers were applied as per the package of practices recommended by Kerala Agricultural University (1982). One month after transplantation ten third instar grubs of *H.vigintioctopunctata* were released on each plant.

The insecticides were mixed with diflubenzuron at their respective doses and a uniform quantity of 50 ml of the spray fluid was applied with an atomizer on each plant containing insects to study the effectiveness of simultaneous applications of chemicals. In the case of sequential application of diflubenzuron and insecticides, initial applications of 50 ml each of the different doses of diflubenzuron were followed by insecticide after 48 hours. For sequential applications of insecticides and diflubenzuron 50 ml each of the selected doses of insecticides were sprayed first on potted plants infested with *H.vigintioctopunctata* and after 48 hours diflubenzuron was also sprayed.

Plants sprayed with water alone were kept as control. The plants were covered with polythene cages to confine the grubs to the plants. Observations were taken daily till the death of grubs or normal adult emergence. The experiment was arranged in a randomised block design. The data were statistically analysed and the treatments were compared with Duncan's multiple range test.

3.5. Evaluation of combinations of diflubenzuron and insecticides for the control of pests of brinjal in the field

The experiment was laid out in the Instructional Farm attached to the College of Agriculture, Vellayani.

Pusa Purple Long variety of brinjal was raised for the experiment. Seedlings raised in the nursery were transplanted in the main field 40 days after sowing, when the plants attained 8-10 cm height. The land for laying out the experiment was ploughed well to get a fine tilth and was levelled. A randomised block design was adopted for the experiment. A spacing of 60x75 cm was adopted for planting. All the cultural operations suggested in the package of practices recommendations, (1982) of Kerala Agricultural University were followed excluding the plant protection measures.

3.5.1. Treatments

Combinations of the doses of diflubenzuron and insecticides found most effective in the experiment described in para 3.4. were evaluated in this field experiment. The treatments were:

1. Diflubenzuron 12.00 ppm + carbaryl 4.00 ppm.
2. Diflubenzuron 12.00 ppm + deltamethrin 2.00 ppm

3. Carbaryl 1500 ppm

4. Water spray

Number of replications - 5

3.5.2. Application of insecticides

Insecticides were sprayed in plots using a hand compression pneumatic sprayer of nine litre capacity, providing screens around the plots to prevent contamination through drift. A thorough and uniform coverage of plant parts was ensured in the spraying.

3.5.3. Assessment of results

Four plants at the centre (excluding border rows all around) were observed for the collection of data. The pest population on the crop was monitored at weekly intervals. Insecticides were applied only when the pest reached sufficient population levels in the pre-treatment counts. Counts at one day after spraying and then at weekly intervals were also recorded. The data were statistically analysed and the treatments were compared with Duncan's Multiple Range Test.

RESULTS

4. RESULTS

4.1. LC_{50} values

4.1.1. LC_{50} values of diflubenzuron and insecticides against third instar larvae of *H.vigintiocto-punctata* and fourth instar numphs of *A.gossypii*

The results of bioassy of deltamethrin, carbaryl and diflubenzuron on the third instar larvae of *H.vigintioctopunctata* and fourth instar nymphs of *A.gossypii* are presented in Table 1. LC_{50} values of deltamethrin, carbaryl and diflubenzuron against *H.vigintioctopunctata* were found to be 1.70, 22.50 and 11.48 ppm respectively and against *A.gossypii* the values of deltamethrin and carbaryl were 0.37 and 4.07 ppm respectively. Deltamethrin was found to be most toxic against both the test insects, while diflubenzuron was not having any toxicity on *A.gossypii*.

4.2. Joint action of test chemicals

4.2.1. Joint action of diflubenzuron and deltamethrin on the third instar grubs of *H.vigintiocto-punctata*

Effect of combination of diflubenzuron and deltamethrin against the third instar larvae of *H.vigintioctopunctata* is presented in Table 1. Combination of diflubenzuron with deltamethrin induced mortality . of grubs from the very first day itself.

Table 1. Toxicity of certain pesticides against third instar larvae of *H. vigintioctopunctata* and fourth instar nymphs of *A. gossypii*.

Insects	Insecticides	LC_{50} (ppm)	Confidence limits for LC_{50}	Regression equation*	LC_{25} (ppm)	LC_{10} (ppm)
H. vigintioctopunctata	Deltamethrin	1.70	1.007 2.94	$y=1.64\ x + 2.98$	0.66	0.28
" "	Carbaryl	22.50	16.64 32.80	$y=1.91\ x + 2.53$	8.74	4.20
" "	Diflubenzuron	11.48	7.02 16.18	$y=1.14\ x + 3.79$	2.94	0.86
A. gossypii	Deltamethrin	0.37	0.27 0.49	$y=1.60\ x + 2.50$	0.14	0.06
" "	Carbaryl	4.07	2.94 5.65	$y=1.26\ x + 2.97$	1.18	0.39
" "	Diflubenzuron	Non toxic				

* Regression equation of probit-mortality (y) on log concentration (x)

Antagonistic effect was apparent between deltamethrin and diflubenzuron in the combinations at LC_{25} and LC_{10} levels of deltamethrin with LC_{50} of diflubenzuron and the combination of LC_{25} of diflubenzuron and LC_{10} of deltamethrin. But additive action was seen in the case of diflubenzuron combined with deltamethrin both at the levels of LC_{25} and LC_{50}. Potentiation effect was observed in the case of combination of diflubenzuro and deltamethrin at LC_{25} and LC_{50} levels respectively. Diflubenzuron at LC_{10} in combination with deltamethrin at LC_{50}, 25 and 10 levels also resulted in potentiation as evidenced by the possitive co-toxicity factors 38.83 61.91 and 33.35 respectively.

4.2.2. Joint action of diflubenzuron and carbaryl against the grubs of *H.vigintioctopunctata*

In table 3, the data on joint action of difluben zuron and carbaryl against third instar grubs of *H.vigintioctopunctata* are presented. Antagonistic effect was observed in the case of diflubenzuron and carbaryl both at LC_{50}levels and also in combinations of LC_{50} and LC_{25}, co-toxicity factor being (-66.70) and (-33.33) respectively. Antagonistic effect was also noticed in the combination of diflubenzuron and carbary at LC_{25} and LC_{50} levels (-28.93) and in combination of LC_{10} and LC_{50} (-38.90). Potentiation was observed in combinations of diflubenzuron and carbaryl at levels

Table 2. Effect of combinations of diflubenzuron and deltamethrin against third instar larvae of *H. vigintioctopunctata*

Treatments	Expected mortality from treatments with		Total expected mortality %	Observed mortality %	Co-toxicity factor	Effect
	diflubenzuron	deltamethrin				
diflubenzuron 11.48 ppm+deltamethrin 1.70 ppm	50	50	100	100	0	Additive
" 11.48 " 0.66 "	50	25	75	60	-20.00	Antagonism
" 11.48 " 0.28 "	50	10	60	40	-33.30	Antagonism
" 2.94 " 1.70 "	25	50	75	93.30	+24.40	Potentiation
" 2.94 " 0.66 "	25	25	50	53.30	+ 6.60	Additive
" 2.94 " 0.28 "	25	10	35	16.67	-52.37	Antagonism
" 0.86 " 1.70 "	10	50	60	83.33	+38.83	Potentiation
" 0.86 " 0.66 "	10	25	35	56.67	+61.91	Potentiation
" 0.86 " 0.28 "	10	10	20	26.67	+33.35	Potentiation

of LC_{50} and LC_{10} (+38.83), LC_{25} and LC_{10} (+23.80) and LC_{10} and LC_{25} (+23.80). But joint action of diflubenzuron and carbaryl, both at LC_{25} levels showed only additive effect (+13.32).

4.3. Effect of diflubenzuron - insecticide mixtures against *H.vigintioctopunctata* grubs released on brinjal plants (Pot culture).

4.3.1. Diflubenzuron and deltamethrin

The results of laboratory experiments presented in Table 2 revealed that diflubenzuron and deltamethrin mixed at different ratios had potentiating and additive actions. Six such combinations were tried in a pot culture experiment against 3rd instar grubs of *H.vigintioctopunctata* and the results are presented in Table 4.

4.3.1.1. Simultaneous application of diflubenzuron and deltamethrin for the control of grubs of *H.vigintioctopunctata*

Maximum mortality (96.66%) was observed in the combination of diflubenzuron 11.48 ppm (LC_{50}) and deltamethrin 1.70 ppm (LC_{50}) and was significantly superior to other treatments. Diflubenzuron 0.86 ppm in combination with deltamethrin 1.70 ppm was next

Table 3. Effect of combinations of diflubenzuron and carbaryl against third instar larvae of *H. vigintioctopunctata*

Treatments	Expected mortality from treatments with diflubenzuron	Expected mortality from treatments with Carbaryl	Total expected mortality %	Observed mortality %	Co-toxicity factor	Effect
diflubenzuron 11.48 ppm+carbaryl 22.50 ppm	50	50	100	33.30	-66.70	Antagonism
" 11.48 " 8.74	50	25	75	50.00	-33.33	Antagonism
" 11.48 " 4.20 "	50	10	60	83.30	+38.83	Potentiation
" 2.94 " 22.50 "	25	50	75	53.30	-28.93	Antagonism
" 2.94 " 8.74 "	25	25	50	56.66	+13.32	Additive
" 2.94 " 4.20 "	25	10	35	43.33	+23.80	Potentiation
" 0.86 " 22.50 "	10	50	60	36.66	-38.90	Antagonism
" 0.86 " 8.74 "	10	25	35	43.33	+23.80	Potentiation
" 0.86 " 4.20 "	10	10	20	26.66	+33.30	Potentiation

in order to be effective with the recorded mortality of 76.66 per cent which was on par with the combination of 2.94 ppm diflubenzuron and 1.70 ppm deltamethrin with 70 per cent mortality. Mixture of diflubenzuron (0.86 ppm) and deltamethrin (0.28 ppm) had the least effect (16.66%) in controlling the pest. Combinations of diflubenzuron and deltamethrin at 2.94 and 0.66 ppm respectively and diflubenzuron at 11.48 ppm were not effective against the pest. Deltamethrin 1.70 ppm alone was on par with the result obtained in the combination of diflubenzuron 0.86 ppm and deltamethrin 0.66 ppm, the mortalities being 40 per cent and 36.66 per cent respectively. All treatments were found superior to control.

4.3.1.2. Sequential application of diflubenzuron followed by deltamethrin

The results of the application of diflubenzuron followed by deltamethrin after 48 h of the first spray are presented in Table 4. The data revealed that diflubenzuron at 11.48 ppm followed by deltamethrin at 1.70 ppm was most effective with 100 per cent mortality. The treatments of diflubenzuron 2.94 ppm and 0.86 ppm with 1.70 ppm of deltamethrin were on par and next in efficacy. But diflubenzuron 0.86 ppm followed by deltamethrin 0.28 ppm was found to be the least effective in controlling the pest with 20 per cent mortality. The other treatments of diflubenzuron 2.94 and 0.86 ppm followed by deltamethrin 1.70 and 0.66 ppm had only intermediary effect in controlling the pest with mortality percentages of 53.33 and 43.33 respectively and were on par.

4.3.1.3. <u>Sequential application of deltamethrin followed by diflubenzuron</u>

The sequential application of deltamethrin 1.70 ppm followed by diflubenzuron 11.48 ppm was found to be most effective with mortality percentage of 93.33 and was superior to other treatments. Deltamethrin 1.70 ppm followed by either diflubenzuron 2.94 ppm or 0.86 ppm had no significant difference, but was effective in controlling the pest and the mortality percentages observed were 73.33 and 66.66 respectively. The application of deltamethrin 0.66 ppm and 0.28 ppm followed by diflubenzuron 2.94 and 0.86 ppm respectively were on par with the treatments of deltamethrin 0.66 ppm followed by diflubenzuron 0.86 ppm and the mortality percentages were 43.33, 23.22 and 33.33 respectively.

4.3.2. <u>Diflubenzuron with carbaryl</u>

The promising combinations of diflubenzuron and carbaryl observed in the laboratory trial were tried in a pot culture experiment against the third instar

Table 4. Effect of diflubenzuron and deltamethrin applied in varying sequence on grubs of *H. vigintioctopunctata* released on brinjal plants

Insecticides applied		Percent mortality of grubs on plants treated with		
diflubenzuron (ppm)	deltamethrin (ppm)	diflubenzuron and deltamethrin simultaneously	diflubenzuron followed by deltamethrin	deltamethrin followed by diflubenzuron
11.48	1.70	96.66 (83.86) a	100 (90.00) a	93.33 (77.71) a
2.94	1.70	70.00 (56.99) bc	76.67 (61.22) b	73.33 (59.70) b
2.94	0.66	46.66 (42.99) cd	53.30 (46.92) bc	43.33 (41.15) cd
0.86	1.70	76.66 (61.92) b	73.33 (59.00) b	66.66 (55.07) bc
0.86	0.66	36.66 (37.23) d	43.33 (41.15) bc	33.33 (34.93) d
0.86	0.28	16.66 (23.86) e	20.00 (26.07) c	23.33 (28.78) d
11.48	::	43.33 (41.15) cd	::	::
::	1.70	40.00 (38.86) d	::	::
Control	::	3.33 (6.14)	3.33 (6.14)	3.33 (6.14)

Means in columns followed by the same letter are not significantly different at p = 0.05 (Duncan's multiple range test). Figures in parenthesis are values after angular transformation.

grubs of *H.vigintioctopunctata* and the results are presented in Table-5.

4.3.2.1. Simultaneous application of diflubenzuron and carbaryl

Diflubenzuron 11.48 ppm in combination with carbaryl 4.20 ppm was found to be effective against epilachna grubs with a mortality of 73.33 per cent and was significantly superior to all other treatments. Combination of diflubenzuron and carbaryl at 2.94 and 8.74 ppm respectively was next to it (50.00%). Combinations of diflubenzuron and carbaryl at 2.94 and 4.20 ppm expressed the least mortality per cent of 30.00 and 20.00 respectively. The rest of the treatments were on par and in between the least and the second effective treatments.

4.3.2.2. Sequential application of diflubenzuron followed by carbaryl

The results indicated that diflubenzuron 11.48 ppm followed by carbaryl 4.20 ppm was effective in controlling the pest with maximum mortality of 40.00 per cent and was superior to other treatments. Next in rank was the combination of carbaryl 8.74 ppm with diflubenzuron 2.94 ppm (43.33%) which was significantly superior to the combination of diflubenzuron and carbaryl 0.86 and 4.20 ppm. The rest of the treatments were on par with observed mortalities of 40.00 and 36.66 per cent.

4.3.2.3. Sequential application of carbaryl followed by diflubenzuron

The data presented revealed that the application of carbaryl 4.20 ppm followed by diflubenzuron 11.48 ppm was the most effective treatment with a mortality of 63.33 per cent against the grubs and was followed by carbaryl and diflubenzuron at 8.74 and 2.94 ppm respectively with 46.66 per cent mortality which were on par. The other treatments were only less effective with mortalities ranging from 36.66 to 16.66 per cent.

4.4. Field evaluation of combinations of diflubenzuron and insecticides for control of brinjal pests

The treatments found effective under pot culture experiment were evaluated in microplots against pests of brinjal and the results are presented below.

4.4.1. Brinjal spotted beetle (*H. vigintioctopunctata*) (adults)

The statistically analysed data are presented in Table 6.

Table 5. Effect of diflubenzuron and Carbaryl applied in varying sequence on grubs of *H. vigintioctopunctata* released on brinjal plants

Insecticide applied		Per cent mortality of grubs on plants treated with		
diflubenzuron	carbaryl	diflubenzuron and carbaryl simultaneously	diflubenzuron followed by carbaryl	carbaryl followed by diflubenzuron
11.48	4.20	73.33 (59.71) a	70.00 (56.99) a	63.33 (53.85) a
2.94	4.20	30.00 (33.00) c	40.00 (39.15) bc	33.30 (34.93) bc
0.86	8.74	33.30 (35.22) bc	36.66 (36.93) bc	36.66 (37.22) bc
0.86	4.20	20.00 (26.09) c	20.00 (26.07) c	16.66 (23.86) c
2.94	8.74	50.00 (45) b	43.33 (41.15) b	46.66 (43.08) ab
11.48	::	40.00 (39.15) bc	::	::
::	22.50	36.66 (37.14) bc	::	::
Control values	::	Nil	Nil	Nil

Means in columns followed by the same letter are not significantly different at $p = 0.05$ (Duncan's multiple range test). Figures in parenthesis are values after angular transformation.

The pre-treatment count of the adults in the plot did not show significant variations. The effect of treatment was obvious one day after spraying and maximum reduction in population was observed in check plots treated with carbaryl 0.15 per cent. Simultaneous application of diflubenzuron 12.00 ppm and carbaryl 4.00 ppm and simultaneous application of diflubenzuron 12.00 ppm and deltamethrin 2.00 ppm were found to be superior to untreated control. The mean number of beetles observed at seven days after treatment ranged from 0.20 in plots treated with carbaryl 0.15 per cent to 1.60 in plots treated with the combination of diflubenzuron and carbaryl, while in control plot it was 2.40. The treatment with carbaryl 0.15 per cent remained superior to other treatments except simultaneous application of diflubenzuron and deltamethrin the latter being on par with the simultaneous application of diflubenzuron and carbaryl and control. The population of beetles remained low in treated plots even at 14 DAS, with zero in the plots treated with carbaryl which was on par with the two combination treatments. But only carbaryl was superior to control. The data did not show any reduction in the population of adult beetles after 21st day after spraying.

Table 6. Control of adults of brinjal spotted beetle (*H. vigintioctopunctata*) in field using diflubenzuron in combination with deltamethrin/carbaryl using carbaryl 0.15% as standard.

Treatments	pre-treatment count (mean number/plot) per 4 plants	mean No. of insects/plot observed on plants at different intervals after spraying (days)				
		1	7	14	21	28
diflubenzuron 12 ppm+ carbaryl 4 ppm	3.80 (2.04)a	2.00 (1.71)b	1.60 (1.58)bc	1.40 (1.51)ab	1.20 (1.42)a	1.60 (1.58)a
diflubenzuron 12 ppm+ deltamethrin 2 ppm	3.00 (1.81)a	1.40 (1.49)b	0.80 (1.31)abc	1.60 (1.56)ab	2.00 (1.68)a	1.60 (1.58)a
carbaryl 1500 ppm	2.60 (1.89)a	0.20 (1.08)a	0.20 (1.08)a	00 (1.00)a	0.80 (1.31	1.60 (1.58)a
control	2.60 (1.86)a	4.60 (2.30)c	2.40 (1.74)c	4.20 (2.25)b	2.20 (1.72)a	2.00 (1.68)a

Means in columns followed by the same letter are not significantly different at $p = 0.05$ (Duncan's multiple range test). Figures in parenthesis are values after $(x+1)^{1/2}$ transformation.

4.4.2. Brinjal spotted beetle grubs (*H. vigintiocto-punctata*)

On the first day after treatment, the plots treated with carbaryl showed maximum reduction of grub population (2.00) followed by simultaneous application of diflubenzuron and deltamethrin (12.40) which were on par (Table 7). Simultaneous application of diflubenzuron 12.00 ppm in combination with carbaryl 4.00 ppm was found on par with control; the population levels being 17.26 and 25.66 respectively. At seven days after spraying difference between the control and treatments was more significant. The mean number of grubs ranged from 0.60 under carbaryl to 7.40 in plots treated with diflubenzuron 12.00 ppm in combination with carbaryl 4.00 ppm, compared to 22.60 in control plot. Simultaneous application of diflubenzuron and deltamethrin was on par with carbaryl. On 14th and 21st DAS the population levels were on par in the treated plots. But on 28th and 35th DAS combinations of diflubenzuron were found significantly superior to carbaryl, the check insecticide which in turn was superior to the control.

4.4.3. Brinjal lace wing bug *Urentius hystricellus* (Riht)

The data and results of statistical analysis are presented in Table 8. Reduction in population

Table 7. Control of brinjal beetle grubs (*H. vigintioctopunctata*) in field using diflubenzuron in combination with deltamethrin/carbaryl using carbaryl 0.15% as standard

Treatments	Pre-treatment count (mean number/ plot)	Mean No. of grubs/plot observed on plants at different intervals after spraying (days)					
		1	7	14	21	28	35
iflubenzuron 12 ppm+ carbaryl 4 ppm	23.80 (4.76) a	17.20 (4.00) bc	7.40 (2.63) b	1.80 (1.56) a	2.80 (1.78) a	4.20 (2.04) a	5.00 (2.34) a
iflubenzuron 12 ppm+ deltamethrin 2ppm	17.20 (4.04) a	12.40 (3.34) ab	4.40 (2.10) ab	1.40 (1.49) a	1.20 (1.39) a	3.80 (2.02) a	5.80 (2.58) a
arbaryl 1500 ppm	27.60 (4.93) a	2.00 (1.59) a	0.60 (1.20) a	2.20 (1.63) a	3.80 (2.14) a	9.80 (3.20) b	14.20 (3.80) b
ontrol	27.20 (5.19) a	25.60 (5.09) c	22.60 (4.79) c	24.80 (5.01) b	28.00 (5.33) b	31.00 (5.60) a	22.80 (4.76) c

Means in columns followed by the same letter are not significantly different at p = 0.05 (Duncan's multiple range test). Figures in parenthesis are values after $(x+1)^{\frac{1}{2}}$ transformation.

was observed one day after spraying and was maximum in plots treated with carbaryl 0.15 per cent with no insects. Simultaneous application of diflubenzuron and carbaryl and the treatment with diflubenzuron and deltamethrin were on par, the means being 4.20 and 3.80 respectively. Observation for four weeks revealed that all the insecticidal treatments were superior to control. From seventh day onwards the combinations of diflubenzuron and insecticides continued to be the effective treatments compared to control.

4.4.4. Brinjal mealy bug *Centrococcus insolitus* (Gr.)

The data presented in Table 9 showed that effect of insecticides was evident on the first day of the treatment with a mean population of 3.20 per plot under carbaryl and no significant difference was observed with that of simultaneous application of diflubenzuron and carbaryl. The other treatment was also superior to control. The population in plots treated with carbaryl 0.15 per cent remained low till 21st day followed by the application of diflubenzuron and deltamethrin. The combination of diflubenzuron and carbaryl had no effect and was on par with control.

Table 8. Control of brinjal lace wing bugs (*U. hystricellus*) in field using diflubenzuron in combination with deltamethrin/carbaryl using carbaryl 0.15% as standard.

Treatments	Pre-treatment count (mean number/plot) per 4 plants	Mean number of insects/plot observed on plants at different intervals after spraying (days)				
		1	7	14	21	28
diflubenzuron 12 ppm+ carbaryl 4 ppm	11.40 (3.31)[a]	4.20 (2.12)[b]	3.40 (2.00)[a]	2.60 (1.88)[a]	3.80 (1.98)[ab]	5.40 (2.27)[a]
diflubenzuron 12 ppm+ deltamethrin 2ppm	10.60 (3.34)[a]	3.80 (2.00)[b]	3.20 (2.02)[a]	1.00 (1.38)[a]	0.00 (1.00)[a]	1.80 (1.56)[a]
carbaryl 1500 ppm	12.00 (3.47)[a]	0.00 (1.00)[a]	0.00 (1.00)[a]	1.80 (1.59)[a]	2.40 (1.76)[ab]	2.60 (1.78)[a]
control	13.00 (3.67)[a]	13.40 (3.64)[c]	13.40 (3.55)[b]	8.60 (2.92)[b]	11.40 (3.23)[b]	12.60 (3.63)[b]

Means in columns followed by the same letter are not significantly different at $p = 0.05$ (Duncan's multiple range test). Figures in parenthesis are values after $(X+1)^{1/2}$ transformation.

Table 9. Control of brinjal mealy bug(*C. insolitus*) in field using diflubenzuron in combination with deltamethrin/carbaryl using carbaryl 0.15% as standard

Treatments	Pre-treat-ment count (mean number/plot)	Mean number of insects/plot observed on plants at different intervals after spraying (days)				
		1	7	14	21	28
diflubenzuron 12 ppm+ carbaryl 4 ppm	8.80 (3.05) a	7.40 (2.70) ab	14.80 (8.59) bc	19.80 (4.42) c	32.80 (5.40) c	29.20 (5.48) a
diflubenzuron 12ppm+deltamethrin 2ppm	15.00 (3.91) a	11.80 (3.40) b	5.60 (2.40) ab	10.00 (3.13) abc	9.20 (3.06) a	24.00 (4.96) a
carbaryl 1500 ppm	13.40 (3.72) a	3.20 (2.02) a	0.60 (1.23) a	3.80 (1.99) a	5.40 (2.41) a	21.20 (4.67) a
control	17.00 (4.16) a	23.20 (4.78) c	22.80 (4.84) c	[illegible] (4.21) bc	27.60 (5.24) bc	20.40 (4.57) a

Means in columns followed by the same letter are not significantly different at $p = 0.05$ (Duncan's multiple range test). Figures in parenthesis are values after $(x+1)^{\frac{1}{2}}$ transformation.

4.4.5. Brinjal aphid (*A.gossypii*)

The results are presented in Table 10. Combination of chitin synthesis inhibitor and insecticides did not show any significant reduction in the population of aphids, whereas carbaryl 0.15 per cent controlled the pest significantly for the first two weeks.

4.4.6. Brinjal fruit and shoot borer (*L.orbonalis*)

The data and results of statistical analysis are presented in Table 11. On 14th day after spraying, simultaneous application of diflubenzuron and deltamethrin was superior to control with a population of 7.30 as against 37.67 under control. During third week all the treatments were superior to control and was on par among themselves. But in fourth week infestation was least in plots treated with diflubenzuron and deltamethrin (12.33) and diflubenzuron and carbaryl (14.05) whereas, treatment with carbaryl alone was on par with control.

4.4.7. Brinjal leaf caterpillar *Selepa docilis* B.

The data are presented in Table 12. Carbaryl was found to be the most effective chemical with a mean number of 0.60 per plot one day after treatment. This was followed by simultaneous application of

Table 10: Control of aphid (*A. gossypii*) in field using diflubenzuron in combination with deltamethrin/ carbaryl using carbaryl 0.15% as standard

Treatments	Pre-treatment count (mean number/plot)	Mean number of insects/plot observed on plants at different intervals after spraying (days)				
		1	7	14	21	28
diflubenzuron 12 ppm+ carbaryl 4 ppm	45.20 (6.61) a	57.80 (7.49) b	58.20 (7.66) b	46.60 (6.62) b	44.40 (6.68) a	38.20 (6.08) a
diflubenzuron,12mm+ deltamethrin 2ppm	67.20 (8.00) a	81.00 (8.83) b	63.00 (7.80) b	38.60 (6.13) b	39.00 (6.22) a	43.00 (6.54) a
carbaryl 1500 ppm	57.40 (7.11) a	9.20 (2.96) a	4.00 (1.82) a	12.20 (3.38) a	31.00 (5.62) a	35.00 (5.91) a
control	60.00 (7.49) a	83.40 (8.73) b	65.00 (8.03) b	63.60 (7.74) b	45.00 (6.71) a	60.20 (7.64) a

Means in columns followed by the same letter are not significantly different at $p = 0.05$ (Duncan's multiple range test). Figures in parenthesis are values after $(x+1)^{\frac{1}{2}}$ transformation.

Table 11. Control of brinjal fruit and shoot borer (L. orbonalis) in field using diflubenzuron in combination with deltamethrin/carbaryl using carbaryl 0.15% as standard

Treatments	Pre-treatment count (mean number/plot)	Mean number of fruits & shoots damaged/plot observed on plants at different intervals after spraying (days)				
		1	7	14	21	28
diflubenzuron 12 ppm+carbaryl 4ppm	41.32 (39.95)a	30.66 (33.36)a	19.00 (20.31)a	9.05 (11.28)ab	6.22 (9.21)a	14.05 (17.28)a
diflubenzuron 12ppm+deltamethrin2ppm	37.66 (37.52)a	27.67 (28.52)a	10.14 (14.50)a	7.30 (10.07)a	18.33 (19.82)a	12.33 (16.13)a
carbaryl 1500 ppm	39.00 (38.31)a	19.66 (23.67)a	25.24 (27.23)a	10.44 (12.27)ab	14.67 (17.68)a	27.57 (28.49)ab
control	43.67 (41.21)a	43.33 (41.10)a	33.88 (35.38)a	37.67 (37.52)b	50.00 (45.00)b	52.00 (46.15)b

Means in columns followed by the same letter are not significantly different at p = 0.05 (Duncan's multiple range test). Figures in parenthesis are values after angular transformation.

diflubenzuron and carbaryl (1.40). The least effective was the combination of diflubenzuron and deltamethrin with a mean population of 2.80 per plot which was on par with control. The most effective treatment on seventh day after spraying was carbaryl (0.00) followed by diflubenzuron with carbaryl (mean population 1.20 per plot) both being on par. Treatments with diflubenzuron and deltamethrin was on par with control only. At 14th and 21st days after treatment carbaryl and simultaneous application of diflubenzuron and carbaryl were superior to control and were on par. On the 28th day after spraying the plots treated with the combination of diflubenzuron and carbaryl and the application of diflubenzuron and deltamethrin had significantly low populations of 0.60 and 0.40 per plot respectively in comparison with 1.80 under carbaryl 0.15 per cent and 4.40 under control which were on par.

Table 12. Control of brinjal leaf caterpillar (*S. docilis*) in field using diflubenzuron in combination with deltamethrin/carbaryl using carbaryl 0.15% as standard

Treatments	Pre-treatment count (mean number/plot)	Mean number of larvae/plot observed on plants at different intervals after spraying (days)				
		1	7	14	21	28
diflubenzuron 12 ppm+ carbaryl 4 ppm	2.20 (1.72)^{a}	1.40 (1.51)^{a}	1.20 (1.41)^{ab}	0.60 (1.23)^{a}	0.60 (1.23)^{a}	0.60 (1.23)^{a}
diflubenzuron 12 ppm+ deltamethrin 2 ppm	3.00 (1.88)^{a}	2.80 (1.81)^{ab}	2.20 (1.66)^{bc}	2.60 (1.78)^{ab}	1.20 (1.46)^{ab}	0.70 (1.25)^{a}
carbaryl 1500 ppm	2.80 (1.90)^{a}	0.60 (1.23)^{a}	0.00 (1.00)^{a}	0.60 (1.23)^{a}	0.80 (1.28)^{a}	1.80 (1.62)^{ab}
control	2.80 (1.84)^{a}	5.80 (2.53)^{b}	4.40 (2.25)^{c}	4.40 (2.27)^{b}	4.20 (2.09)^{b}	4.40 (2.20)^{b}

Means in columns followed by the same letter are not significantly different at $p = 0.05$ (Duncan's multiple range test). Figures in parenthesis are values after $(x+1)^{\frac{1}{2}}$ transformation.

DISCUSSION

DISCUSSION

Results presented on the LC_{50} values of diflubenzuron and insecticides against third instar larvae of *H. vigintioctopunctata* and fouth instar nymphs of *A.gossypii* in para 4.1.1. showed that while diflubenzuron was sufficiently toxic to grubs of *H. vigintioctopunctata*, it had no toxicity against *A.gossypii*. The same result was obtained by Sekhar and Rao (1987). Saradamma *et al*. (1987) also could not find any effect for the chemical on *Aphis craccivora* Koch. This can be attributed to the mode of action of diflubenzuron which acts specifically as a stomach poison as reported by Kandaswamy, (1987).

The data presented in para 4.2.1. revealed that diflubenzuron when used in combination with deltamethrin caused additive, antagonistic and potentiating effects against grubs of *H.vigintioctopunctata*. Potentiation was observed in combinations of diflubenzuron and deltamethrin at ratios 1:0.33, 1:0.58, 1:0.77 and 1:1.98. In ratios 1:0.02, 1:0.06 and 1:0.09 the combinations showed antagonistic effect. Additive effect was observed in ratios of 1:0.15, and 1:0.22. The results thus indicated that with lower dose of deltamethrin, the mixture had an antagonistic effect. Whenever the proportion of deltamethrin was increased from 1:0.09 to 1:0.15 the combinations showed additive effect and the trend was maintained upto a ratio of 1:0.22. Further increase in the content resulted in potentiation effect. Saad et al. (1981) also obtained antagonistic effect when combinations having higher quantities of diflubenzuron was used against S.litura. It may be presumed that at very low ratios (1:0.02, 1:0.06 and 1:0.09) deltamethrin interfered with the activity of diflubenzuron and masked its toxicity. In combinations with higher doses of deltamethrin at ratios ranging from 1:0.33 to 1:1.98, potentiation effect was observed. The potentiation effect of this combination at 1:1 ratio was reported against S.littoralis (Saad et al. 1981). Even though potentiation and additive effects were observed at ratios mentioned, the effective ratios for securing a high degree of control were 1:0.15, 1:0.58 and 1:1.98 of diflubenzuron and deltamethrin, the observed mortality percentage being 100, 93.30 and 83.33 respectively.

In the case of combination of diflubenzuron with carbaryl in different proportions also, additive, potentiating and antagonistic effects were observed (para 4.2.2). But there was no positive correlation with mortality and the dosages of carbaryl used in the combination as observed in the case of diflubenzuron and deltamethrin. Potentiation was obtained in combination of diflubenzuron with carbaryl at ratios of 1:0.36, 1:1.43, 1:4.88 and 1:10.16 and the effective ratio in the combination for obtaining good control was 1:0.36 the highest mortality observed being 83.30 per cent. Radwan et al. (1983b) has reported that the potentiation was on the increase in combination of diflubenzuron and carbamates at ratios of 4:1 and 9:1 against S.littoralis and the present observation is in agreement with the finding.

The result thus indicated the possibility of exploiting the combined use of diflubenzuron and insecticides more advantageously for the control of H.vigintioctopunctata, maintaining correct proportions of the components, whereby the quantity of insecticides can be reduced for practical pest control operations.

While evaluating the efficacy of simultaneous and sequential applications of IGR and insecticides in the pot culture experiment, the percentage mortality of test insects observed was more or less the same as in the laboratory studies, except in the sequential application of diflubenzuron and deltamethrin at LC_{50} levels. The effect of mixtures in different proportions found in the laboratory was seen maintained in the pot culture experiment. The potentiation effect of deltamethrin with higher doses of diflubenzuron was well established here.

In the case of simultaneous application, combination of 0.86 ppm of diflubenzuron and 1.70 ppm of deltamethrin was the best,the mortality being 76.66 per cent compared to 70 per cent in the combination having a high ratio of diflubenzuron viz. 2.94 ppm with 1.70 ppm deltamethrin, though both of the treatments were on par. But the result was reversed in the sequential applications of the insecticides where the ratio of 2.94:1.70 was more advantageous. In all the three sequences tried, the combinations of 1.70 ppm of deltamethrin with varying doses of diflubenzuron has given significant reduction in the pest population varying from 66.66 to 100 per cent. In the sequences, diflubenzuron followed by deltamethrin appeared to be more effective.

With the combinations of diflubenzuron and carbaryl similar results were obtained in the pot culture experiment and laboratory experiments. The combination of diflubenzuron 11.48 ppm and carbaryl 4.20 ppm emerged as the significantly superior combination. The variations among the different sequences tried were not significant though simultaneous application appeared to be better. The potentiation exhibited in the laboratory experiment was observed in the pot culture experiment also. The low mortality observed in the combinations containing low doses of diflubenzuron indicated that unlike with deltamethrin, a higher dose of diflubenzuron is essential when used in combination with carbaryl for effective control of *H.vigintioctopunctata*. In general, a combination of diflubenzuron with a higher proportion of deltamethrin, and the simultaneous application of diflubenzuron and carbaryl with a higher ratio of the former can be chosen as effective treatments against the grubs of *H. vigintioctopunctata* in the pot culture experiment. Since the simultaneous and sequential applications of the combination of diflubenzuron and deltamethrin did not vary significantly, the simultaneous applications was selected for field experiment.

When these combinations were tried in the field in comparison with the field dose of carbaryl against the pests of brinjal, their efficacy varied with different groups of insects as shown in Fig.1. The defoliating grubs of epilachna beetle and the

Fig. 1 Control of brinjal pests using diflubenzuron in combination with carbaryl and deltamethrin.

1. *A. gossypii*
2. *L. orbonalis*
3. *U. hystricellus*
4. *C. insolitus*
5. *H. vigintioctopunctata* (Adults)
6. *H. vigintioctopunctata* (Grubs)
7. *S. docilis*

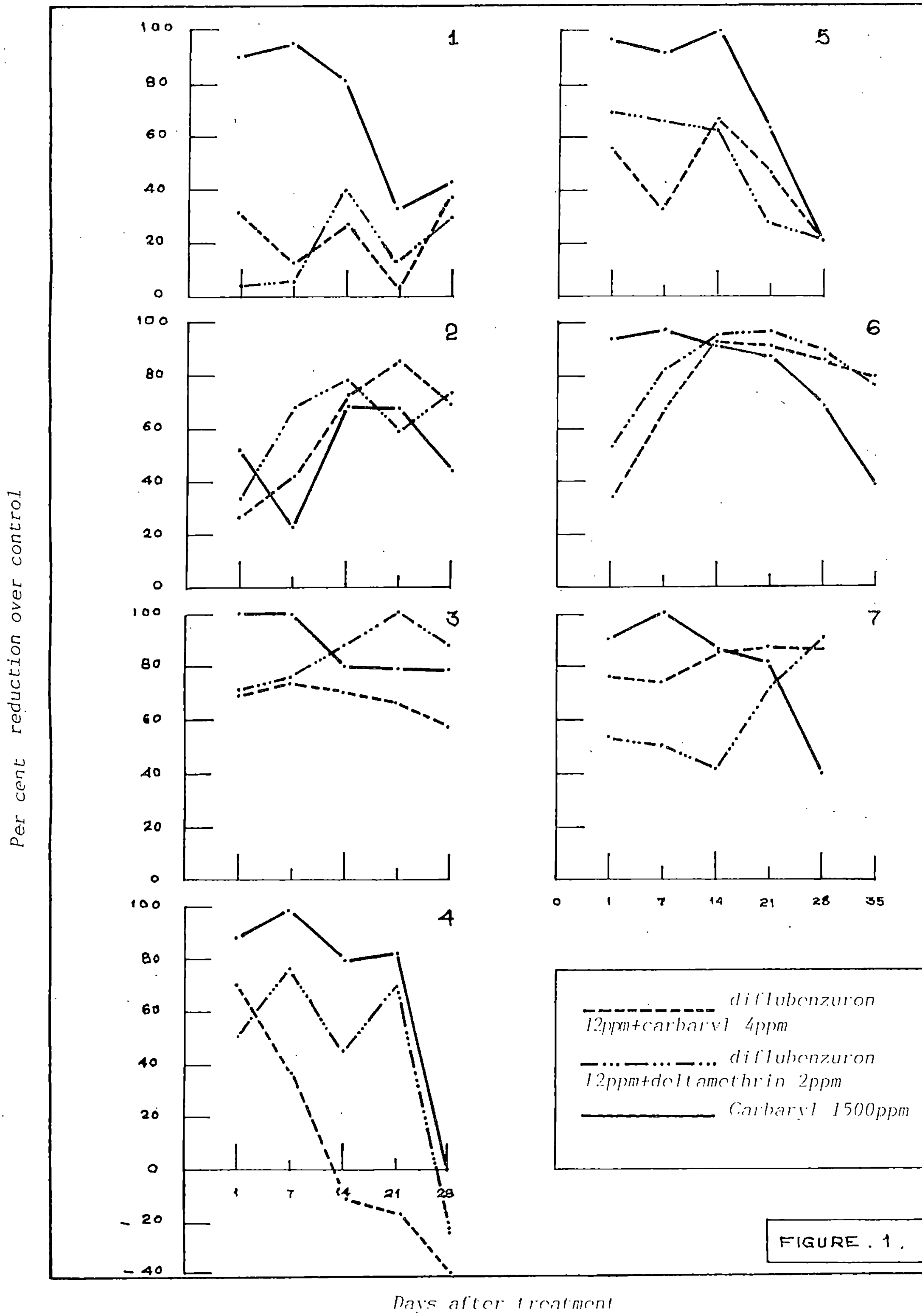
Per cent reduction over control
100
80
60
40
20
0
-20
-40
1
2
3
4
5
6
7
0
1
7
14
21
28
35
diflubenzuron 12ppm+carbaryl 4ppm
diflubenzuron 12ppm+deltamethrin 2ppm
Carbaryl 1500ppm
Days after treatment

FIGURE . 1 .

caterpillars of fruit and shoot borer, *L. orbonalis* were controlled more effectively and the sucking insects remained unaffected. Though the adults of spotted beetles had only a low level of population, the results showed that the field dose of carbaryl was significantly superior to the combinations. As the adult beetles are feeding on the surface of the leaves, low dose of carbaryl present in the combination would not have had sufficient lethal toxicity and since diflubenzuron used in combination with the insecticide might act only as stomach poison and would take time to act, the combination would not prove effective on the first day after treatment. This was confirmed with the observations recorded on seventh and 14th days after treatment when the combinations came on par with carbaryl. The lack of sufficient insect population might be one of the reasons for not getting a significantly superior control beyond 14th DAS as anticipated from the results of laboratory and field experiments.

In the case of grubs of epilachna beetle, the combination of diflubenzuron and deltamethrin could bring effective control even at the first day after treatment. Reddy and Rao (1987b) have reported contact toxicity also for diflubenzuron to

H.vigintioctopunctata. Though carbaryl at 1500 ppm was the most effective treatment upto seven days after treatment, the combinations could keep the grub population at a significantly reduced rate than in the control plot during the first week itself. The combination also came on par with carbaryl on 14th and 21st DAS. This resulted from the action of the chitin synthesis inhibitor which acted as a stomach poison by disrupting normal function of chitin synthesis. From 28th day onwards the combinations were superior to carbaryl 1500 ppm. The chitin synthesis inhibitor has a prolonged action through successive instars in *S.mauritia* as reported by Beevi (1979).

In the case of combinations with carbaryl, the low dose of carbaryl available in the combination could not bring any effect on the insect population one day after application. But on seventh day the activity of diflubenzuron had brought out significant reduction in population compared to that in control plot. The efficacy of the combination was on par with the field dose of carbaryl on 14th and 21st day and was significantly more effective later. When the field dose of carbaryl was losing its toxicity gradually from 28th day onwards the combination was still effective, making possible for the prolonged control of the insect with a single application of the combination. The combinations were significantly superior to carbaryl upto 35 days, possibly with less hazards to higher animals and natural enemies than when treated with insecticide alone (Reddy and Rao 1987a). The significant reduction in population levels compared to control even on 35th day indicated the possibility of prolonged control of the pest with IGR-insecticide combinations than with insecticide alone.

For the control of U.hystricellus carbaryl 1500 ppm produced 100 per cent mortality and the combinations could substantially reduce the pest population on the first day after spraying itself and from the seventh day onwards carbaryl 1500 ppm was on par with the two combinations. The potentiation effect of the combinations might have caused the reduction of population in the first two observations. During the rest of the period under observation, all the three treatments retained the pest population under check. The significant suppression of pest population in the combination with deltamethrin during later observations revealed the advantage of the mixture over carbaryl and combinations of carbaryl. As the lace wing bugs are sap feeders the present result is of interest and the mode of entry of the toxicant needs further investigation. The chitin synthesis inhibitor known as stomach poison is reported to lack the capacity to penetrate into the plant tissues. Consequently, sucking insects as a rule, should not be affected. But contact action had been reported earlier in S.litura (Kandaswamy, 1987) and in H.vigintioctopunctata (Reddy and Rao, 1987b). In the combination with carbaryl, the population of lace wing bugs was higher when compared to the other combination from 14th DAS though not significantly different.

Against mealy bug (C.insolitus) the combination of diflubenzuron and deltamethrin could effectively control the insect and it was on par with carbaryl 1500 ppm upto 21st DAS. But the combination with carbaryl was effective only to a certain extent that too for one day after treatment alone. The result obtained on 28 DAS has confirmed this by the population build up in plants treated with carbaryl in excess of the population recorded in the control.

In the case of brinjal aphid, A.gossypii. results obtained in the laboratory have been reaffirmed in the field experiment. Both the combinations had no effect at any of the occasions, whereas carbaryl in the field dose could control the pest effectively upto 14 DAS. The inefficacy of chitin synthesis inhibitor against *A. gossypii* has been discussed in the first para of this section.

Against brinjal fruit and shoot borer (*L.orbonalis*) the combinations and carbaryl remained ineffective at seven days after spraying. But further increase in infestation wa prevented from 14 DAS.

The control obtained in the treatments with diflubenzuron might be due to ovicidal activity or toxicity towards the first instar larvae. The ovicidal action is well reported by authors like Abo-Elghar *et al.* 1976, Radwan *et al.* 1983b . Among the insecticidal treatments, superiority of the combination of diflubenzuron with deltamethrin can be due to the high rate of toxicity of deltamethrin against this caterpillar pest as reported by Nimbalkar and Ajri (1981). In plants treated with carbaryl the insecticide has persisted on the plant surface upto 21st DAS, while in the two combinations the pest population remained much less upto 28 days. In general, the combinations were highly effective in controlling the fruit and shoot borer from 14 to 28 DAS and are of practical utility.

Eventhough the population of *S.docilis* was very low during the entire period of observation, results obtained were statistically significant and the efficacy of carbaryl and its combination with diflubenzuron against this pest was indicated during the entire period under observation. The combination of diflubenzuron and deltamethrin remained ineffective till seven DAS and then became on par in effectiveness with combination of carbaryl, though inferior to carbaryl alone. But at 28 DAS the combinations were superior to carbaryl as seen in the case of *L.orbonalis* and grubs *H.vigintioctopunctata*.

The comparative efficacy of the three treatments against the pests of brinjal under field conditions showed that one day after spraying carbaryl 1500 ppm could control all the pests except *L.orbonalis.* Though combinations could not produce such immediate results there had been significant reduction in population compared to control plot, and the populations came at manageable levels. On the seventh day after spraying the position had further improved; though the combinations were statistically inferior to the carbaryl treatment. On 14th and 21st DAS, the combinations and carbaryl came on par except in case of brinjal aphid and mealy bug. On 28th DAS, while efficacy of insecticide was reduced, the combinations rendered efficient control. This trend was in agreement with the mode of action of chitin synthesis inhibitors. This has indicated the possibility of using these combinations, against pests of brinjal except mealy bug and aphid. One of the advantages attributed to the combinations of diflubenzuron and low doses of insecticides is their harmlessness to natural enemies. Diflubenzuron is not hazardous to many of the parasites of crop pests. Reddy and Rao (1987a) have reported that diflubenzuron had no adverse effect to the parasites of H.vigintioctopunctata. Other workers like Westigard (1979), Ables et al. (1980), Zungali et al. (1983) also have recorded its harmlessness to parasites. Increased efficacy against the pests can well be anticipated by using higher doses of the components based on the ratios found beneficial in the present studies. Even these doses may be well below the levels that cause toxic hazards to the parasites, predators or higher animals. The advantage that the chitin synthesis inhibitor do not interfere with the systems of higher animals is an added benefit. But further studies are required for determining the optimum dosages of these chemicals for providing an efficient reduction of pest so that the treatment can be suitably fitted in a pest management system.

SUMMARY

SUMMARY

Use of chitin synthesis inhibitor diflubenzuron (Dimilin) in combination with insecticides was investigated in the laboratory and in field for controlling pests of brinjal.

Bioassay of diflubenzuron, deltamethrin and carbaryl was done using the third instar grubs of H.vigintioctopunctata and fourth instar nymphs of A.gossypii adopting standard procedures. From the regression equations LC_{50}, LC_{25} and LC_{10} values for the three insecticides were computed.

The joint action of diflubenzuron and insecticides was assessed by mixing them at LC_{10}, LC_{25} and LC_{50} levels and observing their toxicity in the laboratory to the grubs of H.vigintioctopunctata. Antagonistic, additive and potentiation effects were worked out based on the co-toxicity factor computed from the expected and observed mortalities. Potentiation was observed in combinations of diflubenzuron and deltamethrin at ratios of 1:0.33, 1:0.58, 1:0.77 and 1:1.98. In ratios 1:0.02, 1:0.06 and 1:0.09 the combinations were antagonistic and additive effect was observed in ratios of 1:0.15 and 1:0.22. A high rate of control was observed in combinations of diflubenzuron and deltamethrin at ratios 1:0.15, 1:0.58 and

1:1.98 with mortality per cent of 100, 93.30 and 83.33 respectively. In the combination of diflubenzuron with carbaryl also additive, potentiation and antagonistic effects were observed. Though potentiation was observed in combinations at ratios of 1:0.36 1:1.43, 1:4.88, and 1:10.16, effective combination was at 1.0.36 levels of diflubenzuron and carbaryl giving 83.30 per cent mortality.

The effect of sequential and simultaneous applications of diflubenzuron and deltamethrin and of diflubenzuron and carbaryl were studied in a pot culture experiment against third instar grubs of H.vigintioctopunctata. For this, levels of diflubenzuron and deltamethrin giving potentiation and additive effects were selected. The ratios in which diflubenzuron and deltamethrin were used consisted of 11.48:1.70, 2.94:1.70, 2.94:0.66, 0.86:1.70, 0.86:0.66 and 0.86:0.28 ppm. In one sequential treatment diflubenzuron was applied two days after spraying deltamethrin and in the next treatment the spraying were reversed.Results were compared with Duncan's multiple range test. The potentiation effect of deltamethrin when used at higher doses to diflubenzuron obtained in the laboratory studies was confirmed in the pot culture experiment. The sequential and simultaneous applications were, in general equally effective.

For studying the effect of simultaneous and sequential application of diflubenzuron and carbaryl, the ratios of 11.48:4.20, 2.94:8.74, 2.94:4.20, 0.86:8.74 and 0.86:4.20 were adopted. No significant variation between the sequential and simultaneous applications was observed.

Two effective combinations found in the above experiment were tried in the field in a randomised block design against the pests of brinjal. The treatments were diflubenzuron 12.0 ppm + carbaryl 4.0 ppm and diflubenzuron 12.0 ppm + deltamethrin 2 ppm. Carbaryl 1500 ppm was used as standard treatment and unsprayed plots were maintained as control.

The combinations controlled the epilachna grubs and the fruit and shoot borer more effectively than by carbaryl at 1500 ppm. But the sucking insects remained unaffected.

The combinations were not effective against the adults of epilachna beetles, while they were significantly superior to carbaryl against its grubs from 28 to 35 days after application.

Against lace wing bugs the combinations could reduce the pest population one day after spraying. On seventh and 14th days, the combinations were on par with carbaryl. On 21st and 28th DAS the combinations of diflubenzuron and deltamethrin appeared more effective.

The combinations of diflubenzuron and deltamethrin could control the mealy bugs upto 21st days after spraying and was on par with carbaryl. The other combinations were ineffective and maintained a population level higher than that in the control plot from 14th day onwards.

Against brinjal aphid, both the combinations were inferior to carbaryl.

Against brinjal fruit and shoot borer, the combinations and carbaryl were ineffective upto seven DAS. But the infestation could be controlled from 14th day onwards and the pest was controlled upto 28th DAS and the combinations were superior to carbaryl 1500 ppm at 28 DAS.

Against S.docilis carbaryl was more effective upto seven DAS and combination of diflubenzuron and carbaryl came on par from 14 DAS. At 28 DAS both the combinations were superior.

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CONTROL OF BRINJAL PESTS USING DIFLUBENZURON IN COMBINATION WITH INSECTICIDES

By

REVI D.

ABSTRACT OF A THESIS

submitted in partial fulfilment of the requirement for the degree

MASTER OF SCIENCE IN AGRICULTURE
Faculty of Agriculture
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DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
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ABSTRACT

The joint action of diflubenzuron in combination with deltamethrin and carbaryl was assessed against pests of brinjal using laboratory trials, pot culture experiments and micro plot trials in the field. Standard bioassay technique was adopted in the laboratory studies using grubs of *H.vigintioctopunctata* and nymphs of *A.gossypii* as test insects. Based on these LC_{50}, LC_{25}, LC_{10} values were computed using the dose mortality regression equations. The joint action of diflubenzuron and deltamethrin/carbaryl, mixed in the above doses, was assessed using *H.vigintioctopunctata* as test insect and expressed in terms of co-toxicity factor (Mansour *et al*., 1966).

A pot culture experiment was conducted for studying the effect of simultaneous and sequential applications of chitin synthesis inhibitor and insecticides against grubs of *H.vigintioctopunctata*.

A microplot trial was conducted in the field for assessing the efficacy of two effective combinations of IGR and insecticides for the control of the pests of brinjal.

Laboratory studies showed antagonistic, additive and potentiating effects in the combinations of diflubenzuron with deltamethrin/carbaryl. Potentiation effect was obtained in combincations of diflubenzuron and deltamethrin at ratios 1:0.15, 1:0.58 and 1:1.98 with the mortality percentages of 100, 93.33 and 83.33 respectively. In case of diflubenzuron with carbaryl the ratio 1:0.36 produced maximum potentiation with a mortality per cent of 83.30.

The applications of diflubenzuron and deltamethrin with a higher proportion of the insecticide and the application of diflubenzuron and carbaryl with a higher ratio of diflubenzuron were more effective (100 and 73.33 per cent mortality respectively) in the pot culture experiment against H.vigintioctopunctata. As there was no significant difference between simultaneous and sequential applications of diflubenzuron and deltamethrin, simultaneous applications of the toxicants was selected for field evaluation. The simultaneous application of both the combinations were evaluated in microplots in the field against pests of brinjal.

The combinations were superior to carbaryl 1500 ppm (standard) against grubs of epilachna beetle and larvae of fruit and shoot borer. Against sucking insects the combinations were inferior to the standard except for the lace wing bug for which significant control was obtained. The combinations significantly reduced the population of *S.docilis* from 14th day after spraying and it was on par with carbaryl.

The combinations provided prolonged control fof the grubs of *H.vigintioctopunctata*, *U.hystricellus*, *L.orbonalis* and *S.docilis* when compared with the extent of control obtained with carbaryl.

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No. IUCM/1/95-96/
November 23, 1995

Sampson David
Sr. Cultural Officer

Dear Sir/Madam,

Please find enclosed herewith the Consolidated Report of the Inter University Home Stay Scheme 1994-95, organised by AIU in collaboration with the University Grants Commission.

Kindly acknowledge.

Thanking you,

Yours faithfully,

Sampson David

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