STUDIES ON THE COMPATIBILITY OF SYNTHETIC PYRETHROIDS WITH SOME COMMON FUNGICIDES

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By

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Shri D.V.K.D.R.DIKSHITULU has satisfactorily prosecuted the course of research and that the thesis entitled "STUDIES ON THE COMPATIBILITY OF SYNTHETIC PYRETHROIDS WITH SOME COMMON FUNGICIDES" submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any University.

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C E R T I F I C A T E

This is to certify that the thesis entitled "STUDIES ON THE COMPATIBILITY OF SYNTHETIC PYRETHROIDS WITH SOME COMMON FUNGICIDES" submitted in partial fulfilment of the requirements for the degree of Master of Science in Agriculture of the Andhra Pradesh Agricultural University, Hyderabad, is a record of the bonafide research work carried out by Sri D.V.K.D.R. DIKSHITULU under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma or has been published. Published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

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(D.V.K.D.R.DIKSHITULU)

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A B S T R A C T

In recent years, synthetic pyrethroids are gaining prominence in insect pest control. Often it becomes necessary to combine these chemicals with fungicides to combat insect pests and diseases simultaneously to save time, labour and money. Before recommending such combinations, the compatibility of these chemicals needs to be ascertained and hence the studies were taken.

The biological effectiveness of synthetic pyrethroids and fungicide mixtures was studied against the test insect *Dysdercus cingulatus* Fb. and the test fungus *Helminthosporium turcicum* Pass. The emulsion stability of the pyrethroids when mixed with fungicides and the phytotoxicity of the mixtures on cotton crop were also studied.

The results indicated that cypermethrin,permethrin and fenpropathrin in combination with lower concentrations of carbendazim or mancozeb (10 and 100 ppm) were synergistic to *D.cingulatus* but antagonistic with higher concentrations (1000 and 2000 ppm) of fungicides to the test insect. Carbendazim and mancozeb were synergistic with higher concentrations of pyrethroids to *H.turcicum* but were antagonistic with lower concentrations and had no effect with intermediary concentrations.

The emulsion stability of permethrin and fenpropathrin was affected due to more sedimentation when mixed with mancozeb but unaffected with carbendazim. Cypermethrin,permethrin or fenpropathrin were found physically compatible with carbendazim. These three synthetic pyrethroids in combination with either of the fungicides were non-phytotoxic to cotton.

INTRODUCTION

The intensive agricultural practices such as growing high yielding varieties, excessive use of synthetic fertilizers, monoculturing, irrigated conditions etc., contributed to the tremendous increase in the activity and virulence of insect pests and diseases. More often, insect pests and diseases occur simultaneously causing enormous crop losses warranting the farmer to take up effective control measures. As most of the pesticides cannot control insect pests and diseases occurring simultaneously on a crop, very often it becomes necessary to mix an insecticide with a fungicide and apply on a crop. Grains are also being treated with a mixture of insecticide and fungicide to minimise losses in storage due to insect pests and diseases. By applying a mixture of two or more chemicals the cost of control measures can be reduced provided, it does not cause adverse effects on crop growth, yield and also on the efficacy of either of the pesticides. It also saves time and labour and more area can be covered in a unit time.

Insecticides and fungicides when mixed together tend to react with each other and, in this process, increased or decreased toxicity of any of the chemical may result. The physical properties of the pesticides are likely to be affected. The mixture may also cause phytotoxicity to the crop.

Therefore, it is highly essential to test for these effects before recommending any of the recently popularised synthetic pyrethroids for mixing with a fungicide. Hence present investigations were conducted to test the compatibility of three synthetic pyrethroids with two commonly used fungicides in respect of

i) biological effectiveness

ii) physical compatibility and,

iii) phytotoxicity.

REVIEW OF LITERATURE

Literature on the compatibility of insecticides with fungicides has been reviewed under the following broad areas:

A. Compatibility of insecticides with fungicides,

B. Compatibility of insecticides with fungicides and fertilizers and,

C. Physical compatibility.

A. Compatibility of insecticides with fungicides

Leukel (1953) mentioned that DDT and ceresan mixture reduced both insecticidal and fungicidal effect of DDT and ceresan respectively. Magnesium oxide added to copper carbonate or spergon in seed treatment had reduced the effect of fungicidal property in the control of sorghum loose smut, while magnesium oxide mixed with sulfur increased the fungicidal effect of sulfur.

McClellan *et al.*(1954) tested 29 dust combinations on five rose varieties in field trials. They used zineb alone or in combination with 1.5 per cent Aramite, 1.5 per cent ovotran and 4 per cent malathion. They reported that there was no interaction between the fungicides and insecticides in controlling the black spot *Diplocarpon rosae*.

Ditman *et al.*(1955) observed no significant differences in the efficacy of lindane, chlordane, aldrin or dieldrin when used as emulsions either alone or in combination with fungicides captan and thiram against seed corn maggot Hylemya cilicrura R. and seed decay fungi. They treated seeds of pea, snap bean and lima bean with the above insecticides and fungicides by slurry method.

Arnold and Apple (1957) demonstrated that addition of 30 ml of dieldrin, heptachlor or aldrin per bushel of corn seed had no adverse effect on the fungicidal action of captan, dichlone and thiram when used as a slurry treatment against Pythium spp. Lindane with captan showed similar results while dichlone and thiram reduced germination significantly.

Hansing (1957) observed higher germination of sorghum seed with insecticide-fungicide combinations such as dieldrin-thiram and aldrin-cyano (methylomercuri) guanidine than with fugicide alone. He also tested fungicide and insecticide mixtures in seed treatment for the control of covered kernel smut of sorghum and complete control of smut was obtained with the combinations of thiram-dialdrin, captan - dieldrin and captan-lindane.

Luke et al.(1960) designed fungicide-insecticide combinations for the control of Helminthosporium sativum P.K. and Bakke. and Sitophilus oryzae L. on rye. The four most effective combinations were ceresan M and DDT, Delesan A-D, Ceresan 100 and 50 per cent malathion emulsion, and Orthocide seed protectant.

Travis and Henneberry (1960) combined maneb,ferbam,zineb, captan with acaricides viz., Aramite, malathion,demeton and phorate for the control of *Diplocarpon rosae* and *Tetranychus telarius*. Significant differences in yield were not observed between the treatments of fungicides alone and fungicide and acaricide mixtures.

Allen *et al*., (1961) reported that heptachlor in combination with captan enhanced the protective action of captan. Captan treated seed improved the seedling stand when used with heptachlor fertiliser mixtures.

Rangacharyulu (1970) tested synergistic/antagonistic action of insecticide-fungicide combinations against *Fusarium moniliforme*. He found that ceresan-carbaryl and copper oxychloride-endrin mixtures were synergistic, while the mixtures of zineb-carbaryl copper oxychloride-parathion and Benlate-carbaryl antagonistic.

Thobbi and Jagan Mohan (1971) tried fungicide and insecticide combinations for sorghum seed treatment. There was better growth in furadan and furadan thiram treated plots than in thiram and check plots. Furadan-thiram treatment yielded significantly more grain than the other treatments and control. The fungitoxicity of thiram was not affected when mixed either with furadan or herbicides.

Svamp *et al*.(1974) showed that the activity of maneb, zineb, ziram, mancozeb, dodemorph was increased and that of ethrimol was reduced on mixing with insecticides.

Thobbi *et al.* (1975) achieved satisfactory control of sorghum shoot fly *Atherigona soccata* and grain smut *Sphacelotheca sorghi* with carbofuran thiram treatment. This treatment yielded more grain and significantly more fodder than the other treatments and control.

Ajit Kumar (1976) noticed synergism in combinations of Benlate + carbaryl, Plantvax+carbaryl and Sulfex+malathion. The synergism was with respect to the increased efficacy of insecticide on the fungicide. But combinations of Benlate+malathion, captan+malathion and captan+phosalone showed antagonistic effect against the fungus *Gleosporium ampelophagum* (Pass.)Sacc. and insect pest *Pachymerus chinensis* L.

Brunelli *et al.* (1976) studied the interaction between fungicides and acaricides on cucumber in glass house using the fungus *Erysiphe cichoracearum*. There was often an increase in activity of fungicides on mixing acaricides with fungicides thiophanate, chloranil, formathion, dodemorph and dithiocarbamates.

Hardas *et al.* (1976) tested germination of sorghum seed by using fungicides viz., thiram, agrosan, and captan either alone or in combination with carbofuran against sorghum shoot fly. They concluded that there was no effect of fungicides on germination of seeds either alone or in combination with the insecticide. Dead hearts due to shootfly attack declined with combinations and the efficacy of carbofuran was in no way enhanced or impaired in combination with the fungicides.

Lal and Pandey (1978) studied the compatibility of different concentrations of fungicide ziram with the insecticide phosphamidon, herbicide propanil and macronutrient urea. In all, 189 combinations of the above chemicals were used *in vitro* against *Helminthosporium oryzae*. They found that the combinations were not only compatible but in some cases showed synergistic effect.

Gar (1980) investigated chemical and biological compatibilities of insecticides + fungicides and fungicides + fungicides, and the effectiveness of these combinations in the control of crop diseases and pests. He recommended spraying fruit trees with fungicides and some insecticides against scab (*Venturia* spp.) and powdery mildews.

Dhakshinamoorthy *et al.* (1981) conducted compatability studies for the control of aphid *Myzus persicae* Sulz. and leaf spot and die-back diseases of chillies. They showed that combinations of insecticides and fungicides like methamidophos with maneb/captafol and FMC 35001 with maneb/captafol had an additive effect in the control of aphids. For leaf spot diseases, captafol in combination with insecticides proved better as against maneb. The die-back disease of chillies was checked effectively by most of the insecticide combinations with maneb and captafol respectively. The different combinations of insecticides and fungicides tested were found to be compatible and non-phytotoxic.

Gradis and Sutton (1981) reported that the fungistatic and fungicidal activity of mancozeb as measured by spore germination and germtube length of conidia of Botryosphaeria dothidea and Glomerella cingulata Pens. was reduced by the addition of insecticides phosmet and azinphosmethyl and that of captan by phosmet, azinphosmethyl and sodium borate (a nutrient).

Raju and Rao (1981) reported that Dithane M-45 alone or in combination with acaricides/insecticides dicofol, phosalone, quinalphos, dimethoate, carbaryl and monocrotophos was found effective in the control of chilli mite.

Bhaskaran and Prem Kumar (1982) reported maximum enhancement of insecticidal activity in combinations of quinalphos + Dithane Z-78, malathion + Hinosan and malathion + cunan L when tested with the red flour beetle Tribolium castaneum Herbst. in the laboratory.

Ethion was found to be compatible with copper oxychloride, calixin, nickel chloride and were effective in controlling the pink and purple mites on tea when applied individually and in combination with fungicides at recommended dosage, without any phytotoxicity (Kalyanraman,1982).

Cainos (1983) showed that a combination of metalaxyl and carbofuran lowered the incidence of black shank disease in tobacco and increased the yields higher than with metalaxyl alone.

Dhakshinamoorthy *et al.* (1983) reported that the mixture of dicofol 0.018 per cent and maneb 0.2 per cent was quite compatible and gave good control of the yellow mite *Hemitarsonemous latus* and leaf spot diseases *Alternaria solani* and *Cercospora capsici* on chilli.

Prakash and Kauraw (1983) studied the compatibility of certain insecticides viz., Pyrodust, malathion, etrimfos with fungicides like carbendazim, ceresan and Brassicol for the control of paddy moth, *Sitotroga cerealella* Olivier and seed borne fungi in stored paddy. Out of 16 combinations tested, only four combinations viz., malathion with ceresan, Pyrodust with carbendasim, malathion with carbendazim and etrimfos with carbendazim were significantly compatible and controlled the insect and fungal infestation and enhanced the seed viability.

Mancozeb was found to have synergistic effect with carbaryl, phosphamidon and dimethoate but antagonistic with monocrotophos. There was no appreciable reduction in toxicity when it was mixed with decamethrin, cypermethrin, methyl demeton and quinalphos (Tripathi *et al.*, 1983).

Reddy (1984) observed *in vitro* studies that fenvalerate at LC_{50} was synergistic at lower concentrations of carbendazim but antagonistic at higher concentrations and had no effect at intermediary concentrations. He also observed that the LC_{50} of fenvalerate was synergistic with mancozeb at concentrations ranging from 0.0001 to 0.2 per cent to *Drosophila melanogaster* Meig.

In vitro and *in vivo* studies were made by Abbaiah (1985) to test the compatibility of four insecticides viz., BHC, endosulfan, carbaryl and monocrotophos with seven fungicides viz., carbendazim, triadimefon, vitavax, zineb, mancozeb, sulfur and copper oxychloride. Of the 56 fungicide-insecticide combinations tested against *Drosophila melanogaster*, 6 combinations showed synergism, 1 antagonism, 37 equivalism and the remaining 12 showed both synergism and antagonism. Of the 6 fungicide-insecticide combinations that were synergistic on the mortality of *D.melanogaster*, 3 combinations were synergistic to *Spodoptera litura*.The synergistic combinations were carbaryl-vitavax, monocrotophos-mancozeb, monocrotophos-zineb, vitavax-carbaryl, mancozeb-monocrotophos and zineb-monocrotophos while BHC-sulphur combination proved to be antagonistic.

3. Compatibility of insecticides with fungicides and fertilizers

Nene and Dwivedi (1972) evaluated the fungitoxic activity of thiram when mixed with fertilizers like urea, calcium sulphate, zinc sulphate, ferrous sulphate and borax and insecticides viz., malathion, endrin, metasystox and BHC against *Helminthosporium maydis*. They concluded that the use of these fertilizers and insecticides together did not affect the toxicity of captan and thiram and none of these mixtures produced any phytotoxicity on sprayed plants of maize and wheat in the laboratory.

Dahiphale and Bhirud (1978) tested three fertilizer-pesticidal mixtures for the control of insect pests like the spotted boll worm, pink boll worm and jassid on rainfed cotton and found endosulfan + urea treatment to be most effective followed by endosulfan and dimethoate + urea.

The efficacy of different fertilizer-pesticide mixtures on rice was studied by Mathew _et al_.(1978) and found urea-cytrolane combination the best as it reduced the pest population of stem-borer, gall midge and leaf hopper considerably and thereby increased the yield.

Lal and Pandey (1982) evaluated the biological compatibility between three insecticides, a macronutrient and five foliar fungicides. They showed that the combination of captafol with insecticides and macronutrient was significantly superior. The results also indicated that the insecticides dichlorvos, methyl demeton and phosphamidon and urea were generally compatible with the test fungicides, since the toxicity of the fungicides was not adversely affected in mixtures with the insecticides or urea.

Yein and Harcharan Singh (1982) studied the effect of pesticides and fertilizers on the population of white fly and incidence of yellow-mosaic virus on greengram. Application of aldicarb alone or in combination with endosulfan and captan and urea reduced the virus infection considerably. Application of nitrogenous and phosphatic fertilizers without the use of insecticides encouraged the build-up of white fly population as well as the incidence of yellow-mosaic virus. They recommended use of both the pesticides and the fertilizer for getting higher yield of greengram.

Ranga Reddy *et al.* (1983) studied the compatibility of the fungicide thiram in combination with agro-chemicals. *In vivo* studies showed that thiram was compatible with most of the agro-chemicals except ferrous sulphate. *In vitro* studies indicated that thiram showed antagonistic activity with captan, aldrin, aldicarb, phorate, 2,4-D, hexazine and ferrous sulphate.

Pawar *et al.* (1985) found permethrin and cypermethrin in combination with carbaryl, sulphur and urea effective in controlling fruit borer on okra. Carbaryl, sulphur and urea when mixed with permethrin and/or cypermethrin did not hamper the bioefficacy of these synthetic pyrethroids. They observed no phytotoxic effects on okra plants.

C. Physical compatibility

Poe and Jones (1972) reported that tank mixed fungicides like tetrachloroisopenthalonitrete, captafol and polyram with insecticides like carbaryl, methomyl, parathion and dimethoate in different combinations were physically compatible before spraying except difolatan + parathion + TDE.

Reddy (1984) reported that the emulsion stability of fenvalerate was affected due to more sedimentation when mixed with mancozeb but unaffected with carbendazim. Decamethrin was physically compatible with carbendazim and manocozeb.

MATERIALS AND METHODS

Investigations were carried out in the Department of Entomology, College of Agriculture, Rajendranagar during 1984-'85 to find out

i) the biological effectiveness of three synthetic pyrethroids viz., permethrin, cypermethrin and fenpropathrin when mixed with two commonly used fungicides such as carbendazim and mancozeb,

ii) physical compatibility of the three synthetic pyrethroids with the two fungicides and

iii) the phytotoxic incompatibility of the mixture of these pyrethroids with the fungicides.

3.1.1 Insecticides

The three synthetic pyrethroids selected for the study and their relevant information is furnished below:

Common name of insecticides	Chemical name	Formulation used (%)	Source of supply
Cypermethrin	Cyano (3-Phenoxy phenyl)methyl-cis,trans-3-(2,2-dichloro ethenyl)-2,2-dimethyl cyclopropane carboxylate	10 EC	BASF India Ltd., Bombay.
Permethrin	(3-phenoxy phenyl)methyl-vs trans-3-(2,2-dichloroethenyl) -2,2-dimethyl cyclopropane carboxylate	25 EC	Bharat Pulverising Mills(P)Ltd., Bombay.
Fenpropathrin	(cyano(3-phenoxy phenyl)methyl 2,2,3,3-tetra methyl cyclopropane carboxylate)	10 EC	Rallis India Ltd., Bombay.

3.1.2 Fungicides

The fungicides which are commonly used have been selected for the study and the relevant information of the fungicides is furnished hereunder:

Common name of fungicide	Chemical name	Formulation used (%)	Source of supply
Carbendazim	Methyl-1H-benzimedazole-2-Yl - carbamate	50 WP	BASF India Ltd., Bombay
Mancozeb	Manganese-ethylene bisdithiocarbamate plus zinc	75 WP	Indofil Chemicals Ltd., Bombay

3.1.3 Test organisms

For assessing the biological effectiveness of synthetic pyrethroids in combination with fungicides, the Red cotton bug *Dysdercus cingulatus* Fb. was selected as a test insect. Similarly for evaluating the biological effectiveness of fungicides in combination with synthetic pyrethroids, *Helminthosporium turcicum* Pass. was utilized as a test fungus. These test organisms were selected for utilizing the results of these laboratory studies under field conditions.

3.1.4 Multiplication of *Dysdercus cingulatus*

Nucleus culture of *D.cingulatus* was obtained from the Department of Zoology,Osmania University,Hyderabad and the culture was multiplied as described below:

The adult bugs were allowed to mate in a glass jar of 15.0 cm X 7.5 cm, separated and caged individually in specimen tubes of 7.5 X 2.5 cm. The eggs laid by a single bug were taken and multiplied. The eggs were kept on a filter paper placed in a petri-plate. To provide the required humidity for the eggs to hatch, a cotton swab soaked in water was kept in the petri-plate. Nymphs emerged from the eggs after 3-4 days of incubation. A day after hatching, the nymphs were transferred into glass troughs in which pre-soaked cotton seed (soaked overnight) was placed in small heaps. The cotton seed was changed every alternate day. Nymphs developed into adult bugs in about 15 days time. After mating, each female adult laid about 50-75 eggs in between the cotton seed. These eggs were again transferred into the petri-plates as mentioned earlier and thus multiplied.

3.1.5 Age of the test insect

Ten-day old nymphs of *D.cingulatus* were used as test insect for the studies.

3.1.6 Sterilising glassware

All the glassware used for the culturing of red cotton bug was washed under tap water using a detergent washing powder and cleaned thoroughly. These were kept in an hot air oven at 75°C for 2 hours and then used for rearing purposes.

3.1.7 Test fungus

Single spore isolate of *Helminthosporium turcicum* Pass.

was taken as the test fungus. The culture was maintained on potato dextrose agar culture medium.

3.1.8 Preparation of spore suspension

Spores of *H.turcicum* obtained from ten-day old culture suspended in sterile water tubes were used to carry out the investigations.

3.1.9 Sterilising glassware

All glassware was cleaned first with chromic acid then with a detergent and washed under tap water and was finally rinsed with distilled water and dried in an oven before use.

3.1.10 Preparation of insecticide fluids

Cypermethrin, permethrin and fenpropathrin of 1.0 ml, 0.4 ml and 1.0 ml respectively were measured and transferred to 100 ml volumetric flask separately. About 10 ml acetone was added to each of the flasks and finally made upto 100 ml with constant shaking of the flask taking care that the insecticide was thoroughly mixed with acètone. Each of the three flasks, having 1000 ppm of the active ingredient of insecticide was taken as the stock solution. These stock solutions were kept in a refrigerator and were removed an hour before use so as to bring the solutions to room temperature to avoid variation in the volume due to low temperature. Further dilution to desired concentrations were prepared following the serial dilution technique using distilled water as diluent.

These working concentrations were prepared freshly just before their use every time.

3.1.11 Preparation of fungicide fluids

Carbendazim 200.00 mg and mancozeb 133.33 mg were weighed and transferred to 100 ml volumetric flasks. A few milli litres of acetone was added to fungicides and the flasks were shaken thoroughly to form into paste. These were made upto 100 ml adding acetone while shaking simultaneously. From these fungicide fluids of 1000 ppm different graded concentrations were made by serial dilution method. The fungicide fluids were prepared freshly at every time of their use.

3.1.12 Test concentrations of synthetic pyrethroids

The test insect D.cingulatus was exposed initially to concentrations of wider range and on the basis of mortality recorded thereby, a series of concentrations of narrow range were selected to which the insect was again exposed. The same procedure was repeated till mortality data in a range of 20 to 80 per cent was recorded. The narrow range concentrations of pyrethroids which gave mortality in the above range are furnished here under.

Cypermethrin : 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0 ppm
Permethrin : 0.8, 0.9, 1.0, 2.0, 3.0, 4.0 and 5.0 ppm
Fenpropathrin : 0.1, 0.2, 0.3, 0.4, 0.5, 0.6 and 0.7 ppm

3.1.13 Test concentrations of fungicides

The test fungus H.turcicum was exposed to fungicidal fluids of concentrations of 1, 2, 5, 10, 25, 50, 100, 250, 500 and 1000 ppm and the mortality data were recorded.

3.1.14 Toxicity testing of synthetic pyrethroids to D.cingulatus

Ten day old nymphs of D.cingulatus were transferred into petri-plates of 10 cm X 2 cm, at the rate of ten insects per petri-plate. Each of the petriplate, with insects was exposed to one milli litre of the insecticidal fluid, applied by means of a Potter's tower. After the application of insecticidal fluid, the petri-plates with treated nymphs were kept under a fan for about five minutes. Later, the treated nymphs were transferred to another fresh petri-plate containing pre-soaked cotton seed. Mortality data were recorded 24 hours after treatment. Each treatment was replicated four times.

3.1.15 Toxicity testing of fungicides to H.turcicum

The toxic effects of fungicides to H.turcicum was tested by using the spore germination technique recommended by Montgomery and Moore (1938).

On glass slides, circles of about 18 mm diameter were marked with the help of a marker. The fungicidal fluid of 0.06 ml was placed by means of a one ml pipette and spread uniformly in the marked circle on the slide. These slides were kept under a fan for quick drying of the fungicidal fluid. After complete drying, spore suspension of H.turcicum was transferred at the rate of 0.03 ml in the marked circles by means of one ml pipette, spread evenly and were then incubated in moist chambers.

3.1.15.1 Moist Chambers

Rectangular plastic boxes with moistened tissue paper served as moist chambers. Over the moist tissue paper, 'U' shaped bent glass tube was placed which served as a support for the slides.

3.1.15.2 Incubation of spore suspension in a film of pesticide

The seeded slides placed over the 'U' tube inside the moist chambers were incubated for 18 hours at room temperature (26-30°C). The incubation period of 18 hours was pre-determined as maximum number of conidia germinated during this period. After the specified period of incubation, the number of non-germinated spores were counted. Germination counts of spores were recorded by means of a compound microscope under low power (10 X). Hundred spores were counted for each replication and each treatment was replicated three times.

3.1.16 Calculation of LC_{50} values

The mortality data of test insect and the percentages of non-germinated spores of test fungus at various concentrations of each synthetic pyrethroid and the fungicide respectively were subjected to probit analysis (Finney, 1952)separately and the LC_{50} values were calculated.

3.1.17 Testing the biological effectiveness of synthetic pyrethroids with fungicides against D.cingulatus

The concentration of the synthetic pyrethroid that gave 50 per cent mortality (LC_{50}) was mixed with different concentrations of fungicides (10, 100, 1000 and 2000 ppm) and the nymphs of _D.cingulatus_ were exposed to the mixture of insecticide and fungicide in the same way as described earlier for the insecticide alone and the mortality data were recorded. On the basis of the mortality data obtained, the occurrence of synergism, antagonism or no effect was assessed for the synthetic pyrethroid when mixed with fungicide.

To get a mixture of insecticide and fungicide at desired concentrations, each chemical was mixed at double the desired concentration. Moreover, same quantities of insecticidal and fungicidal fluids were mixed.

3.1.18 Testing the biological effectiveness of fungicides in combination with synthetic pyrethroids against _H.turcicum_

The concentration of the fungicide that inhibited germination of 50 per cent of spores (LC_{50}) of the test fungus was mixed with different concentrations of insecticide. The spores of _H.turcicum_ were exposed to these mixtures of fungicide and synthetic pyrethroid and the spore germination was recorded 18 hours after incubation. The percentage of non-germinated spores was calculated for each mixture. On the basis of the data of non-germinated spores, the occurrence of synergism, antagonism or no effect was assessed for the fungicide when mixed with synthetic pyrethroid.

3.2 PHYSICAL COMPATIBILITY

3.2.1 Emulsion stability test

The three synthetic pyrethroids namely cypermethrin, permethrin and fenpropathrin were subjected to emulsion stability test alone and in combination with the two fungicides - carbendazim and mancozeb following the ISI specification (Anonymous, 1973) given for endosulfan and monocrotophos.

Preparation of standard hard water

Calcium carbonate 2.74 g and magnesium oxide 0.276 g were dissolved in a minimum quantity of 2N HCl. The excess acid was removed by evaporation to drying, first on a water bath and then on a sand bath. The residue was then dissolved in a small quantity of distilled water and was then made upto 100 ml in a graduated flask with water and mixed. Ten milli litres of this solution was taken into a one litre graduated flask and the volume was made upto 1000 ml with distillod water and mixed.

Test

To about 75 to 80 ml of standard hard water taken in a beaker at 30 ± 1°C, 2.0 ml of the available formulation of synthetic pyrethroids was added by means of a Mohr's pipette at the rate of 25 to 30 ml per minute while stirring with a glass rod, at about four revolutions per second. The flow of the insecticide was directed towards the centre keeping the point of pipette 2 cm inside the beaker. It was made upto 100 ml with hard water with continuous stirring and immediately poured into a clean and dry graduated cylinder. The contents were stirred for about three minutes from the beginning of the addition of the insecticide until the emulsion was poured into the cylinder. It was kept at 30 ± 1°C for an hour, examined for the creamed matter at the top and sediment at the bottom and measured if any.

For testing the emulsion stability of the synthetic pyrethroid in combination with fungicide, the fungicide was first added to standard hard water with continuous stirring and then the synthetic pyrethroid was added following the procedure detailed above and observed for creaming and sedimentation.

3.3 PHYTOTOXIC INCOMPATIBILITY

Cotton plants of one month old raised in pots were sprayed with the three synthetic pyrethroids viz., cypermethrin, permethrin and fenpropathrin and the two fungicides, carbendazim and mancozeb alone and combinations and observed for phytotoxicity.

RESULTS

Experiments were conducted in the Department of Entomology, College of Agriculture, Rajendranagar during 1984-85 to study the following aspects:

i) Biological effectiveness of three synthetic pyrethroids viz., cypermethrin, permethrin and fenpropathrin in combination with two fungicides viz., carbendasim and mancozeb

ii) Physical compatibility of the synthetic pyrethroids with the fungicides

iii) Phytotoxic compatibility of the same pyrethroids with the fungicides.

The findings of the above experiments are presented in this chapter.

4.1 BIOLOGICAL EFFECTIVENESS

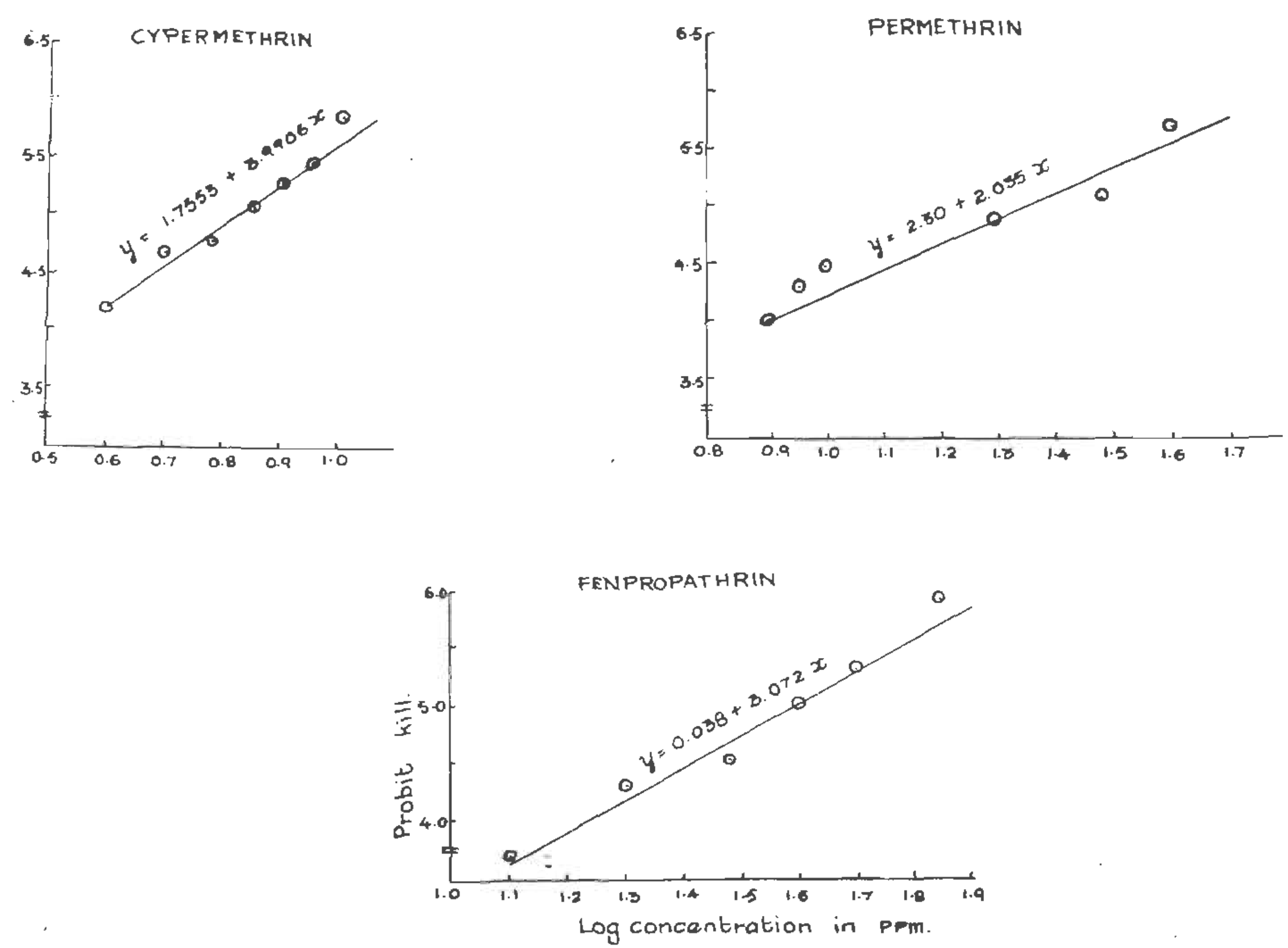
4.1.1 Biological effectiveness of synthetic pyrethroids and fungicides against *Dysdercus cingulatus* Fb.

4.1.1.1 Effect of cypermethrin on mortality of *D.cingulatus*

The mortality data of *D.cingulatus* recorded with seven different concentrations of cypermethrin are given in Table 1. At concentrations of 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0 ppm, the mortality recorded was 20.0, 37.5, 42.5, 52.5, 60.0, 70.0

Table 1 : Effect of cypermethrin on mortality of <u>Dysdercus cingulatus</u> F.

Sl No	Treatment	Concentration (ppm)	Mean mortality (%)	Heterogenity	Regression equation	LC_{50}	Fiducial limits	
							m_1	m_2
1	Cypermethrin	0.4	20.0					
2	Cypermethrin	0.5	37.5					
3	Cypermethrin	0.6	42.5					
4	Cypermethrin	0.7	52.5	$x^2_{(5)}=1.2867$	$y=1.7553 + 3.9906x$	0.65	0.634	0.670
5	Cypermethrin	0.8	60.0					
6	Cypermethrin	0.9	70.0					
7	Cypermethrin	1.0	82.5					



DOSAGE MORTALITY CURVES FOR SYNTHETIC PYRETHROIDS AGAINST *Dysdercus cingulatus*. Fb.

and 82.5 per cent respectively as against no mortality in control. As is clear from the data, the mortality increased progressively with increase in concentration. By subjecting the mortality data to probit analysis (Finney, 1952), the lethal concentration for affecting 50.0 per cent kill of the bug (LC_{50}) was found to be 0.65 ppm.

4.1.1.2 Effect of permethrin on mortality of *D.cingulatus*

The effect of permethrin on mortality of *D.cingulatus* is presented in Table 2. It is seen from the table that mortalities of 15.0, 25.0, 30.0, 45.0, 55.0, 75.0 and 80.0 per cent were recorded at concentrations of 0.8, 0.9, 1.0, 2.0, 3.0, 4.0 and 5.0 ppm respectively. The mortality in control was nil. It is evident from the data that the kill of insects increased steadily with the increase in concentration of the insecticide. The LC_{50} value of permethrin against the test organism was 2.1 ppm.

4.1.1.3 Effect of fenpropathrin on mortality of *D.cingulatus*

The mortality data of *D.cingulatus* observed with seven concentrations of fenpropathrin are presented in Table 3. At concentrations of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6 and 0.7 ppm, mortalities of 20.0, 25.0, 30.0, 50.0, 60.0, 67.5 and 82.5 per cent respectively were recorded. The mortality of the bug increased gradually with increase in concentration of the pyrethroid. The LC_{50} value of the insecticide against red cotton bug was 0.41 ppm.

Table 2 : Effect of permethrin on mortality of *Dysdercus cingulatus* F.

Sl No	Treatment	Concentration (ppm)	Mean mortality (%)	Heterogenity	Regression equation	LC_{50}	Fiducial limits m_1	Fiducial limits m_2
1	Permethrin	0.8	15.0					
2	Permethrin	0.9	25.0					
3	Permethrin	1.0	30.0					
4	Permethrin	2.0	45.0	$X^2_{(5)}=2.466$	$y=2.30 + 2.035x$	2.1	1.774	2.585
5	Permethrin	3.0	55.0					
6	Permethrin	4.0	75.0					
7	Permethrin	5.0	80.0					

Table 3 : Effect of fenpropathrin on mortality of *Dysdercus cinqulatus* F.

Sl No	Treatment	Concentration (ppm)	Mean mortality (%)	Heterogenity	Regression equation	LC_{50}	Fiducial limits	
							m_1	m_2
1	Fenpropathrin	0.1	20.0					
2	Fenpropathrin	0.2	25.0					
3	Fenpropathrin	0.3	30.0					
4	Fenpropathrin	0.4	50.0	$X^2_{(5)}=56.93$	$y=0.0380 + 3.072x$	0.41	0.3290	0.5303
5	Fenpropathrin	0.5	60.0					
6	Fenpropathrin	0.6	67.5					
7	Fenpropathrin	0.7	82.5					

4.1.1.4 Effect of carbendazim on mortality of *D.cingulatus*

The toxicity of fungicide, carbendazim was tested against the test insect, *D.cingulatus* and the data are presented in Table 4. It is clear from the data that carbendazim is non-toxic to the bugs at concentrations of 10.0, 100.0, 1000.0 and 2000 ppm. as the mortality recorded was nil at all the concentrations tested. It is also evident that carbendazim is non-toxic to the test insect even at a higher concentration (2000 ppm) than the concentration generally used in the field for the control of plant diseases (1000 ppm).

4.1.1.5 Effect of mancozeb on mortality of *D.cingulatus*

The toxicity of fungicide, mancozeb to *D.cingulatus* was tested at 10.0, 100.0, 1000.0, 2000.0 and 3000.0 ppm and the data are presented in Table 5. It is evident from the data that the mancozeb was non-toxic to the test insect as there was no mortality of bugs at all the concentrations including the recommended concentration for plant disease control (2000 ppm) as also at higher concentration (3000 ppm) than recommended.

4.1.1.6 Effect of cypermethrin in combination with carbendazim on mortality of *D.cingulatus*

The effect of cypermethrin 0.65 ppm (LC_{50}) in combination with different concentrations of carbendazim on mortality of *D.cingulatus* was studied and the data are presented in Table 6. It is seen from the data that maximum mortality of 90.0 per cent was recorded with cypermethrin 0.65 ppm in combination with

Table 4 : Effect of carbendazim on mortality of *Dysdercus cingulatus* F.

Sl No	Treatment	Concentration (ppm)	Mean mortality (%)
1.	Carbendazim	10.0	0.0
2.	Carbendazim	100.0	0.0
3.	Carbendazim	1000.0	0.0
4.	Carbendazim	2000.0	0.0
5.	Control		0.0

Table 5 : Effect of mancozeb on mortality of *Dysdercus cingulatus* F.

Sl No	Treatment	Concentration (ppm)	Mean mortality (%)
1.	Mancozeb	10.0	0.0
2.	Mancozeb	100.0	0.0
3.	Mancozeb	1000.0	0.0
4.	Mancozeb	2000.0	0.0
5.	Mancozeb	3000.0	0.0
6.	Control		0.0

carbendazim 10 ppm. When the concentration of carbendazim was increased to 100 ppm and 1000 ppm, reduced mortalities of 76.67 and 56.67 per cent respectively were recorded. As the mortality data of these three treatments were more than 50 per cent, cypermethrin would be synergistic with carbendazim at these concentrations. However, when the concentration of the fungicide was further increased to 2000 ppm, mortality of 36.67 per cent was recorded. This clearly shows that cypermethrin 0.65 ppm in combination with carbendazim 2000 ppm would be antagonistic to *D.cingulatus*.

4.1.1.7 Effect of cypermethrin in combination with mancozeb on mortality of *D.cingulatus*

The mortality data of *D.cingulatus* recorded with cypermethrin (LC_{50}) in combination with five different concentrations of mancozeb are given in Table 7. It is clear from the data that when cypermethrin 0.65 ppm was mixed with mancozeb 1000 ppm, maximum mortality of 100.0 per cent was recorded. On decreasing the concentration of mancozeb to 100 ppm and 10 ppm reduced mortalities of 80.0 and 90.0 per cent respectively were recorded. As the mortality recorded at these three concentrations was more than 50.0 per cent, it clearly indicates that cypermethrin 0.65 ppm would be synergistic with mancozeb at 10.0, 100.0 and 1000.0 ppm. But when the concentration of mancozeb was increased to 2000 and 3000 ppm, mortalities of 40.0 and 20.0 per cent respectively were noted. This shows that cypermethrin 0.65 ppm in combination with higher concentrations of the fungicide i.e.,

Table 6 : Effect of cypermethrin in combination with carbendasim on mortality of *Dysdercus cingulatus* F.

Sl No	Treatment	Concentration (ppm)		Mean mortality (%)
1.	Cypermethrin	0.65	(LC_{50})+ Carbendasim 10.0	90.0
2.	Cypermethrin	0.65	(LC_{50})+Carbendasim 100.0	76.67
3.	Cypermethrin	0.65	(LC_{50})+Carbendasim1000.0	56.67
4.	Cypermethrin	0.65	(LC_{50})+Carbendasim2000.0	36.67
5.	Control			0.00

Table 7 : Effect of cypermethrin in combination with mancozeb on mortality of *Dysdercus cingulatus* F.

Sl No	Treatment	(ppm)			Mean mortality (%)
1.	Cypermethrin	0.65	(LC_{50})+ Mancozeb	10.0	90.0
2.	Cypermethrin	0.65	(LC_{50})+ Mancozeb	100.0	80.0
3.	Cypermethrin	0.65	(LC_{50})+ Mancozeb	1000.0	100.0
4.	Cypermethrin	0.65	(LC_{50})+ Mancozeb	2000.0	40.0
5.	Cypermethrin	0.65	(LC_{50})+ Mancozeb	3000.0	20.0
6.	Control				0.0

2000 and 3000 ppm would be antagonistic to D.cingulatus.

4.1.1.8 Effect of permethrin in combination with carbendazim on mortality of D.cingulatus

The effect of permethrin in combination with four different concentrations of carbendazim was studied and the results are given in Table 8. It is seen from the data that permethrin 2.1 ppm (LC_{50}) in combination with carbendazim 10.0, 100.0, 1000.0 and 2000.0 ppm brought about 96.67, 63.33, 43.33 and 26.67 per cent mortality of bugs respectively. Permethrin 2.1 ppm in combination with carbendazim 10 and 100 ppm was synergistic as the mortality recorded was 96.67 and 63.33 per cent respectively. Higher concentrations of carbendazim i.e., 1000 and 2000 ppm combined with permethrin 2.1 ppm exhibited the phenomenon of antagonism as the mortalities recorded were significantly lower than 50.0 per cent.

4.1.1.9 Effect of permethrin in combination with mancozeb on mortality of D.cingulatus

The mortality of D.cingulatus recorded with LC_{50} of permethrin in combination with four different concentrations of mancozeb are presented in Table 9. Permethrin 2.1 ppm (LC_{50}) in combination with mancozeb at 10, 100, 1000 and 2000 ppm concentrations gave 83.33, 66.67, 36.67 and 20.0 per cent mortality of the bugs respectively while in control it was nil. The data clearly indicates that permethrin 2.1 ppm in combination w' mancozeb 10 and 100 ppm showed mortalities of the tes* higher than 50.0 per cent evidencing the operati due to mixing of these two chemicals. But with hi

Table 8 : Effect of permethrin in combination with carbendazim on mortality of *Dysdercus cingulatus* F.

Sl No	Treatment (ppm)		Mean mortality (%)
1.	Permethrin 2.1 (LC_{50}) + Carbendazim	10.0	96.67
2.	Permethrin 2.1 (LC_{50}) + Carbendazim	100.0	63.33
3.	Permethrin 2.1 (LC_{50}) + Carbendazim	1000.0	43.33
4.	Permethrin 2.1 (LC_{50}) + Carbendazim	2000.0	26.67
5.	Control		0.00

Table 9 : Effect of permethrin in combination with mancozeb on mortality of *Dysdercus cingulatus* F.

Sl No	Treatment (ppm)		Mean mortality (%)
1.	Permethrin 2.1 (LC_{50}) + Mancozeb	10.0	83.33
2.	Permethrin 2.1 (LC_{50}) + Mancozeb	100.0	66.67
3.	Permethrin 2.1 (LC_{50}) + Mancozeb	1000.0	36.67
4.	Permethrin 2.1 (LC_{50}) + Mancozeb	2000.0	20.00
5.	Control		0.00

trations of the fungicide i.e., 1000 and 2000 ppm, permethrin showed antagonism.

4.1.1.10 Effect of fenpropathrin in combination with carbendazim on mortality of *D.cingulatus*.

Table 10 shows the effect of fenpropathrin (LC_{50}) in combination with different concentrations of carbendazim against *D.cingulatus*. When fenpropathrin 0.41 ppm (LC_{50}) was mixed with lower concentrations of carbendazim i.e., 10 and 100 ppm, mortalities of 86.67 and 66.67 per cent respectively were recorded, which clearly indicates the synergistic activity of the insecticide with the fungicide. Fenpropathrin in combination with carbendazim 1000 and 2000 ppm resulted in 40.0 and 23.33 per cent mortality respectively of the bug revealing the existence of antagonism.

4.1.1.11 Effect of fenpropathrin in combination with mancozeb on mortality of *D.cingulatus*

The mortality data of *D.cingulatus* recorded on exposure to LC_{50} of fenpropathrin in combination with mancozeb are presented in Table 11. Synergism was exhibited when fenpropathrin 0.41 ppm was combined with mancozeb 10 and 100 ppm as the mortalities noted.were 96.67 and 76.67 per cent respectively. Likewise, antagonism was also exhibited due to the mixing of fenpropathrin 0.41 ppm with mancozeb 1000 and 2000 ppm, wherein the mortalities recorded were 43.44 and 23.33 per cent respectively.

Table 10 : Effect of fenpropathrin in combination with carbendazim on mortality of *Dysdercus cingulatus* F.

Sl No	Treatment (ppm)		Mean mortality (%)
1.	Fenpropathrin 0.41 (LC_{50}) + Carbendazim	10.0	86.67
2.	Fenpropathrin 0.41 (LC_{50})+Carbendazim	100.0	66.67
3.	Fenpropathrin 0.41 (LC_{50})+Carbendazim	1000.0	40.00
4.	Fenpropathrin 0.41 (LC_{50})+Carbendazim	2000.0	23.33
5.	Control		0.00

Table 11 : Effect of fenpropathrin in combination with mancozeb on mortality of *Dysdercus cingulatus* F.

Sl No	Treatment (ppm)		Mean mortality (%)
1.	Fenpropathrin 0.41 (LC_{50}) + Mancozeb	10.0	96.67
2.	Fenpropathrin 0.41 (LC_{50}) + Mancozeb	100.0	76.67
3.	Fenpropathrin 0.41 (LC_{50}) + Mancozeb	1000.0	43.33
4.	Fenpropathrin 0.41 (LC_{50}) + Mancozeb	2000.0	23.33
5.	Control		0.00

4.1.2 Biological effectiveness of synthetic pyrethroids and fungicides against *Helminthosporium turcicum* Pass.

4.1.2.1 Germination of spores of *Helminthosporium turcicum* in distilled water

Table 12 shows the time taken (in hours) for the germination of spores of *H.turcicum* in distilled water. It is clear from the table that there was no spore germination during the first eight hours of incubation. From the ninth hour, spores began germinating and increased steadily reaching a maximum of 100 per cent at 18 hours of incubation.

4.1.2.2 Effect of carbendazim on spore germination of *H.turcicum*

The toxic effect of carbendazim on spore germination of *H.turcicum* is shown in Table 13. At concentrations of 1.0, 2.0, 5.0, 10.0, 25.0, 50.0, 100.0, 250.0, 500.0 and 1000.0 ppm, the percentages of non-germinated spores recorded were 19.00, 24.67, 25.67, 48.67, 65.67, 71.00, 75.00, 77.33, 89.67 and 100.0 per cent respectively. This clearly shows that the percentage of non-germinated spores increased progressively with increase in the concentration of the fungicide and no germination was observed at 1000 ppm. The LC_{50} value of carbendazim against the test fungus was found to be 13.27 ppm.

4.1.2.3 Effect of mancozeb on spore germination of *H.turcicum*

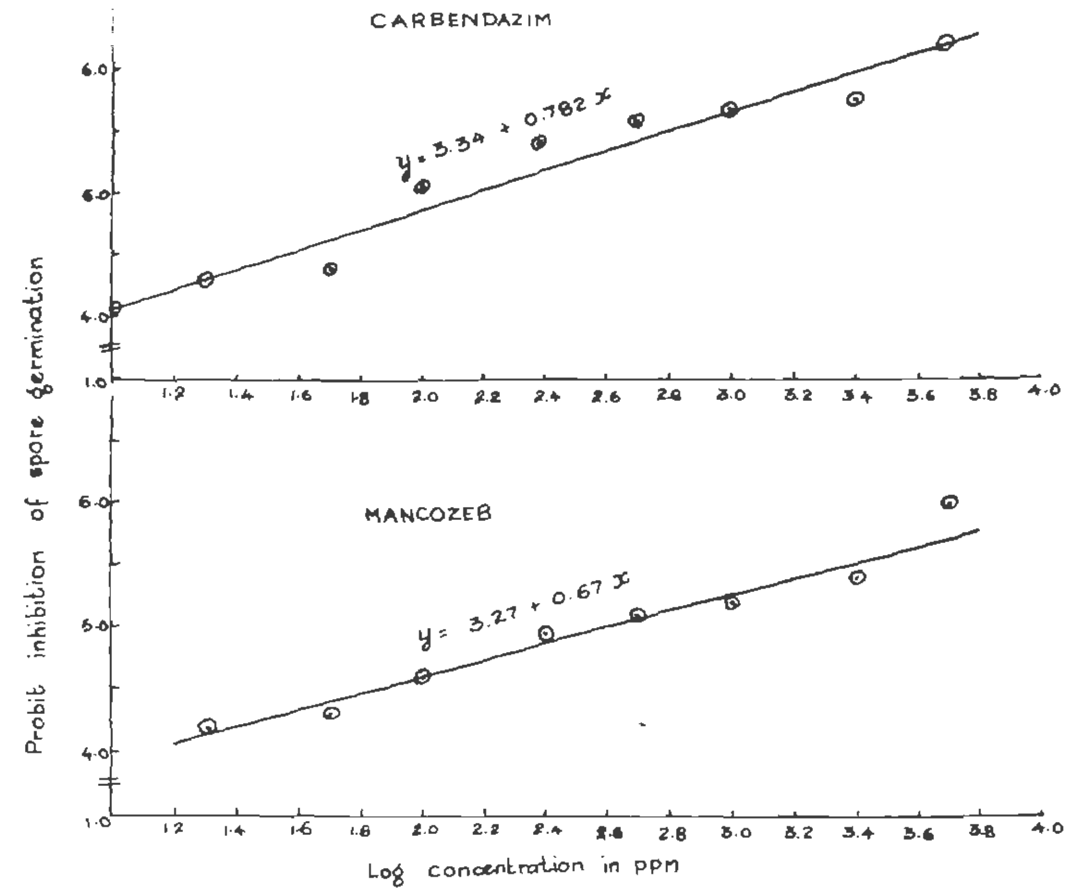
Table 14 indicates the effect of mancozeb on spore germination of *H.turcicum*. The percentages of non-germinated spores recorded were 16.33, 21.00, 23.00, 34.67, 47.67, 54.00, 58.67,

Table 12 : Germination of spores of *Helminthosporium turcicum* Pass. in distilled water

	Incubation in hours												
	1-8	9	10	11	12	13	14	15	16	17	18	19	20-24
Percentage of germinated spores	0.0	37.67	43.00	51.00	59.00	67.00	75.00	84.00	91.00	94.00	100.00	100.00	100.00

Table 13 : Effect of carbendazim on spore germination of *Helminthosporium turcicum* Pass.

Sl No	Concentration (ppm)	Mean of Non-germinated spores (%)	Heterogenity	Regression equation	LC_{50}	Fiducial limits	
						m_1	m_2
1	1.0	19.00					
2	2.0	24.67					
3	5.0	25.67					
4	10.0	48.67					
5	25.0	65.67	$\chi^2_{(8)} = 13.46$	$y = 3.34 + 0.782x$	13.27	9.183	16.334
6	50.0	71.00					
7	100.0	75.00					
8	250.0	77.33					
9	500.0	89.67					
10	1000.0	100.00					



DOSAGE MORTALITY CURVES FOR FUNGICIDES AGAINST
Helminthosporium turcicum Pass.

64.67, 84.00 and 100.0 per cent at 1, 2, 5, 10, 25, 50, 100, 250, 500 and 1000 ppm concentrations of mancozeb respectively. As can be seen from the data, it is clear that there is a progressive increase in the non-germinated spores with increase in the concentration of mancozeb, exhibiting complete inhibition of germination at 1000 ppm. The LC_{50} value of mancozeb against *H.turcicum* was found to be 38.02 ppm.

4.1.2.4 Effect of synthetic pyrethroids on spore germination of *H.turcicum*

The test concentrations of the insecticides were selected based on the LC_{50} value of the pyrethroid against *D.cingulatus*. Three upper and three lower levels of the LC_{50} of the insecticides were tested.

4.1.2.4.1 Effect of cypermethrin on spore germination of *H.turcicum*

The effect of cypermethrin on spore germination of *H.turcicum* is shown in Table 15. It is clear from the data that cypermethrin was non-toxic to *H.turcicum* as all the spores germinated at all the concentrations tested ranging from 0.3 to 0.9 ppm.

4.1.2.4.2 Effect of permethrin on spore germination of *H.turcicum*

Table 16 shows the effect of permethrin on spore germination of *H.turcicum*. Permethrin was tested at concentrations ranging from 1.8 to 2.4 ppm and was found to be non-toxic as the

Table 14 : Effect of mancozeb on spore germination of <u>Helminthosporium turcicum</u> Pass.

Sl No	Concentration (ppm)	Mean of non-germinated spores (%)	Heterogenity	Regression equation	LC_{50}	Fiducial limits m_1	Fiducial limits m_2
1	1.0	16.33					
2	2.0	21.00					
3	5.0	23.00					
4	10.0	34.67					
5	25.0	47.67	$x^2_{(8)}=6.401$	y=3.27 + 0.67x	36.02	28.18	52.24
6	50.0	54.00					
7	100.0	58.67					
8	250.0	64.67					
9	500.0	84.00					
10	1000.0	100.00					

Table 15 : Effect of cypermethrin on spore germination of *Helminthosporium turcicum* Pass.

Sl No	Treatment	Concentration (ppm)	Mean of Non-germinated spores (%)
1.	Cypermethrin	0.30	0.0
2.	Cypermethrin	0.40	0.0
3.	Cypermethrin	0.50	0.0
4.	Cypermethrin	0.60	0.0
5.	Cypermethrin	0.70	0.0
6.	Cypermethrin	0.80	0.0
7.	Cypermethrin	0.90	0.0
8.	Control		0.0

Table 16 : Effect of permethrin on spore germination of *Helminthosporium turcicum* Pass.

Sl No	Treatment	Concentration (ppm)	Mean of non-germinated spores (%)
1.	Permethrin	1.80	0.0
2.	Permethrin	1.90	0.0
3.	Permethrin	2.00	0.0
4.	Permethrin	2.10	0.0
5.	Permethrin	2.20	0.0
6.	Permethrin	2.30	0.0
7.	Permethrin	2.40	0.0
8.	Control		0.0

percentages of non-germinated spores were nil at all the seven concentrations.

4.1.2.4.3 Effect of fenpropathrin on spore germination of *H. turcicum*

The data in Table 17 shows the effect of fenpropathrin on germination of *H. turcicum*. As was seen with the previous two insecticides viz., cypermethrin and permethrin, fenpropathrin was also found to have no toxic effect on spores of *H. turcicum*, when tested at concentrations ranging from 0.1 to 0.7 ppm.

4.1.2.5 Effect of carbendazim in combination with cypermethrin on spore germination of *H. turcicum*

The percentages of non-germinated spores recorded when carbendazim (LC_{50}) was mixed with seven different concentrations of cypermethrin are presented in Table 18.

The phenomenon of synergism clearly existed with mixtures of carbendazim 13.27 ppm (LC_{50}) and cypermethrin 0.65, 0.75, 0.85 and 0.95 ppm as the percentages of non-germinated spores recorded were 54.33, 62.67, 65.33 and 94.33 per cent respectively. When carbendazim 13.27 ppm was combined with cypermethrin 0.55 ppm, there was neither synergism nor antagonism as the percentage of non-germinated spores was 47.0 per cent. Also, the phenomenon of antagonism existed when carbendazim 13.27 ppm was mixed with cypermethrin 0.35 and 0.45 ppm, wherein the percentages of non-germinated spores were 36.33 and 41.00 respectively.

Table 17 : Effect of fenpropathrin on spore germination of *Helminthosporium turcicum* Pass.

Sl No	Treatment	Concentration (ppm)	Mean of non-germinated spores (%)
1.	Fenpropathrin	0.1	0.0
2.	Fenpropathrin	0.2	0.0
3.	Fenpropathrin	0.3	0.0
4.	Fenpropathrin	0.4	0.0
5.	Fenpropathrin	0.5	0.0
6.	Fenpropathrin	0.6	0.0
7.	Fenpropathrin	0.7	0.0
8.	Control		0.0

Table 18 : Effect of carbendazim in combination with cypermethrin on spore germination of *Helminthosporium turcicum* Pass.

Sl No	Treatment (ppm)	Mean of non-germinated spores (%)
1.	Carbendazim 13.27 (LC_{50})+Cypermethrin 0.35	36.33
2.	Carbendazim 13.27 (LC_{50})+Cypermethrin 0.45	41.00
3.	Carbendazim 13.27 (LC_{50})+Cypermethrin 0.55	47.00
4.	Carbendazim 13.27 (LC_{50})+Cypermethrin 0.65	54.33
5.	Carbendazim 13.27 (LC_{50})+Cypermethrin 0.75	62.67
6.	Carbendazim 13.27 (LC_{50})+Cypermethrin 0.85	65.33
7.	Carbendazim 13.27 (LC_{50})+Cypermethrin 0.95	94.33
8.	Control	0.00

4.1.2.6 Effect of carbendazim in combination with permethrin on spore germination of H.turcicum

The toxic effect of carbendazim in combination with permethrin on spore germination of H.turcicum is shown in Table 19.

Carbendazim 13.27 ppm (LC_{50}) in combination with permethrin 2.2, 2.3 and 2.4 ppm resulted in 64.0, 82.0, 82.0 and 100.0 per cent of non-germinated spores, thereby showing synergistic activity. In combination with 2.0 and 2.1 ppm levels of permethrin, carbendazim showed neither synergistic nor antagonistic activity. With still lower levels of permethrin i.e.,1.8 and 1.9 ppm, carbendazim showed slight antagonistic activity as is evidenced by the lower percentages (45.00 and 46.33) of non-germinated spores.

4.1.2.7 Effect of carbendazim in combination with fenpropathrin on spore germination of H.turcicum

Table 20 shows the effect of carbendazim in combination with fenpropathrin on spore germination of H.turcicum. Carbendazim at LC_{50} value (13.27 ppm) in combination with seven different concentrations of fenpropathrin viz., 0.11, 0.21, 0.31, 0.41, 0.51, 0.61 and 0.71 ppm resulted in non-germinated spores of 28.0, 44.33, 48.33, 49.33, 61.33, 73.67 and 87.00 per cent respectively, while all the spores germinated in control. It is clear from the data that carbendazim 13.27 ppm with higher concentrations of fenpropathrin 0.51, 0.61 and 0.71 ppm showed synergistic effect, while with lower concentrations of fenpropathrin (0.11 and 0.21 ppm) showed antagonistic effect. Carbendazim was neither

Table 19 : Effect of carbendazim in combination with permethrin on spore germination of *Helminthosporium turcicum* Pass.

Sl No	Treatment (ppm)	Mean of non-germinated spores (%)
1.	Carbendazim 13.27 (LC_{50}) + Permethrin 1.80	45.00
2.	Carbendazim 13.27 (LC_{50}) + Permethrin 1.90	46.33
3.	Carbendazim 13.27 (LC_{50}) + Permethrin 2.00	50.67
4.	Carbendazim 13.27 (LC_{50}) + Permethrin 2.10	48.33
5.	Carbendazim 13.27 (LC_{50}) + Permethrin 2.20	64.00
6.	Carbendazim 13.27 (LC_{50}) + Permethrin 2.30	82.00
7.	Carbendazim 13.27 (LC_{50}) + Permethrin 2.40	100.00
8.	Control	0.00

Table 20 : Effect of carbendazim in combination with fenpropathrin on spore germination of *Helminthosporium turcicum* Pass.

Sl No	Treatment (ppm)	Mean of non-germinated spores (%)
1.	Carbendazim 13.27 (LC_{50}) + Fenpropathrin 0.11	28.00
2.	Carbendazim 13.27 (LC_{50}) + Fenpropathrin 0.21	44.33
3.	Carbendazim 13.27 (LC_{50}) + Fenpropathrin 0.31	48.33
4.	Carbendazim 13.27 (LC_{50}) + Fenpropathrin 0.41	49.33
5.	Carbendazim 13.27 (LC_{50}) + Fenpropathrin 0.51	61.33
6.	Carbendazim 13.27 (LC_{50}) + Fenpropathrin 0.61	73.67
7.	Carbendazim 13.27 (LC_{50}) + Fenpropathrin 0.71	87.00
8.	Control	0.00

synergistic nor antagonistic with fenpropathrin at 0.31 and 0.41 ppm levels.

4.1.2.8 Effect of mancozeb in combination with cypermethrin on spore germination of *H.turcicum*

The effect of mancozeb (LC_{50}) in combination with seven different concentrations of cypermethrin on spore germination of *H.turcicum* is depicted in Table 21.

Mancozeb 38.02 ppm when mixed with cypermethrin at levels of 0.75, 0.85 and 0.95 ppm caused 72.67, 93.33 and 100.0 per cent of non-germinated spores respectively. This clearly shows that these three concentrations of the pyrethroid caused synergistic activity in mancozeb. The rest of the combinations did not show any significant change in the toxicity of mancozeb to spores of *H.turcicum*.

4.1.2.9 Effect of mancozeb in combination with permethrin on spore germination of *H.turcicum*

The data on the combined effect of mancozeb and permethrin on spore germination of *H.turcicum* is given in Table 22.

When mancozeb 38.02 ppm (LC_{50}) was mixed with lower concentrations viz., 1.8, 1.9, 2.0 and 2.1 ppm of permethrin, no significant change in the toxicity of mancozeb was noticed as is evident from the percentages of non-germinated spores i.e., 45.00, 46.33, 48.00 and 52.00 per cent respectively. Synergism was observed when mancozeb was mixed with higher concentrations of permethrin at 2.2, 2.3 and 2.4 ppm which showed 68.67, 84.33 and 100.0 per cent of non-germinated spores of *H.turcicum*.

Table 21 : Effect of mancozeb in combination with cypermethrin of spore germination of *Helminthosporium turcicum* Pass.

Sl No	Treatment (ppm)	Mean of Non-germinated spores (%)
1.	Mancozeb 38.02 (LC_{50}) + Cypermethrin 0.35	44.67
2.	Mancozeb 38.02 (LC_{50})+Cypermethrin 0.45	45.33
3.	Mancozeb 38.02 (LC_{50})+Cypermethrin 0.55	49.67
4.	Mancozeb 38.02 (LC_{50})+Cypermethrin 0.65	54.33
5.	Mancozeb 38.02 (LC_{50})+Cypermethrin 0.75	72.67
6.	Mancozeb 38.02 (LC_{50})+Cypermethrin 0.85	93.33
7.	Mancozeb 38.02 (LC_{50})+Cypermethrin 0.95	100.00
8.	Control	0.00

Table 22 : Effect of mancozeb in combination with permethrin on spore germination of *Helminthosporium turcicum* Pass.

Sl No	Treatment (ppm)	Mean of Non-mortality spore (%)
1.	Mancozeb 38.02 (LC_{50})+Permethrin 1.8	45.00
2.	Mancozeb 38.02 (LC_{50})+Permethrin 1.9	46.33
3.	Mancozeb 38.02 (LC_{50})+Permethrin 2.0	48.00
4.	Mancozeb 38.02 (LC_{50})+Permethrin 2.1	52.00
5.	Mancozeb 38.02 (LC_{50})+Permethrin 2.2	68.67
6.	Mancozeb 38.02 (LC_{50})+Permethrin 2.3	84.33
7.	Mancozeb 38.02 (LC_{50})+Permethrin 2.4	100.00
8.	Control	0.00

4.1.2.10 Effect of mancozeb in combination with fenpropathrin on spore germination of *H. turcicum*

The effect of mancozeb (LC_{50}) in combination with seven different concentrations of fenpropathrin on spore germination of *H. turcicum* is shown in Table 23. Significant synergistic action was observed when mancozeb 38.02 ppm was mixed with fenpropathrin 0.51, 0.61 and 0.71 ppm wherein 67.67, 87.67 and 100.0 per cent of spores respectively did not germinate. Slight antagonistic action was observed when mancozeb was mixed with fenpropathrin 0.11 and 0.21 ppm where the non-germination of spores was 40.00 and 42.67 per cent respectively. There was no change in the toxicity of mancozeb when mixed with 0.31 and 0.41 ppm of fenpropathrin which showed 46.67 and 54.00 per cent of non-germinated spores.

4.2 PHYSICAL COMPATIBILITY

4.2.1 Emulsion stability of synthetic pyrethroids

The pyrethroids individually and in combination with fungicides were subjected to emulsion stability test and the data recorded on two parameters viz., creaming matter and sedimentation are presented in Table 24.

Cypermethrin, permethrin and fenpropathrin showed 1.0, 2.0, and 0.5 ml of creaming matter respectively at the top and with no sedimentation at the bottom. Carbendazim had no creaming matter but showed 1.0 ml sedimentation. Mancozeb gave 1.0 and 2.0 ml layers of creaming matter and sedimentation respectively.

Table 23 : Effect of mancozeb in combination with fenpropathrin on spore germination of *Helminthosporium turcicum* Pass.

Sl No	Treatment (ppm)	Mean of non-germinated spores (%)
1.	Mancozeb 38.02 (LC_{50}) + Fenpropathrin 0.11	40.00
2.	Mancozeb 38.02 (LC_{50}) + Fenpropathrin 0.21	42.67
3.	Mancozeb 38.02 (LC_{50}) + Fenpropathrin 0.31	46.67
4.	Mancozeb 38.02 (LC_{50}) + Fenpropathrin 0.41	54.00
5.	Mancozeb 38.02 (LC_{50}) + Fenpropathrin 0.51	67.67
6.	Mancozeb 38.02 (LC_{50}) + Fenpropathrin 0.61	87.67
7.	Mancozeb 38.02 (LC_{50}) + Fenpropathrin 0.71	100.00
8.	Control	0.00

When cypermethrin was mixed with carbendazim or mancozeb creaming matter of 1.0 ml and sedimentation of 2.0 ml were observed.

Permethrin in combination with carbendazim gave 2.0 ml creaming matter and 1.0 ml sedimentation. The same pyrethroid in combination with mancozeb gave 2.0 ml creaming matter and 3.0 ml sedimentation.

Fenpropathrin in combination with carbendazim showed 0.5 ml creaming matter and 1.0 ml sedimentation, while in combination with mancozeb showed 1.0 ml and 3.0 ml of creaming matter and sedimentation respectively.

4.3 PHYTOTOXIC INCOMPATIBILITY

The synthetic pyrethroids, cypermethrin, permethrin and fenpropathrin and the fungicides, carbendazim and mancozeb alone and the combinations of pyrethroids with the fungicides were found to be non-phytotoxic to cotton.

Table 24 : Emulsion stability of insecticides, fungicides and combination of both

Sl No	Pesticides	Creaming matter (ml)	Sedimentation (ml)
1.	Cypermethrin	1.0	0.0
2.	Permethrin	2.0	0.0
3.	Fenpropathrin	0.5	0.0
4.	Carbendazim	0.0	1.0
5.	Mancozeb	1.0	2.0
6.	Cypermethrin + Carbendazim	1.0	2.0
7.	Cypermethrin + Mancozeb	1.0	2.0
8.	Permethrin + Carbendazim	2.0	1.0
9.	Permethrin + Mancozeb	2.0	3.0
10.	Fenpropathrin + Carbendazim	0.5	1.0
11.	Fenpropathrin + Mancozeb	1.0	3.0

DISCUSSION AND CONCLUSION

The findings of the experiments in respect of

i) the biological effectiveness of three synthetic pyrethroids viz., cypermethrin, permethrin and fenpropathrin in combination with fungicides such as carbendazim and mancozeb

ii) the physical compatibility of synthetic pyrethroids with the fungicides and,

iii) the phytotoxic incompatibility of the same chemicals

conducted in the Department of Entomology, College of Agriculture, Rajendranagar during 1984-85 are discussed in the following paragraphs.

5.1 BIOLOGICAL EFFECTIVENESS

5.1.1 Biological effectiveness of synthetic pyrethroids in combination with fungicides against *Dysdercus cingulatus* Fb.

5.1.1.1 Biological effectiveness of cypermethrin in combination with carbendazim against *D.cingulatus*

Data on mortality studies with cypermethrin (Table 1) reveal that cypermethrin gave 20.0 per cent mortality of *D.cingulatus* at a concentration of 0.4 ppm and the mortality increased to 82.5 per cent at 1.0 ppm. Fifty per cent mortality of the bug could be obtained with cypermethrin at a concentration of 0.65 ppm.

Carbendazim was found to be non-toxic to *D.cingulatus* at concentrations ranging from 10 to 2000 ppm as the mortalities recorded were nill (Table 4).

Cypermethrin 0.65 ppm (LC_{50}) in combination with carbendazim 2000 ppm gave 36.67 per cent mortality of the test insect (Table 6). This clearly shows antagonistic effect due to mixing of cypermethrin with carbendazim as the mortality recorded was lower than 50 per cent. Similar antagonistic effects were also observed by Reddy (1984) when fenvalerate (LC_{50}) was mixed with higher concentrations of carbendazim against Drosophila melanogaster. Cypermethrin 0.65 ppm was found synergistic with carbendazim at 10, 100 and 1000 ppm concentrations as the mortalities recorded were more than 50 per cent. Similar synergistic effect was observed by Pawar et al. (1985) when cypermethrin was mixed with sulphur .

5.1.1.2 Biological effectiveness of cypermethrin in combination with mancozeb against D.cingulatus

Mancozeb was found to be non-toxic to D.cingulatus at concentrations ranging from 10 to 2000 ppm (Table 5).

Cypermethrin 0.65 ppm mixed with higher concentrations of mancozeb i.e., 2000 and 3000 ppm recorded mortality of the bug considerable less than 50.0 per cent. Therefore cypermethrin is antagonistic with mancozeb at concentrations of 2000 and 3000 ppm But in combination with lower concentrations of mancozeb i.e., 1000, 100 and 10 ppm, cypermethrin gave mortalities fairly higher than 50 per cent evidencing that occurrence of synergism Reddy (1984) recorded synergistic effect in respect of decamethrin when mixed with mancozeb against D.melanogaster. But against Spodoptera litura larvae the synergistic effect observed was slight.

5.1.1.3 Biological effectiveness of permethrin in combinat. with carbendazim against D.cingulatus

From the results summarised in Table 2, it is evident that permethrin 0.8 ppm resulted in 15.0 per cent mortality of D.cingulatus and the mortality increased to 80.0 per cent at a concentration of 5.0 ppm. The mortality of bugs progressively increased with increase in concentration of the pyrethroid. The LC_{50} of permethrin was found to be 2.1 ppm.

Permethrin at 2.1 ppm concentration gave 50 per cent mortality of the bugs but, in combination with carbendazim at 1000 and 2000 ppm gave 43.33 and 26.67 per cent mortalities, respectively (Table 8). This low mortality is evidently due to antagonistic action between permethrin and carbendazim at the above concentrations. Permethrin 2.1 ppm in combination with carbendazim 10.0 and 100.0 ppm sbwed 96.67 and 63.33 per cent mortalities of the test insect respectively. This clearly indicates the occurrence of synergism as the mortality recorded was higher than 50 per cent. Such synergistic effect was reported by Reddy (1984) who observed synergism when fenvalerate at LC_{50} was mixed with lower concentrations of carbendazim. Thobbi et al. (1971) also noticed synergism when a mixture of carbofuran+thiram was given as seed treatment to sorghum for the control of shoot fly.

5.1.1.4 Biological effectiveness of permethrin in combination with mancozeb against D.cingulatus

Permethrin 2.1 ppm in combination with mancozeb at 1000 and 2000 ppm concentrations showed antagonistic action as the mortalities of the bugs recorded were well below 50 per cent (Table 9). Synergism was observed when permethrin 2.1 ppm was mixed with mancozeb 10 and 100 ppm, as the resultant mortality of test insect were higher than 50 per cent. Similar results were obtained by Pawar *et al.* (1985) who observed synergistic action when permethrin was mixed with sulfur. Reddy (1984) also noted synergism when fenvalerate was combined with mancozeb.

5.1.1.5 Biological effectiveness of fenpropathrin in combination with carbendazim against *D.cingulatus*

The results summarised in Table 3 indicate that fenpropathrin gave 20 per cent mortality of *D.cingulatus* at 0.1 ppm and the mortality increased to 82.5 per cent at 0.7 ppm concentration. The lethal concentration of fenpropathrin for 50 per cent mortality of *D.cingulatus* was calculated to be 0.41 ppm.

Fenpropathrin 0.41 ppm (LC_{50}) in combination with carbendazim 1000 and 2000 ppm gave mortalities lesser than 50 per cent indicating antagonistic action in these combinations. Synergistic action was also noticed when fenpropathrin 0.41 ppm was mixed with carbendazim 10 and 100 ppm levels as the mortalities recorded being 86.67 and 66.67 per cent respectively.

5.1.1.6 Biological effectiveness of fenpropathrin in combination with mancozeb against *D.cingulatus*

Fenpropathrin 0.41 ppm gave 50 per cent mortality of *D.cingulatus* but in combination with mancozeb 1000 and 2000 ppm mortalities of 43.33 and 23.33 per cent respectively were recorded

(Table 11). As the mortalities recorded were lower than the expected 50 per cent, there exists antagonistic action between fenpropathrin and mancozeb at the above concentrations. Fenpropathrin 0.41 ppm in combination with mancozeb at 10 and 100 ppm showed 96.67 and 76.67 per cent mortalities of the test insect respectively, which clearly demonstrates the occurrence of synergism.

5.1.2 Biological effectiveness of fungicides in combination with synthetic pyrethroids against *Helminthosporium turcicum* Pass.

5.1.2.1 Biological effectiveness of carbendazim in combination with cypermethrin on spore germination of *H. turcicum*

Carbendazim at 1 ppm concentration caused 19 per cent non-germinated spores which increased to 100 per cent at 1000 ppm concentration (Table 13). Fifty per cent of non-germinated spores was obtained with carbendazim at a concentration of 13.27 ppm.

Cypermethrin was found to be non-toxic to *H. turcicum* as all the spores germinated at different concentrations tested (Table 15).

Carbendazim 13.27 ppm (LC_{50}) in combination with cypermethrin 0.35 and 0.45 ppm resulted in 36.33 and 41.00 per cent of non-germinated spores respectively (Table 18). As the inhibition of spore germination was lower than the expected 50 per cent, carbendazim and cypermethrin at the above concentrations were antagonistic. Similar antagonistic effects were observed by Abbaiah (1985) who found a combination of carbendazim - endosulfan to be antagonistic to *Colletotrichum capsici*. Carbendazim 13.27 ppm in combination with cypermethrin 0.55 and 0.65 ppm gave non-germinated spores nearer to 50 per cent. This shows that cypermethrin does not impair or improve the toxicity of carbendazim against *H. turcicum* when these two pesticides are used in combination at the specified concentrations. Very good synergistic action was shown when carbendazim 13.27 ppm was combined with cypermethrin 0.75, 0.85 and 0.95 ppm, wherein the percentages of non-germinated spores were higher than 50 per cent.

5.1.2.2 Biological effectiveness of carbendazim in combination with permethrin on spore germination of *H. turcicum*

Permethrin was found to be non-toxic to *H. turcicum* as non-germinated spores were nil at various concentrations tested (Table 16). When carbendazim at LC_{50} (13.27 ppm) was combined with permethrin 1.8, 1.9, 2.0 and 2.1 ppm, the percentages of non-germinated spores were nearer to 50.0 per cent (Table 19). Therefore it is inferred that neither synergistic nor antagonistic action exists between carbendazim and permethrin at the above concentrations. But synergism was noted when carbendazim 13.27 ppm was mixed with permethrin at 2.2, 2.3 and 2.4 ppm, wherein the percentages of non-germinated spores were higher than 50 per cent (Table 19). Similar results were obtained by Prakash and Kauraw (1983) who observed carbendazim to be compatible with most of the insecticides like malathion, etrimfos and pyrodust.

5.1.2.3 Biological effectiveness of carbendazim in combination with fenpropathrin on spore germination of *H.turcicum*

Fenpropathrin was found to be non-toxic to *H.turcicum* as there was no inhibition of spore germination at all the concentrations tested (Table 17).

Carbendazim 13.27 ppm was found to give 50 per cent of non-germinated spores, but in combination with fenpropathrin at 0.11 and 0.21 ppm, the non-germinated spores decreased to 28.00 and 44.33 per cent respectively. As the inhibition of spore germination was lower than 50 per cent, there exists antagonism between carbendazim and fenpropathrin at the above combinations. There was neither synergistic nor antagonistic effect when carbendasim 13.27 ppm was mixed with fenpropathrin 0.31 and 0.41 ppm concentrations. But carbendazim 13.27 ppm together with higher concentrations of fenpropathrin (0.51, 0.61 and 0.71 ppm) contributed to higher per cent of non-germinated spores evidencing the operation of synergism.

5.1.2.4 Biological effectiveness of mancozeb in combination with cypermethrin on spore germination of *H.turcicum*

Mancozeb at a concentration of 1.0 ppm caused 16.33 per cent of non-germinated spores which steadily increased to 100 per cent with increase in concentration upto 1000 ppm.

The LC_{50} of mancozeb against spore germination of *H.turcicum* was found to be 38.02 ppm.

Mancozeb 38.02 ppm in combination with cypermethrin 0.35 ppm showed antagonistic action as the percentage of non-germinated spores was found to be 44.67 per cent (Table 21). Mancozeb 38.02 ppm in combination with cypermethrin at 0.45, 0.55 and 0.65 ppm concentrations had neither synergistic nor antagonistic activity as the percentages of non-germinated spores were around 50 per cent. With higher concentrations of cypermethrin such as 0.75, 0.85 and 0.95 ppm mancozeb proved to be highly synergistic as the percentages of non-germinated spores were higher than 50 per cent. Similarly Abbaiah (1985) found a mixture of mancozeb and monocrotophos to be synergistic to *C.capsici*.

5.1.2.5 Biological effectiveness of mancozeb incombination with permethrin on spore germination *H.turcicum*

Though permethrin alone was non-toxic to *H.turcicum*, but in combination with mancozeb, it altered the effect of mancozeb on spore germination of the test fungus. Mancozeb 38.02 ppm in combination with permethrin at 1.8, 1.9, 2.0 and 2.1 ppm showed no marked variation in the toxicity of mancozeb as the percentages of non-germinated spores were around 50 per cent. In combination with higher concentrations of permethrin i.e., 2.2, 2.3 and 2.4 ppm mancozeb exhibited synergistic action against *H.turcicum*. Raju and Rao (1981) found mancozeb alone or incombination with acaricides/insecticides viz., dicofol, phosalone, quinalphos, dimethoate, carbaryl and monocrotophos effective in controlling chilli mites.

5.1.2.6 Biological effectiveness of mancozeb in combination with fenpropathrin on spore germination of *H.turcicum*

Fenpropathrin alone though non-toxic to *H.turcicum* but was found to alter the toxicity of mancozeb in combination with it. Mancozeb at LC_{50} value (38.02 ppm) in combination with fenpropathrin at 0.11 and 0.21 ppm proved to be slightly antagonistic as the percentages of non-germinated spores were slightly lower than 50 per cent (Table 23). Gradis and Sutton (1981) demonstrated that captan or mancozeb when mixed with insecticides viz., phosmet or azinphosmethyl caused reduction in their fungicide activity against *Botryosphaeria dothidea* and *Glomerella cingulata*.

Mancozeb (38.02 ppm) in combination with fenpropathrin 0.31 and 0.41 ppm did not have either synergistic or antagonistic effect against the spores. But with higher concentrations of fenpropathrin i.e., 0.51, 0.61 and 0.71 ppm mancozeb was found to be synergistic as the percentages of non-germinated spores were higher than 50 per cent. Such synergistic effects were observed by Tripathi *et al.* (1983) in their studies with mancozeb in combination with insecticides viz., decamethrin, cypermethrin, methyl demeton and quinalphos.

5.2 PHYSICAL COMPATIBILITY

5.2.1 Emulsion stability of synthetic pyrethroids

A perusal of results of emulsion stability (Table 24) of synthetic pyrethroids when mixed with fungicides revealed that the mixture of cypermethrin and carbendazim gave 1.0 ml of creaming matter and 2.0 ml of sedimentation. Since the sedimentation recorded was lower than the limit (2.0 ml) specified by the Indian Standards Institution, these two chemicals could be safely mixed without affecting the stability of cypermethrin emulsion.

When cypermethrin and mancozeb were mixed, the creaming matter and sedimentation observed was 1.0 ml and 2.0 ml respectively. Therefore cypermethrin and mancozeb could be mixed without impairing the emulsion stability of cypermethrin.

Mixture of permethrin and carbendazim resulted in 2.0 ml of creaming matter and 1.0 ml of sedimentation. Hence these two chemicals could also be mixed without any deleterious effects of emulsion stability. Reddy (1984) found fenvalerate physically compatible when mixed with carbendazim.

Mixture of permethrin and mancozeb showed 2.0 ml creaming matter and 3.0 ml of sedimentation. As the sedimentation level is more than the permissible limit, the emulsion stability of permethrin is affected due to mixing with mancozeb. Similar physical incompatibility was reported by Reddy (1984) wherein more amount of sedimentation resulted when fenvalerate was mixed with mancozeb.

Mixture of fenpropathrin and carbendazim resulted in 0.5 ml of creaming matter and 1.0 ml sedimentation. As the levels are well within the prescribed limit, these two pesticides can be safely mixed. But fenpropathrin in combination with mancozeb gave 1.0 ml creaming matter and 3.0 ml of sedimntation. As the sedimentation level is more than the prescribed limit of 2.0 ml, these two pesticides should not be mixed together. Similarly more sedimentation layer was observed by Reddy (1984) when fenvalerate was mixed with mancozeb.

5.3 PHYTOTOXIC INCOMPATIBILITY

The synthetic pyrethroids, cypermethrin, permethrin and fenpropathrin and the fungicides, carbendazim and mancozeb alone and the mixtures of pyrethroid and fungicide were observed to be non-phytotoxic to cotton and hence could be used alone or in combination without fear of any crop-injury.

5.4 CONCLUSIONS

1. Cypermethrin, permethrin or fenpropathrin was synergistic with lower concentrations of carbendazim or mancozeb but antagonistic with higher concentrations of the fungicides against the test insect *Dysdercus cingulatus*.
2. Carbendazim was synergistic with higher concentrations of cypermethrin, permethrin and fenpropathrin when

tested with *Helminthosporium turcicum* as the test fungus.

3. The toxicity of carbendazim was unaffected when mixed with intermediary concentrations of cypermethrin, permethrin and fenpropathrin against the test fungus.

4. Mancozeb was synergistic with higher concentrations of cypermethrin, permethrin and fenpropathrin, when tested against the fungus.

5. The toxicity of mancozeb was unaffected in combination with the intermediary concentrations of the three pyrethroids.

6. Mancozeb was antagonistic with lower levels of the three pyrethroids.

7. Cypermethrin was physically compatible with carbendazim or mancozeb as the stability of the pyrethroid emulsion was unaffected.

8. Permethrin was physically compatible with carbendazim but physically incompatible with mancozeb as the mixture showed sedimentation beyond the permissible limit.

9. Fenpropathrin was physically compatible with carbendazim but not with mancozeb.

10. Cypermethrin, permethrin or fenpropathrin in combination with carbendazim or mancozeb were non-phytotoxic to cotton.

SUMMARY

Investigations were carried out in the Department of Entomology, College of Agriculture, Rajendranagar during 1984-'85 to find out the biological, physical and phytotoxic compatibilities of three synthetic pyrethroids viz., cypermethrin, permethrin and fenpropathrin with two fungicides namely carbendazim and mancozeb.

For assessing the biological effectiveness of synthetic pyrethroids, the red cotton bug *Dysdercus cingulatus* Fb. was selected. Similarly, *Helminthosporium turcicum* Pass.was selected for assessing the biological effectiveness of fungicides. The test insect was multiplied on cotton seed, whereas the test fungus cultures were maintained on potato dextrose agar media. The toxicity of the synthetic pyrethroids was tested against ten day old *D.cingulatus* nymphs by exposing them to one milli litre of graded concentrations of the insecticidal spray fluids by means of a Potter's tower and the mortality data were recorded 24 hours after treatment. The toxicity of the fungicides against ten day old *H.turcicum* cultures was tested using the spore germination technique reported by Montgomery and Moore (1938) and the percentage of inhibition of spore germination was recorded after 18 hours. Mortality data and the percentage of inhibition of spore germination of graded concentrations of each synthetic pyrethroid and the fungicide against the two test organisms were separately subjected to probit analysis (Finney, 1952) and the LC_{50} values were calculated. For testing the biological effectiveness of synthetic pyrethroids in combination with fungicides against D.cingulatus, the concentration of pyrethroid that gave 50 per cent mortality (LC_{50}) of the test insect was mixed with different concentrations of fungicides. The test insect was exposed to the mixture and the mortality recorded. Similarly, for testing the biological effectiveness of fungicides, the concentration of fungicide that inhibited 50 per cent spore germination was mixed with different concentrations of pyrethroids. The spore suspension of the test fungus was exposed to the mixture following the spore germination technique and the percentage of inhibition of spore germination calculated. On the basis of the mortality and inhibition data, occurrence of synergism, antagonism or no effect was assessed.

The LC_{50} of cypermethrin, permethrin and fenpropathrin to D.cingulatus were 0.65, 2.1 and 0.41 ppm respectively. The fungicides, carbendazim and mancozeb were non-toxic to the test insect. Cypermethrin 0.65 ppm (LC_{50}) was synergistic with lower concentrations (10, 100 and 1000 ppm) of carbendazim but antagonistic with higher concentration (2000 ppm) to D.cingulatus. Permethrin 2.1 ppm (LC_{50}) was synergistic with 10 and 100 ppm concentrations of carbendazim but antagonistic with 1000 and 2000 ppm concentrations to the test insect.

Similarly, fenpropathrin 0.41 ppm (LC_{50}) was synergistic with lower levels (10 and 100 ppm) of carbendazim but antagonistic with higher levels (1000 and 2000 ppm) to D.cingulatus.

Cypermethrin at LC_{50} was synergistic with 10, 100 and 1000 ppm levels of mancozeb but antagonistic with 2000 and 3000 ppm levels to the bug. Permethrin and fenpropathrin at LC_{50} values were synergistic with 10 and 100 ppm levels of mancozeb but antagonistic with 1000 and 2000 ppm concentrations.

The LC_{50} values of carbendazim and mancozeb to H.turcicum were 13.27 and 38.02 ppm respectively. The three pyrethroids were non-toxic to the test fungus. Carbendazim 13.27 ppm (LC_{50}) was synergistic with 0.75, 0.85 and 0.95 ppm of cypermethrin but antagonistic with 0.35 and 0.45 ppm and had no effect with 0.55 and 0.65 ppm to H.turcicum. Carbendazim at LC_{50} value was synergistic with permethrin at 2.2, 2.3 and 2.4 ppm but had no effect with lower levels i.e., 1.8, 1.9, 2.0 and 2.1 ppm to the test fungus. Carbendazim 13.27 ppm was synergistic with 0.51, 0.61 and 0.71 ppm of fenpropathrin but antagonistic with 0.11 and 0.21 ppm and had no effect with 0.31 and 0.41 ppm.

Mancozeb 38.02 ppm (LC_{50}) was synergistic with 0.75, 0.85 and 0.95 ppm of cypermethrin but antagonistic with 0.35 ppm and had no effect with 0.45, 0.55 and 0.65 ppm concentrations to H.turcicum. Similarly, with higher concentrations of permethrin (2.2, 2.3 and 2.4 ppm), mancozeb was synergistic but had no marked variation in the toxicity with 1.9, 2.0 and 2.1 ppm of permethrin. Also with higher levels of fenpropathrin (0.51, 0.61 and 0.71 ppm), mancozeb was synergistic but slightly antagonistic with 0.11 and 0.21 ppm and had no effect with 0.31 and 0.41 ppm to *H. turcicum*.

The emulsion stability of cypermethrin, permethrin and fenpropathrin were unaffected when mixed with carbendazim and therefore physically compatible. Cypermethrin was also physically compatible with mancozeb but permethrin and fenpropathrin were physically incompatible with mancozeb.

Cypermethrin, permethrin and fenpropathrin in combination with carbendazim or mancozeb were not phytotoxic to cotton.

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* Original not seen.

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