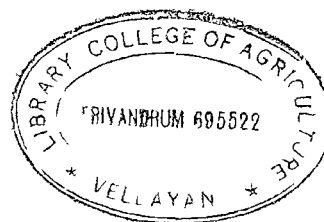


USE OF INSECTICIDES AS GRANULES FOR PROTECTING PADDY CROP AGAINST PESTS

BY

K. SASIDHARAN PILLAI



THESIS

SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE DEGREE
DOCTOR OF PHILOSOPHY
KERALA AGRICULTURAL UNIVERSITY
FACULTY OF AGRICULTURE

DIVISION OF AGRICULTURAL ENTOMOLOGY
COLLEGE OF AGRICULTURE
VELLAYANI, TRIVANDRUM

1981

D E C L A R A T I O N

I hereby declare that this thesis entitled " Use of insecticides as granules for protecting paddy crop against pests " is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associationship, fellowship or other similar title, of any other University or Society.

Veilayandi

31-3-1991

(S. PANDITAN PILLAI)

C E R T I F I C A T E

Certified that this thesis, entitled "Use of insecticides as granules for protecting paddy crop against pests" is a record of research work done independantly by Shri. K. Sasidharan Pillai, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to him.



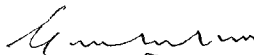
Dr. M.R. Gopalakrishnan Nair
Chairman
Advisory Committee

Vellayani

31--3--1961

APPROVED BY

Chairman



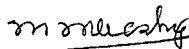
Dr. M.N. Gopalakrishnan Chair

Members

1. Dr. H. Mohan Das



2. Dr. H.N. Koshy


3781

3. Dr. (Mrs.) Mary E. George

4. Dr. C.G. Abraham

ACKNOWLEDGEMENTS

I express my deep sense of gratitude and indebtedness to Dr. I.R. Supalekshmi Rao, Professor and Head of the Department of Entomology (Retired) and the former Director of Research, Kerala Agricultural University for the inspiring interest, ever willing help, valuable guidance and constructive criticisms given during the conduct of this study and in the preparation of the thesis.

My grateful thanks are expressed to Mr. H. Pohan Das, Professor and Head of the Department of Entomology, College of Agriculture, Vellayani, for his valuable suggestions, constant encouragement given to me in the conduct of this work and for scrutinizing the manuscript.

My thanks are also due to Dr. J.N. Zachy, Professor, Research Co-ordination, College of Agriculture, Vellayani, for his valuable suggestions, encouragement and guidance.

I am thankful to Mr. (Mrs.) Mary K. George, Professor of Agricultural Botany for her useful suggestions, encouragement and for going through the manuscript.

To Dr. C.C. Abraham, Associate Director of Research, Kerala Agricultural University, I express my thanks for the valuable suggestions and co-operation extended in the conduct of the work and preparation of the thesis.

My thanks are also due to Mr. (Mrs.) A. Visalakshi, Associate Professor of Agricultural Entomology, College of Agriculture, Vellayuni, for the guidance rendered in residue analyses and in the preparation of the thesis.

I record my thanks to late Prof. M.J. Thomas, Professor of Agricultural Statistics, College of Agriculture, Vellayuni, for his valuable advice in the design of experiments, analyses of data and for helping in the preparation of the manuscript of the thesis.

I appreciate the help rendered by Sri. M.S. Abdu Masak, Assistant Professor of Agricultural Statistics for helping in the analyses of data.

I take this opportunity to express my deep sense of gratitude and indebtedness to Dr. H. Sadasubramanian, Dean, Faculty of Agriculture, Kerala Agricultural University, for providing all facilities required for the conduct of this research programme.

(V. SRIJATHAN PILLAI)

C O N T E N T S

	<u>Page</u>
INTRODUCTION	1
REVIEW OF LITERATURE	6
MATERIALS AND METHODS	43
RESULTS	61
DISCUSSION	135
SUMMARY	161
REFERENCES	i - xiv
APPENDICES	i - xiii

LIST OF TABLES

- Table 1. Mean population per plot of different insect pests and natural enemies under different insecticide granule treatments observed for 24 days following application on 21 DAT (First crop)
- .. 2. Mean population per plot of different insects and natural enemies under different insecticide treatments observed up to harvest after treatment on 45 DAT (First crop)
- .. 3. Mean population per plot of different insect pests and natural enemies under different insecticide treatments observed up to harvest after treatment on 21 and 45 DAT (First crop)
- .. 4. Mean population per plot of different insects and natural enemies under different insecticide granule treatments observed for 24 days after treatment on 21 DAT (Second crop)
- .. 5. Mean population per plot of different insect pests and natural enemies under different insecticide granule treatments observed up to harvest after treatment on 45 DAT (Second crop)
- .. 6. Mean population per plot of different insects and natural enemies under different insecticide treatments observed up to harvest after treatment on 21 and 45 DAT (Second crop)
- .. 7. Mean population per plot of different insects and natural enemies under different insecticide treatments observed for 24 days after treatment on 21 DAT (Third crop)
- .. 8. Mean population per plot of different insects and natural enemies under different insecticide treatments observed up to harvest after treatment on 45 DAT (Third crop)

- Table 9. Mean population per plot of different insects and natural enemies under different insecticide treatments observed up to harvest after treatment on 21 and 45 DAF (Third crop)
- .. 10. Residual toxicity and PE indices of different insecticides in rice plants to BPH when applied at 21 DAF
 - .. 11. Residual toxicity and PE indices of different insecticides in rice plants to rice swarming caterpillar when applied at 21 DAF
 - .. 12. Residual toxicity and PE indices of different insecticides in rice plants to rice leaf roller larvae when applied at 21 DAF
 - .. 13. Mean population of insect pests and natural enemies observed on rice plants under different insecticides applied as granules at different frequencies (First crop season)
 - .. 14. Mean population of insect pests and natural enemies under different insecticide granules applied at different frequencies (Second crop season)
 - .. 15. Mean population of insect pests and natural enemies under different insecticide granules applied at different frequencies (Third crop season)
 - .. 16. Per cent mortalities of BPH on rice plants treated with different insecticide granules at 21 DAF at two levels of irrigation and observed at different intervals after treatment
 - .. 17. Per cent mortalities of BPH on rice plants treated with different insecticide granules at 45 DAF at two levels of irrigation and observed at different intervals after treatment
 - .. 18. Per cent mortalities of rice swarming caterpillar on rice plants treated with different insecticide granules at 21 DAF at two levels of irrigation observed under different intervals after treatment

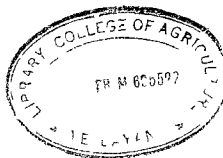
- Table 19. Per cent mortalities of rice swarming caterpillar on rice plants treated with different insecticide granules at 45 DAT at two levels of irrigation and observed at different intervals after treatment
- .. 20. Residues of different insecticides present in paddy grain and straw when applied as granules at different frequencies
 - .. 21. Consolidated representation of relative effectiveness of different insecticide granules in the control of paddy pests in relation to crop seasons and occasions of application
 - .. 22. Consolidated statement of PT indices of different insecticide treatments to different insects
 - .. 23. Consolidated representation of relative efficacy of different insecticide granules on control of paddy pests in relation to frequencies of application
 - .. 24. Persistence of insecticides in rice plants under different levels of irrigation in terms of PT indices to brown plant hopper and rice swarming caterpillar

LIST OF FIGURES

- Fig. 1. Mean population of different insect pests and natural enemies observed for 24 days following application of different insecticide granules at 21 DAF during first crop season
- .. 2. Mean population of different insect pests and natural enemies observed up to harvest following application of different insecticide granules at 45 DAF during first crop season
- .. 3. Mean population of different insect pests and natural enemies observed up to harvest following application of different insecticide granules at 21 and 45 DAF during first crop season
- .. 4. Mean population of different insect pests and natural enemies observed for 24 days following application of different insecticide granules at 21 DAF during second crop season
- .. 5. Mean population of different insect pests and natural enemies observed up to harvest following application of different insecticide granules at 45 DAF during second crop season
- .. 6. Mean population of different insect pests and natural enemies observed up to harvest following application of different insecticide granules at 21 and 45 DAF during second crop season
- .. 7. Mean population of different insect pests and natural enemies observed for 24 days following application of different insecticide granules at 21 DAF during third crop season
- .. 8. Mean population of different insect pests and natural enemies observed up to harvest following application of different insecticide granules at 45 DAF during third crop season

- Fig. 9. Mean population of different insect pests and natural enemies observed up to harvest following application of insecticide granules at 21 and 45 DAT during third crop season
- .. 10. Mortality of brown plant hopper exposed to rice plants at different intervals after application of different insecticide granules at 21 DAT
- .. 11. Mortality of rice swimming caterpillar exposed to rice plants at different intervals after application of different insecticide granules at 21 DAT
- .. 12. Mortality of rice leaf roller larvae exposed to rice plants at different intervals after application of different insecticide granules at 21 DAT
- .. 13. Mean population of insect pests and natural enemies observed on rice plants under different insecticides applied as granules at different frequencies during first crop season
- .. 14. Mean population of insect pests and natural enemies observed on rice plants under different insecticides applied as granules at different frequencies during second crop season
- .. 15. Mean population of insect pests and natural enemies observed on rice plants under different insecticides applied as granules at different frequencies during third crop season
- .. 16. Mortality of brown plant hopper exposed to rice plants at different intervals after application of insecticide granules at 21 DAT under two levels of irrigation
- .. 17. Mortality of brown plant hopper exposed to rice plants at different intervals after application of insecticide granules at 45 DAT under two levels of irrigation

- Fig. 18. Mortality of rice swarming caterpillar exposed to rice plants at different intervals after application of insecticide granules at 21 DAT under two levels of irrigation
- Fig. 19. Mortality of rice swarming caterpillar exposed to rice plants at different intervals after application of insecticide granules at 45 DAT under two levels of irrigation



LIST OF APPENDICES

APPENDIX

- I List of insecticides used
- II Summary of analysis of variance table of mean population per plot of insect pests and natural enemies under different insecticide treatments observed for 24 days following treatment on 21 DAT during first crop season
- III Summary of analysis of variance table of mean population per plot of insect pests and natural enemies under different insecticide treatments observed up to harvest after treatment on 45 DAT during first crop season
- IV Summary of analysis of variance table of mean population per plot of insect pests and natural enemies observed up to harvest after treatment on 21 and 45 DAT during first crop season
- V Summary of analysis of variance table of mean population per plot of insect pests and natural enemies under different insecticide treatments observed for 24 days following treatment on 21 DAT during second crop season
- VI Summary of analysis of variance table of mean population per plot of insect pests and natural enemies under different insecticide treatments observed up to harvest after treatment on 45 DAT during second crop season
- VII Summary of analysis of variance table of mean population per plot of insect pests and natural enemies under different insecticide treatments observed up to harvest after treatment on 21 and 45 DAT during second crop season

APPENDIX

- VII Summary of analysis of variance table of mean population per plot of insect pests and natural enemies under different insecticide treatments observed for 34 days following treatment on 21 DAT during third crop season
- II Summary of analysis of variance table of mean population per plot of insect pests and natural enemies under different insecticide treatments observed up to harvest after treatment on 45 DAT during third crop season
- X Summary of analysis of variance table of mean population per plot of insect pests and natural enemies under different insecticide treatments observed up to harvest after treatment on 21 and 45 DAT during third crop season
- XI Summary of analysis of variance table of mean population of insect pests and natural enemies under different insecticides applied at different frequencies during first crop season
- XII Summary of analysis of variance table of mean population of insect pests and natural enemies under different insecticides applied at different frequencies during second crop season
- XIII Summary of analysis of variance table of mean population of insect pests and natural enemies under different insecticides applied at different frequencies during third crop season.

INTRODUCTION

INTRODUCTION

The problem of insect pest control of rice is highly complex and is becoming more complex as time passes. This state of affairs has resulted on account of a multiplicity of interesting factors. First of all paddy crop is subject to attack by a series of pests with varying feeding habits, from the nursery stage to the harvest stage. The pests may come one after other in sequence or together in various combinations. This necessitates application of different types of insecticides at different frequencies to achieve a complete protection of the crop. Very often the application of insecticides, especially as sprays is not properly undertaken and the usual experience of cultivators of unsatisfactory control of paddy pests in spite of repeated insecticidal applications can be attributed to this. High volume spraying which is generally adopted for the application of insecticides requires the use of 400 to 500 litres of the spray fluid per hectare. This use of spray fluid is in practice rarely used in the paddy fields on account of various operation difficulties including the slushy nature of the paddy field which makes movement of the operator difficult. Further, on account of close planting, the plants grow thickly and at advanced stages of growth, a thick impenetrable canopy is formed on the crop surface and this also

reduces the efficiency of spraying in the control of the pests. Application of insecticides at lower per-hectare dosages will not only not give the desired control of the pest but may also cause other adverse side effects. For instance since repeated application of the insecticide becomes necessary due to inadequate pest control, though the target pest organisms are not materially affected, their natural enemies get systematically eliminated from the ecosystem. This results in pest resurgence and secondary pest outbreaks. The recrudescence of brown plant hopper for example is partly attributed to this phenomenon. Apart from resurgence of this nature, resurgence arising out of stimulated reproductive potential due to insecticides has been reported recently. Such a phenomenon has already been detected in the case of insecticides like DDT, carathion, methyl parathion and decamethrin (Ishikawa, 1972; Chelliah and Heinrichs, 1979). Thus it is clear that efficiency of the use of insecticides for good pest control will depend upon the efficiency of their field application.

One of the advantages of the use of insecticides in the form of granules is the ease of application coupled with efficiency. Since the granules are applied in soil their effect on pest will be largely systemic in nature and as

such systemic insecticides will be more effective for insect control when used as granules. Even non-systemic insecticides like diazinon, DDT, lindane, carbaryl, endrin and quinalphos have been reported to be effective in the control of paddy pests when applied as granules (Pathak, 1966; Abalos, 1968; Alam et al., 1970; Ganguli et al., 1970; Eshwari Rao et al., 1970, 1970a; Satpathy, 1970; Royana, 1971; Kulshreshtha, 1971; Velayuthan et al., 1971; Raj and Bhattachan, 1973 and Bhattachan and Narayanaswami, 1975). The later investigations have shown that the systemic insecticides, especially of the persistent types, are more effective in the control of paddy pests when applied as granules than the non-systemic insecticides. Systemic insecticides also show properties ranging from narrow to broad spectrum in their selective insect control effects. Carbofuran for instance has been reported to be effective against a wide range of pests of paddy including gallmidge, rice stem borer, green leafhopper, brown plant hopper, leaf roller and whorl maggot (Kulshreshtha, 1971; Venkataraman and Abraham, 1973; Balasubramanian et al., 1976; Rai et al., 1976 and Rao et al., 1976). Dieldrin controls gallmidge and whorl maggot (Bhattachan and Narayanaswami, 1975). Heptachlor is reported effective against gallmidge, whorl maggot, rice

stem borer and leaf roller (Tulehreshtha, 1971; Bhaskaran and Narayanaswami, 1975; Sai et al., 1976 and Rao et al., 1976). Phorate is reported effective against such pests of paddy as rice stem borer, gallinidge, leaf roller and brown plant hopper (Jeyaraj, 1976; Lashkaran et al., 1976 and Rao et al., 1976). Quinalphos as granules has been found to be effective in controlling DBM and GMH (*Plasmodium* et al., 1976). Chlorodimethox can control brown plant hopper and stem borer (Anonymous, 1974).

Though information is available on the effect of these various insecticides against particular pests of paddy derived from different and unconnected studies, there is no precise understanding on the use of these toxicants in raising pest free crops and to what extent the different insecticide granules can afford protection against individual or groups of pests throughout the cropping season. It is, however, clear from the work of previous investigators that control of paddy pests is possible by exclusive use of insecticide granules. Considering this, as well as the other favourable attributes of the systemic insecticide granules such as ease of application, efficiency of application and the possibility of the maximum number of plants receiving an effective dose of the insecticide by its movement in soil,

the present studies were undertaken. In these studies field experiments were undertaken to ascertain the use of granules of carbofuran, phorate, methidathion, disulfoton, quinalphos and chlorpyrifos in controlling various pests infesting rice under wet cultivation, during the three cropping seasons of 1971. Studies have also been undertaken to fix frequencies of application of the granules needed for the effective control of the various pests throughout the duration of the crop. The influence of levels of irrigation on the performance of the different insecticide granules with reference to uptake and persistence of the insecticide in the plants also has been studied. Persistence of the various insecticides within the plant with reference to their toxicity to the pests and the toxic residues in straw and grain also have been ascertained.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Literature available on the use of insecticide granules for the control of various insect pests of paddy, persistence of the insecticides in rice plants when applied as granules and the residues of the insecticides, in paddy straw and grain, applied in the granular form are briefly reviewed here.

Use of insecticide granules for the control of pests of paddy

Pathak (1966) in a field trial conducted at Philippines observed that gamma BHC applied to water in rice field at 1.8 and 2.7 lb/acre at tillering and boot leaf stage respectively controlled paddy green hoppers, mainly Chilo suppressalis and Eurygaster integriceps. The effect of the insecticide lasted up to 10 days after application and was not very effective against leaf hoppers.

Abalos (1968) recorded that granules of lindane 6 per cent at 33.33 kg/ha, sevidol 8 per cent, andrin 2 per cent and endosulfan 5 per cent all at 25 kg/ha when applied in rice field, sevidol followed by the others in the descending order markedly reduced the number of deadhearts and white earheads and increased grain yield.

Calora et al. (1968) in a trial conducted at Philippines also observed that among the granules of gamma BHC at 5 kg,

phorate at 3.0, 4.0, 4.5 and 6.0 kg, diazinon at 4 kg, solvinox at 4.0 kg and sevidol at 8.0 kg/ha applied in 2 or 3 doses from 12 DAT onwards in paddy field only diazinon gave satisfactory control of rice stem borer. In another trial carbofuran, sevidol and chlorfenvinphos applied at 0, 22 and 50 DAT, all the three afforded good control of rice stem borer, but only carbofuran continued to give satisfactory control after 56 days.

Ferino (1968) reported that only compounds with systemic action were effective against wheat maggot and the infestation was considerably reduced by diculifeton, sevidol, gamma HCH and phorate applied as granules in irrigation water 15 days after transplantation and again after 20 days.

Koyama et al. (1968) observed that propoxur when applied as granule at 30 kg/ha showed some systemic action after 3 days against adults of Macdiphax striatella (Fab.) and Neophotettix pinaticens but mortality was very low. Diazinon and diculifeton did not show any systemic action when applied as granules.

But Sanchez et al. (1968) reported that granular formulations of phorate, gamma HCH, sevidol and diazinon gave satisfactory control of wheat maggot and rice stem borer and increased grain yields.

Monosilopon et al. (1969) evaluated carbendazim for control of rice water weevil Lissorhynchus oryzae L. at 1 lb/acre and could get 78% mortality up to 4 weeks after application. The treatment at 0.25 and 0.5 lb/acre was also effective against the pest.

Ali et al. (1969) observed that treating rice seed in nursery with phorate did not increase the grain yield. He also noted that two applications at 1 lb or 2 lb ai/acre applied two and six weeks after planting reduced infestation by Lissorhynchus oryzae and Lissorhynchus oryzae with significant increase in yield.

Ali et al. (1970) while comparing diazinon and carbofenthrin in three rice crops found that application of diazinon granules at 20 lb/acre at intervals of 20 days gave best control of green borers with an yield increase of 6.84, 33.27 and 70.48 per cent for 3 seasons respectively. This was followed by carbofenthrin at 40 lb/acre at the same intervals which gave 65.84, 71.27 and 66.94 per cent of increase in yield.

Swelling (1970) observed that carbendazim applied to rice fields covered 22.5 cm laterally within 48 hours in quantities sufficient to be toxic to Lissorhynchus oryzae post-embryonic and

was absorbed through the roots and leaf sheaths of rice plants. It was also observed that carbofuran was retained more in the soil than in plants and the optimum absorption was obtained by placing the insecticides in soil near the roots and then flooding with water.

Choi et al. (1970) observed that granules of fenalfothion 5 per cent and gamma BHC 6 per cent at 3 kg/1000 m² reduced the number of deadhearts and white earheads in rice field and the former one controlled Nephotettix cincticornis also.

Canguli et al. (1970) found that amongst lindane and endrin granules at 3 kg ai/ha in irrigation water, applied 21, 41 and 61 days after transplantation against rice stem borer, lindane was superior in summer crop and both were equally effective during autumn. Increase in grain yield was also significant; lindane with 59.0 and 88.32 per cent and endrin with 29.19 and 44.16 per cent for the summer and autumn crop respectively.

Mitra et al. (1970) studied the effect of carbofuran in seed dressing and pre-transplantation dips on the germination and mortality of Nephotettix cincticornis in green house and field and found that carbofuran when

applied at a rate of 0.5 to 2.0 g toxicant per 100 g seed had no adverse effect on germination and caused 100 per cent mortality to H. immiticong within 6-24 hours.

Prakasarao et al. (1970) reported that out of 29 insecticides evaluated against Truncosia incertulas at Cuttack endrin, nevidol, phorate, cytolane and durban granules were most effective when applied in standing water.

Prakasarao et al. (1970a) also recorded that diazinon was effective against stem borer at 1.25 kg/ha applied 25 and 45 days after transplantation and even though endrin and gamma BHC were effective, they were uneconomical.

Batpathy (1970) observed that endrin granule at 1.5 kg ai/ha applied 10, 30 and 50 DAT reduced the gall midge infestation to 19 from 39.6 per cent and increased yield from 1.46 ton/ha to 2.04 ton/ha. Dicalifeton, endrin and diazinon granules at 1.5 kg ai/ha reduced stem borer infestation and increased yield up to 1.57 tons per hectare.

Experiments conducted at IIRI, Philippines (Anon 1971) confirmed the effectiveness of carbofuran against all pests of paddy. It was also observed that granules of chlorfenvinphos G-10015, monocrotophos, mixtures of lindane

with LISO or propoxur were effective against BHI while diazinon, lindane with carbamates, carbyap and galactosone controlled borers and diazinon, chlorfenvinphos, lindane with azopoxur, dursofen with pyropoxur and dyfonate with phosmat or alone were effective against Tetralia philippina.

Koyama (1971) observed in Japan that disulfoton, diazinon and malathion were effective against Leodelphax striatella (Fall.) in paddy field and the delphacids were killed by coming in contact with the insecticidal vapour absorbed by the rice plant.

Koyama (1971a) reported in Japan that microgranules of diazinon (100-300 μ m) gave better control of Leodelphax striatella and Peribatelia sinensis than diazinon dusts. Granules of 3% diazinon and 5% disulfoton were grain proved to control stem borer (Chilo pyrausta).

Kulshresitha (1971) reported that granules of cyromazine and diazinon applied in irrigation water were the most effective against wall ridge and granules of chlorfenvinphos, cyromazine, gamma LISO, sevidol, carbofuran, fenthion and dursofen controlled stem borer infestation.

Sakai (1971) observed that cartax (noreisterin) and its hydrochloride when applied as granules to rice field

in Japan, the hydrochloride gave effective control of Arctopsa cyanea, Acra cyanea, Graphollocyba nodialis and Parnara vitata.

Sethurathan (1971) found that diazinon applied to irrigation water every 20 days after transplantation controlled pests of rice for a long period but then became ineffective against Nilaparvata lugens and indicated that a gram positive coccoid bacterium was responsible for degradation of the chemical in the presence of ethanol or glucose.

Velayuthan et al. (1971) in Tamil Nadu observed that when granular insecticides were applied soon after the galls (silver sheat) are observed and again twice at intervals of 3 weeks, best control of yellow gall midge was obtained with diazinon granules at 1.25 kg/ha.

Application of carbosulfan 50 in rice nursery at the rate of 3.2 kg ai/ha at 10 days after sowing proved to be effective in controlling the stem borer and leaf roller up to 20 days after application (Anonymous 1973).

Udaguchi and Shibata (1973) found that comparatively few spiders were present in the rice field during the first two weeks of transplantation and the population increased

rapidly in correlation with availability of suitable prey, which was one of the important factors influencing the population density of spiders.

Raj and Menachan (1973) observed at Coimbatore that two granular application of diazinon at 1.5 kg ai/ha produced 9.29 deadhearts and 10.79 white earheads per clump and was lower when compared to the corresponding values of 12.75 and 12.31 respectively for 5 sprays of diazinon at 0.5 kg ai/ha.

Jacobs et al. (1973) observed in Japan that control of leafhopper, with fewer insecticide application appeared possible by using selective insecticides (which resulted in a favourable ratio of predators to prey) rather than non-selective ones.

Venketaraman and Abraham (1973) also found that carbosulfen granules at 0.175 kg ai/sere applied on 30 DAT and at 0.35 kg ai/sere on 60 DAT and the 2 combinations gave best control of Perhoplettia virescens, Hilarnivata lucens, Trimerotropis incertulas and Euchelidnoides grisea with increase in yield.

In a laboratory and green house experiment conducted at ITRI, Philippines, carbosulfen was found effective against green leafhopper and ITRI thrips whereas chlorodimethox was highly

effective against BPH and stemborer but not to whorlbuggot. It was also observed that when the insecticides are applied to paddy water it must be applied every 21 days to protect the crop, (Anchymova 1974).

Gurtodie (1974) reported that seed bed treatment of paddy with granules of phorate and gamma BHC gave complete protection of rice seedlings up to 30 days after treatment and with carbofuran up to 30-45 days.

Hidaka et al. (1974) recorded that out of 15 types of granular insecticides tried against rice gall midge in Thailand, diazinon applied at 2.0 kg ai/ha 14 and 28 DAP was effective.

Baron (1974) compared the efficacy of micro-granule formulation of 0.1 to 0.15 mm diameter with that of dust of carbamate for the control of Perthettia cinatigera and Melanerota lucina and could find no significant difference.

Londono (1974) observed that phenathione when applied as granules (cidal) was least injurious to beneficial fauna of rice field.

Harigan et al. (1974) found that Agronul P at 37.5 kg/ha, chelux 50 at 0.75 kg ai/ha, diazinon 5 per cent granule at 12.5 kg/ha and paddycard at 15 kg/ha were either more effective

or as effective as endos 0.2 per cent spray against rice stemborer.

Abe and Okamoto (1975) recorded that diazinon, fenvalerate (Fenproth-P) and methomyl when applied as granules afforded good control of Chilo samarangensis and Neoheterotis sineticus.

Abacharya and Faraymanovani (1975) in a field trial on the control of rice gall midge and whorl maggot at Tamil Nadu observed that among the granules of diazinon, cypermethrin, endosulfan and azadirachtin all at 2 kg ai/ha, applied to the standing water 5 DAT, only cypermethrin reduced the incidence of gall midge and none reduced the damage due to Hydrochloa assata.

Dowling (1975) in field plot tests conducted in Texas for ten years from 1965 to evaluate granular formulations of various insecticides for the control of rice water weevil observed that malathion (Daz) and carbaryl gave effective control when applied to water at 0.5 or 1.0 lb/acre.

Iwata et al. (1975) reported that granular carbosulfon (carbofen) proved very suitable for the control of major pests. Its effectiveness in controlling Scirpophaga incertella, Scutell, Grasshopper, Scaphinotus medialis, and Neoheterotis sineticus was much greater than that of diazinon. The action against Neoheterotis was also demonstrated by the reduction in Tungro virus disease.

Keyana (1975) observed that it is not advisable to disperse with insecticide in the first generation even if the infestation is below economic level (1 stem borer/hill). Application of chlorodaneform 50-100 ppm (10-20% of normal dose) gave satisfactory control of borer with little effect on the density of spiders.

Nathai et al. (1975) in a field evaluation of insecticide found that carbofuran, sevidol and quinalphos were most effective against stem borer, phorate and carbofuran against gall flies and sevidol and phorate against leaf feeding caterpillars.

Ramkumar et al. (1975) in a field trial conducted at Bhavanisagar observed that effective control of stem borer of paddy was afforded by the application of granules of diazinon 10 per cent at 12.5 kg/ha, diazaton 5 per cent at 25 kg/ha, paddygard 7.5 per cent at 6 kg/ha, carbofuran 3 per cent at 17.5 kg/ha and alldol 4.4 per cent at 15 kg/ha.

Sharma and Singh (1975) in a trial against rice stem borer Exyorhysa incertulap with different formulations and methods of applications found that granules of 10% gamma HCH and 2% endrin applied to water at 12.5 and 25 kg respectively gave best results.

Thomas et al. (1975) while studying the relative systemic toxicity of some insecticides to brown plant hopper when

applied as granules in soil also observed that carbofuran was most toxic to N. lugens but followed by isoprocarnb (IPRO) and aldicarb.

Aquino and Pathak (1976) reported that the residue concentration of carbofuran and chlorodaneform were highest in rice root, stem and leafblade when the toxicant was applied in gelatin capsules to the root zone than when incorporated into soil and when applied to paddy water.

Balambramaniam et al. (1976) reported that among ethalux 50 at 0.5 and 1.0 kg ai/ha, san 155 I - 50 at 0.5 and 1.0 kg ai/ha, san 197 I - 50 at 0.5 and 1.0 kg and furadan 50 at 1.0 kg ai/ha applied in half doses on 20 and 40 DAT, furadan and ethalux both at 1.0 kg ai/ha were equally effective in reducing the green jassid and brown plant hopper incidence, whereas maximum control of stem borer was obtained with san 155 I - 50 at 1.0 kg level.

Chandrasekhar et al. (1976) observed that two applications of carbofuran at 2.5 and 1.5 kg ai/ha at 20 and 50 DAT and one application of carbofuran at 2.5 kg ai/ha at 20 DAT followed by two rounds of foliar spraying with fenitrothion 0.005% on 50 and 60 DAT were effective in controlling leaf roller.

Chelley (1976) recorded that carbosulfan as granule was equally effective to all pests but diaspines was much less toxic to L. striatella in granular form.

Butt et al. (1976) reported that granular application of ekalux at 1.5 kg ai/ha on 12 and 32 DAT followed by foliar application of ekalux 50 at 0.25 litro ai/ha on 57 DAT gave significant result in reducing incidence of deadheart and white earhead during bore season but not in the rain season.

Wolch (1976) observed that while carbosulfan and acephate were highly effective against brown plant hopper and green rice leaf hopper, isoprocarb (IIPC), heptachlor and propoxur were effective only against brown plant hopper.

Khosain et al. (1976) observed that ekalux granules at 1.5 kg ai/ha applied at 10 and 30 DAT followed by foliar spray of ekalux 50 at 250 ml ai/ha applied at 55 DAT gave the best control of stem borer, gallmidge and leaf folder at Rajmangalak. But granular application alone gave control of gallmidge and stem borer, in the vegetative stage, at Varanasi and the foliar application was superior in terms of white ear head and leaf folder control.

Jeyaraj (1976) found that among carbosulfan, phorate, fenitrothion and odian granules each at 0.5, 1.5 and

2.5 kg ai/ha when applied to paddy water at 20 and 30 DAT, carbofuran and phosmate were effective in higher doses, in controlling stem borer and gall midge and carbofuran in all the doses controlled leaf roller. Significant increase in grain yield to the extent of 50.2 and 37.9 per cents was also noted due to carbofuran at 2.5 and 1.5 kg ai/ha followed by phosmate 1.5 kg ai/ha.

Chattopadhyay et al. (1976) reported that phosmate and carbofuran were found equally effective in checking the incidence of gallfly and applications at 15, 20 and 25 DAT were superior to application at 30 DAT.

Randal et al. (1976) found that amongst the insecticides tested, three applications of endosulfan granules at 1.5 kg ai/ha gave the maximum control of paddy stem borer (Scythris incertilinea Walker.) and recorded maximum yield followed by three applications of phosmate at 1.5 kg ai/ha.

Ali et al. (1976) at Dohad concluded that among carbofuran, quinalphos, seviodol, phosmate and methidathion tried against rice stem borer, carbofuran and methidathion at 1.0 kg ai/ha applied at boot-long stage minimised the number of white earheads caused by Scythris incertilinea.

Hao et al. (1976) observed that application of methidathion, chlorfenvinphos, fenvalerthion, carbofuran and EHC in standing water against whorl maggot; methidathion against leaf folder; MIPC, carbofuran and phorate against brown plant hopper and labayoid, carbofuran and U.C. 30045 against stem borers were effective. In another study conducted for a period of 3 years he found that monthly application of carbofuran at 1.5 kg ai/ha could effectively control the stem borers, leafhoppers, plant hoppers and whorl maggot, but was not effective against gallmidge. However, carbofuran placement at the root zone application was found to control gallmidge also effectively.

Sriharan and Gera (1976) found that absorption of carbofuran, phorate and acridol at 2.0 kg ai/ha by the plant determined from the mortality of Homotettix virescens was more rapid when granules were applied near the root zone and soil was flooded with water than the application in moist soil.

Stevens and Berg (1976) proved in a field trial that thioacyclanhydrogen oxalate was effective against Schoenobia incertulag in irrigated rice as 5 per cent granules or 4% micro granule and in India three applications are necessary of which first one to be in the granular form.

In a field evaluation of insecticide granules conducted at IRRI, Philippines carbofuran as applied in paddy water controlled whorl maggot and stem borer while cytolane controlled only stem borer. It was also observed that cytolane at 0.5 kg ai/ha applied to the root zone of rice was not effective against BPH and GBV. Profit was highest when carbofuran at 1.0 kg ai/ha was incorporated into soil (Anonymous 1977).

Chandrasekhar and Jayaram (1977) recorded an increase in the rice leaf roller damage with increasing levels of nitrogen and this necessitated corresponding increase in the dose of carbofuran. He also observed that among carbofuran and phorate, carbofuran controlled the leaf roller effectively and different doses of phorate had no influence in controlling the pest.

Zalode et al. (1977) observed at Hyderabad that seedling root dip treatment with chlorpyrifos at 0.02 per cent on 12-14 days prior to planting, followed by 2 applications of nephosfolan granules at 1.0 kg ai/ha on 30 and 60 DAP effected good control of rice pests in general and increased yield by 76 per cent over untreated control.

Karayanawani et al. (1977) observed in a field study on the effectiveness of insecticides in the later stages of

the crop that maximum reduction of BPH population was with carbofuran 36 at 2.25 kg ai/ha when applied during 9th, 10th, 11th and 12 weeks after transplantation and he also observed that nephosolan was ineffective.

Sai and Singh (1977) in a field trial conducted at Vazanda recorded that counter 50 (1-1(diethyl ethyl) thiol o-o diethyl phosphorodithioate) at 1.5 kg ai/ha and AC 64475 (an experimental systemic organophosphorus granular insecticide) at 1.0 kg ai/ha give effective control of brown plant hopper, rice leaf hopper and rice stem borer on par with carbofuran, nephosolan and phorate.

Ramamurthy et al. (1977) reported that application of phorate, diazinon and carbofuran at 1.0 kg ai/ha on 10 and 30 DAT significantly reduced the incidence of rice whorl maggot Hydrellia philippina and increased yield.

Ramamurthy et al. (1977a) found from an experiment with granules of disulfoton 5 per cent, carbofuran 3 per cent, lindane 5 per cent, phorate 10 per cent, chlorfenvinphos 10 per cent, endrin 5 per cent, parathion 1 per cent (Agronule), Trichlorfon 5 per cent, AC 92100 5 per cent and diazinon 5 per cent against rice leaf folder all at 1.5 kg ai/ha; carbofuran followed by diazinon, lindane and chlorfenvinphos when applied twice in a season afforded the

lowest incidence. Significant increase in grain yield (10.57 kg to 13.53 kg/plot) was also recorded under carbofuran treatment over untreated control (5.13 kg/plot).

Uno and Das (1977) while studying the effect of seedling dip treatment with slurries containing systemic insecticides on the control of pests of rice observed that seedlings dipped in mudslurry containing 0.1% carbofuran gave 70 and 60 per cent mortality of H. larvae on 14 and 20 DAT. Against H. bimaculatus it gave 58.93 and 23.12 per cent mortality on the same days. Carbofuran was found effective against stemborer, rice caseworm and green jassid followed by nephotholan and chlorodimorfen.

Rat Sairamaj et al. (1977) found nephotholan at 1.0 kg ai/ha as superior to carbofuran in controlling the whorl maggot infestation when applied at 50 DAT.

In another trial conducted at IARI, it was observed that 0.5 kg ai/ha of carbofuran applied in paddy water controlled BPH and GMH effectively, while cytolane at 0.5 kg controlled GMH only. Carbofuran had strong ovicidal activity also against BPH (Anon. 1978).

Calera and Ferino (1978) reported that two to four broadcast application of nephotholan at 0.5 to 2.0 kg ai/ha effectively controlled Scirpophaga incertulas and Oryzalin

pyrethrin in India. Residue in water hardly reduced within 7 days and maximum concentration at one day after application at 1.0 kg ai/ha was 2.3 ppm which decreased to 0.7 ppm on 7th day.

Chen and Lin (1978) in a field experiment in Taiwan on the effectiveness of insecticides for the control of brown plant hopper on rice recorded that granules of carbosulfan 3 per cent, propoxur 5 per cent, nixaralan 5 per cent (a mixture of chlorodifotom and isocresol) and Declos 5 per cent (diethyl 1, 1, 3 - dithiotan-yliden phosphorothiolate) at 60, 30 and 30 and 36 kg /ha respectively were highly effective. He also observed that 2 applications at booting and heading stage gave satisfactory control of the pest.

Chai and Ya (1978) observed in a study on the effect of carbosulfan in the density of red-bellied spiders in rice field under different methods of application that the spider population was reduced in waddy water application of carbosulfan treatment and the spider mortality increased with increased application of carbosulfan.

Mathur et al. (1978) studied the efficacy of different fertilizer-insecticide mixtures and reported that mixture of urea + cypermethrin at 0.75 kg ai/ha gave maximum control of

rice stem borer, gall midge and leaf hopper (80 per cent) with significant increase in yield. Urea-furadan (at 0.5 kg ai/ha) mixture ranked next followed by mixtures of diazinon, thiodan and etalux all at 1.0 kg ai/ha with urea.

Murthy et al. (1978) while studying the efficacy of cytolane with different dosage of AC 92100 found that it could effectively reduce the white earheads at a dosage of 1.0 kg ai/ha and obtained highest grain yield.

Velusamy et al (1978) compared the efficacy of certain insecticides as granules and foliar formulation and found that Gallecon (chlorophenamide) granule at 1 kg ai/ha was most effective against leaf roller, stem borer and plant hoppers with the maximum increase in yield (150 per cent over untreated control).

Dakshinam et al. (1979) also studied the efficacy of different fertilizer-pesticide mixtures as soil and foliar application at Balaba. Of the treatments urea + phorate at 10 kg/ha was found most effective in controlling rice stem borer and leaf hopper (84 per cent) and produced highest increase in yield (557 kg/ha over control with urea). This was followed by mixtures of urea + carbofuran at 16.5 kg/ha, urea + cytolane at 10 kg/ha and urea + etalux at 15 kg/ha in the descending order.

Heinrichs et al. (1979) reported from Philippines that carbofuran failed to control BPH when applied at 2 weeks intervals in continuous crops over a period of 3 years and a dose of 6 kg ai/ha was required to kill 98 per cent of BPH.

In another study on the comparative activity of granular carbofuran, isazophos and diazinon when applied as paddy water broadcast and rootzone applications, Heinrichs et al. (1979a) found that only carbofuran and isazophos had sufficient systemic activity to provide control as rootzone application while all the three were effective as water broadcast application. He also found that soil incorporation of carbofuran granule at 0.5, 0.75 and 1.0 kg ai/ha gave effective control against whorlbug. He also observed that carbofuran application in seed bed gave control of caterpillars and deadhearts but not white earhead and whorlbug.

Heinrichs et al. (1979b) while studying the relative efficacy of insecticide granules observed that carbofuran was most effective against GH and BPH giving 100 and 50 per cents of mortality respectively at 14 days after treatment.

Horiba (1979) reported that FNU 35001 (carbamate) 5 per cent granules incorporated into soil at the rate of 50 gm per nursery box controlled Neodolophus sp. and Hemiteles sp. at 10 kg/ha applied to paddy water controlled rice water weevil.

Katarajan and Chandu (1979) while evaluating certain insecticides against major pests of paddy observed that nipcin 40 at 0.5 kg ai/ha controlled BPH and gall midge while ekalux 50 failed to do so and counter 50 at 1.0 kg controlled gall midge.

Saivarnaj and Venugopal (1979a) reported that application of nephesolan granules at 0.75 kg ai/ha was effective in controlling rice stem borer in vegetative and panicle bearing stages. An application at 15 or 20 DAT followed by 3 applications at 20 days interval gave better check.

Shukla et al. (1979) also recorded that quinalphos 50, phorate 100 and carbosulfan 30 were effective in the descending order for the control of gall midge.

Thirumurthy (1979) noted that aldrin and toxaphene granule at 2.5 and 10 kg/ha were injurious to spider followed by phorate at the same dose.

Endhraj et al. (1980) reported that up to the end of 21 days after application of quinalphos, thiodaneton, carbofuran, phorate and disulfoton, all at 1.5 kg ai/ha were superior to the untreated control and carbofuran gave the maximum kill of rice hispa. But on 28 days after application only carbofuran and phorate persisted in rice plant in toxic levels.

Khiti et al. (1980) observed in a field trial at Sindri that when carbofuran at 3.0 kg ai/ha, methidathion, quinalphos, bendin, endosulfan, dimethoate and phorate at 1.5 kg ai/ha were applied as granules twice in undry field in water; methidathion and carbofuran controlled gall midge and leaf hopper effectively while quinalphos gave significant control of gall midge only and the three insecticides increased the yield significantly. He also reported that cyroline and furadan could control gall midge with 89.28 and 84.5 per cent of reduction in silver shoot and 89 and 84 per cent reduction in leaf hopper population. Quinalphos, dimethoate and thimet also reduced the leaf hopper population significantly.

Murthy et al. (1980) studied the efficacy of granules of cyroline, diazinon and AC 92100 (3 (tert-butyl thio) methyl O, O-diethyl phosphoro di thioate) at 1.0 kg ai/ha

applied thrice at 10 DAI, 25 DAI and boot-leaf stage. He observed that the insecticides were effective against rice stem borer but AC 92100 gave higher yield than diazinon.

Sao et al. (1980) observed that nephotholan and diazinon at 2.5 kg ai/ha in two or three split applications were effective in controlling rice borer and nephotholan was superior to diazinon.

Salvaraj (1980) recorded that nephotholan treatments resulted in increased plant weight and panicle length.

Antilopal et al. (1980) reported that among the granules of carbofuran at 0.5 kg, phorate at 1.00 kg, quinalphos at 0.15 kg, diazinon at 1.0 kg, cytrichlor at 1.0 kg, gamma B70 at 1.5 kg ai/ha w/h applied twice at 10 and 30 DAI against rice gall midge in standing water, all the insecticides controlled gall midge and phorate was the most effective one.

Gubamonian et al. (1980) found that carbofuran 30 at 2.5 kg ai/ha applied in between 10 and 15 DAI effectively controlled whorl-borer and at 20-25 DAI controlled stem-borer, leaf-borer and leaf-fletcher. He also noticed that carbofuran 30 at 0.5 kg ai/ha applied 25 and 45 DAI effectively suppressed all pests.

Sundaramaju (1980) reported that carbofuran, methidathion, phorate, quinalphos and isofenphos at 1.0 kg ai/ha applied once on 15 DAT, twice on 15 and 35 DAT were effective in controlling whorl maggot, thrips and leaf folder. He also added that there was no significant difference between one and two applications of carbofuran and methidathion which recorded maximum yields.

Varadaraman (1980) recorded that carbofuran could effectively control leafhopper, stem borer, leaf folder and plant hopper of rice.

Venuesonal et al. (1980) observed that carbofuran significantly stimulated root growth, enhanced plant height, produced more tillers and promoted rapid mortality of insects.

Venkateswamy and Kalode (1980) in a green house experiment to study the effectiveness of 24 granular insecticides applied in water against brown plant hopper observed that DDT and carbofuran showed immediate knock down action recording 100 per cent mortality within 5 hours after ecdysis. The overall persistent toxicity of the chemicals was DDT, disulfoton, gamma BHC, carbofuran, thiodan, chlorodaneform, carbin, carbaryl, lindane and quinalphos in the descending order.

Persistence of the insecticides in rice plants when applied as granules

Investigations on the control of grassy stunt disease and its vector Hilarnavata lugens (Stål.) conducted in IIRRI, Philippines, revealed that insecticide granules applied to rice seedlings did not persist effectively so as to cause significant reduction in disease incidence in main field (Anon 1969).

Sothunathan et al. (1969) observed that diazinon was degraded rapidly from nonsterilized soils indicating microbial participation and the insecticide was highly unstable at pH 4.7 .

Choi et al. (1970) found that fenvalerthion 5 per cent and gamma BHC 6 per cent granules applied at 3 kg/1000 m² gave high mortality of newly hatched larvae of Orissa gammacellia and 50 per cent mortality was retained for 14 days after treatment with gamma BHC.

Manda et al. (1970) while studying the behaviour on and in rice plants of diazinon, applied as granules in paddy field, observed that chloroform soluble portions in the plant increased steadily and was greater in leaf blades than in leaf sheath. The translocation from leaf sheath to leaf blade was faster than from irrigation water to leaf

sheath. The chloroform soluble substances in plant was only 50 per cent on next day after application while more undecomposed diazinon could be detected in the soil.

Kulthrecht et al. (1971) in a trial conducted at Jattook observed that granules of cytolane, diazinon, chlorfenvinphos, gamma HCH, azinphos, carbosulfan, aldrin, dieldrin and dursban were highly toxic to Leptotettix viridis giving up to 75-100 per cent kill of adults 3 days after application. Carbofuran, azinphos, phosalone and cytolane remained highly effective for 21 days. Carbofuran remained effective for the longest period of 25 days, at 1.00 and 2.00 kg ai/ha.

Thontadraya and Panbhavany (1971) reported that phosalone persisted in rice plants in effective dose to kill 50 per cent of Myndus maculipes for about 30 days after application of the insecticide at 1 lb and 2 lb ai/acre.

Jaques (1973) recorded that diazinon at 1.75 lb ai/acre applied 21 days after sowing showed uptake within 24 hours after application, highest concentration (5.9 ppm) on the third day. By the end of 4 weeks after treatment it came down to 0.6 ppm.

Velupatham et al. (1973) reported that phorate at 1.25 kg/ha applied into paddy field against larvae of Hydrillia nana caused 100 per cent mortality within 72 hours.

Takahashi and Imai (1974) studied the behaviour of diazinon applied in paddy field and found that when diazinon was applied as 5 per cent granules to surface of water at 30 kg/ha in Japan, the amount of diazinon detected in water, soil, rice plant and air were relatively high during two first 2 days after treatment and then declined sharply on 4th day and were extremely low by 15th day. The concentration of the insecticide in rice plant was proportional to the concentration in water. A concentration of 0.3 ppm which was maintained in the plant up to 4 days was sufficient to kill the larvae of rice stem borer.

Nagalingam et al. (1975) found that persistence of insecticides applied in rice plant by seedling dip method is short lived. Among four insecticides only phorate appeared to show some significant results. Caterpillars fed on leaves collected from 10th day onwards after treatment with phorate showed complete mortality on 14th day and by 15th day lost its effectiveness. Phosphamidon, disulfoton and methyl demeton persisted for 10-14 days but was not in a toxic level to give high mortality.

of treatment. All the other insecticides gave poor results both for initial and residual toxicity, to brown plant hopper.

Rajulakshmi et al. (1977) studied persistence and degradation of phorate and carbofuran under flooded condition and found that phorate when applied at 1.25 kg ai/ha degraded quickly. But carbofuran at the same dose remained in soil for more than 60 days and thus covering the crop with bioicidal activity.

Venkateswarali (1977) studied the biodegradation of carbofuran in flooded soil and observed that more rapid degradation of the compound occurred under flooded condition than under non-submerged condition. Carbofuran was degraded rapidly between 20 and 40 days after flooding in laterite, alluvial and pokkali soils.

Agnihotri (1978) observed that degradation of diazinaton and phorate was found to be faster under irrigated than in the unirrigated condition. Under flooded condition in rice field, the degradation of these insecticides was much slower than compared to non-flooded fields of greengram or cotton.

An observation made by Hayah et al. (1978) in studying the metabolism of carbofuran in rice plants was that plants treated with carbofuran was more toxic to DDT in laboratory than in the field. Rapid loss of toxicity was correlated with rapid degradation of the insecticide under high sunlight and high temperature.

Kono et al. (1978) found that high level of insecticidal activity of carbof was maintained in the seedling brought from the treated nursery for 2 weeks. It was also concluded that level of carbof in phloem play an important role in the insecticidal activity and the mortality curve did not correspond with HSC values.

Li et al. (1978) observed that neophthalan do not accumulate in rice grain and the concentration in water decreased at a rapid rate due to its degradation by the rice plant, fish and other living organisms in the rice field ecosystem.

Ichikawa et al. (1978) studied the influence of different levels of irrigation on absorption, translocation and persistence of phorbic in rice and recorded that water at field capacity level was conducive to a higher level of insecticide absorption and for its prolonged persistence in the crop.

Rajagopal et al. (1978) reported that carbofuran applied at the rate of 0.5 kg ai/ha in acidic rice soils dissipated to undetectable levels within 21 days after application. But when applied within 7 days after application of lime, considerable amount of insecticide persisted even after three weeks.

Rajukannu (1978) found that persistence of carbofuran in rice soils at Coimbatore was higher at field capacity level than under flooded condition.

Saivinasj et al. (1978) studied the persistence of mephosfolan at field capacity and flooded condition in rice soils of Tamil Nadu and observed that moisture played an important role in persistence of insecticide. Persistence was more in field capacity level than in flooded condition and the half-life have varied from 1.33 to 1.48 weeks and 1.02 to 1.04 weeks respectively.

Rajukannu et al. (1979) found that when carbofuran and phorate applied to paddy at 1.25 kg ai/ha, the uptake and persistence of carbofuran was higher than phorate. Half-life value of the toxicants in plants was 25-27 days and 13 days respectively.

Salvazar et al. (1979) observed that naphosolan persisted for 30-40 days under flooded field condition, when applied at 0.75 kg ai/ha .

Yadav et al. (1980) also observed that among granules of carbofuran at 3.0 kg ai/ha, naphosolan, quinalphos, basudin, endosulfan, dinoseb and phorate at 1.5 kg ai/ha, the residual toxicity (RT index) was higher for carbofuran (500.62) and naphosolan (489.93) whereas quinalphos, dinoseb and phorate were on par with RT values of 219.24, 209.93 and 337.95 respectively.

Kajulaani et al. (1980) observed that application of carbofuran in the rootzone increased persistence than in paddy water broadcast application. Rapid absorption and translocation of carbofuran resulted in accumulation of residue in leaf tips. Degradation was more in water than in soil and related to the high pH of water.

Residue of carbofuran, phorate, naphosolan and other insecticides in rice grain and straw when applied as granules

In a study regarding the residues and usage hazards of phorate in paddy (Anonymous 1971) it was observed that maximum levels of phorate residues were found in paddy plant

at about 50-60 days after the first application of the toxicant. The levels of residues reached well 4.0, 6.5 and 9.5 ppm at the rate of 2.0, 1.0 and 0.5 lb/acre respectively.

Gupta, S.S. (1971) suggested bioassay as a useful tool for determination and study of pesticide residues, as the more important is not the presence or absence of a particular compound but its biological activity.

Michael and Palasibromanian (1976) studied the residue pattern of ethion in rice when applied as granules and could detect residues, but progressively lower, even after 45 days after application of the insecticide. In a pot culture experiment at 1.0 kg level of the insecticide 10.78, 3.67 and 1.47 ppm were recorded on 15, 30 and 45 days after application and in field trial only 6.12, 3.92 and 1.47 ppm were recorded.

Rajukharan et al. (1976) reported that when phorate and carbofuran at 1.25 kg ai/ha and endrin 2.0 kg ai/ha were applied to rice crop at 15 and 45 DAT, residues of phorate and endrin in milled grain were 0.075 to 0.083 ppm and 0.05 to 0.067 ppm respectively. Straw contained 0.15 ppm of phorate residue and 0.05 to 0.10 ppm of endrin which were above MPA tolerance limit. Carbofuran had left

0.03 to 0.057 ppm in hulled grain and 0.15 to 0.19 ppm in straw within the safe limit of 0.2 ppm.

In another study conducted at IIRI, Philippines the carbofuran residue in rice grain was estimated as 0.11 ppm when the insecticide was applied two times at 1.0 kg ai/ha and the values were below the EPA tolerance limit up to 5 rounds of application (Anonymous 1977).

Rajukhanan et al. (1977) estimated residue of phorate and carbofuran in hulled grain and straw when the insecticides were applied at 1.25 kg ai/ha in two split doses at 15 and 45 DAT. He found a toxic residue of 0.083 ppm of phorate which is above the EPA tolerance level of zero for phorate; but carbofuran left only very low residues in grain and straw which were below the tolerance limit.

Saivaraaj and Venugopal (1977a) reported that when carbofuran was applied to paddy at 0.75 kg and 1.0 kg ai/ha at 15 and 35 DAT in a season left a residue of 0.04 ppm in grain and 0.11 to 0.18 ppm in bran. When the application was at three occasions on 20, 40 and 60 DAT corresponding values were 0.10 to 0.15 and 0.18 to 0.75 for grain and bran respectively. The corresponding values for methidathion at the two dosages for 2 applications were 0.10 to 0.20 ppm in grain and 0.12 to 0.17 ppm in bran. When the insecticide

was applied 3 times the residues were amounted to 0.2 to 0.48 and 0.08 to 0.18 in the grain and bran respectively. In husk and straw the residues were in non-detectable levels.

Mathyantha et al. (1978) reported that with an increase in dose of carbofuran there was an increase in residue level, and as the time lag between application and harvest decreased residue in grain and straw increased. Maximum residue shown for applications varying from 0.21 kg to 1.73 kg ai/ha, for 3 occasions was 0.097 ppm in grain and 0.095 ppm in straw, both of which were much below the EPA tolerance limit of 0.2 ppm.

Rajukannu and Krishnamoorthy (1979) observed that carbofuran applied at 1.25 kg ai/ha at 20 DAT left 0.06 and 0.21 ppm residues in paddy grain and straw whereas the corresponding values for phorate at the same dose were 0.08 and 0.15 ppm respectively.

But Visalakshi et al. (1979) reported comparatively higher values of residues when the insecticides were applied at boot-leaf stage. While carbofuran at 0.5 kg ai/ha levels left a residue of non-detectable level in grain and 0.35 to 0.47 ppm in straw, it was 0.62 to 0.81 and 1.0

to 1.44 ppm respectively for 1.0 kg level. For phorate these values at 1.25 kg ai/ha were 0.12 to 0.32 and 0.24 to 0.34 for grain and straw but at a rate 2.5 kg ai/ha the residues amounted to 0.38 to 0.65 and 0.83 to 1.1 ppm respectively.

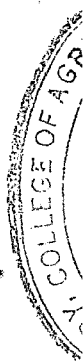
MATERIALS AND METHODS

MATERIALS AND METHODS

Six insecticides in granular form (Appendix I) viz. carbofuran (Dursban 36) supplied by M/s. Rallis India Ltd., Bombay; phorate (Thimet 100) and methidathion (Cyrolane 50) both from M/s. Gyanid India Ltd., Bombay; disulfoton (Solvix 50) and quinalphos (Himlux 50) supplied by M/s. Sandoz India Ltd., Bombay, and chlorodimethoxy hydrochloride from M/s. Ciba-Sieco of India Ltd., Bombay were used for these studies.

Studies on the effect of insecticides applied as granules in soil on the control of different pests of paddy.

Field experiments were laid out in the Instructional Farm, College of Agriculture, Vallayam, during three cropping seasons viz. Viruppu, Mundakan and Pancha of 1976-77. A randomized block design with three replications was adopted. The plots were laid out with alternate buffer plots of 1 m width the gross plot size being 6 x 4 m. Observations were limited to a net plot of 5.1 x 3.4 m. The variety of rice used was 'Triveni' having a duration of 110 days. The seedlings were transplanted in each plot at a close spacing of 15 x 10 cm to favour higher pest infestations. Plots were separated by bunds 30 cm broad.



Separate irrigation and drainage channels were provided for the different plots to avoid interplot contamination. The cultural operations recommended for variety 'Triveni' under the package of practices of Kerala Agricultural University were adopted.

The treatments consisted of six insecticides each used at two doses viz. carbofuran at 0.5 and 1.0 kg ai/ha, phorate at 1.0 and 2.0 kg ai/ha, naphosolan at 0.5 and 1.0 kg ai/ha, disulfoton at 1.0 and 2.0 kg ai/ha, quinalphos at 1.0 and 2.0 kg ai/ha and chlorodaneform at 1.0 and 2.0 kg ai/ha. There were also two control treatments with no insecticide for each experiment.

The insecticides were applied as granules at 2 occasions on a crop; the first treatment was at 21 days after transplantation (DAT) and second on the 45th day after transplantation. Prior to application of the insecticides the plots were weeded, manured and water level maintained at 2.5 cm approximately. The insecticide granules required for each plot were weighed out and mixed up with 100 grammes of dry sand to enable uniform distribution of the material in the plots. The sand-insecticide mixture was applied in the plots by broadcasting. The water level in the plots was retained at 2.5 cm throughout the period of experiment.

The results were assessed in terms of pest incidence in the plots under different treatments by the actual count of the insect concerned or the counts of the affected plant parts. These observations were made just one day prior to the insecticide application and then at regular intervals following the insecticidal application. The first application was done 21 May and the first pest count was taken 2 days after the application and subsequently at intervals of 7 days for a total duration of 24 days. The first count after the second application on 45 May was made 2 days after the application and subsequently at 7 days intervals up to 75 May. Different methods were adopted for the assessment of the population in the plots. Sweeping with a hand net was done for the assessment of population of green leaf hoppers (Homalotettis viridescens Stål. and H. nigricornis Hal.), white leaf hopper (Sicadella brevis Stål.), cicadas (Virgulus downsi Guen.), rice swimming caterpillar (Spodoptera mauritia Bois.), grasshoppers (Merodiphysa benari Fab. and Oryza gibberna Munberg), rice bug (Cer-tosiphia acuta Thunb.), minute bug (Cyrtosiphum lividipennis) and aphids. A sweep net of 33 cm² was used for this purpose. The sweeps were made during the morning hours. Ten sweeps were made in each plot covering the maximum area by walking

from one corner to the opposite corner of the plot. The insects collected from ten sweeps were counted and recorded.

For the counts of brown plant hopper (Nilaparvata lugens Stål.) in each plot two observation units were fixed each containing five hills. The total number of insects infesting the plant in each unit were counted and recorded. Gall midge (Oncopeltus perzasi Wood-Iason) counts were made by counting the number of galls present in two observation units of $1 \times 1/2$ m in each plot. The damage due to the whorl maggot (Hydrellia philippina Ferrière.) was ascertained by counting the number of leaves showing the semilunar scorchings caused by the insect in the two observation units. The population of rice stem borer (Scirpophaga incertulas Walker.) was assessed by counting the number of dead hearts in the early stages and white ear heads in the later stage in the observation plots. The leaf roller (Choristoceros medialis Guen.) infestations were assessed by counting the number of leaf rolls inhabited by living caterpillars in the two observation plots. For computing the data the average counts per plot of each insect was taken and summation of the means observed on different occasions following insecticide applications calculated. On this basis separate data were presented to study the effect of the first application alone, the effect of the second application alone and

effect of the combined applications. The data were analysed by the analysis of variance method.

Studies on the persistent toxicity of insecticides applied as granules in soils to different pests of paddy.

A pot culture experiment with a randomized block design of three replications was undertaken for this purpose. Paddy seedlings ('Trivani') were transplanted in pots of 30 cm dia. with a spacing of 15×10 cm, each pot having four hills of paddy. The usual nurseries and cultural operations were done and the level of water in each pot was kept at 2.5 cm throughout the experiment. The treatments were the same as those described in the field experiment above. The insecticide formulations required for each pot was weighed out and applied to the pot at 21 DAT. The persistent toxicity of the insecticide was assessed to three of the paddy pests viz. brown plant hopper, rice swarming caterpillar and leaf roller.

In the case of brown plant hopper, third instar nymphs from a laboratory reared culture, were used. Two tillers of the treated plants in pots were enclosed in glass tubes open at both ends, 3 cm in diameter and 15 cm in length, by pushing the tube down to the base of the plants and the

open tip closed with muslin. Twenty third-instar nymphs were released into each tube and mortalities taken 48 hours hence. There were three replications for each treatment. The first assessment of the toxicity was made two days after the insecticide application and thereafter at five day intervals till there was no mortality. Nymphs confined similarly on untreated plants formed the control. In the case of rice swarming caterpillar, glass hurricane lamp chimneys were used for confining the larvae on the plants under the different treatments. Twenty third-instar larvae were used in each chimney for the toxicity assessment. Mortality observations were made at the same intervals as mentioned above till there was no mortality. The larvae used for the experiment were reared in the laboratory. For rice leaf roller, third-instar larvae taken from the laboratory culture were used. The leaves of the plants in a bill were brought together by tying with a twine after releasing the caterpillars on the leaves. This prevented the larvae from dropping down or moving away from the plants. The tied up leaves were enclosed in a muslin cloth by using iron wire rings for keeping the bags in an extended condition. Mortality observations were taken as mentioned above. From the data of mortalities observed, corrected mortalities were

obtained using the Abbot's formula and the persistent toxicity was calculated by a method elaborated by Pradhan (1957) (where P = period after treatment in days, T = average residual toxicity and PT = index of persistent toxicity).

Studies on the effect of different frequencies of application of insecticide granules in soil on the control of various pests of paddy.

Field experiments were undertaken during three seasons to study the effect of frequencies of insecticide application on paddy pest control. The details of the lay out of the plots were similar to those of the field experiment undertaken to study the effect of the different insecticide granules for the control of pests of paddy. The treatments under these experiments were as given below:

T ₁	Carbofuran	at	1.00 kg ai/ha	applied	21 DAT
T ₂	"	at	1.00 "	"	45 DAT
T ₃	"	at	1.00 "	"	21 & 45 DAT
T ₄	Thorate	at	2.00 "	"	21 DAT
T ₅	"	at	2.00 "	"	45 DAT
T ₆	"	at	2.00 "	"	21 & 45 DAT
T ₇	Hopfenfolan	at	1.00 "	"	21 DAT
T ₈	"	at	1.00 "	"	45 DAT

T₉ Heptachlor at 1.00 kg ai/ha applied 21 & 45 DAT
 T₁₀ No insecticide (Control).

The application of the insecticides and the assessment of results were made as in the experiment on the effectiveness of different insecticides described above. The data were analysed by analysis of variance method.

Studies on the effect of irrigation levels on the toxicity of different insecticides applied as granules in soil to brown plant hopper and rice sucking caterpillar

In this experiment the different treatments were applied under field conditions and the assessment of results based on bioassay undertaken in the laboratory. In the field experiment a split plot layout in randomized block design with three replications was adopted. The plots were of size 2 x 1.5 m with bunds of 30 cm broad in between. Buffer plots 1 x 1.5 m were alternated with experimental plots. Separate provisions were made for irrigation and drainage for each plot. Rice variety used was 'Trivani' planted with a spacing of 15 x 10 cm. The net plot was of size 1.4 x 1.1 m with 99 hills of paddy. The treatments consisted of two levels of irrigation, three insecticides and two occasions of insecticide applications. Untreated plots formed control.

The treatments were as follows:

T ₁	I ₁ W ₁ S ₁	T ₂	I ₁ W ₁ S ₂
T ₃	I ₁ W ₂ S ₁	T ₄	I ₁ W ₂ S ₂
T ₅	I ₂ W ₁ S ₁	T ₆	I ₂ W ₁ S ₂
T ₇	I ₂ W ₂ S ₁	T ₈	I ₂ W ₂ S ₂
T ₉	I ₃ W ₁ S ₁	T ₁₀	I ₃ W ₁ S ₂
T ₁₁	I ₃ W ₂ S ₁	T ₁₂	I ₃ W ₂ S ₂
T ₁₃	I ₀ W ₁ S ₁	T ₁₄	I ₀ W ₁ S ₂
T ₁₅	I ₀ W ₂ S ₁	T ₁₆	I ₀ W ₂ S ₂

where I₁ = carbofuran 1.0 kg ai/ha, I₂ = phorate 2.0 kg ai/ha, I₃ = methidathion 1.0 kg ai/ha, I₀=control - no treatment; W₁ = field capacity level, W₂ = flooded level; S₁ = 21 DAT, and S₂ = 45 DAT.

The two levels of irrigation were (a) field capacity level i.e. water maintained at field capacity level in which enough water was let into the plots to maintain the soil saturated with water and with no water accumulation on the soil surface, (b) flooded level i.e. water maintained in the plots to a depth of about 2.5 cm. Insecticides were applied at the two occasions as in the insecticidal trials described above.

The uptake and persistence of the insecticides were studied by exposing the test insects on the plants under the different insecticidal treatments at fixed intervals after application. For this, single hill of plants was uprooted at each occasion in such a way that each time the hills uprooted had root system which were not disturbed by the previous removal of hills. Plants from different plots were brought to the laboratory and planted in small pots of 15 cm dia in soil collected from untreated plots.

For the estimation of the persistent toxicity of the insecticides to brown plant hopper two tillers from each of the pots were enclosed in glass tubes of 3 cm diameter. Third-instar nymphs of brown plant hopper numbering 20 were released into each tubes and the openings of the tubes closed with cotton plug, permitting the excess length of the plants, if any, to remain jutting out of the tubes. Mortality observations were made 48 hours after the release of nymphs. There were three replications at each occasion. These observations were continued till there was no mortality of the insect. In the case of rice swarming caterpillars the potted plants were enclosed in hurricane-lamp chimneys in such a way that the leaves of the plants were enclosed within



the chimneys. Third-instar eucyphillae numbering fifteen were released on those plants in each pot and mortality observations made 48 hours after exposure.

Determination of residues of insecticides in straw and grain

The residues of the insecticides in paddy straw and grain were estimated by bioassay using adults of Braconshila melanogaster as the test insect. There were two main steps involved in these estimations, the first consisted of extraction of the residues from the plant parts and clean up of the extract to eliminate the extraneous materials extracted by the solvents. The second step consisted of estimating the insecticide residues in the extracts in terms of the mortality of B. melanogaster exposed to a dry film of the extracts.

The method followed for rearing the test insect, the extraction and clean up of the insecticides and the determination of residues are detailed below.

Rearing of B. melanogaster

B. melanogaster was reared in the laboratory in an artificial diet consisting of agar-agar 40 g, maize flour 100 g, jaggery 40 g, yeast tablet 35 tablets, propionic acid 5 ml and water 2 litres.

The maize flour was first mixed with 250 ml of water. Yeast tablets were powdered and mixed with another 250 ml of water. Agar-agar was mixed with 1500 ml of water and boiled. To this the maize flour mixed with water was added and boiled. The jaggery flakes and yeast suspension were also added and boiled. When the maize flour was sufficiently cooked the diet mixture was removed from fire and the propionic acid was added and stirred. The medium was then poured into wide mouthed bottles to a height of about two centimeters. After cooling 20-25 adults of B. melanogaster were released into each bottle and closed with muslin cloth and the bottles were kept in BOD incubator at 25°C. Unsexed adults not more than a day old were used for the residue determination.

Residue determination using B. melanogaster

The residues of the different insecticides were determined on the basis of standard curves prepared for each insecticide. For preparing the standard curves six graded concentrations of the insecticides (technical materials were used for the determinations of residues) in concerned solvents were prepared (see below). Dry film of the insecticide dilutions were prepared within 24 hours

test tubes 25 cm long and 2.5 cm dia by pouring 1 ml of the dilution into the tube and allowing it to evaporate on its internal surface uniformly by rolling the tubes in a horizontal position. After the solution had evaporated the tubes were placed under fan for 1 hour for clearing the tubes of the fumes of solvent. Fifteen adults of the test insects were then released into the tubes and closed with muslin cloth. The tubes with the insects were then placed in BOD incubator at 25°C and mortality observations made after 8 hours. From the dosage-mortality values regression equation was calculated for each insecticide.

For the determination of the unknown residues contained in an extract the test insects were exposed to the dry films in test tubes made from the extracts, as described above. From the mortalities observed the residues were calculated substituting the values of y in the concerned regression equation.

Extraction and clean-up of different insecticide residues:

Carbofuran in straw

Extraction and purification procedure described by Gupta and Dewan (1973) was followed.

Acid hydrolysis and solvent extraction

Fifty grams of each of the chemical jaddy straw sample were taken in 500 ml conical flask and 500 ml of 0.25 N hydrochloric acid was added (Cook et al., 1969) and refluxed on a water bath using an air condenser for one hour. Then the content was filtered through glass wool over cotton and the volume was made up to 500 ml using hot 0.25 N hydrochloric acid. It was kept over night in storage bottles in refrigerator and 250 ml of supernatant hydrochloric extract was then transferred to 500 ml separating funnel and shaken well with 45 ml of dichloromethane and six drops of 4% solution of sodium lauryl sulphate for two minutes and allowed to stand for some time for separation. The lower dichloromethane layer was drawn out and was then passed through anhydrous sodium sulphate to remove the water present. This step was repeated thrice and collected the combined extract in the same beaker and was concentrated under dry air to less than 50 ml. The volume was then made up to 50 ml with dichloromethane. This was used for bio-assay of the isocoumarin residue.

Carboxams in grain

The procedure adapted by Cook et al. (1969) for the estimation of carboxams in corn kernel was used. Aceto-

nitrile hydrocarbon partition technique described by Jones and Piddick (1952) was used for removing the fatty materials from grain samples. Fifty gram samples of the smashed grain were hydrolysed with 500 ml of 0.25 N hydrochloric acid and extracted in dichloromethane thrice as described above. The combined extract from each sample was concentrated to 10 ml and 50 ml acetonitrile was added to it. The concentration was again continued and the solution was transferred quantitatively into a 250 ml separating funnel. The solution was thrice extracted with 50 ml each of hexane saturated with acetonitrile. The hexane layers were then discarded and the acetonitrile portion was concentrated to less than 2.5 ml. Again it was transferred to 250 ml separating funnel. 50 ml of 0.25 N hydrochloric acid was added to the separating funnel and extracted thrice with 25, 15 and 10 ml each of dichloromethane. These three extracts were mixed and the volume made up to 50 ml. 1 ml of this extract was taken into the bioassay tube and residue assayed.

Phorate in straw

The extraction was made following the method adopted by Sutherland et al. (1964). Ten grams of the chopped paddy straw were macerated with 50 ml of chloroform in a

varing blender and transferred to a 250 ml flask and shaken for 1 hour in a horizontal shaker. The resultant suspension was filtered and dried over anhydrous sodium sulphate. The residue of the plant tissue in filter paper was again washed with 30 ml of chloroform. The filtrate was taken to dryness at 50-60°C and was redissolved in 10 ml of chloroform. The insecticide content was estimated adopting bioassay technique.

Phenols in grain

The fats and waxes in the extract from grain samples were removed by hydrocarbon partition technique of Jones and Riddick (1952). Ten grams of grain samples were crushed in a grinder and extracted with chloroform and cleaned-up as described in the previous experiment.

An equal quantity of acetonitrile was added and was shaken thoroughly for 2 minutes. When the two phases separated, the acetonitrile layer was transferred to a 250 ml flask. The n-hexane solution was again extracted thrice with 15 ml each of acetonitrile. The four acetonitrile fractions were combined and transferred quantitatively to a separating funnel containing 500 ml of 4% aqueous solution of sodium sulphate and then 100 ml of n-hexane was added. This mixture was shaken for 2 minutes and the lower layer of

acetonitrile discarded. The n-hexane was washed with 100 ml each of 4% aqueous solution of sodium sulphate twice and the washings discarded. The n-hexane layer was filtered through anhydrous sodium sulphate and the filtrate evaporated to dryness at 53-60°C and the residue was dissolved in 10 ml of chloroform.

Topsoil in assay

Procedure as described in Anon (1972) was followed. 25 grams of chopped paddy straw from each of the different treatments with carbosolan and carbozol were transferred into 500 ml screw-cap bottles fitted with polythene seal cap. 400 ml chloroform was added into it and closed tightly. The samples were shaken adequately for over night. The extracted mixture was filtered through a 600 ml coarse porosity sacher funnel and collected approximately 500 ml clear filtrate. 200 ml of the filtrate was transferred to a beaker and evaporated on a water bath at 30-35°C to a solution free residue. 25 ml of acetone was added to the residue to dissolve it and filtered through anhydrous sodium sulphate. The filtrate was made up to 25 ml using acetone and the quantity of insecticide estimated.

Nephrolein in grain

Twenty five grams of ruddy grain from each of the canisters with nephrolein were ground and treated with 400 ml chloroform as described under ruddy straw. The solution free residue obtained in the beaker by evaporating 200 ml of the filtrate was subjected to hydrocarbon partition technique. The residue was dissolved in 500 ml hexane and added 100 ml of acetonitrile and transferred the mixture to a 500 ml separating funnel. The mixture was shaken for 30-60 seconds, allowed the phases to separate and the lower acetonitrile layer was drawn into a 500 ml beaker. The hexane layer was again extracted with 100 ml of acetonitrile. The acetonitrile phases were combined and evaporated to dryness. 25 ml of acetone was added to this residue to dissolve it and passed through anhydrous sodium sulfate. The volume was again made up to 25 ml using acetone and the residue determined.

RESULTS

RESULTS

EFFECT OF SOIL APPLICATION OF IMIDACLOPRID GRANULES ON CONTROL OF PAIRY PESTS DURING FIRST CROF SEASON (MAY 20 SEPTEMBER 1976)

In Table 1 and Fig. 1 are presented results of observations made on population of the different pests under the different insecticidal treatments, during 24 days following application 24 days after transplantation (DAT). It will be observed that except the treatments using quinalphos and chlorodiforom granules all the other treatments gave significant reduction in the population of brown plant hopper (BPH) as compared to control. Thus against the mean population of 30.5 per plot in control the populations were 1.33 to 24.00 under the different effective treatments. Among the effective treatments carbofuran at 1.0 kg active ingredient per hectare (ai/ha) gave the best control with 1.33 BPH per plot. Phorate at 2.0 kg ai/ha also was highly effective in controlling BPH (6.00 per plot) and this was on par with carbofuran at 1.0 kg ai/ha. The other treatments which gave effective control of BPH in the descending order of efficacy were methophosalan at 1.0 kg, phorate at 1.0 kg, disulfoton at

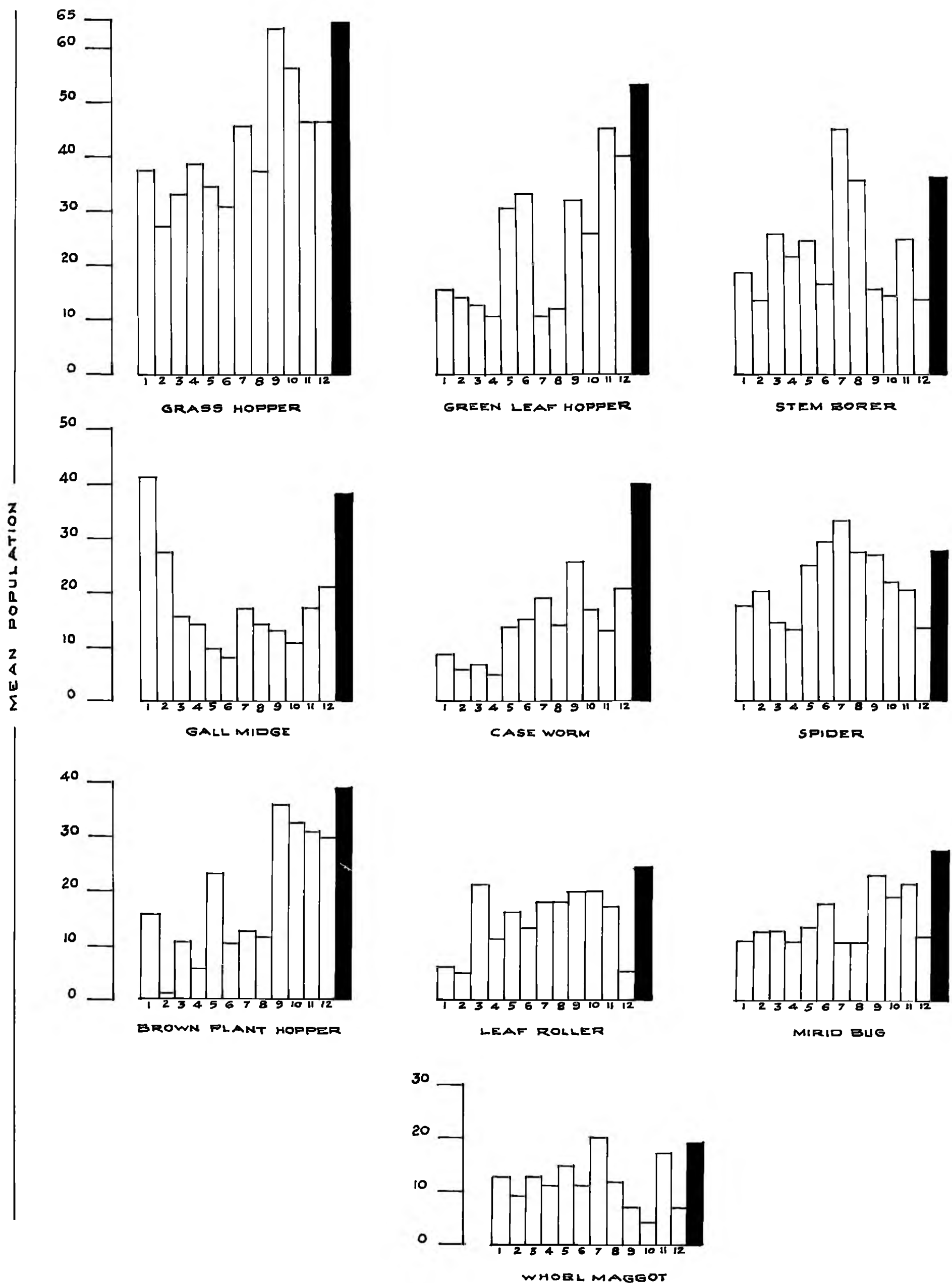
Table 1. Mean population difference in the number of insects per plant and natural enemies under two different treatments 24 days following application of insecticide.

row	ants	1. oc	s	HH	0	all mid o	best m apt	Item box	leaf roller	Cane worm	Cane hopper	Field bug	Spider
	car	ma	0 5	7	73	7	2 67 70	33 0	00 2 60	8 67 (3 08)	32 33 (6 25)	11 00 (3 46)	18 33 (4 34)
2	car	ma	0	3 4	4 3	1 1	7 3 3 20	14 00 07	5 00 2 41	6 00 (2 60)	28 33 (5 41)	13 00 (3 71)	20 00 (4 52)
3	hore	e	0	33 30		7	3 33 75	2 00 5 8	21 33 4 67)	7 33 (2 83)	34 33 5 91	13 00 (3 72)	14 00 3 87)
4	ho				77		0 7 2	22 00 7	1 33 3 49	5 33 (2 50)	32 00 6 30	1 33 3 45	13 00 3 72)
							67	24 7 05	00 4 24	3 67 3 82	3 00 97	4 33 3 07	24 67 05
									2 67 3 66	5 33 4 0	3 00 5 5	00 4 30	2 00 44
							7	1	00 4 36	9 00 4 43	4 7 (6 77)	0 7 4	3 3 5
									7 7 4 43	4 33 3 90	3 3 25	33	77 00 22
							73	7	20 33 50	26 33 6 13	64 7 0 07	22 7 4 00	27 00 26
							7	7	30 33 77	17 33 4 28	57 00 7 5	33 4	20 7 4 5
									7 9	13 00 3 60	47 00 (7 05)		20 00 4 57
							7		4 7 37	20 67 (4 65)	47 00 (6 87)	33 56	3 3 3 7
									2 03 4	40 33 (6 37)	64 67 (8 09)	27 7 5 20	26 50 30
									0	(0 99)	0 92	3	0 92
								97	76	(0 86)	(0 80)	0 96	0 80

Fig. 1. Mean population of different insect pests and natural enemies observed for 24 days following application of different insecticide granules at 21 DAT during first crop season

1.	Carbofuran	at	0.5	kg ai/ha
2.	..	..	1.0	..
3.	Phorate	..	1.0	..
4.	..	..	2.0	..
5.	Mephenfolan	..	0.5	..
6.	..	..	1.0	..
7.	Disulfoton	..	1.0	..
8.	..	..	2.0	..
9.	Quinalphos	..	1.0	..
10.	..	..	2.0	..
11.	Chlorodimethoate	..	1.0	..
12.	..	..	2.0	..
■	Control			

FIG 1 MEAN POPULATION OF DIFFERENT INSECT PESTS AND NATURAL ENEMIES FOLLOWING APPLICATION OF DIFFERENT INSECTICIDE GRANULES AT 21 DAT (FIRST CROP)



2 kg, disulfoton at 1.0 kg, carbosulfan at 0.5 kg and nephotholan at 0.5 kg ai/ha, with populations varying from 11.00 to 24.00 per plot. Among these treatments carbosulfan at 0.5 kg and nephotholan at 0.5 kg ai/ha were significantly less effective than other effective treatments.

In the case of green leaf hopper (GLH) excepting chlorodimethoate, all other insecticide treatments were found to give significant control of the hopper. Among the effective insecticides disulfoton at 1.0 kg ai/ha gave the best control followed in the descending order by phorate at 2.0 kg, disulfoton at 2.0 kg, phorate at 1.0 kg, carbosulfan at 1.0 kg and carbosulfan at 0.5 kg ai/ha. These insecticide treatments with hopper infestations varying from 10.67 to 15.33 per plot as against 32.67 under control were statistically on par in their effectiveness. Nephotholan and quinalphos treatments were found to be significantly less effective than the other effective treatments with hopper populations varying from 26.00 to 44.67 per plot.

All the insecticide treatments except carbosulfan at 0.5 kg ai/ha gave significant control of gall midge infestation as compared to untreated control. Among the effective insecticides the best control was provided by nephotholan

at 1.0 kg ai/ha with eight galls per plot followed in the descending order by nephosfolan at 0.5 kg, quinalphos at 2.0 kg and quinalphos at 1.0 kg ai/ha with infestations varying from 10.67 to 13.00 per plot. These treatments were on par statistically. The other treatments viz. carbofuran at 1 kg ai/ha, the two phorate treatments and the two dicofol treatments and chlorodimeform at 1.0 kg ai/ha with populations of 13.67 to 27.33 per plot gave significantly less control than the former insecticides.

The insecticides which gave significant control of whorl maggot were quinalphos at 2.0 kg and 1.0 kg, carbofuran at 1.0 kg, phorate at 2.0 kg and nephosfolan at 1.0 kg ai/ha in that order of efficacy with infestations varying from 4.0 to 11.53 per plot as against 18.67 in untreated control. All the other treatments were ineffective. Among the effective insecticides excepting phorate at 2.0 kg ai/ha and nephosfolan at 1.0 kg ai/ha all the others were on par and giving better control than these two.

For control of stem borer chlorodimeform at 2.0 kg and carbofuran at 1.0 kg ai/ha with infestations of 14.00 dead-hearts per plot gave the best control. These were followed by quinalphos at 2.0 kg and 1.0 kg, nephosfolan at 1.0 kg, carbofuran at 0.5 kg and phorate at 2.0 kg

ml/ha in that descending order of efficiency with infestation varying from 14.67 to 22.00 per plot as against 36.00 in the control. All the other treatments were ineffective.

The best leaf roller control was given by chlorodimethoate at 2.0 kg ai/ha followed by carbosulfon at 1.0 kg and 0.5 kg, phorate at 2.00 kg, methidathion at 1.0 kg and chlorodimethoate at 1.0 kg ai/ha with infestations varying from 4.67 to 16.67 larvae per plot as against 23.83 larvae in untreated plots. All the other insecticide treatments were ineffective. Among the effective treatments the two carbosulfon treatments and chlorodimethoate at 2.0 kg ai/ha were the best, among themselves being on par.

All the insecticide treatments excepting quinalphos at 1.0 kg ai/ha gave significant control of cane worms, showing infestations from 5.33 to 20.67 larvae per plot as compared to 40.33 under control. Among the effective insecticides those which gave significantly better control were phorate at 2.0 kg, carbosulfon at 1.0 kg, phorate at 1.0 kg and carbosulfon at 0.5 kg ai/ha, which among themselves were on par.

Cane shoot borer were seen to be controlled effectively by all the treatments excepting the quinalphos treatments.

Of the effective insecticides carbofuran at 1.0 kg ai/ha gave the best control, followed by methidathion at 1.0 kg, phorate 1.0 kg, carbofuran 0.5 kg, disulfoton 1.0 kg and phorate at 2.0 kg ai/ha with infestations varying from 28.33 to 39.00 hoppers per plot in comparison to 64.67 under control.

Observations made on the effect of the insecticide treatments on insect predators showed that in the case of mirid bugs significant reduction in the population was brought about by the insecticides carbofuran, phorate, methidathion, disulfoton and chlorodifluorm each at 2.0 kg ai/ha with populations varying from 10.67 to 10.00 per plot, in comparison to 27.67 in the control. The treatments which did not affect the mirid population significantly were quinalphos treatments and chlorodifluorm at 1.0 kg ai/ha.

The population of the spiders was found to be significantly affected by carbofuran at 0.5 kg ai/ha, the phorate treatments and chlorodifluorm at 2.0 kg ai/ha. The other treatments did not affect the spider population significantly.

Table 2 and Fig. 2 present the data on the pest infestation and predator populations observed under the different treatments following their 2nd application at

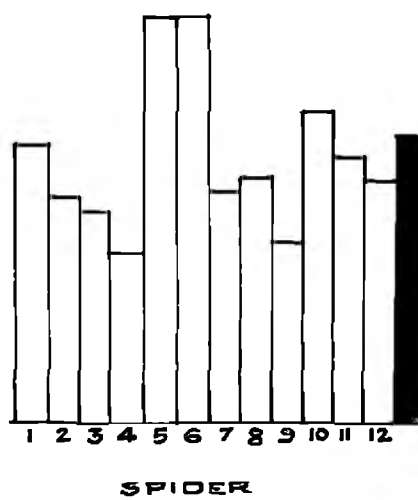
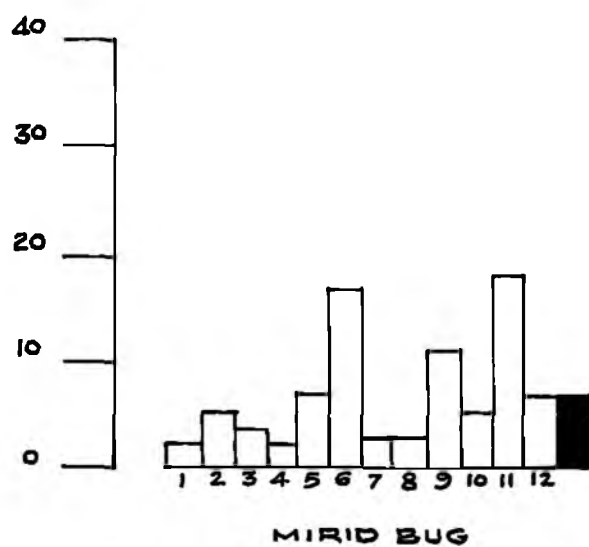
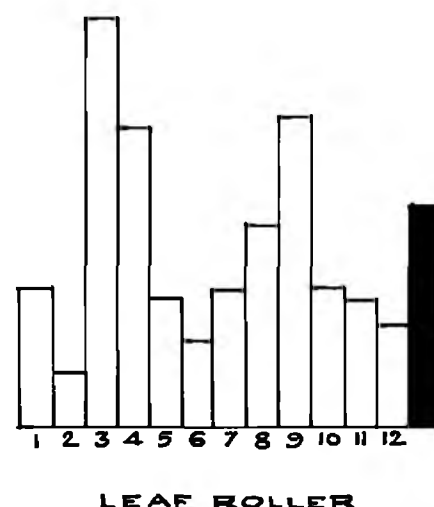
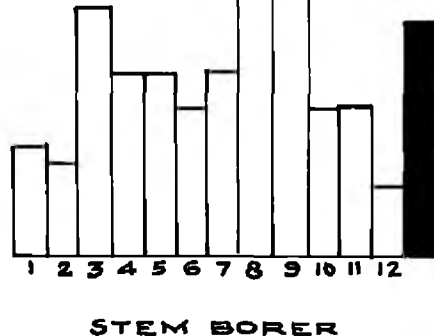
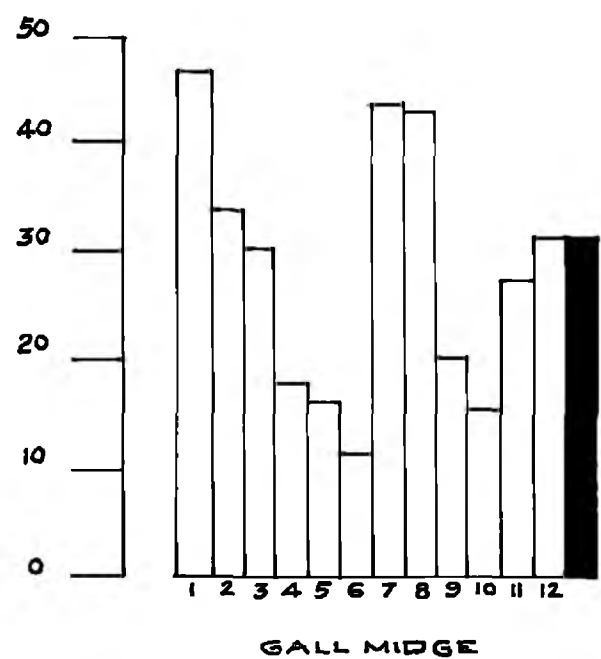
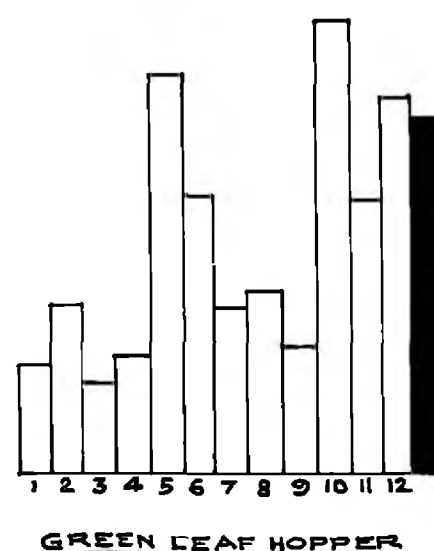
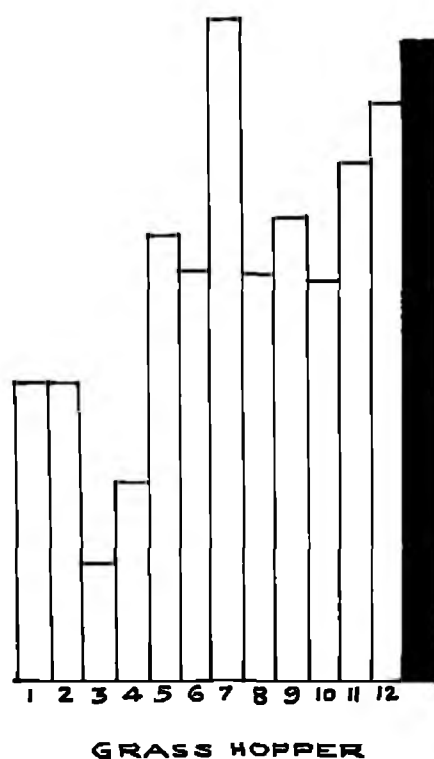
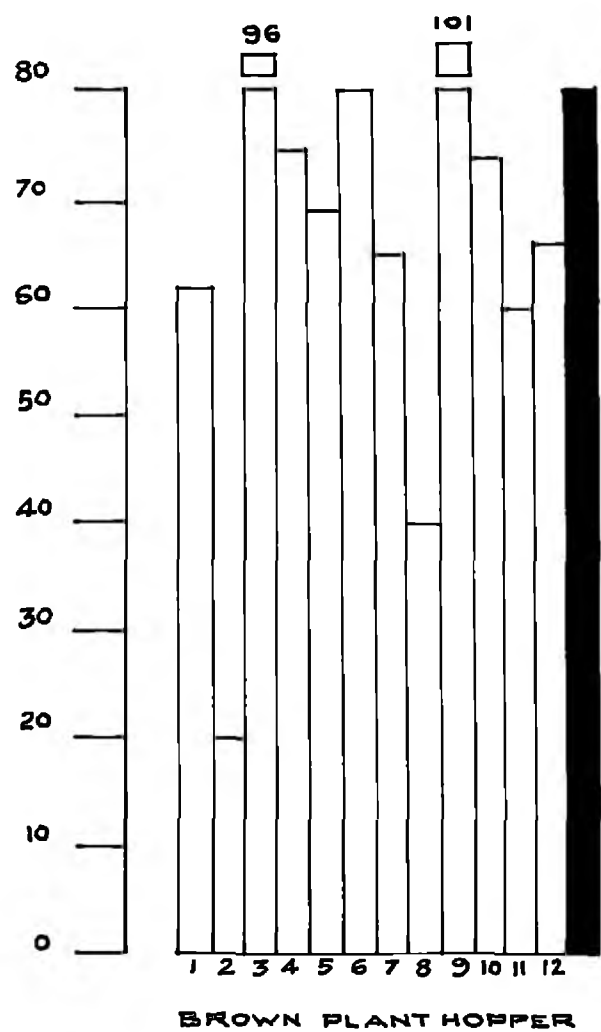
Dr. [REDACTED]

Fig. 2. Mean population of different insect pests and natural enemies observed up to harvest following application of different insecticide granules at 45 DAT during first crop season

1.	Carbofenn	at	0.5 kg	ai/ha
2.	..	..	1.0 kg	..
3.	Phorate	..	1.0 kg	..
4.	..	..	2.0 kg	..
5.	Mephosfolan	..	0.5 kg	..
6.	..	..	1.0 kg	..
7.	Disulfoton	..	1.0 kg	..
8.	..	..	2.0 kg	..
9.	Quinalphos	..	1.0 kg	..
10.	..	..	2.0 kg	..
11.	Chlorodimeform	..	1.0 kg	..
12.	..	..	2.0 kg	..
■	Control			

FIG 2 MEAN POPULATION OF DIFFERENT INSECT PESTS AND NATURAL ENEMIES FOLLOWING APPLICATION OF DIFFERENT INSECTICIDE GRANULES AT 45 DAT (FIRST CROP)

POPULATION



45 DAF. Observations on BPH infestation showed that only carbofuran at 1.0 kg, disulfoton at 2 kg and chlorodimethoate at 1.0 kg ai/ha were effective in giving significant control of the pest with 20.00, 40.00 and 60.00 per plot as against 79.83 under control. All the insecticides except methidathion, quinalphos at 2.0 kg ai/ha and chlorodimethoate gave significant control of green leaf hopper. The treatments phorate at 1.00 kg, carbofuran at 0.5 kg, phorate at 2.0 kg and quinalphos at 1.0 kg ai/ha gave substantial reduction in the leaf hopper population, the population being 9.33 to 12.33 per plot as against 32.83 in the control. No insecticide treatment was found to be effective in controlling gall midge infestation as compared to the infestation in the untreated control plots. Significant control of stem borer infestation was recorded under the treatments of chlorodimethoate at 2.0 kg, carbofuran at 1.0 kg, carbofuran at 0.5 kg, methidathion at 1.0 kg, quinalphos at 2.00 kg and chlorodimethoate at 1.00 kg ai/ha with infestations ranging from 5.67 to 14.00 per plot as against 21.50 under control. Of these effective insecticides chlorodimethoate at 2.0 kg ai/ha and carbofuran treatments gave significantly better control than the rest. The insecticide treatments which

gave maximum control of leaf roller were carbofuran at 1.0 kg, methosfolan at 1.0 kg and chlorodimethoate at 2.0 kg ai/ha with 5.33 to 1033 larvae per plot as against 20.50 in the control. The treatments chlorodimethoate at 1.0 kg ai/ha, disulfoton at 1.0 kg ai/ha and quinalphos at 2.00 kg ai/ha with infestations of 12.35, 12.67 and 15.00 also gave significant control, but inferior to the former three insecticide treatments. The grasshopper infestation was significantly affected by phorate, carbofuran, quinalphos and methosfolan treatments at both the levels and by disulfoton at the higher level. The phorate treatments were found to give substantial reduction of the grasshopper population with 11.33 and 16.00 hoppers per plot respectively as against 53.83 in the control. Populations of the mirid and spider predators were not found to be significantly affected by any of the insecticidal treatments. However, the mirid bug population was the least affected with carbofuran treatment with 2.00 bugs per plot as against 6.67 under control plot. Similarly the phorate treatments showed the maximum reduction in the spider population but not significant, with 15.67 per plot as against 27.00 under the control.

Data on the mean infestation by the different insects observed under the different treatments after the first application and continued after 2nd application up to harvest are presented in Table 3 and Fig. 3. For the

Table 3. Mean no. of insects per plant and insect pests present after 21 and 45 DAT (First crop)

Treatments in (kg ai/ha)	icides	DT	insects	insects	insects	insects	insects	insects	insects	insects	insects	insects
2 Carbo-tran	0	7 00	3 74	2 67	2 33	20 33	0 67	67 00	3 00	44 67		
		0	0	3 70	5 33	4 60	3 00	(8 25)	(3 72)	(6 67)		
2 Carbo-tran	0	72	33 3 74 7	3 33	2 7	1 33	6 00	55 67	18 00	40 67		
				3 20	4 6	(3 34)	(2 60)	(7 53)	(4 33)	(6 44)		
3 Thio-c	0	07 7	33 70	3 33	4 7	19 00	7 33	43 67	6 00	34 00		
		4		3 75	(7 05)	7 75	(2 83)	(6 82)	4 07	(5 91)		
4		07		0 7	3 00	39 67	5 33	57 00	3 33	28 7		
				2		6 37	2 50	(7 02)	3 2	5 42		
5				7		2 00	3 67	7 33	23 7	5 67		
						5 3	3 82	(8 60)	70	7 50		
				3		24 33	5 33	73 00	00	00		
					0	03	4 01	(0 5	07			
				30		3 7	9 00	07	4	3		
				17	7 3	(62	4 45	0 42	04	7 30		
					7 5	7	14 33	76 67	7	46		
						3	(3 00	0 73		0 3		
					4	4 00	26 33	08 00	44 00	33		
						(7 05	(6 13	(0 42	5	7		
						3 33	7 33	94 33	24 00	50 00		
						8	4 28	9 75	4	7		
				7		20 00	13 00	94 67	3 33	4 00		
						4	(3 60	9 78	30	(77		
				7 3	7	00	20 67	10 00	9 67	36 3		
				17		3 97	4 65	0 09	4 4			
				7	7	43 00	40 33	123 50	33 7	73 50		
				2		(63	(6 37	(1 5	(4	7 77		
							0 04	0 99	1 65	2	0 95	
							73	0 00	(1 57	03	0 02	

✓ T

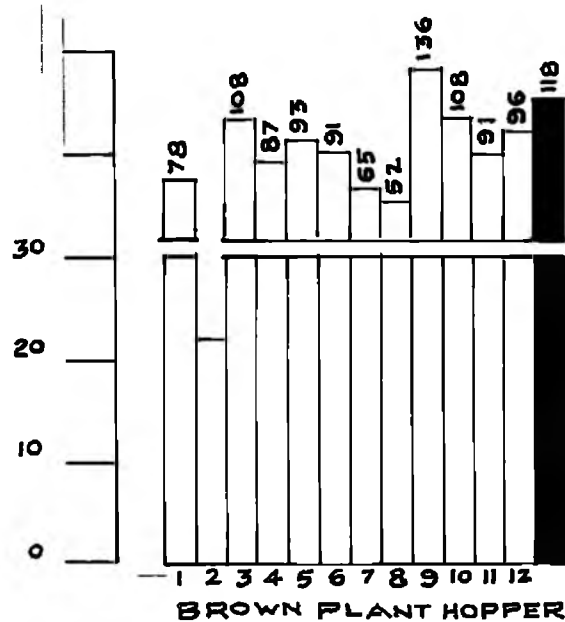
od va 200

Fig. 3. Mean population of different insect pests and natural enemies observed up to harvest following application of different insecticide granules at 21 and 45 DAT during first crop season

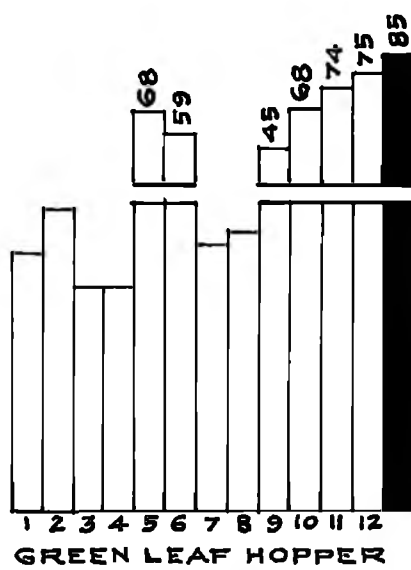
1.	Carbofuran	at	0.5 kg	ai/ha
2.	"	„	1.0 kg	"
3.	Zadexre	„	1.0 kg	"
4.	"	„	2.0 kg	"
5.	Hophosfolan	„	0.5 kg	"
6.	"	„	1.0 kg	"
7.	Bisulfoton	„	1.0 kg	"
8.	"	„	2.0 kg	"
9.	Quinalphas	„	1.0 kg	"
10.	"	„	2.0 kg	"
11.	Chlorodireform	„	1.0 kg	"
12.	"	„	2.0 kg	"
■	Control			

FIG 3 MEAN POPULATION OF DIFFERENT INSECT PESTS AND NATURAL ENEMIES FOLLOWING APPLICATION OF DIFFERENT INSECTICIDE GRANULES AT 21 AND 45 DAT (FIRST CROP)

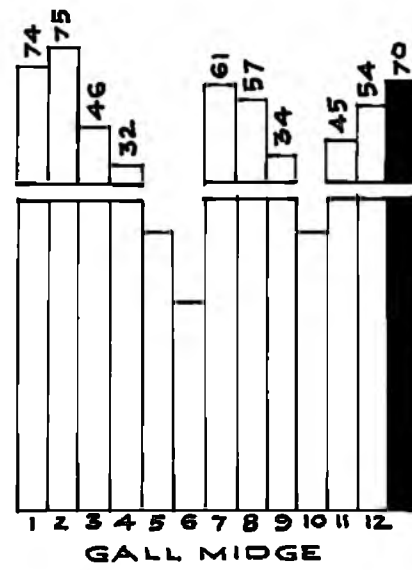
MEAN POPULATION



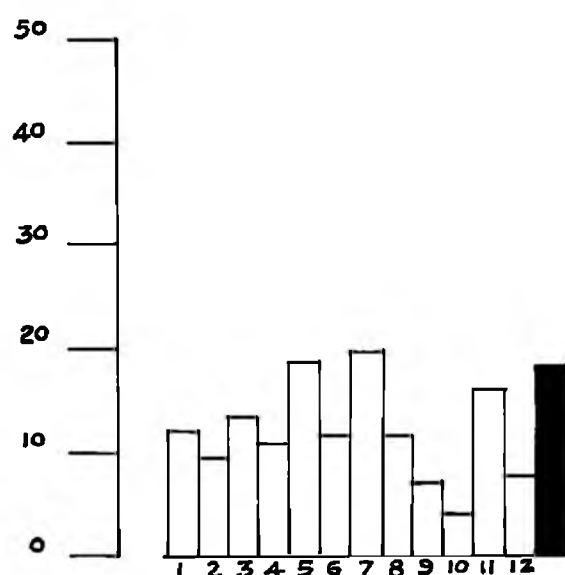
BROWN PLANT HOPPER



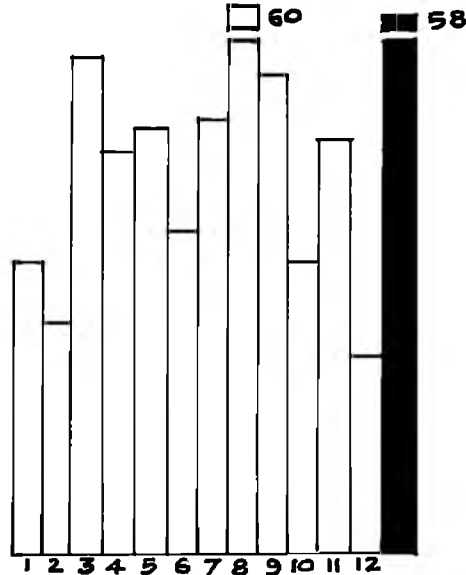
GREEN LEAF HOPPER



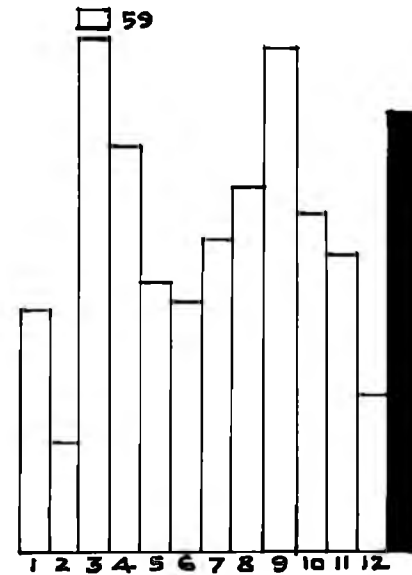
GALL MIDGE



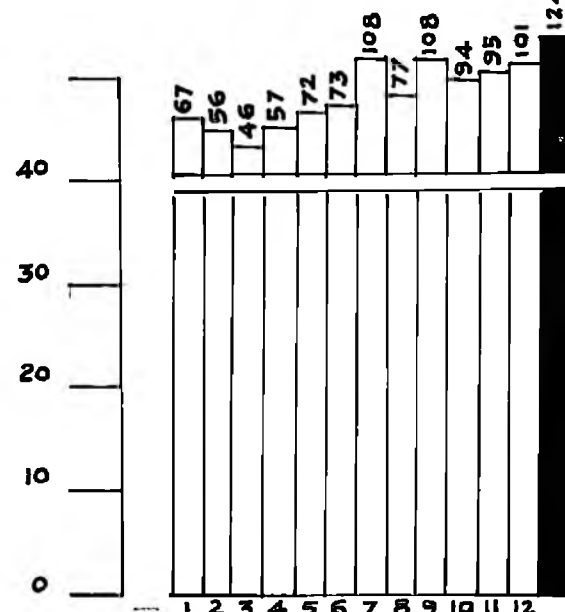
WHORL MAGGOT



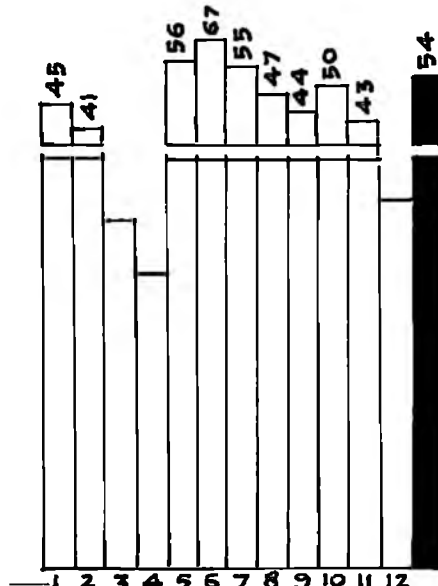
STEM BORER



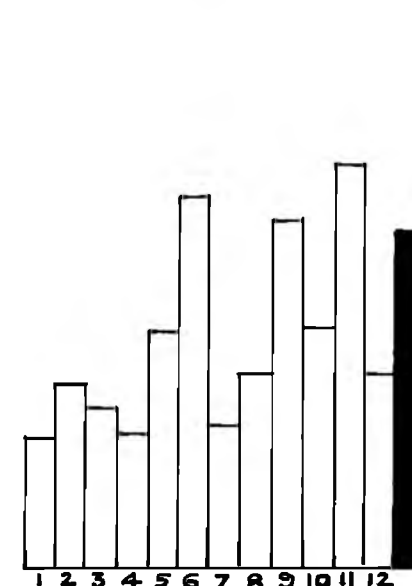
LEAF ROLLER



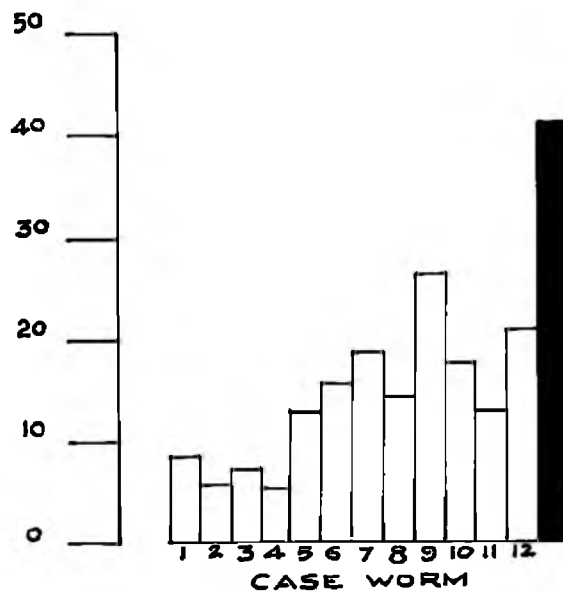
GRASS HOPPER



SPIDER



MIRID BUG



CASE WORM

control of BPH carbofuran at 1.00 kg ai/ha with 21.35 mean population per plot was found to be significantly superior to all the other insecticide treatments. This was followed by disulfoton at 2.00 kg and disulfoton at 1.0 kg ai/ha with 51.67 and 65.00 as against 113.17 under control. The treatments, carbofuran at 0.5 kg, phorate 2.0 kg and chlorodimorph at 1.0 kg ai/ha also gave significant control of AMH as compared to control (78.00 to 91.00 as against 113.17 under control). These were, however, significantly less effective as compared to the first three insecticidal treatments mentioned.

For the control of GHB, the treatments phorate at 2.0 kg and 1.0 kg, carbofuran at 0.5 kg, disulfoton at 1.0 kg and 2.0 kg and carbofuran at 1.0 kg ai/ha were found to be significantly effective with infestations ranging from 22.33 to 30.33 as compared to 85.5 under control. Quinalphos at 1.0 kg ai/ha and rophosolan at 1.0 kg ai/ha also gave significant control of the leaf hopper, though to a lesser extent than the other effective insecticides.

For the control of gall midge infestation the insecticide treatments found most effective were rophosolan at 1.0 kg and 0.5 kg and quinalphos at 2.0 kg ai/ha; these among themselves being on par. The other treatments which gave significant control of the pest, but to a lesser extent in

effectiveness were phorate at 2.00 kg, quinalphos at 1.0 kg and chlorodimethoate at 1.00 kg, phorate at 1.0 kg and chlorodimethoate at 2.0 kg ai/ha with number of silver shoots ranging from 32.0 to 33.67 as against 69.67 under control.

The whorl borer population was significantly reduced in the treatments with quinalphos at 2.00 kg, chlorodimethoate at 2.0 kg, quinalphos at 1.0 kg, carbofuran at 1.0 kg and phorate at 2.0 kg ai/ha in that descending order with population varying from 4.0 to 10.67 as against 18.67 in the untreated control.

As regards to the stem borer infestation chlorodimethoate at 2.00 kg, carbofuran at 1.0 kg, quinalphos at 2.0 kg and carbofuran at 0.5 kg ai/ha with infestations ranging from 10.67 to 29.33 per plot in comparison to 57.67 under control gave the best control. The other treatments which gave significant reduction in stem borer infestation but with lesser effectiveness were nephtofolan at 1.0 kg, phorate at 2.0 kg, chlorodimethoate at 1.0 kg and nephtofolan at 0.5 kg ai/ha.

The insecticide treatments which gave the best control of leaf roller were carbofuran at 1.0 kg and chlorodimethoate at 2.0 kg ai/ha with infestations of 10.33 and 15.00 larvae per plot in comparison with 43 larvae in the control plot.

The other treatments which gave lesser but significant control of the pest were carbofuran at 0.5 kg, nephotholan at 1.0 kg and 0.5 kg, chlorodinoform at 1.0 kg, disulfoton at 1.0 kg and quinalphos at 2.0 kg ai/ha with infestations ranging from 20.53 to 33.33 per plot.

The most effective insecticides found suitable for grasshopper control were phorate at 1.0 kg, carbofuran at 1.0 kg, phorate at 2.0 kg and carbofuran 0.5 kg ai/ha with mean infestations of 45.67 to 67.00 as against 123.50 per plot under control. Nephotholan at 1.0 kg and 0.5 kg and disulfoton at 2.0 kg ai/ha also gave significant control of grasshoppers, but they were less effective than the former insecticides, with 72.53 & 75.67 infestations.

Mixid bug population was found to be suppressed by the carbofuran and phorate treatments, the disulfoton treatments and chlorodinoform at 2.0 kg ai/ha, the most population being 13.00 to 23.67 in comparison with 33.67 in the control plot. The other insecticidal treatments did not affect the mixid bug populations. The treatments which affected the spider population significantly were phorate at 2.0 kg, phorate at 1.0 kg, carbofuran at 1.0 kg and chlorodinoform at 2.0 kg ai/ha. The other insecticides did not affect the spider population.

EFFECT OF SOIL APPLICATION OF INSECTICIDE GRANULES
ON CONTROL OF RADDY LARVAE DURING SECOND CROP SPINACH
(SEPTEMBER TO JANUARY 1976-77)

The data relating to the effect of different insecticide treatments following their application 21 DAE on infestation by various insects for a period of 24 days are presented in Table 4 and Fig. 4. The treatments which gave the maximum control of BPH were carbofuran at 1.0 kg, phorate at 2.0 kg and 1.0 kg, naphosolan at 1.0 kg, disulfoton at 1.0 kg and carbofuran at 0.5 kg ai/ha with infestations of 8.00 to 10.00 per plot as against 24.67 under control. These treatments were on par in their effectiveness. All the other insecticidal treatments with infestations varying from 11.67 to 16.67 also gave significant control of the insects though they were less in effectiveness than the former group. All the treatments excepting quinalphos at 1.0 kg, chlorodimethoate at 2.0 kg and naphosolan at 0.5 kg ai/ha gave significant control of green leaf hopper. Among the effective treatments, those which gave maximum control were phorate at 2.0 kg and 1.0 kg, quinalphos at 2.0 kg, disulfoton at 2.0 kg, carbofuran at 2.0 kg and disulfoton at 1.0 kg ai/ha with infestations ranging from 18.00 to 20.00 per plot in comparison to 56.17 under control. All these treatments were on par in their effectiveness. Significant control of gall midge was obtained under

Table 4. Mean population of principal insects and natural enemies under different insecticide treatments 4 days after treatment on 21 DAT (Second crop)

Treatments insecticides kg ai/ha	SPV	GLH	Call midge	hori m. at	Star borer	Leaf roller	Cane worm	Grass hopper	Rice ear- ing water- pillar	Mixid bug	Spider	
Carbo -an	0.5	0.00 3.30	33.00 6.20	3 7.77	35.33 9.77	7.00 (2.66)	0.33 3.35	5.33 (4.00)	24.00 (4.87)	3.33 (2.45)	37.00 (6.4)	7.00 (2.85)
T ₂ Carbo -an	0	0.00 2.90	27.00 5.2	3.6 7.34	80.00 9.43	2.67 (.7)	3.3 2.06	6.00 (2.57)	8.33 (4.38)	4.67 (2.56)	26.00 (4.99)	10.00 (3.3)
T ₃ Phos -e	0	0.33 3.0	20.7 0	67 (.6)	33 0	3.00 3.57	10.00 4.35	25.00 (5.06)	18.33 (4.3)	6.00 2.64	2.33 4.66	7.00 2.79
Ph -e	2.0	33 4	0		0	9.7 3.04	0.3 4.38	9.00 4.44	20.33 (4.54)	1.00 99	8.00 4.24	6.00 2.63
or -e -an	0		2	77 77		3.33 3.6	00 3.5	26.00 5.6	30.33 5.75	6.00 2.55	44.00 (6.69)	6.00 4.2
6						3.00	7 5	29.67 5.50	23.33 4.85	00 99	37.00 0	5.00 77
7					7		67 00	28.67 5.42	3.00 (.63)	2 3.60	47 (6.7)	67 3.78
8					3.7	67	0.33 3	0.00 4.27	29.33 (5.48)	8.33 3.04	1.7 (.44)	0.00 30
9	IL	0	3	(	7	5.0	3 0	4.33 3.66	4.67 (.6)	7.67 4.30	45.33 (6)	7.00 2.83
0						30 5	53	6.00 (2.57)	48.00 (6.99)	6.67 (4.7)	3.7 (.6)	9.00 3.5
CL -e -an	0		1			4.3	7 6	7.00 4.19	38.33 (6.26)	6.00 (2.64)	36.00 6.00	33 4.46
2	or -e -an	2.0	67 (	40.67 6.33	33 3	3.67	7	33 4.46	32.67 (5.79)	6.33 2.66	30.33 5.57	13.00 73
3			4.7 3	7.7 2	7.30 90	2 7	2.00 54	23.7 4.08	37.00 (6.16)	14.00 (3.06)	46.67 (6.85)	6.00 4
no	05	6	3	34	2		0.73	0.6	(.16)*	0.77)*	(.53)*	0.74)*
1	05	93	7			4	0.6	0.52	01)*	(0.67)	32	0.64)

in no /x 1 informed val es

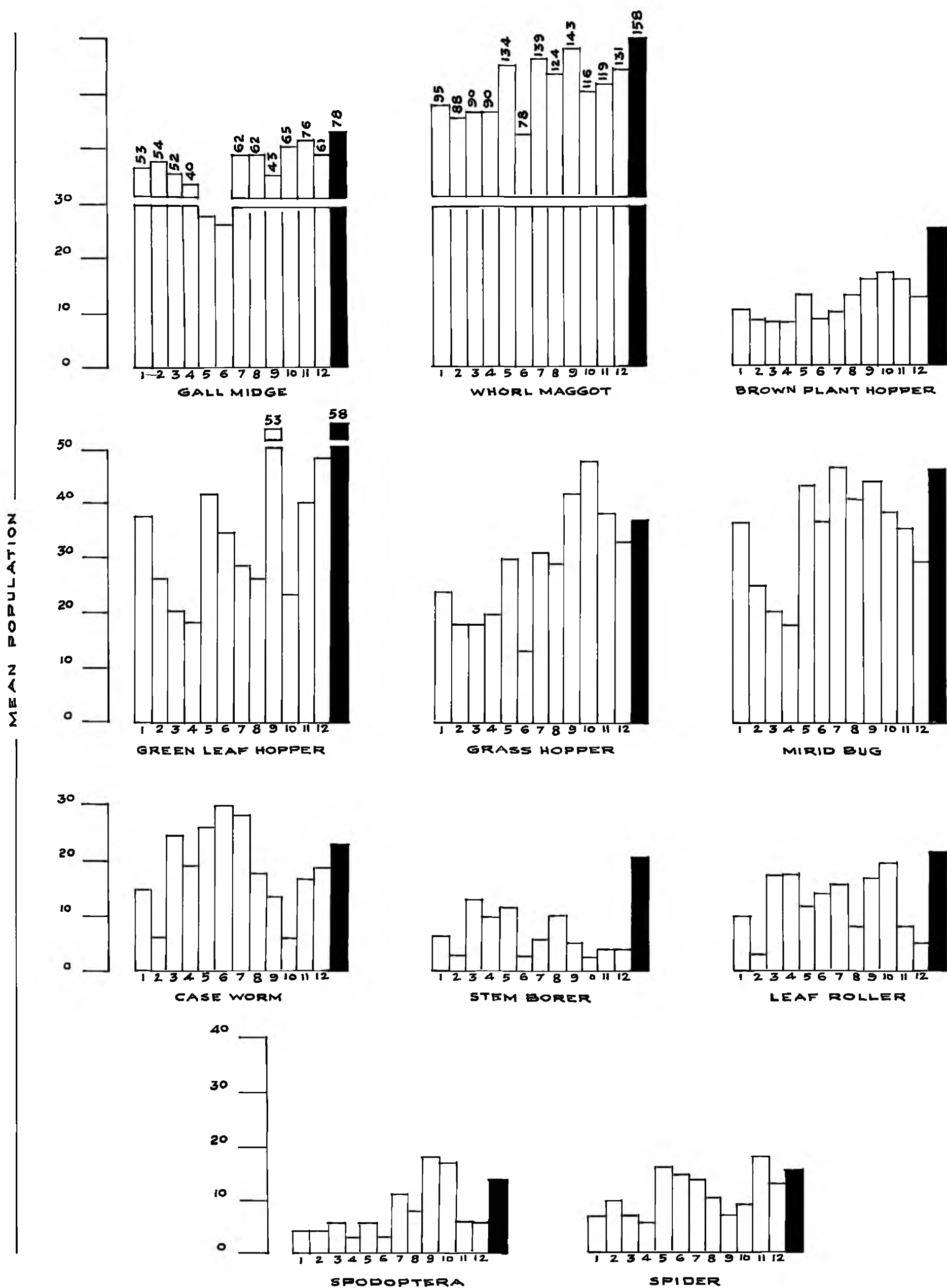
no

x v

Fig. 4. Mean population of different insect pests and natural enemies observed for 24 days following application of different insecticide granules at 21 DAF during second crop season

1.	Carbofuran	at	0.5	kg ai/ha
2.	..	..	1.0	..
3.	Phorate	..	1.0	..
4.	..	..	2.0	..
5.	Nephosolan	..	0.5	..
6.	..	..	1.0	..
7.	Disulfoton	..	1.0	..
8.	..	..	2.0	..
9.	Quinalphos	..	1.0	..
10.	..	..	2.0	..
11.	Chlorodimethomate	..	1.0	..
12.	..	..	2.0	..
■	Control			

FIG 4 MEAN POPULATION OF DIFFERENT INSECT PESTS AND NATURAL ENEMIES FOLLOWING APPLICATION OF DIFFERENT INSECTICIDE GRANULES AT 21 DAT (SECOND CROP)



the treatment nephasfolan at 1.0 kg and 0.5 kg, phorate at 2.0 kg, quinalphos at 1.0 kg, chlorate at 1.0 kg and carbosulfan at 0.5 kg ai/ha with infestations ranging from 26.00 to 54.33 per plot as compared to 70.5 in control. Among these treatments, however, nephasfolan treatments and phorate at 2.0 kg ai/ha ranked significantly superior over the others in their effectiveness. Wheat target infestation was significantly reduced by the treatments nephasfolan at 1.0 kg, carbosulfan at 1.0 kg, phorate at 2.0 kg, phorate at 1.0 kg and chlorosulfan at 0.5 kg ai/ha, showing infestations of 70.00 to 95.33 as against 150.33 in untreated control. All these insecticides were on par in their effectiveness. Quinalphos at 2 kg and chlorodimethox at 1.0 kg also gave significant control of the mawget but to a lesser extent.

All the insecticidal treatments except nephasfolan at 0.5 kg and phorate at 1.0 kg ai/ha were found to give significant reduction in stem borer infestation, the infestation under the insecticide treatments varying from 2.67 to 13.00 as against 21.00 under control. The different insecticide treatments did not show significant variations among themselves in their effectiveness. However, carbosulfan at 1.0 kg, nephasfolan at 1.0 kg, quinalphos at 2.0 kg and chlorodimethox at 2.0 kg ai/ha with infestations varying from 2.67 to 3.67 were the most effective among all the insecticides.

Leaf roller infestation was observed to be significantly suppressed by all treatments except the phorate and quinalphos treatments with infestations ranging between 3.33 and 15.67 per plot in comparison to 22.33 under untreated control. Among the various insecticide treatments, those which gave the best control were, carbofuran at 1.0 kg, chlorodaneform at 2.0 l; and chlorodaneform at 1.0 kg ai/ha with infestations of 3.33 to 7.67 larvae per plot. These were on par in their effectiveness. Significant control of the case worms was given by carbofuran at 1.0 kg, quinalphos at 2.0 kg, quinalphos at 1.0 kg, carbofuran at 0.5 kg, chlorodaneform at 1.0 kg and dimetheton at 2.0 kg ai/ha with infestations of 6.00 to 18.00 larvae per plot as against 23.17 under control. Of the various effective treatments carbofuran at 1.0 kg and quinalphos at 2.0 kg ai/ha with infestation of 6.0 larvae per plot were the most effective insecticides, the others being less in effectiveness. Grasshopper infestation was significantly controlled by phorate at 1.0 kg, carbofuran at 1.0 kg, phorate at 2.0 kg, methofoles at 1.0 kg and carbofuran at 0.5 kg ai/ha with infestations of 10.33 to 24.00 hoppers per plot, in comparison to 37.00 hoppers in control plot. These insecticides were on par in their effectiveness. The rice shearing caterpillar was effectively controlled by all the treatments excepting

disulfoton at 1.0 kg and quinalphos at 1.0 kg and 2.0 kg ai/ha. All the effective treatments with infestations ranging from 3.00 to 0.33 caterpillars per plot in comparison to 14.00 in control plot were on par in their effectiveness. The mixed bug population suffered significant reduction under both the treatments of phorate and under carbofuran at 1.0 kg ai/ha, the populations being 18.00 to 25.00 per plot as against 46.67 in control. The other treatments did not affected the population significantly. The spider population was significantly affected by the carbofuran treatment, the phorate treatment, the quinalphos treatments and by disulfoton at 2.0 kg ai/ha. The populations per plot under the treatments were 6.00 to 10.00 as against 18.00 under control.

In Table 5 and Fig. 5 is presented the data on the effect of different insecticide treatments applied 45 DAT on the control of various paddy pests. It was observed that best control of RH was recorded by carbofuran at 1.0 kg, phorate at 1.0 kg, carbofuran at 0.5 kg, phorate at 1.0 kg and disulfoton at 2.0 kg ai/ha with infestations varying from 15.55 to 35.33 per plot in comparison to 66.17 under control. These five insecticide treatments were on par in their effectiveness. Disulfoton at 1.0 kg ai/ha

Table 5. Mean evaluation of effect of insect pests and natural enemies under different insecticide granule treatments on sorghum at harvest after treatment on 45 DAT (Second crop)

Treatment	Insecticide	kg ai/ha	DPH	GL	Call mid o	Roller	tea borer	leaf roller	Ono worm	Grass hopper	Rice swarming caterpillar	Mirid bug	Spider
1	Carbo	nan	0.5	22.00 4.76	23.00 4.89	4.0 (6.43)	0.00 (2)	23.33 4.90	7.00 2.79	6.67 (4.6)	7.00 (2.81)	13.00 (4.54)	14.00 (3.85)
2	Carbo	nan	0	5.33 4.03	23.00 4.79	15.7 3.0	0.00 72	10.67 3.38	2.00 (66)	9.67 (3.24)	5.00 (2.44)	22.00 (4.77)	14.00 (3.82)
3	ho	e	0	2.67 (.09)	7.33 4.27	0 3.4	0.33 03	70.67 (0.45)	204.33 4.29	8.67 (2.97)	13.67 (3.79)	17.00 (4.20)	12.33 (3.60)
4	ho	e	0	0 43	3.00 0	0	0.33 9.16	23.67 10.75	0	12.00 (3.59)	6.33 2.66	17.00 4.7	2.00 (3.50)
5		nan	0	0.3	7.33	7	7	27.00 08	37.00 90	9.00 4.47	7.67 2.90	20.00 4.2	17.00 4.24
		nan						34.33 25	23.00 4.90	infestation	14.0 3.80	3.33 3	6.00 4.3
7					7			0.34 0	46.00 0	2.33 4.72	5.00 90	3.00 6	2.00 4.66
								4.3 (0.40)	109.00 (0.40)	0.7 3.07	4.7 2.7	32.00 5.69	19.00 4.30
9	1			7				7 7	4.0 73	3.00 3.70	0.7 3.0	2.00 4.2	5.7 4.02
				7				0 2	77	18.00 (4.34)	3.33 2.3	0.00 08	0.00 4.0
	1				37			7.3 75		7.67 4.24	6.67 2.75	2.00 4.7	0.00 3.30
	1			4				7 0	4.3 0	13.00 (3.64)	5.00 2.44	7.00 20	0.00 7
3				7		7		7 5	3 2.44	22.33 (4.80)	4.67 93	2.3 5.34	20.0 4
							7	0		1	0.75	36	00.75
0	nan	nan		2				2		(0.96)	0.65	18.88	0.4

and $\sqrt{x-1}$ for all fixed values

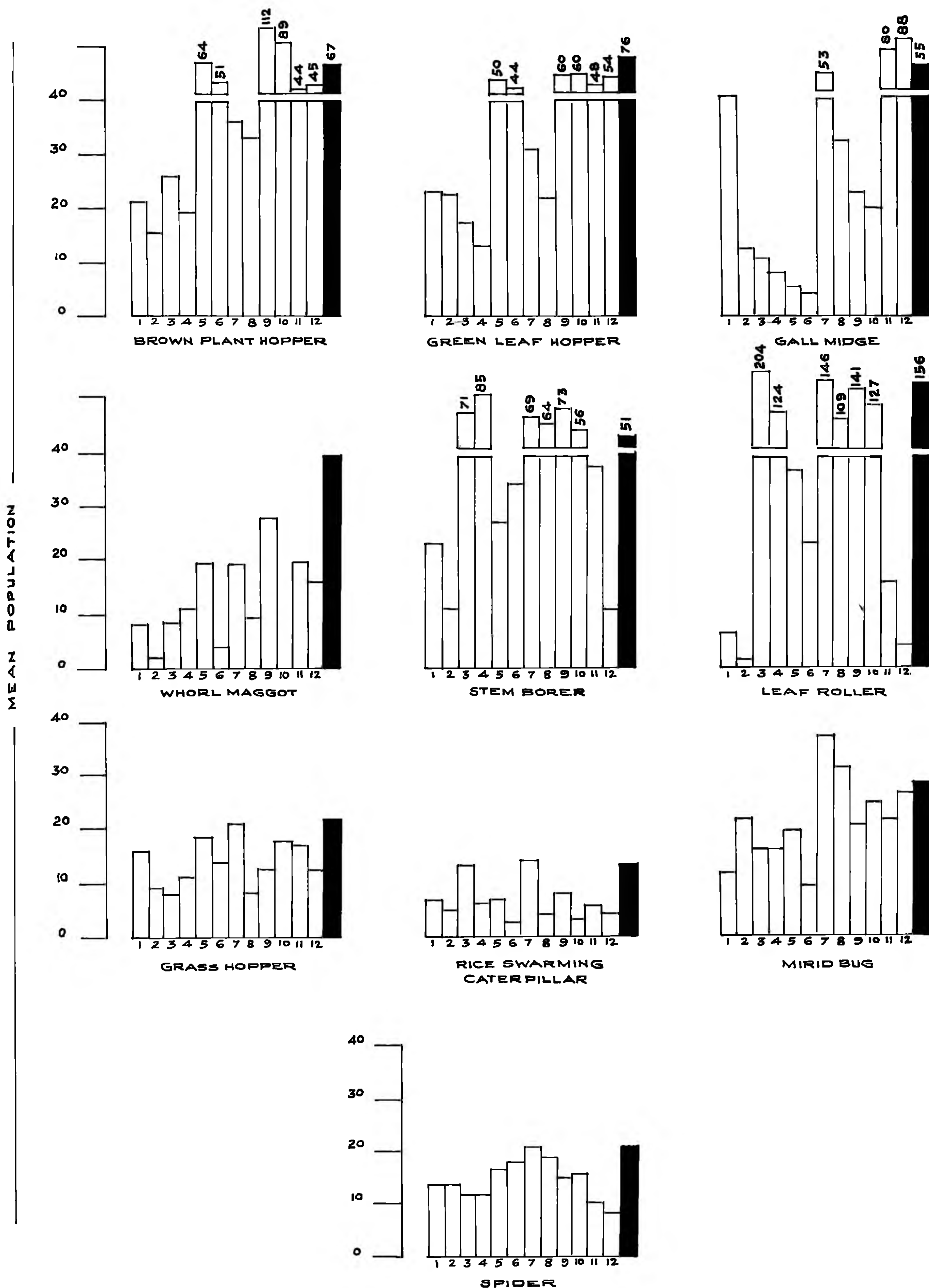
nl

nan x y

Fig. 5. Mean population of different insect pests and natural enemies observed up to harvest following application of different insecticide granules at 45 DAF during second crop season

1.	Carbofuran	at	0.5	kg ai/ha
2.	"	"	1.0	"
3.	Phorate	"	1.0	"
4.	"	"	2.0	"
5.	Nephosolan	"	0.5	"
6.	"	"	1.0	"
7.	Disulfoton	"	1.0	"
8.	"	"	2.0	"
9.	Quinalphos	"	1.0	"
10.	"	"	2.0	"
11.	Chlorodimethom	"	1.0	"
12.	"	"	2.0	"
■	Control			

FIG 5 MEAN POPULATION OF DIFFERENT INSECT PESTS AND NATURAL ENEMIES FOLLOWING APPLICATION OF DIFFERENT INSECTICIDE GRANULES AT 45 DAT (SECOND CROP)



also gave significant control of B-H though less effective than the others. All the other treatments were ineffective. Best control of green leaf hopper was recorded under thionate at 2.0 kg and 1.0 kg, dimetheton at 2.0 kg, carbosulfen at 1.0 kg and carbosulfen at 0.5 kg ai/ha with infestations of 13.00 to 23.00 per plot as against 75.65 in control plot. Dimetheton at 1.00 kg ai/ha also gave significant control of green leaf hopper, though to a lesser extent than the others. The other treatments were ineffective. Gall midge was best controlled by nephtosolan at 1.0 kg and 0.5 kg, phorate at 2.0 kg and 1.0 kg and carbosulfen at 1.0 kg ai/ha with infestations of 4.33 to 15.67 per plot as against 55.50 under control; these were on a par in their effectiveness. Lesser, but significant control of gall midge was recorded under quinalphos at 2.0 kg and 1.0 kg and dimetheton at 2.0 kg ai/ha with infestations of 20.00 to 32.33. The other treatments were ineffective. All the insecticide treatments except quinalphos at 1.0 kg ai/ha gave significant control of whorl maggot with infestations of 2.00 to 19.67 per plot under the various treatments as compared to 39.17 under control. Among the different treatments carbosulfen at 1.0 kg and nephtosolan at 1.0 kg ai/ha gave significantly better control than all the rest with infestations of

2.0 and 4.33 per plot respectively. Maximum stem borer control was recorded under the treatment carbofuran at 1.0 kg and chlorodimeform at 2.0 kg ai/ha with 10.67 infestation per plot as against 51.17 under control. Carbofuran at 0.5 kg and nephoesolan at 1.0 kg ai/ha ranked next with 23.33 and 34.33 infestation respectively. All the other treatments were ineffective. Leaf roller control was obtained under the treatments of carbofuran at 1.0 kg, chlorodimeform at 2.0 kg, carbofuran at 0.5 kg and chlorodimeform at 1.0 kg ai/ha with infestations of 2.00 to 16.33 larvae per plot as against 156.33 larvae in control. All these insecticides were on par. Nephoesolan at 1.0 kg and 0.5 kg ai/ha ranked next in effectiveness and this was followed by disulfoton at 2.0 kg ai/ha. All the other insecticides were ineffective. Significant control of grasshopper was recorded under the treatments of phorate at 1.0 kg, disulfoton at 2.0 kg, carbofuran at 1.0 kg, phorate at 2.0 kg, chlorodimeform at 2.0 kg, quinalphos at 1.0 kg and nephoesolan at 1.0 kg ai/ha with grasshopper populations ranging between 8.67 and 14.00 per plot as against 22.33 in control. All the other treatments were ineffective and all the effective insecticides were on par. The insecticide treatments which gave maximum control of rice swarming

caterpillar were methosfolan at 1.0 kg, quinalphos at 2.0 kg, disulfoton at 2.0 kg, carbofuran at 1.0 kg, chlorodimethoat at 2.0 kg and 1.0 kg and carbofuran at 0.5 kg ai/ha, with infestations varying from 3.33 to 7.00 caterpillars per plot as against 14.67 under control. Methosfolan at 0.5 kg and quinalphos at 1.0 kg ai/ha ranked next. All the other insecticides were ineffective. The mirid bug population was observed not affected significantly by any of the insecticide treatments, but the spider population was found to be significantly affected by chlorodimethoat treatment and phorate treatments with populations of 0.00 to 12.33 per plot in comparison to 23.50 under control. The other insecticide treatments did not affect the spider population.

The mean effect of the two insecticide treatments (21 and 45 DAF) on the various paddy pests is presented in Table C and Fig. 6. It will be observed that except the two quinalphos treatments and methosfolan at 0.5 kg ai/ha all other insecticide treatments gave significant control of RHV with the hopper population varying from 23.33 to 66.00 per plot as against 90.83 in untreated control plots. Of the various treatments, best control of the pest was given by carbofuran at 1.0 kg, phorate at 2.0 kg, carbofuran at 0.5 kg and phorate at 1.0 kg ai/ha, all these treatments being on par in their effectiveness. Disulfoton at 1.0 kg

Table 6 Mean population per plot of different insects on or different insecticide treatments observed up to harvest after treatment on 21 & 25 second crop

Treatments	insecticide (kg ai/ha)	APH	OLH	Call midge	hork root	Stem borer	Leaf roller	Grass worm	Grass hopper	Rice shearing caterpillar	Mirid bug	Spider
1	Carbo. uran 0.5	32.00 (7.7)	6.00 7.5	87.67 9.4	03.33 (0.7)	30.33 (5.98)	7.33 4.24	5.33 4.00	40.67 (6.35)	12.33 (3.6)	57.00 (7.57)	21.00 (4.68)
2	Carbo. uran 0	23.33 8.9	46.67 (6.87)	69.3 3	92.33 (5)	3.33 3.71	5.33 2.49	6.00 5.7	28.00 3.8	9.67 (3.26)	48.00 (6.96)	24.00 (4.97)
3	Phos. 0	37.33 6.7	37.33	0 7	7 0.0	83.67 (9.10)	222.33 4.9	25.00 5.06	27.00 5.27	9.67 4.53	33.33 (6.26)	19.33 (4.45)
4	Phos. 2.0	27.33 2.5	3.00	5	0	93.00 (9.70)	3.7 5	9.00 4.44	32.33 (4.73)	9.33 3	35.00 5.91	18.00 4.36
5	Carbo. uran 0.5	3 9.32	2 5	3		39.33 (6.80)	4.00 (0.94)	26.00 5.16	52.00 7.24	3.33 3.73	64.00 8.03	33.00 (5.83)
	1.0	0 0.7				37.33 6.5	37.67 6.22	29.67 5.50	3.7 6.22	6 7	47.00 (7.7)	33.00 0
7		0 6				7.00 0.70	7 9	23.67 4.2	2.33 7	7.33 5	00 9	3.67 2
			7			73.67 0.60	3 0.80	8.00 5.27	10.00 6.22	3.00 3.7	73.7 7	29.00 4
		00 0				77.67 8	3 4	4.33 3.86	54.7 (7.4)	3 5	6.33 4	22.66 4.84
11						00 7.7	0	6.00 2.57	6.00 0.7	20.00 5	3.7 0.2	2.00 4.89
12	Carbo. uran 1.0	0	27.77			4.67 (0.90)	4.00 6.3	7.00 4.9	56.00 (7)	2.7 3.70	9.00 7.7	2.7 4
13	Carbo. uran 1.0	0	0	47		4.33 3.70	00 6	9.33 4.46	45.67 (6.81)	33 3.50	57.3 3	2.00 4.9
3	Carbo. uran 1.0				4	72 47	9.7 3.3	23.7 4.08	59.33 7.3	28.7 5.43	7.67 (0.70)	36.50 6.09
5						60	9	0.6	0.9	0.93	36	88
control						7	72	0.52	0.94	0.80	0	0

Ln are transformed values

3 on half ov 1

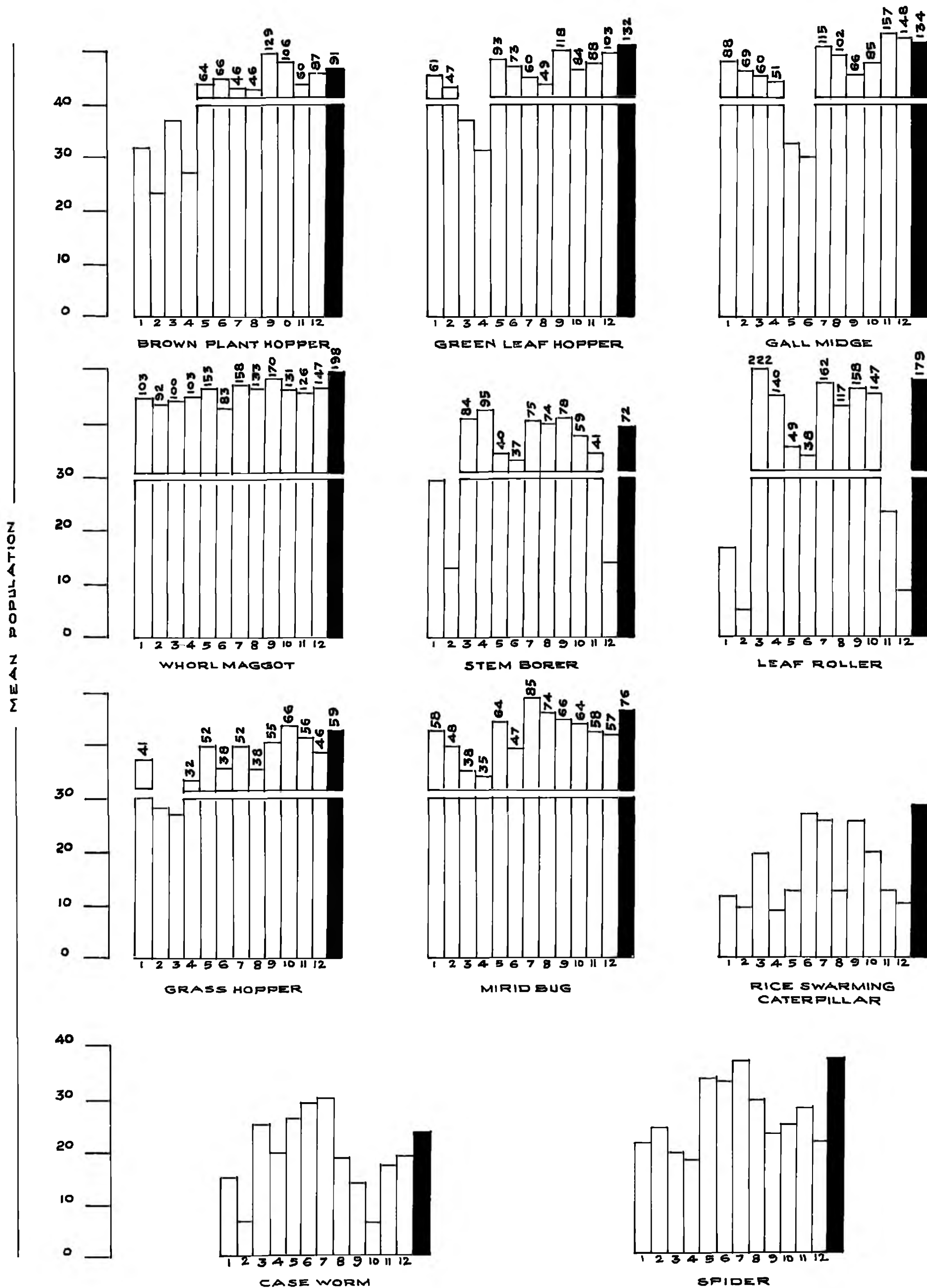
A.

pendix

Fig. 6. Mean population of different insect pests and natural enemies observed up to harvest following application of different insecticide granules at 21 and 45 DAT during second crop season

1.	Carbofuran	at	0.5	kg ai/ha
2.	..	..	1.0	..
3.	Phorate	..	1.0	..
4.	..	..	2.0	..
5.	Mephosfolan	..	0.5	..
6.	..	..	1.0	..
7.	Disulfoton	..	1.0	..
8.	..	..	2.0	..
9.	Quinalphos	..	1.0	..
10.	..	..	2.0	..
11.	Chlorodimethoz	..	1.0	..
12.	..	..	2.0	..
■	Control			

FIG 6 MEAN POPULATION OF DIFFERENT INSECT PESTS AND NATURAL ENEMIES FOLLOWING APPLICATION OF DIFFERENT INSECTICIDE GRANULES AT 21 AND 45 DAT (SECOND CROP)



and 2.0 kg ai/ha ranked next, followed by chlorodimethozin at 2.0 kg and 1.0 kg and nephotholan at 1.0 kg ai/ha. With regard to *SHH* the two phorate treatments, carbofuran at 1.0 kg and diazinofen at 2.0 kg ai/ha gave the maximum control, they being on par in their effectiveness with infestations of 31.00 to 40.67 per plot in comparison to 192.33 in control. Diazinofen at 1.0 kg, carbofuran at 0.5 kg, nephotholan at 1.0 kg and quinalphos at 2.0 kg ai/ha ranked next. All the other treatments except quinalphos at 1.0 kg ai/ha ranked next. The best gall midge control was afforded by nephotholan at 1.0 kg and 0.5 kg and phorate at 2.0 kg ai/ha with infestations of 30.33 to 50.67 as against 134.16 in control, these three being on par. Phorate at 1.0 kg ai/ha and quinalphos at 1.0 kg ai/ha ranked next followed by carbofuran at 1.0 kg, quinalphos at 2.0 kg and carbofuran at 0.5 kg ai/ha. All the other treatments were ineffective. All the treatments except quinalphos at 1.0 kg ai/ha could give significant control of whorl maggot infestation. Among the different treatments, however, the most highly effective were nephotholan at 1.0 kg, carbofuran at 1.0 kg, phorate at 1.0 kg and 2.0 kg and carbofuran at 0.5 kg ai/ha with infestations ranging from 22.67 to 103.33 per plot as against 107.50 under control. All these five treatments were on par in their effectiveness.

15-06-54
A.C.R.

The best stem borer control was given under the treatments carbofuran at 1.0 kg and chlorodimeform at 2.0 kg ai/ha with mean infestations of 13.33 and 14.33 per plot, as against 72.16 under control. Carbofuran at 0.5 kg, naphosolan at 1.0 kg and 0.5 kg and chlorodimeform at 1.0 kg ai/ha ranked next with infestations of 30.33 to 41.67. All other treatments were ineffective. The highest control of leaf roller was obtained under the treatments of carbofuran at 1.0 kg, chlorodimeform at 2.0 kg and carbofuran at 0.5 kg ai/ha with infestations of 5.33 to 17.33 per plot as compared to 178.67 in control, the first three being on par in their effect. Chlorodimeform at 1.0 kg ai/ha was also close to these three in its effectiveness. Naphosolan at 1.0 kg and 0.5 kg ai/ha ranked next and they were followed by disulfoton at 2.0 kg ai/ha and phorate at 2.0 kg ai/ha. The rest of the insecticides were not effective. Grasshopper control could be obtained by the treatments of phorate at 1.0 kg, carbofuran at 1.0 kg, phorate at 2.0 kg, disulfoton at 2.0 kg, naphosolan at 1.0 kg and carbofuran at 0.5 kg ai/ha with populations varying from 27.00 to 40.67 per plot, as compared to 59.33 in control. The rest of the insecticides were not effective. Rice swarming caterpillar showed significant control under all the treatments excepting quinalphos at 1.0 kg and

disulfoton at 1.0 kg ai/ha. But the best control was obtained under the treatments of naphosfolon at 1.0 kg, phorate at 2.0 kg, carbofuran at 1.0 kg, chlorodimethoate at 2.0 kg and carbofuran at 0.5 kg ai/ha with larval populations of 6.67 to 12.33 per plot in comparison to 28.67 in control. The nixid bug population was affected by treatments of phorate at 2.0 kg and 1.0 kg, naphosfolon at 1.0 kg and carbofuran at 1.0 kg ai/ha with 35 to 43 nixid bugs per plot against 75.67 in the control, while carbofuran at 0.5 kg ai/ha caused significant reduction to a lesser extent. The spider population showed significant reduction under the treatments of phorate at 2.0 kg and 1.0 kg, carbofuran at 0.5 kg and 1.0 kg and quinalphos at 1.0 kg and 2.0 kg ai/ha.

EFFECT OF SOIL APPLICATION OF INSECTICIDE GRANULES
ON CONTROL OF BABY CUTS DURING TILED CROP SEASON
(JANUARY TO MAY 1977)

The observations made on the effect of different insecticide treatments applied 21 DAT on the different pests of maddy during 24 days after application are presented in Table 7 and Fig. 7. All the insecticide treatments except the two disulfoton treatments and chlorodimethene at 1.0 kg ai/ha gave significant control of B with infestations varying from 7.67 to 22.67 per plot in comparison to 32.17 in untreated control. Among the various treatments disulfoton at 2.0 kg ai/ha and carbofuran at 1.0 ai/ha gave the best control, they being superior to all the rest. These are closely followed by neophosfolan at 1.0 kg ai/ha. The other treatments which gave significant but inferior control were disulfoton at 1.0 kg, carbofuran at 0.5 kg, chlorodimethene at 2.0 kg, phorate at 1.0 kg, neophosfolan at 0.5 kg and phorate at 2.0 kg ai/ha, in that order of descending effectiveness. Significant control of GR was given by phorate at 2.0 kg disulfoton at 2.0 kg and 1.0 kg and phorate at 1.0 kg ai/ha with infestations of 7.33 to 11.33 as against 30.00 in control. These four insecticides were on par. The other treatments were not effective. Gall ridge was best controlled by the treatments neophosfolan at 1.0 kg, phorate

Table 7. Mean no. of insects on 24 days after treatment on 2 DAT
 insecticide — n t. m o b served for 24 days a or treatment on 2 DAT
 third ro

code	insecticide	kg ai/ha	HC	GL	fall m' s	no 1 rot	stem bore	leaf roller	Cane worm	Grass hopper	Fl + swarming cutworm- pillar	Field bug	Spider
1	Gal	van	0 5	00	2 3	20 7	8 33 (8 63)	2 33 4 67	9 00 5)	6 33 (2 69)	3 33 2 06)	26 67 5 17)	28 67 (4 44)
2	arbo	nan	0	0 00	05	4 07	8 33 (73)	4 33 (2 31)	2 00 3 30	4 00 2 16)	1 33 (41)	30 33 (5 55)	19 67 (4 52)
3	M	er e	1 0	20 00	33	0	8 0 2 4	97 9 87	0 00 (3 29)	5 00 (2 40)	6 00 (2 55)	29 33 (5 49)	24 33 (4 99)
4			0	7	7	4	5 67 (2 4)	75 67 0 70	4 00 (2 2)	33 (4	4 67 2 30	2 00 4 66)	17 00 (4 17)
5							13 00 (3 87)	36 67 6 02	1 00 (3 44)	33 2	0 00 00	00 4 35	43 67 (7 04)
6							2 0 6	2 33 4 76	5 00 2 39	6 0 2 63	0 0 00	2 07 37	8 00 5 33
							36 (6	6 67 0 34	15 00 3 95	4 00 3 7	7	3 7	43 00 (97)
							0 4	3 67 4	18 00 4 26	2 00	3	4 0	3 27
							7 2	6 3 0 3	13 00 3 60	2 7 4 7	7 7	00 50	36 67 (04)
0							2	3 67 7 6	10 33 3 32	5 0 3 04	00	07 04	27 67 3
							5 4	9 00 3	17 00 4 2)	24 33 4 9	2 9	3 33 (22)	3 67 (5 56)
							0	0 3 2	14 33 (3 87)	9 33 (3 19)	7 7 2 2	4 07 05	35 7 (6 05)
							35 (2	03 07	19 33 (4 51)	23 7 (4 84)	7 3 4 24	2 7 4 07	4 00 (6 9
								0	26) 88	(0 97	(00	07	33
							0	56	09 "	(0 84)	0 06	0 02 00	0 "

re / x transformed values

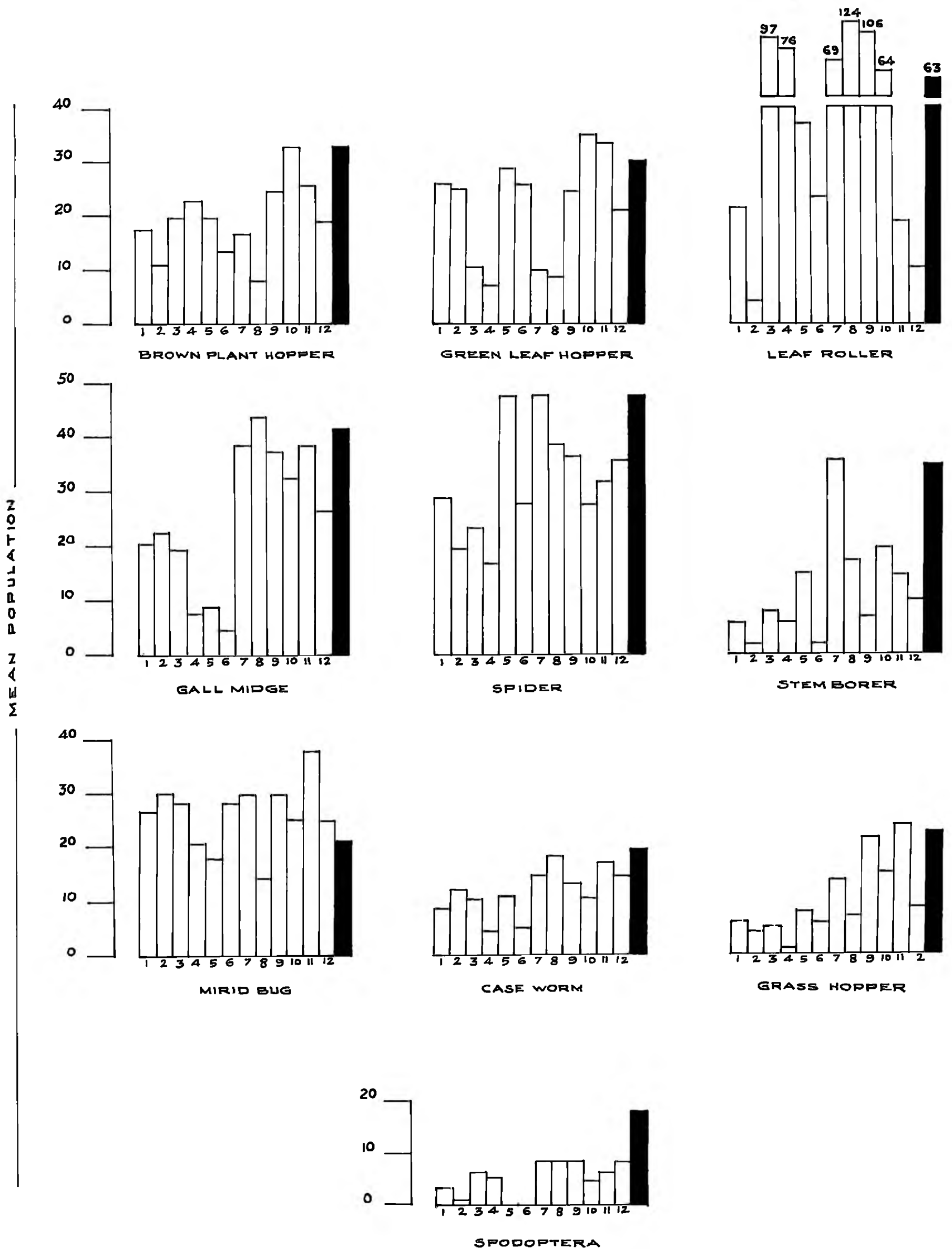
ai-ni cant

re all

Fig. 7. Mean population of different insect pests and natural enemies observed for 24 days following application of different insecticide granules at 21 DAT during third crop season

1.	Carbofuran	at	0.5	kg ai/ha
2.	..	..	1.0	..
3.	Phorate	..	1.0	..
4.	..	..	2.0	..
5.	Mephosfolan	..	0.5	..
6.	..	..	1.0	..
7.	Disulfoton	..	1.0	..
8.	..	..	2.0	..
9.	Quinalphos	..	1.0	..
10.	..	..	2.0	..
11.	Chlorodiazoxm	..	1.0	..
12.	..	..	2.0	..
■	Control			

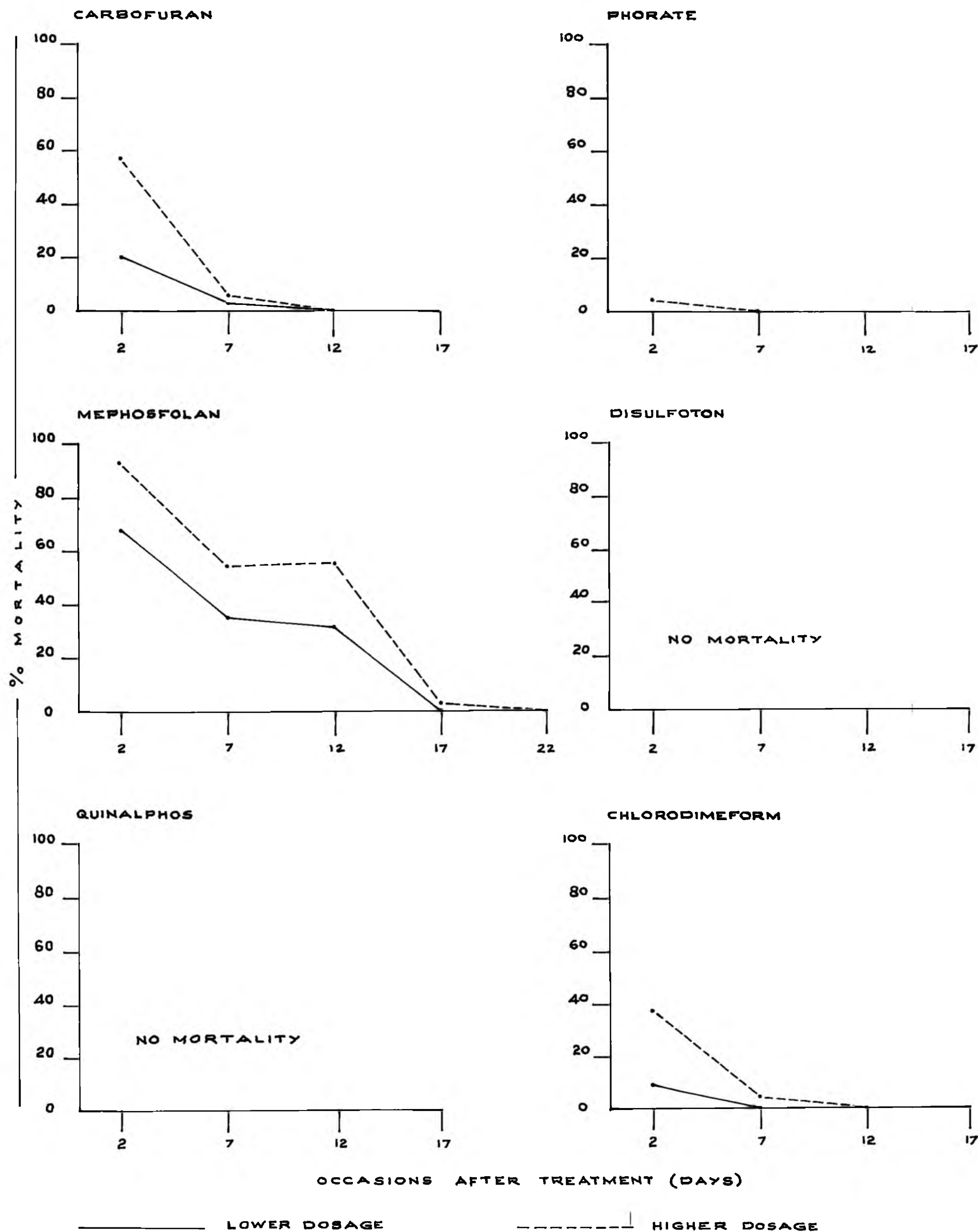
FIG 7 MEAN POPULATION OF DIFFERENT INSECT PESTS AND NATURAL ENEMIES FOLLOWING APPLICATION OF DIFFERENT INSECTICIDE GRANULES AT 21 DAT (THIRD CROP)



at 2.0 kg and nephosfolan at 0.5 kg ai/ha with infestations of 5.0 to 9.0 as against 42.33 in control. These were followed by phorate at 1.0 kg and carbofuran at 0.5 kg and 1.0 kg ai/ha which gave inferior but significant control of the pest. The other treatments were not effective. The best stemborer control was given by nephosfolan at 1.0 kg, carbofuran at 1.0 kg, phorate at 2.0 kg, carbofuran at 0.5 kg and disulfoton 1.0 kg ai/ha with infestations varying from 2.00 to 7.00 per plot as against 35.00 in control. All the other treatments excepting disulfoton at 1.0 kg ai/ha also gave significant control of the pest, but to a lesser extent. The best leaf roller control was recorded under the treatments carbofuran at 1.0 kg and chlorodaneform at 2.0 kg ai/ha with infestations of 4.33 and 10.33 per plot in comparison to 62.83 under control. The other treatments which gave significant control, but lesser in effectiveness were chlorodaneform at 1.0 kg, carbofuran at 0.5 kg, nephosfolan at 1.0 kg and nephosfolan at 0.5 kg ai/ha. The other treatments were ineffective. Significant control of case worm was given by the treatments of phorate at 2.0 kg, nephosfolan at 1.0 kg, carbofuran at 0.5 kg, phorate at 1.0 kg, quinalphos at 2.0 kg and carbofuran at 1.0 kg ai/ha in that order of effectiveness with infestations ranging from 4.00 to 12.00 larvae per plot

as against 19.33 in control. These insecticides were, however, on par in their effectiveness. The rest of the insecticides were not effective. Significant control of grasshoppers could be observed under all the treatments except quinalphos at 1.0 kg ai/ha. The maximum control was seen under phorate at 2.0 kg ai/ha and carbofuran at 1.0 kg ai/ha with hopper populations of 1.33 and 4.00 per plot against 23.17 in untreated plots. The other treatments which gave significant control, but to a lesser extent were phorate at 1.0 kg, methidathion at 1.0 kg, carbofuran at 0.5 kg, disulfoton at 2.0 kg and methidathion at 0.5 kg ai/ha in that order of effectiveness and with infestations of 5.00 to 8.33 per plot. All the treatments gave significant control of the rice earwing caterpillar with infestations varying from 0 to 8.33 larvae per plot under the different treatments in comparison to 17.33 under untreated control. Significantly better control was given by the treatments methidathion at 1.0 kg and 0.5 kg and carbofuran at 1.0 kg ai/ha when compared to other insecticides. The mirid bug population was not affected by any of the treatments. Population of spider was affected significantly by the treatments of phorate at 2.0 kg, carbofuran at 1.0 kg, quinalphos at 2.0 kg, methidathion at 1.0 kg and carbofuran at 0.5 kg ai/ha with populations of 17.00 to 28.67 per plot as against 48.00 in control. All these insecticides were on par in their effectiveness.

FIG 11 MORTALITY OF RICE SWARMING CATERPILLAR EXPOSED TO RICE PLANTS AT DIFFERENT INTERVALS AFTER APPLICATION OF DIFFERENT INSECTICIDE GRANULES AT 21 DAT



Data on the observations made on the control of the various pests following second application of insecticides 45 DAT are presented in Table 3 and Fig. 8. BPH was significantly controlled by the treatments of carbofuran at 1.0 kg, disulfoton at 1.0 kg, phorate at 2.0 kg, carbofuran at 0.5 kg and phorate at 1.0 kg ai/ha with infestations varying from 5.33 to 6.67 per plot as against 12.33 in control plots. These insecticides were on par in their effectiveness. All the other treatments were ineffective. Significant control of EMH was given by disulfoton at 2.0 kg, phorate at 2.0 kg, carbofuran at 1.0 kg and phorate at 1.0 kg ai/ha showing infestations of 9.33 to 16.00 per plot as against 26.83 under control treatment. These insecticides were on par and the other treatments did not show any effect. Significant control of gall midge could be achieved under the treatments of phorate at 1.0 kg and 2.0 kg and nephotholan at 1.0 kg ai/ha with infestations of 0 to 2.00 per plot as against 12.00 in control plots. All the other insecticides were ineffective. Maximum control of stem borer infestation was seen under the treatments of chlorodimorph at 2.0 kg, carbofuran at 1.0 kg and 0.5 kg, nephotholan at 1.0 kg, phorate at 2.0 kg and quinalphos at 2.0 kg ai/ha with infestations varying from 12.67 to 21.00 per plot as against 34.83 under untreated control. Chlorodimorph at 1.0 kg ai/ha ranked

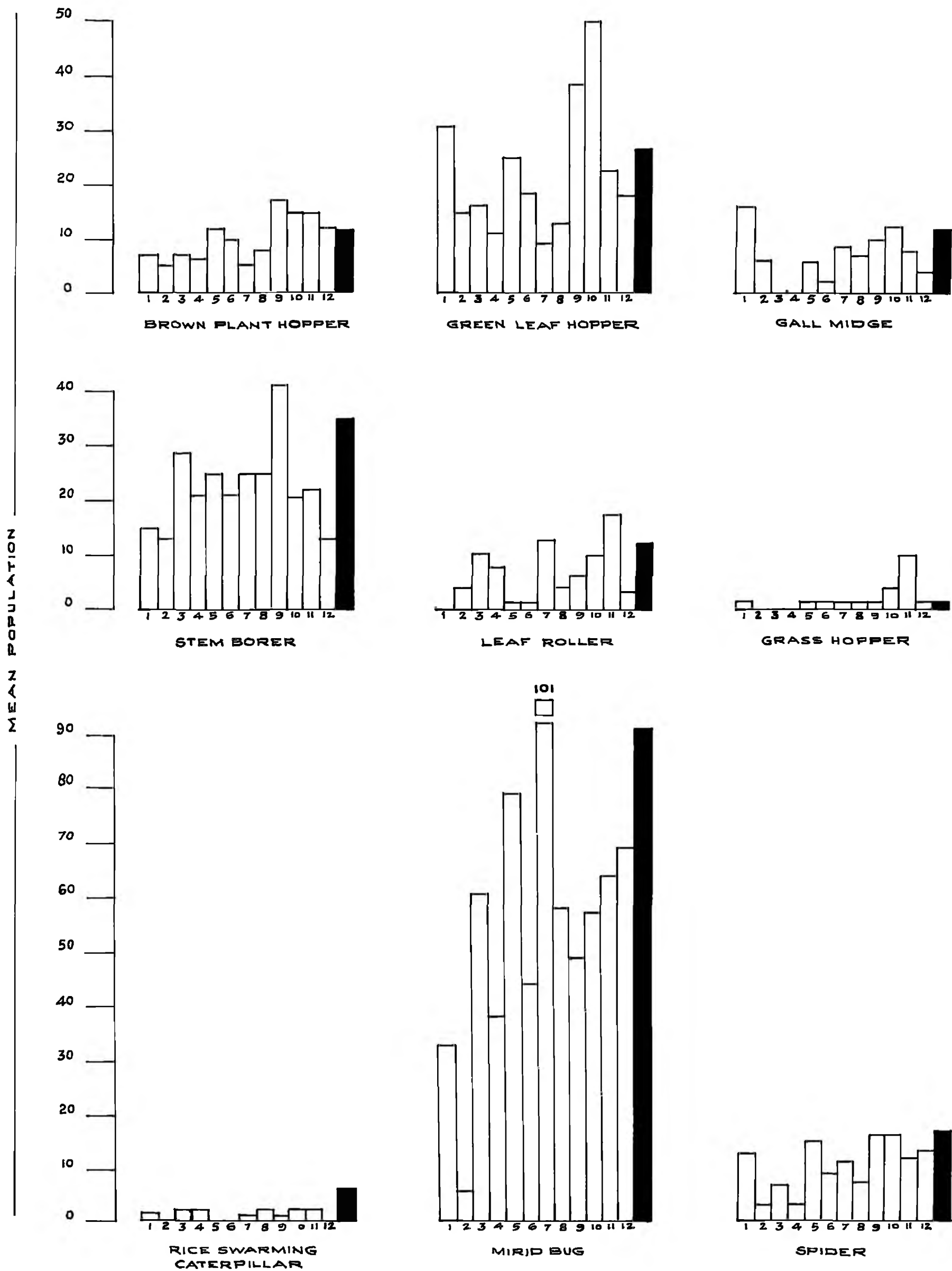
Table 8. Mean population in plot of rice up to harvest for various insecticide treatments observed

Treatments	Insecticides (kg ai/ha)	PH	Q	Grasshopper	1st	2nd	Leaf roller	Cane worm	Grasshopper	Rice swarming caterpillar	Florida bug	Spider
1	Carbofuran	0.5	6.67 (2.75)	50.67 5.0	6	3	5.00 (3.98)	0.00 0.00	0.67 24	1.33 (1.49)	33.33 (5.81)	13.33 (3.87)
2	Carbofuran	0	33 2.49	4.67 (3.00)	6.3 2.4		13.00 3.73	3.67 2.62	0.00 (0.00)	0.00 (1.00)	6.33 2.63	3.33 (1.91)
3	Thionex	0	7 2.7	6.00 0	0		2.67 (3.44)	0.33 3	0.00 0.00	2.00 66	60.67 7.02	7.33 (2.73)
4	Thionex	0	3		0		0.00 (4.64)	0.0 2.24	0.00 0.00	0.7 40	33.67 6.29	33 2.21
	Thionex						4.67 0.4	0.7 4	0.57 24	0.00 30	7.33	4.6 3.07
							0.7 4	Infestation	0.7 24			37 7
							13 4		0.67 24		0.00 (0.00)	33 30
									0.67 (0.4)	0 3	0.00 0.07	7.33 4.0
									0.67 4	3 4	4 0.07	0.00 4.0
									3.67 2.13	2.00 66	7.33 7.4	0.00 4.0
									0.00 (3.28)	2.0 66	64.0 7.5	0
									0.67 (1.24)	0.00 1.03	6.33 0.33	3 4
									0.67 (0.21)	3.67 (1.9)	9.33 (9.4)	30 7
									0.63	0.0	0.0	42
									(0.54) 0.0	(0.87) 0.0	(0.64) 0.0	23

Fig. 8. Mean population of different insect pests and natural enemies observed up to harvest following application of different insecticide granules at 45 DAF during third crop season

1.	Carbofuran	at	0.5	kg ai/ha
2.	..	..	1.0	..
3.	Phorate	..	1.0	..
4.	..	..	2.0	..
5.	Nephosolan	..	0.5	..
6.	..	..	1.0	..
7.	Diazinaton	..	1.0	..
8.	..	..	2.0	..
9.	Quinalphos	..	1.0	..
10.	..	..	2.0	..
11.	Chlorodimethoz	..	1.0	..
12.	..	..	2.0	..
■	Control			

FIG 8 MEAN POPULATION OF DIFFERENT INSECT PESTS AND NATURAL ENEMIES FOLLOWING APPLICATION OF DIFFERENT INSECTICIDE GRANULES AT 45 DAT (THIRD CROP)



next in effectiveness. All other treatments were ineffective. The effect of insecticides on leaf roller under the different insecticidal treatments was not significant which appeared to be due to the very low level of infestation which was 12.00 per plot in untreated plots. No significant effect of the insecticide treatments could be observed on grasshopper populations due to the low population which existed in the field and so also was the effect on rice swarming caterpillar. The mirid bug population was significantly affected by the treatments of carbofuran at 1.0 kg and 0.5 kg, phorate at 2.0 kg, quinalphos at 1.0 kg and 2.0 kg and disulfoton at 0.5 kg ai/ha with population levels of 6.55 to 50.00 per plot as against 91.33 in untreated plots. Carbofuran at 1.0 kg ai/ha affected the mirid population significantly more than the rest, giving a population of 6.55 per plot. The spider population was significantly suppressed by the treatments of carbofuran at 1.0 kg, phorate at 2.0 kg and 1.0 kg and disulfoton at 2.0 kg ai/ha, the populations being 3.55 to 7.55 per plot in comparison to 16.50 in control plots. The other treatments did not affect the population.

The combined effects of two applications of the various insecticides on paddy pest infestation are presented in Table 9 and Fig.9. All the insecticide treatments excepting

Table 9 Mean popul. ion per ml t of diff re insects under dif rent insecticide treatments observed up to harvest after tr a ch on Δ 4 D (Third crop

Treatments	Insecti- cides	kg ai/ha	B.	I	Gall midges	1 m. v.	Stem borer	leaf roller	Cane worm	Grass hopper	Rice swarming cater- pillar	Mirid bug	Spider
1	Carbofuran	0.5	25.67 4.96	57.00 7.4	3.33 5.00		21.33 (4.67)	21.33 4.67	9.00 3.5)	7.00 2.3)	4.67 (2.38)	60.00 (7.71)	42.00 (6.55)
2	Carbofuran	0	33 4.02	4.0 (.32)	2 5		3.33 (4.04)	0.00 2	2.00 3.50)	4.00 2.6)	1.33 (1.4)	36.67 (6.12)	23.00 (4.85)
3	Thionex	0	~C				36.67 (6.12)	07.00 0.38	0.00 3.7)	5.00 (2.40)	8.00 2.95	90.00 9.52	31.67 (5.68)
4	"			7	0		26.67 5.20)	03.67 9.2	4.00 2	1.33 (.4)	6.33 2.54	3 0.70	70.33 4.66)
5	"						3.67 36)	7.3 07	0.00 (3.4)	9.00 3.0	0.0 00	97.33	3.33 0.29
							07 04	2					7.3
							06		5.00	4.67 3.86			7.3
								0	0.00	7.67 2.00	0.33	73.33	40.00 01
							4.00 (.3)	0.34	3.0	23.33 4.04		7	4.0
0							67	7	3.3	10.67 4.57	6.00 2.6		4.67
									3.3	4.57	2.6		
							17.6 6.9	2.7	7.00 4.2	34.33 5.82	0.33 3.0	0.3 0.05	42 55
							67 4.04	3	14.33 3.07	10.67 3.40)	9.33 3	9.00 9.74	4.70 7.07
1							03 5	6.0 0.2	3 4	23.63 4.89	20.7 4.54)	2.50 0.2	64.50 0
									2 0.3	0.99)	(.10)	(.89)	
										0.86	(0.95)	63	3

✓ T

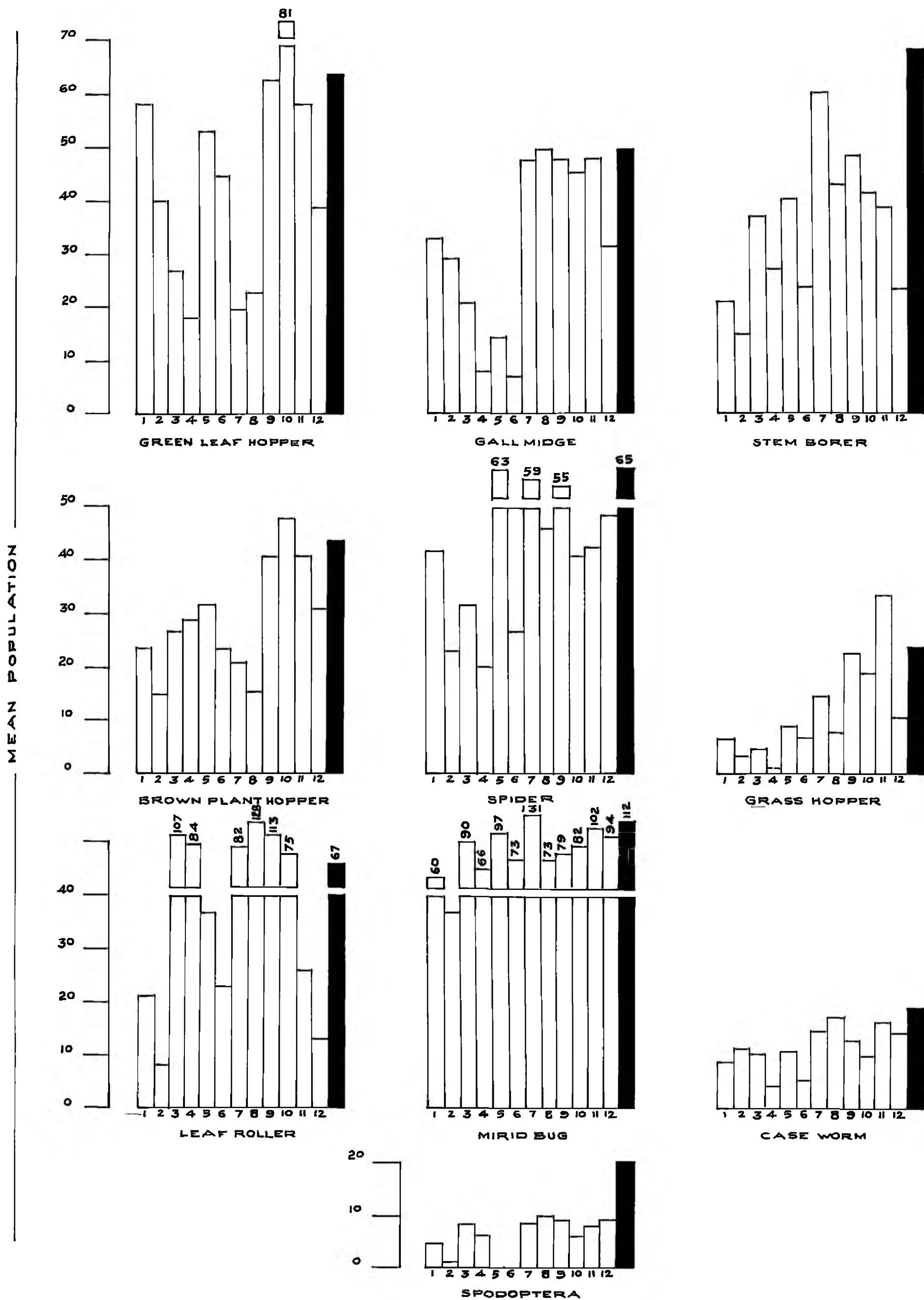
n

remai

Fig. 9. Mean population of different insect pests and natural enemies observed up to harvest following application of insecticide granules at 24 and 45 DAT during third crop season

1.	Carbofuran	at	0.5	kg ai/ha
2.	..	..	1.0	..
3.	Phorate	..	1.0	..
4.	..	..	2.0	..
5.	Dyphosfolan	..	0.5	..
6.	..	..	1.0	..
7.	Disulfeton	..	1.0	..
8.	..	..	2.0	..
9.	Quinalphos	..	1.0	..
10.	..	..	2.0	..
11.	Chlorodimethom	..	1.0	..
12.	..	..	2.0	..
■	Control			

FIG 9 MEAN POPULATION OF DIFFERENT INSECT PESTS AND NATURAL ENEMIES FOLLOWING APPLICATION OF DIFFERENT INSECTICIDE GRANULES AT 21 AND 45 DAT (THIRD CROP)



quinalphos and chlorodimeform at 1.0 kg ai/ha gave significant control of BPH. Among the different treatments, carbofuran at 1.0 kg and disulfoton at 2.0 kg and 1.0 kg ai/ha gave the best results with infestations of 15.33 to 21.33 per plot as against 44.83 in control plots. Carbofuran at 0.5 kg, mephosfolan at 1.0 kg and phorate at 1.0 kg and 2.0 kg ai/ha ranked next in effectiveness with infestations of 23.67 to 28.67. Chlorodimeform at 2.0 kg and mephosfolan at 0.5 kg ai/ha were the least effective. The best control of GLH could be observed under the treatments of phorate at 2.0 kg, disulfoton at 1.0 kg and 2.0 kg and phorate at 1.0 kg ai/ha showing infestations of 16.67 to 27.33 per plot as against 63.87 in control plots. These insecticides were on par in their effectiveness. Chlorodimeform at 2.0 kg and carbofuran at 1.0 kg ai/ha ranked next with less effectiveness but gave significant control. All the other treatments were not effective. Maximum gall midge control was given by the treatments of mephosfolan at 1.0 kg, phorate at 2.0 kg and mephosfolan at 0.5 kg ai/ha with infestations of 7.00 to 14.67 per plot. These were followed by phorate at 1.0 kg, carbofuran at 1.0 kg, chlorodimeform at 2.0 kg and carbofuran at 0.5 kg ai/ha giving infestations of 20.67 to 33.33 as compared to 54.33 in control plots. The rest of the insecticides did not give significant control. All the treatments excepting disulfoton

at 1.0 kg ai/ha gave significant suppression of stem borer infestations. But among the treatments best control was given by carbofuran at 1.0 kg and 0.5 kg, chlorodimethoate at 2.0 kg and methidathion at 1.0 kg ai/ha with infestations of 15.33 to 22.67 per plot as against 69.83 in control plots. All the other treatments gave inferior control. The best control of leaf roller was observed under carbofuran at 1.0 kg, chlorodimethoate at 2.0 kg and carbofuran at 0.5 kg ai/ha showing infestations of 8.00 to 21.33 larvae per plot as against 67.00 in untreated control. Methidathion at 1.0 kg, chlorodimethoate at 1.0 kg and methidathion at 0.5 kg ai/ha also gave significant control though to a lesser degree. All the other insecticides were found to be inferior. Significant control of grasshopper was given by all the treatments excepting quinalphos treatments and chlorodimethoate at 1.0 kg ai/ha. Among the different treatments, however, the best control was given by phorate at 2.0 kg, carbofuran at 1.0 kg and phorate at 1.0 kg ai/ha giving populations of 1.33 to 5.00 per plot as against 25.83 in the control plots. All the other treatments were found to be inferior. Though all the treatments gave significant control of rice earwing caterpillars, the most effective treatments were observed to be methidathion at 0.5 and 1.0 kg ai/ha and carbofuran at 1.0 kg ai/ha with larval populations of 1 to 1.33 per plot as against 20.17

observed in the control plots. Mixed bug population showed maximum suppression under the two carbofuran treatments with populations of 35.67 and 60.00 per plot as against 112.5 in the untreated control plot. The other treatments which showed significant reduction in the bug population were phorate at 2.0 kg, mephosfolan at 1.0 kg, disulfoton at 2.0 kg and quinalphos at 1.0 kg ai/ha. The other treatments did not give any effect on the population. Spider population suffered maximum reduction under the treatments of phorate at 2.0 kg, carbofuran at 1.0 kg and phorate at 1.0 kg ai/ha with populations of 29.33 to 31.67 per plot as against 64.5 in control plots. Mephosfolan at 1.0 kg, chlorodimeform at 1.0 kg and carbofuran at 0.5 kg ai/ha treatments also reduced the spider populations significantly. The other treatments had very little effect.

PERSISTENCE OF INSECTICIDES IN RICE PLANTS
WHEN APPLIED AS GRANULES IN SOIL

This study was undertaken in terms of the residual toxicity of the insecticides to 3 test insects viz. BPH, rice swarming caterpillar and leaf roller caterpillar, observed at different intervals after the application of the insecticides. In Table 10 and Fig. 10 are presented the data relating to the persistent toxicity of insecticides to BPH, 21 DAT after the application of insecticides. It was observed that carbofuran at both doses persisted up to 12 days after application, the amount of insecticide persisting being more at the higher dose. Thus from an initial mortality of 38.7% observed on the 2nd day of application the mortality increased to 69.4% on the 7th day and decreased to 21.9% on the 12th day. Under carbofuran at 0.5 kg ai/ha, on the 17th day there was no mortality. For the higher dose of 1.0 kg ai/ha the initial mortality was 64.5% which increased to 87.7% on the 7th day and then came down to 29.0% on the 12 day. Phorate at 1.0 and 2.0 kg ai/ha gave mortalities of 36.1% and 46.1% initially and were reduced to 20.7% and 27.6% respectively on the 7th day; there was no mortality from 7th day onwards. Nephosolan at the lower and higher doses gave 20.0% and 49.4% mortality respectively initially and

Table 10. Residual toxicity and PT indices of different insecticides in rice plants to BPH when applied at 21 DAT

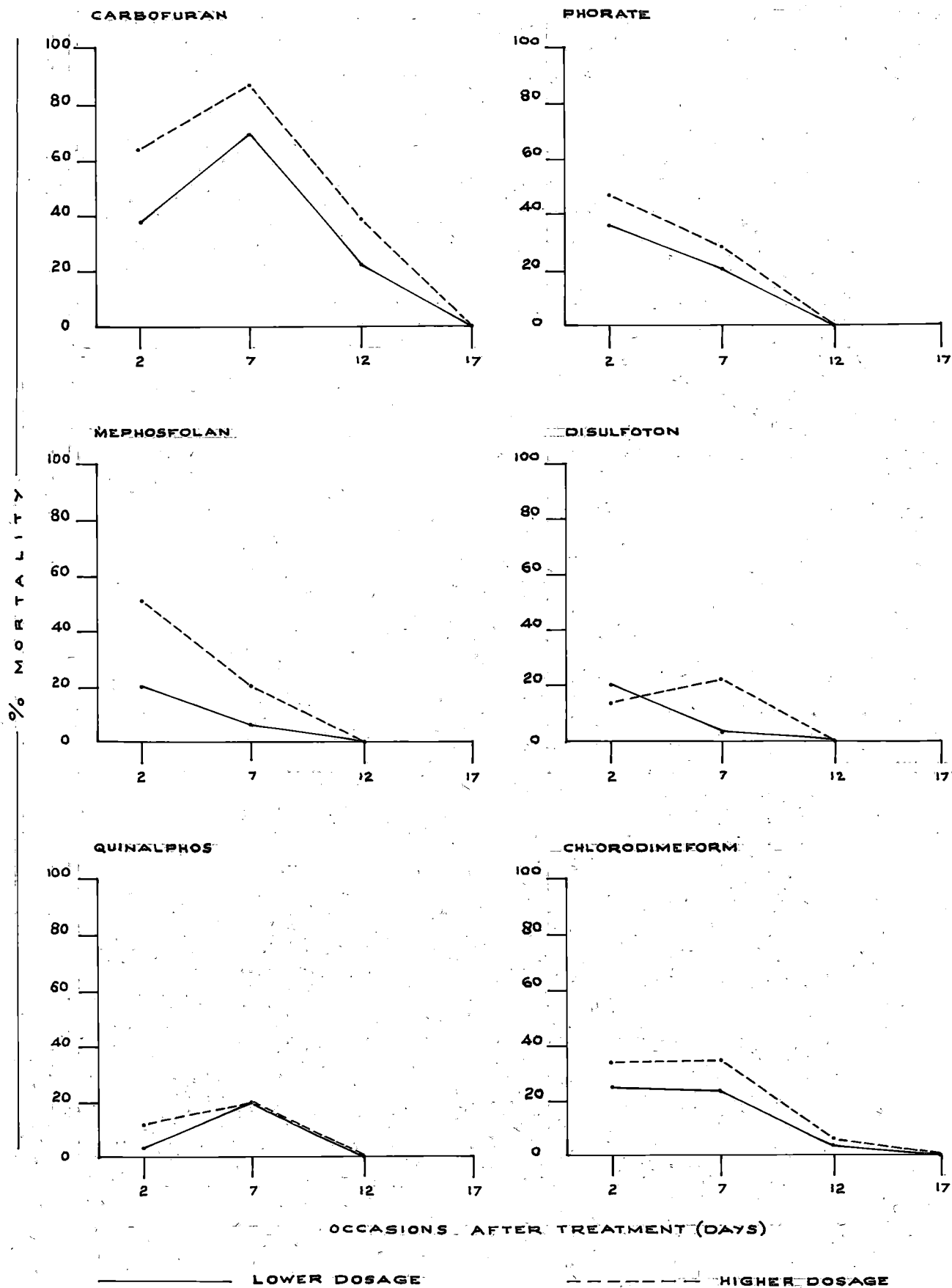
Insecticide treatment (kg ai/ha)			Per cent mortality at different occasions after treatment (days)				P	T	PT
			2	7	12	17			
T ₁	Carbofuran	0.5	38.7	69.4	71.9	0.0	12	13.30	520.00
T ₂	Carbofuran	1.0	64.5	87.7	89.0	0.0	12	18.40	724.80
T ₃	Phorate	1.0	36.1	20.7	0.0	0.0	7	18.40	198.80
T ₄	Phorate	2.0	46.1	27.6	0.0	0.0	7	16.85	257.95
T ₅	Nephesolan	0.5	20.0	7.1	0.0	0.0	7	13.55	94.50
T ₆	Nephesolan	1.0	49.4	20.7	0.0	0.0	7	15.05	245.35
T ₇	Disulfoton	1.0	20.0	3.4	0.0	0.0	7	11.70	81.90
T ₈	Disulfoton	2.0	13.3	21.9	0.0	0.0	7	17.60	123.20
T ₉	Quinalphos	1.0	3.6	20.0	0.0	0.0	7	11.80	82.60
T ₁₀	Quinalphos	2.0	12.5	20.0	0.0	0.0	7	16.25	113.75
T ₁₁	Chlorodimethoate	1.0	26.5	24.1	3.6	0.0	12	18.07	216.79
T ₁₂	Chlorodimethoate	2.0	34.4	33.3	6.6	0.0	12	14.76	297.20

P = Period after treatment in days

T = Average residual toxicity

PT = Index of persistent toxicity

FIG. 10 MORTALITY OF BROWN PLANT HOPPER EXPOSED TO RICE PLANTS AT DIFFERENT INTERVALS AFTER APPLICATION OF DIFFERENT INSECTICIDE GRANULES AT 21 DAT



and which were reduced to 7.1 and 20.7% respectively on the 7th day and no mortality afterwards. In the case of disulfoton at 1.0 kg and 2.0 kg ai/ha the mortalities were 20.0 and 3.4% and 13.3 and 21.9% on the 2nd and 7th day respectively for the two doses. There was no mortality subsequently. Quinalphos at 1.0 and 2.0 kg ai/ha gave 3.6 and 12.5% mortalities respectively initially and the mortalities increased to 20.0% for both the doses on the 7th day. From the 12th day onwards there was no mortality. Chlorodimethoate at 1.0 and 2.0 kg ai/ha gave initial mortalities of 20.5 and 34.4% respectively which decreased to 24.17 and 33.3% respectively on the 7th day. On the 10th day the percentages of mortalities were reduced drastically to 3.6 and 6.6 respectively; there were no mortalities afterwards.

Comparing the persistent toxicity in terms of PT index values of the different insecticide treatments it was observed that the highest values of 520.00 and 724.80 for the two doses were observed under carbofuran indicating that the insecticide was the most highly persistent in the plants. The insecticide which ranked next was chlorodimethoate at 1.0 and 2.0 kg ai/ha giving PT values of 216.79 and 297.20 respectively. Phorate ranked next in persistence, the PT values being 198.0 and 257.95 for the two doses. This was followed by

K 86 N 81 SA

c

mephosfolan with 94.50 and 245.35 PT index values for the lower and higher doses. Disulfoton and quinalphos showed nearly equal persistence, two doses of these insecticides showing PT index values of 81.90 and 123.20, and 82.60 and 113.75 respectively.

The persistent toxicities of the insecticidal treatments to larvae of Spodoptera mauritia are presented in Table 11 and Fig. 11. Carbofuran at the two doses gave initial mortalities (on 2nd day) of 20.7% and 58.1% respectively and these were reduced to 3.3% and 6.2% respectively on the 7th day; there were no mortalities thereafter. Phorate at 1.0 kg ai/ha was not toxic to caterpillars at all, but under the insecticide treatment at the higher dose of 2.0 kg ai/ha mortality to the extent of 3.3% was observed initially. But there was no mortality thereafter. Mephosfolan at 0.5 kg and 1.0 kg ai/ha gave initial toxicities of 67.7 and 93.1%. The insecticide persisted up to 12 days at the lower dose and up to 17 days at the higher dose. Disulfoton and quinalphos did not give any mortalities of the caterpillars even from the beginning. Chlorodaneform at 1.0 kg ai/ha gave an initial mortality of 10.3% and no mortality from the 7th day onwards, while at 2.0 kg ai/ha the initial mortality of 38.7% and a mortality of 5.7% on the 7th day were observed. Thereafter there was no mortality.

Table 11. Residual toxicity and PT indices of different insecticides in rice plants to rice swarming caterpillar when applied at 21 BAE

Insecticide treatment (kg ai/ha)			Per cent mortality at different occasions after treatment (days)					P	T	PT
			2	7	12	17	22			
T ₁	Carbofuran	0.5	20.7	3.3	0.0	0.0	0.0	7	12.00	84.0
T ₂	Carbofuran	1.0	58.1	0.2	0.0	0.0	0.0	7	52.15	225.05
T ₃	Phorate	1.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
T ₄	Phorate	2.0	3.3	0.0	0.0	0.0	0.0	2	3.3	6.6
T ₅	Kephesfolan	0.5	67.7	39.5	32.3	0.0	0.0	12	45.17	542.0
T ₆	Kephesfolan	1.0	93.1	55.2	58.1	3.2	0.0	17	52.40	590.8
T ₇	Disulfoton	1.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
T ₈	Disulfoton	2.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
T ₉	Quinalphos	1.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
T ₁₀	Quinalphos	2.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
T ₁₁	Chlorodimethom	1.0	10.3	0.0	0.0	0.0	0.0	2	10.3	20.6
T ₁₂	Chlorodimethom	2.0	38.7	5.7	0.0	0.0	0.0	7	22.2	155.4

P = Period after treatment in days

T = Average residual toxicity

PT = Index of persistent toxicity

A comparison of the PT indices will show that very high values of 542.0 and 690.6 were observed for the two doses of nephosolan indicating the highly persistent and toxic nature of the insecticide against this caterpillar. Carbofuran ranked next with PT index values of 84.00 and 225.05 respectively for the lower and higher doses. Chlorodimorph ranked the next with PT index values of 20.6 and 155.4 for the two doses.

Data on the residual toxicity of the insecticidal treatments to larvae of rice leaf roller are presented in Table 12 and Fig. 12. Carbofuran at 0.5 kg ai/ha gave an initial toxicity of 43.9% which was raised to 56.7% on the 7th day and lowered to 30.0% on the 12th day, there being no mortality subsequently. At the higher dose of 1.0 kg ai/ha the initial mortality of 66.7% increased to 83.3% on the 7th day and then decreased to 10% mortality on the 17th day. There was no mortality thereafter. Phorate at the two doses gave 23.3 and 26.3% mortalities on the 2nd day and these were reduced to 20.6 and 23.3% respectively on the 7th day and without mortality subsequently. Nephosolan at 0.5 kg ai/ha persisted up to the 7th day with 13.7% mortality and at 1.0 kg ai/ha up to 12 days with 6.3% mortality, the initial mortalities being 17.7 and 27.7% respectively. Malathion at both the doses

Table 12. Residual toxicity and PT indices of different insecticides in rice plants to rice leaf roller larvae when applied at 21 DAT

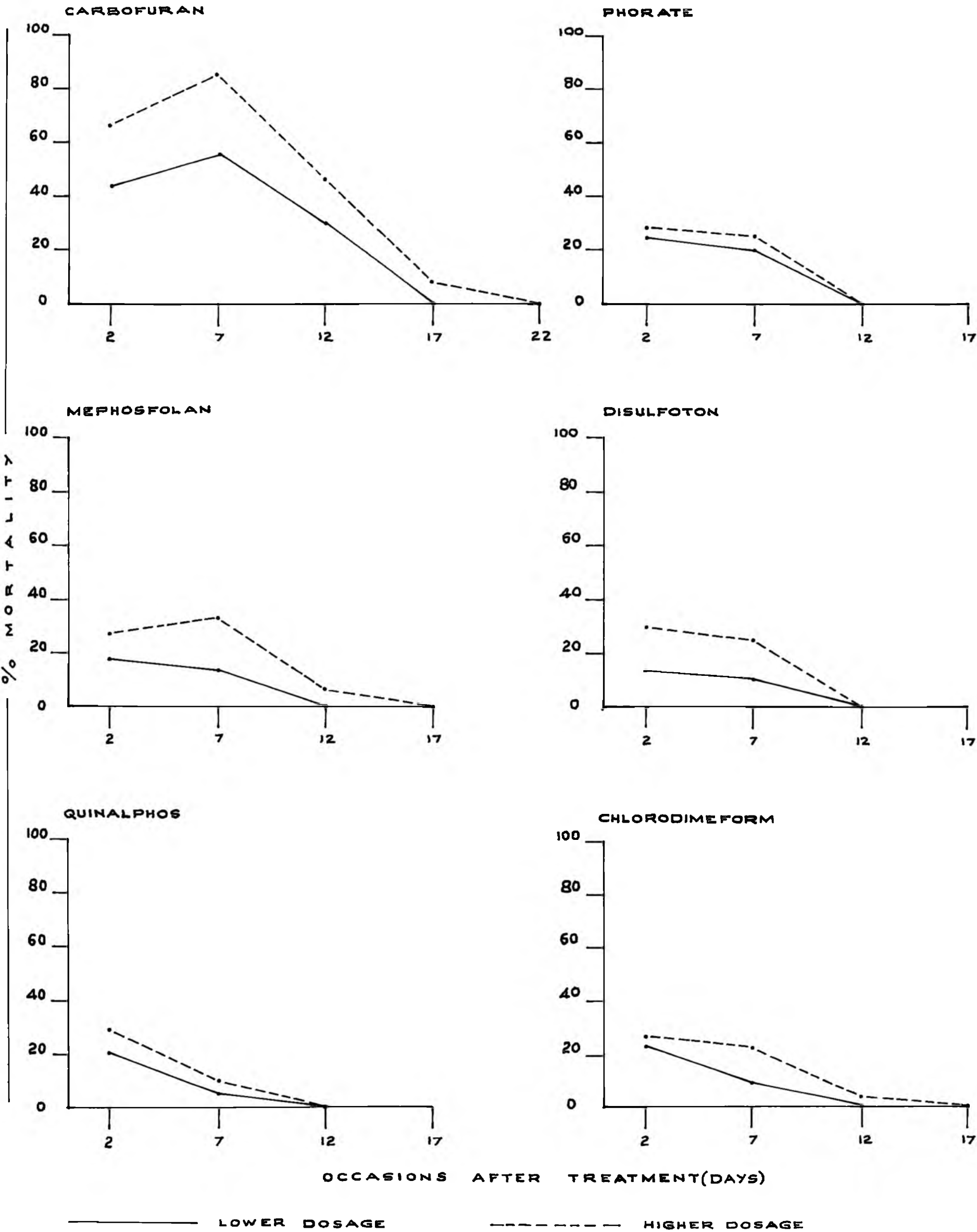
Insecticide treatment (kg ai/ha)	Percentage mortality at different occasions after treatment (days)						P	T	PT
	2	7	12	17	22				
T ₁ Carbofuran	0.5	43.3	56.7	30.0	0.0	0.0	12	43.53	520.0
T ₂ Carbofuran	1.0	66.7	83.3	46.7	10.0	0.0	17	51.67	873.5
T ₃ Thorate	1.0	23.3	20.6	0.0	0.0	0.0	7	21.95	153.6
T ₄ Thorate	2.0	23.3	23.3	0.0	0.0	0.0	7	25.80	180.6
T ₅ Hophenfolan	0.5	17.7	15.7	0.0	0.0	0.0	7	15.70	109.9
T ₆ Pyrethofolan	1.0	27.7	33.7	6.3	0.0	0.0	12	22.57	270.8
T ₇ Disulfoton	1.0	13.3	10.3	0.0	0.0	0.0	7	11.8	82.6
T ₈ Disulfoton	2.0	30.0	26.7	0.0	0.0	0.0	7	28.35	198.5
T ₉ Quinalphos	1.0	23.7	6.7	0.0	0.0	0.0	7	15.20	106.4
T ₁₀ Quinalphos	2.0	30.3	10.0	0.0	0.0	0.0	7	20.15	141.0
T ₁₁ Chlorodimethoate	1.0	23.3	10.0	0.0	0.0	0.0	7	16.65	116.5
T ₁₂ Chlorodimethoate	2.0	26.7	23.4	3.3	0.0	0.0	12	17.8	213.6

P = Period after treatment in days

T = Average residual toxicity

PT = Index of persistent toxicity

FIG 12 MORTALITY OF RICE LEAF ROLLER LARVAE EXPOSED TO RICE PLANTS AT DIFFERENT INTERVALS AFTER APPLICATION OF DIFFERENT INSECTICIDE GRANULES AT 21 DAT



persisted only up to the 7th day with initial and final mortalities of 13.3%, 10.3% and 30.0%, 26.7% for the two doses respectively. Quinalphos also persisted only 7 days, the initial and final mortalities observed were 23.7% and 6.7% and 30.3% and 10.0% for the two doses respectively. Chlorodimethoate at 1.0 kg ai/ha persisted up to 7 days, initial and final mortalities being 25.3 and 10.0% respectively, while at 2.0 kg ai/ha it persisted up to 12 days with initial and final mortalities of 26.7 and 3.3% respectively. The FT index values showed that carbofuran had considerably higher persistent toxicity to the leaf roller caterpillar, than the other insecticides with index values of 520.00 and 578.50 for the two doses. Nephosolon ranked next with FT values of 199.00 and 270.00 for the two doses. Chlorodimethoate came next with index values of 116.5 and 213.6 for the two doses. Phoslate ranked next giving FT values of 153.60 to 160.60. Dieldrin with 82.6 and 136.5 FT index values came next followed by quinalphos with FT values of 106.4 and 141.1 for the two doses respectively.

EFFECT OF DIFFERENT FREQUENCIES OF APPLICATION OF
INSECTICIDE GRANULES IN SOIL ON CONTROL OF
WHEAT HOPPER DURING FIRST GROW SEASON
(MAY - SEPTEMBER 1978)

Results of the experiment are presented in Table 13 and Fig. 13. Carbofuran when applied at 1.0 kg ai/ha was found to give significant control of GHs at all the three frequencies of application with infestations of 16.00 to 27.33 per plot as against 41.33 in control. The maximum control of leaf hopper was obtained when the insecticide was applied at both occasions of 21 and 45 DAT. Equally good control was obtained by a single application of the insecticide at 21 DAT. A single application at 45 DAT gave insignificant control of the leaf hopper. No significant results were observed with DMK. This was possibly due to the low population of the hopper during the period. Though leaf roller was found to be controlled with a single application of the insecticide at 45 DAT with an infestation of 24.00 per plot against 44.67 in the untreated control; the other two frequencies did not give any control of the pest to the level of significance. Further, even the single application at 45 DAT did not vary significantly in its effect from the other two frequencies. The effect of the insecticide on wheat maggot control was not found to be significant. Single application at 21 DAT

Table 3 Mean population of insect pests and natural enemies observed on rice plants under different insecticides applied as granules (first crop season)

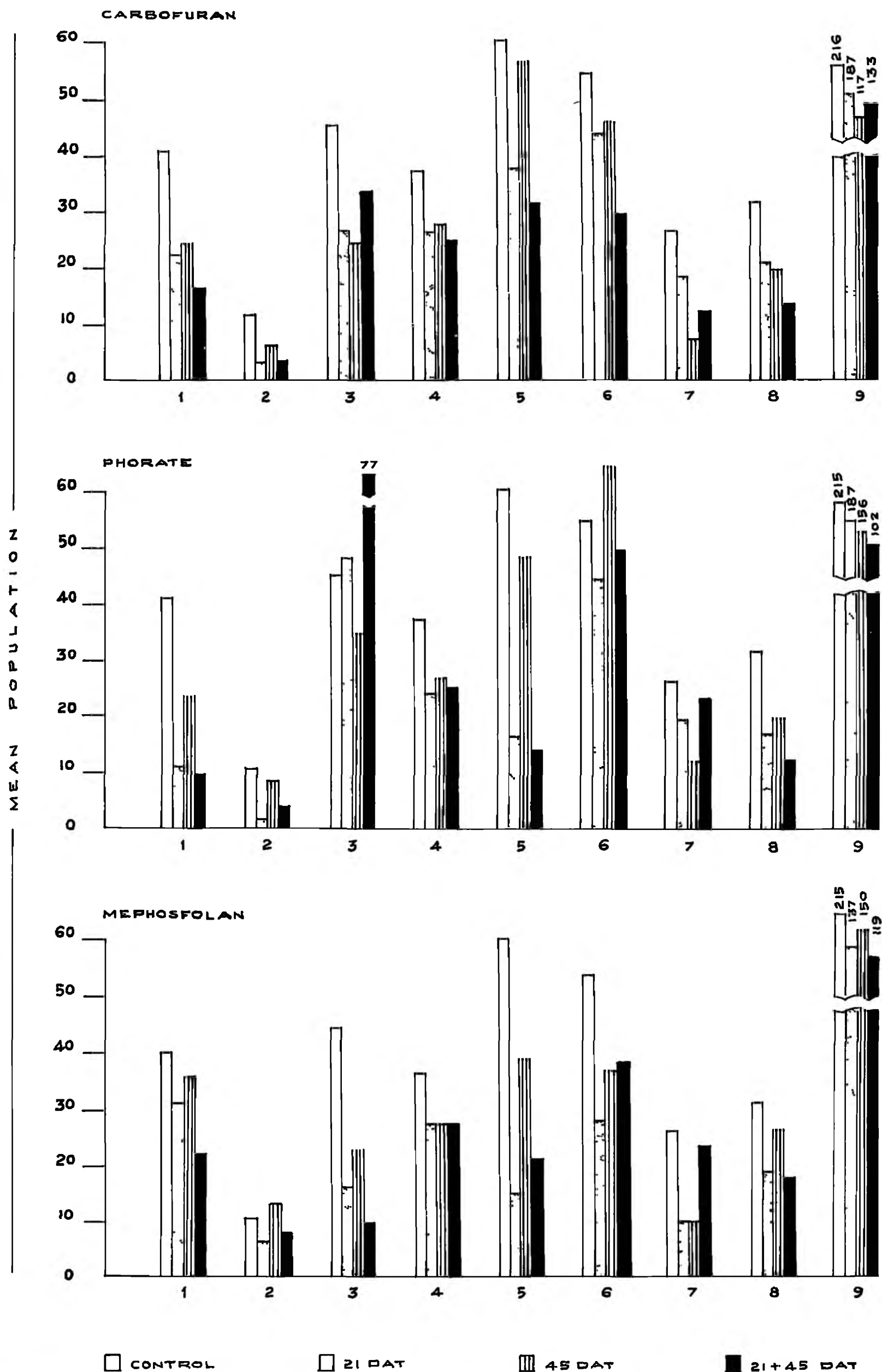
Insecticide rate/ha and remarks	GRM	BPH	Leaf miner	Earhopper	Grasshopper	Stem borer	Rice bug	Spider	Field bug	Yield (kg)
<u>Carbofuran 1.5</u>										
1 app date 2 D	23 33 4 2	33 2 07	00	67	37 37 (6 7)	43 67 (6 7)	18 33 (4 28)	19 33 (4 43)	187 33 (13 80)	3 78
2 a pl date 45	77 33 2	6 00 2 59	24	77 00 2	56 00 (7 2)	45 33 (6 75)	7 33 (2 79)	8 67 (4 43)	117 33 (10 71)	3 75
3 a od 2 245	00	3 4		67 6	30 67 (5 2)	20 67 (5 9)	2 00 3 48	3 33 3 63	33 33 (72)	4 08
<u>0</u>										
					6 00 4	43 67 (6 90)	8 67 (4 30)	7 4 0	33	02
				7	47 7 (6 00)	6 67 8 7	2 00 3 43	0 67 4 42	15 2 9	4
			77		4 00 3 7	49 33 (7	22 67 (4 79)	3 4	2 20	03
<u>non</u>										
7 11					5 7 3 0	3 7 5 87	10 33 3 22)	9 33 4 53	37 33 2 05	3 70
8 app					6	7 00 6 24	0 00 3 27	23 6 4 3	30 00 2 47	30
9 a 5		7			6 4	00 5 9	24 00 (4 74)	18 33 4 24	0 7 0 94	
0 70		67			6 7	3 67 7	26 00 4 82)	3 33 5 96	213 67 14 83	3 00
<u>57 1 67 30 3 44 0 92</u>										
<u>89</u>										

values within parentheses are $\sqrt{x}$ transformed values

Fig. 13. Mean population of insect pests and natural enemies observed on rice plants under different insecticides applied as granules at different frequencies during first crop season

1. Green leaf hopper
2. Brown plant hopper
3. Leaf roller
4. Whorl maggot
5. Gall midge
6. Stem borer
7. Rice bug
8. Spider
9. Mirid bug

FIG 13 MEAN POPULATION OF INSECT PESTS AND NATURAL ENEMIES UNDER DIFFERENT INSECTICIDES APPLIED AS GRANULES AT DIFFERENT FREQUENCIES DURING THE FIRST CROP SEASON



and the combined applications at 21 and 45 DAT gave significant control of the gall midge infestation, whereas single application at 45 DAT did not show any significant effect on the control of the pest. Stem borer infestation was controlled only by the combined applications at 21 and 45 DAT with infestations of 28.67 as against 53.67 in control plots. The single application treatment did not give effective control. As regards rice bug, significant control was obtained by a single application of the insecticide at 45 DAT with a population of 7.33 per plot in comparison to 26.00 under control. The spider population was significantly reduced at all the occasions of the insecticidal applications showing populations of 13.33 to 19.33 per plot as against the population of 31.33 in the control plot. The mirid bug population was observed to be significantly reduced when the insecticide was applied at 45 DAT while the other frequencies did not give significant effect. The yield of paddy showed significant increase under application of the insecticide at 21 and 45 DAT with an yield of 4.03 kg per plot as against 3.0 kg in the control plot. The other two frequencies also showed increase in yield (3.75 to 3.78 kg per plot) though not to significant levels.



As regards phorate, when applied at 2.0 kg ai/ha GHE was found to be controlled significantly in all the different frequencies of application. The maximum control was indicated under the combined applications at 21 and 45 DAT and single application at 21 DAT with populations of 10.0 and 11.0 per plot respectively as against 41.33 per plot under untreated control. Single application at 45 DAT gave inferior control. The results observed on BPH were insignificant. Leaf roller did not show significant control under any of the frequencies of treatments. Wheat raggot control also was not significant under any of the treatments. Gall midge control was highly significant in the single application at 21 DAT and in the two applications at 21 and 45 DAT with levels of infestations of 14.00 to 16.00 per plot as against 60.00 in the control plot. Single application at 45 DAT did not show effective control. None of the treatments gave significant control of stem borer and rice bug infestations. All the treatments showed significant suppression of epider population with populations of 11.67 to 18.67 per plot as against 31.33 in the untreated control plot. Mirid bug population was not affected by any of the treatments and the increase in yield recorded at 21 DAT and 21 and 45 DAT was not significant.

With neposofolan, when applied at 1.00 kg ai/ha, only two applications of the insecticide at 21 and 45 DAT gave significant control of green leaf hopper. Leaf roller

infestation was significantly controlled by all the treatments, the two applications giving better control than the single application with infestations varying from 10.00 to 23.33 in comparison to the population of 44.67 per plot in the control. Whorl maggot infestation was not controlled by any of the treatments. Gall midge was observed to be controlled by the application at 21 DAT and at 21 and 45 DAT while the single application at 45 DAT did not give significant control. The maximum control of the midge population with infestation of 15.67 per plot was observed at the single application at 21 DAT as against 60.00 per plot under the untreated check. Stem borer control was also significant under the 21 DAT and 21 and 45 DAT treatments with infestations of 29.00 and 31.67 per plot as against 53.67 under untreated control. Single application at 45 DAT was ineffective. Rice bug infestation was not controlled by any of the treatments significantly. Significant reduction in spider population was seen at the single application at 21 DAT and two applications at 21 and 45 DAT. Reduction of mixed bug population was significant in all the treatments.

Significant increase in yield was recorded under the treatment of two applications at 21 and 45 DAT while the increase in the other treatments was not significant.

EFFECT OF DIFFERENT FREQUENCIES OF APPLICATION OF
INSECTICIDE GRANULES IN SOIL ON CONTROL OF RICE PESTS
DURING SECOND CROP SEASON (SEPTEMBER - JANUARY 1978- 79)

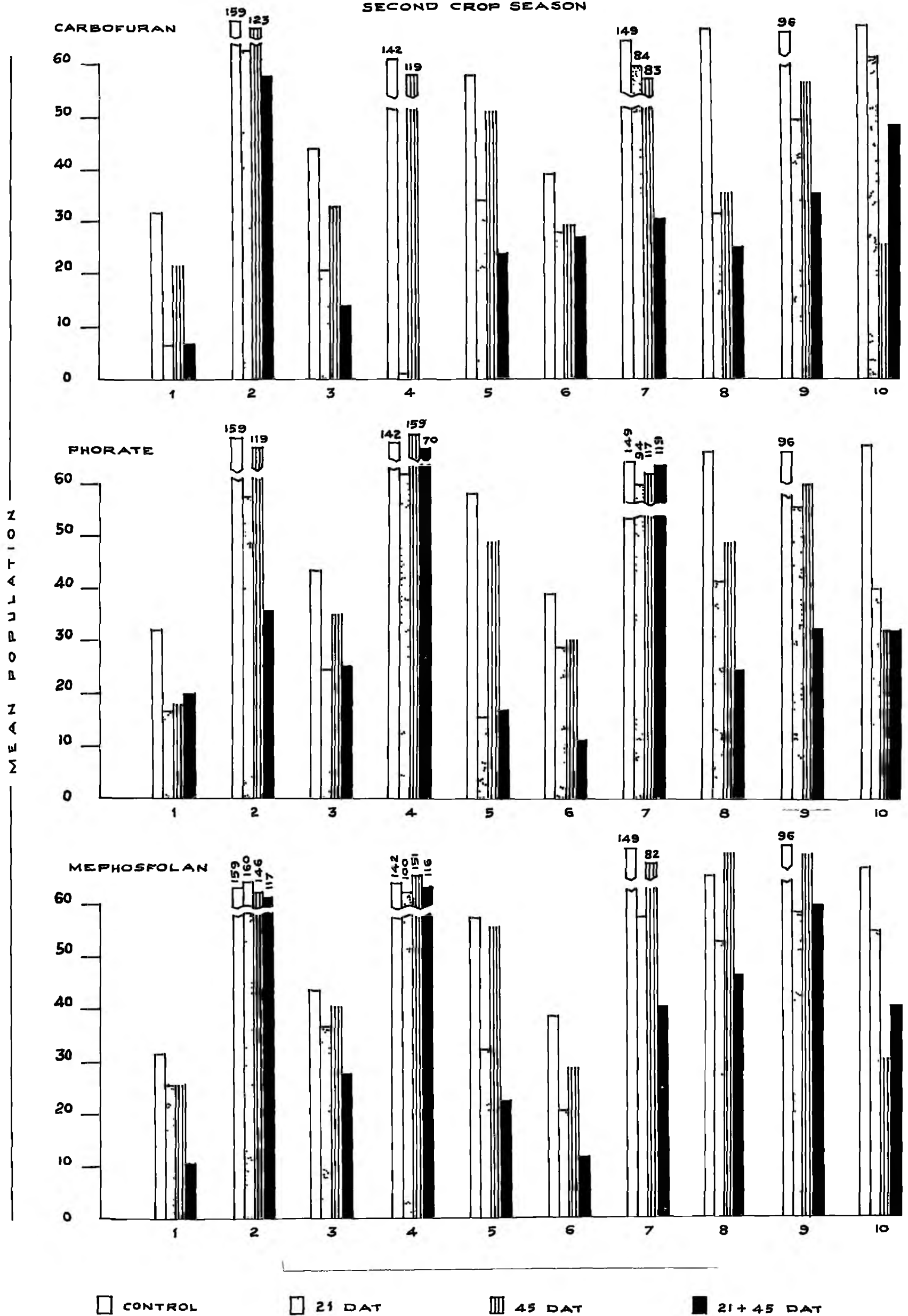
Data on the effect of different frequencies of application of insecticide granules on the control of rice pest observed during 2nd crop season are presented in Table 14 and Fig. 14.

Single application of carbofuran at 21 DAT and two applications at 21 and 45 DAT gave significant control of white leaf hopper with population of 7.33 and 7.0 per plot as against 32.33 under control. The single application of 45 DAT was not effective. Control of GH also was seen to be significant under the single application at 21 DAT and two applications at 21 and 45 DAT with populations of 62.67 and 56.67 as compared to 158.67 under untreated control. Control of RPH also showed the same pattern with applications at 21 DAT and 21 & 45 DAT giving significant reduction of the populations, they being 26.67 and 14.33 per plot in comparison to 44.33 in control plot. Significant control of case worm also was recorded under 21 DAT treatment and 21 & 45 DAT treatment with infestations of 1.0 and 0.0 per plot as against 141.67 in the untreated plots. Moth borer registered significant control under the treatments of 21 DAT and 21 & 45 DAT with infestations of 33.67 and 23.67 per plot as against

Fig. 14. Mean population of insect pests and natural enemies observed on rice plants under different insecticides applied as granules at different frequencies during second crop season

1. White leaf hopper
2. Green leaf hopper
3. Brown plant hopper
4. Cassowary
5. Whorl maggot
6. Gall midge
7. Oton boxer
8. Rice bug
9. Field bug
10. Spider

FIG 14 MEAN POPULATION OF INSECT PESTS AND NATURAL ENEMIES UNDER DIFFERENT INSECTICIDES APPLIED AS GRANULES AT DIFFERENT FREQUENCIES DURING SECOND CROP SEASON



90.33 in control plot. None of the carbosulfan treatments showed significant control of gall midge infestation. All the carbosulfan treatments gave significant control of stem borer infestation with populations ranging from 29.67 to 84.00 per plot as against 140.67 in the control plot. Among the three frequencies, however, application of granules both at the 21st and 45th DAT gave significantly better control than the other treatments. Rice bug did not show any significant control under the different treatments. Spider population was significantly affected by 21 DAT and 21 and 45 DAT applications with populations of 31.33 and 24.67 per plot as against 65.67 in the control. Thrid bug population was observed significantly affected by all the treatments with population was observed significantly affected by all the treatments with populations of 35.00 to 55.67 as compared to 96.33 under control. The combined treatments showed the maximum reduction in population. The grain yield was observed to be significantly increased under all the carbosulfan treatments. Among the three treatments two applications of the insecticide with an yield of 5.23 kg per plot gave the highest yield followed by the other two treatments giving 4.72 and 4.67 kg per plot which were on par. Yield in the control plot was 2.66 kg per plot.

Phorate gave significant control of white leaf hopper under the single application treatments with population of 17.33 and 17.66 as against 32.33 under untreated control. GUE showed significant control under the 21 DAF and 21 & 45 DAF treatments with population of 56.67 and 36.0 as compared to 158.67 in control plot. No significant control of HCH could be observed under the phorate treatments. Once worm control was significant under 21 DAF and 21 & 45 DAF treatments with populations of 63.33 and 70.33 per plot as compared to 141.67 in the control. Significant control of wheat maggot infestation was observed under the 21 DAF and 21 & 45 DAF treatments with infestations of 15.00 and 16.67 per plot as against 58.33 under control. Only the combined application of 21 and 45 DAF gave significant control of gall midge with infestation of 11.00 per plot as against 34.33 in control. Only 21 DAF treatment was found to give significant control of rice stem borer giving an infestation of 93.67 per plot as compared to 148.67 in control. Rice bug was not controlled by phorate treatments. Soldier population was significantly reduced by all the phorate treatments with populations of 25.33 to 49.00 as against 65.67 under control. Midge bug population also was significantly reduced by all the phorate treatments with populations of 33.33 to 60.00 per plot.

as against 96.33 in control. None of the treatments showed significant increase in yield even though all the treatments indicated increase.

With nepposolan combined treatments at 21 and 45 DAT gave significant control of white leaf hopper showing a population of 11.33 per plot as against 32.33 in control. The other treatments were ineffective. None of the treatments gave significant control of GLH. BPH also was not controlled significantly by the nepposolan treatments. Cass worms showed significant control only under the 21 DAT treatment with population of 100.33 as compared to 141.67 in the control. Thornl maggot showed significant control under 21 DAT and 21 & 45 DAT treatments with populations of 22.67 and 33.33 in comparison to 58.33 in control. Gall midge registered significant control under the combined applications at 21 and 45 DAT with a population of 12.0 per plot as against 54.33 in the control. Stem borer infestation showed significant control under all the treatments of nepposolan. A population of 40.67 as against 148.67 under untreated control was recorded at the 21 & 45 DAT treatment. The other two treatments gave inferior control with infestations of 58.00 and 61.67 per plot. Results on rice bug control were not significant. Spider population

Was not affected by nephosolan treatments, but all the treatments gave significant reduction of the mirid bug population with the populations under the treatments being 55.67 to 68.00 as against 96.33 under control. All the nephosolan treatments showed highly significant increase in the grain yield over untreated control, the yield being 4.90 to 5.09 kg per plot as against 2.66 kg under control.

EFFECT OF DIFFERENT FREQUENCIES OF APPLICATION OF
INSECTICIDE GRANULES IN SOIL ON CONTROL OF RICE PESTS
DURING THIRD CROP SEASON (JANUARY - MAY 1979)

In Table 15 and Fig. 15 are presented data on the effect of different frequencies of application of the insecticide granules on the various paddy pests observed during the third crop season. It was observed that carbofuran gave significant control of white leaf hopper under all the frequencies. The 21 DAT and 21 & 45 DAT treatments gave the best control with infestation of 2.67 and 4.67 per plot as compared to 23.67 in the control plots. The 45 DAT treatment gave inferior control. GHN showed significant control under 21 DAT and 21 & 45 DAT treatments with infestations of 19.67 and 17.33 per plot as against 44.00 in control. Significant control of NPH was given by the 21 DAT and 21 & 45 DAT treatments showing infestations of 19.67 and 15.00 per plot as compared to 49.33 in untreated control. Leaf roller control was observed significant under the treatments 45 DAT and 21 & 45 DAT with infestations of 3.66 and 7.33 as compared to 23.33 in control plots. 21 DAT treatment gave inferior control. Significant control of whorl maggot infestation was observed under 21 DAT and 21 & 45 DAT treatments with infestation of 19.67 as against 39.67 in control plots. Stem borer control was significant

Table 5. San population of beetles on granules at different times of day (bird droppings) on different insecticides applied.

Treatment to nss aides			hi e lea. hopper	l.	waf roller	horiz m yot	Jtem borer	Rice bug	Spider	Mirid bug	Yield (kg)	
Crb	van	2	67 0	67 32	7 4	33 48)	9 67 4 5	2 33 4 63)	57 0 (7 42)	16 00 (4 23)	14 33 (3 91)	3 89
2 Cna	van	45	4	23 0	7 3	3 66 93)	73 7 53	-0 34 6 10)	13 67 (3 41)	28 33 (5 67)	13 67 (3 78)	3 58
		4				7 73 50	67 4 5	7 67 4 05	8 00 4 39	7 33 (4 27)	00 3 43	65
						6 00 6	7 4 3	20 00 5 32	46 00 (6 7)	1 00 3 34	5 00 3 98	73
						67 02	9 3 6 7	42 33 (6 4)	3 7 6 6	20 4	2 6	
						73	2 7 3	7 4 9	0 33 52		3	7
							0 3	67 3 6	40 00 (		30	
						30 31	54 00	4 67 (6 2	3 33 4 50	5 3		
						7	4	7 0 6	25 00 5 09	22 67	67	4 0
								43 67 (65	30 00 43	37 67	7 A	

v

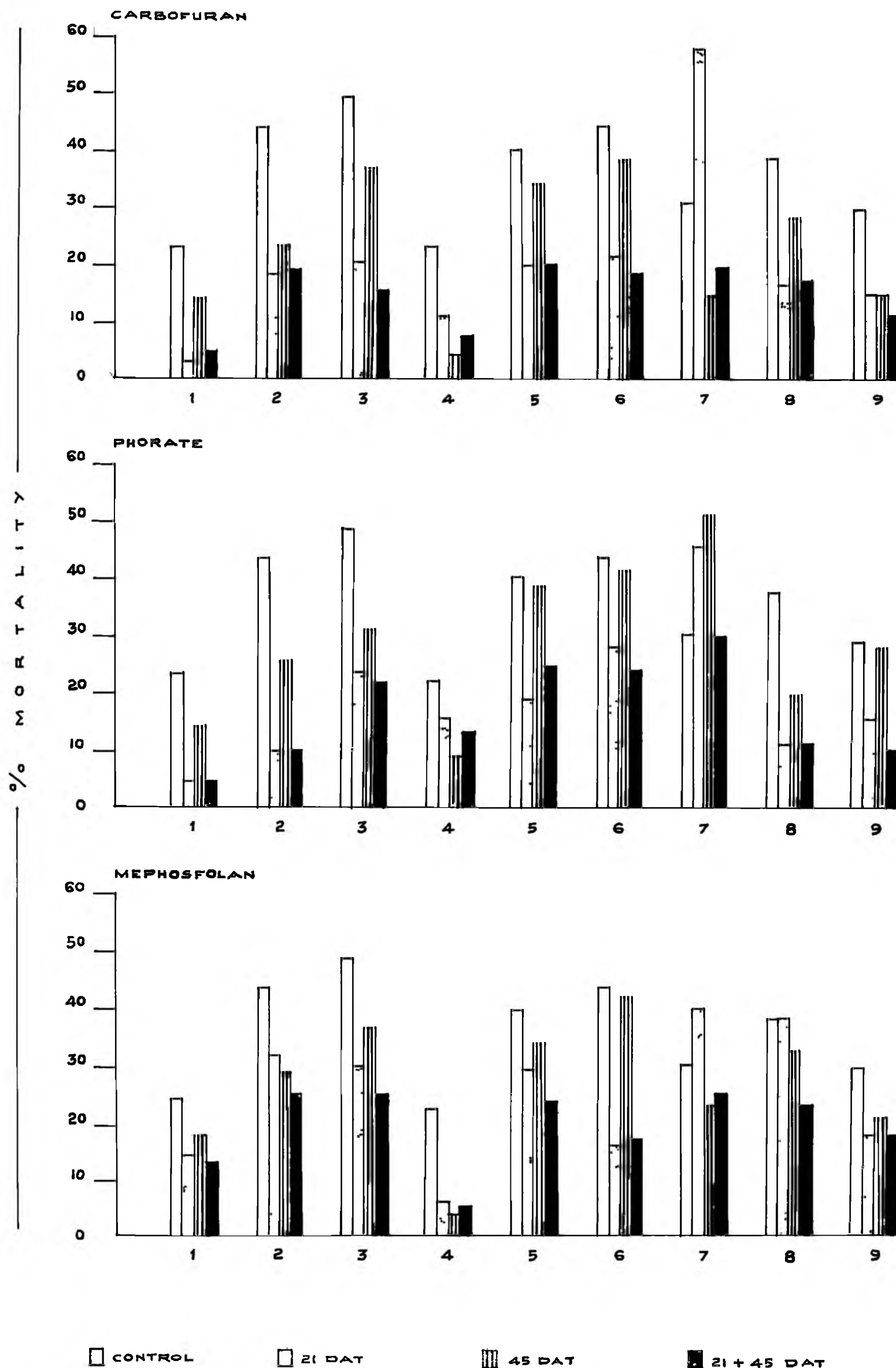
—ros within parentheses are $\sqrt{x}$
transformed values

7000

Fig. 15. Mean population of insect pest and natural enemies observed on rice plants under different insecticides applied as granules at different frequencies during third crop season

- 1. White leaf hopper**
- 2. Green leaf hopper**
- 3. Brown plant hopper**
- 4. Leaf roller**
- 5. Whorl maggot**
- 6. Stem borer**
- 7. Rice bug**
- 8. Spider**
- 9. Mirid bug**

FIG 15 MEAN POPULATION OF INSECT PESTS AND NATURAL ENEMIES UNDER DIFFERENT INSECTICIDES APPLIED AS GRANULES AT DIFFERENT FREQUENCIES UNDER THIRD CROP SEASON



under the 21 DAF and 21 & 45 DAF treatments showing infestations of 17.67 to 21.33 per plot in comparison to 43.67 in untreated control. Significant control of rice bug infestation was recorded under the 45 DAF treatment with infestations of 13.67 as compared to 50.00 in the control plot. The 21 DAF and 21 & 45 DAF treatments showed significant reduction of earhopper population, the population levels being 16.0 and 17.33 as against 37.67 per plot under control. All the carbosulfan treatments suppressed the mild bug population significantly, to levels of 11.00 to 14.33 per plot in comparison to 28.67 in untreated plots. The grain yield was significantly increased under the treatment 21 DAF and 21 & 45 DAF of which the latter treatment gave the highest yield of 5.65 kg per plot as against 2.85 kg from control plots. The 21 DAF treatment ranked next with an yield of 3.85 kg per plot.

Phorate gave significant control of white leaf hopper at the frequencies of 21 DAF and 21 & 45 DAF with a population of 4.67 per plot as compared to 23.67 in the untreated control. GKN showed significant control under the 21 DAF and 21 & 45 DAF treatments with infestations of 10.33 and 9.67 per plot in comparison to 44.00 in the control plot. SEI also showed a significant control under the 21 DAF and 21 & 45 DAF treatments with infestations of 23.67 and 22.33 per plot as against 49.33 in control plot. Leaf roller showed control to significant

locs under 45 DAF and 21 & 45 DAF treatments with infestations of 8.67 and 15.33 per plot as against 23.33 in the control plot. Whorl maggot infestation was significantly controlled under 21 DAF and 21 & 45 DAF treatments with infestations of 18.67 and 24.67 in comparison with 39.67 in the untreated check. None of the phorate treatments gave significant control of stem borer. Rice bug also did not show any significant control under the phorate treatments. Aphid population was significantly suppressed by the 21 DAF and 21 & 45 DAF treatments with populations of 11.00 and 11.33 per plot as against 37.67 in control plots. Hird bug population also showed reduction under those two treatments with population of 10.33 and 15.00 per plot in comparison to 23.67 in the untreated control. The grain yield showed significant increase over control under the treatments 21 DAF and 21 & 45 DAF with yields of 3.73 and 3.75 kg per plot respectively as against 2.85 in control.

Permethrin showed significant control of white leaf hopper under 21 DAF and 21 & 45 DAF treatments with populations of 14.00 and 13.00 per plot as against 23.67 in untreated plot. None of the treatments gave significant control of GLH. BFH was controlled effectively by the 21 DAF and 21 & 45 DAF treatments, with populations of 25.00 and 29.67 as compared to

49.55 in control plot. All the treatments were effective in controlling leaf roller infestation with infestations varying from 4.00 to 6.00 per plot as against 25.55 in untreated plot. Only the 21 & 45 DAZ gave significant control of wheat nigger infestation, with an infestation of 24.00 per plot as against 39.67 in control. Stem borer infestation showed significant control under the treatments of 21 DAZ and 21 & 45 DAZ with infestations of 15.67 and 17.00 per plot as against 43.67 in untreated control. Rice bug was not controlled effectively by any of the neophosolan treatments. Spider population was not affected by the neophosolan treatments. Bird bug population also was not affected by any of the treatments. Grain yield showed significant increases over control under all the treatments with yields of 4.23 kg to 4.5 kg per plot as compared to 2.85 in the untreated control plot.

EFFECT OF FIVE LEVELS OF IRRIGATION ON RESISTANCE TOXICITY
TO RPH OF INSECTICIDES APPLIED AT 21 DAYS IN FLOOD

In Table 16 and Fig. 16 are presented the mortalities of RPH released on rice plants treated with insecticides at 21 DAF at two levels of irrigation, observed at different intervals after insecticide application. It was observed that the initial mortality due to carbosulfan at 6 hours after application (50.6%) at field capacity level was much higher than at water level at 2.5 cm (39.32%). This trend was maintained throughout the period of observation. The maximum mortality under the two levels of irrigation was manifested up to the 3rd day following the insecticidal application. There was a gradual decrease in the mortality of RPH on plants tested thereafter and mortality was in evidence up to the 14th day after the insecticide application under the flooded level of irrigation. Under the field capacity irrigation level, mortality to the extent of 3.3% was recorded on the 15th day of insecticide application and there was no mortality subsequently. The LC index values showed a much higher value (492.49) at the field capacity level than at the flooded level (295.06).

The initial toxicity of phosmito was higher under the field capacity level than under flooded condition the mortalities being 46.65% and 30.46% respectively at 6 hours after treatment.

Table 16. Per cent mortalities of IPH or rice plants treated with different insecticide granules at 21 DIT at 2 levels of irrigation and observed at different intervals after treatment

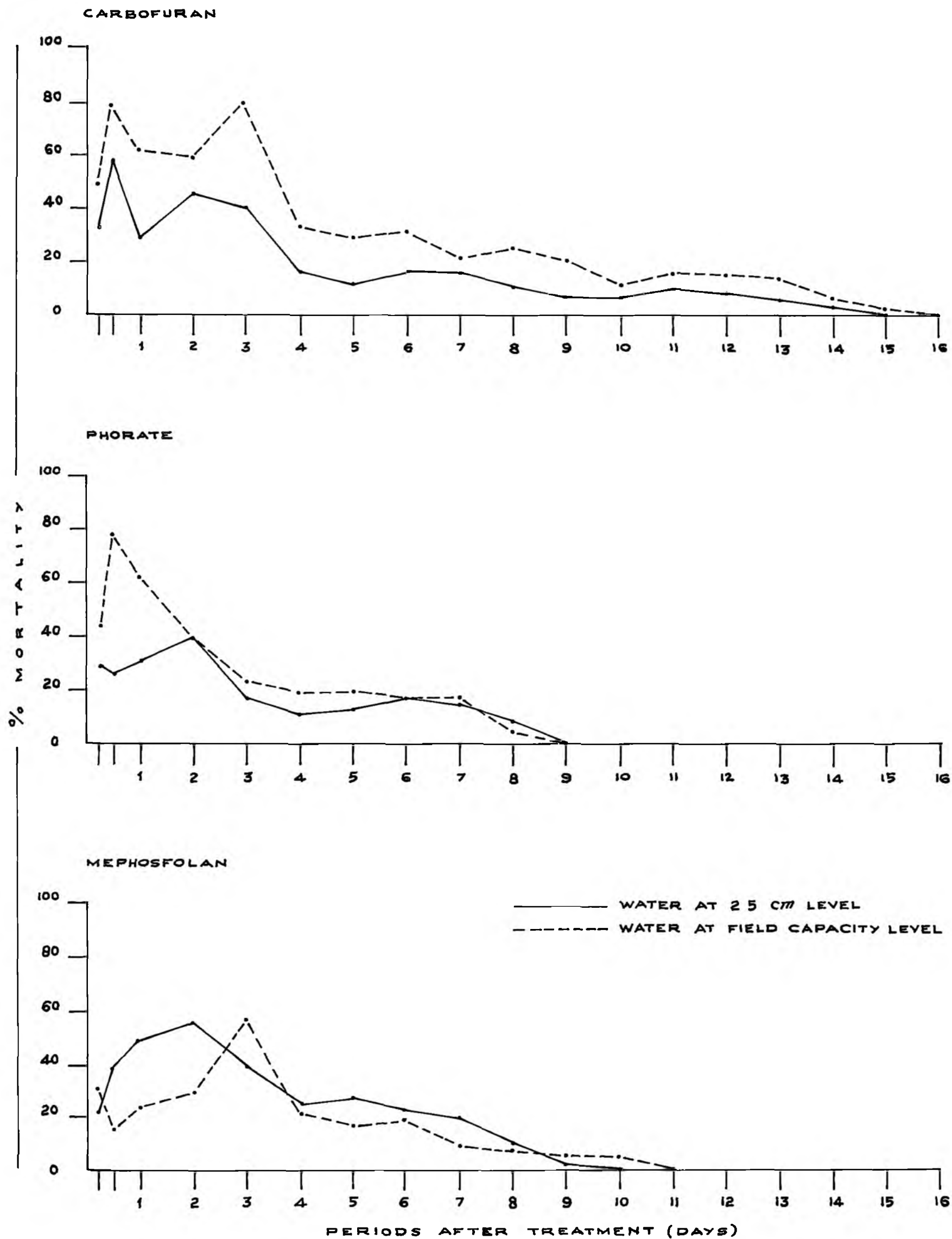
Insecticides	Carbofuran (1 kg ai/ ha) at		Phorate (2 kg ai/ha) at		Mephosfolan (1 kg ai/ ha) at	
	2.5cm water level	Field capa- city level	2.5cm water level	Field capa- city level	2.5cm water level	Field capa- city level
Intervals						
6 hours	59.32	59.60	30.46	46.69	24.81	29.10
12 hours	59.64	80.29	23.23	77.27	37.66	15.15
24 hours	26.60	61.54	31.36	61.54	49.07	25.57
2 days	45.76	59.90	40.31	42.23	60.32	30.25
3 days	41.26	79.13	18.13	23.73	40.17	47.02
4 days	18.48	33.04	11.58	19.99	25.00	22.08
5 days	12.90	30.18	13.64	19.77	27.27	12.12
6 days	16.03	31.32	18.18	17.13	24.10	20.66
7 days	15.93	22.73	15.22	17.00	23.00	10.09
8 days	11.73	25.02	7.60	6.25	10.00	9.10
9 days	8.02	20.00	0.00	0.00	3.45	6.90
10 days	10.71	8.77			0.00	6.67
11 days	7.49	16.57				3.33
12 days	8.33	15.35				0.00
13 days	7.24	13.33				
14 days	3.45	6.67				
15 days	0.00	3.33				
16 days		0.00				
(P)	14	15	8	5	9	11
(T)	20.99	32.83	21.53	33.73	29.26	18.64
$P \pm T$	209.06	432.45	172.29	269.64	263.34	205.34

T = Period after treatment in days

T = Average residual toxicity

PT = Index of persistent toxicity

FIG 16 MORTALITY OF BROWN PLANT HOPPER EXPOSED TO RICE PLANTS AT DIFFERENT INTERVALS AFTER APPLICATION OF INSECTICIDE GRANULES AT 21 DAT UNDER TWO LEVELS OF IRRIGATION



The mortality of BPH under the two levels of irrigation remained high up to 2 days after application, decreasing drastically thereafter. There was no mortality from the 9th day onwards. A higher FT index value of 269.84 was seen under the field capacity level as compared to 172.29 under the flooded condition.

For nephtosolan in general higher mortality of the insect was observed under the flooded condition than under the field capacity level. Thus though at 6 hours after the treatment there was higher mortality of 29.1% under field capacity as against 24.81% under flooded condition, from 12 hours onwards the position was generally reversed, the mortality at 12 hours, 24 hours and 2 days being 37.66, 49.07 and 60.32% under flooded condition as against 15.16, 23.57 and 30.25% respectively under the field capacity level. The persistence of the insecticide, however, seemed to be slightly more at the field capacity level, the mortality of hopper taking place up to 11th day, while under the flooded condition mortality was in evidence only up to the 9th day. FT index value was higher (263.34) at flooded condition than at the field capacity level (205.04).

In Table 17 and Fig. 17 are presented the data relating to the persistent toxicity of the insecticides when applied

Table 17. Far cent mortalities of BPH on rice plants treated with different insecticide granules at 45 DAG at 2 levels of irrigation and observed at different intervals after treatment

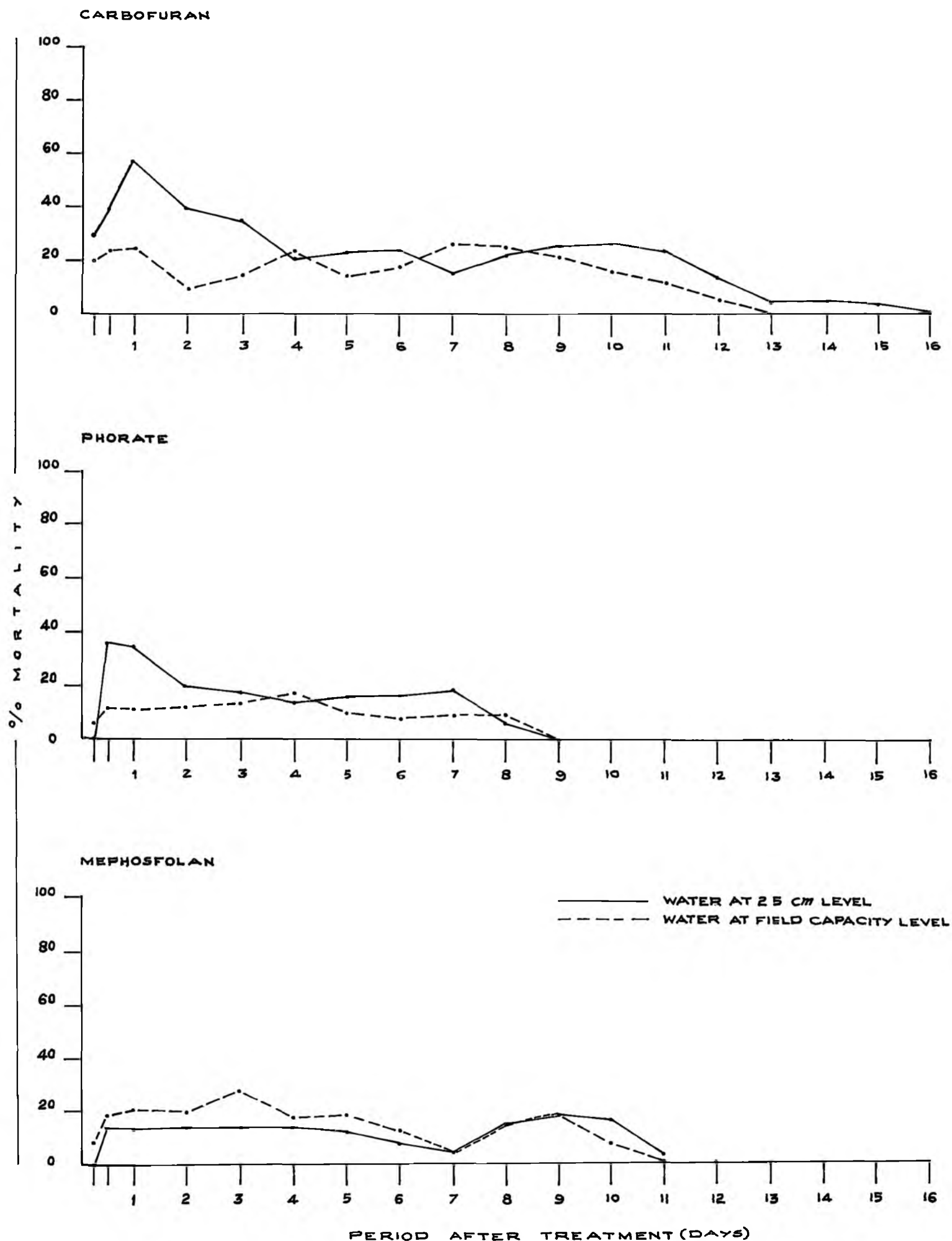
Insecticides	Carbofuran (1 kg ai/ ha) at		Phorate (2 kg ai/ha) at		Mephosfolan (1 kg ai/ ha) at	
	2.5cm water level	Field capa- city level	2.5cm water level	Field capa- city level	2.5cm water level	Field capa- city level
Intervals						
6 hours	29.50	19.35	0.00	6.45	0.00	7.69
12 hours	39.06	24.06	36.83	12.05	15.12	18.06
24 hours	53.31	24.94	35.00	11.91	11.69	19.61
2 days	35.58	10.58	19.79	15.31	14.80	19.61
3 days	34.73	15.13	17.61	15.70	14.17	28.29
4 days	22.00	23.71	14.61	18.01	16.80	17.99
5 days	23.25	15.18	16.93	9.27	15.23	18.15
6 days	24.03	17.50	18.17	8.35	7.68	14.28
7 days	16.04	27.27	20.49	9.69	6.08	6.08
8 days	21.49	26.09	8.19	9.69	16.52	15.39
9 days	25.57	22.19	0.00	0.00	18.98	19.70
10 days	27.03	17.07			16.67	8.00
11 days	24.50	11.60			3.45	0.00
12 days	13.42	6.90			0.00	
13 days	4.82	0.00				
14 days	4.63					
15 days	3.70					
16 days	0.00					
P	15	12	8	8	11	10
T	24.22	18.72	18.76	11.64	11.72	16.07
PT	363.30	224.64	150.08	93.12	128.92	160.70

P = Period after treatment in days

T = Average residual toxicity

PT = Index of persistent toxicity

FIG 17 MORTALITY OF BROWN PLANT HOPPER EXPOSED TO RICE PLANTS AT DIFFERENT INTERVALS AFTER APPLICATION OF INSECTICIDE GRANULES AT 45 DAT UNDER TWO LEVELS OF IRRIGATION



at 45 DAI. The results have shown that in the case of carbosuan higher mortality of BPH was observed on plants under the flooded condition of irrigation than under the field capacity level. Thus the mortalities on the occasions of 6, 12 and 24 hours, 2 days and 3 days were 29.5, 39.06, 50.51, 59.56 and 74.78% respectively under the flooded field condition whereas these were 19.33, 24.06, 24.94, 10.58 and 15.18 respectively under the field capacity level of irrigation. Further, mortalities of the insect were in evidence on the plants up to 15 days after insecticide application under the flooded condition, while these were seen only up to 12 days under field capacity level. PT index value also was found to be higher (363.3) at the flooded condition than at the field capacity level (224.64). With phos also a similar trend was evidenced and up to 3 days the mortalities were higher on plants at flooded condition, the mortalities being 36.83, 35.00, 19.79 and 17.61% at 12 hr., 24 hr., 2 days and 3 days respectively after the application of insecticides. These mortalities were lower at field capacity level being 12.05, 11.91, 15.31 and 15.70% respectively. Insecticides persisted in the plant up to 8 days under both the conditions of irrigation. The PT index value also was considerably higher (150.08) at the flooded level than at field capacity level

(99.12). Diphosfolan showed higher mortality of the plant hopper at the field capacity level than at the flooded level. Thus when the mortalities were 13.42, 11.59, 14.00 and 14.17% at 12 and 24 hours, and 2 and 3 days following application at the flooded level, these mortalities were 18.06, 16.61, 19.61 and 23.29% respectively under the field capacity level. Under the flooded condition the insecticide persisted up to 11 days while it was only up to 10 days in the field capacity level of irrigation. The PI index value was higher at the field capacity level being 160.79 than in the flooded condition being 128.92.

EFFECT OF DIFFERENT LEVELS OF IRRIGATION ON
MORTALITY DUE TO HIGH QUANTITY OF LARVAE
OF INSECTICIDES APPLIED AS SPRAYS IN SOIL

The results relating to the application of insecticides at 21 DAT are presented in Table 18 and Fig. 18. The mortality of caterpillars was much higher on plants under field capacity level of irrigation than under flooded condition. The mortalities of larvae when fed on plants after 6 hours, 12 hours, 24 hours and 2 days after application of the insecticide were 19.66, 29.02 and 35.30 under flooded irrigation while there were 79.59, 61.51 and 52.15, respectively under the field capacity level. Further, no mortality of larvae occurred after 7th day of insecticide application under field capacity level and after 6 days under flooded level. The PT index value was much higher under the field capacity level being 257.18 than under the flooded level being 140.24. Phosale in general was ineffective in killing the larvae under both the irrigated conditions. Nephrosolan gave cent per cent mortality of the larvae up to 3 days after the application under both the levels of irrigation. From the 4th day onwards the results presented showed that the larval mortality was much higher under the field capacity level than under the flooded level of irrigation. On the 5th, 6th and 7th days of

Table 16. Per cent mortalities of Rice Swarming Caterpillar on rice plants treated with different insecticide granules at 21 DAT at 2 levels of irrigation observed at different intervals after treatment

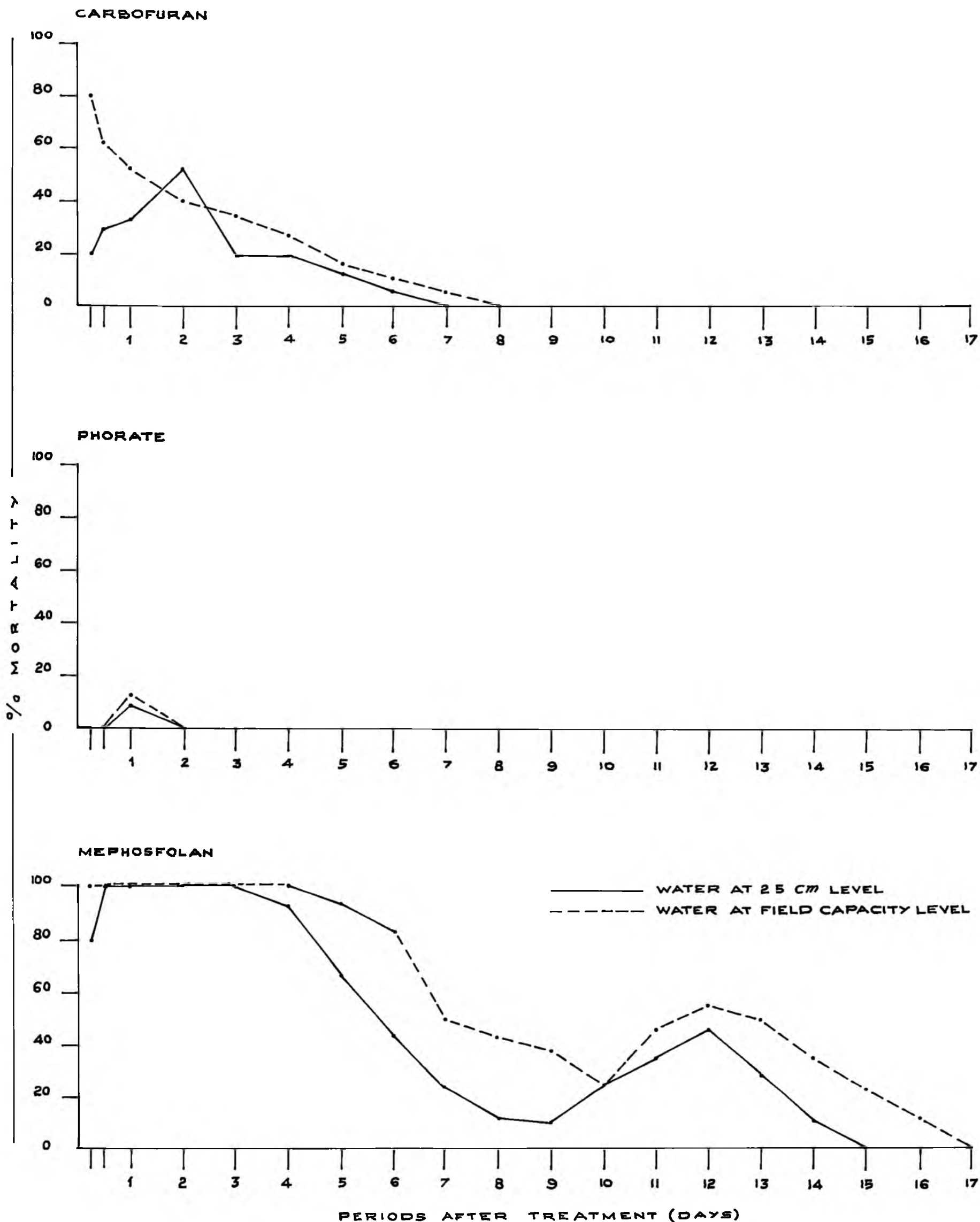
Insecticides	Carbofuran (1 kg ai/ ha) at		Phorate (2 kg ai/ha) at		Dyphosfolan (1 kg ai/ ha) at	
	2.5cm water level	Field capa- city level	2.5cm water level	Field capa- city level	2.5cm water level	Field capa- city level
Intervals						
6 hours	19.66	79.60	0.00	0.00	80.00	100.00
12 hours	29.82	61.51	0.00	0.00	100.00	100.00
24 hours	35.50	52.15	9.10	12.00	100.00	100.00
2 days	52.68	41.17	0.00	0.00	100.00	100.00
3 days	29.63	35.24			100.00	100.00
4 days	20.24	27.78			94.41	100.00
5 days	12.90	16.67			66.67	94.44
6 days	5.56	11.11			44.44	83.33
7 days	0.00	5.26			22.22	50.00
8 days		0.00			11.76	44.44
9 days					10.53	38.89
10 days					25.33	26.32
11 days					36.00	45.00
12 days					45.33	56.25
13 days					20.17	50.00
14 days					12.00	45.83
15 days					0.00	24.00
16 days						15.34
17 days						0.00
P	6	7	3	3	14	16
T	24.57	36.74	3.03	4.00	54.90	65.24
PT	146.24	257.18	9.10	12.00	768.60	1045.84

P = Period after treatment in days

T = Average residual toxicity

PT = Index of persistent toxicity

FIG 18 MORTALITY OF RICE SWARMING CATERPILLAR EXPOSED TO RICE PLANTS AT DIFFERENT INTERVALS AFTER APPLICATION OF INSECTICIDE GRANULES AT 21 DAT UNDER TWO LEVELS OF IRRIGATION



insecticidal application the larval mortalities were 66.67, 44.44 and 22.22 respectively under the flooded level of irrigation while the corresponding mortalities were 91.44, 85.57 and 50.00 in the field capacity level of irrigation. The insecticide persisted in the plant for a higher period of 16 days under the field capacity level than under flooded condition, the persistence being 14 days. The PT index also was considerably higher under the field capacity level being 1045.84 under the flooded condition being 768.60.

The data relating to the application of the insecticide at 45 DAF presented in Table 19 and Fig. 19 showed that carbosulfan gave higher mortality of the larvae at the field capacity level of irrigation than under the flooded level. The larval mortality 6 hours after the application of insecticide was 12.90% in the field capacity level whereas it was zero per cent under the flooded condition of irrigation. The larval mortalities under the two levels were 13.75 and 25.00, and 37.50 and 16.67 and 25% at 12 hours, 24 hours and 2 days respectively. Insecticide persisted up to 3 days under the flooded level as against 5 days under the field capacity level. The PT index was more than double at the field capacity level (97.50) than that at flooded level (40.26). Thiazote in general gave very low mortalities of

Table 19. Per cent mortalities of Rice Swarming Caterpillar on rice plants treated with different insecticide granules at 45 DAT at 2 levels of irrigation and observed at different intervals after treatment

Insecticides	Carbofuran (1 kg ai/ ha) at		Phorate (2 kg ai/ ha) at		Mephosfolan (1 kg ai/ ha) at	
	2.5cm water level	Field capa- city level	2.5cm water level	Field capacity level	2.5cm water level	Field capa- city level
Intervals						
6 hours	0.00	12.50	0.00	0.00	100.00	100.00
12 hours	18.75	25.00	0.00	12.50	75.00	80.00
24 hours	25.00	37.50	0.00	17.65	100.00	100.00
2 days	16.67	25.00	12.50	31.25	100.00	100.00
3 days	6.67	18.75	10.00	20.00	65.71	65.25
4 days	0.00	11.11	6.67	15.00	70.59	75.00
5 days		6.67	9.09	6.67	52.94	60.00
6 days		0.00		0.00	75.00	62.50
7 days					74.75	65.00
8 days					72.22	65.00
9 days					65.16	70.00
10 days					60.00	65.00
11 days					35.00	55.00
12 days					30.43	50.33
13 days					16.67	62.50
14 days					12.50	62.50
15 days					0.00	25.00
16 days						12.50
17 days						6.25
18 days						0.00
T	3	5	4	5	14	17
T	13.42	19.50	4.07	14.72	64.10	60.15
PT	40.26	97.50	19.49	73.60	897.40	1022.55

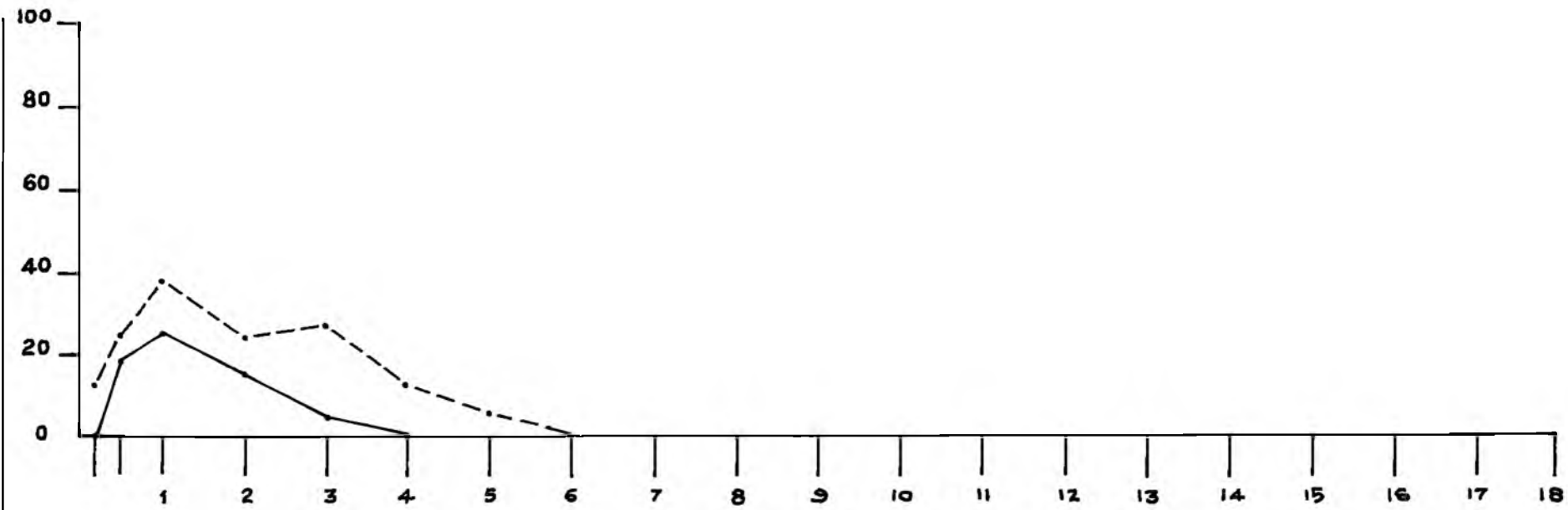
P = Period after treatment in days

T = Average residual toxicity

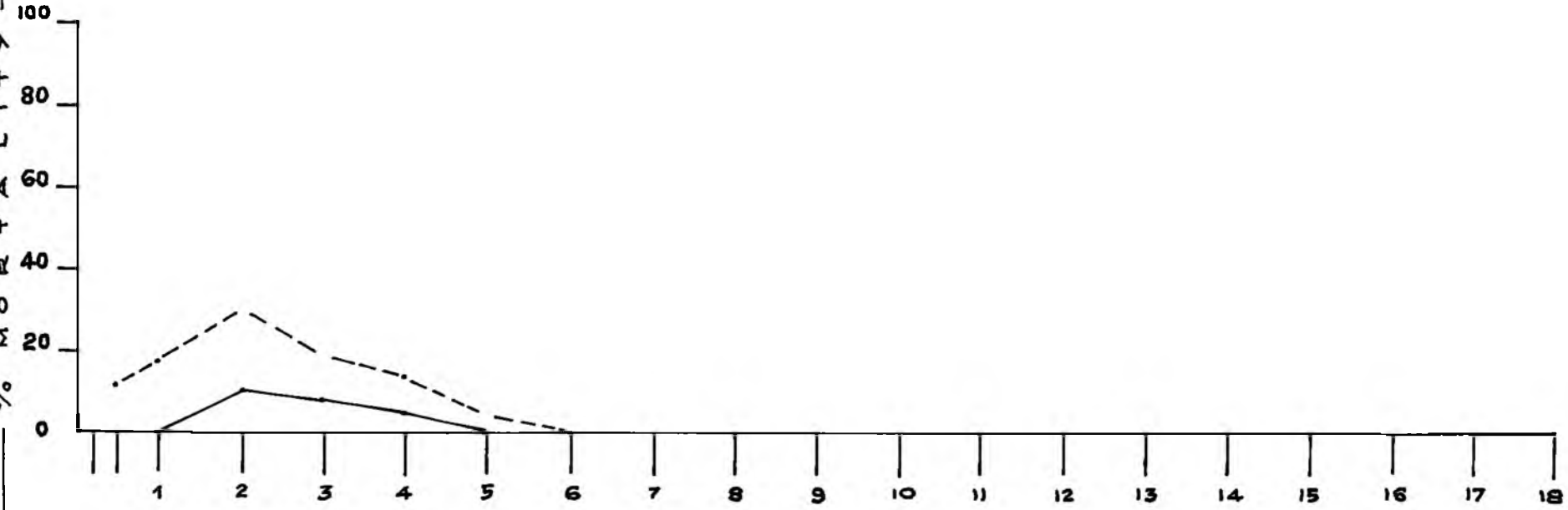
PT = Index of persistent toxicity

FIG 19 MORTALITY OF RICE SWARMING CATERPILLAR EXPOSED TO RICE PLANTS AT DIFFERENT INTERVALS AFTER APPLICATION OF INSECTICIDE GRANULES AT 45 DAT UNDER TWO LEVELS OF IRRIGATION

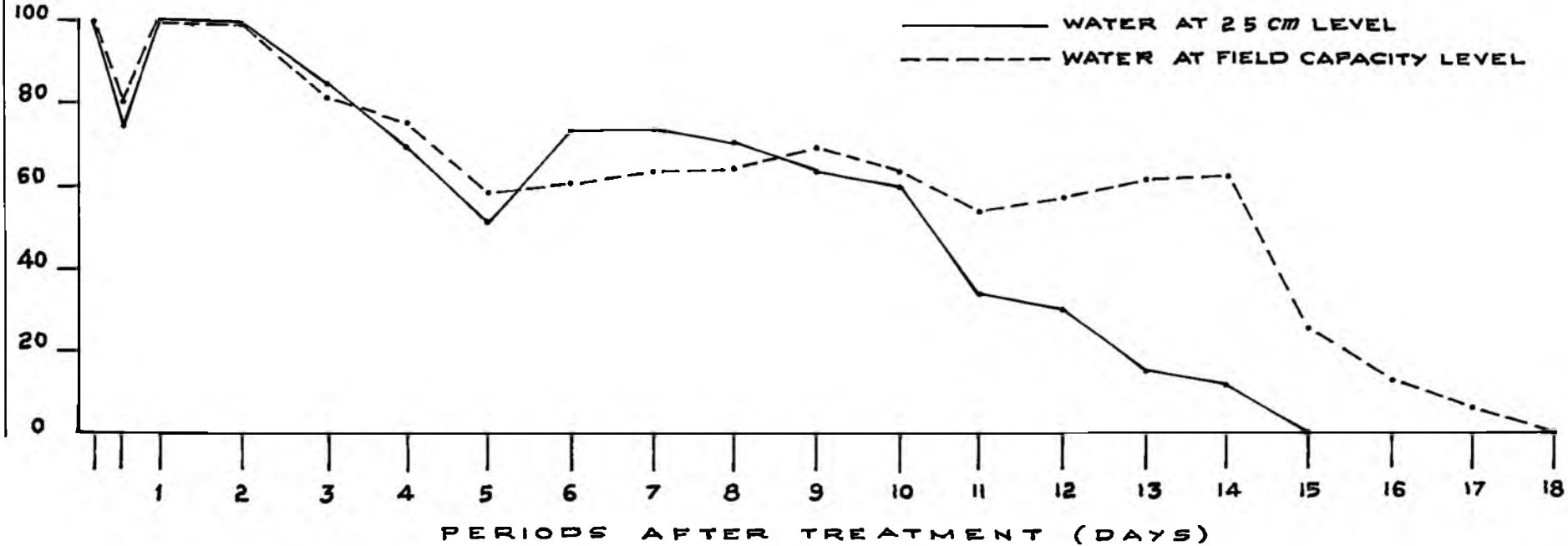
CARBOFURAN



PHORATE



MEPHOSFOLAN



the larvae under both the levels of irrigation and whatever values of mortalities recorded showed higher mortality at the field capacity level.

Mephasfolan gave 100% mortality under both the irrigation levels 2 days following insecticidal application. Afterwards the mortalities more or less remained in the same magnitude under both irrigation levels. The insecticide, however, persisted for a longer duration (17 days) under the field capacity level than under the flooded level of irrigation, being only 14 days. The PI index was much higher under the field capacity level being 1022.55 than under the flooded condition being 897.40.

RESIDUES OF INSECTICIDES IN RADDY STRAW AND GRAIN
WITH WHEAT AS SHOWN IN TABLE

Results of bioassay estimations of the residues are presented in Table 20.

The residues of all the insecticides were least in both straw and grain under the different applications at 21 DAT. The residues were much higher under single application of 45 DAT and highest under combined application at 21 & 45 DAT. The residues of carbendazim were 0.036 ppm in straw and grain under the 21 DAT treatment while they were 0.100 and 0.087 ppm under 45 DAT treatment and 0.102 and 0.107 ppm under the combined treatments of 21 & 45 DAT. Phorate showed the residue of 0.048 ppm in straw and grain in the 21 DAT treatment, 0.099 and 0.091 ppm under the 45 DAT treatment and 0.161 and 0.115 ppm under the combined treatments. Diphosfolan left residues of 0.035 and 0.033 ppm in straw and grain at 21 DAT. These increased to 0.061 and 0.159 ppm respectively at 45 DAT and 0.095 and 0.168 ppm respectively under the combined treatment of 21 & 45 DAT.

Table 20. Residues of different insecticides present in paddy grain and straw when applied as granules at different frequencies

	Applied at 01 DAT	Applied at 35 DAT	Applied at 21 & 45 DAT
<u>Carbofuran:</u>			
Straw	0.078	0.100	0.102
Grain	0.028	0.097	0.107
<u>Phorate:</u>			
Straw	0.048	0.099	0.161
Grain	0.048	0.091	0.115
<u>Dithiosolan:</u>			
Straw	0.035	0.081	0.095
Grain	0.048	0.159	0.168

DISCUSSION

DISCUSSION

In the present studies efforts have been made to ascertain the use of insecticides in controlling various pests of paddy, when applied as granules in soil. The effect of the various insecticides on pest control has been studied with respect to two graded doses, three seasons of cultivation and different frequencies of application. Effect of these insecticide treatments on population of troublesome mild bugs and spiders also has been observed. The influence of two levels of irrigation on the uptake and translocation of insecticides within the plants was studied. Residues of the insecticides persisting in straw and grain consequent on the application pesticides at different intervals after planting also was determined. Results of these studies are discussed below.

Table 21 represents the effect of different insecticides on paddy pests with reference to different seasons of cultivation and different occasions of application. It will be observed that there are variations in the effectiveness of insecticides for control of particular pests, during different seasons. These may be partially due to the intensity of infestations in the different seasons and partially due to the effect of the various weather factors.

Table 2. Consolidated recommendations on the effectiveness of different insecticide granules in the control of dry grain loss on to crop losses and occasions of application.

Insecticide and dose	Crop season	DPH	GLH	Gn.L. mid-e	bor-1 on rot	Stem borer	leaf roller	Cass worm	Green hopper	BGC	Mirid bug	Spider
		2 3	2 3	3	1 2 3	1 2 3	2 3	2 3	1 2 3	1 2 3	1 2 3	1 2 3
T ₁ Carbofuran 0.5 cl/ha		x x	x x x		x x	x x + x x x	x x x	+ +	x + x x	x x x +	+ + +	+ + +
T ₂ Carbomathion 0.1 cl/ha	I I	x x x x x	x x x x	x	x x x x	x x x x x	x x x x x x	x x +	x x x	x x x x x	+ + x x	+ + +
3 0 ° cl/LA		x	x x x x					x x x	x x x x	x		x
4 /						x x + +		x x x	x x x x	x x x x		x
/				x		x	x		x x	x x x x x		
7 /												
or cl			x						x x	x +		
11 cl 0 / ha								+	+			
11 ° /						x		+ x	+		x	
12 L 0 cl/ha										x x		
13 / ha						x x x x x	x x x x		+	x x x +		
45 no ant		d na	a			2 n on	4 and	no ill harvest after application at 4				
			nt			at sig.	ificant	x significantly better than other insecticides				

Carbofuran at 0.5 kg ai/ha was found to give significantly effective control of brown plant hopper in all the seasons. Though higher dosage of the insecticide was showing a relatively better control of the insect, the two doses did not vary significantly in controlling BPH. Green leaf hoppers also were effectively controlled by carbofuran at both the dosages though there was much higher control at the higher dose than at the lower dose. At the lower dose the insecticide was found to be ineffective during the third crop season which appeared to be due to the low population of the insect which existed during that season. Gall midge control was found to be more effective after the first application of the granules at 21 DAF than at 45 DAF. This showed that the insecticide could be used for the effective control of the pest during its initial infestation on the rice crop, while the subsequent infestations which occurred on the tillers could not be controlled effectively. But considering the overall effect, carbofuran appeared to be effective in controlling gall midge infestations significantly. The insignificant control of gall midge observed during the first crop season could be due to the lower level of infestation. Wheel and spot infestation was controlled significantly by carbofuran treatments at both the dosages.

The effect was, however, relatively better at the higher dose. Whorl maggot infestation appeared during the early vegetative phase of the crop and the application of carbofuran at 21 DAT gave highly significant control of the pest. The insignificant control of the whorl maggot indicated during the first crop season under the 0.5 kg dosage could be attributed to the low level of infestation which existed during that season. Both the carbofuran dosages gave highly significant control of rice stem borer. Significant control of the pest infestation indicated for the individual 21 DAT and 45 DAT applications showed that both the earlier infestation leading to dead heart formation and the later infestation leading to white earhead formation were effectively controlled by the insecticide. From the results presented it appeared that even at the lower dose of 0.5 kg ai/ha carbofuran could be used for stem borer control effectively. Leaf roller infestations were effectively controlled by the carbofuran treatments. Leaf roller infestation existed on the crop from the early vegetative phase to the late reproductive phase and thus there was a need for protecting the crop from the infestation throughout the cropping season. The results presented show that the overall effect of the two applications of the insecticides gave significant control of leaf roller infestation during

the whole cropping season. The higher dose of 1.0 kg ai/ha gave much better control than the lower dose of 0.5 kg ai/ha. Carbofuran control also was highly significant under the carbofuran treatments, there being little difference between the two doses. Infestation by meadowworm appeared only during the early vegetative phase of the crop and application of the granules at 21 DAT gave significant control of the infestation. The carbofuran treatments gave highly significant control of the grasshopper infestation and both the damages were effective in giving the control. The control of the grasshopper was seen to be highly efficient after the application at 21 DAT than at the later stage. This was significant on account of the fact that severe damage to the rice crop by the grasshoppers occurred during the vegetative phase. The overall effect of the treatments on the control of the grasshoppers also was indicated to be significantly effective. Rice swarming caterpillar (RSC) was controlled significantly by both the carbofuran treatments, the application at 21 DAT giving significant control. As regards the effect of carbofuran granules on population of the mid and soldier predators it was indicated that generally carbofuran affected their population adversely. These predators feed mainly on the hoppers and their immature stages and reduction

in their populations may be due to the reduction of their host population under the insecticide treatment rather than due to any direct toxic effect. From the results presented it is clear that carbofuran manifested broad spectrum action, being effective in controlling a wide variety of insects, both sap feeders and bulk tissue feeders, infesting paddy crop. A similar observation was made by Subramanian et al. (1980) based on his studies conducted in Tamil Nadu. From the results presented it appeared that carbofuran granules could be used advantageously for protecting the paddy crop from all the major pests infesting it. It is also indicated that this insecticide was effective even at a lower dose of 0.5 kg ai/ha.

Studies of earlier workers like Inchai et al. (1975), Jayaraj (1976), Rao (1976), Anonymous (1977), Rao (1977), Subramanian et al. (1980), Varadharajan (1980) and others have shown that carbofuran granules applied in soil gave effective control of stem borer, whorl maggot, GRM, BPH, caseworm, leaf roller, gall midge, rice hispa and rice thrips. These earlier findings thus supported the present findings also. The observations made under the present studies that carbofuran could give effective control of rice swarming caterpillar and grasshoppers,

were additional information on the broad spectrum action of the insecticide. Another new information which emerged out of the present studies related to the adverse effect of this insecticide on populations of the predaceous organisms such as mirid bug and spiders. The reduction in population of the predators in the plots showing effective control of DPH and GMI could be due to the reduction in the population of their hosts (Kobayashi et al., 1973) rather than due to any direct effect.

Phorate at both the levels was effective in giving significant control of DPH, GMI, gall midge, whorl maggot, cane borer, grasshopper and rice swarming caterpillar. For the control of gall midge phorate appeared to be better than carbofuran treatments and application of the granules at the two occasions of 21 and 45 D12 gave effective control of gall midge following each application indicating that the residual infestation of the insect which persisted on the tillers of the reproductive phase of the crop were also effectively controlled by the insecticide. As regards stem borer, phorate at 1.0 kg ai/ha did not give significant control, while at its higher dose of 2.0 kg ai/ha infestation occurring at the earlier period of the crop alone could be controlled effectively. The phorate treatments did not show any signi-

ficant control of the leaf roller infestation. But the other caterpillar pests like the case worm and rice swarming caterpillar showed effective control by the insecticide at both the levels except in second season in the case of case worm. Grasshopper infestation also was effectively controlled by the phorate treatments. Mird bug and spider populations showed population reductions under the phorate treatments. The mird population however, showed minimum suppression under phorate 1.0 kg ai/ha. Thus phorate was found to be in general effective in controlling the major insect pests damaging rice excepting rice stem borer and leaf roller and in its effectiveness the dose of 1 kg ai/ha compared well with the higher dose of 2 kg ai/ha.

Phorate has been found in earlier studies of Phontodazaya et al. (1971), Nathai et al. (1975), Jayaraj (1976), Lakshmanan (1976), Sundararaja (1980) and others to be effective in controlling GHL, BPH, stem borer, gall midge, whorl maggot and rice thrips. In the present studies also BPH, GHL, gall midge, whorl maggot, case worm, rice swarming caterpillar and grasshopper were found to be effectively controlled by the insecticide. Stem-borer control was, however, effective only at the higher dose of 2 kg ai/ha and not at 1.0 kg ai/ha. Leaf roller control

was observed to be not satisfactory. The observation that this insecticide could control case worm, rice stunting caterpillar and grasshoppers provided additional information on the effectiveness of this insecticide. The adverse effect of phorate indicated on the population of predators could be correlated to the suppression of the population of their host insects due to the insecticide treatment. But Thirumurthi (1979) has indicated that phorate was injurious to spiders.

Mephosfolan at the lower dose of 0.5 kg ai/ha did not give effective control of BPH and GMH. At its higher dose though effective control of both these insects during the early vegetative phase was indicated, control of the pest during the later period was not satisfactory. Gall midge infestation was controlled effectively by this insecticide at both the levels and protection of the crop against this pest throughout the cropping season could be obtained by the application of this insecticide. Wheat maggot control was not significant at the lower dose while at higher dose significant control was obtained. For control of stem borer, mephosfolan at the higher dose was much better than at the lower dose. Leaf roller infestation could be controlled effectively by both the doses of mephosfolan while case worm control was not satisfactory under the lower dose. For the

control of grasshoppers the higher dose gave better results than the lower dose and although fairly satisfactory control was given by both the doses. Rice swarming caterpillar was effectively controlled by methosfolan at both the doses. Populations of the mirid bug and spiders were not significantly affected by the methosfolan treatments which could be correlated with the poor suppression of their hosts BPH and GH under the insecticide treatments. It could be concluded that methosfolan was useful for effective control of such pests as gall midge, stem borer, leaf roller, grasshoppers and rice swarming caterpillars, without affecting the predators of the hoppers adversely.

From the review of literature of workers like Rao (1976), Saivara; et al. (1976), Anonymous (1977), Rao (1977), Saivara; et al. (1977), Anonymous (1978), Sundararaju (1980) and others, it is seen that methosfolan was effective for the control of such paddy pests as stem borer, GH, gall midge, whorl maggot, leaf roller and thrips. From the present studies, methosfolan was found to be effective for the control of gall midge, whorl maggot, stem borer, leaf roller, case worm, grasshopper and rice swarming caterpillar. Its effectiveness against the plant and leaf hoppers was not up to the mark. Narayanaswami et al. (1977) and workers of IRRI, Philippines (Anonymous, 1978)

also had recorded nephotholan as ineffective against BPH. Effectiveness of this insecticide against grasshoppers, rice swarming caterpillar and case worm observed under the present studies and absence of any deleterious effect on the population of the predators were new findings.

Disulfoton at both the doses was effective in the control of the two sucking pests BPH and GLH and ineffective against gall midge, whorl maggot, stem borer, leaf roller and case worm. It was effective at higher dose for the control of grasshopper and rice swarming caterpillar. The predators were by and large not affected adversely. The studies indicated the suitability of disulfoton for the control of the plant and leaf hoppers at both the doses and against grasshoppers and rice swarming caterpillar at the higher dose.

Successful control of pests of paddy using disulfoton granules was not observed by earlier workers like Narayan et al. (1974), Ramkumar et al. (1975), Bastaman and Narayanaswami (1975), Ramaswamy et al. (1977) and others.

Quinalphos did not give consistent results for the control of the pests of rice when used as granules excepting gall midge, whorl maggot, case worm and rice swarming caterpillar, that

too at its higher dose. This, probably because, quinalphos was largely a contact poison with little or no systemic action.

Earlier workers such as Nathai et al. (1975), Muesain (1976), Balasubramanian (1976), Gundakarama (1980) and others have given instances of successful control of rice stem borer, leaf roller, gall midge, thrips, whorl maggot, GMH and APH by the use of granules of quinalphos. In the present studies, however, quinalphos at 1.0 and 2.0 kg ai/ha could not give satisfactory control of the pests observed. The stray instances of effective control of gall midge, whorl maggot, rice case worm and rice swarming caterpillar by the use of quinalphos granules observed during the course of the field studies were not constant and hence could not be accepted on an over-all appraisal.

Results presented show that chlorodimethoate was effective in the control of the three caterpillar pests viz. stem borer, leaf roller and rice swarming caterpillar. The gas effect of the insecticide which was reported to be particularly effective against young caterpillars (Jair, 1978) can be attributed to the control of these larvae. When added to irrigation water the insecticide was taken up by the plant and translocated up. It then left the plant tissue in the gas phase which was lethal to young larvae. The predators

also were not adversely affected by the insecticide. Thus in situations where exclusive control of stem borer or of leaf roller was needed, this insecticide could be advantageously used without killing the predators of the hoppers.

Review of work done by previous workers such as Anonymous (1974), Rao et al. (1977), Valucamy et al. (1978) and others will show that successful control using chlorodimeform was reported for stem borer, leaf roller and BPH. In the present studies also stem borer and leaf roller control was highly effective with this insecticide. But effective control of BPH was not observed. Though the insecticide was reported earlier to be ineffective against whorl maggot (Anonymous, 1974), in the present studies effective control of the insect was given by the insecticide especially at its higher dose of 2.00 kg ai/ha. That the insecticide could control RSC effectively was an additional information. So also were, the observations that the insecticide was by and large not injurious to the predator population. Royama (1975) also had reported that this insecticide had little effect on the density of spider population.

Results of studies on the persistence of insecticides within plants have shown that against BPH all the insecticides showed residual toxicity. Among the different insecticides

(Table 22) carbofuran was the most highly toxic and persisting for longer period than the others. Though chlorodimethoate ranked next to carbofuran, followed by phorate and methidathion, the toxicity exerted by these insecticides to JPM was low. But chlorodimethoate persisted within the plant up to 12 days and others for 7 days after application. The other insecticides showed lower toxicity and lower persistence. Venkataswamy and Kalode (1980) also have reported higher PT indices for disulfoton, carbofuran and chlorodimethoate and except for disulfoton, it is in agreement with the present studies and findings. Against leaf roller larvae carbofuran showed much higher toxicity and higher persistence than all other insecticides, the other insecticides manifesting approximately similar toxicities and persistence among themselves. Among these, however, methidathion and chlorodimethoate were superior to the rest.

From the results discussed above with respect to the spectrum of action and longer persistence within the plant, the insecticides carbofuran, phorate and methidathion were observed to be superior for paddy pest control in general than disulfoton, quinalphos and chlorodimethoate. So for further studies only these three insecticides were used.

Table 22. Consolidated statement of PT indices of different insecticide treatments to different insects

Insecticide treatment			BPH	RSC	Leaf roller
Carbofuran	at 0.5 kg ai/ha		520.00	84.00	520.00
"	at 1.0	"	724.80	225.05	970.50
Phorate	at 1.0	"	198.50	0.00	153.60
"	at 2.0	"	257.95	6.60	180.60
Heptachlor	at 0.5	"	94.50	542.00	109.90
"	at 1.0	"	245.35	890.80	270.80
Disulfoton	at 1.0	"	81.90	0.00	82.60
"	at 2.0	"	123.20	0.00	198.40
Malathion	at 1.0	"	82.60	0.00	106.40
"	at 2.0	"	113.75	0.00	141.00
Chlorodaneform	at 1.0	"	216.79	20.60	116.50
"	at 2.0	"	297.20	155.40	213.60

A consolidated representation of the results of field studies undertaken on the effect of different frequencies of insecticide application on paddy pest control is given in Table 23. For the control of white leaf hopper, application of carbofuran at 21 DAT was found to give significant results, while application at 45 DAT did not indicate constant control of the leaf hopper; the overall effect of the two applications gave significant results. It was thus indicated that the 21 DAT application was sufficient to control this leaf hopper. Similar results were indicated for GH also wherein 21 DAT application was sufficient to keep the pest under control. As regards control of BH, the 21 DAT application of carbofuran granule gave significant control while 45 DAT application did not, thereby indicating that the early application by itself could keep the population under check throughout the cropping season. For control of leaf roller the 45 DAT application was found to give better control than the other frequencies. This was probably because this was an insect which preferred the broad leaved stages of the crop for infestation and the boot-leaf stage offered such a situation. For shoot maggot control which occurred during the early vegetative phase, 21 DAT application could give significant control. Gall midge control was poor under all the frequencies. Cane worm showed significant control after the 21 DAT

Table 25 Consolidated representation of relative efficiency of 11 forest insecticide groups on control of paddy pests in relation to frequencies of application

Treatment		WEM			GUE		DPU		Leaf roller		borer		Gall midge		Cane worm		Stem borer		Rice bug		Spider		Mirid bug		Yield			
		2	3	3	2	3	2	3	1	3	2	3	1	3	2	3	2	3	1	3	1	2	3	1	2	3	1	2
1	Carb. run at 20 kg ai/ha applied at 2 DA	x	x	x			x							+		x						+	x	x	+		+	+
2	45 D								x									+										+
3	20 D	x	x	x	x			x						+		x		+	x				x	x	x		x	
4	borate a 20 kg ai/ha applied at														x								x					
5																												
6													x		x									x	x			
7	in a 1:1																											
8	4														x				x									
9															x				x									

=

2 = control

3 = control

=

=

=

=

over

x to

only

NI = No infestation during the season

NS = Data not significant

application which coincided with its period of appearance. Effective stem borer control could be accomplished only by both the applications at 21 and 45 DAT while the other frequencies did not give constant results. The epidid population was least affected by the 45 DAT application while at the other frequencies the population was adversely affected. Minid bug population was adversely affected at all the frequencies. As regards yield the application of carbofuran granule at both the occasions gave the maximum yield followed by the exclusive 21 DAT application.

Jayaraj (1976) observed an increase in yield by 37.9% and 50.2% under treatments of carbofuran granules at 1.5 kg and 2.5 kg ai/ha. Ramasurthy et al. (1977a) and Sundararaju (1980) also recorded maximum increase in yields under the treatments of carbofuran (106 to 183%) at 1.0 kg ai/ha when applied at 15 and 35 DAT. These findings are in conformity with the present observations wherein 36.60 to 98.23% increase in grain yield over control was recorded for the three seasons under two applications of carbofuran at 1.0 kg ai/ha.

From this it could be concluded that the maximum protection to the crop from the various insect pests was afforded by two rounds of application of the insecticide at 21 and 45 DAT. It was also indicated that carbosulfan could be used for the effective control of *WPI*, *GM*, *WML*, *whorl maggot* and *cane worm* by single applications at 21 DAT and for leaf roller an application at 45 DAT would be required. For stem borer control, however, 2 applications of the insecticide would be needed.

Phorate was found to be effective in controlling *WPI*, *GM*, *WML*, *whorl maggot* and *gall midge*, by a single application at 21 DAT. Leaf roller, stem borer and rice bug did not give significant control by phorate. A single application at 45 DAT did not give significant control of the more important pests like *WPI* and rice stem borer. The predator populations were adversely affected by all the phorate treatments. The overall effect of the phorate treatments on the yield did not appear to be favorable (27.3 to 49.5% increase over control under two applications during three seasons). This was evidently due to control of a limited number of pests infesting paddy.

Nephtocifan showed effective control of leaf roller, gall midge, cane worm and stem borer by a single application at 21 DAT

while other insects could not be controlled in this way. Two applications of the insecticide afforded highly significant control of leaf roller, whorl maggot, gall midge and stem borer. A single application at 45 DAT did not appear to be advantageous for the control of any of the pests. The predators in general were not adversely affected by the methosfolan treatment. The yield showed significant increase under all the treatments, two applications giving the maximum increase in the yield ranging from 31.00 to 91.35% over control during three seasons. Sundararaju (1980) also observed maximum increase in yield of paddy grain when methosfolan was applied twice at 1.0 kg ai/ha and thus supported the present finding. A single application of methosfolan at 21 DAT thus appeared to be useful for the control of such pests as leaf roller, whorl maggot, gall midge, cane worm and stem borer.

The results of studies made on uptake and persistence of the insecticides by rice plants under the flooded (2.5 cm deep) and field capacity levels of irrigation in terms of mortalities of BPH and rice shearing caterpillar (Table 24) have shown that in general the uptake and persistence were higher at the field capacity level than at the flooded level.

Table 24. Persistence of insecticides in rice plants under different levels of irrigation in terms of PT indices to BPH and RSS

Treatment	Carbofuran		Phorate		Yenhoesfolan	
	2.5cm level	Field cana-city level	Flooded	Field cana-city level	Flooded	Field cana-city level
<u>BPH</u>						
<u>PT Indices</u>						
21 DAT	293.86	492.45	172.29	269.84	263.34	205.04
45 DAT	363.30	224.64	150.08	93.12	128.92	160.70
<u>Rice growing caterpillars</u>						
<u>PT Indices</u>						
21 DAT	146.24	257.13	9.10	12.00	768.00	1043.04
45 DAT	40.26	97.50	19.43	73.60	897.40	1022.55

One exception to this conclusion was that of the mortalities shown by BEH to the insecticides applied at 45 DAT. When applied at 21 DAT the PT index of carbofuran was much higher at field capacity level being 492.45 than at the flooded level being 293.86. A similar pattern was seen in phorate also with PT indices of 269.64 and 172.29 respectively. In the case of methidathion, however, the PT index was slightly lower at field capacity level than at the flooded level. The relative positions of the PT indices were reversed for all these insecticides at the 45 DAT applications. In the case of rice swarming caterpillar the PT indices were much higher at the field capacity level than at the flooded level for all the insecticides at both the occasions of applications. These findings are in conformity with the observations made by earlier workers. Venkateswaralu et al. (1977) had reported that degradation of carbofuran was more rapid under flooded condition than under non-submerged condition. Rajukannu (1977) had recorded that carbofuran persisted in soil more at field capacity level than under flooded condition. Agnihotri (1978) showed that phorate (and disulfoton) was degraded at a faster rate under flooded condition than under unirrigated condition. Mohandas and Vimalakshi (1978) had observed that maintenance of soil moisture at field capacity

level was conducive to a higher level of absorption of phorate by paddy plants and more prolonged persistence in them as compared to maintenance of water at flooded level. The reversion of response shown by NPH at 45 DAT application of the insecticides appeared to be related to the feeding habits of the insect and the rate of translocation of the insecticides to different plant parts.

Results of studies of insecticide residues in straw and grain have indicated that residues of the various insecticides persisted within straw and grain even when applied at 21 DAT; the residues persisting were more after 45 DAT application than after 21 DAT application and most under the combined applications. The residues of carbofuran varying from 0.038 to 0.102 ppm persisting in straw and 0.038 to 0.107 ppm persisting in grains were much below the tolerance limit of 0.2 ppm fixed for carbofuran. But residues of phorate in straw and grains ranging from 0.048 to 0.161 ppm were above the tolerance limit of zero ppm fixed for the insecticide. The residues of methidathion observed in straw and grains ranged from 0.033 to 0.168 ppm. As regards residues of carbofuran the present findings in general agreed with those reported by Rajukannan et al. (1976), Saivara; et. al.(1977), Anonymous (1977a), Anonymous (1978) and Kithyantha et.al.(1978)

who had reported residues varying from ND levels to 0.192 ppm in grains and straw. Vimalakshi et.al. (1979) had, however, recorded higher residues of up to 1.44 ppm in straw and 0.81 ppm in grains. The residues of phorate in grains and straw observed under the present studies confirmed the results reported by Rajuikarna et.al. (1976). The residues of phorate recorded by Vimalakshi et.al. (1979) in grains and straw were of higher magnitude. Nephosolan residue recorded in the present studies agreed with the values reported by Saivaranj et.al. (1977).

Thus in general it could be concluded that carbofuran, phorate and nephosolan could safely be used as granules for the control of variousaddy pests when applied up to 45 DAI.

Practical significance of the findings

The results presented and discussed reveal clearly that almost complete protection of rice crop from the various destructive pests can be obtained exclusively by the use of granules. Carbofuran when used as granules even at a lower dose of 0.5 kg ai/ha controlled effectively such important pests as BPH, DM, gall midge, whorl maggot, stem borer, leaf roller, cane worm, grass hopper and rice swarming caterpillars. Even a single application of the granule at 24 DAI gave fairly good protection of the crop from most of

these pests. A second application at 45 DAF appeared to be needed only in case of secondary build up of the pest populations which generally happened with BPH, leaf roller and stem borer. The grain yield also responded favourably to carbofuran treatment, the maximum increase in yield to the extent of 98.95% being observed when two applications of the insecticide were given. Phorate was also found to be effective against WBH, GLH, BPH, whorl maggot, gall midge and grasshopper. Mephosfolan in the present studies emerged out as especially useful for control of the caterpillar pests such as leaf roller, stem borer and rice swarming caterpillar as well as for the control of gall midge and grasshoppers. This insecticide did not affect the spider and bird populations which were effective predators of the sucking insects. Thus wherever leaf roller, stem borer, rice swarming caterpillar or gall midge was the exclusive problem mephosfolan could be used without adversely affecting the host-predator relations of BPH and GLH. The yield also showed considerable increase up to 91.35% under the mephosfolan treatments.

One of the important factors which adversely affected the efficiency of plant protection measures in paddy field was the faulty application of the insecticides. Very often the spraying operations were not undertaken properly and the

dosages fixed for different insecticides were rarely adhered to. Thus in effect, the insecticide application could not give the desired effect as the doses were not enough to kill the pests. There was also the risks of resurgence of pests caused by the reproductive stimulation of sublethal doses of the insecticides. One of the great advantages in using insecticide granules was the possibility of ensuring application of the insecticide at the toxic dosage levels. Such an efficiency of application in using granules could be achieved even in situations of thick growth of the plants where sprays would not be able to check the pest infestation effectively. When the strategy of need based application of insecticides was adopted the amount of insecticide granules to be used per hectare could be reduced considerably. Considering all these factors use of granules of such insecticides as carbosulfan, phosanto and naphosfolan appeared to have great scope and possibilities for the control of paddy pests. However, more elaborate field experiments, following need-based application practices may have to be undertaken for making precise recommendations on the use of granules for the control of pest problems of paddy.

SUMMARY

SUMMARY

Effect of carbofuran at 0.5 and 1.0 kg ai/ha, phorate at 1.0 and 2.0 kg ai/ha, rophosfolan at 0.5 and 1.0 kg ai/ha, disulfoton at 1.0 and 2.0 kg ai/ha, quinalphos at 1.0 and 2.0 kg ai/ha and chlorodimethoate at 1.0 and 2.0 kg ai/ha when applied as granules at 21 and 45 DAT on control of paddy pests was ascertained in field experiments undertaken during three cropping seasons.

Results of the experiment undertaken during the first crop season showed that carbofuran at 0.5 kg ai/ha gave significant control of BPH, GLH, stem borer, leaf roller, caseworm and grasshopper. At 1.0 kg ai/ha it gave significant control of BPH, GLH, gall midge, whorl maggot, stem borer, leaf roller, caseworm and grasshopper. The populations of mirid bug and spider was adversely affected by both the carbofuran treatments. Phorate at 1.0 kg ai/ha gave significant control of GLH, gall midge, caseworm and grasshopper. At 2.0 kg ai/ha significant control was given of BPH, GLH, gall midge, whorl maggot, stem borer, caseworm and grasshopper. Both the doses affected the mirid and spider populations significantly. Nephosfolan at 0.5 kg ai/ha gave significant control of gall midge, leaf roller, caseworm and grasshopper and at 1.0 kg ai/ha showed significant control

of BPH, GLH, gall midge, whorl maggot, stem borer, leaf roller, caseworm and grasshopper. Moxid and spider populations were not affected adversely. Disulfoton at 1.0 kg ai/ha gave significant control of BPH, GLH, leaf roller and caseworm while the 2.00 kg ai/ha significant control was given for BPH, GLH, caseworm and grasshopper. The predator populations were not significantly affected by the insecticide. Quinalphos at 1.0 kg ai/ha showed effective control of GLH, gall midge and whorl maggot while at 2.0 kg ai/ha gave effective control of gall midge, whorl maggot, stem borer and caseworm. Predator populations did not show any significant effect. Chlorodaneform at 1.0 kg ai/ha gave satisfactory control of BPH, gall midge, stem borer, leaf roller and caseworm and at 2.0 kg ai/ha effective control of whorl maggot, stem borer, leaf roller and caseworm. Predator populations were not adversely affected.

The results of field experiment undertaken during the second crop season showed that carbendazim at both the doses gave significant control of BPH, GLH, gall midge, whorl maggot, stem borer, leaf roller, caseworm, grasshopper and rice swarming caterpillar. The predator populations were adversely affected. Phorate at both the doses controlled BPH, GLH, gall midge, whorl maggot, grasshopper and RSC effectively. The predator populations also were affected adversely.

Nephtesolan at its two doses gave significant control of gall midge, whorl maggot, leaf roller and RSC while satisfactory control of EPH and GHM was given by the higher dose only. Predator populations were not affected. Disulfoton at the two doses gave effective control of EPH and GHM while effective control of gall midge, leaf roller, cawworm, grass hopper and rice sunning caterpillar was given only by its higher dose. Predator populations were not affected. Quinalphos at both the doses showed significant control of gall midge, cane worm and RSC, while there was no effect on predator population. Chlorodimethorm was effective at both the doses in the control of whorl maggot, stem borer, leaf roller and RSC. It did not affect the predator population.

Results of the field experiment undertaken during the third crop season showed that carbosulfon at both the doses gave effective control of EPH, gall midge, stem borer, leaf roller, cawworm, grasshopper and RSC. The predator populations were adversely affected. GHM control was given only at the higher dose. Phorate at both the doses significantly controlled EPH, GHM, gall midge, stem borer, cawworm and grasshopper, and affected the predator population adversely. Nephtesolan at both the doses controlled EPH, gall midge, stem borer, leaf roller, grasshopper and RSC effectively. Predator

population was not affected. Caseworm was controlled only at the higher dose. Disulfoton at both the doses gave effective control of BPH, GMH and RSC and did not affect the predator population. Quinalphos at 1.0 kg ai/ha showed satisfactory control of stem borer and RSC while at its higher dose caseworm and rice swarming caterpillar alone showed effective control. Chlorodimeform at its both doses gave effective control of stem borer, leaf roller and RSC and did not affect the predator population.

Persistence of insecticides in paddy plants when applied as granules was assessed in terms of mortalities of BPH, RSC and leaf roller exposed to treated plants in pots at different occasions following treatment. Residual toxicity to BPH was highest for carbofuran followed in the descending order by chlorodimeform, phorate, naphosolan, disulfoton and quinalphos. Naphosolan showed higher residual toxicity to RSC followed by carbofuran and chlorodimeform in that order. Other insecticides did not show residual toxicity. Against leaf roller caterpillar maximum persistent toxicity was shown by carbofuran followed by naphosolan, chlorodimeform, phorate, disulfoton and quinalphos.

Field experiments were undertaken to study the effect of insecticide granules on the control of paddy pests when applied at 21 DAF only at 45 DAT only and at 21 and 45 DAT during three cropping seasons.

During the first crop season carbosulfan at 1.0 kg ai/ha when applied at 21 DAT only gave significant control of GLH and gall midge; spider and mirid populations were reduced significantly. When applied at 45 DAT only significant control was indicated for GLH, leaf roller and rice bug with no effect on spider population and significant effect on mirid populations. Two applications at 21 and 45 DAT gave significant control of GLH, gall midge and stem borer. The predator populations were reduced drastically. The yield showed significant increase of 36% over the control for the two applications at 21 and 45 DAT.

Phorate at 2.0 kg ai/ha applied during the first crop gave significant control of GLH at all the three frequencies and of gall midge at 21 DAT and 21 & 45 DAT. Spider population was adversely affected at all the frequencies. Yield did not show significant increase. Mephosfolan at 1.0 kg ai/ha showed significant control of GLH at 21 & 45 DAT; of leaf roller at all the frequencies; of gall midge at 21 DAT and 21 & 45 DAT frequencies and of stem borer at 21 DAT and 21 & 45 DAT frequencies. Spider population was affected only under the 21 & 45 DAT treatments. Significant increase of yield (31%) was seen under the 21 and 45 DAT treatment.

During the 2nd crop season carbosulfan gave significant control of WHH, GSH, BPH, whorl maggot and caseworm at 21 DAT and 21 & 45 DAT frequencies and of stem borer at all the frequencies. The predator populations were reduced significantly under most of the frequencies. The yield showed significant increase over control under all the frequencies ranging from 75.56 to 96.62%. Phorate granules showed significant control of WHH at 21 DAT and 45 DAT treatments, of GSH, whorl maggot and caseworm at 21 DAT and 21 & 45 DAT treatments and of gall midge at 21 and 45 DAT treatments. The predator populations were adversely affected at all the frequencies. Diphosfolan gave significant control of WHH at 21 and 45 DAT treatment, of BPH and whorl maggot at 21 DAT and 21 & 45 DAT treatments; of gall midge at 21 and 45 DAT treatments; of case-worm at 21 DAT treatment and of stem borer at all the treatments. Predator populations were not affected significantly. Grain yield showed significant increase over control under all the treatments to the extent of 84.21 to 91.35%.

During the third crop season carbosulfan gave effective control of WHH at all the frequencies, of GSH at 21 DAT and 21 & 45 DAT treatments; of leaf roller at all the treatments, of whorl maggot at 21 DAT and 21 & 45 DAT treatments; of

stem borer at 21 DAT and 21 & 45 DAT treatments and of rice bug at 45 DAT treatment. Midge population was adversely affected. Significant increase in yield over control was shown under 21 DAT treatments and 21 & 45 DAT treatments, the increase being 54.33 to 98.25%. Phosfolan gave significant control of VMH, GMH, LPH and whorl maggot at 21 DAT and 21 & 45 DAT treatments and of leaf roller at 45 DAT and 21 & 45 DAT treatments. Spider and midge bug populations were adversely affected at 21 DAT and 21 & 45 DAT treatments. Significant increase in the grain yield was given under 21 DAT and 21 & 45 DAT treatments by 27.6 and 31.58% increase over control respectively. Phosfolan gave significant control of VMH, BPH and stem borer at 21 DAT and 21 & 45 DAT treatments; of leaf roller at all the treatments and of whorl maggot at 21 & 45 DAT treatments; the predator populations were not affected by any of the treatments. Significant increase of grain yield over control was observed under all the treatments to the extent of 48.4 to 53.6%.

Field and laboratory studies were undertaken to ascertain the effect of irrigation levels at field capacity and 2.5 cm level, on the uptake and persistence of insecticides applied as granules, in terms of residual toxicity to

DPH and NSO. These effects were studied when granules were applied at 21 DAT and at 45 DAT. When the insecticide granules were applied at 21 DAT the PT index values of DPH under carbofuran at 1.0 kg ai/ha and phorate at 2.0 kg ai/ha were considerably higher at field capacity level than at level of 2.5 cm; for nephenfolan higher PT index was observed at 2.5 cm water level. At 45 DAT treatment the PT index values were higher at 2.5 cm water level than at field capacity level with carbofuran and phorate while reverse was the result with nephenfolan. On both occasions persistence was maximum for carbofuran followed by nephenfolan and phorate. For rice earwing caterpillar PT index values were higher for all the three insecticides under the field capacity level of irrigation than under 2.5 cm water level. At both the occasions of application, among the three insecticides, maximum uptake and persistence was shown by nephenfolan followed by carbofuran and phorate.

Residues of the insecticides applied as granules at 21 DAT only, at 45 DAT only and at 21 & 45 DAT present in straw and grain at the time of harvest were determined by bio-assay. All the insecticides under all the frequencies of applications were found to leave residues in both grain and

straw, varying from 0.038 to 0.107 ppm for carbosulfon, 0.048 to 0.161 for phorate and 0.033 to 0.168 ppm for methidathion.

Utility of the insecticide granules for control of various paddy pest problems has been discussed in detail.

REFERENCES

REFERENCES

- * Abalos, R.S. (1968). Effect of different chemicals against the yellow rice stem borer (*Pyrausta nictitans* Walker.) Philippine Journal of Plant Industry 23(1) : 15.
- * Abo, Y. and Okamoto, B. (1975). Effect of nonorganophosphorus insecticides and analysis of lethal effect against 2 major rice pests by the application of insecticides in soil and water. Bulletin, Gurein National Agricultural Experiment Station 18 : 1-55.
- Agnihotri, N.P. (1976). Degradation of Pesticides in Soil. Proc. All India Symposium on Pesticide Residues in Environment, Bangalore, 345-356.
- Alan, H.Z. and Appas, T. (1970). A comparative study of granular diazinon, caridol and foliar diazinon for the control of borers on IRRI rice in West Pakistan. PAES 16(5) pp 525-520.
- Anonymous (1969). Annual report of the International Rice Research Institute, Philippines, Los Banos, Philippines.
- Anonymous (1971). Annual report of the International Rice Research Institute, Philippines.
- Anonymous (1971a). Summary of the 1968 report on Thiot 100 with special references to its residue and usage in paddy. University of Agricultural Sciences, Bangalore.
- Anonymous (1972). Cytochrome - Determination of residues in rice grain and straw by gas-liquid chromatography. American Cyanamid Company, Princeton, New Jersey. 16 pp.
- Anonymous (1973). Chemical control in nursery. Annual Report, Konkan Krichi Vidyapeeth, Varjat. pp 2-4.

Anonymous (1974). Laboratory and green house experiments. Annual report of the International Rice Research Institute, Los Banos, Philippines.

Anonymous (1977). Carbofuran residues in rice grain. Annual report of International Rice Research Institute, Los Banos, Philippines.

Anonymous (1978). Activity of granular insecticides applied in paddy water at 0.5 kg ai/ha for RPH and GSH. Annual report of International Rice Research Institute, Los Banos, Philippines.

Aquino, G.B. and Pathak, M.D. (1976). Enhanced absorption and persistence of carbofuran and chlorodimethoate in rice plant as root zone application under flooded condition. J. Econ. Ent. 69(5) : 686-690.

Balasubramanian, N. and Michael, R.H.P.M. (1976). Effect of quinalphos and other granular insecticides on the incidence of some paddy pests. Madras agric. J. 53 (5-7) : 288-289.

Basharan, P. and Narayanaswamy, P. (1975). Field trial on the control of rice gall midge Pachydiplaxia pryzae and the rice whorl maggot (Hydrellia senilis). Rice Entomology Newsletter 2 : 32-33.

Bowling, C.C. (1970). Lateral movement, uptake and retention of carbofuran applied to flooded rice plants. J. econ. Ent. 63 (2) : 239-242.

Bowling, C.C. (1975). Rice water weevil control with granular insecticides. J. econ. Ent. 68(5) : 680-682.

Bhudhraj, K., Rawat, R.R. and Singh, S.P. (1960). Note on persistence of toxicity of some granular insecticides against the rice hispa. Indian J. agric. Sci. 50(10) : 801-802.

Calora, P.B., Terino, M.P., Glass, R.H. and Abale, R.S. (1968). Systemic granular insecticides against rice stem borers with consideration on the pattern and characteristics of infestation. Philipp. Ent. 1(1) : 54-56.

Galora, F.B. and Porino, H.P. (1978). Cyroloano methasfolan systemic insecticide for rice insect control and its safety under paddy conditions. Cynamid Agri-cultural Research Foundation, Inc. Laguna, Philippines : 299-312.

Chandramohan, N. and Jayaraj, S. (1976). Evaluation of certain granular and foliar insecticides against Rice leaf roller. Madras agric. J. 63 (5-7) : 364-366.

Chandramohan, N. and Jayaraj, S. (1977). Effect of different levels of nitrogen and granular insecticides in the control of rice leaf roller Chorivalocrocis pedonalis (Guon.) Madras agric. J. 64(8) : 544-548.

Chelliah and Heinrichs. (1979). Insecticide evaluation report. International Rice Research Institute, Philippines, p. 7.

- * Cheng, C.H. and Liu, T.S. (1978). Re-evaluation of chemicals for brown plant hopper control in Taiwan. Journal of Agricultural Research in China, 27(1) : 1-11.
- * Choi, S.Y., Bae, S.H. and Jeng, Y.H. (1978). Simultaneous control of several rice insect pests by broadcasting application of granulated insecticides. Korean Journal of Plant Protection 2(1) : 29-32.
- * Choi, S.Y. and Leett, R. (1976). Selective toxicity of insecticide to plant and leaf hoppers. Korean Journal of Plant Protection 15(1) : 16-20.
- * Choi, S.Y., Lee, H.R. and Raju, J.M. (1978). Effect of carbosuran root-zone placement on the epider population in paddy fields. Korean Journal of Plant Protection 17(2) : 99-103.
- Cock, R.F., Stanovick, R.P. and Cassil, C.C. (1969). Determination of carbosuran and its carbamate metabolite residues in corn using Nitrogen - specific Gas chromatographic Detector. J. agric. Food Chem. 17(2) : 277-282.
- * Curtodio, H.A. (1974). Chemical control of insect pests and disease of rice. Philippines Journal of Plant Industry, pp 35-99.

- Bahiphalo, K.V., Bhirad, H.M. and Chahus. (1979). Efficacy of different fertilizer pesticidal mixtures as soil and foliar application on paddy for the control of stem borer and leaf hopper. Pesticides 13(6) : 20-23.
- Bonoso Lopez, J.G. and Grigoriek, A.A. (1969). An evaluation of carbofuran for control of several stages of rice water weevil in green-house test. J. econ. Ent. 62(5) : 1024-1026.
- Dutt, H. and Bhand, B.K. (1976). Evaluation of insecticides in reducing stem borer and gall midge in paddy. Proc. Seminar on Entomologists role in rural development, Kalyani.
- * Farino, H.P. The biology and control of rice leaf-whorl maggot, Hydrellia philippina Farino. Philippine Agriculturalists 32(6) : 332-385.
- Janguli, B.N., Roy, D.N. and Bayschowdhuri, A.T. (1970). Control of rice stem borer (Scythopyga incertulaga Walker.) by granular insecticides in Tripura. Indian J. Ent. 32(1) : 94-96.
- George Mathew, Chalambarthy, D.P., Ghosh, G.C. and Dima, S.P. (1978). Efficacy of different fertilizer-pesticide mixture as granular application in rice. Pesticides 12(1) : 23-25.
- Gupta, D.S. (1971). Place of bioassay in residue analysis. Proc. SPRA. 215-218.
- Gupta, R.G. and Dewan, L.S. (1973). A rapid colorimetric method for the estimation of carbofuran residues. Proc. Symposium on Progress and Problems in Pesticide Residue Analysis, Ludhiana pp. 208-214.
- Heinrichs, D.A. and Valencia, S.L. (1979). Resistance of BPH to carbofuran at IRRI. International Rice Research News letter 3(4) : 18.
- Heinrichs, D.A. and Arce (1979a). Rootzone application of granular insecticides. Insecticide evaluation report. International Rice Research Institute, Los Banos, Philippines.

- Heinrichs and Valencia (1979b). Activity of granular formulations of insecticides. Insecticide evaluation report. International Rice Research Institute, Los Banos, Philippines.
- * Hidaka, T., Yungwiltabutr, P. and Tadoko, S. (1974). Studies on ecology and control of rice gall midge in Thailand. Technical Bulletin, Tropical Agricultural Research Centre, 8 : 113 pp.
- * Hsieh, C.Y. (1976). Field re-evaluation of commercial insecticides for control of the green rice leaf hopper and brown plant hopper. Rice Entomology News Letter, Taiwan, 4 : 23.
- * Huque (1973). The fate of diazinon applied to rice plants. Memories - Food and agriculture, Agricultural Research Council, Karachi, 29-32.
- Hussain, M.A. and Asam, F.M. (1976). Efficacy of Binlux granules and SC in the control of paddy pests. Madras agric. J. 63 (5-7) : 292-298.
- * Rayn, H.V. and Morallo Reyes, B. (1978). Carbofuran to the Brown Plant Hopper Nilaparvata lugens and its metabolism in rice plants. Philippines entomologist, 3(2) : 117-128.
- Ishikawa, S. (1972). Environmental toxicity of pesticides. Academic Press, New York and London, pp 22-24.
- * Iwaya, T. and Kollmer, G. (1975). Effectiveness of curaterrgranules against rice pests. Bayar Agrl. Chemical Institute, Tokyo, 28(1) : 137-143.
- Jayaraj, S., Chandramohan, N. and Sankaranarayanan, R. (1976). Control of rice stem borer, leaf roller and gall midge through water surface application of granular insecticides. Madras agric. J. 63(5-7) : 308-311.
- Jones, L.R. and Hiddick, J.A. (1952). Separating organic insecticide from plant and animal tissues. Anal. Chem. 24 : 569-571.
- Kalode, M.B., Bhaskara Rao, T., Ganeswara Rao, A., Srinivasu, E. and Subba Rao, A. (1977). Field evaluation of various methods of insecticide applications in the control of rice pests. Pesticides 11(10) : 18-21.

- * Kobayashi, S. and Shibata, T. (1973). Seasonal changes in population density of spiders in paddy field with reference to the ecological control of rice insect pests. Jap. Jour. Ap. Ent. and Zool. 17(4) : 193-202.
- * Kono, Y., Inoue, M. and Sakai, K. (1978). Movement of Cartap in the rice plant and its insecticidal activity to the sucking insects when applied in nursery box. Jap. Jour. Ap. Ent. and Zool. 22(2) : 74-80.
- * Koyama, T. and Tsurumachi, M. (1968). Studies on the control of leaf and plant hopper by submerged application with insecticides. Jap. Jour. Ap. Ent. and Zool. 12(3) : 156-163.
- Koyama, T. (1971). Lethal mechanisms of granulated insecticides. PANS. 17(2) : 198-201.
- * Koyama, T. (1971a). Improvement of chemical application for control of rice stem borer and hoppers. JANG 5(1) : 33-37.
- * Koyama, T. (1975). Studies on the diminution of insecticide application to rice stem borer Chilo suppressalis and the effect of insecticide application on the density of larvae of the rice stem borer and spiders. Jap. Jour. Ap. Ent. and Zool. 19(3) : 125-132.
- Lu, C.C., Kapoor, I.P. and Rosen, J.D. (1978). Metabolism of cytolane (Mephosfolan) systemic insecticide [(diethoxy phosphoro phenyl) dithio imido carbonic acid cyclic propylene ester] in a simulated rice field. Journal of Agril. and Food Chemistry 26(6) : 1352-1357.
- Kulhreshtha, J.L., Prakash Rao, P.S. and Rajamoni, S. (1971). Recent developments in control of insect pests of rice crop in India. Central Rice Research Institute, Cuttack. pp 329-336.
- * Kurosui, Y. (1974). Insecticidal activity of carbamate insecticide against leaf hoppers and plant hoppers. Annual report of Central Research Laboratory, Kodogaya. pp 60-65.

- Isakhsanan, P.L. and Jayaraj, S. (1976). Control of rice gall fly by water surface application of granular insecticide with special reference to timing of application. Madras agric. J. 63(10) : 299-303.
- Lalan Rai and Singh, H.K. (1977). Efficacy of two granular systemic insecticides against pest complex of rice. Pesticides 11(7) : 13-15.
- Maity, R.K., Ghosh, G.C. and Chakraborty, D.P. (1980). Studies on the evaluation and economics of some important insecticides in rice. Pesticides 14(9) : 11-14.
- Mandal, S.C. and Jha, A.K. (1976). Pest management in rice crop with particular reference to paddy stem borer (Exynorvza incertalae Walker). Proc. Seminar on Entomologicals' role in rural development, Kalyani.
- * Masuda, T. and Fukuda, H. (1970). Behaviour on and in rice plants of diazinon applied on to the surface of paddy soil. Betsuyakagaku 35(4) : 134-140.
- Mathai, S., Christudas, S.P. and Nair, M.R.G.K. (1975). Notes on field evaluation of insecticides against pests of paddy. Agril. Res. Jour. of Kerala 13(1) : 90-91.
- Mathai, S., Christudas, S.P., Pillai, K.S. and Nair M.R.G.K. (1976). Efficacy of some systemic granular insecticide in controlling brown plant hopper. Madras agric. J. 63(5-7) : 361.
- * Mondosa, S.J. (1974). Influence of pesticides on the beneficial fauna of rice. Universidad Nacional Pedro Ruiz Celis Poon 370-372.
- Michael, R.E.P.M. and Balasubramanian, M. (1976). Residue pattern of Emlax (Guinalphos) in rice. Madras agric. J. 63(5-7) : 366-368.
- Mithyantha, H.S., Agnihotradu, Ducker, A.H.A., Shetty, H.S. and Gour, T.B. (1978). Residue of carbofuran in some crops. Proc. All India Symposium on Pesticide Residues in Environment, Bangalore. 197-205.

Mitra, D.R., Raychaudhuri, S.P., Everett, T.R., Ghosh, A. and Niasi, I.R. (1970). Control of rice green leaf hopper with insecticidal seed treatment and pretransplant seedling soak. J. econ. Ent. 63(6) : 1958-1961.

Mohandas, N. and Visalakshi, A. (1978). Effect of different levels of irrigation on the uptake and persistence of phorate in rice. Proc. All India Symposium on Pesticide Residues in Environment, Bangalore. 454-456.

Murthy, K.S.R.R., Zaheduddin, S.M. and Krishnamurthy Rao, B.R. (1978). Studies on the efficiencies of cytolane with different dosage of AO 92100 against rice stem borer. Pesticides 14(2) : 13-14.

Murugan, K.S., Murugan, K.A. and Sreeramulu, V.S. (1974). Granular insecticides to control paddy stem borer. Pesticides 3(10) : 46-47.

Nagalingam and Nair, H.R.G.K. (1975). Studies on the persistence of some systemic insecticides in rice. Andhra Agri. J. 22(1-2) : 41-43.

Nair, H.R.G.K. (1978). A monograph on crop pests of Kerala and their control. Kerala Agricultural University, Trichur. 150 pp.

Narayanaswamy, P., Balasubramanian, N. and Bhaskaran, P. (1975). Studies on the persistence of granular phorate (Thimet 100) insecticide applied to rice plant. Rice Ent. Newsl. 2 : 38.

Narayanaswami, P. and Balasubramanian, N. (1977). Insecticidal control of BPH in the field. International Rice Research Newsletter. p 9.

Natarajan, K. and Chandy, K.S. (1979). Evaluation of certain insecticides against major pests of rice. Karnat agric. J. 63(3) : 196-198.

Pandian, H.R. (1975). Uptake and persistence of phorate as influenced by soil plant relationship. M.Sc. Thesis of Annamalai University.

Bathak, M.D. (1966). Application of insecticide to paddy water for rice pest control. Proc. of the Eleventh Pacific Science Conference, Tokyo. pp 108-122.

Pradhan, (1967). Strategy of integrated pest control. Indian J. Ent. 29(1) : 105-122.

Prakash Rao, P.S., Kolode, M.S., Prasanna, K.S., Varma, A. and Israel, P. (1970). Field evaluation of new insecticides applied in standing water in the control of rice stem borer. Oryza 7(2) : 113-120.

Prakash Rao, P.S., Rao, Y.S. and Israel, P. (1970a). Problems and prospects with chemical control of rice stem borer. Pedras agric. J. 63(5-7) : 369-371.

Rai, L. and Suthai, H.K. (1969). Efficacy of thimet 100 in controlling some major paddy insect pests. Plant Protection Informer. Cynamid India Ltd., Bombay, 2(1) : 1-6.

Rai, P.S. and Gouda, G. (1976). Efficacy of some granular insecticides in checking the white head incidences in rice. Science and Culture 42(4) : 230.

Raj, S.L., Morschan, Y.B. (1973). Incidence of stem borer and leaf roller on IR-8 rice as influenced by fertilization and diazinon application. Indian J. agric. Science 43 : 290-294.

Rajagopal, K. and Rajaram, K.P. (1978). Dissipation of carbofuran in rice soil. Proc. All India Symposium on Pesticide residues in Environment. Bangalore, pp 440-443.

Rajukhanna, V., Saivara, J., Ali, S.A., Subramaniam, S.R. and Krishnamoorthi, K.S. (1976). Residues of granular and foliar insecticides applied to rice. Pedras agric. J. 63(5-7) : 369-371.

Rajukhanna, K., Regaraj, R., Krishnamurthy, K.K. and Subramaniam, S.R. (1977). Persistence of phorate and carbofuran in flooded soils. Pesticides 11(1) : 14-15.

Rajukhanna, K. (1978). Studies on the dynamics of carbofuran in soils and certain vegetable crops. M.Sc.(Ag.) Thesis, College of Agriculture, Coimbatore.

COLLEGE OF AGRICULTURE
COIMBATORE

Rajukannu, K. and Krishnamoorthy, K.K. (1979). Uptake and persistence of phorate and carbofuran in IR-20 rice. IL RISO. 28 : 1979.

Rajukannu, K., Chelliah, S., Balasubramanian, M. and Vasudevan, P. (1980). Carbofuran in rice pest control. Paper presented in the Symposium on Pest Management in Rice. Tamil Nadu Agricultural University, Coimbatore.

Ramamurthy, V.V., Kumaraswami, C. and Jayaraj, S. (1977). Efficacy of water surface application of granular insecticide against the rice whorl maggot Hydrellia philippina. Pesticides 11(2) : 26-28.

Ramamurthy, V.V. and Jayaraj, S. (1977a). Efficacy of foliar and water surface application of insecticides in the control of rice leaf folder Choristoceros medinalis Guen. Madras agric. J. 54(4) : 252-254.

Ramkumar, V., Mathew, P.K. and Narayan, K.A. (1975). Evaluation of some granular insecticides for controlling paddy stem borer. Pesticides 2(10) : 39-40.

Rao, B.S. and Rao, B.H.K. (1980). Studies on the dosage and periodicity of application of granular insecticides for control of rice gall midge Grassia oryzae (Wc.) Panl. Paper presented in the Seminar on Pest management in Rice. Tamil Nadu Agricultural University, Coimbatore.

Rao, B.S. and Rao, B.H. (1977). Studies on the effect of seedling dip treatment with systemic insecticide solutions on the control of pests of transplanted paddy. Paper presented in the Symposium on Rice Research and Development, Rice Research Station, Pattambi.

Rao, P.L.H., Davi, R.C. and Prakash Rao, P.S. (1976). Recent studies on the control of rice pests. Madras agric. J. 63(5-7) : 281-287.

Saivarnaj, E., Ali, K.A. and Chandy, T.C. (1976). Insecticidal control of stem borer and gall midge in rice. Madras agric. J. 63(5-7) : 303-305.

Saivarnaj, E. and Venugopal, M.S. (1977). Studies on the control of rice whorl maggot Hydrellia assakii with special reference to the time of application of insecticide granule. Paper presented in the Symposium on Rice Research and Development. Rice Research Station, Pattambi.

Saivaranj, E. and Venugopal, M.S. (1977a). Residue pattern in rice following different doses and times of application of insecticide granules. Paper presented in the Symposium on Rice Research and Development, Rice Research Station, Pattambi.

Saivaranj, E. and Venugopal, M.S. (1978). Persistence of methosfolan in rice soils of Tamil Nadu. Proc. All India Symposium on pesticide residues in environment, p 65.

Saivaranj, E. and Venugopal, M.S. (1979). Uptake and persistence of methosfolan in rice plants under flooded conditions. Pesticides 13 (12) : 30-37.

Saivaranj, E. and Venugopal, M.S. (1979a). Control of rice stem borer Tryporyza incertulas Walk. with water surface application of granular insecticides. Madras agric. J. 66(4) : 255-259.

Saivaranj, E., Venugopal, M.S. (1980). Influence of carbofuran and methosfolan on plant growth. Paper presented in the Seminar on pest management in rice. Tamil Nadu Agricultural University, Coimbatore.

Sakai, K. (1971). The chemistry and action of Cartap. Japan Pesticide information 6 : 15-19.

Sankarapal, V.S., Dumbre, R.S. and Thanvilkar, V.C. (1980). Efficacy of some granular insecticides against rice gall midge Oraesia oryzae. Pesticides 16(12) : 9-10.

Sarma, J.N. and Singh, S. (1975). Chemical control of rice stem borer (Tryporyza incertulas Wlk.) with different formulations of insecticides applied by different methods. Plant Protection Bulletin, India, 23(2) : 33-35.

- * Sanchez, F.F., Laguarda, N.H. and Dalinger C.G. (1968). Rates and timings of Acothion and Ampithion high volume sprays and granular application of several insecticides on the control of stem borers and other insects affecting rice. Philippine Agriculturist 52(6) : 384-392.
- * Sasaba, T., Kiritani, K. and Urabe, T. (1973). A preliminary model to stimulate the effect of insecticides on a spider leaf hopper system in the paddy field. Researches on population ecology, Japan. 15(1) : 9-22.

Matpathy, Y.N. (1970). Further studies on the insecticidal control of rice stem borer and gall midge. Oryza 7(2) : 85-88

Cotnamachan, P. (1971). Bione prediction of diazinon on paddy fields as a cause of its inefficiency for controlling Brown Plant Hopper in rice fields. DANS 17(1) : 18-19.

Sethuramshan, N. and Ihe Eke, I.C. (1969). Persistence and biodegradation of diazinon in submerged soils. J. agric. Ed. Chem. 17(2) : 221-225.

Shrikla, V.G., Shrivastava, S.V., Beshmakh, P.D., Kophale, D.J., Koushik, V.V., Gangrade, G.A. and Pattadak, C.S. (1979). Evaluation of insecticides for gall midge control. International Rice Research News letter 4(7) : 21.

Srinivas, S. and Gugg, A.V. (1976). Effectiveness of granular placement of carbosulfan, phorate and sevidol on the absorption by rice plant and control of green leaf hopper. Indian J. Agric. Sci. 44(8) : 549-544.

Stevens, P.V.N. and Borg, U. (1976). Effectiveness of various thiocycalin hydrogen oxalate against various pests of irrigated rice and sugarcane. Agro Rega. Soc., Sanders Ltd., Switzerland, 555-565.

Subramanian, A. and Anubhavanathan, V.N. (1980). Recent findings in the chemical control of insect pests of rice. Paper presented in the Seminar on pest management in rice. Tamil Nadu Agricultural University, Coimbatore.

Sundaraman, D. (1980). Efficiency of granular insecticides in controlling rice pests in Goa. Paper presented in the Seminar on pest management in rice, Tamil Nadu Agricultural University, Coimbatore.

Authorland, G.S., Wang, T.A. and Archer, A.U. (1964). "Thinet. Analytical Methods for pesticides, plant growth regulators and food additives" Vol.2, 457-505, Academic Press, New York.

- * Takahashi, I. and Nagai, S. (1974). Behaviour of diazinon applied into paddy field and investigation on suitable application period. Jap. Jour. in. Ent. and Zool. 18(4) 171-176.

Thirumurthi, S. (1979). Effect of certain soil insecticides on spiders inhabiting an old field. Paper presented in the Workshop on Futurology on use of chemicals in agriculture with particular reference to future trend in pest control.

Thomas, M.J., Mathew, K.P., Abraham, G.C. and Hair, M.B.G.N. (1975). Relative systemic toxicity of some insecticides to the brown plant hopper when applied as granules in soil. Agri. Res. Jour. Kerala, 15(1) : 88-89.

Thontaduraya, T.S. and Prabhawany, H.P. (1971). Efficacy of Phorate in the control of rice leaf hoppers and plant hoppers. Indian Science Congress.

Varadharajan, G. (1980). Carbofuran a versatile insecticide in rice pest management. Paper presented in the Seminar on pest management in rice. Tamil Nadu Agricultural University, Coimbatore.

Velayutham, B., Subramanian, A. and Santhanarajan, T. (1971). Studies on insecticidal control of rice gall midge Pachydictyla oryzae W. Madras agric. J. 28(b) : 453-456.

Velayutham, B., Santhanarajan, T., Subramanian, T.R. and Subramanian, A. (1973). Life history and control of Hydrellia negaki a new pest of rice crop in Tamil Nadu. Madras agric. J. 60(3) : 210-213.

Velusamy, R., Janaki, I.P. and Jayaraj, S. (1978). Efficacy of certain insecticides as granules and foliar formulations in the control of stem borer, leaf roller and plant hopper in rice. Pesticides 12(2) : 11-14.

Venkataraman, A. and Abraham, N. Carbofuran for control of pests of rice. Madras agric. J. 66(2) : 93-95.

Venkatawamy, V. and Kalode, R.B. (1980). Effectiveness of various insecticide formulations against brown plant hopper Nilaparvata lugens. Pesticides 14(11) : 10-14.

Venkateswarulu, K., Sridharan Govda, T.V. and Sathumathan, E. (1977). Persistence and biodegradation of carbofuran in flooded soils. J. agric. Sci. Camb. 25 : 555-556.

Venugopal, H.S. and Linstinger, R.A. (1980). Dilemma for rice pest management - Carbofuran - a phytotoxic insecticide - paper presented in the seminar on pest management in rice. Tamil Nadu Agricultural University, Coimbatore.

Visalakshi, A., Senthilnarani, E., Palanisami, S. and Subandus, E. (1979). Residues of cone systemic insecticides used for rice pest control in rice main and straw. Larcon 4(4) : 333-334.

* Original not seen.

APPENDICES

APPENDIX I

LIST OF INSECTICIDES USED

Carbofuran	- 2,3-dihydro 2,2 dimethyl benzo furanyl - 7 H - methyl carbonate
Phorate	- O,O-diethyl S-ethyl thiomethyl phosphorus dithioate
Mephenfolan	- (2-diethoxyphosphoryl)-4 methyl-1,3 dithiolate
Disulfoton (Thiodaneton)	- O,O-diethyl S-2 (ethyl thio) ethyl phosphorus dithioate
Quinalphos	- O,O-diethyl-O-quinazolin-xy1 phosphorus thioate
Chlorodimethomorph	- N-(2-methyl-4-chlorophenyl) N,N' dimethyl formamidine

Summary of analysis of variance tables of mean yield per plot of insect pests and natural enemies under different insecticide treatments observed for 24 days following treatment on 2 D during first crop season

Source	df	mean squares									
		BPH	G	Grill midra	3 ma not	on boxer	leaf roller	Th s- worm	Onion- hopper	Ward bug	Spider
Block	2	83 783	4 568	0 094	0 400	0 128	0 439	0 19	2 758	515	0 345
Treatment		323	4 757	2 687	56	2 475	2 328	3 124	892	0 821	1 454
Co rol	2	444	32 657	2 753	4 757	7 424	6 853	33 287	12 784	9 537	1 578
Error	27	0 43	0 0	0 3		4 1	0 20	0 357	0 309	0 447	0 310

Level

of significant

2
d.f.

mean observed in crop
of insect pests and natural
enemies after treatment on

Source	df	SS							
		11 ml		12 ml		13 ml		Ward bug	Spider
Block	2	380	7 4			777	2	142	0 273
Treatment		450	87	87	7	88	68	737	578
Error	27	5	7	0	57	5	4 078	0 077	0 282
Total	27	5 9	0	4 4		7	2	0 533	0 651

Summary of analysis of variance on the population of plants of insect pests
and natural enemies under different treatments of insecticide from sowing to harvest
2 and 45 D after sowing

Source	df	Mean square									
		DTT	Gall midge	meat	on borers	on rollers	Cane worms	Grass hopper	Field bug	Spider	
Block	2	9 030	6 243	0 27	00	0 363	0 302	0 9	0 803	2 171	0 276
Treatments		0 020	0 46	5 633	0	3 88	4 500	3 24	4 373	2 682	1 713
Replication		5 070	30 443	3 2	38	9 253	6 88	33 201	26 483	7 303	857
Error	27	0	0		3 5	0 523	0 26	0 357	0 55	0 536	0 327

5 level
ave

Mean square of insects and natural enemies
observed for 24 days following

Mean square											
	df	DTT		Gall midge	meat	on borers	on rollers	Cane worms	Grass hopper	Field bug	Spider
Block	2	1	771	77	18	3	6 311	3 033	0 331	7 323	135
Treatments			1	1		13	2 027	2 274	773	63	013
Replication					77	3	013	2 603	5 12	4 763	2 573
Error	27				77		0	0 492	0 217	0 850	0 201

VI

Summary of a. al. bio. varians a. a. on per. t of insect pests and natural
 45 d. ag second crop a. do. or cost of treatment on

Loc. no.	d	cost of treatment on									
		D	all mid-o	in	t	on borer	co. ro. lo.	grass hopper	LBG	Spider bag	Spider
10	2		0 3	0	0 3	3 4	25 454	2 5	0 306	0 25	0 192
re do		81	55	57	55	85	6 22	0 968	0 77	708	0 710
3			5 77		5	45	0 388	85	6 728	759	2 588
				0		5	0	0 4	0 203	0 76	0 4 4

to

insect on 2 and on 2 and

cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									
cost of treatment on									

A. T. VIII

Summary of analysis of value of control of corn silage for pest pests and natural enemies under different treatments received for 24 hours following treatment on D. d. r. n. bird rop a con

Source	df	mean sq. on									
		IL	mid c	be or	leaf roller	on wa n	Grass to per	MSC	bird bug	Spider	
Mo	2	0 3 7	278	0	3 900	0 576	0 0	5 750	320	5 790	097
montan	1	937	3 001	6 233	744	900	24	3 200	500	1 000	2 320
Co rol	1	4	4 020	3 540	0	340	5 00	14 800	20 800	230	5 540
Arro	27	0 2 3	0 5	0 7	5	100	0 73	0 344	0 363	0 4 3	0 690

val
level

low
lowin
sta and not
treatment o

LSTO							
				mass	IL	bird	
				ho or		bu	
				557	0 093	368	0 0
				77	0 250	0 347	5 0
rol	0	7	50	0 249	0 977	25 900	500
				5	0 43	1 305	0 737

val
level

Summary of analysis of variance on the effect of insect pests and natural enemies under different treatments in the first and second years of the experiment.

Source	df	Mean squares									
		Total	11 mid c	10 borer	Leaf roller	1000	Grass hopper	RBC	Field bug	Spider	
Total	2	0.0	34	7	9.7	0.5	0.0	6.300	439	4.109	0.071
1st year		15	6.8	7.4	8.0	0.8	24	4.530	2.148	5.431	3.575
2nd year		14	1.2	1	7.5	3.7	31	7.05	22.247	2.256	2.454
Error	27	0		7		250	0.573	0.30	0.437	2.0	0.5

1000
1000

1000 and natural enemies
1000

Source	df	Mean squares				
		Total	11 mid c	10 borer	1000	Field bug
Total		0	7		1.4	3
1st year		3.1			3	1.43
Error	7	0			4	0.948

ABSTRACT

Field studies were undertaken to ascertain the use of insecticides in controlling the various pests of paddy when applied as granules in soil. The insecticides used for these studies were carbofuran, phosato, methiofene, disulfoton, quinalphos and chlorodan which were used at two graded concentrations of 0.5 and 1.0 kg ai/ha, 1.0 and 2.0 kg ai/ha, 0.5 and 1.0 kg ai/ha, 1.0 and 2 kg ai/ha, 1.0 and 2.0 kg ai/ha and 1.0 and 2.0 kg ai/ha respectively. To study the relative efficacy of these insecticides a field experiment was laid out adopting randomized block design. The insecticides were applied at two occasions viz. 21 DAT (days after transplanting) and 45 DAT. The results were assessed by observing the effect of the treatments on the population of various pests as a result of the application at 21 DAT and 45 DAT separately and of the two combined treatments. This experiment was undertaken during three seasons viz. vizirpu (May to September), mundam (September to January) and punchu (January to May). The persistent toxicity of the insecticides to BPH (Brown Plant Hopper), RSC (rice awarming caterpillar), and leaf roller caterpillar was assessed by applying the treatments in pots in which the plants were

raised and exposing the insects on them. To study the effect of different frequencies of application of the insecticide granules on the control of paddy pests field experiments were laid out and insecticide granules applied at 21 DAT only, 45 DAT only and at both the occasions; the experiment was repeated in three seasons. Effect of two levels of irrigation vis. field capacity level and water level at 2.5 cm, on the uptake and persistence of the insecticide in the plants was ascertained by exposing BPH and rice swarming caterpillars on the treated plants at different intervals following the applications. Residues of the insecticides when applied at 21 DAT only, at 45 DAT only and at both the occasions, remaining in straw and grains were estimated by bioassay technique.

Carbofuran when applied as granules at 0.5 and 1.0 kg ai/ha gave effective control of BPH, GLH (Green Leaf Hopper), whorl maggot, stem borer, leaf roller, caseworm, grasshoppers and rice swarming caterpillar. Gall midge control was effective only at its higher dose. The mite and spider populations showed reduction by this insecticide. Thiomate at 1.0 and 2.0 kg ai/ha gave effective control of BPH, GLH, gall midge and whorl maggots and rice swarming caterpillars. Predators were adversely affected. Mephosfolan at 0.5 and 1.0 kg ai/ha showed effective control of

gall midge, whorl maggot, stem borer, leaf roller, grasshoppers and rice swarming caterpillar. Predators were not affected. Disulfoton could show effective control of BPH and GH and to some extent of grasshoppers and rice swarming caterpillars; the predators were not affected. Quinalphos did not appear to be effective in the control of the major pests though some control was given for whorl maggot and caseworm. Chlorodimethoate was especially effective against the caterpillars including stem borer, leaf roller and rice swarming caterpillar.

Carbofuran showed maximum persistent toxicity to BPH followed by chlorodimethoate, phorate, methidathion, disulfoton and quinalphos. To rice swarming caterpillar maximum persistent toxicity was shown by methidathion followed by carbofuran and chlorodimethoate. To leaf roller caterpillars carbofuran showed the highest persistent toxicity followed by methidathion, chlorodimethoate, phorate, quinalphos and disulfoton.

A single application of carbofuran at 21 DAP, at a dose of 1 kg ai/ha gave effective control of WBH (White Leaf Hopper), GH, BPH, caseworm and whorl maggot. Application at 45 DAP showed control of leaf roller and rice bug. Two applications at 21 and 45 DAP showed

effective control of stem borer and gave the maximum increase in the yield up to 93.25%. A single application of phorate at 2 kg ai/ha at 21 DAT controlled WIG, GH, whorl maggot and caseworm effectively. Two applications of phorate gave additional control of gall midge infestation. Mephosfolan applied at 1.0 kg ai/ha at 21 DAT gave effective control of leaf roller and stem borer; application at 45 DAT also gave good control of leaf roller while for gall midge control two applications were needed. The increase in yield also was more (up to 91.35%) when there were two applications of mephosfolan.

In general the absorption and persistence of insecticides were more efficient at the field capacity level of irrigation than at a water level of 2.5 cm. All the three insecticides viz. carbofuran, phorate and mephosfolan left residues within straw and grains whether applied on single occasion or on both the occasions. Residues were below the tolerance limits in the case of carbofuran while it was above the tolerance limit of zero in the case of phorate.