STUDIES ON INSECT PESTS AND DISEASES OF RICE EARHEAD AND THEIR CONTROL

By
ANNIE THOMAS

THESIS

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DECLARATION

I hereby declare that this thesis entitled "Studies on insect pests and diseases of rice earhead and their control" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

ANNIE THOMAS

Vellayani,
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CERTIFICATE

Certified that this thesis entitled "Studies on insect pests and diseases of rice earhead and their control" is a record of research work done independently by Smt. ANNIE THOMAS, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to her.

P.A. RAJAN ASARI
Chairman
Advisory Board
(Assistant Professor of Entomology)

Vellayani,
28-11-1987.

Approved

Chairman:

Sri. P.A. RAJAN ASARI.

Members:

1. Dr. N. MOHAN DAS.

2. Dr. JOHN KURIYAN.

4. Dr. M. CHANDRASEKHARAN NAIR.

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C O N T E N T S

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

INTRODUCTION

INTRODUCTION

The increasing demand for rice led to the introduction of modern agricultural technologies like use of high yielding varieties and improved crop husbandry practices. The introduction of high yielding varieties and the use of optimum dose of fertilizers for maximum production had been conducive to pest build up. Crop losses by pest can be prevented by various methods and the control using insecticides have great impetus on rice production. However irrational use of pest control chemicals have resulted in problems like pest resurgence, residues on food and environment, destruction of natural enemy complex and even grain setting due to sterility caused to pollen. Many chemicals used during the flowering stage cause deleterious effect on pollen and thereby grain setting. A host of pests and diseases invade the rice inflorescence and earhead and the control strategy becomes difficult. To get an idea of the pest and disease infesting the rice inflorescence, a random survey on the incidence had been taken up. It becomes very difficult to identify the pest involved by observing the nature of damage especially in mixed infestations. Hence the nature and extent of damage caused by various pests and also the biology of new pest were studied.

The pest and disease problems have to be tackled with the least deleterious effect on the inflorescence. Hence the present investigation has been carried out to choose the best pesticide with the least deleterious effect at flowering stage of rice.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Several species of insects infest rice during the flowering stage causing considerable reduction in yield. The information available on the type of insect pests and diseases affecting rice earhead, nature and extent of damage caused by them and the biology of pests and etiology of disease, as also control of pests and diseases using pesticides and gametocidal action of plant protection chemicals are briefly reviewed here.

1. *Leptocorisa acuta* (Thunb.) Rice bug (Hemiptera : Alydidae)

A. Investigation on the incidence of rice bug

The incidence of rice bug infestation on rice earhead was reported by Flectcher (1913a) from South Kanara, Madras, Briggs (1920) from Guam Agricultural Experimental Station, Hutson (1920) from Ceylon and Vandenberg (1927) from the Island of North Western Guam. Corbett (1930a) had observed in Malaya that *L. acuta* migrated from various grasses to rice at the flowering stage.

Hutson (1930) observed that the prevalence of *L. acuta* was due to its ability to survive periods when food was scarce and delay oviposition until favourable breeding conditions prevail and to the fact that the pest infested the maturing rice from the flowering stage onwards. The severity of attack was comparatively slight when large areas were sown with varieties of rice that flowered and ripened simultaneously.

Jepson _et_ _al_. (1930) reported irregularity of infestation of rice that occurred in adjacent fields in the same or successive seasons and observed that plants that flowered before or after the main crop season were liable to concentrated attack.

Dresner (1955) reported that though rice in small flooded plots were attacked by _L_. _acuta_ the pest was most injurious in nonflooded plots. Shujaat ul Akbar (1958) reported _L_. _varicornis_ as a major pest of rice near Aligarh.

Sen and Chaudheri (1959) observed that rice gundhy bug, _L_. _varicornis_ was a major pest of rice in India, feeding on developing grains during both the nymphal and adult stages.

Ahmad (1965) recorded _L_. _varicornis_ as a major pest of rice in Far East, particularly India, Sarawak and New Guinea. _L_. _varicornis_ is a synonym of _L_. _acuta_, the range of which extended from India in the west to Samoa, New Caledonia and Fiji in the east, though it was not known in Java and Ceylon. _L_. _acuta_ had in the past been misidentified as _L_. _oratoria_, of which the distribution extends westward to Ceylon, northwards to Malabar, East Pakistan, Bhutan and Tibet, eastwards to Solomon Is and southwards into North Queensland. L. acuta, L. oratoria and L. chinensis, which occur in Bhutan and China in the north to Sumatra in the south and Malaya in the east, and L. corbetti in China are synonyms, for a group of rice pests widely distributed in the Far East.

Banerjee and Chatterjee (1965) reported that in northern Bengal, L. acuta which normally attacked rice, after harvest developed on millets, grasses and wild rice, and over-wintered on forest trees, returned to rice when the new grains were at the milky stage.

Misra (1968) reported that infestation of rice by L. acuta reached its peak during September at Kanpur in the Indian State of Uttar Pradesh. Four overlapping generations of this pest were recorded on the growing crop during the active period.

Chakrabarti et al. (1971) reviewed the pests and disease incidence of High Yielding Varieties of rice recently developed or introduced into India and reported the occurrence of L. acuta.

Diwakar (1975) reported the occurrence of L. acuta in different parts of India.

Banerjee and Chatterjee (1982) reported _L. acuta_ from the hilly areas of Darjeeling districts, where the crop is grown on bench terraces up to an altitude of 1335 m. The bug destroyed 25 to 35 per cent of panicles.

Dyck _et al_. (1983) reported that the economic injury level was apparently three bugs per square metre for _Leptocorisa_ spp.

B. Nature and extent of damage by Rice bug

Flectcher (1913a) reported that rice bug _Leptocorisa_ well known as 'Bambuchu' did great damage to paddy crop by sucking out the milky juice of the younger grains, so that no proper grain is formed. It was also observed that the bugs fed on the seed of wild grains also.

Hargreaves (1936) from Sierra Leone reported that _L. apicalis_ was injurious to rice ears in the milk stage.

Lever (1939) observed that _L. varicornis_ which was found in Fiji on grasses, occasionally injured rice by sucking the sap from the grains when they were in the milky stage of ripeness.

Fernando et al. (1958) reported that L. varicornis was the most important insect pest of Ceylon and it migrated from wild grasses to rice in flower and destroyed the freshly set grains.

Rothchild (1970) observed the feeding rate of adults of L. oratoria on rice under field and insectary conditions in Malayasia. An average of four fully milkripe grains were probed by an adult per day but this increased to nearly eight per day when the ears were at the early post flowering stage. There was a positive correlation between the number of grains in any one ear and the number of attacks, but only ten per cent of the available grains were attacked. Grains attacked at the fully ripe stage were able to produce only 40 to 60 per cent of their normal endosperm content.

Vasantharaj David and Kumaraswamy (1975) reported that L. acuta was the most important pest of rice throughout India generally appearing before the flowering stage and continuing up to the milk stage. Both adults and nymphs fed on the sap of peduncle, tender stem and milky grains making them turn chaffy. Apart from rice it bred on various grasses.

The insects fed on developing grains during the day especially in the early morning and dusk or when the sunlight was not intense. Grain that was soft and milky was vulnerable to attack. During the hottest part of the day the insect could be found sheltering itself on the underside of leaves. As a result of feeding panicles might bear partially or entirely empty grains. Brown spot occurred where the insects had fed. In addition the grain might smell unpleasant when bulked and lowered the market value. The presence of the bugs in the field was indicated by the characteristic smell (Anon., 1976b).

Mohuiddin *et al*. (1976) reported from India that *L. acuta* acted as a vector for the transmission of *Xanthomonas oryzae* the causal agent of bacterial rice leaf blight.

Nair (1978) had reported that *L. acuta* was present in all rice growing tracts of India. The adults fed by sucking the milky contents of tender grains which later turned chaff. The infested crop showed the presence of many such chaffy grains on the earheads. Such earheads stood erect unlike the normal bend ones. The damage by the bug caused up to 30 per cent loss in the yield. The adults appeared in the fields when the earheads were in the milky stage and disappeared when the grains hardened. Apart from rice the insect fed on various types of grasses, cocoa and clove leaves.

C. Biology

Corbett (1930b) reported the bionomics of rice bug from Malaya. Oviposition occurred mainly at dusk, the egg being deposited in two regular rows on the upper surface of the leaf, but in some cases on the lower, towards the apex, which frequently became rolled. The average number laid by a female was about 100. Under laboratory conditions the eggs were first laid nine to 41 days after females had attained the adult stage, and total egg laying period ranged from eleven to 60 days. The eggs of all species of Leptocorisa hatched in about seven days and the nymphs began to feed three to four hour after hatching. The nymphal periods of L. acuta, L. corbetti, L. varicornis and L. lepida were remarkably similar with an average total of about three weeks.

Shujaatul Akbar (1958) reported that in the laboratory the eggs hatched four to five days during July to September ıd in five to six days during October to December mostly t night. There were five nymphal instars lasting three to our, two to three, two to three, four and five days respectively, at maximum temperatures of 88 to 101°F, minimum emperature of 66 to 74°F and 65 to 75 per cent relative umidity. The adult males and females lived for averages f 33 and 55 days, with maxima of 50 and 104 days respectively. . varicornis bred freely on wild grasses in June to July and igrated to rice in July to October, but sheltered on the ower parts between ten A.M. and four P.M. In November to ecember it became active in the late morning. Flights were short especially those by males. The adults were inactive between December and March and the absence of suitable food plants usually prevented much activity until April to June. Eggs and nymphs did not survive the winter.

Vasantharaj David and Kumaraswamy (1975) reported that the female laid 250 to 300 eggs on leaf blades in long rows of ten to 25 eggs and the incubation period was a week. The slender greenish nymphs became adult in two weeks. The longevity of the adults was three to four months.

Nair (1978) reported that the female bug laid eggs on the leaves in rows of ten to twenty. The eggs were reddish brown, two mm long and somewhat boat shaped. The eggs hatched in about a week. The nymphs were elongated and green or yellowish-green in colour. They fed on the juice of the leaves and stems of rice and passed through five instars to become adults in two weeks.

Domingo et al. (1982) studied the life cycle of L. oratorius, on potted rice plants in the green house in the Philippines at 20.5 - 34.3°C (average 27.4°C) and 63 to 93.8 per cent relative humidity (average 81 per cent), the eggs hatched in six to nine days (average 7.5 days) and the five nymphal instars together lasted nineteen to 22 days (average 20.5 days). The preoviposition period lasted nine to 25 days (average fifteen days). Adults lived for 26 - 134 days (average 80 days). Gravid females laid eggs in single or double rows on the leaves of potted plants at the late booting stage rather than at the stage of milky ripeness. A few eggs were laid on the panicles.

D. Control using insecticides

Calora (1956) reported that application of insecticides viz. parathion, tetra ethyl pyrophosphate (TEPP) and toxaphene was followed by the reduction in the percentage of panicles injured by L. acuta and increase in yield, but none of the difference was significant. There was no insecticide damage to the plant at the time of application but the leaves of the treated plants yellowed more rapidly than untreated ones, when the rice was in the late dough stage. In the laboratory parathion gave complete mortality of nymphs and adults of L. acuta in 72 and 48 hours respectively, whereas TEPP and toxaphene killed twelve and nineteen respectively of 30 nymphs in 72 hours and 28 of 30 adults in 68 hours. Surviving nymphs transformed to adults in 96 hours. All the insecticides repelled both nymphs and adults. All insects fed to some extent on treated plants and adults laid eggs.

Fernando et al (1958) in Ceylon studied the resistance to benzene hexachloride of the rice bug L. varicornis and its insecticidal control. Large populations of Leptocorisa developed resistance especially when flowering season was prolonged and the whole crops were seen destroyed. The use of dust containing γ BHC (0.35 per cent) has been recommended since 1947 but these have given inadequate control and the causes were investigated during 1954-56. In the laboratory tests adults collected from areas in which BHC had been applied every season for atleast eight years, applied for a few years, or not applied at all, were all treated topically with γ BHC in acetone. The results showed that strains resistant to γ BHC had developed, the LD_{50} values varying from 0.0209 g per adult for bugs from two untreated districts to 0.139 g for those from a continuously treated area surrounding high forest. In similar tests, endrin, dieldrin, isodrin, malathion and diazinon were all less effective than γ BHC. In field trials, 1.5 per cent endrin or 0.65 or 1.3 per cent γ BHC as dust gave complete kill.

Sen and Chaudheri (1959) reported that by dusting with five per cent BHC or aldrin at 20 lb per acre gave good control of rice bug in India.

Kalode _et al_. (1969) reported that in a comparative test of the residues from nine insecticides applied in sprays at 0.05 per cent for the control of _L. acuta_ on rice in Orissa, all the products afforded over 57 per cent mortality when deposits were two hour older, but most lost their toxicity to a great extent after 24 hour with the exception of fenthion and phosphamidon, which gave 94.4 and 66.6 per cent mortality respectively after 48 hour.

Vasantharaj David and Kumaraswamy (1975) have reported that dusting BHC ten per cent and repeating the application depending upon the severity of infestation afforded protection against infestation of rice bug.

Recommendations for chemical control of rice bug include chlorfenvinphos 1 to 1.5 kg ai/ha, Dichlorvos 0.3 to 0.5 kg ai/ha, Dicrotophos 0.25 to 0.5 kg ai/ha, Fenthion dust 0.6 to 1.2 kg ai/ha, Monocrotophos 0.5 kg ai/ha, Phenthoate 0.5 kg ai/ha (Anon., 1976b).

In severe cases of incidence of the pest, insecticides useful for the control were sprays of carbaryl and methyl parathion and dusts of BHC and malathion (Nair, 1978).

Jain et al. (1980) conducted trials on the residues of insecticides in rice and reported that insecticide granules of five per cent disulfoton and ten per cent phorate at the rate of 1.5 kg ai/ha applied after seven days of transplantation in the wet field, 0.1 per cent malathion, 0.05 per cent fenitrothion, 0.05 per cent chlorpyriphos, 0.07 per cent endosulfan, 0.1 per cent lindane at the rate of 500 litre per hectare applied at the time of ear emergence were equally effective for the control of rice bug. There was cent per cent mortality within an hour of application and no build up of population was noticed up to the tenth day.

Heinrichs et al. (1982) tested numerous insecticides in the Philippines for the control of *L. oratorius* on rice. Adult females two day old, were confined on panicles that had been sprayed a day before with insecticides applied at manufacturers recommended doses. Mortality was recorded after 48 hour. The effective treatments were 0.05 per cent monocrotophos, a mixture of monocrotophos and mevinphos 0.06 per cent spray, 0.07 per cent phosphamidon, 0.20 per cent diazinon, 0.09 per cent acephate, 0.07 per cent triazophos, 0.05 per cent fenitrothion, 0.12 per cent carbaryl and 0.03 per cent primicarb.

Argente and Heinrichs (1983) carried out studies in Philippines on the correlation between insect mortality and insecticides residue levels in rice grain during the development of the crop and at harvest and to determine the relative toxicities of monocrotophos, lindane and carbaryl to the alydid L. oratoria. Monocrotophos was the most effective compound against the pest, while lindane gave control for only one day and carbaryl was ineffective.

Pillai et al. (1983) reported that carbosulfan and deltamethrin maintained Leptocorisa population at significantly low levels up to 23 days after application and throughout the season respectively. The pest infested the crop only from the ninth day onwards after the treatment and the incidence was very low. However on the ninth day the population was significantly low in plots treated with carbofuran, carbosulfan and carbaryl when compared to the control plot. On the sixteenth day carbofuran had no effect on rice bug while carbosulfan and carbaryl continued to be effective. It was observed that on 30th day none of the insecticides were able to reduce the pest population, but carbofuran had induced the pest multiplication, while carbaryl and carbosulfan exhibited no effect. Carbosulfan could also maintain the population of rice bug in significantly low level up to 23 days after application. Deltametrin could maintain a low population level throughout the season.

2. Menida histrio (Fb.) Red Spotted Earhead Bug (Hemiptera : Pentatomidae)

A. Investigations on the incidence of Red Spotted Earhead bug

Flectcher (1913b) reported that M. histrio was found throughout southern India as a minor pest of paddy and also of wheat, cholam and pulses.

Esaki (1926) reported that pentatomid M. histrio infested rice in Formosa. Grist and Lever (1969) reported that the pest was recorded from Ceylon, Pakistan, India, Nepal, Burma and Malaysia as a minor pest of paddy, wheat and pulses.

Rai (1982) reported that M. histrio was found damaging the rice grains during the kharif season around Mangalore.

B. Nature and extent of damage by Red spotted earhead bug

Grist and Lever (1969) reported that the damage was caused to the ripening grain as a result of bug sucking the sap during development.

Vasantharaj David and Kumaraswamy (1975) reported that the brownish earhead bug *M. histrio* was feeding the sap from the rice panicle.

The dark brown nymphs and the adults were seen infesting the earhead. The extent of damage caused by this bug to the earhead and the grains had not been understood (Nair, 1978).

Rai (1982) conducted studies on the damage caused by the bug to rice crop and found that the bugs suck sap from the developing grains resulting in half filled and chaffy grains.

3. *Haplothrips ganglbaueri* (Schmutz) Cereal thrips
   (Thysanoptera : Phlaeothripidae)

Corbett and Pagden (1941) from Malaya reported that healthy rice with empty glumes was found to be heavily infested by *H. ganglbaueri*.

Grist and Lever (1969) reported that *H. ganglbaueri* was found feeding on rice grain heads from Malaya, Indonesia and New Guinea.

Chaudhery and Ramzan (1971) reported for the first time that H. ganglbaueri was numerous on the IR-8 and TN-1 varieties at Punjab Agricultural University Farm, Ludhiana, in the ear bearing stage of the crop in October 1967.

Abraham et al. (1972) reported that the adult and nymphs of H. ganglbaueri as a serious pest of developing rice panicles in Trichur and Palghat districts during the second crop season of the year 1971-72 (August-September to January-February) on IR-8 and Jaya varieties. The incidence of the pest was relatively more serious in the first fortnight of December and the observations taken from the infested fields in the peak period of the activity of the pest have indicated numerical preponderance of the nymphs in the population estimated at 90 per cent.

H. ganglbaueri was known in India, Pakistan and Sri Lanka mainly as a pest of rice, but over 30 other food plants are recorded for it (Ananthakrishnan and Thangavelu, 1976), one of the most important was found during the studies in India in 1974-76 to be Echinochloa crusgalli which grows abundantly almost throughout the year and permitted a build up of Haplothrips populations in November, a corresponding examination of the rice inflorescence indicated increasing infestation from late November onwards, and it appeared likely that *H. ganglbaueri* migrated from the weed to rice in November-December.

H. aculeatus was studied in the Fukien Province of China in 1974-75 and was reported to be less injurious to rice but was usually abundant on wheat and sorghum (Anon., 1976a).

B. Nature and extent of damage caused by Cereal thrips

Chaudhery and Ramzan (1971) reported that chaffy grains were produced because of the continuous withdrawal of the sap from the emerging ears by the thrips *H. ganglbaueri*.

Abraham *et al*. (1972) found out that nymphs and adults were seen to cluster on flower buds, lacerating and feeding on the lemma, palea and ovarian tissues. The feeding damage on the lemma and palea caused development of irregularly oval diffused and brownish patches on the surface of the grains.

Nair (1978) reported that the thrips were more abundant in the field during the first fortnight of December. The damage was caused by the nymphs and adults lacerating and feeding on lemma, palea and ovarian tissues. Irregularly oval and diffused brownish patches developed on the lemma and palea due to thrips damage.

Vidyasagar and Kulshreshtha (1983) reported that the damage caused by H. ganglbaueri in Cuttack was of three types comprising early attack on the inflorescence, before the spikelets opened, resulting in light brown spots with perforation at the tip, larval feeding on the ovarian tissue during flowering causing drying and eventual whitening of spikelet and oozing of 'milk' over the grains in the earhead without external feeding marks. The presence of H. ganglbaueri in Orissa, and eastern India was recorded for the first time.

C. Control using Insecticides

Chaudhery and Ramzan (1971) reported that application of malathion 0.5 kg and γ BHC at 0.3 kg/ha in emulsion sprays and carbaryl at 0.5 kg/ha caused significant reductions in cereal thrip population.

Abraham et al. (1972) reported that pest outbreaks were successfully controlled by low volume application of phosphamidon applied at 400 g ai/ha.

Nair (1978) reported that the pest could be controlled by application of systemic insecticide like phosphamidon.

4. <u>Alesia</u> <u>discolor</u> (F.) Leaf/ear-eating beetle, Coccinellid beetle (Hemiptera : Coccinellidae)

Grist and Lever (1969) reported that <u>A</u>. (<u>Micraspis</u>) <u>discolor</u> caused injury to pollen in rice.

Vasantharaj David and Kumaraswamy (1975) reported that <u>A</u>. <u>discolor</u> fed on pollen in rice

5. <u>Tetroda</u> <u>histeroides</u> (Fab.) Striped bug (Hemiptera : Pentatomidae)

A. <u>Investigations on the incidence of striped bug</u>

Flectcher (1913b) reported that <u>T</u>. <u>histeroides</u> has been found at Salem and Coimbatore as an occasional minor pest of paddy.

Duport (1913) reported that rice was attacked by a pest called <u>T</u>. <u>histeroides</u> which feed on grains.

Krishna Ayyar (1929) reported that <u>T</u>. <u>histeroides</u> occurred on rice in Madras in July 1929. It had been known as a minor pest of rice for a number of years and the sudden increase of the pest was due to the practice of growing five crops in two years.

Grist and Lever (1969) reported that <u>T</u>. <u>histeroides</u> was a pest of rice in Pakistan, India, Cambodia, Vietnam and Malayasia.

Nguyen Cog Thuat (1982) reported *T. histeroides* on rice from Vietnam.

B. Nature of damage caused by Striped bug

Duport (1913) reported that *Tetroda* feeds on rice grain.

Krishna Ayyar (1929) described the nature of damage caused by striped bug. The fields presented a characteristic yellowish brown dried up appearance and although the crop was very young it looked from a distance as if it was ready for harvest. There were a few fields in the neighbourhood which were only just begun to receive the attention of the pest and there the gradual process of destruction could be easily made out in different stages. The first affected portions of the plants were the outer leaf sheaths which turned yellow and dried and later the plant died. When the plants in an area had been sucked dry, the bugs flew in quest of fresh green fields.

6. *Nezara viridula* Linn. Green vegetable bug, Southern green stink bug (Hemiptera : Pentatomidae)

Frogatt (1939) reported that the bug *N. viridula smaragdula* attacked the seed head and seeds of rice.

Corperz (1969) reported that in the field N. viridula was found on cabbage, rice, maize, okra (Hibiscus esculentus), beans, and citrus.

The pest N. viridula was found wherever rice was grown but did not always attack rice (Anon., 1976b).

Tomokuni (1981) reported that N. viridula had appeared to spread in relation to cultivated crops such as rice and citrus.

B. Nature of damage caused by Green vegetable bug

Grist and Lever (1969) reported that N. viridula infested rice by sucking sap from stem and developing grains.

Lim (1970) reported from Malayasia that severe damage was caused to rice crops, the affected plants shrivelled, unfilled grains were usually covered with brownish spots and fungal growth, when enclosed in a cage with the whole rice plant at the milky stage of the development.

7. Sitophilus oryzae Linn. Rice Weevil (Coleoptera : Curculionidae)

Flectcher (1913b) reported that Calandra oryzae the rice weevil, could scarcely be considered a pest of rice although occasionally found in the field on ripe earhead, but was a serious pest of stored rice.

Kawano (1939) observed that females of C. oryzae oviposit more commonly on the middle part of a grain of rice than near or at the ends.

Two species of rice weevils have been confused under the name S. oryzae, large one and small one. Since the Linnaean specimen have apparently being lost, it was uncertain to which extent it was to be applied. European workers have in general applied to smaller one, and Japanese workers to the larger one, and authors accept the latter view using the name S. oryzae (with synonyms S. zeamais Motsch and C. oryzae var. platensis Zacher) for the larger one and S. sasakii (Tale) for the small one for which the common "lesser rice weevil" is proposed (Floyd and Newson, 1959).

Kiritani (1959) reported that in Japan, S. (Calandra) oryzae infested standing crops in the fields, whereas S. (C.) sasakii (small rice weevil) had not and was restricted to stored cereals.

Saradamma and Nair (1973) reported the effect of pre-harvest application of insecticides on the infestation of stored rice by S. oryzae. Damage assessment after three months of storage showed that 0.2 per cent carbaryl gave the best protection.

Vasanthraj David and Kumaraswamy (1975) reported that S. oryzae infested the grain, both in storage and field.

Both S. oryzae (rice weevil) and S. zeamais (maize weevil) (formerly known as the small and large strains of rice weevil, (Calandra) oryzae respectively) were of some minor importance as pests of paddy and rice. S. oryzae was in fact the most serious pest of milled rice. Although both the species might be found in store, there was some indication, in view of its pronounced flight activity, that S. zeamais is largely responsible for preharvest infestation (Anon., 1976b).

Sudhakar and Pandey (1983) carried out laboratory studies in India and showed that raw rice grains were preferred to parboiled ones for oviposition and development by S. oryzae . The development was longer in parboiled than in raw rice. Of ten varieties tested Mashuri, Ratna and Jaya were most susceptible when raw and Jaya and IR-24 when parboiled.

8. Aulacophora foveicollis (Lucas), A. stevensi (Baly.) Pumpkin beetles (Coleoptera : Chrysomelidae)

Grist and Lever (1969) reported A. foveicollis from Vietnam. They also reported that A. olivieri and A. hilaris were normally pumpkin pests but fed on growing rice heads in New South Wales.

9. Monolepta signata (Oliv.) Flea beetle (Coleoptera : Chrysomelidae)

Grist and Lever (1969) reported M. bifasciata as a major pest of rice feeding on pollen in Philippines and Malaya. They also reported that M. signata was a pest of rice in Nepal.

10. Eusarcocorris ventralis (Thunb.) Stink bugs (Hemiptera : Pentatomidae)

A. Investigations on the incidence of Stink bugs

Maxwell-Lefroy and Howlett (1909) reported that Eusarcocorris included small bugs of rounded form similar to Coptosoma with the scutellum rather large and prominent. These were found on plants. E. guttiger and E. ventralis were the common plain species.

Flectcher (1914) reported that the main food plant of E. ventralis was gingelly and was found as a serious pest distributed in Ganjam (Bangalore district). E. guttiger was distributed throughout the plains of Southern India and food plants included cumbu (Pennisetum typhoideum), and was a minor pest of cumbu. The life history of the pest was not known.

Yang (Hung-ju) (1935) reported that stink bug E. guttiger fed on various graminaceous plants and was usually distributed in South and East Asia. It caused considerable injury to rice in Chekiang.

Grist and Lever (1969) reported that E. guttiger as a pest of rice from many parts of Asia including India.

Vasantharaj David and Kumaraswamy (1975) reported that the pest was seen infesting gingelly.

B. Nature and extent of damage caused by stink bugs

Yang (Hung-ju) (1935) has reported the nature of damage caused by stink bugs. The bugs fed on grains and sometimes on the leaves and stems, retarding the growth of the plant. The infestation on the grains led to the formation of seedless spikes.

Grist and Lever (1969) reported that the stink bugs extracted sap from the rice stems and immature grains thus adversely affected the growth of the plants and the development of grains.

C. Biology

The biology of the bug was studied by Yang (Hung-ju) (1935). Hibernation occurred in the adult stage. In the laboratory, females laid 20 to 100 eggs in batches of ten or more in the ears or tips on leaves of rice. The nymphs had three instars, each lasting three to four days in hot weather and four instars, each lasting about 20 days in cold weather. The adults were not attracted to light and always hid in the darkest parts of food plants. They lived for about one to two weeks in summer.

Grist and Lever (1969) reported that the irregularly shaped egg mass contained about ten eggs; the total laid per female varied from 20 to 100. Adults hibernated near roots of grasses or under leaves for periods of 180 days, but lived afterwards for only one or two weeks. This insect was photophobic, hiding in the most shaded parts of the plants, and so would not be attracted towards light traps.

11. Hysteroneura sp. Plum-peach aphid (Hemiptera : Aphididae)

Orlobb and Medles (1961) reported that Carolinaia (H. setariae) fed on a single species of grass and did not colonise cereals in the field.

Raja Singh (1968) reported that the plum aphid (H. setariae) was an American emigrant and had been living exclusively in the new world. Its main host was plum tree but in summer it attacked all grain crops like wheat, oats, barley, etc. Now it was found to affect rice, sorghum, Italian millet and others. It was noted first in Madras, a comparatively warm place. Further, it had spread out widely in South India in the plains as well as hills and had been found in the eastern sections of Himalayas in Kalimpong and Shillong. The diagnostic features of this aphid were, (1) small brown aphid with brown antennae and cornicles and a pale cauda, (2) the last segment of the antennae had a short base and a long process, (3) the hind wing in the winged form had only one oblique vein instead of the usual and (4) the cauda had two pairs of hairs. It lived throughout the year by producing males. Unlike leaf or root feeding aphids, it lived on grains sucking out the vital juice. The presence of the aphid was luckily being indicated by the black ant which lived in close association with the aphid. Attempts should be made to trace out the aphids in the developing earhead of the grain crops and control measure adopted with insecticides like BHC, endrin, a systemic insecticide.

Garg and Sethi (1978) studied the seasonal incidence of *C. setariae* infesting paddy in Delhi, in 1975-76. Aphid activity occurred throughout the year, reaching a peak at the flowering stage of the crop. It was suggested that control measure should be taken at the time of flowering and that grasses growing near the crop that harbour the pest outside the growing season should be avoided.

Mandal *et al*. (1978) reported that different morphs of *H. setariae* include apterous and alate viviparous females, apterous oviparous females and nymphs. Host plants included *Cynodon dactylon*, *Hordeum vulgare* and many unidentified grasses.

12. *Lygaeid*

Grist and Lever (1969) reported that the Lawn Chinch Bug, *Blissus insularis* caused shrivelling of the leaf blades sometimes giving the crop a burnt appearance, it also injured the nodes and leaf sheaths resulting in empty panicles which remained upright instead of being pendant; fields so attacked appeared white. *B. saccharivorus* Okaj. attacked sugarcane as well as paddy. *Paromius longulus* Dall. attacked rice and strawberry plants. Damage resulted in the so called 'pecky rice'.

Kisimoto (1983) reported the damage caused by rice stink bugs and their control. It included eight pentatomids, two mirids, two lygaeids and a coreid, an alydid and a rhopalid were the main species causing pecky rice grain there.

Gametocidal action of Insecticides

The gametocidal action and phytotoxic effects of insecticides and fungicides are briefly reviewed here.

Visalakshi and Nair (1970) studied the gametocidal action of insecticides on rice pollen. In order to ascertain the direct effect of insecticides on the pollen grains it was brought into direct contact with insecticides such as endrin and parathion and their viability tested using the acetocarmine staining methods of Zirkle (1937). In the case of pollen treated with parathion the bursting resulted in internal contents coming out of the pollen on all sides and getting distributed all around. In the pollen treated with endrin, the bursting took place only at one point and internal contents coming out only at a point.

Visalakshi et al. (1976) studied the effect of application of pesticides on grain setting in rice. It was seen that among contact insecticides and fungicides under trial, BHC, quinalphos and Hinosan have reduced the grain setting significantly, the percentage of grain setting being 56.7, 55.4 and 45.1 respectively. The effect of time of application of pesticides on grain set was significant; pesticide application at twelve noon had given significantly more suppression in grain set than application at ten A.M. and eleven A.M. Among the three systemic insecticides applied as granules, mephospholan and carbofuran had suppressed the grain weight significantly, while suppression of grain weight by phorate was not significant.

Sheath blight

The control of sheath blight using fungicide Hinosan and insecticides are briefly reviewed here.

i. Fungicides

Kannaiyan and Prasad (1976) conducted studies on the efficacy of certain fungicides and reported that

Benlate gave best control of the disease caused by *Corticium sasakii* followed by Hinosan.

Mathai and Nair (1977) reported that Hinosan was better than six other fungicides in reducing sheath blight intensity and increasing yield.

Varma and Menon (1977) reported that Kitazin granule was the most effective in reducing *C. sasakii* infection followed by aureofungin and Hinosan. Hinosan however was significantly better than all except kitazin granule, in increasing yield.

Jaganathan and Kannaiyan (1978) conducted field evaluations against *Thanatephorus cucumeris* in 1976-77 and showed that three sprays at ten days intervals (during maximum tillering) with Hinosan (edifenphos), Kitazin (IBP), Cuman-L or Bavistin (carbendazin) provided good protection.

Mukherjee (1978) reported that Bavistin 50 WP and Hinosan 50 EC gave best control.

Nair and Rajan (1978) reported that in field trials significantly lower scores of sheath blight (*C. sasakii*) were obtained following treatment with Benlate, Difolatan or Hinosan than with the other five fungicides tested for the control.

Kannaiyan and Prasad (1979) reported that Benlate, Kitazin, Hinosan, Demosan and Daeonil proved best in controlling sheath blight of rice.

Rajan et al. (1979) reported that best results were given by Hinosan, Kitazin, Dithane Z-78 and Dithane M-45 in controlling the disease.

Mathai et al. (1981) conducted field experiments in Kerala and reported that Hinosan was best in reducing sheath blight of rice and increasing the yields.

ii. Insecticides

Bollen (1961) reported that chlorinated hydrocarbon insecticides are fungitoxic in proportion to their water solubility and vapour pressure. Tested by plate culture technique against Rhizoctonia solani lindane which has a relatively high water solubility was most toxic in super saturation at 25 ppm. Aldrin and dieldrin, methoxychlor having solubilities of a few tenths ppm had a low fungal toxicity. Heptachlor was most effective and DDT had no effect.

Haeskaylo and Stewart (1962) reported the efficacy of phorate as a fungicide. R. solani grew vigorously and produced sclerotia abundantly on control plates. A few sclerotia and less vigorous mycelium formed in the 5 ppm plates but at 50 ppm and above no sclerotia were formed and mycelial growth was sharply inhibited.

Naguib (1968) showed that insecticide sevin up to 125 ppm reduced the rate of respiration and growth of R. (Corticium) solani coupled with low sugar and p absorption.

Purushothaman et al. (1976) studied the influence of six granular insecticides viz. diazinon, cytrolane, carbofuran, carbaryl and lindane, quinalphos and Dursban on the quantitative changes in the microbial population of rice field soils. When applied at recommended doses six to eight kg ai/ha there was no deleterious effect on the fungal population due to insecticides.

Rodriguez et al. (1976) reported that fensulfothion at ten to 100 µg/ml inhibited the growth of Sclerotium rolfsii and R. solani in PDA but did not greatly affect the growth of the fungal antagonist Tricho norzianum. In plate with unsterilized field soil fensulfothion did not affect mycelial development of S. rolfsii but significantly reduced proportion of Sclerotium initials and eliminated formation of mature sclerotia. Fensulfothion did not affect the rate of development of TSPP on colonies of S. rolfsii in the soil plates.

Kandaswamy et al. (1979) conducted studies to test the effect of two carbamate insecticides viz. aldicarb and carbofuran on soil microbial population and activity of amylase and invertase. Aldicarb and carbofuran each at ten and 20 ppm ai were mixed uniformly with sandy soil on pots and watered regularly on alternate days to field capacity; soil samples were taken on three, seven, fifteen and 30 day after the pesticide application for enumerating microbial populations.

Lakshmanan and Chandrasekharan Nair (1980) conducted invitro tests among four granular insecticides, Furadan, Solvirex, Sevidol and Thimet against R. solani. Sevidol and thimet were found to be highly inhibitory to the fungal growth and sclerotial formation. The toxicity of sevidol might be due to the presence of BHC moiety as its component.

Ruppel and Hecker (1982) reported that Aldicarb and phorate, applied as side dressings one month after planting increased the severity of _R. solani_ infection. Carbofuran also increased root rot slightly. Numbers of harvestable roots were reduced by all treatments but significantly so by phorate only. Both aldicarb and phorate was slightly fungistatic to _R. solani_ on PDS. _Trichoderma_ sp. a potential antagonist of _R. solani_ was slightly inhibited by the two insecticides but soon overcame the effect. Increase in field infection might be thus be due to some effect of chemicals on the host infection process.

Investigations on the incidence of diseases in rice

A brief review of the incidence of diseases of rice earhead viz. Brown spot, Sheath rot, False smut and grain discolouration are reviewed here.

a. Brown spot

Chattopadhyay _et al_. (1975) estimated the loss in yield of rice due to infection of brown spot incited by _Helminthosporium oryzae_. The percentage of infection on total grains were calculated for 'fertile spotted', 'sterile spotted' and 'sterile spotless' as different categories of infection in two cultivars, the susceptible Tilakkacherry and the moderately resistant Bhasamanik naturally infected with Cochiliobolus miyabeanus. The percentages of grain infection were subjected to linear multiple regression analysis for estimation of loss in yield. In the cv Bhasamanik only sterile spotless grains caused loss in yield. A close parallel was observed between the extent of grain infection and yield loss in both cvs.

Dasgupta and Chattopadhyay (1977) conducted studies on the effect of environment factors on the development of brown spot of rice caused by H. oryzae. The disease caused by C. miyabeanus occurred at fifteen to 40°C. Infection and lesion expansion was maximum at 25 to 30°C and 25 to 35°C respectively and both were reduced by the preinoculation or postinoculation exposure at 15°C. Inhibitory effect of low temperatures could be nullified by exposure to a humid atmosphere before and after inoculation.

Mujim et al. (1983) conducted survey of low land rice disease in the province of La pung, Indonesia II and reported that the most prevalent diseases included Helminthosporium. No substantial difference in occurrence of these diseases were observed between rainly and dry diseases. Watering conditions in the rice fields were suggested as a factor in disease development.

b. Sheath rot

Sheath rot was first reported from Taiwan by Sawada in 1922 hither to known to occur as a common disease only in certain parts of South East Asia and Japan (Ou, 1972).

Agnihothrudu (1973) reported *Acrocylindrium oryzae* Sawada causing sheath rot in rice for the first time from India.

Chui (1974) from Malayasia reported that sheath rot caused by *A. oryzae* occurred on both injured and uninjured plants, but inoculation experiments showed that it was severe in injured plants, like those attacked by stem borers.

Prabhakaran *et al*. (1974) reported the occurrence of sheath rot disease of rice caused by *A.oryzae* from Annamalainagar.

Ahmad *et al*. (1975) reported that the fungus was tentatively identified as *A. oryzae* was found on rice in 1972 and 1973 and shown to be pathogenic. This was the first record of *Acrocylindrium* sheath rot disease of rice in India.

Nair and Sathyarajan (1975) reported that a heavy incidence of sheath rot of rice caused by *A. oryzae* occurred in Vellayani. The symptoms appeared only on the sheath which cover the panicles. They appeared as long, oblong lesions.

The fully developed lesions varied in size from 0.5 to two cm in length and 0.5 to one cm in width. Young spots appeared uniformly greyish brown but when old the centre turned whitish grey with brown margin. The individual lesions coalesced together and in advanced stages covered the sheath almost completely. Whitish mycelial growth of the fungus could be observed in the central portion of the spots. As a result of infection the panicles were shy to emerge or even rolled while inside the leaf sheath. They were soon invaded by secondary organisms also. In the infected field, panicle could be observed at various stages of emergence. The fungal growth could be observed as whitish powdery mass inside the affected sheath.

Hsieh *et al*. (1977) reported that *A. oryzae* was consistently isolated from sterile rice plants collected from various localities in Taiwan. Typical symptoms of sheath rot and sterility were induced by inoculating plants with the isolate.

Chien and Huang (1979) reported that sheath rot caused by *Sarocladium* (*A. oryzae*) had been wide spread in rice in Southern Taiwan, Japonica cvs were more susceptible than Indica ones.

Mohan and Subramanian (1979) reported the yield loss in sixteen rice cvs due to sheath rot. Variability in result from different areas might be attributed to pathogenic differences in environmental factors.

Ghufan _et al_. (1980) reported that _A. oryzae_ was observed causing sheath rot of rice in several parts of Bihar in 1977.

Raina and Gurjit Singh (1980) reported that moderately severe outbreaks of _A. oryzae_ on rice were observed in Punjab during 1978-79, the most susceptible cv was PR-106.

Furkayastha and Ghosal (1982) reported that in recent years the disease, caused by _A. oryzae_ has increased in importance in certain rice growing areas of the world.

Kang and Rattan (1983) reported that for the previous three years _Fusarium_ spp. had been associated with sheath and panicle rot of rice particularly on the cultivar PR-106, but hitherto _S. oryzae_ was considered the main cause and the _Fusarium_ spp. secondary invaders. In 1981 and 1982 _F. equiseti_ and _F. moniliforme_ were isolated from rice leaf sheaths. When used to inoculate the plants as conidial suspension or mycelia in PDA medium before panicle emergence, lesion developed in a week and sheath rolled in three weeks. The _Fusarium_ spp. caused disease and produced identical symptoms.

c. False smut

Chou (1967) carried out investigations on the occurrence of false smut (*Ustilaginoidea virens* (Cooks) Takahashi in the paddy field). Incidence was less on rice variety Taichung No. 65 than on Tainan No. 3, both varieties being, Japonica type. Diseased stubbles were scattered in affected fields. Over 50 per cent of affected ears contained one smut ball/ ear, many have two to four, and a few more than five balls; they were most numerous in the basal and middle parts of the affected ears. Greenish yellow balls were more numerous in the basal and middle parts of the affected ears. Greenish yellow balls were more numerous than yellow, green or brown ones.

Singh and Dube (1976) reported that true sclerotia of *U. virens* were found in collections of altitude 1200 m and over in Kumaon region of Uttar Pradesh. These structures were not produced in diseased rice plants grown in plains.

Singh and Dube (1979) assessed the loss in seven rice cultivars due to false smut by *U. virens* under natural heavy infection. In addition to the direct infection and loss of grain, the disease also caused an increase in chaffiness and a decrease in grain weight.

Roy (1980) observed that there was heavy attack of false smut of rice in Assam in 1964 and 1965.

Agarwal and Verma (1981) conducted studies on the varietal reaction and losses due to false smut disease of rice. Data were presented on the field reaction of 1034 varieties to _U. virens_. More smut balls occurred in the middle part than in the basal or top portion of the panicle. Total loss in infected panicles varied with varieties from 7.67 to 75.4 per cent.

d. Grain discolouration

Mia _et al_. (1979) isolated the microorganisms associated with spotted and discoloured rice grains in Bangaladesh. Isolations from grains of seven rice lines in three seasons yielded seventeen fungi, two bacteria and an actinomycete.

Raymundo and Fomba (1979) from Sierra Leone reported that the disorder occurred in all rice growing zones in the country and could cause losses of 50 per cent, and it was associated with the presence of _H. oryzae_ (_C. miyabeanus_), _Leptosphaeria_ sp., _Phoma sorghina_, _Diplodiella oryzae_, _Alternaria_ sp. and _Fusarium_ sp.

Lee and Tugwell (1980) conducted studies on the 'pecky rice' and quality reduction in Arkansas rice production. Three types of damage were found in commercial long grain rice kernels: hull spotting caused by _H. oryzae_ (_C. miyabeanus_), hull discolouration caused by insect damage and _Curvularia lunata_ (_C. lunatus_) and kernels with chalky grain due to insect damage. Losses from 3.4 to 12.7 per cent were sustained from these combined causes.

MATERIALS AND METHODS

MATERIALS AND METHODS

A. Investigation on the insect pests and diseases infesting rice during flowering stage

A random survey on the occurrence of insect pests and diseases of rice at the flowering stage was conducted in four taluks in Trivandrum district viz. Chirayinkil, Trivandrum, Nedumangad and Neyyattinkara during Virippu season (August-September) of 1984. Incidence of insects and diseases was assessed with sweep net counts and score chart.

The following rice growing tracts were surveyed.

I. Chirayinkil Taluk

The State Seed Farm, Chirayinkil.

II. Trivandrum Taluk

a) Instructional Farm, College of Agriculture, Vellayani.

b) Private holding opposite to the Agricultural development Unit, Kazhakuttam.

c) Rice field at State Seed Farm, Ulloor and private holdings of adjacent area.

d) Rice fields of Cropping Pattern Research Station, Karamana.

e) Rice field in the Attingal ela at Kollampuzha under the Attingal Agricultural Sub-divisional Office.

III. Nedumangad Taluk

Paddy fields at Kulavilakonam and Nedumangad ela under the Nedumangad Agricultural Sub-divisional Unit.

IV. Neyyattinkara Taluk

Rice fields in Maruthur ela under Neyyattinkara Agricultural Sub-divisional Unit.

Assessment of results

Observations on the incidence of all the pests and diseases that occurred during flowering and earhead stage were taken.

Insect Pests: Population of the insect pests was taken based on sweep net counts and the number of grains damaged.

Diseases: Incidence of disease on the earhead was noted during the survey. The assessment of incidence was done with the help of score chart.

(a) Sheath blight: Incidence of sheath blight was scored according to the Standard Evaluation System for Rice (Anonymous, 1976c).

(b) Brown spot: Incidence of Brown spot was measured using a score chart prepared for the purpose (Plate I). Samples were collected from the field randomly and the intensity was graded on 1 to 7 scale as shown below.

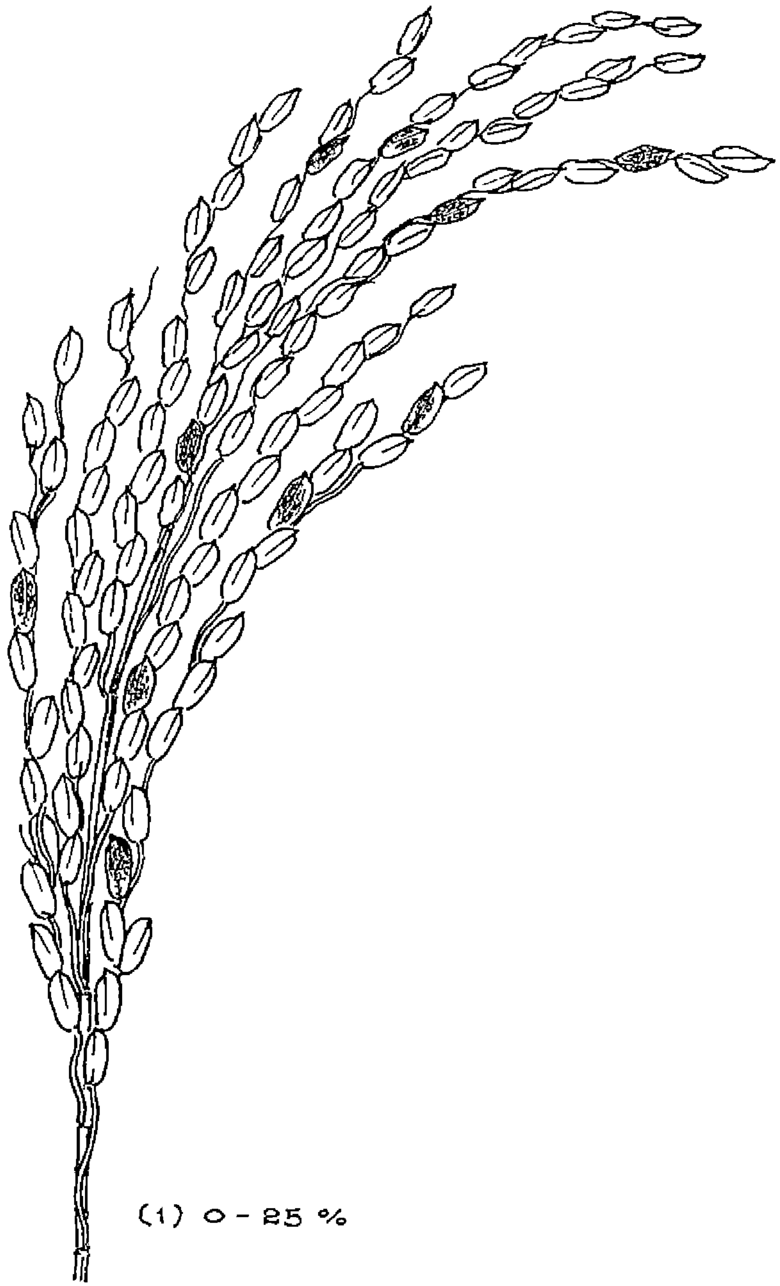
Grade	Description (Per cent damage)
1	0 - 25
3	26 - 50
5	51 - 75
7	76 - 100

Incidence of sheath rot, glume discolouration and false smut was assessed by visual observation and graded as 'slight' and 'very slight'.

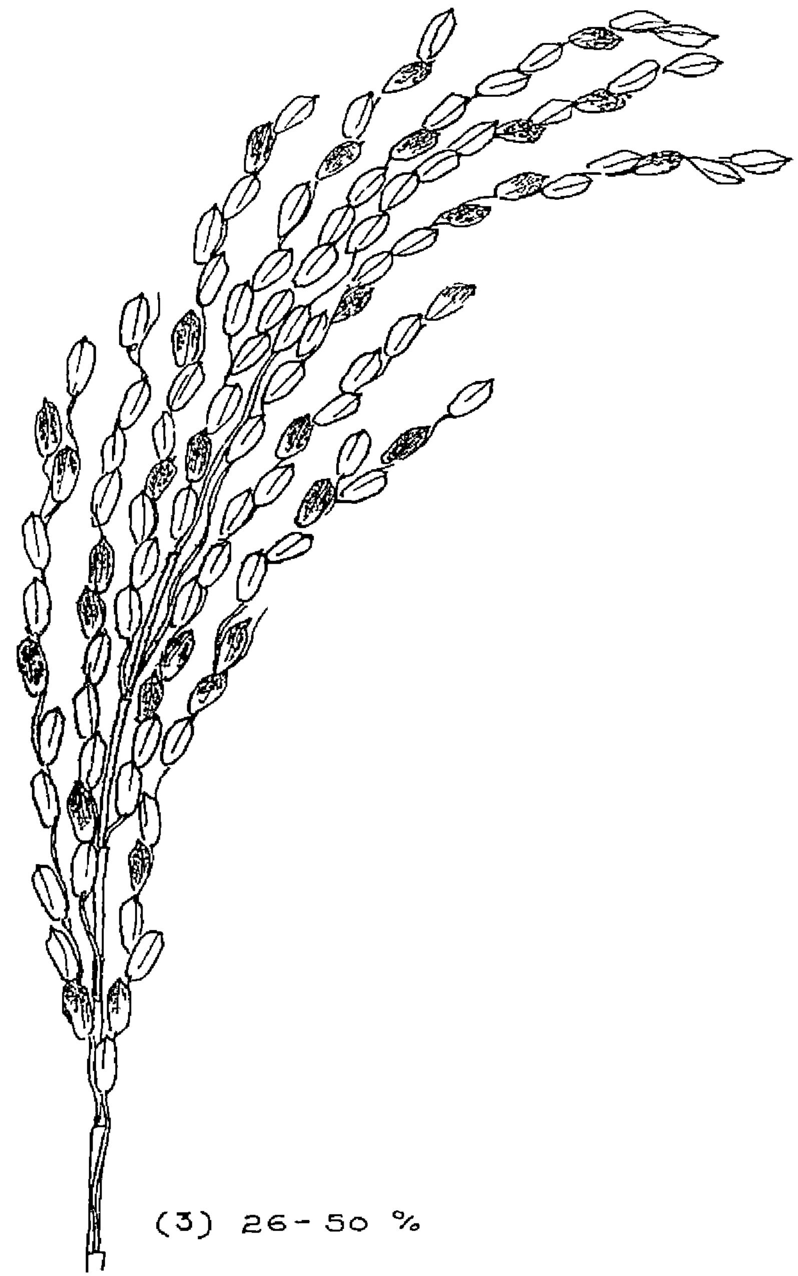
Collection of specimens

Insect Pests: Insects obtained by sweep nets and hand collections were brought to laboratory for examination and identification. Collections were preserved in ten per cent formalin. The adult insects were preserved by proper setting and drying. For the study of aphids and thrips permanent whole mounts were made as described below. The insect pests were identified by Dr. M. Mohanasundaram, Professor and Head of the Department of Entomology, Tamil Nadu Agricultural University, Coimbatore.

PLATE I SCORE CHART FOR MEASURING BROWN SPOT DISEASE

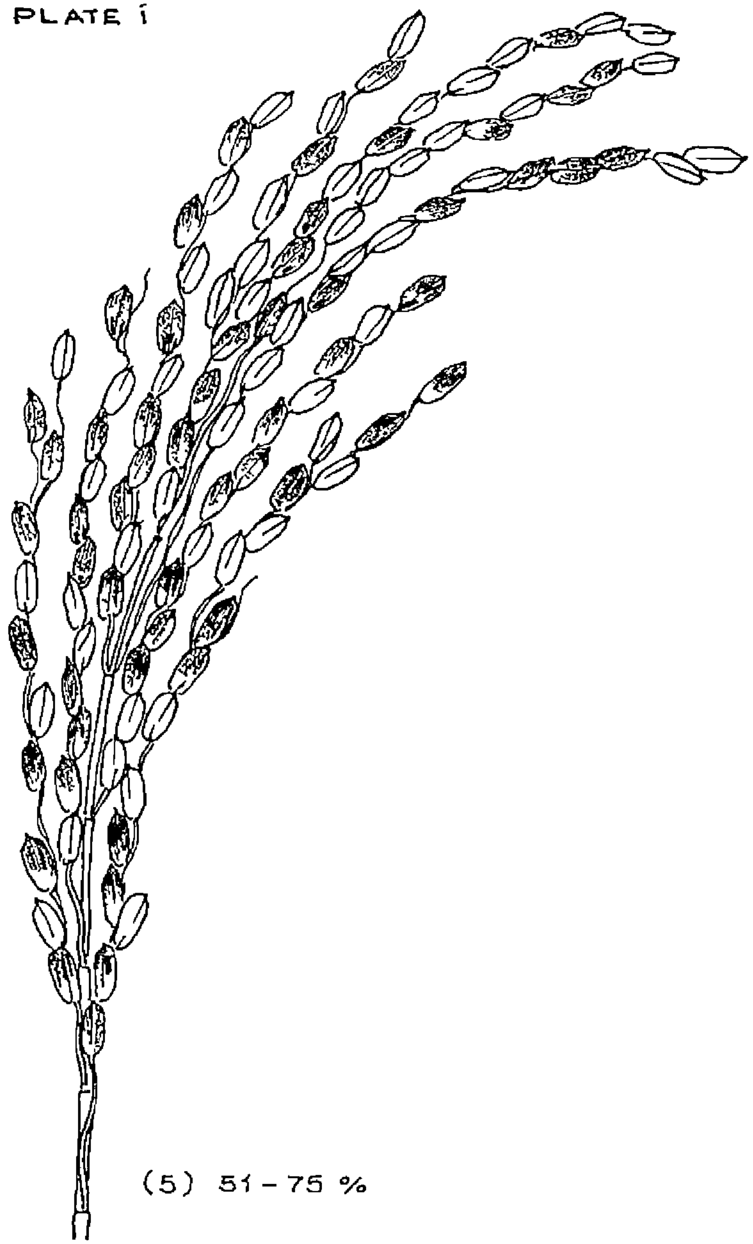


(1) 0 - 25 %

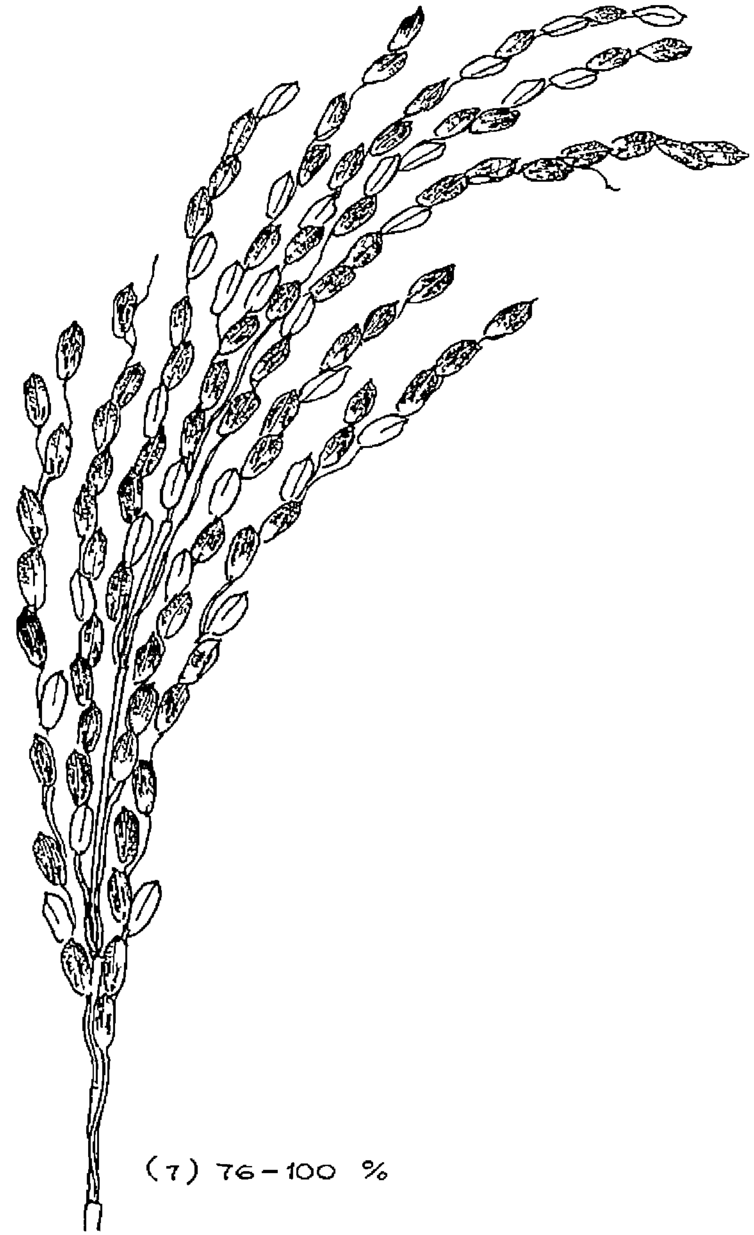


(3) 26 - 50 %

PLATE I



(5) 51-75 %



(7) 76-100 %

Whole Mounts: Permanent whole mounts were made by boiling the specimens of aphid and thrips in ten per cent potassium hydroxide solution for five minutes. The specimens were transferred to glacial acetic acid and then to saturated carboxy xylol for dehydration. The dehydrated specimens were mounted in DPX mountant after passing through xylol.

Diseases: Infected specimens collected from the field were kept in polythene bags in which moist cotton wool was provided. They were kept in humid chambers in the laboratory for two to four days for the development of the pathogen before identification. The identification was done by Dr. M.C. Nair, Professor, Department of Plant Pathology, College of Agriculture, Vellayani.

B. Nature and extent of damage caused by pests of rice earhead

The nature and extent of damage caused by insect pests viz. Red spotted earhead bug *M. histrio*, Stink bug *E. ventralis*, Cereal thrips *H. ganglbaueri*, Leaf/ear-eating beetle *A. discolor* and Flea beetle *M. signata* were studied by conducting laboratory experiments.

1. M. histrio (Fb.) Red spotted earhead bug (Hemiptera : Pentatomidae)

Adults and nymphs of M. histrio were released on rice plants confined in cages as explained under biology studies. Twelve adults were released in each cage.

2. E. ventralis (Thunb.) Stink bug (Hemiptera : Pentatomidae)

The insects were confined in cages as explained. Ten adults were released in each cage.

3. H. ganglbaueri (Schmutz.) Cereal thrips (Thysanoptera : Phlaeothripidae)

Infested inflorescence was collected from the field and the thrips were released into potted rice plants using a sable hair brush. The plants with inflorescences where the spikelets opened on the next day were used for the study.

4. A. discolor (F.) Leaf/ear-eating beetle. Coccinellid beetle (Coleoptera : Coccinellidae)

The adult beetles collected from the field were used for the investigation. Rice spikelets which opened on the next day, with the flag leaf was collected, cut and taken in a specimen tube. The inflorescence was maintained fresh by dipping the cut stem in water contained in a specimen tube, the mouth of which was tightly plugged with moist cotton wool. The whole preparation was kept on a petri dish and was enclosed within hurricane chimney. The open end was covered with moist muslin cloth. The whole arrangement was replaced as and when necessary. Ten adult beetles were introduced on to the inflorescence and feeding activity was noticed.

5. *M. signata* (Oliv.) Flea beetle (Coleoptera : Chrysomelidae)

The beetles were released to the rice inflorescence kept as explained earlier. Ten adults were released to each inflorescence.

C. Biology

The biology of the bug *E. ventralis* was studied by conducting laboratory experiments.

The adults of the bugs were collected from the rice fields. Rice plants were grown in flower pots. Cylindrical cages of polythene sheets of 200 gauge were made by rolling into columns of 70 cm height and 10 cm diameter. The insects were released into the cages when the plants were in the grain filling to milk stage. The bugs laid eggs and the newly emerged nymphs were transferred into similar potted plants by using sable hair brush. Two newly hatched nymphs were released into each potted rice plant consisting of seven to ten tillers. A circular paper was spread above the water to collect the moults and the paper was replaced every day. Observations were taken every day. The experiment was repeated six times.

D. Field experiment to investigate the effect of pesticides on the incidence of pests and diseases

A statistically designed experiment was conducted to study the efficacy of certain pesticides on the control of pests and diseases in rice during flowering stage. The deleterious effect of the pesticides, if any, by way of gametocidal action was also assessed in the experiment.

Location of the experiment

The experiment was laid out in the Instructional Farm, College of Agriculture, Vellayani. The Farm represents the Trivandrum District both in soil and climatic conditions.

Soil

The soil belonged to the textural group of sandy clay loam and fair in organic matter and total nutrients and strongly acidic.

During the second crop season the pest incidence of rice is greater and hence the present experiment was carried out during the second crop season (Mundakan) of the year 1983 which normally extends from September-October to December-January.

Design and layout of the Experiment

The field experiment with Randomised Block Design was laid out for the investigation.

The seedlings of variety 'Jaya' were raised and transplanted in the experimental plots and were maintained following Package of Practices Recommendations of Kerala Agricultural University, 1982.

Need based application of pesticides was followed. The treatment consisted of eight insecticides, one fungicide and a control. The pesticides used were hexachlorocyclohexane 10 per cent dust, carbaryl 50 WP, monocrotophos 36 EC, phosphamidon 85 EC, methyl parathion 50 EC, malathion 50 EC, phorate 10 granules, carbofuran 3 granules and Hinosan 50 EC.

The insecticides phorate and carbofuran were applied as granules 40 days after transplanting (DAT). The water level in the plot was maintained at two to five cm throughout the period of experiment. The first application of pesticide was done on 20--1--1984 at 57 DAT. The second application of the pesticides was done at 65 DAT. The third and fourth rounds of application were done at 69 DAT and at 79 DAT.

A pneumatic hand compression knapsac sprayer of nine litre capacity was used for spraying of liquid pesticides. The volume of the liquid used was at the rate of 450 litre per hectare. A plunger duster was used for the application of dust formulation. No spraying was done in the control plot. The crop was harvested on 7th March, 1984.

Assessment of results

The results were assessed in terms of pest incidence in the plots under various treatments and estimated by the actual counts of insects concerned or count of the affected plant part. The observations were made at one, two, four and seven days of pesticide application. The following methods were adopted for the assessment of infestation.

Pests

i) Rice bug

The population of rice bug and damage caused by the pest on rice grains were assessed.

(a) Sweep net count: Sweep net count of rice bug was taken after each spraying. Ten sweeps were made in each plot covering the maximum area by walking from one corner to the adjacent corner of the plot.

(b) Assessment of damage caused by Rice bug (Acid fuchsin technique)

Acid fuchsin technique described by Litsinger *et al.* (1981) was used. When rice bug fed on rice grain it secreted a proteinaceous stylet sheath. Stylet sheath could be stained with acid fuchsin dye. If an unfilled discoloured grain resulted from rice bug feeding, then a stylet sheath should be evident on the rice hull.

Random samples 100 grains from five earhead were taken from each plot. The rice grains from each plot were placed in a petri dish and submerged in a staining solution of following ingredients.

Phenol	:	1 part
Lactic acid	:	1 part
Distilled water	:	1 part
Glycerine	:	2 parts
Acid fuchsin	:	Quantity enough to stain the solution red.

After staining the rice grains in solution for thirty minutes they were washed in water and dried on a piece of blotting paper. The grains were observed for the presence of stylet sheath.

To assess the rice bug injury, filled and unfilled grains were separated from each sample and counted. The unfilled grains with stylet sheath were caused by the rice bug. The filled grains with stylet sheath were boiled in potassium hydroxide to determine the number of pecky grains in the sample by rice bug feeding.

ii) Striped bug

Sweep net count of the bug was made after the appearance of the pest in the field. Ten sweeps were taken.

iii) Rice weevil

Sweep net counts were taken.

iv) Cereal thrips

Grain damage by cereal thrips was counted. For this, four hills were selected from four corners of an one metre square area in the centre of the experimental plot. Damaged grains from each hill were estimated.

Diseases

Sheath blight: Observations on incidence and intensity of sheath blight disease were recorded seven days before harvest. This was done according to the standard evaluation system for rice (Anon., 1976c).

Intensity of sheath blight was estimated by observing sixteen hills leaving two rows on either side, on the eighth, twelfth and sixteenth row in each plot. Grading was done as detailed below.

Descriptions for the score chart

Grade 1. Lesions limited to lower 25 per cent of leaf sheath.

Grade 3. Lesions present on lower than 50 per cent of leaf sheath.

Grade 5. Lesions present on more than 50 per cent of leaf sheath.

Grade 7. Lesions present on more than 75 per cent of leaf sheath, severe infestation on lower leaves and slight infestation on upper leaves (flag and second leaf).

Grade 9. Lesions reaching top of tillers severe infestation on all leaves.

Disease index was calculated based on the following formula and statistically analysed.

$$\text{Disease index} = \frac{\text{Total numerical ratings} \times 100}{\text{Total No. of hills observed} \times \text{Maximum score}}$$

Yield

The grain yield and weight of straw and chaff were recorded and statistically analysed.

Assessment of Gametocidal action of Insecticides by Pollen viability studies

Gametocidal action of insecticides to rice pollen was ascertained by dusting the pollen from rice inflorescence on glass slides (Zirkle, 1937). Pollen grains were collected one, two and four hour after the application of insecticides. The insecticides were sprayed in the morning and the rice inflorescence dehisced between 8-30 and 9-00 A.M. A little quantity of glycerine-acetocarmine stain was taken on a marked glass slide and rice inflorescence was gently tapped so that rice pollen collected from the field could be spread over the slide. It was kept for two hours for the absorption of the stain by the pollen. Five slideswere collected from each plot and ten observations were taken at random under a microscope. The pollen grains which appeared normal, plump, well stained and uniformly pink in colour was taken as viable ones. The sterile pollen grains were light coloured, shrivelled and in some cases broken. Pollen sterility was calculated by the following equation.

$$\text{Pollen sterility} = \frac{\text{Total number of sterile pollen} \times 100}{\text{Total number of pollen grains examined}}$$

RESULTS

RESULTS

To identify the pest and disease problem of rice earhead a random survey on their incidence had been conducted. The nature and extent of damage caused by pests and diseases and the biology of a new pest seen infesting were studied. The effect of pesticides applied on pests and diseases, and also on rice inflorescence had been investigated.

The results of the survey of insect pests and diseases are presented in Table 1, Plate II and Plate III.

A. Investigation on the insect pests and diseases infesting rice during flowering stage

1. Karamana

It was observed that the populations of Rice bug *Leptocorisa acuta* and that of Red spotted earhead bug *Menida histrio* were very low with an average of 0.25 and 0.15 respectively per 20 standard sweeps. No considerable damage could be observed. Adults of pumpkin beetle were seen resting on earhead during flowering stage but could not record any detectable damage.

Laboratory examinations of the diseases observed could reveal that the Brown spot was caused by *Helminthosporium oryzae* and glume discolouration by *Curvularia* sp. and *Rhizopus* sp.

2. Vellayani

The population of Rice bug L. acuta was high in various plots. Both adults and nymphs were seen to infest the crop. They were found to suck sap from the base of the plants, tender leaves and also from developing grains. L. acuta was found to prefer to feed at the junction of palea and lemma. When a rice bug fed on a rice grain, it secreted a proteinaceous sheath around the stylet. This stylet sheath could be stained by using acid fuschin dye as described earlier. Thus a stylet sheath could be seen on the rice hull on an unfilled or discoloured grain resulted from rice bug feeding. The mean sweep net count varied between 0 and 4 with an average of 2.45 (Table 1).

The adults and nymphs of Red spotted earhead bug was seen infesting the earhead, stem and leaves of rice plant. They were found to suck sap from the plants. The details of the nature of damage and extent of damage caused by the pest were studied and described. The mean sweepnet count varied between 0 to 3 for 20 standard sweeps with an average of 2.4.

The adults and nymphs of the thrips were seen to infest the crop when they were in the flowering stage. Detailed studies were conducted and the results were presented. The mean sweepnet count varied between 0 and 7 with an average of 1.55.

The adults of Leaf/ear-eating beetle, A. discolor, was found to infest the rice earhead. They were found to feed on the pollen occasionally.

The adults of N. viridula, the Green rice bug and T. histeroides, Green shield bug were seen infesting the crop during the experiment. The mean sweepnet count was 1.5.

The adults of rice weevil were found to infest the rice earhead at the grain filling to dough stage. The sweepnet counts varied from one to nine with a mean value of 1.3.

The adults of Flea beetle, M. signata Pumpkin beetles A. foveicollis and A. stevensi were found to congregate on the rice inflorescence.

The adults and nymphs of Stink bug E. ventralis were seen to infest the rice inflorescence. The infestation was seen continuing during the grain filling stage also.

The organisms associated with the rice earhead disease during the survey were as follows:

	Disease	Causal organism
1.	Brown spot	H. oryzae
2.	Sheath blight	C. sasakii
3.	Sheath rot	S. oryzae (A. oryzae)
4.	Glume discolouration	Curvularia sp.

3. Ulloor

The incidence of rice bug was low in the wet lands of Seed Farm area, the counts ranging from 0 to 3 with an average of 0.6 per 20 sweeps.

The incidence of rice bug was fairly high in nearby fields owned by farmers. It was estimated that mean sweet-net counts varied from 0 to 4 with an average of 2.1.

The adults and nymphs of red spotted earhead bug were found infesting the rice earhead in the farmers' field also. The average counts were found to vary from 0 to 1 with a mean value of 0.5.

The population of cereal thrips was ranging from 0 to 6 per sweep, with a mean value of 2.5

In the Seed Farm, in one block where the crop was in the grain filling to dough stage the earheads were found to be infested with adults of rice weevil (*S. oryzae*). The variety planted was Jaya. Eighteen to 22 weevils were observed per earhead.

The incidence of *E. ventralis* (Stink bug) and that of *A. discolor*, leaf/ear-eating beetle was only very low as these pests were seen only occasionally in private holdings.

The diseases observed were caused by

	Disease	Causal organism
1.	Brown spot	H. oryzae
2.	Sheath blight	C. sasakii
3.	Sheath rot	S. oryzae (A. oryzae)
4.	Glume discolouration	Curvularia sp. and Rhizopus sp.

4. Kazhakuttam

The incidence of pest at Kazhakuttam was very low. Only the Rice bug, L. acuta was observed to infest the crop. A local variety Thavalakannan was cultivated. The population of rice bug was found to vary between 0 to 1 with a mean of 0.25 for 20 sweeps.

The diseases observed were caused by the following organisms.

	Disease	Causal organism
1.	Brown spot	H. oryzae
2.	Sheath rot	S. oryzae (A. oryzae)

The higher incidence of Brown spot was observed. Random samples of the earhead were collected from the field and scored for the disease. Other organism associated with the earhead were identified as Helminthosporium sp., Fusarium sp., and Curvularia sp.

5. Chirayinkil

The incidence of rice bug was low in Chirayinkil Seed Farm ranging from 0 to 2 in 20 sweepnet with an average of 0.9.

The nymphs and adults of Red spotted earhead bug were seen infesting rice earhead and young plants. The counts of insects varied from 0 to 2 with a mean value of 0.55.

The thrips were seen infesting the rice inflorescence. The counts were ranging from 0 to 7 in 20 sweeps with a mean value 2.25.

The adults of Leaf/ear-eating beetle A. discolor were seen infesting rice grains in the milk stage. It was observed that an average of 0.8 adults and nymphs of the aphid were present per earhead.

The diseases observed were caused by

1.	Brown spot	H. oryzae
2.	Glume discolouration	Fusarium sp., Curvularia sp., Penicillium sp.

6. Attingal

The average number of L. acuta was 0.75 per twenty sweeps with a minimum of 0 and maximum of 2. The incidence of thrips was ranging from 0 to 3 with an average of 0.96 in twenty sweeps. The average sweepnet catch of red spotted earhead bug was 0.25 with a range of 0 to 1. Grass hoppers were also obtained during the sweepnet catches whose population was ranging from 0 to 2 with an average of 0.57.

The diseases observed with the respective causal agent at Attingal area were as follows:

	Disease	Causal organism
1.	Brown spot	*H. oryzae*
2.	Sheath blight	*C. sasakii*
3.	Sheath rot	*S. oryzae* (*A. oryzae*)
4.	Glume discolouration	*A. oryzae*, *Fusarium* sp., *Penicillium* sp., *Curvularia* sp.

7. Nedumangad

In both the localities nymphs and adults of rice bug *L. acuta* were seen infesting rice earhead. The average sweepnet count for twenty sweeps was 1.7 ranging from 0 to 4.

The nymphs and adults of red spotted earhead bug were seen infesting the rice earhead. The sweepnet count varied from 0 to 1 with an average of 0.65. The mean population of grass hopper was 0.6 ranging from 0 to 1.

Table 1. Insect Pests and Diseases observed

Sl. No.	Locality	Varieties grown	Stage of the crop	Insect pests	Mean value per 20 standard sweepnet counts	Diseases	Mean %
1.	Karamana. Cropping Pattern Research Station	High yielding varieties (Jaya, Jyothi, Triveni)	Flowering stage	*Leptocorisa acuta* (Thunb.)	0.25	Brown spot,	1 - 2.5%
				Menida histrio (Fb.)	0.15	Glume dis-colouration	Very slight
				Sitophilus oryzae (Linn.)	0.10		
				Aulocophora foveicollis (Lucas)	0.12		
2.	Vellayani	High yielding varieties (Jaya, TN-1)	Flowering earhead stage	*Leptocorisa acuta* (Thunb.)	2.45	Brown spot	5%
				Menida histrio (Fb.)	2.40	Sheath blight	Slight
				Haplothrips ganglbaueri (Schmutz.)	1.55	Sheath rot	Very slight
				Alesia discolor (F.)	0.6	Glume dis-solouration	Very slight
				Tetroda histeroides (Fab.)	1.6		
				Nezara viridula (Linn.)	1.50		
				Sitophilus oryzae (Linn.)	1.3		
				Aulocophora foveicollis (Lucas)	0.1		
				Aulocophora stevensi (Baly)	0.1		
				Monolepta signata (Oliv.)	0.1		
				Eusarcocorris ventralis (Thunb.)	0.2		
				Hieroglyphus banian (Fab.) / *Oxya chinensis* (Thunberg) (= *velox*)	0.45		
3.	Ulloor	Jaya, Thavalakannan	Flowering to ear-head	*Leptocorisa acuta* (Thunb.) (Ulloor Seed Farm)	0.6	Brown spot	12.5%
				L. acuta (Thunb.)(Farmers' field)	2.1	Sheath blight	Slight
				Menida histrio (Fb.)	0.5	Sheath rot	Very slight.
				Haplothrips ganglbaueri (Schmutz)	2.5	Glume dis-colouration	Very slight
				Alesia discolor (F.)			
				Sitophilus oryzae (Linn.)	18 to 22 per earhead		
				Aulocophora foveicollis (Lucas)			
				Monolepta signata (Oliv.)	0.1		
				Eusarcocorris ventralis (Thunb.)	0.2		
				Oxya chinensis (Thunb.) (= *velox*)	0.6		

Table 1. (Contd.) Insect Pests and Diseases observed

Sl. No.	Locality	Varieties grown	Stage of the crop	Insect pests	Mean value per 20 standard sweepnet counts	Diseases	Mean %
4.	Kazhakuttom	Thavalakannan	Flowering to dough stage	*Leptocorisa acuta* (Thunb.)	0.25	Brown spot	65%
5.	Chirayinkil	Local variety Thavalakannan, High yielding variety Jaya.	Earhead stage	*Leptocorisa acuta* (Thunb.)	0.9	Brown spot	40%
				Menida histrio (Fb.)	0.55	Glume-discolouration	Slight
				Haplothrips ganglbaueri (Schmutz)	2.25		
				Alesia discolor (F)	0.6		
				Hysteroneura sp.	0.8 adult and nymph per earhead		
6.	Attingal	Local variety Thavalakkanan High yielding variety Jyothi	Earhead stage.	*Leptocorisa acuta* (Thunb.)	0.75	Brown spot	30%
				Menida histrio (Fb.)	0.25	Sheath blight	Slight
				Haplothrips ganglbaueri (Schmutz)	0.96	Sheath rot	Slight
				Sitophilus oryzae (Linn.)		Glume discolouration	Very slight
				Hieroglyphus banian (Fab.)	0 57		
				Oxya chinensis (Thunberg)			
7.	Nedumangad	Cheradi		*Leptocorisa acuta* (Thunb.)	1.70	Sheath blight	Slight
				Menida histrio (Fb.)	0.65	False smut	Very slight
				Haplothrips ganglbaueri (Schmutz.)	0.96		
				Alesia discolor (F.)	0.20		
				Hieroglyphus banian (Fab)	0.6		
				Oxya chinensis (Thunberg) = (*velox*)			
8.	Neyyattinkara	Cheradi	Earhead stage	*Leptocorisa acuta* (Thunb.)	0.25	Sheath blight	Slight
				Menida histrio (Fb.)	0.25		
				Alesia discolor (F.)			

PLATE II INCIDENCE OF INSECT PESTS INFESTING RICE EARHEAD IN TRIVANDRUM DISTRICT

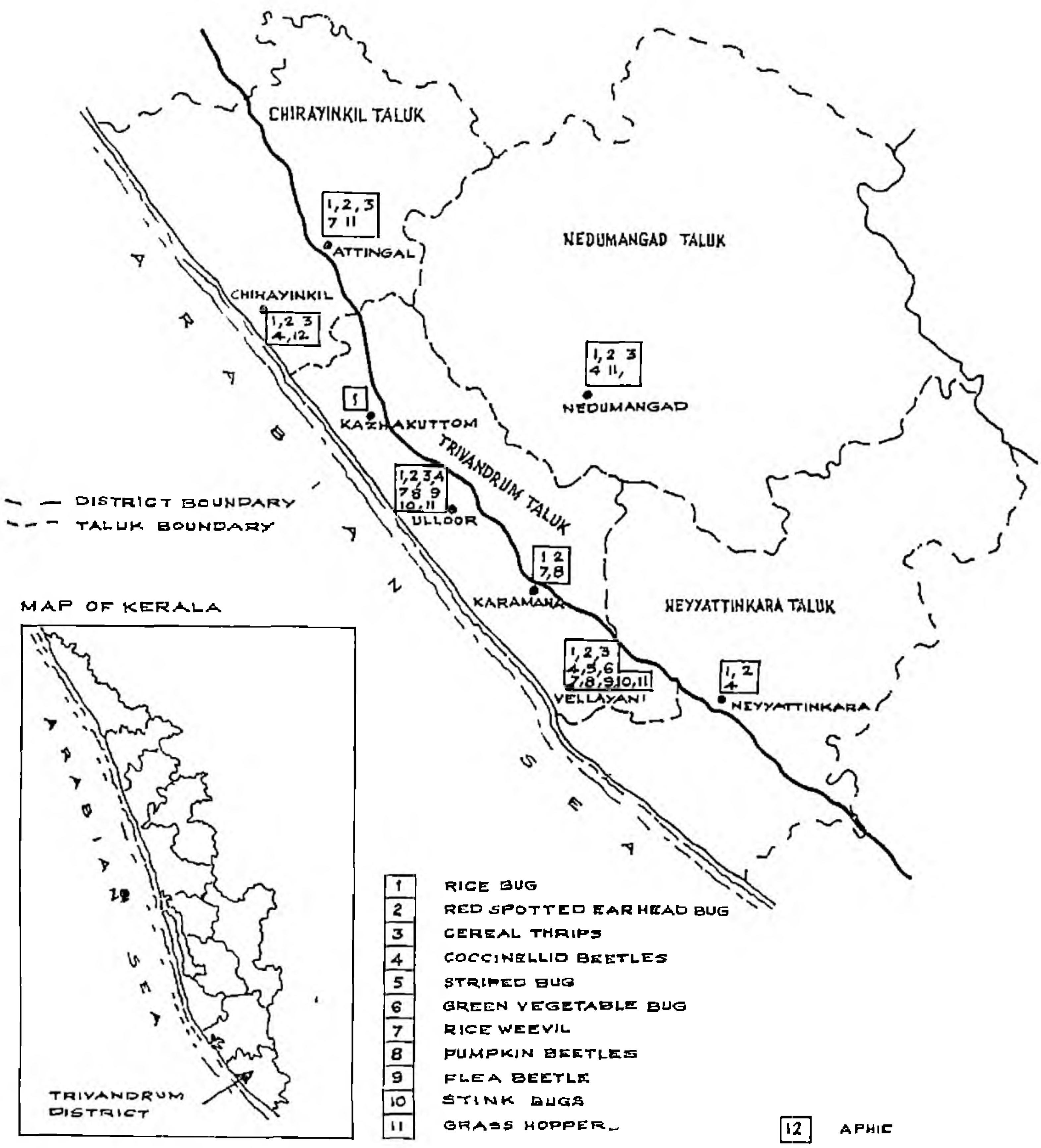
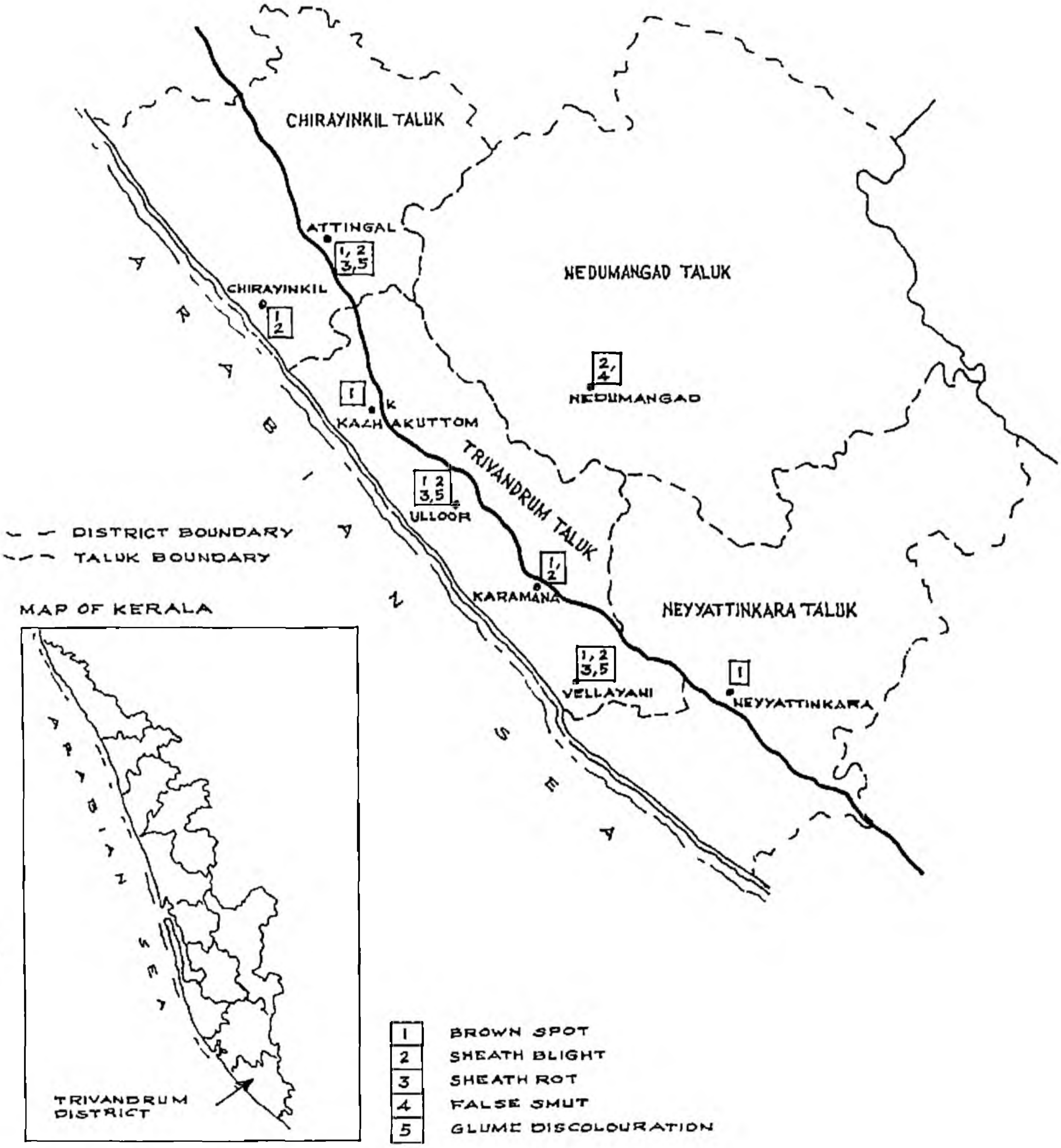


PLATE III INCIDENCE OF DISEASES IN RICE –
EARHEAD IN TRIVANDRUM DISTRICT



The causal organism associated with the disease, sheath blight was C. sasakii and that of False smut was Ustilaginoidea virens.

8. Neyyattinkara

The mean population of rice bug was found to vary between 0 to 1 with an average of 0.25 for twenty standard sweeps. The mean population of M. histrio was found to vary between 0 and 1 with an average of 0.25.

B. Nature and extent of damage caused

1. M. histrio (Fb.) Red spotted earhead bug (Hemiptera : Pentatomidae)

The nymphs and adults of the bug were found to congregate on the rice earhead feeding from the tender grains at the milky stage.

While at rest the rostrum was kept concealed by being flexed beneath the thorax with its apex directed downwards. When the insect was about to feed, the rostrum was extended from its position of repose and inclined downwards. The stylets were able to pierce the grains by bending the rostrum. The contents of the grains and leaves were sucked in through the stylets.

The point from which the insect pierce the stylet and feed, developed a brownish colouration, and later the locus of feeding could be recognised as a brown spot. Many such brown spots developed on the lemma and palea of a single grain seemed to coalesce to result in the complete discolouration of the grain. As a result of feeding the grains became unfilled or half filled.

After the penetration of the stylets into the grains, the saliva injected reacted with plant sap which formed a tubular sheath around the stylet. This stylet sheath was observed red after staining with acid fuchsin.

Certain of the brown incomplete grains showed white fungal growth which was identified to be Fusarium sp. as a secondary infection. At times the nymphs and adults of Red spotted earhead bug were also found to feed from the leaves, leaf sheath and main culm of the plant.

The nature of damage caused by the nymphs and adults were found to be similar.

Under laboratory conditions twelve adults were able to completely destroy in twelve days one potted plant which contained nine to ten tillers.

2. _E. ventralis_ Rice stink bugs (Hemiptera : Pentatomidae)

The damage was observed to be caused by the adults and nymphs of the stink bugs feeding on the leaves, leaf sheath and on the developing rice grains. The lemma and palea of the grain were equally chosen by the bugs for feeding. Mostly the developing grains were affected than the leaves or stems. The insect imbibed the milky juice from the developing grains by passing the proboscis through the surface of lemma or palea. The point of insertion of the stylet could be located by the presence of diffused light brown areas with a white spot at the centre. The salivary secretion formed a gelatinous stylet sheath covering the bundle of stylets at the site of probing.

A portion of the stylet sheath when stained with acid fuchsin could be identified easily as seen red projecting out of the grain surface. Up to four stylet sheaths could be located on a single grain. The infested grains became empty or partially filled and shrivelled. It could be observed that pecky grains were formed when the infestation by _E. ventralis_ occurred during later grain filling stage.

3. _H. ganglbaueri_ Cereal thrips (Thysanoptera : Phlaeothripidae)

The adults and nymphs were found to lacerate and feed on the lemma, palea and ovarian tissues. This led to the development of light brownish colouration on the spikelets and the grains. The spikelets remained partially opened at the tip. In the field, ants were seen on the thrips infested spikelets. The ant was identified as Monomorium sp.

The thrips were found to feed on the ovarian tissues of rice inflorescence. When feeding on the developing grains the feeding scars could be observed on the surface of the lemma and palea. The scars appeared to be brownish and irregularly shaped.

4. A. discolor Leaf/ear-eating beetle, Coccinellid beetle (Coleoptera : Coccinellidae)

The adult bugs were found to congregate on the rice earhead in groups up to six and found to feed on the pollen. They were not observed to cause any damage leading to economic loss.

5. M. Signata Flea beetle (Coleoptera : Chrysomelidae)

The adults of M. signata were observed to frequent rice inflorescence. No economic damage could be detected as caused by their presence.

C. Biology

E. ventralis (Thunb.) Rice stink bug (Hemiptera : Pentatomidae)

(1) Egg: The eggs were laid in batches of two to six in rows on leaf axils, junction of leaf and leaf sheath and on upper surface of leaves. When laid on leaf surfaces the eggs were arranged in two to three rows.

Freshly laid eggs were barrel shaped with an operculum of 0.6 mm in length on an average and were glued on to the leaf surface. The eggs when laid were pale green in colour which later turned brown in five days, just before hatching. The percentage of hatching of eggs was found to be 84.8.

(2) Nymph: The first instar nymph was less than a millimetre in length and dark reddish brown in colour. The first stadium lasted for three days.

The second instar nymph was about 1.5 mm in length. There was a variation in colour, the thorax being dark brown, abdomen reddish brown with distinct and diffused black patches with pale margins dorsally. The nymphs were found to be feeding on the rachis of inflorescence and on very tender grains. This stage lasted for four days.

The third instar nymphs were seen uniformly light greenish to brown in colour. The black blotch seen dorsally on the abdomen was surrounded by a white colour. The head and thorax were light brown. The nymph attained a length of three mm. The antenna was light brown with a dark brown tip. The nymphs had undergone ecdysis after five days.

The fourth instar nymph was four mm in length. The wing buds could be seen very clearly. It took five days to become adult.

(3) Adult: The adult bug was six mm in length. It was brownish black with a dark greenish tint. There were two distinct white spots on either side on the hemelytra at the abdominal region.

Under laboratory conditions the total life cycle lasted for 22 days. Adults started laying eggs seven days after emergence. Adult females laid fifteen to 40 eggs in batches. Adult longevity was found to be up to three weeks.

D. Effect of Pesticides on the incidence of Pests and Diseases

The effect of application of pesticides commonly recommended for the control of pests and diseases of rice earhead had been evaluated in the field experiment. The granular insecticides were applied at 40 days after transplanting (DAT) and the sprays were need based. Four sprayings were done starting from 57 DAT with an interval of three to eleven days between applications. The results relating to the experiment were presented below.

1. Rice bug

The data on the incidence of rice bug, before application of pesticides were presented in the Table 2, and found to be statistically not significant. The pesticides were applied at 57 DAT when the plants began to flower. The mean percentage count after application of insecticide, as presented in Table 3 and Fig. 1, ranged from 13 to 35, 34 being the count in the control plot. Statistically significant reduction of pest incidence at five per cent level of probability was resulted due to application of pesticide. It could be observed that monocrotophos (T_3) was the most effective pesticide in reducing population of rice bug. Treatments methyl parathion (T_5), carbaryl (T_2), hexachlorocyclohexane (T_1) and phosphamidon (T_4) were on par with monocrotophos showing that these chemicals could also check rice bug infestation. It was observed that the treatment phorate (T_7), carbofuran (T_8), Hinosan (T_9) and malathion (T_6) were not effective in bringing down the population of rice bugs.

Table 2. Incidence of rice bug (*L. acuta*) on rice before the application of pesticides

	Treatment	Mean rice bug count per 10 standard sweeps observed at 57 DAT
T_1	Hexachlorocyclohexane 10DP	21.00 (4.68)
T_2	Carbaryl 50 WP	20.33 (4.59)
T_3	Monocrotophos 36 EC	22.00 (4.78)
T_4	Phosphamidon 85 EC	25.67 (5.13)
T_5	Methyl parathion 50 EC	20.00 (4.58)
T_6	Malathion 50 EC	20.00 (4.52)
T_7	Phorate 10 G	23.00 (4.89)
T_8	Carbofuran 3 G	20.00 (4.54)
T_9	Hinosan 50 EC	24.67 (4.99)
T_{10}	Control	23.66 (4.86)

Abstract of Analysis of variance

	df	Mean squares
Treatments	9	0.12559
Error	18	0.15109
C.D. for comparing treatments		NS

Figures within parentheses are $\sqrt{x + 1}$ values.

NS : Not significant.

A second spraying of the treatments were given on 65 DAT. Counts of rice bugs were taken to find out the effect of need based application of pesticides. It was found that there was progressive reduction in the pest population due to application of pesticides, the mean population ranged between 4.67 to 35.33. The application of chemicals could significantly reduce the pest population at one per cent level of probability, monocrotophos being the most effective one. The pesticides phosphamidon (T_4) and hexachlorocyclohexane (T_1) were on par with monocrotophos (T_3).

The third spraying of pesticides were given on 69 DAT and counts of rice bug were taken. The data are presented in Table 4 and Figure 2. Population counts proved that the application of pesticides could significantly reduce the infestation at one per cent level. The mean population ranged between 1 to 14. Monocrotophos proved to be most effective in controlling the rice bug infestation. The other insecticides which were on par in the descending order of effectiveness were phosphamidon (T_4), carbaryl (T_2), hexachlorocyclohexane (T_1) and malathion (T_6). Other pesticides carbofuran (T_8) and phorate (T_7) have reduced the population when compared to control. Hinosan (T_9) which was on par with control (T_{10}) has no effect in bringing down the pest population.

Table 3. Effect of pesticides on the incidence of rice bug (*L. acuta*) on rice.

	Treatment	Dosage	Mean rice bug count per 10 standard sweeps observed at	
			First application	Second application
T_1	Hexachlorocyclohexane 10 DP	25kg/ha	15.67(4.07)	13.67(3.83)
T_2	Carbaryl 50 WP	2.5kg/ha	14.33(3.91)	18.00(4.25)
T_3	Monocrotophos 36 EC	667ml/ha	13.00(3.74)	4.67(2.38)
T_4	Phosphamidon 85 EC	294ml/ha	18.67(4.36)	16.33(3.83)
T_5	Methyl parathion 50 EC	500ml/ha	13.33(3.78)	18.00(4.13)
T_6	Malathion 50 EC	1000ml/ha	23.66(4.96)	18.33(4.33)
T_7	Phorate 10 G	12.5kg/ha	31.00(5.50)	28.33(5.19)
T_8	Carbofuran 3 G	18kg/ha	33.67(5.79)	32.33(5.74)
T_9	Hinosan 50 EC	500ml/ha	35.00(5.96)	18.00(4.13)
T_{10}	Control	Untreated	34.00(5.84)	35.33(5.99)

<u>Abstract of ANOVA</u>

	df	Mean squares	
Treatments	9	2.542*	3.283**
Error	18	13.093	0.903
C.D. for comparing treatments		1.463	1.63

Figures within parentheses are $\sqrt{x + 1}$ values.

* Data significant at 0.05 level.

** Data significant at 0.01 level.

Treatments phorate and carbofuran were applied 40 days after transplanting and all other treatments were applied 57, 65 days after transplanting.

FIG 1 EFFECT OF PESTICIDES ON THE INCIDENCE OF RICE BUG (*Leptocorisa acuta*) AT 58 AND 66 DAT

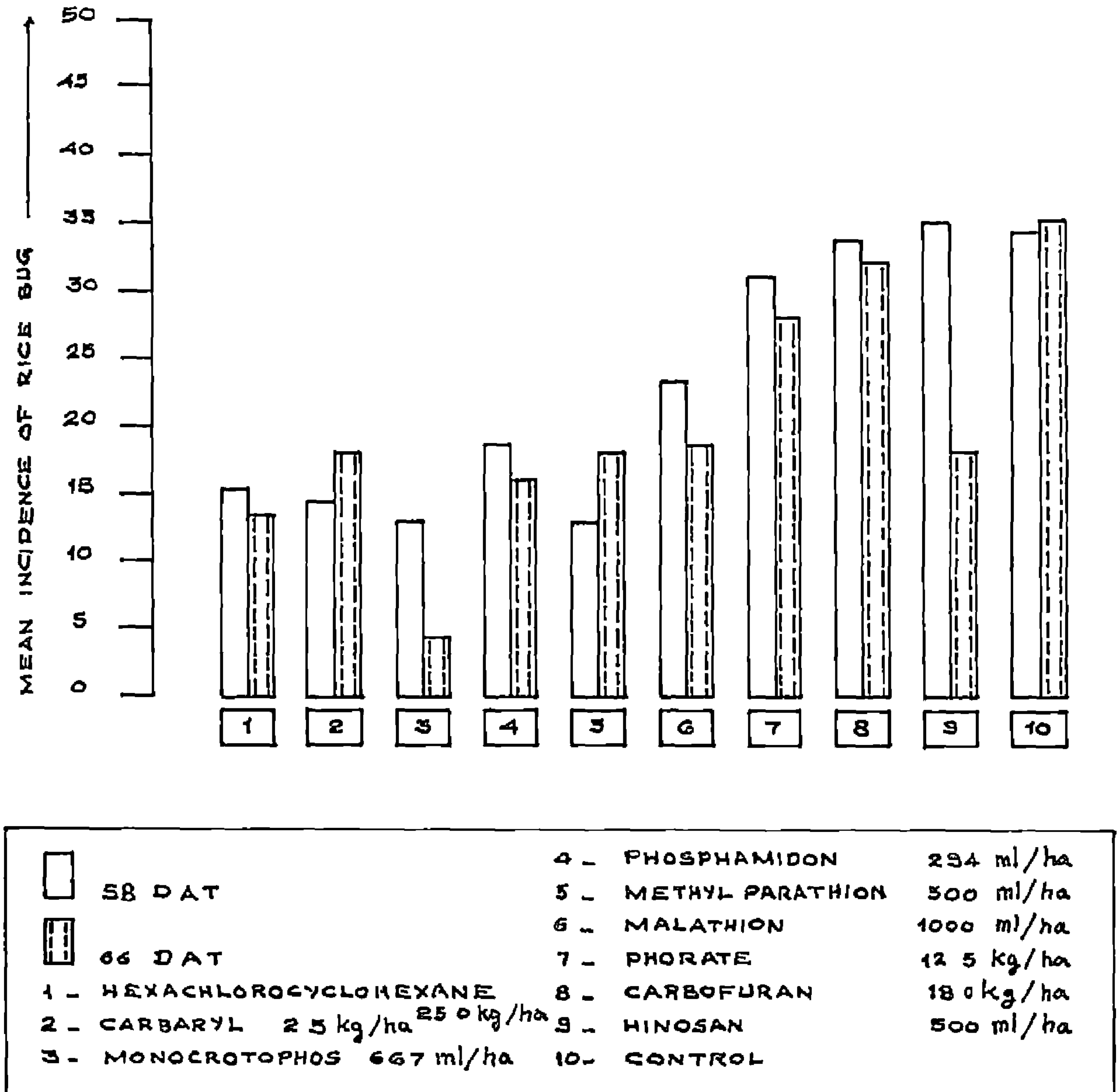


Table 4. Effect of pesticides on the incidence of rice bug (*L. acuta*) on rice

	Treatment	Dosage	70 DAT	74 DAT
T_1	Hexachlorocyclohexane 10 DP	25kg/ha	1.67(1.63)	1.00(1.38)
T_2	Carbaryl 50 WP	2.5kg/ha	1.67(1.63)	1.67(1.63)
T_3	Monocrotophos 36 EC	667ml/ha	1.00(1.38)	0.33(1.14)
T_4	Phosphamidon 85 EC	294ml/ha	1.67(1.48)	3.00(1.72)
T_5	Methyl parathion 50 EC	500ml/ha	2.00(1.72)	1.33(1.49)
T_6	Malathion 50 EC	1000ml/ha	1.67(1.63)	2.33(1.82)
T_7	Phorate 10 G	12.5kg/ha	8.00(2.95)	8.00(2.95)
T_8	Carbofuran 3 G	18kg/ha	6.67(2.69)	7.33(2.85)
T_9	Hinosan 50 EC	500ml/ha	8.67(3.09)	11.67(3.54)
T_{10}	Control	Untreated	14.00(3.87)	13.70(3.81)

<u>Abstract of ANOVA</u>

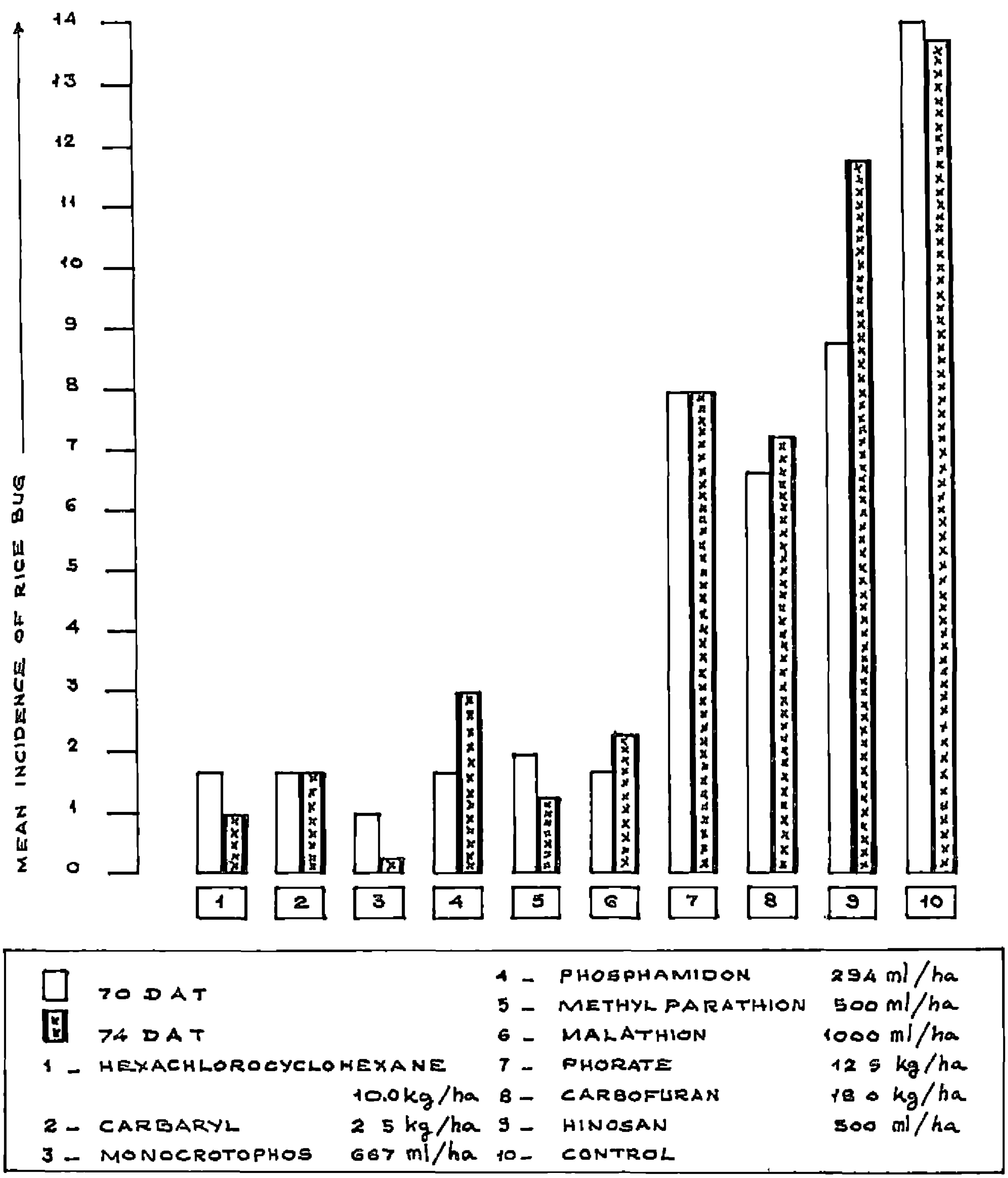
	df	Mean square	
Treatments	9	2.306**	2.812**
Error	18	0.214	0.212
C.D. for comparing treatments		0.793	0.79

Figures within parentheses are $\sqrt{x + 1}$ values.

** Data significant at 0.01 level.

Treatments were applied 69 days after transplanting.

FIG. 2 EFFECT OF PESTICIDES ON THE INCIDENCE OF RICE BUG (*Leptocorisa acuta*) AT 70 AND 74 DAT



The population counts five days after application of pesticides showed that pesticide could also maintain the infestation at a low level. The mean population ranged between 0.33 to 13.7, monocrotophos was the most effective chemical in controlling the rice bug infestation. The other insecticides which were on par in the descending order of effectiveness were hexachlorocyclohexane (T_1), methyl parathion (T_5), carbaryl (T_2), phosphamidon (T_4) and malathion (T_6). The treatments carbofuran (T_8), phorate (T_7) and Hinosan (T_9) were ineffective in controlling pest population.

The final spraying of insecticide was given on 79 DAT and counts of rice bug was taken. The data are presented in the Table 5 and Fig. 3. The population counts proved that the application of pesticides could significantly reduce the infestation. The mean population count 80 DAT ranged from 0 to 9.67. The treatments hexachlorocyclohexane (T_1), carbaryl (T_2), monocrotophos (T_3) and phosphamidon (T_4), methyl parathion (T_5) and malathion (T_6) were equally effective and reduced the rice bug population completely. The other pesticides ranked in the order of descending order of effectiveness were carbofuran (T_8), phorate (T_7) and Hinosan (T_9).

The population counts 87 DAT proved that the application of pesticides could significantly reduce the infestation of rice bug at one per cent level. The mean population count ranged from 0 to 12. The pesticide monocrotophos (T_3) and hexachlorocyclohexane (T_1) were equally effective and completely reduced the rice bug population. The chemicals phosphamidon (T_4), methyl parathion (T_5) and malathion (T_6) were on par with monocrotophos (T_3) and hexachlorocyclohexane (T_1). The other pesticides in the descending order of effectiveness were carbaryl (T_2), carbofuran (T_8), Hinosan (T_9) and phorate (T_7).

The population counts 94 DAT also showed that the application of pesticides could significantly reduce the infestation at one per cent level. The mean population count ranged from 5.33 to 58.67. The treatments monocrotophos (T_3), hexachlorocyclohexane (T_1) and phosphamidon (T_4) were on par in reducing the rice bug infestation. The other pesticides ranked in the descending order of effectiveness were methyl parathion (T_3), carbaryl (T_2), carbofuran (T_8), phorate (T_7), malathion (T_6) and Hinosan (T_9).

The observations taken on 97 DAT were not statistically significant. The mean population count ranged from 31 to 81.67.

Table 5. Effect of pesticides on the incidence of rice bug (L. acuta) on rice

Treatment	Dosage	Mean rice bug incidence observed at					
		80 DAT	87 DAT	94 DAT	97 DAT	100 DAT	102 DAT
T_1 Hexachlorocyclohexane 10 DP	25kg/ha	0.00 (1.00)	0.00 (1.00)	8.00 (2.81)	52.33 (7.12)	68.00 (8.09)	66.00 (7.94)
T_2 Carbaryl 50 WP	2.5kg/ha	0.00 (1.00)	1.33 (1.52)	23.33 (4.87)	41.00 (6.43)	62.67 (7.87)	47.33 (6.91)
T_3 Monocrotophos 36 EC	667ml/ha	0.00 (1.00)	0.00 (1.00)	5.33 (2.46)	47.67 (6.58)	59.67 (7.36)	50.67 (6.98)
T_4 Phosphamidon 85 EC	294ml/ha	0.00 (1.00)	0.33 (1.14)	9.33 (2.98)	32.33 (5.55)	36.33 (5.87)	39.67 (6.30)
T_5 Methyl parathion 50 EC	500ml/ha	0.00 (1.00)	0.33 (1.14)	20.00 (4.58)	81.67 (8.86)	90.67 (9.33)	79.00 (8.57)
T_6 Malathion 50 EC	1000ml/ha	0.00 (1.00)	0.67 (1.28)	29.67 (5.48)	31.00 (5.52)	37.67 (6.08)	49.00 (7.07)
T_7 Phorate 10 G	12.5kg/ha	6.33 (2.51)	5.00 (2.44)	29.67 (5.50)	44.33 (6.62)	52.33 (7.24)	50.33 (7.10)
T_8 Carbofuran 3 G	18kg/ha	3.33 (2.07)	4.00 (2.23)	28.00 (5.34)	40.67 (6.36)	48.00 (6.92)	62.33 (7.77)
T_9 Hinosan 50 EC	500ml/ha	5.67 (2.57)	5.00 (2.43)	42.33 (6.43)	69.67 (8.32)	72.33 (8.47)	76.33 (8.75)
T_{10} Control		9.67 (3.27)	12.00 (3.59)	58.67 (7.78)	33.67 (5.78)	41.67 (6.43)	43.67 (6.61)

Abstract of ANOVA

	df	Mean squares					
Treatments	9	2.301**	2.232**	8.582**	3.744	3.625	2.019
Error	18	0.023	0.055	0.913	2.236	2.736	2.942
C.D. for comparing treatments		0.262	0.394	1.639	NS	NS	NS

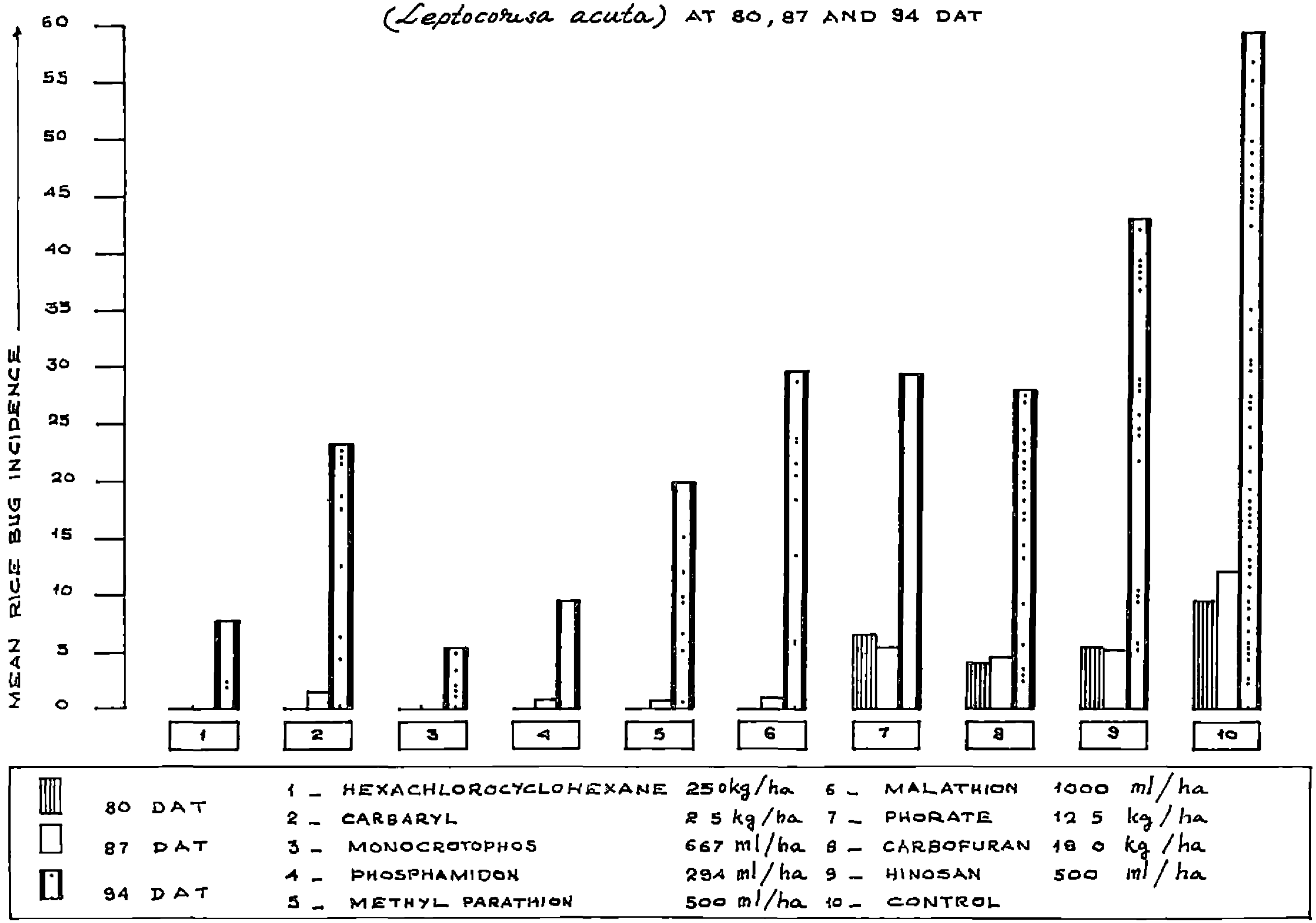
Figures within parentheses are $\sqrt{x + 1}$ values.

Treatments were applied 79 days after transplanting.

** Data significant at 0.01 level

NS - Not significant.

FIG 3 EFFECT OF PESTICIDES ON THE INCIDENCE OF RICE BUG (*Leptocorisa acuta*) AT 80, 87 AND 94 DAT



The observation taken on 100 DAT were not statistically significant. The mean population count ranged from 36.33 to 90.67.

The data of population counts taken on 102 DAT were also not statistically significant. The mean population count ranged from 39.67 to 79.

The mean population values showed that there was no effect of pesticides after 97 DAT. Again counts for the different days showed that there was no variation in the population after 97 days of transplanting.

Statistical analysis of the pooled data on the population of rice bug after the spraying was done. It was observed that there did not exist any significant difference between days after application but there was difference in efficacy only with respect to pesticides. There could not reveal any significant interaction between days and treatments. Monocrotophos (T_3) was the best insecticide to control the rice bug infestation. Other chemicals hexachlorocyclohexane (T_1), methyl parathion (T_5), carbaryl (T_2), phosphamidon (T_4) and malathion (T_6) were on par with monocrotophos showing that the chemicals could reduce rice bug infestation. Hinosan (T_9) was found to be not effective in checking the rice bug population.

Statistical analysis of the pooled data on the population of rice bug after the fourth round of spraying was done. It was observed that there was statistical difference in population between days after the fourth round of spraying. The incidence of rice bug was found to be lower on the first and eighth day after application of pesticides but there was no significant difference in the population between days. The incidence was found to be significant on the 15th day and it was found to be increasing on 18th, 21st and 23rd day after application of insecticide. There was no significant difference in the incidence between 18th, 21st and 23rd day.

Statistically significant difference in the efficacy of the pesticides was observed. The insecticide phosphamidon (T_4) was found to be effective in controlling rice bug than carbofuran (T_8), phorate (T_7), methyl parathion (T_5) and Hinosan (T_9) and it was on par with monocrotophos (T_3), malathion (T_6), hexachlorocyclohexane (T_1) and carbaryl (T_2). Hinosan (T_9) was on par with control (T_{10}) and showed no significant control of rice bug population.

Statistically significant interaction was observed, between days and application of insecticides. No infestation was noted up to eight days after application for hexachlorocyclohexane (T_1) and monocrotophos (T_3), while for other treatments, infestation was noted from first day onwards. All the treatments hexachlorocyclohexane (T_1), carbaryl (T_2), monocrotophos (T_3), methyl parathion (T_5) and phorate (T_7) showed a declining trend in the population after 22 days except phosphamidon (T_4), malathion (T_6), carbofuran (T_8) and Hinosan (T_9).

(2) Cereal thrips

The data on the grains damaged per hill by cereal thrips were presented in the Table 6 and Figure 4. Percentage of damaged grains per hill was observed to assess the relative efficacy of pesticides against cereal thrips. The data on the mean number of grains damaged on 58 DAT were not statistically significant. The mean percentage of damaged grains observed per hill ranged from 2.07 to 13.92, 10.54 being in the control plots.

The mean counts of grains damaged by thrips observed on 66 DAT were also not statistically significant. The mean percentage of damaged grains observed per hill ranged from 11.92 to 38.19, 32.08 being in the control plot.

The observations taken on 74 DAT showed that the treatments caused statistically significant reduction of infestation by cereal thrips at five per cent level of probability. The mean percentage of damaged grains observed per hill ranged from 12.60 to 63.70. The pesticides monocrotophos (T_3), phosphamidon (T_4), methyl parathion (T_5) and hexachlorocyclohexane (T_1), Hinosan (T_9) and carbaryl (T_2) were on par in reducing the damage by cereal thrips. The other treatments ranked in the descending order of effectiveness were carbofuran (T_8), malathion (T_6) and phorate (T_7).

The observations taken on 80 DAT showed statistically significant reduction of thrips damage at five per cent level of probability. The mean percentage of damaged grains varied from 8.05 to 66.73. The pesticides monocrotophos (T_3), phosphamidon (T_4), methyl parathion (T_5), hexachlorocyclohexane (T_1), Hinosan (T_9) and carbaryl (T_2) were on par in controlling the damage by cereal thrips. The treatments malathion (T_6), carbofuran (T_8) and phorate (T_7) were ineffective.

Statistical analysis of pooled data on the damaged grains caused by cereal thrips was done. It was observed that there existed statistical difference in damage between days after application of pesticides at one per cent level of probability. Damage by thrips was significantly lower on 58 DAT than on 66, 74 and 80 DAT though it was on par

Table 6. Effect of pesticides on the incidence of cereal thrips (*H. ganglbaueri*) on rice

	Treatment	Dosage	Mean percentage of damaged grains per hill at			
			58 DAT	66 DAT	74 DAT	80 DAT
T_1	Hexachlorocyclohexane 10 DP	25kg/ha	3.99 (10.79)	11.92 (19.85)	15.85 (23.22)	16.29 (23.37)
T_2	Carbaryl 50 WP	2.5kg/ha	9.37 (17.55)	23.88 (28.55)	31.37 (33.24)	32.80 (33.89)
T_3	Monocrotophos 36 EC	667ml/ha	5.59 (12.83)	16.54 (23.90)	12.60 (20.51)	8.05 (15.59)
T_4	Phosphamidon 85 EC	294ml/ha	5.58 (12.08)	17.57 (24.37)	17.27 (24.12)	10.90 (17.46)
T_5	Methyl parathion 50 EC	500ml/ha	8.96 (16.70)	19.52 (26.06)	13.84 (21.60)	14.40 (20.82)
T_6	Malathion 50 EC	1000ml/ha	13.92 (21.13)	32.22 (32.55)	45.66 (42.17)	42.57 (55.30)
T_7	Phorate 10 G	12.5kg/ha	2.07 (8.12)	38.19 (37.02)	54.28 (47.36)	66.73 (58.20)
T_8	Carbofuran 3 G	18kg/ha	9.02 (17.43)	32.22 (34.16)	44.10 (41.57)	66.43 (57.45)
T_9	Hinosan 50 EC	500ml/ha	4.51 (12.07)	18.49 (25.31)	22.18 (28.07)	30.99 (32.93)
T_{10}	Control		10.54 (17.95)	32.08 (33.22)	63.70 (55.96)	58.45 (50.59)

Abstract of ANOVA

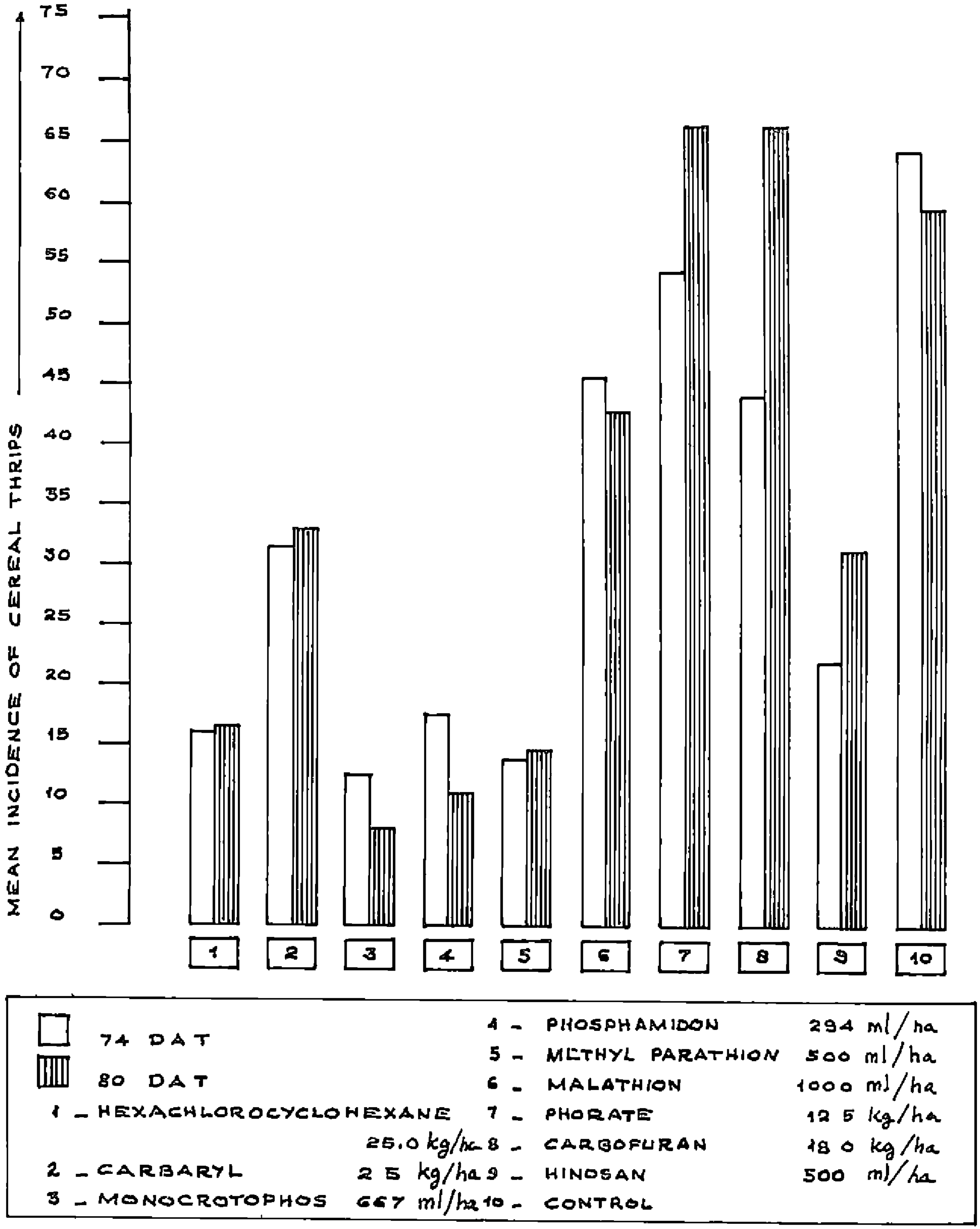
	df	Mean squares			
Treatments	9	49.09	90.85	456.38*	899.86*
Error	18	23.19	75.5	139.08	264.21
C.D. for comparing treatments		NS	NS	20.23	27.88

Figures within parentheses are in angles.

* Data significant at 0.05 level.

NS - Not significant.

FIG 4 EFFECT OF PESTICIDES ON THE INCIDENCE OF CEREAL THRIPS (*Haplothrips ganglbaueri*) ON RICE AT 74 AND 80 DAT



with 74 DAT showing that the infestation was progressively increasing from 58 DAT to 74 DAT.

Statistically significant difference in the efficacy of the pesticides were observed on a whole. The treatments monocrotophos (T_3), hexachlorocyclohexane (T_1), phosphamidon (T_4), methyl parathion (T_5), Hinosan (T_9) and carbaryl (T_2) were on par in controlling the damage by thrips. The damage by thrips was highest in control plot and it was on par with carbofuran (T_8), phorate (T_7) and malathion (T_6).

There could not reveal any significant interaction between days and treatments.

(3) <u>The striped bug</u>

The data on the incidence of striped bug are presented in Table 7 and Figure 5. No incidence of striped bug was observed until 97 DAT. The data on the sweepnet count on the incidence of striped bug was not found to be statistically significant. The mean counts ranged from 9 to 30.67. The population count of striped bug on 100 DAT was also not statistically significant. The mean sweepnet count ranged from 14 to 34.67.

The population count of striped bug was statistically significant at one per cent level of probability on 102 DAT.

The mean sweepnet count ranged from 9.33 to 44.33. It could be observed that methyl parathion (T_5) was the most effective chemical in controlling population of striped bug. Treatments monocrotophos (T_3), phosphamidon (T_4), hexachlorocyclohexane (T_1) and malathion (T_6) were on par with methyl parathion (T_3) showing that these chemicals could also check the striped bug infestation. The other chemicals in the descending order of effectiveness were carbofuran (T_8), carbaryl (T_2), phorate (T_7) and Hinosan (T_9).

Statistical analysis of the pooled data on the population of striped bug was done to assess the overall effect of the pesticides on the incidence of the pest. A significant difference between days after application of chemicals was observed. The data were statistically significant at one per cent level. The population of striped bug was significantly lower during 97 DAT but progressively increased afterwards up to 102 DAT.

There existed significant difference among the treatment in controlling the striped bug infestation at one per cent level of probability. Methyl parathion (T_5) was the most effective treatment against striped bug which was followed by monocrotophos (T_3), hexachlorocyclohexane (T_1), Hinosan (T_9), control (T_{10}) and phorate (T_7) in the order of decreasing efficiency.

Table 7. Effect of pesticides on the incidence of striped bug (*T. histeroides*) on rice

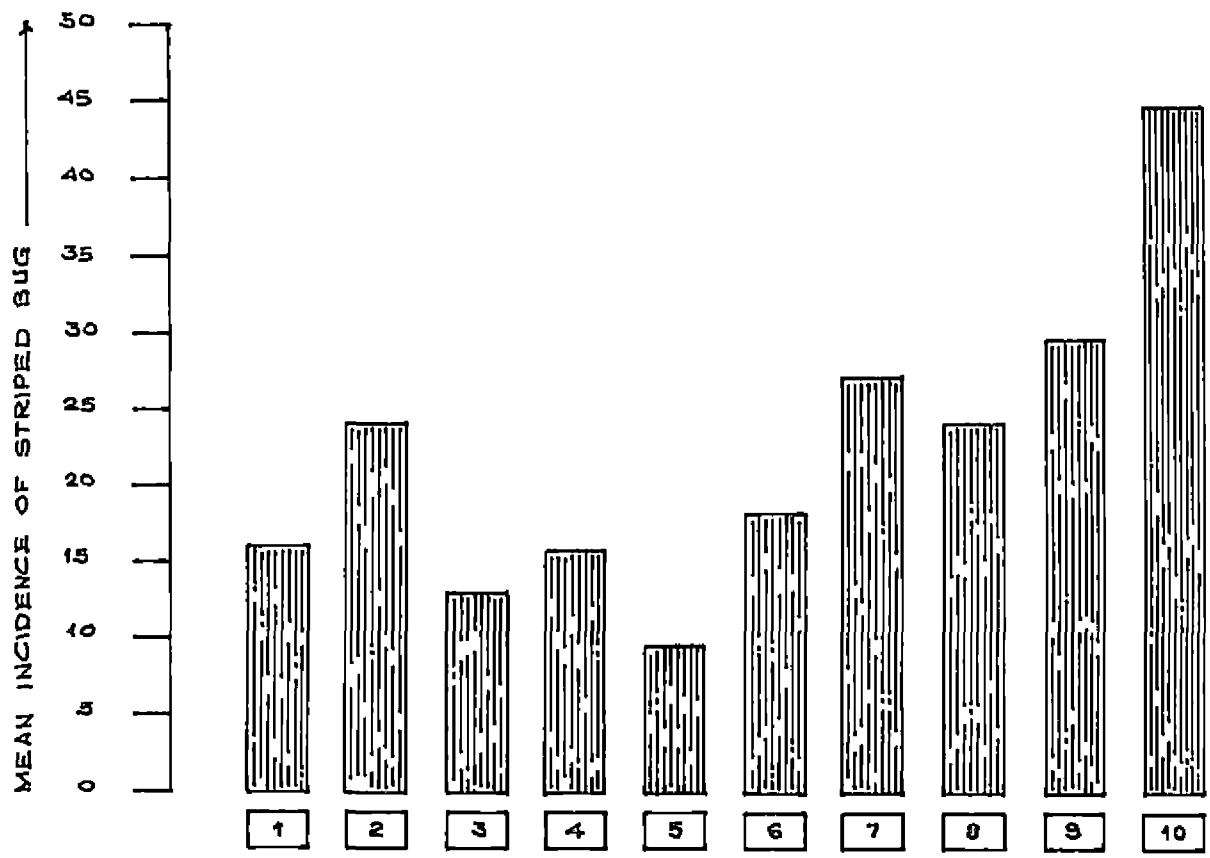
	Treatment	Dosage	Mean incidence at		
			97 DAT	100 DAT	102 DAT
T_1	Hexachlorocyclohexane 10 DP	25 kg/ha	11.67 (3.46)	14.00 (3.81)	16.67 (4.16)
T_2	Carbaryl 50 WP	2.5 kg/ha	10.00 (3.33)	23.00 (5.35)	24.67 (5.01)
T_3	Monocrotophos 36 EC	667 ml/ha	12.33 (3.58)	17.00 (4.18)	13.33 (3.66)
T_4	Phosphamidon 85 EC	294 ml/ha	10.67 (3.40)	14.67 (3.94)	16.00 (4.11)
T_5	Methyl parathion 50 EC	500 ml/ha	9.00 (3.15)	16.67 (3.90)	9.33 (3.13)
T_6	Malathion 50 EC	1000 ml/ha	12.00 (3.53)	16.00 (4.02)	18.00 (4.31)
T_7	Phorate 10 G	12.5 kg/ha	30.67 (5.43)	34.67 (5.81)	27.00 (5.21)
T_8	Carbofuran 3 G	18 kg/ha	16.00 (4.09)	20.33 (4.58)	24.00 (4.93)
T_9	Hinosan 50 EC	500 ml/ha	17.00 (4.29)	23.00 (4.88)	29.33 (5.46)
T_{10}	Control		15.67 (4.03)	21.00 (4.62)	44.33 (6.72)

<u>Abstract of ANOVA</u>

	df	Mean squares		
Treatments	9	1.33	1.37	3.12**
Error	18	0.66	0.97	0.59
C.D. for comparing treatments		NS	NS	1.31

Figures within parentheses are $\sqrt{x + 1}$ values.
** Data significant at 0.01 level.
NS - Not significant.

FIG. 5 EFFECT OF PESTICIDES ON THE INCIDENCE OF STRIPED BUG (*Tetroda histeroides*) ON RICE AT 102 DAT



1 – HEXACHLOROCYCLOHEXANE 25 0 kg/ha
2 – CARBARYL 2.5 kg/ha
3 – MONOCROTOPHOS 667 ml/ha
4 – PHOSPHAMIDON 294 ml/ha
5 – METHYL PARATHION 500 ml/ha
6 – MALATHION 1000 ml/ha
7 – PHORATE 12 5 kg/ha
8 – CARBOFURAN 18 0 kg/ha
9 – HINOSAN 500 ml/ha
10 – CONTROL

There could not reveal any significant interaction between days and treatments.

(4) Rice Weevil

The data relating to this pest are presented in Table 8 and Figure 6. The adults of rice weevil *S. oryzae* were seen infesting the ripening earhead sparingly in the experimental plots about five days before harvest. The population was found to be increasing slightly and sweepnet count of the pest before harvest was not statistically significant. The mean sweepnet count of rice weevil was found to vary between 20.67 to 49.33 and 45.33 being the mean count in the control plot.

(5) Control of Sheath blight

Data on the incidence of sheath blight disease during the experiment was assessed by score chart method and are presented in the Table 9 and in Figure 7. The mean value of disease index varied between 28.78 and 70.52.

Statistical analysis of the data showed that Hinosan (T_9) was the most effective pesticide in controlling the disease with a mean value of 28.78. Effect of treatments T_1, T_4 and T_5 corresponding to application of hexachlorocyclohexane, phosphamidon and methyl parathion was on par

Table 8. Effect of pesticides on the incidence of rice weevil (*S. oryzae*)

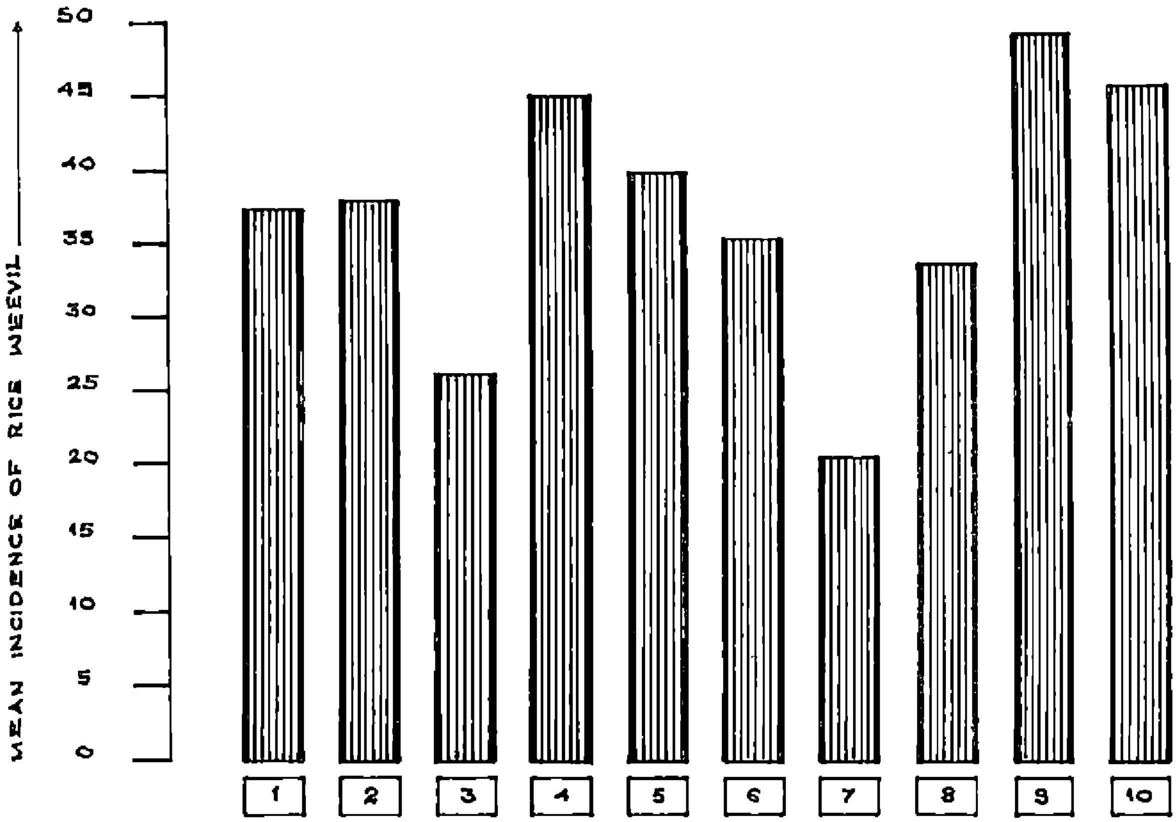
	Treatment	Dosage	Mean rice weevil count per 10 standard sweeps observed at 102 DAT
T_1	Hexachlorocyclohexane 10 DP	25kg/ha	37.33 (5.97)
T_2	Carbaryl 50 WP	2.5kg/ha	38.00 (5.49)
T_3	Monocrotophos 36 EC	667ml/ha	26.33 (5.08)
T_4	Phosphamidon 85 EC	294ml/ha	45.00 (6.38)
T_5	Methyl parathion 50 EC	500ml/ha	40.00 (6.37)
T_6	Malathion 50 EC	1000ml/ha	35.67 (5.86)
T_7	Phorate 10 G	12.5kg/ha	20.67 (4.27)
T_8	Carbofuran 3 G	18kg/ha	33.67 (5.31)
T_9	Hinosan	500ml/ha	49.33 (6.69)
T_{10}	Control	Untreated	45.33 (6.43)

Abstract of ANOVA	df	Mean squares
Treatments	9	1.691
Error	18	3.2
C.D. for comparing treatments		NS

Figures within parentheses are $\sqrt{x}$ values.

NS - Not significant.

FIG 6 EFFECT OF PESTICIDES ON THE INCIDENCE OF RICE WEEVIL (*Sitophilus oryzae*) AT 102 DAT



1 _ HEXACHLOROCYCLOHEXANE 25 0 kg/ha
2 _ CARBARYL 2 5 kg/ha
3 _ MONOCROTOPHOS 667 ml/ha
4 _ PHOSPHAMIDON 284 ml/ha
5 _ METHYL PARATHION 500 ml/ha
6 _ MALATHION 1000 ml/ha
7 _ PHORATE 12.5 kg/ha
8 _ CARBOFURAN 18 0 kg/ha
9 _ HINOSAN 500 ml/ha
10 _ CONTROL

Table 9. Effect of pesticides on the incidence of sheath blight on rice

	Treatment	Dosage	Disease index
T_1	Hexachlorocyclo-hexane 10 DP	25kg/ha	33.02 (11.61)
T_2	Carbaryl 50 WP	2.5kg/ha	59.26 (17.65)
T_3	Monocrotophos 36 EC	667ml/ha	51.62 (15.98)
T_4	Phosphamidon 85 EC	294ml/ha	42.98 (13.59)
T_5	Methyl parathion 50 EC	500ml/ha	44.59 (13.94)
T_6	Malathion 50 EC	1000ml/ha	60.00 (16.77)
T_7	Phorate 10 G	12.5kg/ha	58.33 (16.60)
T_8	Carbofuran 3 G	18kg/ha	58.49 (16.64)
T_9	Hinosan	500ml/ha	28.78 (10.71)
T_{10}	Control		70.52 (19.00)

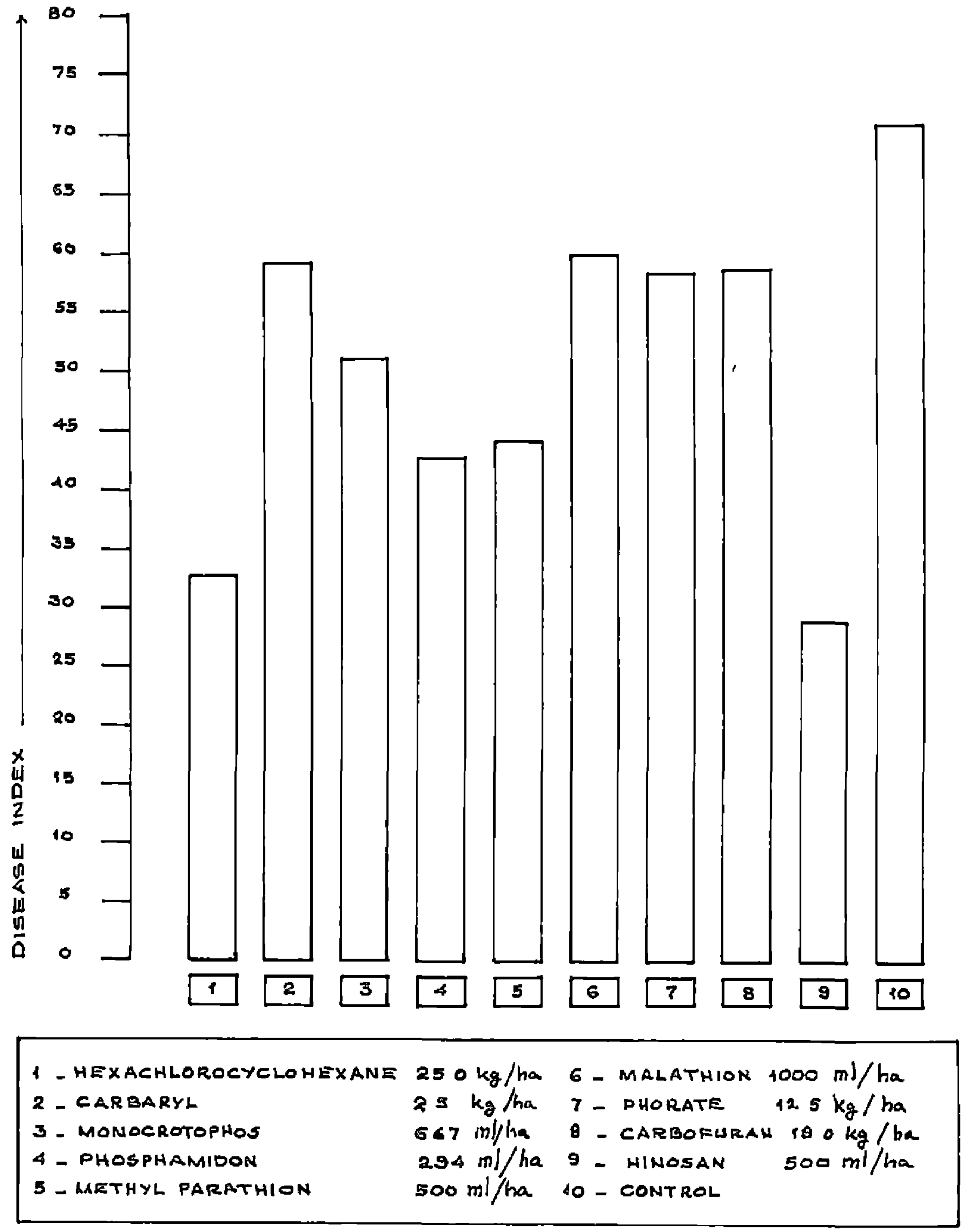
Abstract of ANOVA

	df	Mean squares
Treatments	9	182.006*
Error	18	62.593
C.D. for comparing treatments		13.572

Figures within parentheses are angular values.

* Data significant at 0.01 level.

FIG 7 EFFECT OF PESTICIDES ON THE INCIDENCE OF SHEATH BLIGHT ON RICE AT 96 DAT



with that of Hinosan (T_9) proving that these chemicals were also effective in checking the disease incidence at five per cent level of probability.

Other treatments T_3, T_7, T_8, T_6 and T_2 corresponding to application of monocrotophos, phorate, carbofuran, malathion and carbaryl were not effective in controlling the disease incidence. The pesticides were ranked in the descending order of effectiveness as Hinosan (T_9), hexachlorocyclohexane (T_1), phosphamidon (T_4), methyl parathion (T_5), malathion (T_6) and carbaryl (T_2).

(6) Gametocidal action of pesticides

The data on the pollen sterility counts observed after 1 hour, 2 hour and 4 hour after application of insecticides are presented in the Table 10 and Figure 8.

Statistically significant difference in pollen sterility at one per cent level of probability was observed an hour after application of pesticides. The mean percentage pollen sterility count varied between 0.86 and 10.91. The pesticides phorate (T_7), phosphamidon (T_4) and carbofuran (T_8) were on par and caused greater sterility of pollen than monocrotophos (T_3), hexachlorocyclohexane (T_1), carbaryl (T_2), Hinosan (T_9), methyl parathion (T_5), malathion (T_6) and control. The pesticides ranked in the descending order of effectiveness were phorate (T_7), phosphamidon (T_4), carbofuran (T_8), monocrotophos (T_3), hexachlorocyclohexane (T_1), carbaryl (T_2), Hinosan (T_9), methyl parathion (T_5) and malathion (T_6). The treatment malathion (T_6) showed least sterility and it was on par with methyl parathion (T_5) and Hinosan (T_9).

The observation taken on pollen sterility 2 hours after application of pesticides also showed statistically significant difference both at one per cent and five per cent level of probability. The mean percentage pollen sterility count varied between 0.79 to 12.08. The treatments phorate (T_7), phosphamidon (T_4) and carbofuran (T_8) were on par in causing pollen sterility. The other treatments ranked in the descending order of causing sterility were monocrotophos (T_3), carbaryl (T_2), malathion (T_6), Hinosan (T_9), hexachlorocyclohexane (T_1) and methyl parathion (T_5). The treatment methyl parathion was on par with control and caused least sterility.

Statistically significant difference in pollen sterility at one per cent level of probability was observed 4 hour after application of pesticide. The mean percentage pollen sterility varied between 0.55 and 13.72. The treatments phorate (T_7), phosphamidon (T_4) and carbofuran (T_8) were on par in causing pollen sterility. The other treatments ranked in the descending order of causing sterility were carbaryl (T_2), monocrotophos (T_3), Hinosan (T_9), hexachlorocyclohexane (T_1), malathion (T_6) and methyl parathion (T_5). The treatment methyl parathion was on par with control and caused least sterility.

Statistical analysis of the pooled data on the sterile pollen observed one hour, two hour and four hour after application of pesticides was done. The percentage of sterile pollen was high in plants treated with phorate (T_7) and phosphamidon (T_4) and this percentage was markedly higher compared to other treatments. The treatments carbofuran (T_8) produced more sterile pollen compared to other treatments. The treatments monocrotophos (T_3), carbaryl (T_2) and hexachlorocyclohexane (T_1) were of equally responsive but monocrotophos (T_3) produced more sterile pollen compared to Hinosan (T_9), malathion (T_6) and methyl parathion (T_5) while carbaryl (T_2) produced more compared to malathion (T_6) and methyl parathion (T_5) which were found to respond equally. However, in all the treated plants the sterile pollen was high compared to control. The sterile pollen compared to control was 5.03 times in the case of phorate, the count being taken four hour after application of pesticides. In the case of phosphamidon, four hour after application of pesticide, the value was 4.619 and 1.864 for methyl parathion after four hour of application.

The observations were recorded after one hour, two hour and four hour of application. In an attempt to compare the effect of pesticides on pollen between hour of observation it was noted that the percentage of sterile pollen was high after four hour of application compared to one hour of application. No significant difference in sterile pollen was noticed between one and two hour of application, and also between two hour and four hour of application.

A significant interaction was noticed for treatments at different periods of observations (Fig. 9). Differential responses were observed for treatments after one, two and four hour of application of treatments. Sterile pollen was found to increase with increase in the time of application for treatments carbaryl (T_2), phosphamidon (T_4), phorate (T_7), carbofuran (T_8) and Hinosan (T_9) while for methyl parathion (T_5) and control (T_{10}) the sterile pollen was found to decrease with an increase in time. Hexachlorocyclohexane (T_1) and monocrotophos (T_3) showed no significant difference in sterile pollen after one, two and four hour of application of treatments. But for malathion (T_6) a marked increase in sterile pollen was observed after two hour compared to one hour and the percentage decreased at four hour.

Table 10. Gametocidal action of pesticides on rice

Treatment	Dosage	Mean percentage sterility of pollen observed at		
		One hour after application	Two hour after application	Four hour after application
T_1 Hexachlorocyclohexane 10 DP	25 kg/ha	4.80 (2.02)	3.72 (1.91)	4.69 (2.10)
T_2 Carbaryl 50 WP	2.5 kg/ha	4.36 (1.97)	5.50 (2.25)	6.72 (2.46)
T_3 Monocrotophos 36 EC	667 ml/ha	5.26 (2.25)	7.78 (2.60)	5.85 (2.56)
T_4 Phosphamidon 85 EC	294 ml/ha	9.39 (3.06)	10.07 (3.16)	11.66 (3.40)
T_5 Methyl parathion 50 EC	500 ml/ha	3.24 (1.73)	2.57 (1.58)	1.90 (1.37)
T_6 Malathion 50 EC	1000 ml/ha	1.54 (1.24)	4.36 (2.06)	3.36 (1.83)
T_7 Phorate 10 G	12.5 kg/ha	10.91 (3.30)	12.08 (3.47)	13.72 (3.70)
T_8 Carbofuran 3 G	18 kg/ha	6.83 (2.51)	7.62 (2.74)	10.58 (3.23)
T_9 Hinosan 50 EC	500 ml/ha	3.03 (1.74)	3.96 (1.96)	4.88 (2.18)
T_{10} Control		0.86 (0.89)	0.79 (0.88)	0.55 (0.79)

Abstract of ANOVA

	df	Mean squares		
Treatments	9	1.68**	1.75**	2.55 **
Error	18	0.25	0.29	0.19
C.D. for comparing treatments		0.86	0.82	0.74

Figures in parentheses are in angles.

** Data significant at 0.01 level.

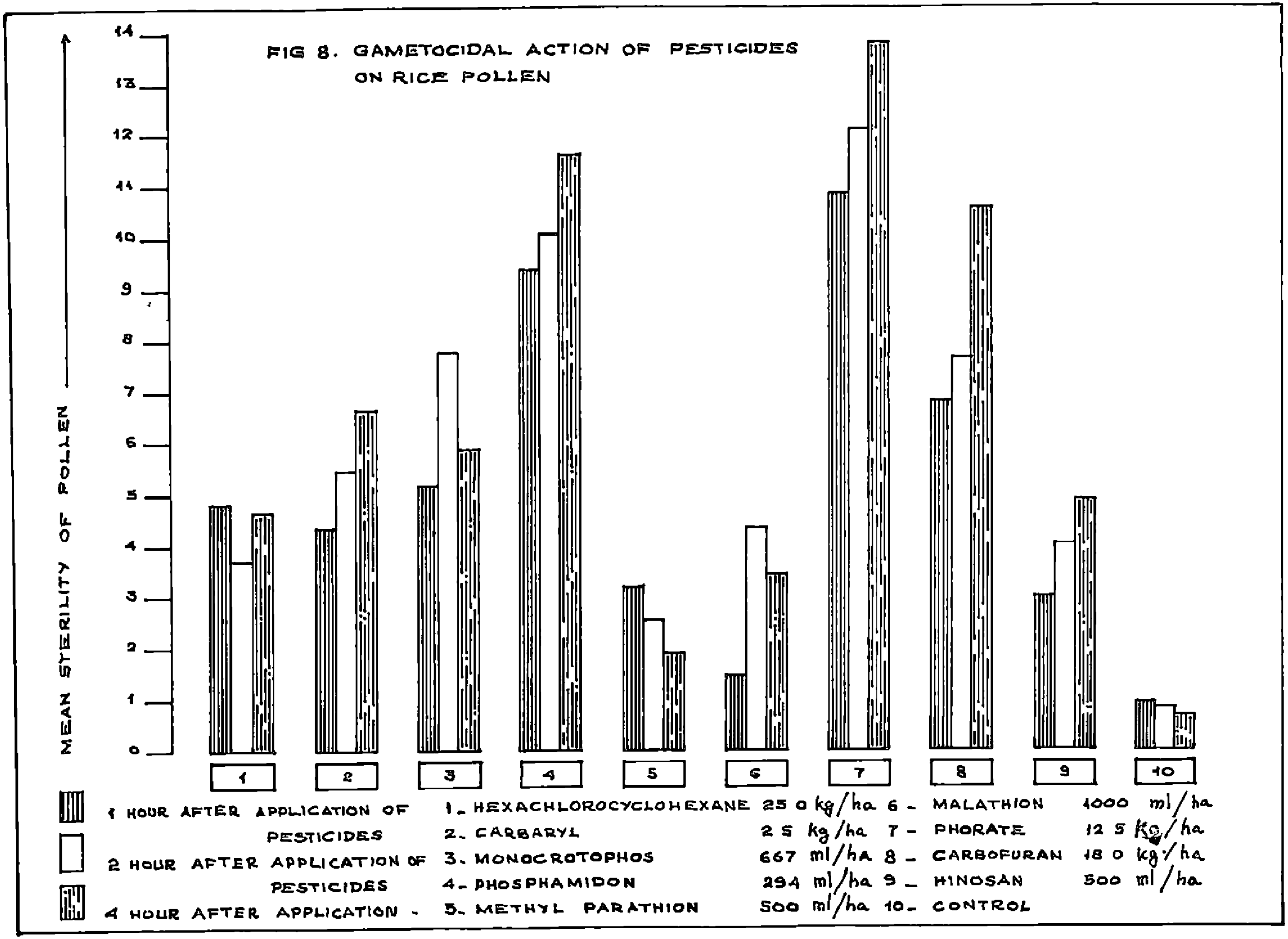
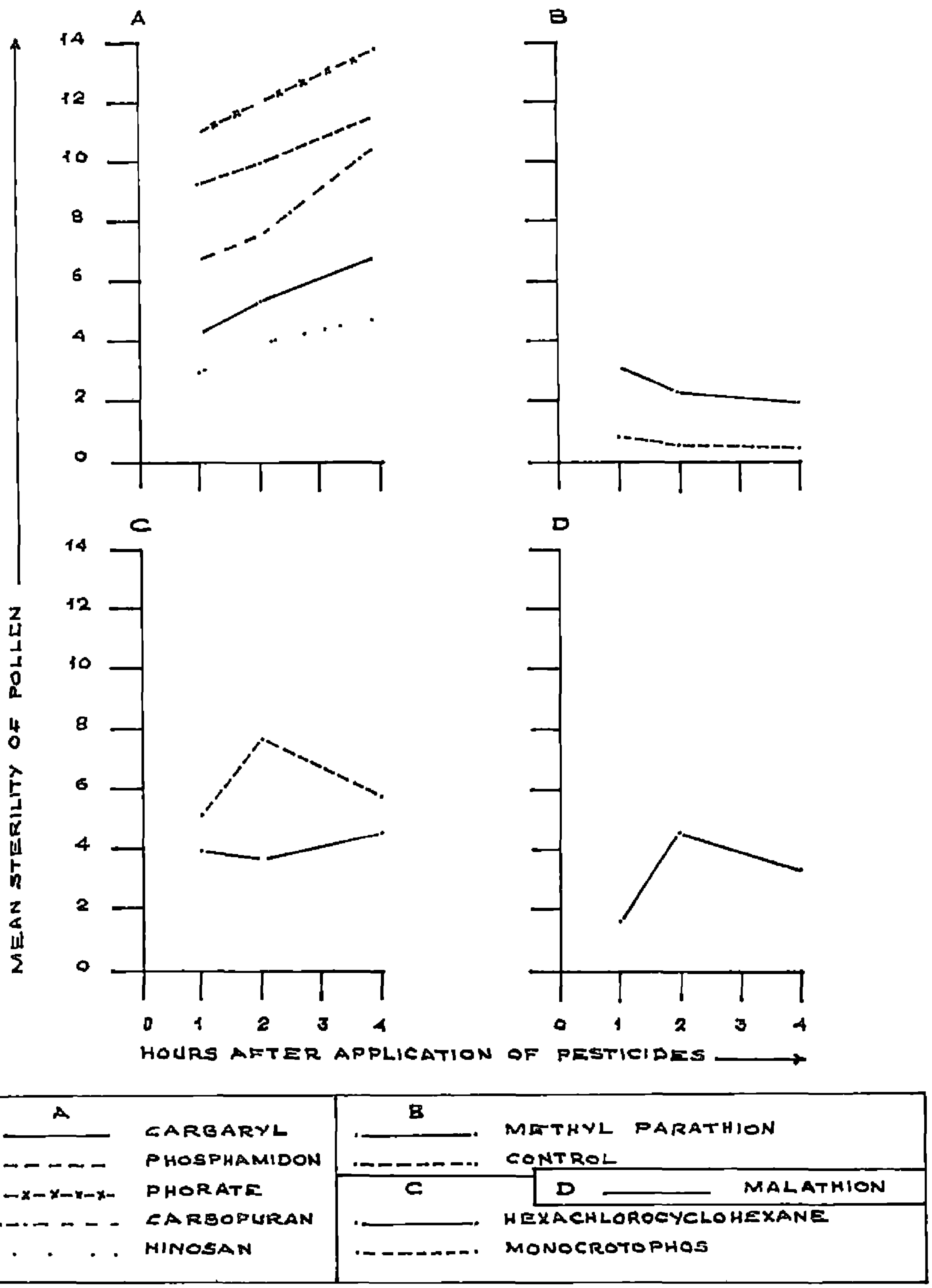


FIG 8. GAMETOCIDAL ACTION OF PESTICIDES ON RICE POLLEN

FIG 9 TREATMENT TIME INTERACTION ON THE GAMETOCIDAL ACTION OF PESTICIDES ON RICE POLLEN



(7) Yield

The data relating to yield in the field experiment are presented in the Table 11. The data on fresh weight both grain and straw were not statistically significant at five per cent level. The data on the dry weight of grains were statistically significant at five per cent level of probability showing that the application of pesticides influence the yield.

The effect of monocrotophos (T_3) was superior to that of others in increasing yield and methyl parathion (T_5), phosphamidon (T_4) and hexachlorocyclohexane (T_1)were on par with it. The treatments ranked in the descending order were monocrotophos (T_3), methyl parathion (T_5), phosphamidon (T_4), hexachlorocyclohexane (T_1), malathion (T_6), Hinosan (T_9), phorate (T_7), carbaryl (T_2), control (T_{10}), carbofuran (T_8). Yield was lowest in control and plots treated with carbofuran.

(8) Damage and loss of yield due to rice bug infestation

The number of stylet sheath caused by the feeding of rice bug on rice grains were observed. The data on the percentage of unfilled grains with stylet sheath and filled grains with stylet sheath were presented in Table 12 and in Figure 10. The mean percentage of unfilled grains with stylet sheath varied from 24.67 to 96.49. The maximum number

Table 11. Effect of pesticides on yield

	Treatment	Dosage	Mean yield per plot of size 4m x 4m			
			Fresh grain weight (kg)	Straw (kg)	Dry grain weight (kg)	Chaff (kg)
T_1	Hexachlorocyclohexane 10 DP	25kg/ha	0.67	2.50	0.55	0.08
T_2	Carbaryl 50 WP	2.5kg/ha	0.72	3.35	0.53	0.17
T_3	Monocrotophos 36 EC	667ml/ha	0.75	3.17	0.67	0.10
T_4	Phosphamidon 85 EC	294ml/ha	0.72	2.35	0.67	0.08
T_5	Methyl parathion 50 EC	500ml/ha	0.67	2.60	0.55	0.05
T_6	Malathion 50 EC	1000ml/ha	0.59	2.83	0.50	0.06
T_7	Phorate 10 G	12.5kg/ha	0.75	3.17	0.67	0.10
T_8	Carbofuran 3 G	18kg/ha	0.48	3.32	0.33	0.15
T_9	Hinosan 50 EC	500ml/ha	0.62	2.33	0.47	0.10
T_{10}	Control		0.40	2.67	0.33	0.08

Abstract of ANOVA

	df	Mean squares			
Treatments	9	0.2999	2.033	0.387*	0.006528
Error	18	0.1492	2.182	0.124	0.00658
C.D. for comparing treatments		NS	NS	0.604	NS

* Data significant at 0.01 level.
NS - Not significant.

of stylet sheaths on unfilled were observed in the control plot and the minimum in plots treated with phosphamidon. The data were statistically significant at one per cent level showing the effect of the treatments in reducing the number of unfilled grains and phosphamidon was found to be most effective in reducing the rice bug infestation and it was on par with that of methyl parathion and monocrotophos. The efficiency of other treatments were similar.

The data on the percentage of filled grain with stylet sheath are presented in the Table 12. Statistical analysis showed significant at five per cent level and one per cent level. The number of filled grains with stylet sheath varied between 13.13 to 89.27. The control plot showed the greatest damage. The other treatments in the descending order of effectiveness in checking insect infestation are carbaryl (T_2), methyl parathion (T_5), phorate (T_7), hexachlorocyclohexane (T_1), carbofuran (T_8), Hinosan (T_9), monocrotophos (T_3), phosphamidon (T_4), malathion (T_6) and control (T_{10}).

The data relating to chaff was not statistically significant.

Table 12. Effect of pesticides on the damage due to rice bug infestation (stylet sheath count)

	Treatment	Dosage	Mean percentage of unfilled grain with stylet sheath	Mean percentage of filled grain with stylet sheath
T_1	Hexachlorocyclohexane 10 DP	25 kg/ha	52.56(46.502)	25.01(29.767)
T_2	Carbaryl 50 WP	2.5 kg/ha	51.86(46.014)	13.49(17.757)
T_3	Monocrotophos 36 EC	667 ml/ha	40.15(32.881)	30.59(30.893)
T_4	Phosphamidon 85 EC	294 ml/ha	24.67(28.34)	27.60(31.65)
T_5	Methyl parathion 50 EC	500 ml/ha	40.15(39.10)	13.13(22.06)
T_6	Malathion 50 EC	1000 ml/ha	58.88(50.30)	31.53(33.93)
T_7	Phorate 10 G	12.5 kg/ha	52.05(46.40)	21.79(27.62)
T_8	Carbofuran 3 G	18 kg/ha	51.39(45.84)	26.56(30.26)
T_9	Dinosan 50 EC	500 ml/ha	67.12(55.11)	25.52(30.52)
T_{10}	Control		96.49(79.49)	89.27(74.58)

Abstract of ANOVA

	df	Mean squares	
Treatments	9	230.587**	713.656**
Error	18	70.79	118.294
C.D. for comparing treatments		14.433	18.656

Figures within parentheses are angular values.

** Data significant at 0.01 level.

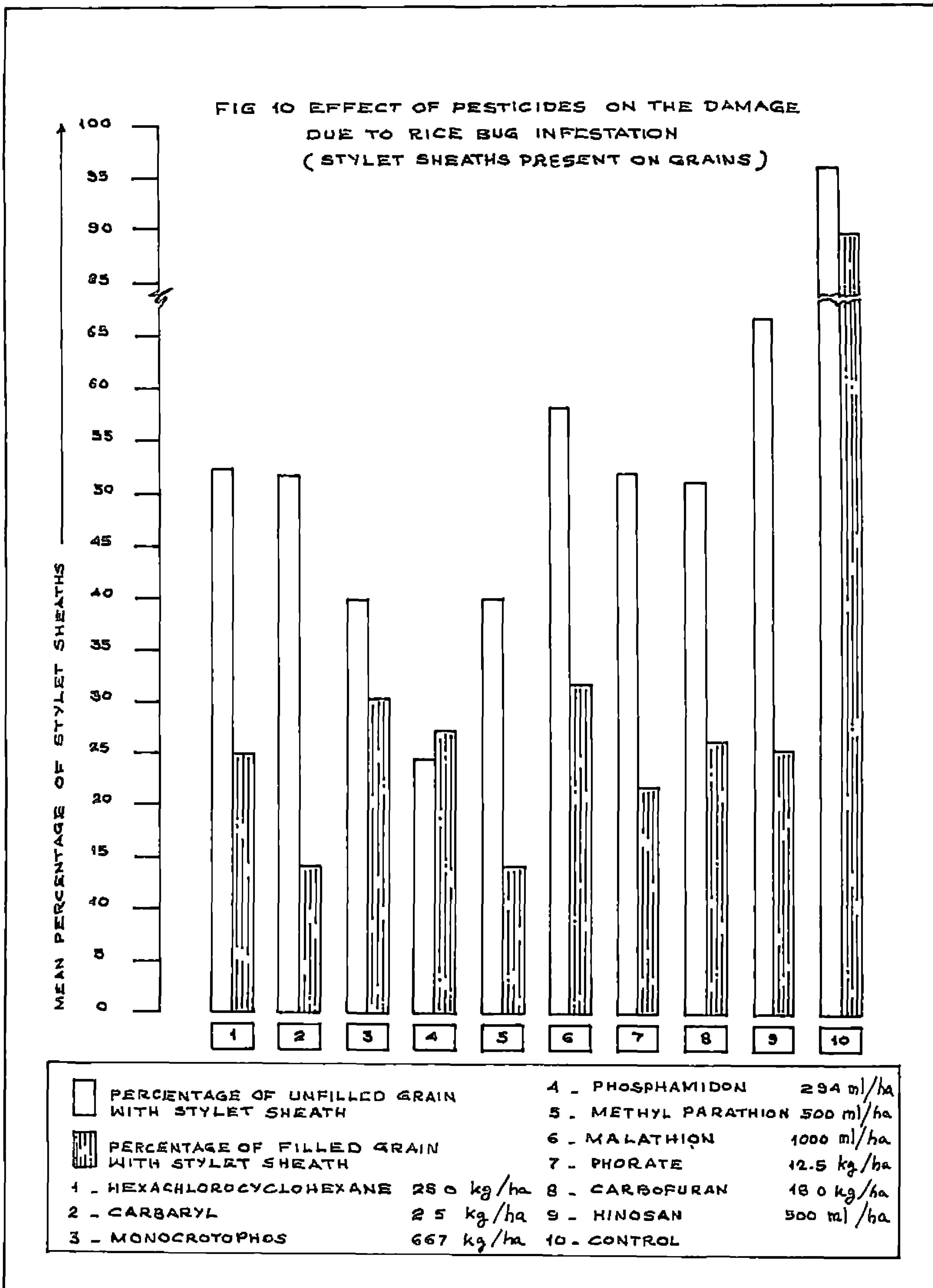


FIG 10 EFFECT OF PESTICIDES ON THE DAMAGE DUE TO RICE BUG INFESTATION (STYLET SHEATHS PRESENT ON GRAINS)

DISCUSSION

DISCUSSION

A random sample survey on insect pests and diseases infesting rice during flowering stage was conducted to collect information on the occurrence of pests and diseases on rice earhead of different localities in Trivandrum district. It could be observed that *L. acuta* was the most important pest occurring throughout the area surveyed. The importance of rice bug was further proved by the mean number of insects present in different localities. The mean number of rice bug varied from 0.25 to 2.45 which showed the existence of considerable variation according to localities and varieties. The high yielding varieties invariably were seen more susceptible to the pest infestation than the local cultivars.

Next to *L. acuta*, Red spotted earhead bug *M. histrio* was more prevalent. It could be observed that the pest was also present in all the localities except Kazhakuttom. The absence of the pest might be due to the fact that local varieties were cultivated, and the climatic conditions prevailing in the locality might not have been congenial for pest infestation.

The cereal thrips, *H. ganglbaueri* were present in most of the areas except Kazhakuttom and Neyyattinkara. In all the areas where the infestation by thrips was absent local varieties like Thavalakkannan and Cheradi were cultivated.

The rice weevil, S. oryzae was observed in Karamana, Vellayani, Ulloor and Attingal. Sitophilus infested rice grains in the field when grain was mature and ready for harvest.

The stink bug, E. ventralis was found in two localities, the fields adjacent to Ulloor Seed Farm and Instructional Farm, College of Agriculture, Vellayani. As this was not reported earlier as a pest of rice in Kerala, though a pest of oil seeds (gingelly) and millets (cumbu) and formed a pest of rice in other parts of India, further investigations were made.

The population of insect pests in Karamana area was very low and so also the incidence of disease. This might be due to the high management practices followed in the Public Sector Farm.

The population of insect pests in Vellayani area was fairly high compared to other areas. This was due to the fact that the observations were made from bulk plantings where no pesticide was used. As such all the pests multiplied in numbers in the plot and also attracted more of them, thus warranting the application of pesticides when needed.

The important diseases observed included Brown spot, Sheath blight, Sheath rot and False smut. The disease brown spot was observed from all the localities except Nedumangad and Neyyattinkara. The incidence of brown spot was higher in Kazhakuttom, Chirayinkil and Attingal. The reason for the highest incidence of brown spot in Kazhakuttom area might be attributed to heavy application of nitrogenous fertilizers.

In areas viz. Karamana, Vellayani and Ulloor, where the cultivation is followed as per Package of Practices Recommendations, there was no incidence of brown spot disease.

Sheath blight was found to occur in Vellayani, Ulloor, Attingal, Nedumangad and Neyyattinkara areas.

The present investigation could not reveal any correlation between the incidence of pests and the occurrence of disease.

The studies on the nature of feeding and damage caused by M. histrio, the red spotted earhead bug, could reveal that the insect sucks sap from the grain piercing through the lemma and palea. Diffused brownish spots were developed at the loci of feeding. On staining with acid fuchsin, it could be observed that the stylet sheath took the stain and appeared red. The feeding patterns studied could reveal peculiarities in the nature of damage caused by various pests. The occurrence and nature of damage of one or more of the pests studied could be identified by observing the feeding patterns even in mixed infestations. Thus the infestation by M. histrio was accompanied by the presence of diffused brown spot on the surface of lemma and palea around the site where the stylet was penetrating. The infestation could be confirmed by acid fuchsin stain.

The nature of feeding and damage caused by E. ventralis the stink bug were also studied. Even though the occurrence of E. ventralis on rice has been reported from India (Grist and Lever, 1969), it formed a major pest of millets and oil seeds only (Vasantharaj David and Kumaraswamy, 1975; Flectcher, 1914). It was for the first time that the occurrence of this pest is reported from Kerala causing earhead damage to rice.

The point of piercing the stylets on the surface of the grain, developed brownish patches with a small white spot at the centre. This type of symptom of damage caused was easily distinguished from those caused by other sucking insects, as it was very characteristic of the pest. Even in the case of mixed infestations the nature of damage suggested the occurrence of the pest. The stylet sheath formed during the feeding activity stained red and could be identified.

The nature of damage caused by H. ganglbaueri, the cereal thrips was studied and found that both the adults and nymphs were causing damage to the spikelets and grains. The thrips could damage during the flowering and grain filling stages, so that the damage caused was heavy.

Having reached the inflorescence, the pests entered the flowers and moved to the ovarian tissues where they congregated to feed on. As a result of infestation at the ovarian tissues normal grains were not developed and resulted in chaff. When observed externally no indication of feeding was noted.

The infestation when occurred on the grains resulted in the development of brownish and irregularly shaped feeding scars on the surface of grains on lemma and palea.

Thus it could be observed that according to the stage of the crop and the site of infestation the symptoms of damage caused by the thrips were varied.

A. discolor and M. signata were found to frequent the rice inflorescence. The occurrence coinciding with the flowering stage suggested that the insect feed on the pollen and often floral parts, but could not indicate any economic damage.

The biology of *E. ventralis*, the stink bug, was reported by Yang (1935) and Grist and Lever (1969). The eggs were laid in batches as reported earlier but the number of eggs per batch and also total number laid by a single female were fewer. This might probably be due to the influence of host and climatic conditions. The site of egg laying varied, leaf axils, junction of leaf and leaf sheath, leaf tips or surface. The number of eggs in a mass was reported to be ten (Grist and Lever, 1969) but was observed as varying from two to six per batch.

Four nymphal stages were observed each with three to five days time the total period lasted for 22 days. Yang (1935) has reported that there existed three or four nymphal instars according to the season. Four nymphal stages could be observed during the studies. The adult longevity observed was up to three weeks which was slightly higher than those reported.

The hibernation of the adult was reported by Grist and Lever (1969) which lasted up to 180 days. But such hibernation could not be observed in the present studies. However, a preoviposition period of seven days could be observed during the adult stage.

In the field experiment conducted, the effect of nine pesticides for the control of pest and diseases of rice earhead had been evaluated with an objective to find out the best chemical suitable for application. The pretreatment incidence of insect pests showed that only rice bug was present at 56 DAT when flowering began. Analysis of the data on pretreatment counts revealed that there did not exist any variation in occurrence of pests in various plots and as such the insect population was uniformly distributed in all the plots before the application of pesticides. The effect of block was found to be statistically significant showing that the experiment was designed properly.

The application of pesticide resulted in statistically significant reduction of insect pest incidence at five per cent level of probability. It was observed that monocrotophos (T_3) ranked most effective in controlling the rice bug incidence. The observations made were in conformity with the reports by Heinrichs et al. (1982) and Argente and Heinrichs (1983).

Methyl parathion, carbaryl, hexachlorocyclohexane and phosphamidon were found to be on par with monocrotophos in their efficacy of pest control. Nair (1978), Pillai et al. (1983), David and Kumaraswamy (1975) have reported respectively that the above mentioned chemicals were effective in controlling rice bug infestation. There was no effect for carbofuran and this information was in agreement with the observations made by Pillai et al. (1983). Phorate was found to be not effective in controlling bug infestation and this was not in agreement with observations made by Jain et al. (1980). This discrepancy could be due to the fact that Jain had studied mortality of rice bug ten days after application of insecticide whereas the present experiment followed the package of practice recommendation where the application of granules was done at 40 DAT and the incidence had occurred after 57 DAT.

Progressive reduction in pest population due to the application of pesticide was observed, monocrotophos being the most effective chemical. Phosphamidon and hexachlorocyclohexane were on par with monocrotophos proving the effect in reducing the incidence of rice bug infestation.

Data collected after the subsequent application of insecticides, also showed that monocrotophos was the most effective in all the applications. The other treatments which were on par with monocrotophos were phosphamidon, carbaryl and hexachlorocyclohexane. Malathion was found to be without any effect, this being contrary to the findings