STUDIES ON ESTIMATION OF ECONOMIC THRESHOLD LEVELS FOR RICE STEM BORERS AND GALL MIDGE

A THESIS SUBMITTED TO
THE ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, BHUBANESWAR
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

MASTER OF SCIENCE IN AGRICULTURE
(ENTOMOLOGY)

BY

Gunanidhi Pradhan

Department of Entomology
COLLEGE OF AGRICULTURE
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'HESIS ADVISOR Dr. A. P. SAMALO

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APPROVED BY :

CHAIRMAN : ______________ 10/7/89

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C E R T I F I C A T E

This is to certify that the thesis entitled "Studies on estimation of economic threshold levels for rice stem borers and gall midge" submitted in partial fulfilment of the requirements for the award of the degree of MASTER OF SCIENCE IN AGRICULTURE (ENTOMOLOGY) by the Orissa University of Agriculture and Technology, Bhubaneswar is a faithful record of bona fide research work carried out by Sri Gunanidhi Pradhan under my guidance and supervision. No part of the thesis has been submitted for any other Degree or Diploma or published in any other form.

The assistance and information received by him during the course of investigation has been duly acknowledged.

Bhubaneswar

Dated the 19 th, June, 1989

(A. P. SAMALO)

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Bhubaneswar

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(Gunanidhi Pradhan)

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CHAPTER I

INTRODUCTION

I N T R O D U C T I O N

The use of modern insecticides to control insect pests has been a necessary part of crop production and the prevention of insect related health problems. In all probability, insecticides will continue to be used and needed for some more time to come. For too long a time pesticides have been used in high dosage as extra insurance or on a calender basis. These practices have brought about adverse biological and ecological impacts and compounded the original problems.

In the present strategy of pest management, control measures should not be carried out unless it is known that the pest is present in sufficient numbers to cause an economic loss. This statement is made with the assumption that adequate research has been conducted on the particular pest and its host to establish the economic threshold. Insecticidal treatments applied below this threshold, where the cost of control exceeds the value of the crop being treated result in financial loss. Too often pesticide treatments have been made on a "visibility threshold" which implies that if insects are observed even in trace or low numbers chemical controls are necessary.

It is evident from published literature that economic injury levels and economic thresholds for most pests on a majority of crops are not available to guide those individuals making recommendations. In recent years entomologists engaged in pest management, talks a good deal about economic injury levels and economic threshold without establishing them with quantitative data. No doubt it is a complicated process to establish either level. Many of the biological and ecological complexities, like crop conditions, climate, pest related factors, legal factors and public attitude are involved in determining the economic thresholds and economic injury levels. According to Stern (1973) only about 12 economic thresholds have been established on 10 important crops, for specific insects in California.

The gall midge and stem borers are the major pests of rice in India. Crude threshold values are being recommended for both these pest without sound and proven data. Although enough literature is available an individual control tactic of the major rice pests, very little is known on the exact economic injury levels and economic thresholds of rice gall midge and stem borers. Based on assumption from past experiments and experiences crude threshold value are being recommended by several workers (AICRIP 1976, 1979, 1988, Kulshreshtha *et al*. 1976, Chatterji *et al*., 1977 and Heinrichs, 1979).

It is high time to develop clear concept of economic injury levels related to pest population of different crops on location specific basis. In other words how much loss can be expected from a particular number of pests at a particular stage of crop development. The decision regarding any control action must be evaluated not only on immediate costs and pest reduction, but on long range effects as well.

Keeping this in view the present study was undertaken to find out the economic injury levels/threshold values for the rice gall midge and stem borers under Bhubaneswar condition.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

In studies pertaining the economic injury levels and economic threshold levels, the factors influencing these levels have to be carefully analysed first. While working on an integrated pest control programme the threshold values have to be taken into account. A brief account on the extent of crop losses caused by two major rice pests namely gall midge and stem borers and the work done on economic injury levels and economic thresholds have been reviewed in the following pages.

Integrated pest management :

There are so many instances in the world where dependance on chemical control alone created health hazards, offset the balance in nature and gradually failed to control insect pests. It is to forestall these serious limitation of chemical control that integrated pest control came into force. Besides, monocultures of mixed germ plasm are being replaced with those of narrower and narrower germ plasm in the form of pure varieties. Intensification of pest susceptible, fertilizer responsive rice varieties coupled with improved agronomic practices further aggravated the situation. These adverse side effects of modern agriculture can be minimised to a large extent by replacing single approach pest control with diversified pest control, which should be properly integrated and scheduled.

Barlett (1956) was the first to coin the term "integrated pest control" through which the meant to combine or integrate biological agents with insecticides in the control of insect pests. Obviously, these methods stood in direct conflict with each other since the insecticides were likely to kill the biological agents. To overcome this anomaly Geier and Clark (1961) provided a new expression, "Integrated pest management, briefly IPM" wherein not only biological and chemical but all available methods were meant to be integrated. The definition of IPM has since been improved.

The panel of experts of the Food and Agriculture Organisation (FAO, 1967) defined it as "a system that, in the context of the associated environment and the population dynamics of the pest species, utilize all suitable techniques and methods in as compatible a manner as possible and maintain the pest populations at levels below those causing economic injury".

In the recent past, Smith (1978) has defined it as "a multidisciplinary, ecological approach in the management of pest population which utilizes a variety of control tactics compatibly in a coordinated pest management". In other words IPM aims at combining all available methods or tools of insect pest control in a manner that minimise insecticide use and disturbance to the ecosystem.

Pest management requires a knowledge of the population dynamics of the pest and its natural enemies in relation to cultural practices and plant varieties. All control must be considered within the context of agro-ecosystem and economics of production. Pest management does not exclude the use of pesticides, but attempts to work them into ecosystem as compatible components of modern agriculture. Pest management is a concept, not a fixed technique (Davis and McMurtry, 1985).

All available control measures can play their own roles towards achieving this goal. Plants themselves possess an appreciable degree of natural tolerance to insect pests. It is only when the pest population goes beyond the limit the injury becomes economically important. A decision to undertake the control operation should be taken only when the value and the quantum of the crop that can be protected is greater than the expenditure involved in the control operations. Hence economic injury levels and economic threshold levels are the important components to implement IPM for any crop (Srivastava, 1988).

We must develop a concept of economic injury levels related to pest populations - in other words how much economic loss can be expected from a particular number of pests at a particular stage of crop development. The decision regarding any control action must be evaluated not only on immediate costs and pest reduction, but on long - range effects as well. An action which results in immediate control may commit a grower to a sequence of procedures which would be very expensive in the long run.

For our Indian farmer the methods of pest control to be integrated must be simple to use, inexpensive, minimum toxic hazard to the operator and must be acceptable by the cultivators. Attention has to be diverted to identify and encourage the use of such techniques in the control schedule which are compatible with the local agronomic practices. The role of varietal resistance in the integrated control of rice pest seems to be most vital. The use of even moderately resistant varieties alongwith timely cultural operations will have a definite impact in reducing the insecticidal applications. Multiple resistant varieties suited for different locations and key pest complexes are still under development and their further adoption in the large scale will be one of the important strategies of rice pest control (Mathur, 1978).

Economic injury levels and economic thresholds :

The economic injury levels and economic thresholds are important parameters of integrated pest management. There are different terms expressing the same meanings of economic threshold. According to Stern (1973) economic threshold means the density at which the control measures should be determined to prevent an increasing pest population, from reaching the economic injury level.

Economic injury level is defined as the lowest pest population density that will cause economic damage. Judging by fragmentary evidence these levels are almost invariably higher than expected (Chant, 1966).

According to National Academy Science (1969) economic injury level is the loss caused by the pest equals in value the cost of available control measures.

Headley (1972) has defined economic injury level as the pest "population that produce incremental damage equal to the cost of preventing the damage".

In a pest management programme, the economic injury level must first be established in order to employ the concept of economic threshold. The lack of study based on economic thresholds and injury levels is well verified by the survey conducted by Stern (1973) and further stated by De Bach (1974) and Hoyt and Burts (1974).

The economic threshold always represents a pest density lower than that of the economic injury level, to allow the initiation of control measures, so that they can take effect before the pest density exceeds the economic injury level.

Development of thresholds for rice pests :

Before the concept of threshold was developed Murthy and Khan (1958) from India used a value of one per cent deadheart to determine, when to spray for stem borers. Likewise in Japan Torii (1967) used 5 per cent deadhearts while Kobayashi (1971) and Koyama (1973, 1975) developed thresholds for stem borers in Japan based on percentage damage of infested tillers. But actually threshold as a concept have been mainly developed for rice from the 1970s (Reissig et al., 1985).

Thresholds were developed from green house or field trials where increasing number of insects were artificially infested on plants and the yield loss recorded. From these results action thresholds were estimated and assumed to work under farmers conditions as few trials were run on farmers' field to verify them. Farmers' field evaluation of thresholds started in earnest in 1980's in the Philippines, Malaysia, India and Korea (IRRI, 1974).

The methodology used at International Rice Research Institute (IRRI) was to test two treatments having high and low threshold values, for the major pests and comparing the yield increases to an untreated check, prophylactic practice, and farmers practice. In these field tirals the farmers' applied their own agronomic practices to all treatments. The farmers' practice was established in the adjoining paddy to the small plot treatments. It was observed that the farmers' changed their practices for each crop and they usually sprayed their crop when they saw signs of damage rather than following a schedule.

Thresholds as a technology have taken over a decade to develop. This slowness was due to the fact that they can only be tested when pests become abundant in the field. Most pests are not commonly abundant each crop season. Also threshold technology involves a number of components, all of which must work if the technique is to be successful. Each threshold is consisted of a unit of measurement or a character either based on insect damage (% deadhearts) or the insect itself (number of egg masses/m^2). Most of early thresholds were based on damage rather than the insect itself. This according to the authors proved to be the poor choice as there was inherent delay from the time the damage was done until it was noticed. This delay made the thresholds less responsive. Often the pest that caused the damage had already pupated when the decision was made to spray and the insecticide was wasted as pupae do not feed. Besides, damaged plants can not become less damaged upon spraying so that the damage persisted causing unnecessary repeated application of insecticides (Pers. comm. with Reissig). Therefore, better characters are those based on the presence of the insect itself. Based on the results of several multilocational trials, percentage damage can be taken as a measure of threshold.

Economic threshold values for rice pests have been established by Kalode (1976) for timely insecticide application. The threshold values suggested for the major rice pests are :

Stem borer - 5 per cent deadhearts or one egg mass or one adult moth/sq.m.

Gall midge - One gall/sqm. in endemic areas and 5 per cent gall in non-endemic areas.

The economic threshold values have also been worked out by Kulshreshtha (1976) for the purpose of advising control operations in the Operational Research Project on Integrated control of rice pests in Orissa. The author suggests 5 per cent deadhearts or 2 egg masses per square metre, at vegetative stage needs attention for the control of rice stem borers.

Chatterji <u>et al</u>. (1977) recommended economic threshold values for the stem borers at vegetative stage as 10 per cent deadhearts or 2 moths/sqm, for planthoppers 4-5 nymphs/adults/hill at the early vegetative stage, and 20-25 at the panicle formation stage, for leaffolder and rice hispa 5 per cent damaged leaves and for earhead bug 10 nymphs/adults/sqm.

Mathur (1978) has reported that economic thresholds for major pests of rice have to be fixed based on releable experimental data. The economic threshold should be closely linked to variety, cost of final produce and protection cost. Since the last two factors are variable in different points of the country and year a rapid method to fix economic threshold has to be developed.

Economic thresholds have been developed by Heinrichs (1979) for stem borers Tryporyza incertulas (deadhearts), brown planthoppers (BPH) and the rice bug, Leptocorisa spp. Crude economic thresholds have been set for defoliators. The BPH threshold of 1/tiller has been verified through testing in farmers' fields. However it has been difficult to prove the practical utility of the stem borer and rice bug thresholds in farmers' fields.

The economic threshold depends on the pest species, year, variety under cultivation, price fluctuation of the components of the control operations and the final produce. Plant protection measures should be undertaken when the pests cross the threshold limit based on surveillance information (Heinrichs, 1979).

AICRIP (1979) suggested economic threshold values for rice pests as :

Gall midge - 5 % silver shoots.

Stem borers - 10 % deadhearts and 2 % whiteheads.

Green leafhopper (GLH) and Brown planthoppers (BPH)	25 insects/hill

Leaffolder - 3 damaged leaves/hill.

All other insects - 1 insect/hill.

A common economic threshold is not adoptable in all regions due to complex factors involved. Thresholds are to be worked out associating, crop variety, season, and cost of plant protection.

Based on the surveillance record economic thresholds have been developed by various workers for major rice pests (Panda et al., 1983). According to the authors predicting yield loss, when damage can still be remedied economically, is an important component of pest management programme. Currently the available threshold values are mostly empirical, however, it is advantageous in using such parameters for pest management.

Economic thresholds have historically been based on percentage damaged tillers or percentage deadhearts. However these characters have proven unreliable as the damage is done before a threshold can be measured. Using the presence of moths also has been unreliable because they are not easily frightened or flushed from the fields to rice gall midge and stem borers in Orissa. The pests and locations are indicated below :

Stem borer - Moderate to severe in Puri, Sambalpur, Cuttack and Balasore.

Gall midge - Severe in Sambalpur and Cuttack.

Based on economic thresholds AICRIP (1988) suggested the threshold values for field action for Orissa as follows

Planting to pre-tillering :

Stem borers - 5 per cent deadhearts or one egg mass/sqm.

Gall midge - One gall/sqm. in endemic areas, 5 per cent affected tillers in non endemic areas.

Mid-tillering :

Stem borers - 5 per cent deadhearts.

Gall midge - 5 per cent affected tillers.

Panicle initiation to booting :

Stem borers - One moth/sqm.

Rice gall midge :

The rice the gall midge <u>Orseolia</u> <u>oryzae</u> (Wood. Mason) Mani is a major pest of rainy season rice in India. With the introduction of fertilizer responsive, high yielding, dwarf rice varieties in mid-sixties and its intensification in larger areas coupled with favourable environmental conditions provided unique opportunity for the midges to multiply. Many of the single factor control approaches, failed to suppress this pest successfully. Therefore integrated control approaches based on crude threshold values were designed and implemented at various test locations in India and elsewhere. So far no sound control tactics, based on economic threshold values, are available in the published literature. However most of the recent approaches to bring gall midge incidence below the economic injury level are designed keeping in mind percentage damaged tillers or in other words the percentage of silver shoots.

A brief review of the work done at various test locations are presented in the following paragraphs.

Jena (1978) conducted field trials on pest management in rice at Bhubaneswar. According to the author silver shoot incidence of 33.15 per cent was noticed at 44 days after transplanting (DAT) in plots receiving no insecticidal treatment and 4.31 per cent in the maximum protection treatment. The results clearly indicated that in order to keep the gall midge incidence within 12 per cent, granular mephospholan has to be applied twoce at 10 and 40 DAT. The maximum protection treatment where insecticides were applied six times controlled the pest effectively.

According to the author such insecticidal protection was effective but uneconomical. Further it was suggested that need based application of insecticide based on threshold values have to be worked out.

The data further envisaged that growing a midge resistant variety like 'Shakti' with no insecticidal protection had almost same level of silver shoots as in Jaya (susceptible) with maximum protection.

For the control of major pests of rice Parida (1979) conducted replicated field trial at the Central Research Station, Bhubaneswar. The results indicated that the gall midge incidence varied between 4.35 and 28.78 per cent in different treatments. It was interesting to note that alternate spraying of the insecticides like quinalphos and Fenitrothion @ 0.5 kg a.i./ha instead of controlling gall midge recorded higher incidence over untreated check. However, application of mephosfolan granule in paddy water was better than the foliar spray. One application of the granule @ 1.0 kg a.i./ha at 24 DAT was good enough to control the gall midge. A second round application of the same granule at 47 DAT was considered superfluous to mitigate the gall midge infestation. Further more application of the insecticide either as granules or emulsifiable concentrate with or without seedling root dip in the resistant variety 'Shakti' was considered as a wasteful investment as the incidence was below the threshold level.

Assessment of loss due to gall midge infestation :

Parida (1979) worked out the regression equation between plot yield and the estimated percentage incidence of the rice gall midge, in the susceptible rice variety 'Jaya'. For every unit (%) increase of the gall midge incidence there was a loss of 35.4 kg grain/ha.

Israel *et al*. (1959) have worked out a regression method for estimating the losses due to the gall midge incidence. The authors found out that for every unit (%) increase in rice gall midge incidence there was a loss of 26.62 of grains kg/ha.

For the control of rice gall midge with special reference to frequency and mode of insecticidal application Samalo (1983) conducted field experiments both under Bhubaneswar and Chiplima conditions. According to the author treating the crop with insecticide/s by any of the methods significantly reduced midge damage as compared to untreated control. The maximum protection treatment given with the combination of seedling root dip in chlorpyriphos solution, water surface treatment with phorate granules and foliar spray of quinalphos undoubtedly afforded maximum protection at different times following the treatment.

Granular phorate applied once @ 1.0 kg a.i./ha in mud balls also afforded promising control of the pest.

Placement of the insecticide in the vicinity of the rice roots was distinctly advantageous as such treatment was as good as or slightly better than the same insecticide applied twice as broadcast treatment.

From the point of grain yield maximum protection resulted in highest yield of 4.27 t/ha. Significantly higher yield was also obtained (3.9 t/ha) from plots treated with phorate mud balls.

The cost/benefit ratio suggested (Samalo, 1983) that the maximum protection treatment which no doubt proved to be the best for gall midge control was not economical as the cost of plant protection worked out to be very high. Two or more water surface treatment with granular phorate or such treatment in combination with quinalphos spray needed more than Rs.300/- ha for the gall midge control which is beyond the means of an average farmer in the country. But it was seen that single treatment with pherate granules involved the least cost (Rs.272/- ha) with the highest (Rs.816/- ha) nett return. Hence from the point of both effectiveness and economy applying phorate @ 1.0 kg a.i./ha at 25 DAT in the root zone of the rice plant was found to be most profitable.

Estimation of losses due to insect pest :

According to AICRIP (1985) the extent of losses caused by insect pest is a prerequisite for proper plant protection strategy. The extent of losses may vary in different stages of crop growth depending on the qualitative and quantitative pest composition, losses may also differ in relation to variety used and its inherent resistance to various insect pest.

Studies conducted under AICRIP (1985) trials at Sambalpur indicated that the rice yield was only 1212 kg/ha under unprotected conditions in the susceptible variety IET 5656. Providing protection to the crop by broadcasting granular phorate @ 1.5 kg a.i./ha at 25 to 30 DAT followed by spraying quinalphos @ 0.5 kg a.i./ha at 45 to 50 DAT, increased the grain yield by 40.2 per cent. Providing protection in all the growth stages of the crop doubled the yield as compared to the unprotected crop.

Pest management trials conducted under AICRIP (1986) indicated that only a low level of net profit (Rs.48/- to Rs.221/- ha) was obtained in the resistant varieties as against losses in susceptible varieties at Sambalpur. More expenditure (Rs.900/- ha) incurred towards plant protection in susceptible variety appeared to be responsible for the losses. The results further envisaged that in gall midge stress area, pest management with resistant varieties incurred a net profit of Rs.48/- to Rs.1398/- ha as compared to susceptible variety which incurred a loss of Rs.121/- ha to a profit of Rs.1189/- ha.

Rice stem borers :

The stem borers are the most important pests throughout the rice growing tracts of the world (Kapur, 1964).

There were 18 pyralids and 3 noctuid species which were identified as rice stem borers. Out of these 5 species of pyralids occur in the new world and the remaining 16 species occur in the old world.

In Orissa 3 species of stem borers have been recorded on rice (Sengupta and Behura, 1959 and Panda, et al. 1974). They are the yellow stem borer, Scirpophaga incertulas Walker, the striped borer, Chilo suppressalis Walker, and the pinkborer Sesamia inferens Walker. Out of these three, the yellow stem borer is considered as serious. Results of experiments conducted at the IRRI, Manila, Philippines indicated that from transplanting to harvest yellow stem borer was the dominant species in the rice field comprising 70 per cent of the borer population, but after harvest of the crop, in stubbles Chilo suppressalis population increased while yellow borers declined. (Mervyn and Edwin, 1965). Crist (1953) reported that after the harvest of rice crop the larvae of C. suppressalis were found 10 to 17.5 cm above the soil surface and about 20 per cent remain in stubbles.

The stem borers of rice are more abundant in the coastal districts of Orissa (Sengupta and Behura, 1959). Both yellow and striped borers are reported to be serious in summer rice due to multiple cropping (Khan and Kurthy, 1955). The yellow stem borers completed 3 generations between January and May (Kulshreshtha, et al., 1970). There was overlapping of the second and third broods till April and heavy moth emergence continued up to March and April resulting in abnormally high incidence of shiteheads.

Tripathy and Ram (1969) reported that the presence of a large population of hibernating larvae in rice stubbles act as potential source of infestation to several varieties for next cropping season. Israel (1969) also reported that the origin of stem borer population in summer rice was mainly due to stubbles of rainy season crops. Moths started emerging from stubbles in the last week of January with a peak emergence during second week of February which ultimately affect the summer crop.

Kaksham (1977) tested different insecticides and their mode of application on the incidence of rice stem borers in susceptible Jaya under field contition. The results indicated that plots receiving no insecticidal treatments had 42.31 per cent deadhearts and 12.0 per cent whiteheads. On the contrary plots treated with granular diazinon @ 1.5 kg a.i./ha at 20 and 50 DAT significantly decreased (33.22 per cent deadheart and 2.53 per cent whitehead) the borer incidence. Maximum grain yield of 4073 kg/ha was obtained by protecting the crop with diazinon. The corresponding yield in the untreated plot was only 1603 kg/ha.

According to Samalo (1983) treating the rice crop with carbofuran or mephosfolan granules @ 1 kg a.i./ha either alone or in combination with other insecticidal solution significantly reduced the deadheart incidence at 45 and 60 DAT as compared to the unprotected crop. The maximum protection treatment involving seedling root dip in 0.04 per cent a.i. of chlorpyriphos for 12 hours followed by broadcasting of granules of any of the above insecticides at 25 and 55 DAT, and subsequent spraying with 0.5 kg a.i./ha of quinalphos, a month later, gave excellent protection against rice stem borers. Under such insecticidal pressure the borer damage never reached the economic injury level.

The author further reported that carbofuran and mephosfolan granules even at a lower dose of 0.75 kg a.i./ha when implanted in the mud balls in the vicinity of the roots at 25 days following transplanting gave excellent control of the borers. Such treatment afforded as much control of the pest as the maximum protection treatment, where insecticides were applied several times. In general

At Faizabad pest management experiments with resistant variety accrued a marginal net profit (Rs.76/- to Rs.236/-ha) as compared to losses in susceptible variety. Inadequate control of the stem borer at both vegetative and heading stages by pest management treatments appeared to be the main reason for it.

Similar trial at Jorhat indicated that insecticidal protection was a wasteful expenditure resulting a loss of Rs.1080 - 1573/ha.

This was mainly due to low pest load. In general more expenditure incurred towards pesticide application seemed to be responsible for low level of net profit.

Losses due to stem borers :

Stem borers have been estimated to be responsible for 3-95 per cent loss (Ghose et al., 1960).

In study with yellow stem borer infestation at different growth stages of IR 46, Viajante et al. (1985) reported that deadhearts occured in the 39 days after transplanting (DAT) and whiteheads occured at 54, 69 and 84 DAT treatments respectively. Tiller damage was more severe in 39 and 84 DAT with 66.4 and 99.0 per cent respectively, while only 7 and 20 per cent in the 54 and

69 DAT treatments, respectively. Tiller number decreased correspondingly with infestation level at 39 DAT. There was a direct relationship in the infestation level and percentage unfilled grains in the 39 and 84 DAT but did not increase in 54 and 69 DAT treatments. Grain yields at the 800 larvae per 36 hills of the 54 and 69 DAT were 617 and 433 g per m^2 respectively, while yield were dramatically reduced in the 39 and 84 DAT having 96.4 and 166.5 g per m^2 respectively.

Based on the regression of yields and number of larvae indicated a close relationship between 39 and 84 DAT both having high yield losses. There was only slight yield reduction in the 54 and 69 DAT even at highest infestation levels of 800 larvae per 36 hills.

Green house test dealing with *S. incertulas* development and survival indicated a rapid development of *S. incertulas* larvae on tillering 35 DAT, booting 69 DAT, flowering 84 DAT and slowest in the panicle initiation stage i.e. 54 DAT. At 36 DAT 30-80 per cent become adults on tillering, booting and flowering while only 4 per cent at panicle initiation. The over-all survival however at tillering stage and panicle initiation had the least (45 and 35 per cent respectively) while maximum tillering booting and flowering had the most percentage survival ranging from 68-88 per cent.

Rice leaffolder :

The rice leaffolder, Cnaphalocrocis medinalis Guenee (Pyralidae : Lepidoptera) was formerly a minor pest, but has now become more abundant since the introduction of high yielding varieties (Lefroy, 1909; Fletcher, 1914, 1917; Mishra, 1920; Ballad, 1921; Ayyar, 1932; Usman and Puttarudriah, 1955; Kadam *et al*. 1960; Reddy, 1968; Vevai, 1968; Rajamma and Das, 1969; Dorge *et al*. 1971, Vishakantaiah *et al*. 1972; Velusamy *et al*. 1974; Hale and Hale, 1975; Hirao, 1976; Chandramohan and Jayaraj, 1977; Pathak, 1977; Chang *et al*. 1980; and Pangtey and Sachan, 1982).

According to Ramakrishna Ayyar (1932) *C. medinalis* (Gn.) is serious in the east and west-coast of South India.

Rajamma and Das (1969) reported that the rice leaffolder larvae cause injury by folding and webbing the leaves and scrapping the green tissues. A single larva can damage several leaves.

Pathak (1977) reported that in the beginning the larva do not fold or roll the leaf, but subsequently it connects the margins of the leaf creating a tube, and continue feeding on the epidermis. Usually only one caterpillar is found within a fold. The larval feeding results in white, transparent streaks of 1.2 mm wide and 15 to 20 cm long, running parallel to the mid-rib. These streaks represent the areas from which the green matter had been eaten by the larvae. Each leaf blade might contain several such streaks and under heavy infestations each plant may contain several folded leaves.

Fraenkel and Fallil (1981) observed that during feeding the larvae remains longitudinally on the leaf and scrapes out the soft tissue between the veins longitudinally, leaving only the veins, sclerenchyma, epidermis and the cuticle. Feeding is restricted to the green mesophyll tissue involving practically the whole leaf surface. In case of thick or tough leaves, feeding occurs in irrigular non-linear fashion.

Damage potentiality

The damage was more severe in shady areas, particularly near the bunds and also in crops with excess vegetative growth due to close planting followed by application of heavy doses of nitrogenous fertilizers (Velusamy et al. 1974; Ramasubbaiah et al. 1980; and Rohan et al. 1982).

Das and Nair (1974) released fourth instar larvae of the leaffolder on rice leaves and recorded that within 48 hours a single larva damaged 354.5 to 446.5 mm^2 in some moderately susceptible varieties. In some susceptible varieties, the extent of damage was as high as 784.4 mm^2 during the same period.

Studies on yield losses revealed that the degree of yield reduction under low, medium and high infestation was 4, 27 and 74 % respectively. (Chaudhary and Bindra, 1970).

In a field test in Karnatak the yields from rice plots infested by rice leaffolder averaged 2853.12 kg/ha, as compared with 3320.83 kg/ha in plots that had been disinfested by mechanical removal of the larvae every week until harvest (Rai et al. (1978).

In Madhya Pradesh the late planted rice varieties usually show heavy infestation (Gargav et al. 1971). The crop transplanted in the first week of July is damaged by the leaffolder in August-September and the peak period was noticed in September. August planted crop showed the peak incidence in November. The crop raised in September-October suffered heavy damage from the second week of October to December. The January planted crop showed heavy incidence from middle of February to April (Vishakantaiah, 1972; Velusamy et al. 1974).

In Punjab, the insect was more abundant from September to October in the kharif season (Chhabra et al. 1976). Similar report was also obtained from CRRI, Cuttack (Annual Report, 1978).

Pathak (1977) stated that the rice leaffolder moths are present through out the year in the warm tropics, but they were most abundant in the rainy season. In places with cool winter the insect was found active from May to October during which it completed four to five generations. The latter generations were usually overlapping.

Chatterjee (1979) reported that infestation was first observed in late April and it reached a peak in the second week of May.

Light trap collections from different locations (Aduthurai, Cuttack, Mandya, Rajendra nagar, Pattambi) revealed that the highest leaffolders were trapped from the last week of September to first week of November and the peak period was middle of October (Annual Report, AICRIP, 1978, 79, 80).

In Japan, the leaffolder moths appeared in fields in the later half of June each year, when the females were proportionately more in number than the males. On the average 1000 moths were observed in a hectare and they were moving from field to field (Miyahara, Wada and Kobayashi, 1981).

Pangtey <u>et al</u>. (1982) reported that the leaffolder caused heavy damage in early September during the wet season (June to November).

Pathak (1977) stated that high humidity and optimum temperature (30°C) were the important factors which influence the rapid multiplication of the insect.

Work done at CRRI (1978) revealed that the peak of leaffolder activity was noticed in late October when the minimum temperature was 18.5 to 18.8°C and maximum temperature 28.3 to 30.4°C with rainfall varying from 0.0 to 51.2 mm for a 5 day period.

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

Experimental site and season :

During rainy season, 1988 and summer, 1989 two separate field experiments were conducted at the Central Research Station of the Orissa University of Agriculture and Technology (O.U.A.T.), Bhubaneswar. The main objectives of these experiments are to estimate the economic threshold levels for rice gall midge and stem borers, under Bhubaneswar condition.

The Central Research Station of O.U.A.T., Bhubaneswar is situated at 20° - 15' N latitude and 85° - 22' East longitude with an elevation of 25.9 m above the mean sea level. The soil type of experimental field was sandy loam having irrigation and drainage facilities. The pH of the soil is acidic (5.0). The chemical composition of soil is given as under :

Salt composition :

Millimhos/cm	-	0.375
Available P kg/ha	-	5.3
Available K kg/ha	-	131.36
Carbon %	-	0.60

Table 1. Meteorological information during the period from July, 1988 to May, 1989

Year/ Month	Week	Temperature °C Minimum	Maximum	Relative humidity (%) Morning	Afternoon	Rainfall (mm)
1988						
July	1	32.7	26.0	89	74	7.4
	2	32.6	25.7	90	79	65.6
	3	32.9	26.6	89	77	62.0
	4	32.2	25.6	91	79	121.4
August	1	31.4	26.0	91	79	131.6
	2	31.5	25.4	90	85	74.1
	3	32.7	25.8	88	74	19.6
	4	32.3	25.8	90	79	8.0
Aug. & Sept.	1	33.1	25.9	92	79	4.2
	2	32.3	25.1	93	97	96.2
	3	33.7	25.0	92	73	8.0
	4	30.9	24.6	95	88	162.1
	5	33.1	25.7	92	72	4.8
Oct.	1	31.8	24.9	90	74	88.4
	2	32.5	21.7	82	55	0.0
	3	32.9	21.1	82	52	0.6
	4	33.0	21.1	89	81	0.0
Oct. & Nov.	1	32.4	21.7	91	52	0.0
	2	31.3	18.1	84	40	0.0
	3	31.0	17.8	77	35	0.0
	4	30.8	16.5	82	33	0.0
	5	28.8	18.0	77	45	0.0
Dec.	1	30.3	15.9	90	36	0.0
	2	30.2	17.8	80	40	0.0
	3	28.8	14.9	88	34	0.0
	4	29.2	15.2	89	45	0.0
1989						
Jan.	1	29.2	16.1	93	44	0.0
	2	28.1	14.8	86	40	0.0
	3	28.3	16.7	84	42	0.0
	4	28.1	13.2	88	30	0.0
Jan. & Fbe.	1	31.8	14.2	88	25	0.0
	2	33.7	18.9	89	26	0.0
	3	33.8	19.6	96	35	0.0
	4	30.5	16.4	77	29	0.0
Feb. & March	1	34.7	18.9	91	30	0.0
	2	34.2	20.3	91	35	0.0
	3	33.0	20.2	91	37	1.8
	4	38.3	23.1	87	24	0.0
March, & April	1	35.6	22.3	81	30	2.4
	2	38.0	24.3	88	35	0.0
	3	39.1	25.4	90	38	0.0
	4	37.6	25.3	87	42	0.0
	5	38.3	25.8	89	50	4.7
May 30.4. to 6.5.		29.2	27.7	87	40	0.0

Experimental design :

Both the experiments were laid out in Randomised Block Design (RBD) with three replications during rainy season, 1988 and four replications during summer season, 1989. The sub-plot size was 7.5 m x 4.0 m (30 sqm) for both season trials. The rice variety Jaya T (N) 1 x T 141 was taken for the study. In order to avoid mixing up of the insecticide in soil solution by surface run off and seepage each plot was separated by wider bunds. The layout plan of the experimental fields are enclosed.

Experimental materials :

During rainy season the midge susceptible rice variety Jaya and resistant variety IET 9689 were taken for estimation of economic threshold level of rice gall midge.

In summer season only the borer susceptible Jaya variety was taken for the economic threshold studies against rice stem borers.

Estimation of economic threshold level for rice gall midge and stem borers :

In order to keep the gall infestation at the desired levels granular carbofuran was applied @ 1.0 kg a.i./ha whenever the expected level of pest damage was reached. For this observations on pest incidence was

LAY OUT DESIGN OF RAINY SEASON TRIAL

R_1		R_2		R_3	
T_1	T_8	T_2	T_6	T_2	T_3
T_2	T_7	T_4	T_5	T_4	T_7
T_3	T_6	T_8	T_3	T_5	T_1
T_4	T_5	T_1	T_7	T_6	T_8

T_1 = MAXIMUM PROTECTION (S.D. + GRANULAR CARBOFURAN AT 20, 40, 60 DAT + NEED SPRAY)

T_2 = PROTECTION AT 5% GALL BY CARBOFURAN

T_3 = PROTECTION AT 10% GALL BY CARBOFURAN

T_4 = PROTECTION AT 15% GALL BY CARBOFURAN

T_5 = PROTECTION AT 20% GALL BY CARBOFURAN

T_6 = PROTECTION AT 25% GALL BY CARBOFURAN

T_7 = UNTREATED CHECK

T_8 = RESISTANT VARIETY IET 9689 WITHOUT PROTECTION

LAY OUT DESIGN OF SUMMER SEASON TRIAL

R_1	T_1	T_2	T_3	T_4	T_5	T_6	T_7
R_2	T_2	T_6	T_5	T_7	T_3	T_4	T_1
R_3	T_3	T_1	T_5	T_2	T_7	T_6	T_4
R_4	T_6	T_1	T_7	T_2	T_3	T_4	T_5

T_1 : 0 % INFESTATION

T_2 = 2 % INFESTATION

T_3 = 5 % INFESTATION

T_4 = 10 % INFESTATION

T_5 = 15% INFESTATION

T_6 = 20% INFESTATION

T_7 : UNTREATED CHECK

recorded every 5th day starting from 15 DAT. The desired levels of gall midge infestations were 0, 5, 10, 15, 20 and 25 per cent and whenever such levels reached, the crop was protected by treating the plot with granular carbofuran @ 1 kg a.i./ha.

In order to estimate the economic threshold values for rice stem borers insecticidal protection was provided at desired levels of infestation (0, 2, 5, 10, 15, 20 per cent). The crop was protected with padan 4G when the infestation reached the required level of injury. Observations on the incidence of borer damage were taken from 20 randomly selected clumps at an interval of 5 days starting from 20 DAT.

Table 2. Particulars of insecticides used :

Generic name of the insecticides	Trade name & available formulation	Chemical name	Source
Carbofuran	Furadan 3G	(2, 3-dihydro-2, 2-dimethyl-7-benzofuranyl methyl carbamate)	Rallis India Ltd., Bombay-1
Cartap	Padan 4G	1, 3-Bis (Carbamoylthio)-2-(N,N-dimethylamino) propane hydrochloride.	Coromandel Indag Products, India Pvt. Ltd., 62 Spur Tank Road, Madras - 600031.
Chlorpyriphos	Dursban 20EC	O, O-diethyl-O-(3, 5, 6-trichloro 2-pyridylphosphorothioate	Motilal pesticides, India Pvt. Ltd. C 556 Defence Colony, New Delhi-24

Cultural operations :

The experimental plots were well ploughed before laying out of the experiment. Well decomposed farm yard manure was spread @ 2 t/ha uniformly and mixed thoroughly in all the sub-plots.

Nursery beds were prepared by making raised beds of 1 metre wide and 5 metres long. These beds were manured with the basal dose of the farm yard manure and kept weed free.

For the rainy season trial foundation seeds of midge susceptible (Jaya) and midge resistant (IET 9689) varieties were sown in separate beds on July 11, 1988. Delayed sowing was intentionally done to have more pest incidence.

Prior to planting experimental sub-plots were thoroughly puddled and basal dose of NPK was applied @ 50-50-50 kg/ha. Rest 50 kg/ha of N was applied in two equal splits at 21 and 55 DAT. Healthy 25 days old seedlings of both the rice varieties were transplanted @ 2 seedlings/hill at a inter-and intra-row spacing of 15 and 15 cm respectively.

The summer season trial was also conducted by using the stem borer susceptible rice variety 'Jaya'. The seed bed sowing was done on December 27, 1988, which was transplanted on February 4, 1989. Manure and fertilizer applications were kept constant as it was done for the rainy season trial. Healthy seedlings were transplanted @ 2-3 seedlings/hill and regular weeding, timely irrigations and other cultural operations were done as per the recommended practices. Care was taken to impound water at least for 5 days following each insecticidal application.

Seedling root dip :

For root dip treatment the rice seedlings were uprooted a day prior to transplanting, the mud sticking to the root zone was thoroughly cleaned in running water and the seedlings were placed in the galvanised iron trays having 0.02 % a.i. chlorpyriphos solution in such a manner that the root portion remained immersed in the solution for 12 hours. The treated as well as untreated seedlings were transplanted in the sub-plots as per the requirement of the treatment. Seedling root dip was done only for the maximum protection treatment with a view to keeping the infestation level at '0' per cent.

Application of granules :

In the rainy season trial carbofuran (Furadan 3G) was used @ 1.0 kg a.i./ha against the rice gall midge when the desired levels of infestation reached. Before applying granules the water level in the sub-plots were checked and maintained at 5 cm level. Carbofuran G was applied @ 1.0 kg a.i./ha as soon as the infestation reached the desired level or nearer to that and observations on midge incidence were recorded at 15, 20, 25, 30, 40 and 51 DAT. From each sub-plot 20 clumps were randomly selected and carefully examined. The extent of silver shoot incidence was calculated by using the formula.

$$\text{Silver shoot (\%)} = \frac{\text{Total silver shoot per 20 clumps}}{\text{Total tillers in 20 clumps}} \times 100$$

In the summer season trial cartap G was used @ 1.5 kg a.i./ha instead of carbofuran 3G against the rice stem borer infestation. The actual days of insecticidal application in different treatments differed based on the desired level of deadheart incidence. Based on the level of borer injury Padan G was applied at 15, 20, 30, 45, 47, 50, 55 and 60 DAT in order to restrict the deadheart injury at 0, 2, 5, 10, 15 and 20 per cent level.

Method of recording observations :

The deadheart and whitehead incidence was calculated based on 20 randomly selected hills from each treatment by using the following formulae.

$$\text{Deadheart (\%)} = \frac{\text{Total deadhearts per 20 clumps}}{\text{Total tillers in 20 clumps}} \times 100$$

$$\text{Whitehead (\%)} = \frac{\text{Total number of whiteheads}}{\text{Total number of panicle bearing tillers}} \times 100$$

The stem borer incidence was recorded at 20, 30, 40, 50 and 60 DAT while whitehead incidence 10 days prior to harvest.

Stem borer incidence in observation strips :

In order to confirm the levels of stem borer infestation on the rice yield observations on the degree of infestation in the observation strips were kept at the peak infestation stage (60 DAT) for deadheart incidence and 10 days prior to harvest for the whitehead incidence. Square metre areas having different degree of stem borer infestation were selected and the level of actual infestation was estimated. Based on the range of borer incidence, they were replicated and the mean infestation of DH and WH and its impact on yield estimated.

Incidence of other insect pests :

In the rainy season trial mild incidence of whorl maggot and leaffolder was noticed in all the treatments. Observations on the percentage whorl maggot and leaffolder infestation was recorded alongwith healthy leaves from 20 hills selected randomly from each treatment . In the summer season trial leaffolder infestation was noticed in addition to stem borer incidence. The percentage leaf damage by leaffolder was calculated by using the formula.

$$\text{Percentage leaf damage by leaffolder} = \frac{\text{Total damaged leaves in 20 clumps}}{\text{Total leaves in 20 clumps}} \times 100$$

During rainy season counts on whorl maggat was taken at 35 DAT and that for leaffolder at 55 DAT while leaffolder damage for the summer crop was taken at 60 DAT.

Grain yield :

During rainy season the Jaya variety was harvested at 101 DAT while IET 9689 at 88 DAT. In the summer trial was harvested at 108 DAT, when more than 90 per cent grains were ripened. Yield data was recorded sub-plotwise leaving the boarder 2 rows from all sides and converted to kg/ha. During rainy season 20 random hills were harvested separately and yield recorded. This was done to further confirm the yield data. During summer season, however, yield data from 1 sqm. areas were recorded.

Statistical analysis :

The observation data pooled from the different treatments at different times were subjected to statistical analysis (Snedecor and Cochran, 1959). Data pertaining to insect population recorded in percentage were converted to square root transformation where the range was inbetween 0-30 per cent. When most of the values were small $\sqrt{x + 0.5}$ instead of $\sqrt{x}$ was used. (Gomez and Gomez 1976). For the comparing the mean values of different treatment Duncan's Multiple Range Test has been applied (Duncan, 1955).

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

To find out the economic threshold values for the rice gall midge and stem borers, two separate field trials were conducted during the rainy season of 1988 and summer season of 1989, at the Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar. The salient findings of these experiments are presented in the following pages.

Need based insecticidal application for the control of rice gall midge :

The rice gall midge, Orseolia oryzae (W-M) is a serious pest of rainy season rice. In order to find out the economic threshold value for this important pest insecticidal protection with carbofuran granules (G) was given when the desired levels of infestations were reached to check further damage.

The results revealed that in order to keep the midge incidence at '0' level the crop was protected by providing seedling root dip in 0.02 per cent chlorpyriphos followed by two round broadcasting of carbofuran G at 15 and 40 days after transplanting (DAT). In spite of this the injury level attained 0.23 per cent at 35 DAT and 2.46 per cent at 50 DAT.

Similar treatment with granular carbofuran at 20 and 45 DAT effectively suppressed the midge injury

Table 3. Need based insecticidal application for control of rice gall midge

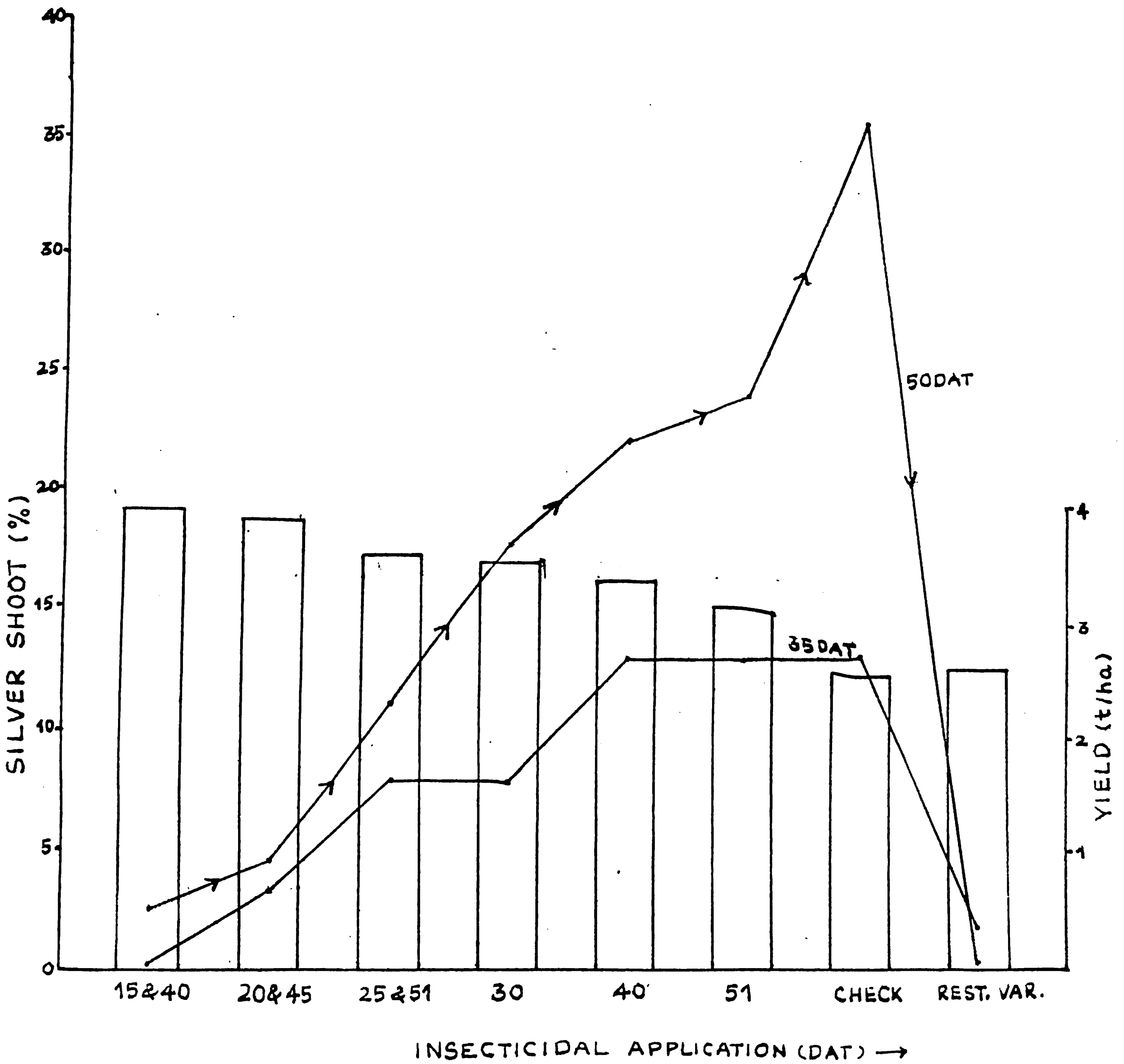
Carbofuran G Treatment (DAT)	Desired level of infestation (SS%)	Gall midge incidence (%) * at 35 DAT	50 DAT	Yield (kg/ha)
SD +				
15, 40	0	0.23 (0.84) a	2.46 (8.53) b	3794 e
20, 45	5	3.27 (1.92) c	4.60 (11.87) b	3678 d
25, 51	10	7.97 (2.91) d	10.93 (19.16) c	3424 cd
30	15	7.50 (2.83) d	17.50 (24.71) d	3334 cd
40	20	12.77 (3.64) e	21.90 (27.90) d	3216 c
51	25	12.70 (3.63) e	24.06 (29.35) d	3011 bc
untreated check	-	13.83 (3.78) e	35.96 (36.85) e	2610 a
Resistant variety	-	1.87 (1.51) b	0.22 (1.56) a	2663 ab

* Mean of 3 replications

Figures in parenthesis are converted values i.e. $\sqrt{x + 0.5}$
carbofuran G broadcast @ 1.0 kg a.i./ha/application.

Similar letters in a column indicated that the differences are not statistically significant. (Duncan's multiple range and multiple 'F' test 1955).

S.D.= Seedling root dip in 0.02 % a.i. chlorpyriphos for 12 hours.



TIME AND FREQUENCY OF INSECTICIDAL APPLICATION ON SILVER SHOOT INCIDENCE AND YIELD and the infestation level did not exceed 4.6 per cent. A marginal delay in the first dose of insecticidal application (25 and 51 DAT) resulted 7.97 and 10.93 per cent galls at 35 and 50 DAT respectively.

One round application of granular carbofuran @ 1.0 kg a.i./ha between 30 and 51 DAT resulted varying level of silver shoot incidence (17.50 to 24.06 per cent) as against 35.96 per cent injury in untreated check.

Under the same environmental conditions the midge resistant rice variety IET 9689, without insecticidal protection had less than 2 per cent damaged tillers (Table 3).

In order to reach the intended level of infestation insecticidal protection was provided to different treatments, based on periodical observations. The results revealed that to restrict the midge injury within 11.0 per cent two round applications of carbofuran was needed, the first application necessitated with in 25 DAT followed by a second round within 40 to 51 DAT. Application of granules beyond 30 DAT could not suppress gall fly incidence effectively and such delayed insecticidal application remained significantly inferior to earlier treatments.

Rainy season rice crop remains most vulnerable to midge attack within 21 to 35 DAT and therefore providing insecticidal protection with 25 DAT exhibit better control of the midge pest while later applications failed to protect the crop. Further, tillers produced beyond 45 DAT are mostly unproductive and remain vulnerable to gall midge attack. Providing protection to such unwanted tillers is of no value. Rather such tillers contain parasitized galls favouring the multiplication of the beneficial parasite, Platygaster oryzae. At this stage the parasite is capable enough to keep gall midge infestation in check. Therefore insecticidal protection against gall midge at this juncture is a wasteful investment. Working with the integrated control of rice gall midge Samalo (1983) and Parida (1979) have expressed similar views. Our present findings are in confirmity with the above workers.

Time and frequency of insecticidal application on panicle bearing tillers (PBT) and grain yield :

Under natural conditions the tillers of susceptible rice varieties are subjected to attack by insect pests particularly the rice gall midge. Timely insecticidal protection to the crop saved the productive tillers from midge injury and ultimately influenced the number of panicle bearing tillers and grain yield.

From our present study it was found (Table 4) that applying carbofuran G. within 25 DAT and subsequent supplementation by a similar dose in the maximum tillering

Table 4. Percentage panicle bearing tillers and grain yield as influenced by insecticidal treatment

Carbofuran G Treatment (DAT)	Dose (kg a.i./ha)	Panicle bearing tillers (%) * at 72 DAT	Grain yield from 20 hills (gms)
SD +			
15, 40	1.0	88.3 (70.2) e	238 d
20, 45	1.0	79.7 (63.3) d	213 bc
25, 51	1.0	78.9 (62.7) d	206 b
30	1.0	72.4 (58.4) c	211 bc
40	1.0	66.4 (54.6) bc	202 b
51	1.0	60.5 (51.1) ab	203 b
Untreated check	-	54.8 (47.8) a	184 a
Resistant variety	-	90.2 (71.8) e	222 c

* Mean of 3 replications.

Figures in parenthesis are transformed values $\sqrt{x + 0.5}$.

Similar letters in a column indicate that the differences are not statistically significant. (Duncan's multiple range and multiple 'F' test) 1955.

S.D. = Seedlings root dip in 0.02 % a.i. chlorpyriphos for 12 hours.

stage attributed towards higher percentage of panicle bearing tillers (78.9 to 88.3 per cent) as compared to 60.5 to 72.4 per cent in delayed applications and 54.8 per cent in plots receiving no such protection. From the data it is further evident that granular carbofuran applied at 15 and 40 DAT afforded excellent protection against the midge pest and attributed towards significantly higher percentage (88.3) of productive tillers. However, the midge resistant rice variety IET 9689 without any insecticidal protection also had 90.2 per cent PBT which was at par with Jaya receiving carbofuran treatment twice i.e., at 15 and 40 DAT.

Granular carbofuran applied between 20 and 25 DAT and subsequent dose at 51 DAT remained inferior to earlier application, but proved superior to delayed single round application at varying DAT (Table 4). Carbofuran applied at 51 DAT and plots receiving no insecticides had almost the same percentage of PBT. This may be due to the fact that late application of the insecticide fail to provide enough protection to the productive tillers resulting less percentage of PBT comparable to the PBT of the unprotected crop.

As the percentage panicle bearing tillers had a direct influence on the grain yield, it is necessary to apply insecticides early (20 to 25 DAT) and a second dose around 50 DAT. Such insecticidal protection provides excellent control not only to the gall midge but to the other major pests infesting rice at this crop stage and ultimately increase the yield.

It may be pointed out that (AICRIP, 1976) providing seedling root dip followed by two round application of granular insecticide gives excellent protection against the midge pest. Although, in the maximum protection recommendation of AICRIP, a 3rd round application of granules at 60 DAT has been suggested. Such indiscriminate use of pesticide goes against the principles of IPM. Such over use of granular insecticide is uneconomical but also quite harmful to the natural enemy faunna present in the rice ecosystem.

Time and frequency of insecticidal treatment on the incidence of whorl maggot and leaffolder :

In the experiment laidout for evaluating the economic threshold values for rice gall midge, infestation by whorl maggot in the early growth stage and leaffolder at late tillering phase were encountered. However, both these pests infestation remained mild. Apprehending that they might have influenced the yield to some extent mention has been made regarding the extent of damage by these two insects.

It is evident from the Table 5 that the whorl maggot infestation varied between 1.45 and 3.29 per cent in different treatments. Insecticidal treatment appeared to have least influence although some variation has been noticed depending on the time of insecticidal application. Neither insecticidal treatment nor varietal resistance influence the whorl maggot damage. It may be just possible that the differences were not significant because of low infestation.

The leaffolder incidence (percentage leaf damage) at 55 DAT varied from 1.40 to 3.46 per cent in different treatments. The time of carbofuran protection either once or twice at varying dates least influenced the leaffolder activity. Application of granular carbofuran once at 30 DAT (Table 5) however recorded minimum damage.

As both whorl maggot and leaffolder incidence did not reach the threshold level no separate protection was provided to check these two insects. It is presumed that such low incidence might have least influenced the grain yield. Hence while estimating the threshold value for gall midge these neligible infestations were not taken into account.

Economics of plant protection :

In the present strategy of pest management, minimum use of insecticide on need basis is recommended

Table 5. Effect of carbofuran treatment on the incidence of whorl maggot and leaffolders in wet season rice

Insecticidal treatment (DAT)	Dose (kg a.i./ha) per application	Whorl maggot incidence (%) at * 35 DAT	Leaffolder incidence (%) at 55 DAT *
SD +			
15, 40	1.0	1.45(1.36)a	2.95(1.80)
20, 45	1.0	2.55(1.74)abc	2.63(1.75)
25, 51	1.0	2.06(1.59)abc	2.42(1.69)
30	1.0	1.26(1.30)a	1.52(1.40)
40	1.0	3.29(1.94)c	3.46(1.99)
51	1.0	3.01(1.87)bc	2.94(1.85)
Untreated check	-	2.40(1.69)abc	2.73(1.76)
Midge resistant variety	-	1.66(1.45)ab	1.40(1.48)

* Mean of 3 replications

Figures in parenthesis are transformed values $\sqrt{x + 0.5}$

Similar letters in a column indicate that the differences are not statistically significant. Duncan's multiple range and multiple 'F' test 1955.

S.D.= Seedlings root dip in 0.02 % a.i. chlorpyriphos for 12 hours.

for the control of major rice pests. Depending on the desired level of gall midge infestation insecticide applications were scheduled. The benefit cost ratio of such treatments are presented in the following paragraphs.

The result in Table 6 clearly demonstrated that for providing effective control of the rice gall midge and to obtain higher grain yields application of insecticides should be done at least once within a month after transplanting. Application of granules twice within 45 DAT accounted for more than 3.6 tonns of paddy/ha while delayed applications (25 and 51 DAT) and a single application beyond 30 DAT failed to provide adequate protection, against the pest and resulted in low yields (Table 6).

The economics of plant protection as evident from data that applying carbofuran granules once at 30 DAT gave maximum nett benefit of Rs.530/- ha followed by two applications of the same granule at 15 and 40 DAT (Rs.506/- ha) with an investment cost of Rs.990/- and Rs.1980/- towards insecticides. Treatment with carbofuran granules at 15 and 40 DAT not only control the midge pest effectively but also gave around 3.8 tonns paddy per hectare. But a close scrutiny of the data indicated that the investment cost towards crop protection was around Rs.2000/- ha. In other words to derive the same nett return of

Table 6. Economics of rice gall midge control by insecticides

Carbofuran G Treatment (DAT)	Dose (kg a.i./ha)	Cost of plant protection (Rs/ha)	Yield (kg/ha)	Cost of yield (Rs/ha)	Cost of extra yield (Rs/ha)	Net benefit (Rs/ha)
SD +						
15, 40	1.0	2100	3794	7967	2486	386
20, 45	1.0	1980	3678	7724	2243	263
25, 51	1.0	1980	3424	7190	1709	-271
30	1.0	990	3324	7001	1520	530
40	1.0	990	3216	6754	1273	283
51	1.0	990	3011	6323	842	-148
Untreated check			2610	5481		
Resistant variety			2663	5592		

Cost of yield calculated @ Rs.2.10/kg insecticide and labour cost calculated at the prevailing rates.

S.D.= Seedlings root dip in 0.02 % a.i. chlorpyriphos for 12 hours.

Rs.500/- or little more per hectare a farmer has to invest Rs.2000/-, which is beyond the reach of an ordinary farmer in India. Even untimely application of insecticides instead of yielding benefits resulted in nett loss ranging from Rs.148/- to Rs.271/- ha (Table 6).

From the foregoing results it may be pointed out that for effective gall midge control and for deriving maximum moneytary benefits effective insecticides should be applied within 30 DAT. Similar treatments beyond 40 DAT not only failed to protect the midge pest but the investment towards pesticide application goes waste.

As the cost of plant protection is exceptionaly high (about Rs.1000/-ha) and beyond the reach of an ordinary farmer it is necessary to search for cheaper and effective insecticides which will minimise the cost of plant protection at the same time give maximum nett profit.

Economic threshold level for rice stem borers :

Summer rice is mostly attacked by rice stem borers, in the tillering and heading stages. The actual time of infestation is dependent on the emergence of first brood moths from the left over stubbles of rainy season crop. Insecticidal protection (Cartap 5 G @ 1.5 kg a.i./ha) was provided to the crop at varying degrees of borer infestation to check further infestation and its impact on the yield was determined. Where ever necessary second application of the same granule at the same rate was given to keep the stem borer damage at the desired level. In spite of our best efforts the infestation level could not be checked strictly at the intended level but it fluctuated around it.

Based on field observations at 5 days an interval, cartap G was applied on need basis. It may be mentioned here that to restrict the stem borer injury level, at '0' and 2 per cent granular cartap was broadcast in the transplanted rice crop @ 1.5 kg a.i./ha twice (20 and 50 DAT). In other treatments the borer incidence was allowed to increase to the desired levels of 5, 10, 15 and 20 per cent deadhearts. Observation indicated that 5 per cent incidence was reached at 30 DAT, 10 per cent around 50 DAT and 15-20 per cent around 60 DAT, necessitating/warranting insecticidal applications at 30, 47, 55 and 60 DAT respectively.

Time and frequency of insecticidal application on borer incidence :

The stem borer incidence remained within 3 per cent at 20 DAT and 1.95 to 9.0 per cent at 30 DAT in different treatments. Although the treatments receiving insecticides within 15-20 DAT had low incidence of deadheart, it did not vary significantly from the untreated plots. As the percentage deadhearts was quite low upto 30 DAT, there was no significant difference within the treatments.

The borer injury, however increased beyond 30 DAT and the effect of insectical protection significantly influenced the pest damage. The borer damage at 40 DAT indicated that application of granular cartap either at 15 or 20 DAT significantly reduced the deadhearts as compared to delayed application of the same insecticide at 30 DAT. The results further indicated that granular cartap applied beyond 30 DAT had no significant effect on the borer pest as the level of injury was at par with untreated check. In fact, at the time of 40 DAT observation plots intended for higher damage did not received insecticidal protection (47, 55 and 60 DAT).

The borer incidence at 50 DAT indicated that cartap applied @ 1.5 kg a.i./ha at 15 and 20 DAT caused 2.44 and 2.0 per cent dead hearts. These two treatments remained superior to delayed applications of cartap at 47, 55 and 60 DAT. Cartap granules applied once each at 47, 55, and 60 DAT had infestation levels equal to that in unprotected plots.

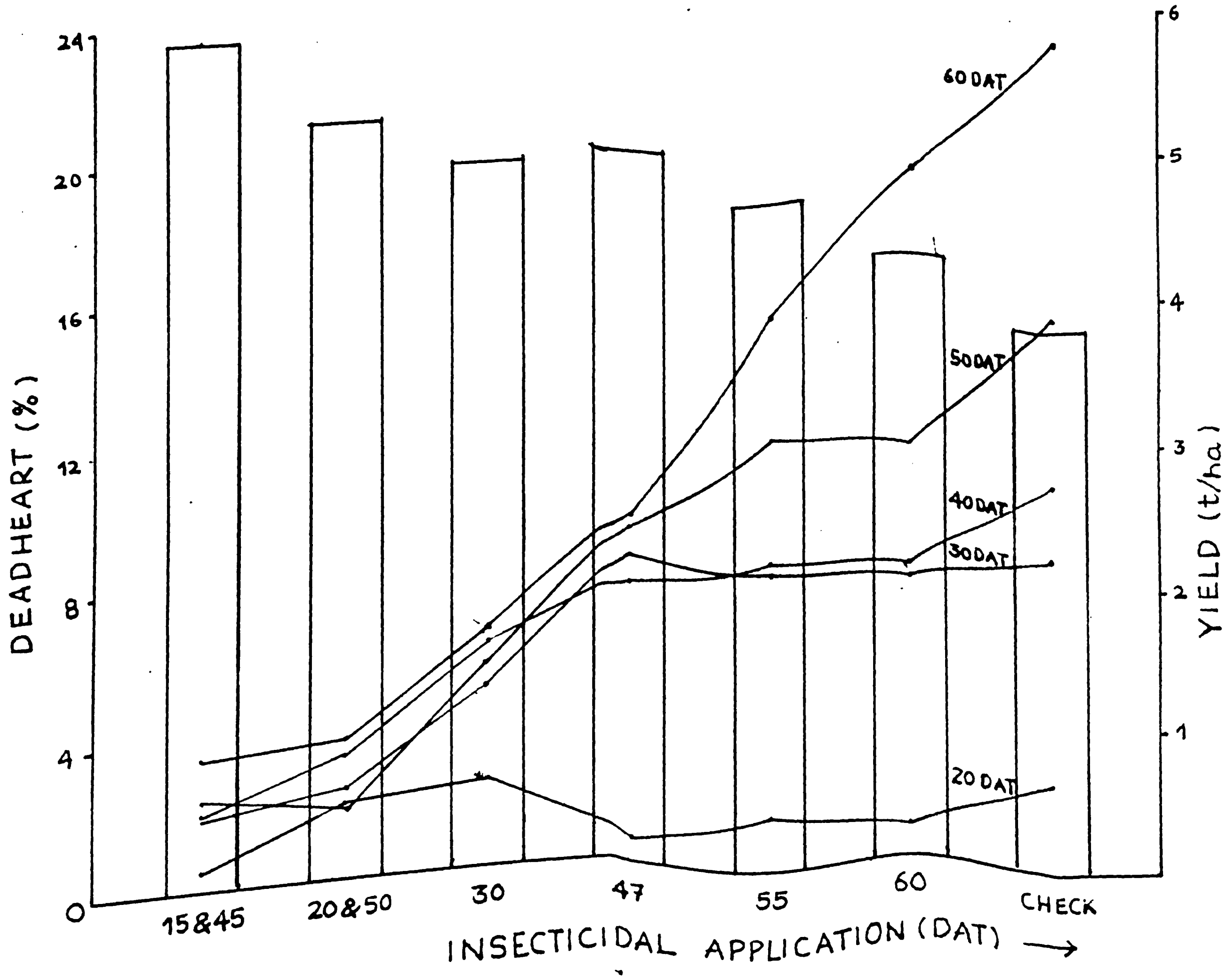
The stem borer infestation in the 60 day old transplanted crop showed that cartap G applied twice 15 and 20 DAT restricted the damage to less than 4 per cent, which proved significantly superior to delayed applications (Table 7). Broadcasting the insecticide granules @ 1.5

Table 7. Need based insecticidal protection for the control of rice stem borers

Cartap G Treatment (DAT)	Dose (kg a.i./ ha)	Desired level of infestation	Deadheart incidence (%) at * DAT					Yield in (kg/ha)
			20	30	40	50	60	
15, 45	1.5	0	00.5 (0.92)	1.95 (1.55)	2.02 (1.57)a	2.44 (1.61) ab	3.50 (1.99) a	5920 d
20, 50	1.5	2	2.07 (1.47)	2.58 (1.63)	3.47 (1.94)a	2.0 (1.41) a	3.82 (2.07) a	5328 cd
30	1.5	5	2.37 (1.68)	5.08 (2.36)	6.21 (2.56) b	5.57 (2.43)bc	6.67 (2.67)b	4994 bcd
47	1.5	10	0.68 (1.03)	8.65 (2.88)	7.91 (2.90) bc	9.53 (3.11) cd	9.85 (3.21) c	5062 bcd
55	1.5	15	1.57 (1.38)	8.50 (2.82)	8.71 (3.02) bc	12.22 (3.56) d	15.56 (4.0) d	4706 bc
60	1.5	20	0.94 (1.17)	7.86 (2.84)	8.16 (2.93) bc	11.66 (3.43) cd	19.42 (4.44) de	4235 ab
Untreated check	-	-	2.60 (1.75)	9.0 (3.07)	11.15 (3.40) c	15.66 (4.01) d	23.20 (4.86) e	3825 a

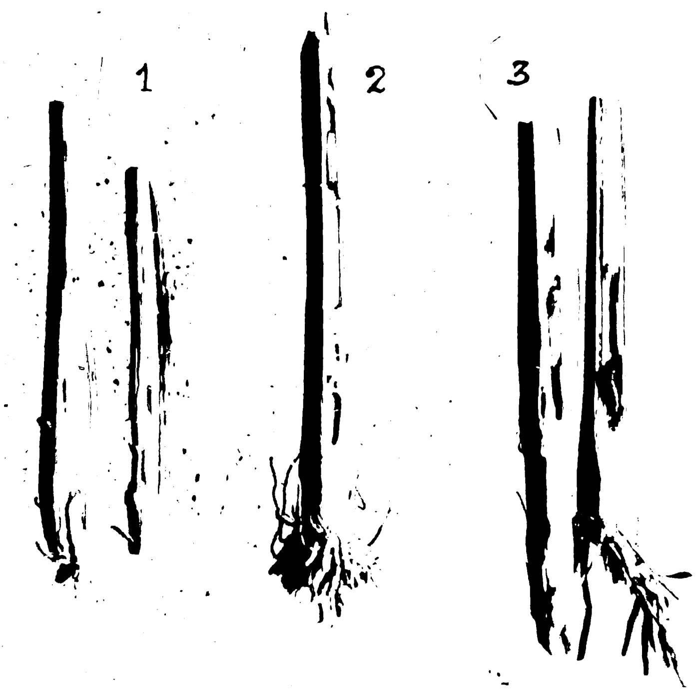
* Mean of 4 replications

Figures in parenthesis are transformed values $\sqrt{x + 0.5}$. Similar letters in column indicate that the differences are not statistically significant (Duncan's multiple range and multiple 'F', 1955).



TIME AND FREQUENCY OF INSECTICIDAL APPLICATION ON DEADHEART INCIDENCE AND YIELD

Egg mass of yellow stem borer



Stem borer damaged tillers

1. YELLOW STEMBORER
2. STRIPED BORER
3. PINK BORER

Healthy tillers   Stem borer infested tillers kg a.i./ha at 30 DAT proved significantly inferior to earlier but superior to delayed applications.

Time and frequency of insecticidal application on grain yield :

The grain yield in different treatments varied between 3825 and 5920 kg/ha. Plots receiving two round insecticidal protection at 15 and 45 DAT gave 5920 kg/ha, while delayed application of the same granule once at or beyond 30 DAT (Table 7) recorded 4235 to 5062 kg/ha. The data further indicated that insecticidal protection provided at 60 DAT against rice stem borers could not check the pest effectively and hence the grain yield obtained from such treatment was almost equal to the yields obtained from the untreated plots.

From the yield data it becomes clear that for effective control of rice stem borers and to get higher yields (5328 to 5920 kg/ha) two round application of insecticide is necessary. But from the point of economy such applications of insecticide may not be remunerative, and acceptable by the marginal farmers in India. A close look to the data indicates that one round insecticidal treatment at 30 or 47 DAT gave around 5000 kg/paddy per hectare. From the results it is further evident that in order to save the crop from borer damage and at the same time to obtain comparatively higher yields one round insecticidal treatment within 30 to 47 DAT is necessary. However providing such protection against stem borer damage beyond 55 DAT was uneconomical.

The present recommendations however, should not be taken as a general principle for controlling the borer pests of rice because the brood emergence is mostly governed by the environmental factors which differs in different agroclimatic zones. Integrated control schedules has to be drawn up on location specific basis based on sound bio-ecological studies in order to derive maximum benefits.

Time and frequency of insecticidal treatment on panicle bearing tillers, whiteheads and yield :

It is a well established fact that providing timely insecticidal protection to rice crop not only prevents pest damage but also attribute towards higher yields. In the present study the effect of time and frequency of insecticidal application on the panicle bearing tillers, whiteheads and grain yield were evaluated (Table 9).

The results indicated that the time of insecticidal application has a profound influence on the percentage panicle bearing tillers. Plots receiving insecticides within 47 DAT produced 80 to 86 per cent panicle bearing tillers as against 65 per cent in the untreated check.

Table 8. Time of insecticidal treatment on the panicle bearing tillers, whitehead and yield

Cartap G Treatment (DAT)	Dose in (kg a.i./ha)	Panicle bearing tiller (%)	Whiteheads (%) *	Yield (g/m^2)
15, 45	1.5	86 e	1.74	592.0 d
20, 50	1.5	82 cde	1.64	532.8 cd
30	1.5	84 de	1.83	499.4 bcd
47	1.5	80 cd	1.91	506.2 bcd
55	1.5	76 b	1.57	470.6 bc
60	1.5	77 bc	1.43	423.5 ab
Untreated control	-	65 a	2.33	332.5 a

* Mean of 4 replications

Similar letters in a column indicate that the differences are not statistically significant (Duncan's multiple range and multiple 'F' test 1955).

In general insecticidal protection gave significantly higher percentage of panicle bearing tillers as compared to unprotected check.

It may be mentioned here that stem borer infestation in the early tillering phase was compensated by the production of new tillers but such injury in late tillering/heading stage is not substituted by new tillers. From the data it becomes clear that treatments receiving insecticidal protection at early growth stages had comparatively more number of panicle bearing tillers as against plots receiving such insecticidal protection at a later date.

The whitehead incidence was quite low (1.43 to 2.33 %) during the test season. Because of low incidence the effect of insecticide in controlling the borers population in the reproductive stage could not be understood properly.

Observations on the stem borer incidence indicated that the second brood moths damaged the crop in the pre-booting stage (around 60 DAT). As the larva inflicted the injury prior to late application of insecticides such delayed treatment was wasteful. The cause of low whitehead incidence could not be understood properly. It is presumed that as there was no brood emergence within the panicle initiation period probably the occurrence of the pest was low, hence minimum whiteheads. The grain yield reduced with the decrease in the percentage of productive tillers.

Cartap G applied within 47 DAT did not bring about a marked change in the yield level. In general the crop protected with granular cartap gave comparatively higher yields than unprotected check. Insecticidal protection provided at 60 DAT, however, did not bring about a significant difference in yield over the untreated check.

In order to confirm the level of stem borer infestation on grain yield, observations on the incidence of stem borers were recorded from adjacent unprotected crop transplanted 15 days later. The combined effect of deadhearts and whiteheads incidence on yield has been presented in the Table 9. It is evident from the data that with the increase in the level of borer injury the grain yield decreased. Stem borer incidence comprising of 3.67 per cent deadhearts and 1.81 per cent whiteheads recorded 525 gm dry paddy/m^2. The yield level was reduced to 455.7 gm/m^2 when the damage levels were 7.37 per cent deadhearts and 2.92 per cent whiteheads. A borer damage level of 14.02 per cent deadhearts and 5.02 per cent whiteheads gave little over 418.6 gm paddy/m^2. The yield was further reduced to 381.5 gm/m^2 with a further increase in the borer injury (Table 9).

Table 9. Combined effect of deadheart and whitehead incidence on yield

Sl. No.	Level of stem borer infestation			Yield	
	Deadhearts at 60 DAT (%)	Whiteheads 10 days before harvesting (%) *	Total damage	(g/m^2)	(kg/ha)
1	3.67	1.81	5.48	525	5250
2	7.37	2.92	10.29	455.7	4557
3	14.02	5.02	19.04	418.6	4186
4	17.09	6.74	23.83	381.5	3815

* Mean of 4 replications

Combined effect of stem borer and leaffolder infestation on grain yield :

While evaluating the economic threshold values for rice stem borers by applying insecticides at desired levels of infestations, the crop was simultaneously infested with leaffolders. However, the percentage leaf damage in different treatments was restricted to 12.92 per cent at the peak infestation stage i.e., 60 DAT (Table 10).

The effect of insecticidal protection at different times on the incidence of leaffolder indicated that granular cartap applied at 15 and 45 DAT remained quite effective, against the leaffolders and the damage level was restricted to 4.0 per cent, closely followed by similar insecticidal treatment at 20 and 50 DAT. The damage intensity was comparatively high in plots receiving granular insecticides once between 30 and 60 DAT. Delayed application of insecticide had no profound influence on the leaffolder infestation, and in some cases the injury level in such treatments was higher than untreated check.

In this regard it may be mentioned here that untimely applications of ineffective insecticides instead of decreasing the leaffolder population, favour for its multiplication by killing the natural enemies. Because of this reason probably the pest load was higher in plots receiving insecticidal protection at a later stage.

Table 10. Time of insecticidal treatment on leaffolder and stem borer infestation and its impact on yield

Cartap G Treatment (DAT)	Dose in (kg. a.i./ ha)	Leaffolder incidence (%) at 60 DAT *	Stem borer incidence (%) at 60DAT	Yield (kg/ha)
15, 45	1.5	6.66 (2.60) ab	3.50 (1.90) a	5920d
20, 50	1.5	4.09 (2.13) a	3.82 (2.07) a	5328cd
30	1.5	10.68 (3.34) bc	6.67 (2.67) b	4994bcd
47	1.5	9.54 (3.01) bc	9.85 (3.21) c	5062bcd
55	1.5	12.92 (3.85) c	15.56 (4.0) d	4706bc
60	1.5	9.30 (3.12) bc	19.42 (4.44) de	4235ab
Untreated control	-	11.76 (3.50) c	23.20 (4.86e	3825a

* Mean of 4 replications

Figures in parenthesis are transformed values $\sqrt{x + 0.5}$. Similar letters in a column indicate that differences are not statistically significant (DMRT & 'F' test)

It is difficult to distinguish how much loss is caused by individual pest under field conditions. Inspite of all precautions more than one insect normally occur under field conditions causing varying levels of infestation. In our present trial too, the grain yield might have influenced, to certain degree, by the simultaneous attack of leaffolder and stem borers. In trials conducted under field conditions it becomes practically difficult to find out the threshold values separately for individual pest and apply insecticide in time to each and every pest. Therefore the yield data obtained from such trials should be interpreted accordingly.

Economics of rice stem borer control :

The economics of rice stem borer control by insecticidal application at varying level of deadheart incidence indicated that cartap G applied @ 1.5 kg a.i./ha at 15 and 45 DAT afforded excellent protection against the borer pest and gave a nett return of Rs.2130/- ha. However, the investment cost towards plant protection was equally high (Rs.2270/- ha) which is beyond the reach of an ordinary farmer in India. The same insecticide when applied once at 30 or 47 DAT with an investiment cost of Rs.1135/- ha gave a nett benefit ranging between Rs.1320/- to Rs.1454/- ha.Further delay in the insecticidal treatment not only reduced the nett benefits but also proved uneconomical (Table 11).

Table 11. Economics of rice stem borer control

Cartap G Treatment (DAT)	Dose (kg a.i./ha)	Cost of plant protection (Rs./ha)	Yield (kg/ha)	Cost of yield (Rs./ha)	Cost of extra (Rs./ha)	Net benefit (Rs./ha)
15, 45	1.5	2270	5920	12,432	4400	2130
20, 50	1.5	2270	5328	11,189	3157	887
30	1.5	1135	4994	10,487	2455	1320
47	1.5	1135	5060	10,630	2589	1454
55	1.5	1135	4706	9883	1951	716
60	1.5	1135	4235	8893	861	-274
Untreated check	-	-	3825	8032	-	-

Cost of yield calculated @ Rs.2.10/kg.
Insecticides and labour cost calculated at the prevailing local rates.

In order to keep the borer incidence at the desired levels, insecticidal protection was given at higher doses i.e. 1.5 kg a.i./ha. This resulted in high investment cost towards plant protection, which may not be acceptdble to the farmers. Therefore, effective insecticides at lower costs have to be identified and tested or the dose may be reduced to derive maximum nett benefits from plant protection.

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

To findout the economic threshold values for rice gall midge and stem borers separate field trials were conducted during wet season, 1988 and summer, 1989 respectively at the Central Research Station, Bhubaneswar. The salient findings of these experiments are summarised in the following paragraphs.

Threshold values for rice gall midge was estimated by providing insecticidal protection at different levels of midge infestation.

It is evident from the data that seedling root dip in chlorpyriphos 0.02 per cent a.i. followed by two round applications of granular carbofuran (first application at 15 to 20 and second at 40 to 45 DAT) kept the midge injury below the economic threshold level (5 % silver shoot). Further delay in the insecticidal application failed to keep the midge infestation below this level. Granular carbafuran applied @ 1.0 kg a.i./ha once at 25 recorded 7.97 and 10.93 per cent silver shoot at 35 DAT and at 50 DAT respectively. Similar insecticidal protection once at 30 DAT also restricted the midge damage to 7.50 per cent at 35 DAT and 17.50 per cent at 50 DAT, suggesting that the midge pest can not be restricted to below economic damage level by one round treatment with carbofuran G. Further delay on the insecticidal application failed to keep the pest infestation below the desired level.

The effect of time and frequency of insecticidal applications on the panicle bearing tillers in midge susceptible variety 'Jaya' revealed that the productive tillers were significantly more (88.3 per cent) in plots receiving carbofuran G at 15 and 40 DAT. Similar insecticidal treatments at 20, 45 and 25, 51 DAT recorded 79.7 and 78.9 per cent panicle bearing tillers respectively which remained significantly inferior to earlier treatment but superior to delayed single round application of the same insecticide at 30, 40, 54 or 60 DAT. The midge resistant variety 'IET 9689' without insecticidal protection produced 90.2 per cent panicle bearing tillers. However, the average tillering capacity of the resistant variety was lower than Jaya.

The time and frequency of insecticidal applications on the grain yield indicated that highest paddy yield of 3794 kg/ha was obtained from plots receiving a combined treatment of seedling root dip in 0.02 per cent chlorpyriphos followed by two applications of granular carbofuran at 15 and 40 DAT. Curtailing the number of insecticidal applications or applying at a later date significantly decreased the grain yield. However, providing protection with granular carbofuran either once or twice afforded better protection against the midge pest and significantly increased the grain yield, over untreated control. The low yield in the midge resistant variety IET 9689 was probably due to low varietal potentiality coupled with its early maturing character.

The economics of gall midge control based on threshold levels indicated that carbofuran G applied @ 1.0 kg a.i./ha at 30 DAT with 7.50 and 17.50 per cent silver shoots incidence at 35 and 50 DAT respectively afforded maximum net benefit of Rs.530/- ha. The investment cost towards plant protection is exceptionally high (Rs.1980-Rs.2100/- ha) where carbofuran G was applied twice. Because of high investment cost towards plant protection the net benefit was marginal (Rs.263 - Rs.386/-ha) when two round insecticidal application was done at 15, 40 or 20, 45 DAT. Such insecticidal protection in some cases accrued net loss of Rs.148 - Rs.271/- ha. For gall midge control providing insecticidal protection beyond 40 DAT not only failed to control the pest resulting low yields but accnued net loss of Rs.148/- ha.

Studies on the estimation of economic threshold values for rice stem borers revealed that granular cartap applied twice (at 15 and 45 or 20 and 50 DAT) effectively suppressed the rice stem borers below the economic damage level. However, the borer incidence exceeded the threshold level, when insecticidal protection with the same granule was restricted to one application at 30 or 47 or 55 or 60 DAT. In such treatments the deadheart incidence at 60 DAT ranged from 6.67 to 19.42 per cent. The corresponding damage in the untreated check was 23.20 per cent .

The number of panicle bearing tillers was greatly influenced by the time and frequency of insecticidal protection against rice stem borers. Granular cartap applied @ 1.5 kg a.i./ha once at 30 DAT or twice within 50 DAT attributed towards higher productive tillers ranging from 80.0 to 86.0 per cent. Further delay in the initial cartap treatment not only decreased the productive tillers but also reduced the yields. Plots without insecticidal protection had significantly lower percentage of panicle bearing tillers, probably due to higher (23.20 per cent deadheart) borer incidence.

The summer rice crop was attacked by rice leaffolder Cnaphalocrosis medinalis (Guenee) and peak infestation ranging between 4.09 and 12.92 per cent at 60 DAT. The effect of two round insecticidal treatments (first application at 15 to 20 and second at 45 to 50 DAT) resulted 4.09 to 6.66 per cent leaf damage. Cartap G applied once between 30 and 60 DAT failed to keep the pest under check and the level of infestation in these treatments was at par with untreated check.

Time and frequency of insecticidal application against rice stem borer and its effect on grain yield revealed that granular cartap applied either once or twice between 50 DAT gave almost equal yields, although two applications attributed towards higher yields (5328 to to 5920 kg/ha). Further delay in the insecticidal treatment lowered the grain yield. On an average grain yield was boosted up by 24.16 when cartap G was applied once and by 47.0 per cent when applied twice.

The economics of stem borer control in summer rice revealed that two round cartap application at 15 and 45 DAT afforded excellent protection against the rice borers and gave a net benefit of Rs.2130/- ha. However the investment cost on insecticide was equally high (Rs.2270/- ha). A marginal delay in the insecticidal application curtailed the net profit to Rs.887/- ha. One round application of the same granule between 30 and 47 DAT, with an investment cost of Rs.1135/- ha towards plant protection gave net benefit of Rs.1320 to Rs.1454/- ha. Providing protection beyond 47 DAT was not remunerative.

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