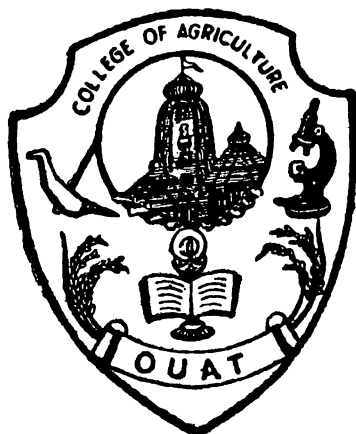


**STUDIES ON RICE LEAFFOLDERS WITH PARTICULAR
REFERENCE TO SEASONAL ACTIVITY, HOST PLANT
RESISTANCE AND INSECTICIDAL MANAGEMENT**

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
Bibekananda Sarangi



**DEPARTMENT OF ENTOMOLOGY
COLLEGE OF AGRICULTURE
Orissa University of Agriculture & Technology
BHUBANESWAR - 751003
1997**

THESIS ADVISOR

Dr. A. P. SAMALO

Dedicated
to
My Beloved Parents

Prof. A.P. Samalo Ph.D.
Associate Director of Research
RRTTS, Mahishapat, Dhenkanal.

Bhubaneswar
31st October, 1998

CERTIFICATE - I

This is to certify that the thesis entitled "Studies on rice leaffolders with particular reference to seasonal activity, host plant resistance and insecticidal management" submitted in partial fulfilment of the requirements for the award of the degree of "MASTER OF SCIENCE IN AGRICULTURE (DEPARTMENT OF ENTOMOLOGY)" to the Orissa University of Agriculture and Technology, Bhubaneswar, is a faithful record of *bona fide* research work carried out by SRI BIBEKANANDA SARANGI under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma or published in any other form.

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

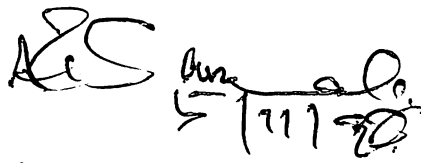

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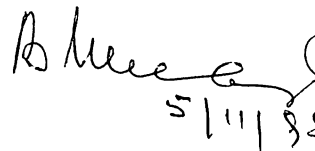
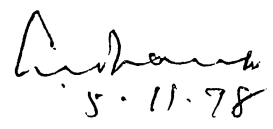
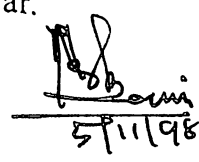

CERTIFICATE - II

This is to certify that the thesis entitled "Studies on rice leaffolders with particular reference to seasonal activity, host plant resistance and insecticidal management" submitted by SRI BIBEKANANDA SARANGI in partial fulfilment of the requirements for the award of degree of MASTER OF SCIENCE IN AGRICULTURE (ENTOMOLOGY) to the Orissa University of Agriculture and Technology, Bhubaneswar has been approved by the advisory committee after an oral examination on the same in collaboration with an external examiner.

ADVISORY COMMITTEE.

Chairman. : **Dr. A.P. Samal.** 
Associate Director of Research
RRTTS, Mahishapat, Dhenkanal.

MEMBERS

1. **Dr. B. Senapati**
Prof. and Head of the Department
of Entomology, College of
Agriculture. Bhubaneswar. 
2. **Dr. A. K. Mohanty**
Reader, Department of Plant
Pathology, College of Agriculture
Bhubaneswar. 
3. **Dr. N.C. Patnaik**
Professor,
Dept. of Entomology 

External Examiner.

(K. NATUR)

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I solicit the benediction of "MAA DURGA" for my progress and prosperity.

Bhubaneswar

3rd October, 1998

Bibekananda Sarangi
(Bibekananda Sarangi)

Name of the student : Bibekananda Sarangi
Adm. No. : 88 Ent./95
Title of the Thesis : Studies on rice leaffolders with particular reference to seasonal activity, host-plant resistance and insecticidal management.
Degree for which submitted : M.Sc. (Ag.)
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Name of the Advisor : Dr. A. P. Samalo.

ABSTRACT

In order to study the seasonal incidence, host-plant resistance and insecticidal management of rice leaffolders, two separate field experiments were conducted during wet season, 1997 and summer, 1998 at Bhubaneswar. The rice variety Jaya was included for the seasonal incidence and leaffolder management study, while four rice varieties namely IR 36, Tapaswini, Bhubana and TN I and five insecticides viz., monocrotophos, carbaryl, endosulfan, deltamethrin and imidacloprid were used for the variety cum insecticidal interaction study. The incidence of rice leaffolder during both test seasons were monitored at 10 days interval starting from 30 Days after Transplanting (DAT) and continued upto 90 DAT. The leaffolder infestation was quite mild (0.73 to 3.29 per cent) during wet season and 0.76 to 15.08 per cent in the summer crops. The effect of environmental factors on the incidence of rice leaffolders revealed that temperature ranging from 25.2 to 33.9°C and RH of 77-78 per cent during wet season and 24.2 to 38.3°C and 68-69 per cent during summer favoured leaffolder infestation. The larval presence in the standing crop was recorded from 27th Aug. to 11th Nov.1997 (35th to 45th standard week), the maximum larval recovery (2.1 larva/m²) was in the 2nd week of September while in summer crop as high as 3.8 larva/m² was recorded in the 3rd week of April.

The interaction between rice varieties and insecticides indicated that irrespective of insecticidal treatments leaf damage varies from 9.25 to 13.48 per cent in the four test varieties and Bhubana remained least (9.25 per cent) and IR 36 significantly susceptible. Among the insecticides imidacloprid @0.02 kg a.i/ha restricted the damage to 7.13 per cent closely followed by endosulfan @0.5 kg a.i/ha. The corresponding infestation in untreated check was 19.43

per cent. Leaffolder infestation in the top three leaves revealed that 21.34 to 32.74 per cent damage in the rice varieties IR 36, Tapaswini, Bhubana and TN 1. The rice variety IR 36 with 32.74 per cent leaf damage remained significantly susceptible while Bhubana with 21.34 per cent infestation proved resistant. Among the insecticides, imidacloprid @0.02 kg a.i/ha proved significantly superior (19.14 per cent leaf infestation) while carbaryl @1.0 kg a.i/ha remained least effective (36.96 per cent damage). The interaction between variety and insecticide revealed that Bhubana sprayed with endosulfan proved significantly superior in checking leaffolder infestation.

The relationship between flag leaf area damage and percentage grain filling revealed that increased in flag leaf area damage, decrease grain filling both during wet and summer seasons. Flag leaf area damage of 10 per cent produced 135.20 and 118.50 filled grains/panicle during wet and summer season while the number decreased to 87.20 and 72.60 grains/panicle when the flag leaves were totally defoliated. The insecticides monocrotophos followed by chlorpyrifos, quinalphos, and ethofenprox restricted the leaf infestation to 6.0 per cent and larval recovery to a maximum of 2.0 numbers at 8 DAS as against 16.70 per cent infestation and larval recovery of 14.0 numbers in untreated check. Neem based pesticides were comparatively less effective (11.21 to 13.98 per cent damaged leaves). The grain yield in different insecticidal treatments varied between 2.94 and 4.0 t/ha as against 2.86 t/ha in untreated check. Plots receiving monocrotophos @0.5 kg a.i/ha at 60 DAT contributed towards highest grain yield of 4.0 t/ha closely followed by similar dose of chlorpyrifos (3.91 t/ha) and quinalphos (3.83 t/ha). The economics of insecticidal protection revealed a maximum net benefit of Rs.3075.00/ha from plots treated with chlorpyrifos but highest benefit cost ratio of 6.04 : 1 was obtained by spraying monocrotophos at 60 DAT.

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CHAPTER I

INTRODUCTION

INTRODUCTION

Rice, the blessing grain of God, is the most important food crop of the world and approximately 60 per cent of world population depend on rice as a major source of calories (De Datta, 1981). About 90 per cent of this most important food crop is grown in Asia alone. However, the production is hardly two tonnes/ha. Among the various constraints of low production in eastern India, insect pests alone is believed to cause 40 per cent yield loss in rice (Pathak and Dhaliwal, 1981).

The humid climate in the tropics under which rice is grown is also conducive to the proliferation of insect pests. Besides intensification of agriculture with pest susceptible high yielding rice varieties as well as monoculture of rice further aggravated the situation. The altered rice agroecosystem encouraged some of the minor pests to assume major status. The rice leaffolders *Cnaphalocrocis medinalis* (Guenee) hitherto considered as a minor pest of rice has assumed major pest status from mid 1980's. Moreover three more species of leaffolders namely *Marasmia exigua* (Butler), *Marasmia patnalis* (Bradley), and *Brachmia arotraea* (Meyrick) were found attacking rice under Orissa condition (Mishra, 1995). This has further aggravated the situation and outbreak of rice leaffolders, were experienced in wet season as well as summer rice in several parts of India, Pakistan and Sri Lanka between 1987 and 1990 (Teng *et al.* 1993)

As regards to the assessment of yield loss due to leaffolders, different workers have opined different views. According to Murugesan and Chelliah 50.0 per cent flag leaf damage caused 40.0 per cent yield loss and when the

damage exceeded 75 per cent yield was reduced by 70.0 per cent. Further they reported that a 10.0 per cent increase in flag leaf damage increased unfilled grains by 4.5 per cent per tiller. Subramanian and Gopalan (1992) reported that 1.0 per cent increase in leaf damage caused yield loss of 41.3, 41.3 and 25.7 kg/ha of grains and 28.7, 30.3, and 52.1 kg/ha of straw in IR 64, IR 36, and IR 50 respectively.

Although leaffolders at present are considered as major pests of rice, detailed information on its bioecology, extent of damage, yield loss and effective chemical control schedule are not available for guiding the field workers as well as farmers. Hence, the present study was undertaken with the following objectives.

- (i) To study the seasonal activity of rice leaffolders under natural infestation condition.
- (ii) To study the reaction of some rice varieties against leaffolder and
- (iii) Management of rice leaffolders through application of selective insecticides.

It is hoped that the results obtained from our present investigation would contribute in understanding more about leaffolders attacking rice and for adopting timely plant protection majors with selective insecticides to avoid yield losses. The information generated is likely to benefit the rice farming community of Orissa.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Rice is a more adaptable crop but its yield is affected by various biotic and abiotic factors. Among the biotic constraints, insect damage to rice crop is recognised as a major limiting factor in realising the full yield potential. Among the major rice pests leaffolders have gained major importance for the last two decades as a result of practices associated with intensified crop production. Population build up has been favoured by multi-rice cropping, nitrogenous fertiliser and insecticides induced resistance. At present leaffolders are chronic pest of rice and occur in all rice environments all round the year. A brief review on various aspects of rice leaffolders has been presented below.

2.1 Distribution :

Reports on rice leaffolders (LF) menace dates back as early as 1863 when J. Lederer recorded two genera, viz., *Cnaphalocrocis* and *Marasmia* belonging to the family Pyraustidae, Lepidoptera. By the year 1987, one species of the former genus (*C. medinalis*, Guenee) and seven species of the later genus i.e., *M. exigua*(Butler), *M. bilinealis*(Hampson), *M.patnalis*(Bradley), *M.suspicalis*(Walker), *M.trapezalis*(Guenee), *M.ruralis*(Walker) and *M.venialialis* (Guenee) were known to comprise the leaffolder complex of rice. (Grist and Lever, 1969; Bradley, 1981; Mathew and Menon, 1984, 1986; Reissig *et al.*, 1985 and Barrion *et al.*, 1987). Prior to 1977 leaffolders were considered as minor pests of rice. But there after the increase in the number of outbreaks indicated that it has assumed a serious pest status and are widely distributed in the rice growing tracts of 29 humid tropical and temperate countries in Asia, Australia and Africa between 48°N and 24°S latitude and 0°E and 172°E longitude.

The pest is more abundant in the tropics and occur in most of the rice tracts of Asia. The distribution of this pest in the Asian countries include Indonesia, Philippines, Thailand, Malaysia, Sri Lanka, Vietnam, Nepal, China and India (Chang *et al.*, 1980; Custodio, 1980; Fernando, 1980; Lim *et al.*, 1980 and Nguyer, 1982). The distribution of *Cnaphalocrocis medinalis* (Guenee) in the tropics and subtropics was so wide that it has become a major threat to rice production in Asia in the last decade (Heinrichs *et al.*, 1985 and Khan *et al.*, 1988).

Two other lepidopterous species namely *Bradina admixtalis* (Walker) belonging to the family Pyraustidae (Nakayama, 1929; Kuwana, 1930; Clausen, 1931; Lee *et al.*, 1973) and *Brachmia arotraea*(Meyrick) of the family Gelechiidae (Kalra *et al.*, 1966, Sen and Chakravorty, 1970; Natarajan *et al.*, 1987, Nodorajan and Nair 1987; and Tunga, 1989) have been reported as leaffolders of rice.

The genera of leaffolder i.e., *Bradina*, *Cnaphalocrocis* and *Marasmia* occur in Asia (Mathew and Menon, 1986). *Bradina admixtalis*(Walker) a forage pest is confined to India. *Marasmia trapezalis* (Guenee) has expanded it's distribution from Africa to India becoming a pest of sugarcane (Raghunath and Ramakrishna, 1979).

In India the incidence of *C. medinalis* has been reported from West Bengal, Bihar, Gujrat, Maharashtra, Orissa, Andhra Pradesh, Tamil Nadu, Karnataka and throughout the planes of south India (Singh and Sinha, 1978; Chhabra and Singh, 1979 and Rao *et al.*, 1982). According to Verma *et al.* (1979) *C. medinalis* occurred in the hilly tracts of Tarai region upto a height of 1500 m.

Brachmia arotraea (Meyrick) was reported for the first time from Central Rice Research Institute (CRRI), Cuttack, Orissa by Natarajan *et al.*, (1978) and from Kerala by Nodorajan and Nair (1987).

Joshi *et al.* (1985) found simultaneous occurrence of *C. medinalis* and *M. patnalis* in International Rice Research Institute (IRRI) Philippines from October, 1983 to March, 1984. According to Pangtey and Sachman, (1982) *C. medinalis* caused serious damage to wet-season rice crop in Nagaland. The leaf damage was around 20 per cent even above 1400m from mean sea level (MSL) to 36 per cent at 200m above MSL. The infestation increased upto 70 per cent in IR8 and local varieties during 1981.

Pradhan and Shahi (1983) recorded *C. medinalis* as an important rice pest in Nepal. while the occurrence of *M. patnalis* and *M. ruralis* was reported by Gunathilagaraj and Gopalan (1986) from Madurai area of Tamil Nadu.

A Survey of leaffolder incidence (*C. medinalis*) during 1989-90 in the Punjab, Pakistan in 2941 rice fields at 73 locations in eight rice growing districts indicated that the pest has caused serious damage to rice crop during August-September. The infestation was 51.0 per cent at Dardha, Dogran in Sheikhpura. In Sialkot, Jassarwale the infestation showed 25.0 per cent. In Faisalabad, Okra, Kasur, Lahore the infestation was 10.0 per cent. Aromatic high yielding varieties of rice (Basmati 385) occupied 80.0 per cent of the area planted under rice. Average damage to this crop was 16.6 per cent whereas damage on Basmati 370, Kashmira and Palman was 12.7, 5.7, and 57.3 per cent respectively (Salim *et al.*, 1991) Sachan and Garg (1992) reported that *C. medinalis* was found to be a major pest of rice among the recorded 27 insect pests in the hilly tracts of UP, India. Among the leaffolder species *C. medinalis* was recorded both under irrigated and upland rain-fed conditions.

Sachan (1992) reported that *C. medinalis* was the serious pests of rice under both irrigated and upland conditions in the hills of Uttar Pradesh during Kharif 1991. A severe outbreak occurred in the irrigated valley regions of Almora districts.

2.2 Seasonal abundance :

The rice leaffolders, *C. medinalis* has as many as 76 alternate host plants on which it survives feeding throughout the year on one or the other host. Many workers have reported the seasonal occurrence of leaffolders in rice crop grown in different times of the year.

Viswakantaih (1972) and Veluswamy *et al.*, (1974) reported that the leaffolder incidence was regulated, according to the planting dates. When the rice crop was transplanted in July the peak period of leaffolder incidence was noticed in September, when transplanted in August, showed peak incidence in November and the crop raised in September-October suffered heavy damage from the second week of October to December. In January transplanted rice crop, heavy incidence of leaffolder was recorded from the middle of February to April.

Evidences showed that leaffolder attack in paddy was less in early transplanted crop than those transplanted late. Late transplanted rice varieties during *kharif* season suffered from heavy loss due to *C. medinalis* attack in Madhya Pradesh (Gargav *et al.*, 1971) whereas infestation in the *Rabi* crop was at a low level when transplanted in October (Chandramohan *et al.*, 1976).

Chhabra *et al.* (1976) reported that the rice leaffolder was mere abundant during September and October in the *Kharif* crop at Kapurthala, the Punjab.

The CRRI, Cuttack Annual Report (1978) also reported similar time of occurrence of rice leaffolders under Orissa conditions.

In the warm humid tropics the leaffolder moths are prevalent throughout the year, but they are more abundant in rainy season. The insect was more active from May to October in the places with cold winter during which it completes 4-5 generations. The later generations are usually overlapping (Pathak, 1977).

According to Singh *et al.* (1978) *C. medinalis* occurred in serious form in Kapurthala, India in 1976 and the infestation ranged between 17.6 and 37.2 attacked leaves per 5 hills.

Chatterjee (1979) reported the outbreak of rice leaffolder in upland Autumn rice in North Bengal in the foot hills of Himalaya. In that area the crop was sown in the month of March-April and harvested in July-August, and the peak infestation was recorded in the second week of May, although activity of the pest commenced from late April.

Light trap collections of leaffolder moths at different rice research centres like Aduthurai, Cuttack, Mandya, Rajendranagar and Pattambi revealed that the maximum leaffolder collection was obtained from the last week of September to first week of November with peak in the mid-October (AICRIP, 1978, 1979 and 1980).

In Japan, Hirao (1981) observed leaffolder outbreak during July to mid-September whereas in Sri Lanka outbreak of *C. medinalis* was recorded from April to July (Rohan *et al.*, 1982). On the contrary, the above species remained active from May to November in Nepal (Pradhan and Sahi, 1983).

According to CRRI Annual Report, (1980) *C. medinalis* and *M. exigua* occurred in equal numbers in the beginning of January but in the first week of February the population of *Marasmia* started to increase and in the third week of February it represented 98.6 per cent of total leaffolder population. There after it's population declined to 5.8 per cent in April, whereas *Cnaphalocrocis* population increased.

Miyahara *et al.* (1981) observed that the leaffolder moths appeared in the fields in the later part of June every year under Japan conditions. The female population was more and around 1000 moths were recorded from one hectare of crop field.

Studies during *Rabi* season 1982 at CRRI, Cuttack showed that only *C. medinalis* was present throughout the season and peak activity was during August, while *B. arotraea* during first week of November (CRRI, 1982).

Crops planted between 5th August and 5th September in Tamil Nadu were heavily damaged (2.54 to 15.46%) by leaffolders. Leaf damage was significantly lower (0.30 to 3.69%) for crops planted between 20th September and 5th November. (Saroja and Raju, 1983).

In Tamil Nadu conditions irrespective of planting date the population of leaffolder was highest in September (Karuppuchamy and Gopalan. 1986).

Barrion *et al.* (1991) noticed distinct periods for both dry and wet seasons in IRRI farm in 1986. Peak leaffolder catches from light-traps indicated extremely low population at the time of harvest in both dry and wet season crops.

Salim *et al.* (1991) reported that *C. medinalis* which was considered a minor pest in Pakistan, has attained the status of a major pest in last few years and caused considerable loss to rice crop.

In the valleys of Almora district of UP, India rice leaffolders appeared in July and remained until October. Infestation reached peak from early August to late September (Sachan, 1992).

The pink stemborer and leaffolder occurred from late August through October, with peak period of infestation at panicle initiation stage, i.e., the last week of September under Sikkim conditions (Ray *et al.*, 1993).

Harinkhere *et al.* (1998) carried out investigation on seasonal abundance of rice leaffolder (*C. medinalis*) during wet season for 8 years at Waraseoni, MP and reported that the moth catches and field incidence begun in the first week of August and showed significant increasing trend in the month of September. The peak period of moth abundance and field incidence was in the month of September followed by October. The significant positive association between light trap catches and field incidence reflected the severity pattern of leaffolders in the field. Pest incidence during 8 years period revealed regular occurrence of leaffolder with considerable damage in the eastern part of M.P.

2.3 Population ecology :

Pathak (1977) reported that high humidity and optimum temperature of 30°C were the important abiotic factors that influenced the rapid multiplication of *C. medinalis*.

Humidity of 90 per cent in the morning hours and 75 per cent in the afternoon hours favoured the multiplication of leaffolders (CRRI, 1980). Patel

et al. (1987) presumed that the long dry spell interrupted by cloudy weather might have alternatively affected the number of natural enemies promoting leaffolders build up.

According to Wada and Kabayashi (1980) the threshold temperature for development of eggs, larvae and pupal stages of *C. medinalis* were 12.5, 12.2 and 14.2°C respectively. The cumulative effective temperature above the threshold for completion of each stage were 57.1, 203.7 and 82.2°C respectively.

Chatterjee (1987) reported that the unusual dry spell in August, followed by super abundant rainfall (508 mm) between 22nd September and 8th October around Chinsurah, West Bengal favoured outbreak of leaffolders.

According to Barrion *et al.* (1991) *C. medinalis* was the dominant species comprising 46.6 per cent of total population followed by *M. patnalis* 34.9 per cent and *M. exigua* 20.0 per cent in the Phillipines condition. They concluded that the population is regulated by the stage of the crop. The preference of early stage crop by *C. medinalis* was responsible for more population as compared to *M. patnalis* and *M. exigua*.

Salim *et al.* (1991) reported that infestation of rice leaffolders in shady areas was much higher than non shady areas.

According to Barrion *et al.* (1991), sub-habitat can also be important in terms of surveillance of leaffolder population, as greater damage occurs in shady patches. The shady portion of the fields should be monitored first separately from open areas.

2.4 Nature and extent of damage :

A single larva could damage 354.5 to 446.5 mm² and as high as 784.4 mm² leaf areas in case of moderately susceptible and susceptible rice varieties respectively in 48 hours (Das and Nair, 1974).

Fraenkel *et al.* (1981) reported that the greenish white first instar larvae seen after hatching moves towards the leaf tips in search for a suitable site to be folded. Young larvae preferred younger leaves of a tiller. At late second instar stage it may become solitary and roll up leaves regularly.

The leaf tips and margins were folded and fastened with a few silk threads or the leaves were folded over themselves to form a roll. In severe infestation leaf margins and tips were entirely dried up (Kulshreshtha *et al.*, 1976).

Murugesan and Chelliah (1983) artificially infested the flag leaves of potted IR 20 plants with one 4th instar larva/tiller. Larva was confined to the flagleaf only. They observed that the flag leaf damage ranged from 5 to 85 per cent in different tillers and categorised as 25, 26-50, 51-75 and 75 per cent leaf area damage upto 50 per cent reduced mean yield per tiller by 47 per cent. When the damage exceed 75 per cent, yield was reduced by 70 per cent. A 10 per cent increase in flag leaf damage increased unfilled grains by 4.5 per cent per tiller.

Murugesan and Chelliah (1983) further conducted an experiment on leaf folder damage and its impact on yield and reported that the leaf damage was significantly lower when only one larva fed on one tiller and the yield did not differ significantly. The yield was reduced by 49.0 to 57.0 per cent

for all treatments and 26.0 to 29.0 per cent grains were unfilled. A 10.0 per cent increase in damaged leaves reduced yield by 0.15g/tiller and increased the unfilled grains by 2.0 per cent.

Nair (1986) observed that all stages of rice plants were attacked by *C. medinalis*. When young seedlings and plants were attacked, 3-4 adjacent plants were webbed together forming longitudinal composite folds. In grown up plants a single leaf was folded longitudinally or transversely. Scraping of the green matter of the leaves by the caterpillar gave a whitish appearance to the infected plants. A single caterpillar damaged several leaves. The infected leaves dried up, weakened and the yield was reduced upto 50.0 per cent.

Salim *et al.* (1991) reported an outbreak of leaffolders in the Punjab province of Pakistan and observed that the crop damage reached to an extent of 51.0 per cent. The damage to the varieties Basmati 385, Basmati 370, Kashmira and Palman were 16.6, 12.7, 5.7 and 57.3 per cent respectively.

Studies by Subramanian and Gopalan (1992) showed that with 1.0 per cent increase in leaf damage a loss of 41.3, 41.3 and 25.7 kg/ha of grains and 28.7, 30.3 and 52.1 kg/ha of straw in IR 64, IR36 and IR50 respectively were incurred. Upto 80.0 per cent of the leaves in IR50 were damaged by the leaffolder during 1989-90 at Coimbatore, India.

According to Sachan (1992) the rice growing areas of Almora district of UP, India, suffered from leaffolder damage to the tune of 85, 72, 85, 78, 72 and 72 per cent in the popular varieties of Govinda, Pant Dhan, VL 16, VLK 39, VL 8 and IR 24 respectively.

Subramanian and Gopalan (1992) observed that the larvae prior to feeding folded the leaves longitudinally and stitched the leaf margin with silken threads. Then it fed by scrapping the green mesophyll tissue from within the folded leaves, causing pale white stripes. Consequently the vigour and photosynthetic ability of the rice plant reduced.

Panda (1992) reported that during 1991 the leaffolder incidence was quite mild in Bhubaneswar. The extent of infestation in summer rice varied from 0.0 to 2.41 per cent with peak infestation at 48 DAT, while in the wet season it ranged between 0.0 to 8.17 per cent with maximum at 46 DAT. Every unit per cent increase in the leaf infestation in wet season Jaya crop caused an yield reduction of 36.7 kg/ha.

Patel (1993) reported that the extent of leaffolder damage to wet season crop at Bhubaneswar was found to be 7.5, 18.2 and 14.2 per cent at 30, 50 and 75 DAT respectively.

2.5 Economic Threshold Level (ETL) :

The economic threshold (ET) level of the leaffolders is important for deciding chemical control measures. The economic threshold value for leaffolder as reported by different authors is presented in the following paragraphs.

According to Stern *et al.* (1973) the economic threshold means "the density at which the control measure should be determined to prevent an increasing pest population from reaching the economic injury level." The economic threshold always represent pest density lower than that of economic injury level (EIL) to allow the initiation of control measures so that pest density cannot exceed this critical level.

Kalode (1976) and Chatterjee *et al.* (1977) developed economic threshold values for leaffolder for timely application of insecticides. They stated that 5.0 per cent damaged leaves is considered to be economic threshold level for leaffolders. But subsequently AICRIP (1979), suggested three damaged leaves/hill as economic threshold for rice leaffolders.

Bautista *et al.* (1984) have established the ETL to be 4.2 per cent damage at flagleaf stage. Action thresholds were developed based on the larval stage, with values ranging from 0.5 to 2.0 larvae/hill. Lower values were set during the flag leaf stage and in location where less ability of the crop to compensate from leaffolder damage was observed.

Shen and Liu (1984) estimated the ETL as 0.75 to 1.4 number of third instar larvae/hill at tillering stage of rice and 0.5 to 0.75 larvae/hill at early earing stage.

Reissig *et al.* (1986) reported that a damage of 15.0 per cent damaged leaves can be tolerated at vegetative stage and 5.0 per cent damaged leaves at reproductive and ripening stages.

Saroja (1989) estimated that ETL as 10.0 per cent damaged leaves at vegetative stage and 5.0 per cent at earing stage for leaffolders under Tamil Nadu conditions.

2.6 Host-plant resistance :

Efforts for leaffolder resistance in rice varieties were initiated by Heinrichs *et al.* (1985) who identified 115 rice accessions as potential donors from ten countries, viz., Bangladesh, India, Indonesia, Italy, Malayasia, Phillipines, Main Land China, Sri Lanka, Taiwan-China and Thailand. Of these, 35 cultivars

mostly from Bangladesh and India were reported to have high resistance reactions. Based on the recommendation of the researchers, the plant breeders selected Co 1263, Tkm 6, Muthumanikan, Ptb. 33 and GEB 24 as donors in leaf folder resistance breeding lines.

Rajendran (1985) screened some rice accessions for LF resistance and scored them in 0-9 point scale. He found out IET 8100 and IET 8105 as resistant entries with a score of one (1-10% leaf damage).

Joshi *et al.* (1986) screened 26 IR varieties against *M. patnalis* and recorded IR 40 as least susceptible. According to Rajendran and Velusamy (1987), of the 37 accessions, six (BKNBR 1088-83, RP 1579-43, RP 2199-41-25-30-55, RP 2199-249-209, TNAULFR 832042 and TNAULFR 831324) were resistant to the LF.

At IRRI, Philippines there are several improved lines identified for possessing moderate levels of resistance to *C. medinalis* and some other rice pests. These lines could further be used as a tool to magnify the level of resistance against *C. medinalis* (Khan *et al.*, 1988).

Of a good number of rice varieties tested under green house condition by releasing one 5th instar *C. medinalis* larva on 45-day old caged plants. The cultivars Choorapundy, Gorasa, Ptb 33 and Ptb 19 showed high level of resistance with 71 mm², 94.6 mm², 113.8 mm² and 118.3 mm² leaf damage as against 325 mm² and 161.3 mm² in the susceptible and resistance checks, TN I and Tkm 6 respectively (Bentur and Kalode, 1989).

Srivastava (1989) evaluated eight varieties for their resistance to rice LF and arrived at the conclusion that in respect of susceptibility Kranti,

Mashari, Madhuri, Asha, Guramatia, Safari 17, Makdo and CR 1014 ranked in that order. Kranti was most susceptible with 24.63 per cent leaf damage whereas CR 1014 had the minimum leaf damage of 12.21 per cent.

Tomar *et al.* (1990) screened 81 rice cultivars during 1986 and 1987 for leaffolder resistance. The damaged and healthy leaves of each test entry were counted in 1 m² area in each replication and the average was converted to 0-9 scale. Cultivars having 0-3 score were taken as resistant and these cultivars were as given below.

- RP 1714-111-7-3-2, CR 811-2
- RP 2217-71-13-14, RP 2522-16-14-80
NDR 119, UPR 83-28, UPR 83-20, NDR 224,
NDR 22, BG 367-4, CN 747-1-4.
- RP 2515-203-5-1-2, RP 2535-35-40-50,
TNAU 301790, Akashi, TNAU 81804, NRL 502,
NR 571-I, MAUSEL 10, RAU 151-56, JR 35;
MRL 502, RTN 500.

Barrion *et al.* (1991) screened 16,972 accessions including 264 rices for *C. medinalis* resistance in green house during 1985-86 and selected nine entries such as original century patna (From Korea); Honduras, B 57541-8-3-I and B 58146-545 (From USA) Uzbelskiy 2 (from USSR), HR 19 (From India) Trang Nho (From Vietnam) and Suwon 152 (From South Korea) as resistant to leaffolder.

Thamrin and Rosmini (1993) carried out a field trial by taking 22 rice cultivars against leaffolder under wet land ecosystem in the wet season of 1991-92. The damage was evaluated at 45 DAT. The only line IR 24637-38-2-2 was found resistant while other were moderately resistant.

Ray *et al.*, (1993) from Sikkim reported high degree of infestation by *C. medinalis* and *Sesamia inferens*. Among the 24 cultivars tested Sikre, Khororullo, Kusaro, RCPL-3-5 and Dhasa were found resistant to rice leaffolder.

2.7 Time of sowing/planting :

Gargav and Katiyar (1971) reported that late planted rice crops were heavily infested by rice leaffolder in MP while Khuswaha and Sharma (1983) observed more LF incidence in crops transplanted in third week of July than in the first week.

Saroja *et al.* (1983) reported that the crop planted between 5th August and 5th September though coincided with the peak pest population, sustained the heavy damage due to maximum tillering.

Leaffolder damage increase significantly with the delay in planting dates. There was corresponding gradual increase in leaf damage of 37.3, 47.8 57.3 and 64.8 per cent with planting dates of 15th, 30th August, 15th and 30th September at RRU, Bapatala, Andhra Pradesh, India (Chiranjeevi and Rao, 1991).

2.8 Effect of spacing and Fertilizers :

Balasubramanian and Michael (1976) reported that there was reduced level of leaffolder infestation when potassium applied at increased levels. The maximum reaction was observed at both 200 and 250 Kg K₂O/ha.

Chantaraprapha *et al.* (1980) applied increasing levels of Nitrogen starting from 0 to 195 kg/ha with 15 kg differences. The result showed that the percentage of damaged leaves rose proportionally with increasing nitrogen levels. At 0 Kg/ha the damaged leaves were only 5.34 per cent while at 195

kg/ha the damage was as high as 64.2 per cent. The percentage of damaged leaves sharply increased at 75 kg N/ha level and was significantly different from that in the untreated control treatment.

Saroja *et al.* (1981) conducted an experiment at paddy experiment station, Tirur in 1979-80 wet season showed that a significant increase in percentage of leaffolder damage to leaves was achieved only by a very high level of nitrogen (200 kg N/ha). The N was applied basally half of the amount and the rest top dressed in two splits at 25 and 45 DAT. When 75 and 150 kg N were applied basally the leaf damage was observed to be 11.07 and 30.4 per cent respectively.

Thangamuthu *et al.* (1982) studied the effect of spacing and fertilizer on leaffolder damage at Coimbatore, India by applying NPK dose of 75-40-40 kg/ha. The total number of leaves and the infested leaves were counted at 55 DAT. At a spacing of 10cm x 15cm, 36.0 per cent leaves were infested and it was 26.0 per cent at 15cm x 25cm, 7.0 per cent at 22.5cm x 20cm and 12.0 per cent at 30 cm x 20cm.

Urea super granules recorded higher percentage of infested leaves (17.7%) than prilled urea applied in three split (14.8%) or urea super granules placed by trampling (10.4%) (CRRI, 1982).

Nitrogenous fertilizer which generally contribute a greater part on yield in modern rice cultivars encouraged insect survival, reproduction and feeding rates, leading to greater damage (Chantarprapha *et al.* 1980; Upadhyay *et al.*, 1981 and Subramanian and Gopalan, 1992).

2.9 Chemical Control :

Literature on the management of leaffolders of rice indicated that so far insecticides remained as the most reliable tool for the control of this pest. A large number of insecticides have been field and laboratory evaluated against the rice LFs from time to time and some of them have proved their worth. Amongst the test toxicants monocrotophos has been reported to be most effective and thus, has enjoyed wide acceptance by the rice farming community during 1980s and even in the current decade. (Heinrichs and Valencia, 1980; Hirao, 1982; Endo *et al.*, 1987; Macatula and Mochioa, 1987; Sain *et al.*, 1987; Saroja, 1989; CRRI, 1989 and Jena *et al.*, 1992).

Endo and Masuda (1981) after testing the relative toxicity of chlorpyrifos, methyl dimethylvinphos, tetrachlorvinphos and cartap against larvae of leaffolder by leaf dip method, recommended cartap application at six days after observing peak population of adult and other insecticides at 9-12 days after adult peak.

Chlorpyrifos has been found effective by many rice Entomologists (Kareem and Viswanath, 1981; Hirao, 1982; Endo and Masuda, 1981; Sain *et al.*, 1987; Raju *et al.*, 1988 and Jena *et al.*, 1992).

Saroja and Raju (1982) studied the efficacy of six foliar insecticides on rice stem borers and leaffolders during 1980-81 samba season. They took Carbosulfan, Bendiocarb, BPMC, Acephate, Vamidotion and Ethion and found that Bendiocarb, Acephate and Carbosulfan were more effective against both the pests. The leaffolder damage was least (2.5%) in Bendiocarb and highest (48.2%) in Ethion treated plots at 75 DAT.

Amongst the granular insecticides, carbofuran at 1.0 kg a.i/ha afforded effective control of this pest (Pillai and Nair, 1984 and Murthy *et al.*, 1990).

Fenitrothion @0.05 per cent and Quinalphos @ 0.02 per cent were most effective causing 76.54 and 74.48 per cent larval mortality at 48 hours after application (Godase and Dumbre, 1985).

At CRRI (1989) quinalphos, methyl parathion and oxydemeton methyl have been found to control the leaffolder effectively.

Saroja (1989) reported that spraying of monocrotophos (Nuvacron) @500 ml/ha on need basis was found most effective against rice leaffolders. Quinalphos and phosalone ranked second in order of efficacy. Action of chlorpyrifos and phosphamidon were moderate while fenitrothion, diachlorvos and carbaryl were less effective.

Of the recently synthesized insecticides ethofenprox at 0.04 per cent concentration (Anon, 1989 and Jena *et al.* 1992), cartap granules at 1.5 kg a.i/ha (Mo *et al.*, 1983, Endo *et al.*, 1987 and Panda and Shi, 1989) and triazophos at 0.75 kg a.i/ha (Rao *et al.*, 1984) proved excellent in controlling the rice leaffolders.

Amongst the other insecticides which have been reported effective against the rice leaffolders were phosphamidon at 0.04 per cent (Raju *et al.*, 1988 and Jena *et al.*, 1992) and BPMC at 0.04 per cent (Jena *et al.*, 1992).

Work done at the All India Co-ordinated Rice Improvement Project (AICRIP) Directorate of Rice Research, Hyderabad from 1990 to 1994 indicated that cartap 3 G at 0.75 to 1.0 kg a.i/ha, cartap 50 wp at 0.3 kg a.i/ha, ethofenprox at 0.05 kg a.i/ha, triazophos at 0.35 kg a.i/ha., quinalphos at 0.5

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kg a.i/ha, chlorpyriphos at 0.5 kg a.i/ha and BPMC at 0.5 kg a.i/ha afforded appreciable control of the rice leaffolders (Annon, 1990-1994).

Biswas and Mandal (1992) recommended the use of carbofuran and phorate granules @ 1kg a.i/ha or spray with methyl parathion or quinalphos (0.05%) and fenvalerate (0.01% a.i) or phosphamidon (0.05% a.i) against rice leaffolders.

CHAPTER III

MATERIALS AND METHODS

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3.1 Experimental site and season :

During the wet season of 1997 and summer, 1998 two separate field experiments were conducted at the Central Rice Research Station of Orissa University of Agriculture and Technology (O.U.A.T) Bhubaneswar. The main objectives of the experiments were (i) to study the seasonal activity of rice leaffolders under natural infestation condition. (ii) To study the reaction of some rice varieties against leaffolder and (iii) Management of rice leaffolders through application of selective insecticides.

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 mean sea level (MSL). The soil type of the experimental fields were sandy loam having irrigation and drainage facilities. The pH of the soil was slightly acidic.

3.2. Experimental design :

Both season experiments were laid out in Randomized Block Design (RBD) with three replications each. In both the seasons the sub-plot size was maintained at 3.5m x 4.0 m. The rice variety Jaya (TN 1 x T 141) susceptible to rice leaffolder was taken for the study. The inter-and intra-row spacings of plants were maintained at 20 cm and 15 cm respectively in both the seasons. To avoid mixing up of the insecticidal solutions and fertilizers by surface runoff and seepage of water, each sub-plot was separated from the other by field bunds and channels.

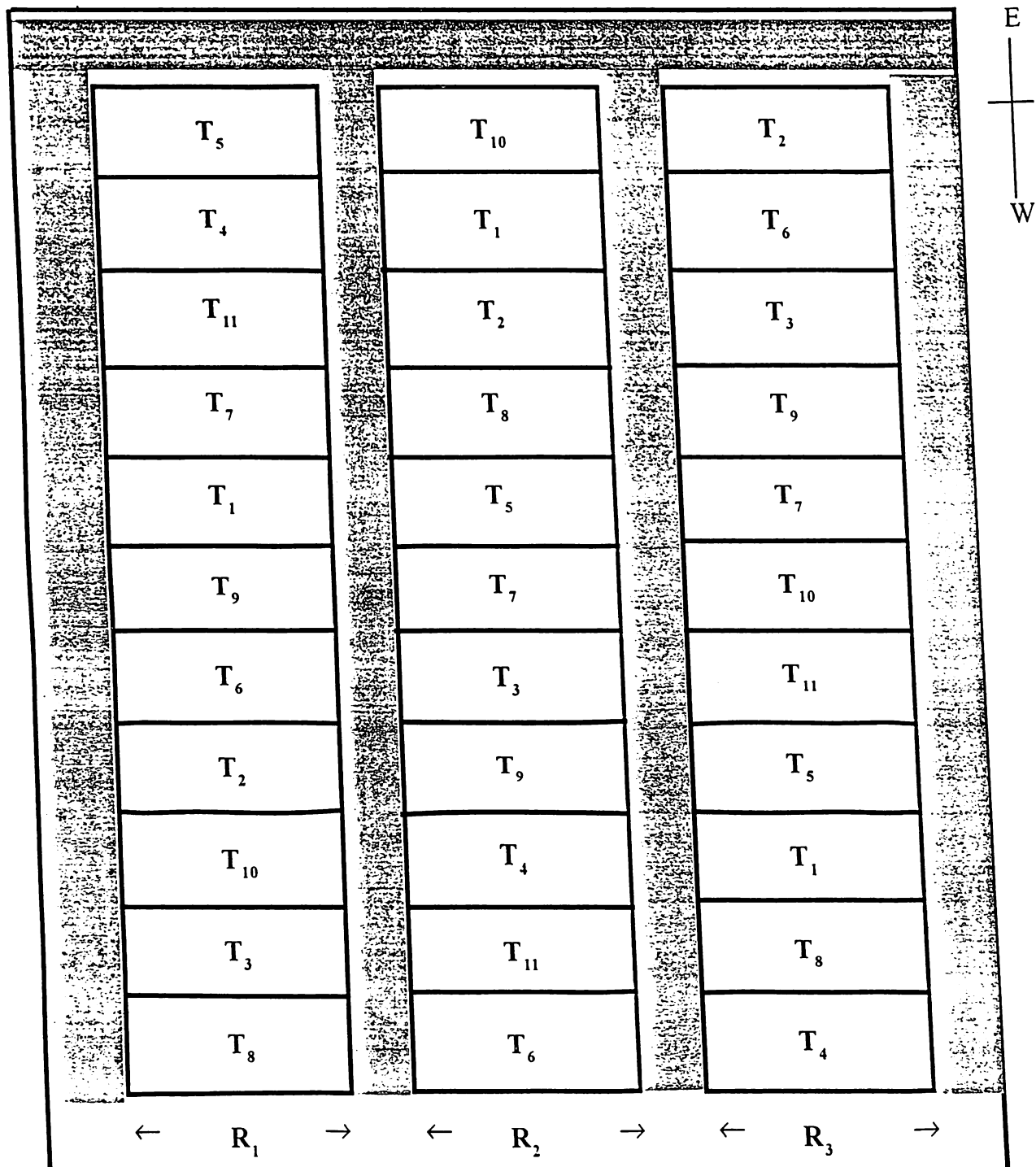


Fig 1. LAYOUT PLAN FOR LEAFFOLDER TRIAL WET SEASON, 1997

INDEX - BUND

DRAINAGE CHANNEL

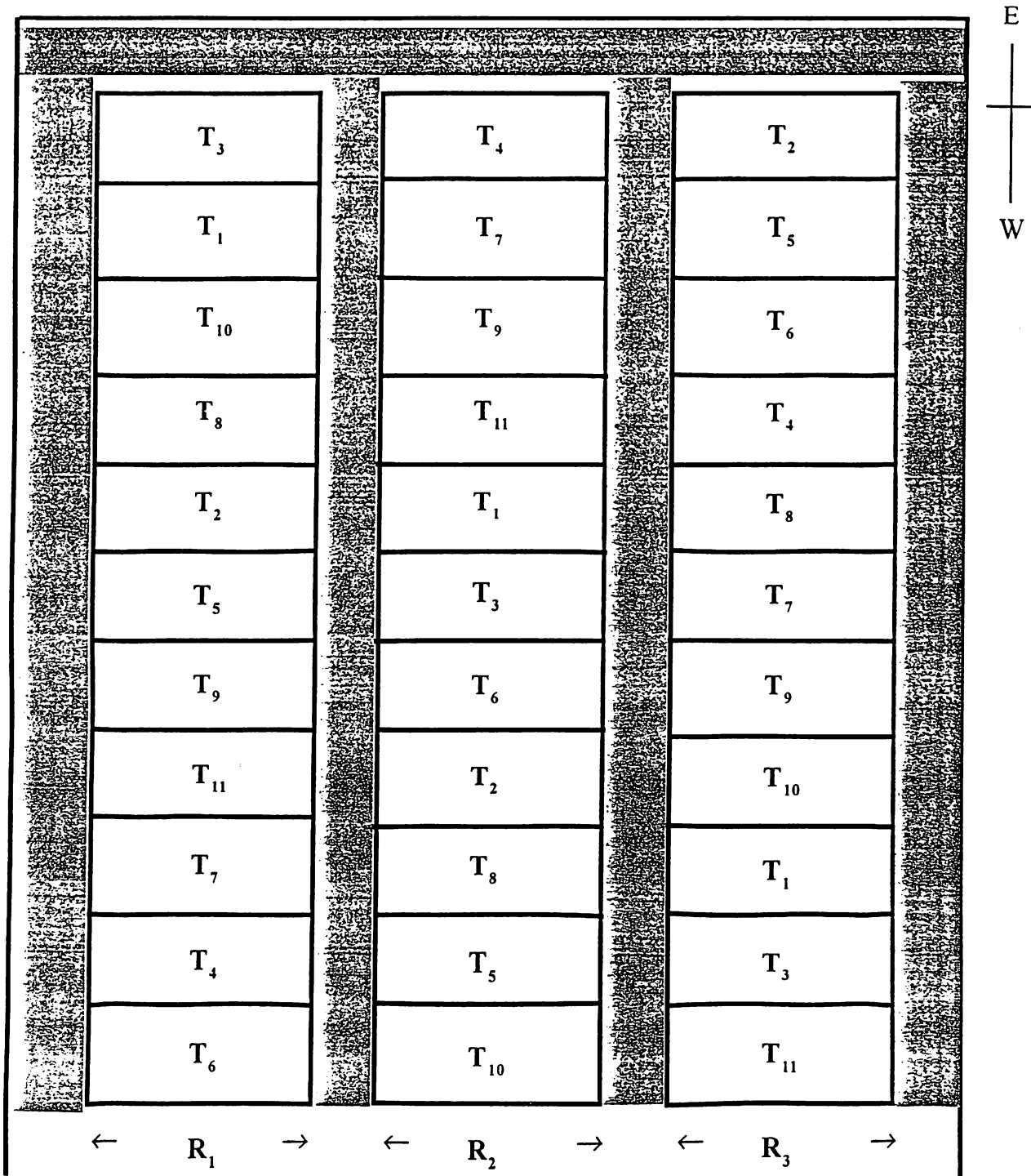


Fig 2. LAYOUT PLAN FOR LEAFFOLDER TRIAL SUMMER SEASON, 1998

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DRAINAGE CHANNEL

3.3 Cultural operations :

The experimental plots were well ploughed and levelled before laying out the trials. In all the sub-plots well decomposed farm yard manure was uniformly spread @ 2.5 t/ha.

Nursery beds were prepared by making raised seed beds of a metre wide and seven metres long. These beds were manured with a basal dose of Farm yard manure and kept weed free. Foundation seeds of Jaya were sown on these bed on 28.6.97 for the wet season trial and on 15.01.98 for the summer trial.

The experimental sub-plots were thoroughly puddled and basal dose of N.P.K., was applied @ 40:40:40 kg/ha. The rest 50 per cent nitrogen was top dressed in two equal splits at 25 and 60 days after transplanting (DAT). Healthy Jaya seedlings were transplanted @ 2 seedlings/hill on 30.7.97 for the wet season experiment and on 15.02.98 for the summer experiment. In all the sub-plots water level was maintained properly and excess water was drained out wherever necessary. The weeding operation was completed before each top dressing of nitrogen in the form of urea. The calendar of operation for both season trials has been presented in Table 1.

3.4 Natural infestation of rice leaffolders :

In order to know the occurrence and extent of leaffolder infestation under natural conditions, observations on incidence of rice leaffolders were recorded from transplanted Jaya crop grown without insecticidal protection in both the seasons. Observations on the percentage damaged leaves were recorded at 10-day-intervals starting from 30 DAT in both the crop seasons. During

Tabel 1. Leaffolder trial plots calendar of operation

Season and date of operation		Types of operations
Wet season, 1997	Summer, 1998	
27.06.97	14.01.98	Preparation of raised nursery beds and application of manures.
28.06.97	15.01.98	Sowing of Jaya paddy seeds in the nursery beds.
26.07.97 to 28.07.97	12.02.98 to 14.02.98	Land preparation (puddling, levelling) bunds trimming and application of FYM.
30.07.97	15.02.98	Basal application of fertilisers and transplanting.
22.08.97	05.03.98	First weeding.
25.08.97	10.03.98	First top dressing of N 25% in shape of Urea.
	16.04.98	Spraying of Insecticides
26.09.97	23.04.98	Weeding second round.
27.09.97	24.04.98	Top dressing Urea 25% N
	20.05.98	Harvesting of sample clumps having flag leave area cuttings.
10.11.97	30.05.98	Harvesting of crops from the trial plots and leaving them for drying on the field.
12.11.97 to 16.11.97	01.06.98 to 04.06.98	Transportation of the harvested crop to the threshing floor, threshing, drying and recording the yield.

each observation 10 clumps selected randomly were thoroughly examined and the total and damaged leaves were counted. The observations were continued upto 90 DAT in both the seasons. (Tables 5 and 6). The percentage leaf infestation was calculated as per the formula given below.

$$\begin{aligned} & \text{Rice leaffolder damaged leaves (\%)} \\ & = \frac{\text{Damaged leaves in 10 clumps}}{\text{Total leaves in 10 clumps}} \times 100 \end{aligned}$$

3.5 Host plant resistance against rice leaffolders :

Observations on the incidence of rice leaffolder were recorded from four rice varieties treated with six different insecticides during the summer, 1998 at 60 DAT. The trial was laid out in strip plot design. The leaffolder damage was assessed as percentage infested leaves by counting total leaves and number of infested leaves from 10 randomly selected hills from each plot. The degree of leaffolder infestation on top 3 leaves were recorded on 10 randomly selected clumps of each treatment.

3.6 Management of rice leaffolders by selective insecticides.

For management of rice leaffolders by selective insecticides, a replicated field experiment was conducted. The treatment details with different doses are given below (Table 2). All the insecticides were sprayed once at 60 DAT.

T₁ = Quinalphos (Growlux) @ 0.5 kg a.i/ha

T₂ = Quinalphos (Growlux) @0.25 kg a.i/ha

T₃ = Chlorpyriphos (Durmet) @ 0.5 kg a.i./ha

T₄ = Chlorpyriphos (Durmet) @ 0.25 kg a.i./ha.

T₅ = Fortune Aza @ 1500 ppm/ha

Table 2. List of insecticidal treatments

Treatment number	Insecticide used		Manufacturing Firm	Dose
	Common name	Trade formulation		
T ₁	Quinalphos	Growlux 25 EC	Growell Agri products (Pvt.) Ltd. Bahadurgarh	0.5 kg a.i./ha
T ₂	Quinalphos	Growlux 25 EC	Growell Agri products (Pvt.) Ltd. Bahadurgarh	0.25 kg a.i./ha
T ₃	Chlorpyrifos	Durmet 20 EC	Cyanamid India Ltd.	0.5 kg a.i./ha
T ₄	Chlorpyrifos	Durmet 20 EC	Cyanamid India Ltd.	0.25 kg a.i./ha
T ₅	Azadirachtin	Fortune Aza 0.15 w/w	Fortune Biotech. Ltd. Secunderabad	1500 ppm
T ₆	Azadirachtin	Fortune Aza 0.15w/w	Fortune Biotech. Ltd. Secunderabad	750 ppm
T ₇	Azadirachtin	Nivaar 0.15 w/w	Shri Disha Biotech. Pvt. Ltd. Hyderabad	1500 ppm
T ₈	Azadirachtin	Nivaar 0.15 w/w	Shri Disha Biotech Pvt. Ltd. Hyderabad	750 ppm.
T ₉	Ethofenprox	Trebon 10 EC	Dhanuka Pesticide Limited, Gurgaon, Haryana	0.1 kg a.i./ha
T ₁₀	Monocrotophos	Nuvacron 36 EC	Hindustan Ciba-Geigy Ltd. Mumbai.	0.5 kg a.i./ha

- T₆ = Fortune Aza @ 750 ppm/ha.
T₇ = Nivaar @ 1500 ppm/ha
T₈ = Nivaar @ 750 ppm/ha
T₉ = Ethofenprox (Trebon) @ 0.1 kg a.i./ha
T₁₀ = Monocrotophos @ 0.5 kg a.i./ha
T₁₁ = Untreated check.

Observations on the extent of leaf damage by rice leaffolder was recorded at one day before spraying of the above insecticides. Besides, larval population of rice leaffolders was also recorded one day before and two and eight days after spraying of insecticides. The larval population was worked out by counting the total number of larvae present on 10 infested clumps from each treatment.

3.7 Estimation of yield loss due to leaffolder infestation :

In order to estimate the yield loss due to leaffolder infestation, observations on the extent of flag leaf area damage and associated yield loss was worked out by tagging individual infested primary tillers. The extent of leaf area damage was also categorised into ten groups i.e. 1-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80, 81-90, and 91-100 separately.

The panicle of the tagged plants were carefully cut at harvest and kept in separate labelled paper envelopes for counting the number of filled and unfilled grains/panicle. The infested plants identified in each category were replicated thrice with a minimum of five panicles per replication. Individual panicle was carefully examined and the number of filled and unfilled grains were recorded.

Table 3. Meteorological data during the period of study (June to Nov.,1997) at Central Research Station, O.U.A.T. ,Bhubaneswar

Months	Date	Standar d Week	Temperature (⁰ C)		R.H. (%)		Rainfall in m.m.
			Max.	Min.	Morn.	Aftn.	
May/June	28-03	22	39.7	26.7	85	46	2.8 (1)
	04-10	23	39.1	26.8	89	51	31.7 (3)
	11-17	24	37.0	26.6	87	51	9.4 (1)
	18-24	25	34.5	24.7	89	72	61.2 (3)
June/July	25-01	26	31.7	24.9	91	74	78.9 (5)
	02.08	27	32.6	25.0	94	77	28.9 (5)
	09-15	28	34.2	26.2	89	63	2.8 (2)
	16.22	29	32.7	25.4	93	77	3.9 (5)
	23.29	30	34.0	25.9	92	73	16.5 (3)
July/August	30-05	31	31.4	24.7	95	83	211.9(5)
	06-12	32	32.6	25.0	94	78	69.8 (6)
	13-19	33	32.1	25.6	94	77	31.0 (6)
	20-26	34	31.6	24.8	94	80	218.2(3)
August/ September	27-02	35	32.8	25.4	95	78	133.5(3)
September	03.09	36	32.0	24.1	95	80	97.3 (4)
	10-16	37	31.0	23.8	95	79	33.0 (5)
	17-23	38	33.9	25.5	94	81	45.6 (4)
	24-30	39	31.8	24.5	96	79	172.7(4)
October	01-07	40	33.9	22.9	94	60	69.0(1)
	08-14	41	33.6	23.2	95	60	0
	15-21	42	33.1	22.4	96	56	8.40(1)
	22-28	43	33.2	21.2	93	61	9.40(1)
October/ November	29-04	44	30.9	21.6	93	64	7.60 (1)
November	05-11	45	32.4	20.4	92	53	0
	12-18	46	32.7	21.6	96	59	9.40 (1)
	19-25	47	31.9	19.9	93	52	0

* Figures in parentheses are number of rainy days.

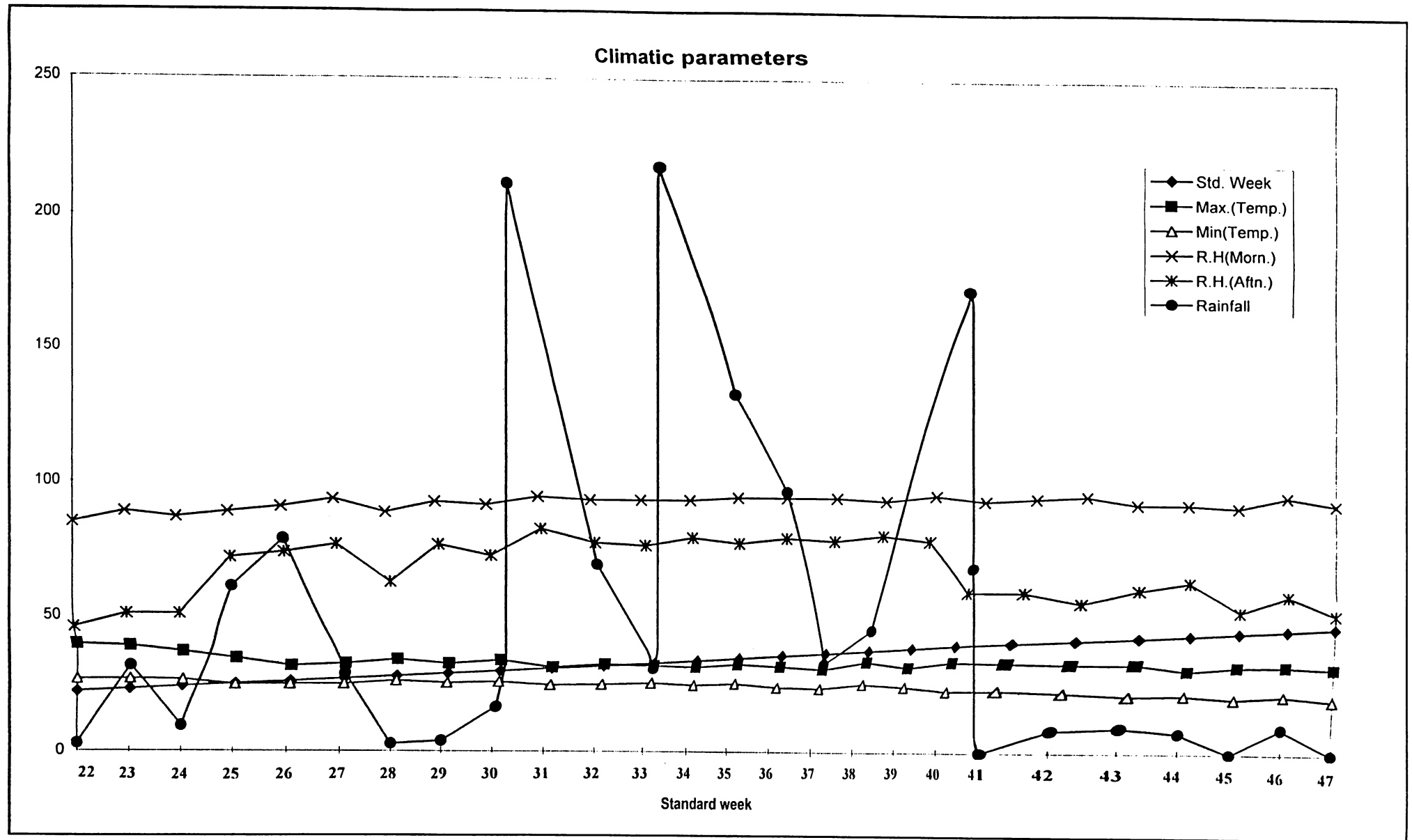


Fig 3. Meteorological data during wet season, 1997

Table 4. Meteorological data during the period of study (Jan. to May, 1998) at Central Research Station, O.U.A.T., Bhubaneswar.

Month	Date	Standard Week	Temperature ($^{\circ}$ C)		R.H. (%)		Rainfall in mm
			Max.	Min	Morn.	Aftn.	
January	01-07	01	27.9	14.1	87	24	0
	08-14	02	29.4	16.2	94	47	0
	15-21	03	30.3	17.9	91	61	25.4 (1)
	22-28	04	26.9	16.3	89	56	1.0 (1)
January/ Febreary	29-04	05	30.9	19.4	94	56	0
Febreary	05-11	06	27.7	16.1	91	53	7.0 (2)
	12-18	07	32.8	16.2	91	34	0
	19-25	08	31.7	22.0	95	64	9.6 (2)
February/ March	26-04	09	32.4	22.2	95	58	35.8 (2)
March	05-11	10	33.2	21.8	94	54	0.8 (1)
	12-18	11	33.3	21.5	94	60	23.4 (3)
	19-25	12	35.1	23.3	92	51	7.4 (1)
March/ April	26.01	13	33.8	22.3	95	55	23.0 (3)
April	02-08	14	34.2	22.8	95	59	45.3 (2)
	09-15	15	36.0	25.2	94	50	0
	16-22	16	36.7	25.8	90	54	0
	23-29	17	38.2	24.2	87	50	13.7 (2)
April/May	30-06	18	36.6	26.1	91	59	2.1 (2)
	07.13	19	37.2	25.6	87	51	37.4(2)
	14-20	20	38.4	26.5	87	43	0
	21-27	21	39.5	28.6	85	52	1.0 (1)
May/June	28-03	22	43.3	29.2	83	36	0

* Figures in parentheses are number of rainy days.

Climatic parameters

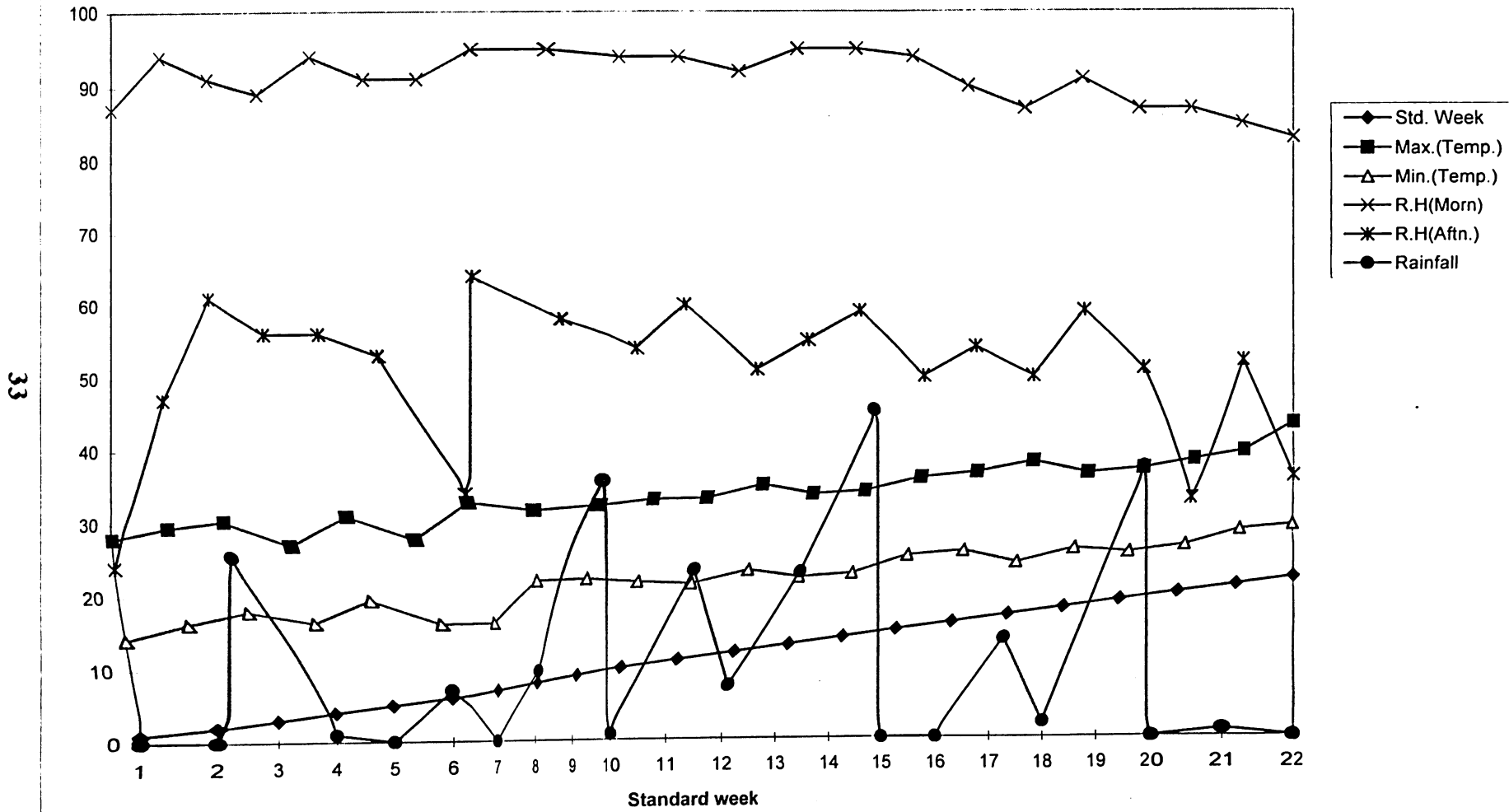


Fig 4. Meteorological data during summer, 1998

3.8 Recording of yield data :

When the rice crop attained more than 90 per cent physiological maturity, the water from the sub-plot was completely drained out and the field was allowed to dry. Harvesting of the crop was done treatment wise.

For the leafhopper management trial the grain yield obtained from each sub-plot was recorded separately after proper drying. The plot yield was converted to tonnes/ha.

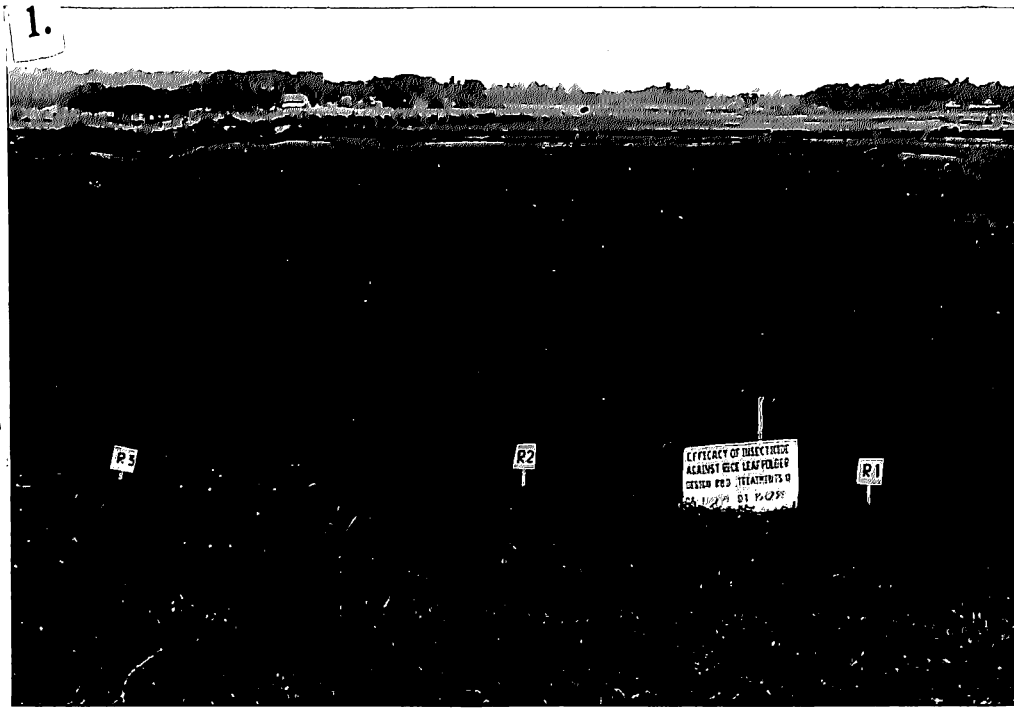
3.9 Meteorological observations :

Meteorological data for the period from June to November, 1997 and January to May, 1998 was obtained from meteorological observatory (located within 1 km radius of the experimental site) of Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar. The data on different weather parameters has been presented in Table 3 & 4, Fig 3 and 4.

3.10 Statistical analysis :

The data obtained from various experiments were subjected to statistical analysis after suitable transformation wherever necessary. (Gomez and Gomez, 1984). The treatment variations were tested for significance by "F" test. The standard error of means $[SE(m)\pm]$ and critical difference (CD) at five per cent level of significance were calculated following the standard procedures and used for comparison of treatment means. Based on these statistically analysed data the results of the investigation are presented and discussed in separate chapter.

PLATES



Leaffolder management Experiment conducted during summer, 1998



Rice Leaffolder infested rice clump (Var,-Jaya)

RESULTS

During the wet season of 1997 and summer, 1998 two field experiments were conducted at the Central Research Station of the Orissa University of Agriculture and Technology, Bhubaneswar in order to study the seasonal incidence in relation to weather factors, host plant resistance and insecticidal management of rice leaffolders. The salient findings of the study are presented in the following paragraphs.

4.1 Rice leaffolder activity under natural infestation condition :

The activity of rice leaffolders was monitored at 10 days interval starting from 30 DAT on an unprotected Jaya crop grown in irrigated medium land in the *kharif* season of 1997 and summer, 1998.

The incidence of rice leaffolders during the *kharif* season was mild. The extent of leaf infestation varied from 0.73 per cent to 3.29 per cent at different dates of transplanting. The pest activity commenced from 30 DAT and continued till 90 DAT. The percentage of leaf infestation rice leaffolders is presented in Table 5 and Fig 5. At 30 DAT the leaffolders damage varies from 0.77 per cent to 1.13 per cent. At 40 DAT it varied from a minimum of 1.06 per cent to maximum of 1.31 per cent. Similarly a slight increase of infestation occurred at 50 DAT i.e., minimum of 1.89 per cent to maximum of 2.53 per cent. At 60 DAT the infestation reached the highest level varying from 2.91 to 3.29 per cent. Thereafter the population declined. The percentage of leaf infestation was at the lower ebb throughout the season.

Table 5. Rice leaffolder activity under natural infestation condition (Var. - Jaya, Wet season, 1997)

Treatment	Leaffolder infested leaves (%) *						
	Days after transplanting (DAT)						
	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT	90 DAT
T ₁	0.91 (1.17)	1.27(1.32)	2.08(1.60)	3.19(1.92)	1.99(1.58)	2.01 (1.58)	0.75(1.11)
T ₂	1.13(1.27)	1.11(1.26)	2.89(1.54)	3.29(1.94)	2.53(1.73)	2.13(1.62)	0.79(1.13)
T ₃	0.77(1.12)	1.31(1.34)	2.16(1.62)	2.91(1.84)	2.48(1.72)	2.11(1.61)	0.81(1.13)
T ₄	0.77(1.12)	1.16(1.28)	2.53(1.73)	3.08(1.88)	2.36(1.68)	2.20(1.64)	0.78(1.12)
T ₅	0.82(1.14)	1.21(1.30)	2.50(1.73)	2.97(1.85)	2.61(1.76)	2.19(1.64)	0.83(1.14)
T ₆	0.85(1.15)	1.06(1.24)	2.52(1.73)	3.29(1.94)	2.39(1.70)	2.15(1.62)	0.73(1.10)
T ₇	0.95(1.19)	1.20(1.30)	2.46(1.71)	3.24(1.93)	2.21(1.63)	2.17(1.63)	0.74(1.10)
T ₈	0.87(1.15)	1.22(1.30)	1.90(1.54)	3.20(1.91)	2.28(1.66)	2.08(1.60)	0.92(1.19)
T ₉	0.80(1.13)	1.20(1.30)	2.33(1.67)	3.26(1.93)	2.09(1.60)	2.18(1.63)	0.98(1.20)
T ₁₀	1.01(1.22)	1.29(1.33)	2.50(1.72)	3.19(1.91)	2.15(1.62)	2.16(1.62)	0.76(1.11)
T ₁₁	1.05(1.23)	1.07(1.24)	2.52(1.73)	3.24(1.93)	2.20(1.63)	2.07(1.60)	0.77(1.12)
Mean	0.90	1.19	2.40	3.17	2.30	2.13	0.80

* Figures in the parentheses are the transformed ($\sqrt{X + 0.5}$) values

* Mean of three replications.

Table 6. Rice leaffolder activity under natural infestation condition(Var.-Jaya, Summer season, 1998)

Treatment	Leaffolder infested leaves (%) *						
	Days after transplanting (DAT)						
	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT	90 DAT
T ₁	0.94(1.20)	1.49 (1.40)	4.88(2.31)	7.50(2.82)	11.42(3.43)	7.38(2.80)	1.43(1.38)
T ₂	0.92(1.19)	1.39 (1.36)	5.14(2.36)	7.23(2.77)	11.36(3.43)	7.46(2.81)	1.82(1.52)
T ₃	1.01(1.22)	1.27 (1.32)	5.16(2.35)	6.18(2.58)	13.05(3.65)	6.92(2.71)	1.76(1.50)
T ₄	1.05(1.23)	0.93 (1.19)	4.80(2.29)	6.02(2.54)	13.48(3.72)	6.84(2.70)	1.66(1.45)
T ₅	0.88(1.17)	0.98 (1.20)	4.78(2.28)	7.07(2.74)	11.99(3.53)	7.01(2.74)	1.88(1.54)
T ₆	0.76(1.12)	1.64 (1.45)	4.50(2.23)	6.46(2.63)	13.80(3.78)	6.63(2.65)	1.49(1.40)
T ₇	1.21(1.30)	1.53(1.41)	5.01(2.33)	6.83(2.70)	14.50(3.86)	6.88(2.70)	1.38(1.36)
T ₈	1.18(1.28)	1.16(1.28)	4.82(2.30)	6.66(2.66)	14.88(3.92)	7.05(2.73)	1.87(1.54)
T ₉	0.95(1.20)	1.23(1.31)	4.69(2.27)	6.96(2.72)	12.98(3.67)	7.10(2.74)	1.75(1.50)
T ₁₀	1.08(1.24)	1.24(1.31)	4.50(2.22)	7.16(2.76)	15.08(3.94)	6.89(2.71)	1.77(1.51)
T ₁₁	0.98(1.20)	1.29(1.33)	4.90(2.32)	7.05(2.73)	13.82(3.79)	6.91(2.71)	1.51(1.41)
Mean	0.996	1.29	4.83	6.83	13.30	7.00	1.66

* Figures in the parentheses are the transformed ($\sqrt{X + 0.5}$) values.

* Mean of three replications.

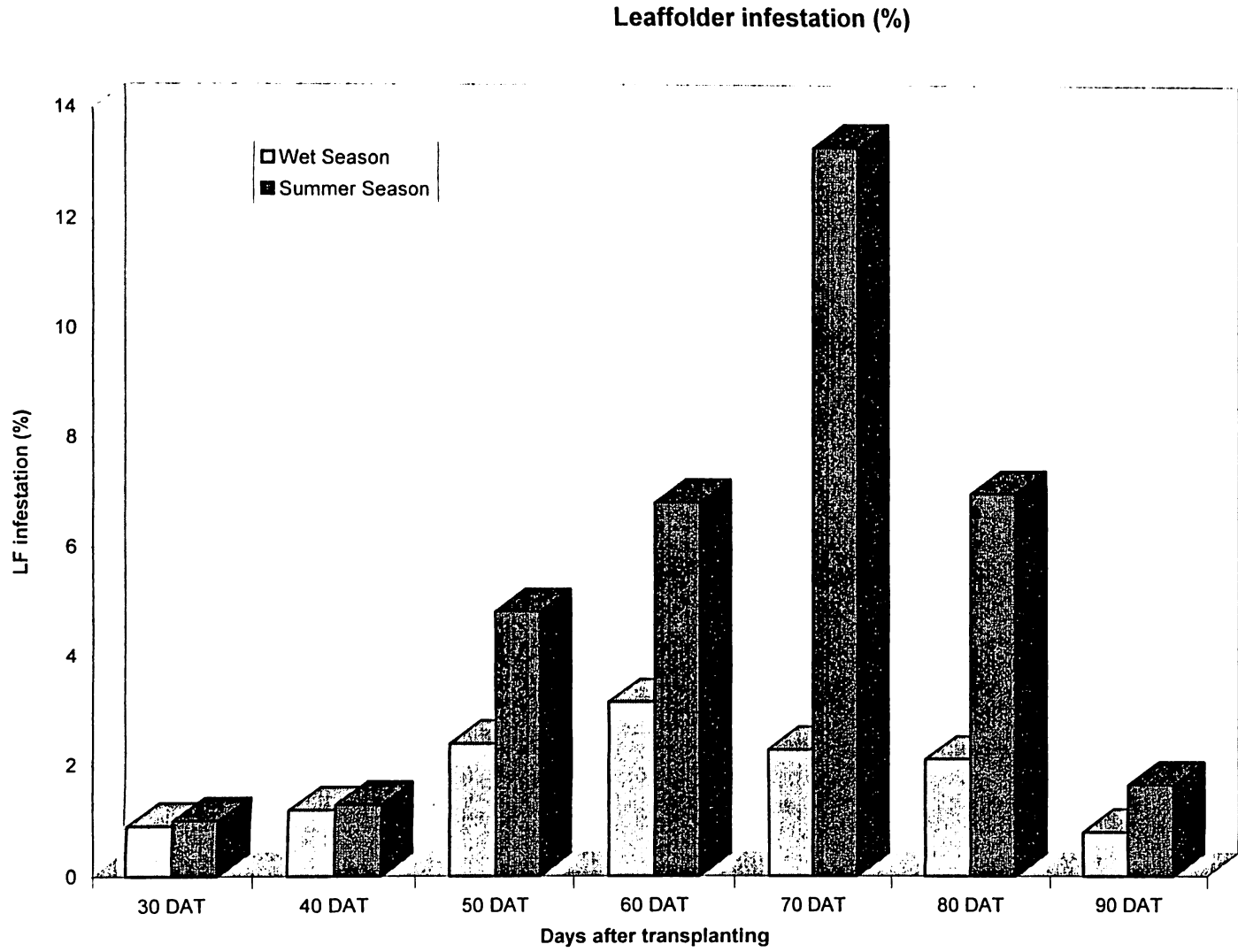


Fig 5. Leaffolder infestation (%) at different DAT

During summer, 1998 similar observations on leaffolder infestation in Jaya rice was recorded at 10 days interval under natural infestation condition. As compared to wet season, the pest load was comparatively higher and it varies from 0.76 to 1.21 per cent, 0.93 to 1.64 per cent at 30 and 40 DAT respectively. A sharp increase in the leaffolder incidence was recorded at 50 DAT which varied from 4.50 to 5.16 per cent (Table 6 and Fig 5). The pest activity gradually increased upto 70 DAT reaching as high as 15.08 per cent. The activity gradually declined thereafter.

The effect of environmental factors on the incidence of rice leaffolder during wet season, 1997 revealed that temperature varying from 25.5-33.9^o C and relative humidity of 87-88 per cent was conducive for the build up of this pest. The population build up was negligible probably due to predominance of natural enemies.

The effect of environmental factors on the incidence of rice leaffolders during summer, 1998 revealed that temperature ranging between 24.2 and 38.2^o C during fourth week of April and corresponding relative humidity of 68.0-69.0 per cent favoured the build up and multiplication of rice leaffolders.

4.2 Recovery of larval population of rice leaffolder under natural infestation condition :

In order to estimate the larval population of *C. medinalis*, observations were recorded from randomly selected one m² area during each observation. The infested leaves were thoroughly examined for the presence of the larvae and the numbers collected were tabulated. This procedure was adopted during both wet season of 1997 and summer season of 1998 (Table 7.)

PLATES



Leaffolder infested rice plot.



Larva of *Cnaphalocrocis medinalis*

Table 7. Recovery of larval population of *C. medinalis* under natural infestation condition (Var.-Jaya)

Standard Week	<u>Mean larval population/m²</u> Wet season, 1997	Standard Week	<u>Mean larval population/m²</u> Summer season, 1998
33	0.00	9	0.00
34	0.00	10	0.00
35	1.20	11	0.80
36	1.80	12	0.90
37	2.10	13	2.20
38	1.90	14	2.30
39	1.50	15	3.40
40	1.50	16	3.80
41	0.90	17	3.00
42	0.80	18	2.00
43	0.60	19	1.20
44	0.40	20	0.60
45	0.20	21	0.30

The results revealed that larval presence was noticed from 35th standard week (Aug. 27th to Sept. 2nd) and continued upto 45th standard week (Nov. 5th to 11) during wet season, 1997. A maximum larval recovery of 2.1 larvae/m² was recorded in the 37th standard week (Sept. 10 to 16) closely followed by the subsequent week. The larval recovery gradually declined thereafter reaching hardly 0.2 larvae/m² in the 45th standard week.

During summer, 1998 the larval presence was recorded in the 11th standard week (Mar. 12 to 18) which gradually increased upto 16th standard week (April 16 to 22). As high as 3.80 larvae/m² was recorded during 3rd week of April, 1998. The larval population gradually declined and as low as 0.30 larvae/m² was recorded during 21st standard week i.e., fourth week of May, 1998.

4.3 Interaction between variety and insecticide on incidence of rice leaffolder : (Summer, 1998)

A field experiment was conducted to study the interaction between four rice varieties namely IR36, Tapaswini, Bhubana and TN1 and five insecticides viz., monocrotophos, carbaryl, endosulfan, deltamethrin and imidacloprid. An untreated control plot was also maintained to compare the infestation. Observations on the incidence of leaffolder was recorded once at the peak infestation level i.e., 60 DAT.

The results of the interaction study has been presented in Table 8. It is evident from the data that irrespective of insecticidal treatment the percentage leaf infestation varied from 9.25 to 13.48 per cent between the varieties. Amongst them Bhubana remained least susceptible. However, the level of infestation in TN1 and Tapaswini remained at par with Bhubana. On the

Table 8. Interaction between variety and insecticides against rice leaffolder infestation (Summer, 1998)

Insecticide	Dose (kg.a.i/ha)	Rice leaffolder infested leaves(%) at 60 DAT				
		Variety				Mean
		IR 36	Tapaswin i	Bhubana	TN1	
Monocrotophos	0.5	9.57 (3.71)	9.25 (3.12)	9.05 (3.08)	10.37 (3.26)	9.56 (3.29)
Carbaryl	1.0	11.00 (3.37)	9.75 (3.19)	9.49 (3.16)	10.44 (3.29)	10.17 (3.25)
Endosulfan	0.5	10.17 (3.25)	7.86 (2.85)	7.10 (2.74)	7.22 (2.77)	8.08 (2.90)
Deltamethrin	0.012	15.70 (3.99)	10.54 (3.32)	10.18 (3.27)	9.83 (3.17)	11.56 (3.43)
Imidacloprid	0.02	8.71 (3.01)	6.49 (2.61)	6.59 (2.65)	6.75 (2.67)	7.13 (2.73)
Untreated check		25.76 (5.12)	18.67 (4.34)	13.13 (3.66)	20.18 (4.54)	19.43 (4.41)
Mean		13.48 (3.74)	10.42 (3.23)	9.25 (3.09)	10.79 (3.28)	
		SE(m)±		CD _(0.05)		
Variety		0.08		0.27		
Insecticide		0.119		0.37		
Variety x Insecticide		--		NS		

Figures inside the parentheses are the transformed ($\sqrt{X+0.5}$) values.

contrary, IR36 proved significantly susceptible with 13.48 per cent damaged leaves.

Among the test insecticides imidacloprid at the rate of 0.02 kg a.i./ha proved most effective in checking leaffolder infestation and in this treatment hardly 7.13 per cent leaves were affected by leaffolders. The corresponding damage in endosulfan (0.5 kg a.i./ha) treatment was 8.08 per cent. In monocrotophos and deltamethrin treatments the infestation level varied from 10.17 to 11.56 per cent. The infestation level between imidacloprid and endosulfan remained at par with each other. Similar was the case with deltamethrin and monocrotophos. A significantly higher infestation of 19.43 per cent damaged leaves was recorded in the plots receiving no insecticide. The interaction between variety and insecticide remained non significant.

4.4 Leaffolder infestation in the top three leaves of four rice varieties:

The effect of leaffolder infestation on the top three leaves of four rice varieties namely IR 36, Tapaswini, Bhubana and TN1 treated with five insecticides namely monocrotophos, carbaryl, endosulfan, deltamethrin and imidacloprid were recorded at 70 DAT.

The results revealed that 21.34 to 32.74 per cent top leaves were infested by leaffolder in the four rice variety mentioned above. Maximum infestation of 32.74 per cent was recorded in IR 36 while it varied from 21.34 to 26.38 per cent in the other three varieties (Table 9). However, there was no significant difference in the level of infestation between the test varieties.

Among the test insecticides imidacloprid proved significantly superior over other insecticides in checking the top leaf infestation by rice leaffolders.

Table 9. Interaction between rice variety and insecticides on rice leaffolder infestation in the top three leaves. (Summer, 1998)

Insecticide	Dose (kg a.i./ha)	Leaffolder infestation (%) in top three leaves at 70 DAT				
		Rice Variety				Mean
		IR 36	Tapaswin i	Bhuban a	TN1	
Monocrotophos	0.5	27.25 (5.20)	27.55 (5.29)	20.58 (4.58)	37.35 (6.13)	28.18 (5.30)
Carbaryl	1.0	42.10 (6.48)	35.96 (6.02)	26.09 (5.08)	33.68 (5.70)	36.96 (5.82)
Endosulfan	0.5	39.31 (6.26)	14.73 (3.86)	11.32 (3.41)	20.84 (4.61)	21.55 (4.53)
Deltamethrin	0.012	27.63 (4.94)	25.34 (5.05)	17.81 (4.27)	22.43 (4.78)	23.30 (4.76)
Imidacloprid	0.02	24.77 (4.99)	20.11 (4.53)	17.88 (4.19)	13.81 (3.73)	19.14 (4.36)
Untreated check		35.38 (5.09)	34.61 (5.86)	34.40 (5.90)	29.43 (5.40)	33.45 (5.56)
Mean		32.74 (5.49)	26.38 (5.10)	21.34 (4.68)	26.25 (5.05)	
		SE (m) _±		CD _(0.05)		
Variety		--		NS		
Insecticide		0.26		0.81		
Variety x Insecticide		0.34		0.98		

Figures inside the parentheses are the transformed ($\sqrt{X + 0.5}$) values.

Carbaryl treatment proved least effective against leaffolder and the infestation level reached 36.96 per cent, even higher than untreated control (Table 9). In contrast, endosulfan proved quite effective and limited the infestation level to less than 22.0 per cent. In untreated control 33.45 per cent of top leaves were affected by rice leaffolder.

The interaction between variety and insecticide revealed that the variety Bhubana sprayed with endosulfan (0.5 kg a.i/ha) drastically limited the leaffolder infestation to 11.32 per cent which remained significantly superior to most other treatments. On the other hand, the variety IR 36 treated with carbaryl recorded highest infestation of 42.10 per cent.

4.5 Leaffolder infestation in the flag leaf and its effect on grain filling:

It has already been reported by several Entomologists that leaffolder infestation in the flag leaf has a direct bearing on grain filling. In order to find out the relation between extent of leaf area defoliation by rice leaffolder and its effect on grain filling, observations were recorded from 10 randomly selected 10 clumps and the data has been presented in Table 10 and Fig 6.

It is evident from the table that increase in flag leaf area damage decreased grain filling to varying degree. In the wet season rice crop leaf area damage upto 10 per cent produced 135.20 filled grain per panicle while total defoliation of the flag leaf decreased the filled grain to as low as 87.20 number.

As regards to the chaffy grains leaf area damage upto 10 per cent recorded 35.00 chaffy grains per panicle which increase to 64.40 numbers when the flag leaf was totally defoliated.

**Table 10. ; Leaffolder infestation in the flag leaf and its effect on grain filling.
(Var.-Jaya)**

Leaf area damaged (%)	Wet season, 1997		Summer, 1998	
	filled grains*	chaffy grains*	filled grains*	chaffy grains*
1-10	135.20	35.00	118.50	37.20
11-20	125.80	41.20	106.30	49.30
21-30	124.30	41.80	102.50	51.20
31-40	119.90	45.30	92.80	52.30
41-50	105.20	52.80	89.80	60.30
51-60	103.80	51.70	88.90	60.80
61-70	101.20	55.80	82.60	61.20
71-80	100.40	59.30	79.30	63.30
81-90	98.20	60.10	75.50	67.20
91-100	87.20	64.40	72.60	68.90

* mean of 10 panicles

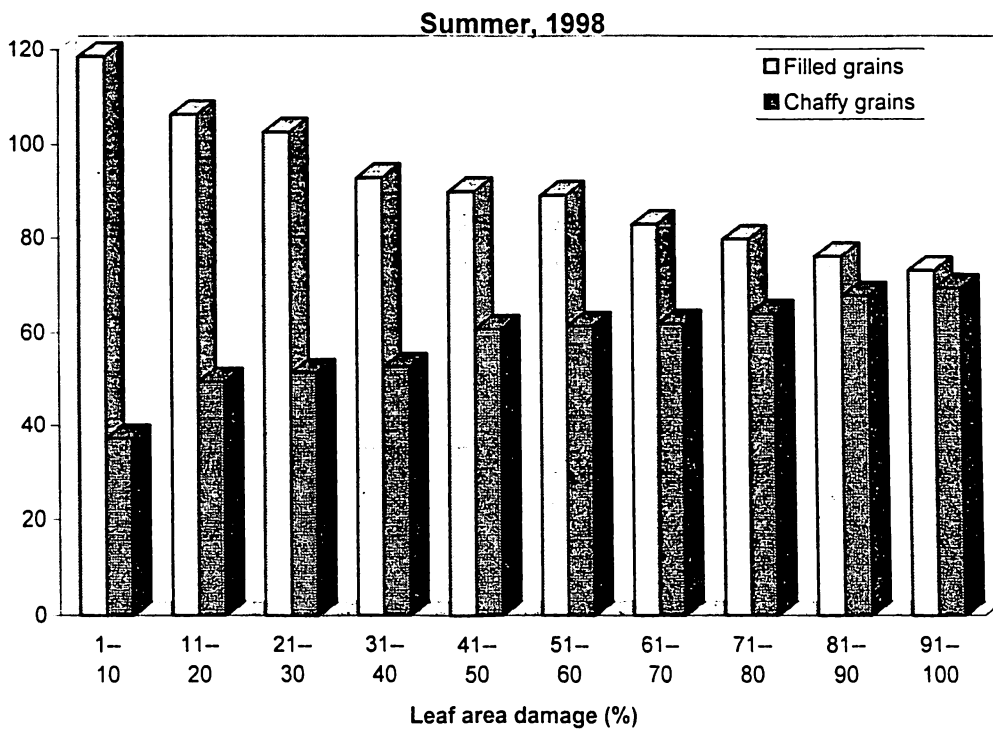
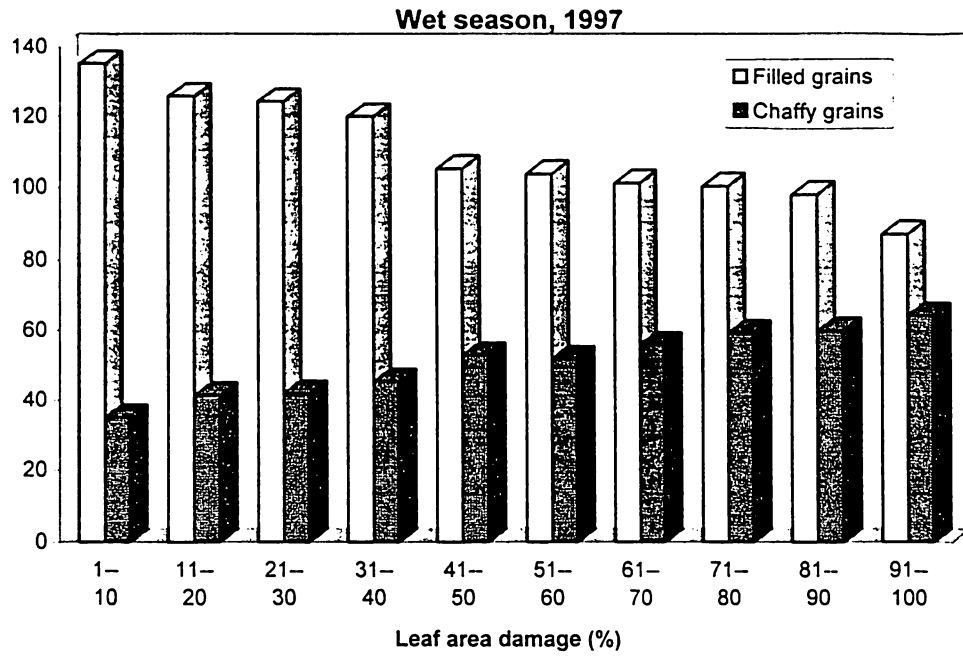


Fig 6. Relation between leaf area damage (flag leaf) and grain filling

During summer also with every increase in the leaf area damage there was general reduction in the number of filled grains per panicle and the reverse was true for unfilled grains.

4.6 Efficacy of certain insecticides against rice leaffolder :

The efficacy of 10 insecticides along with control were tested against rice leaffolder infestation under field conditions. The extent of leaf infestation was taken into account one day before application of insecticides as well as two and eight days after spraying.

It is evident from the result presented in Table 11 and Fig 7. that the extent of leaf infestation varied between 6.02 and 7.50 per cent one day before spraying. There was no significant difference in infestation between the treatments including untreated check.

Two days after spraying of insecticides a marginal increase in the infestation was noticed. The percentage leaf infestation varied from 5.98 to 9.39 per cent in the insecticidal treated plots and 11.82 per cent in untreated control. Among the insecticides chlorpyrifos at the rate of 0.5 kg a.i./ha restricted the leaf infestation to less than six per cent. Even the same chemical at the rate of 0.25 kg a.i./ha also proved significantly superior to rest of the test chemicals. The insecticides quinalphos (0.5 kg a.i./ha), monocrotophos (0.5 kg a.i./ha) and trebon (0.1 kg a.i./ha) proved equally effective against leaffolder infestation. The neem based pesticide Nivaar (750-1500 ppm) remained least effective against leaffolder infestation and in this treatment the extent of leaf damage varied from 9.21 to 9.39 per cent. In untreated check the level of leaf damage was significantly higher (11.82 per cent) than the protected plots.

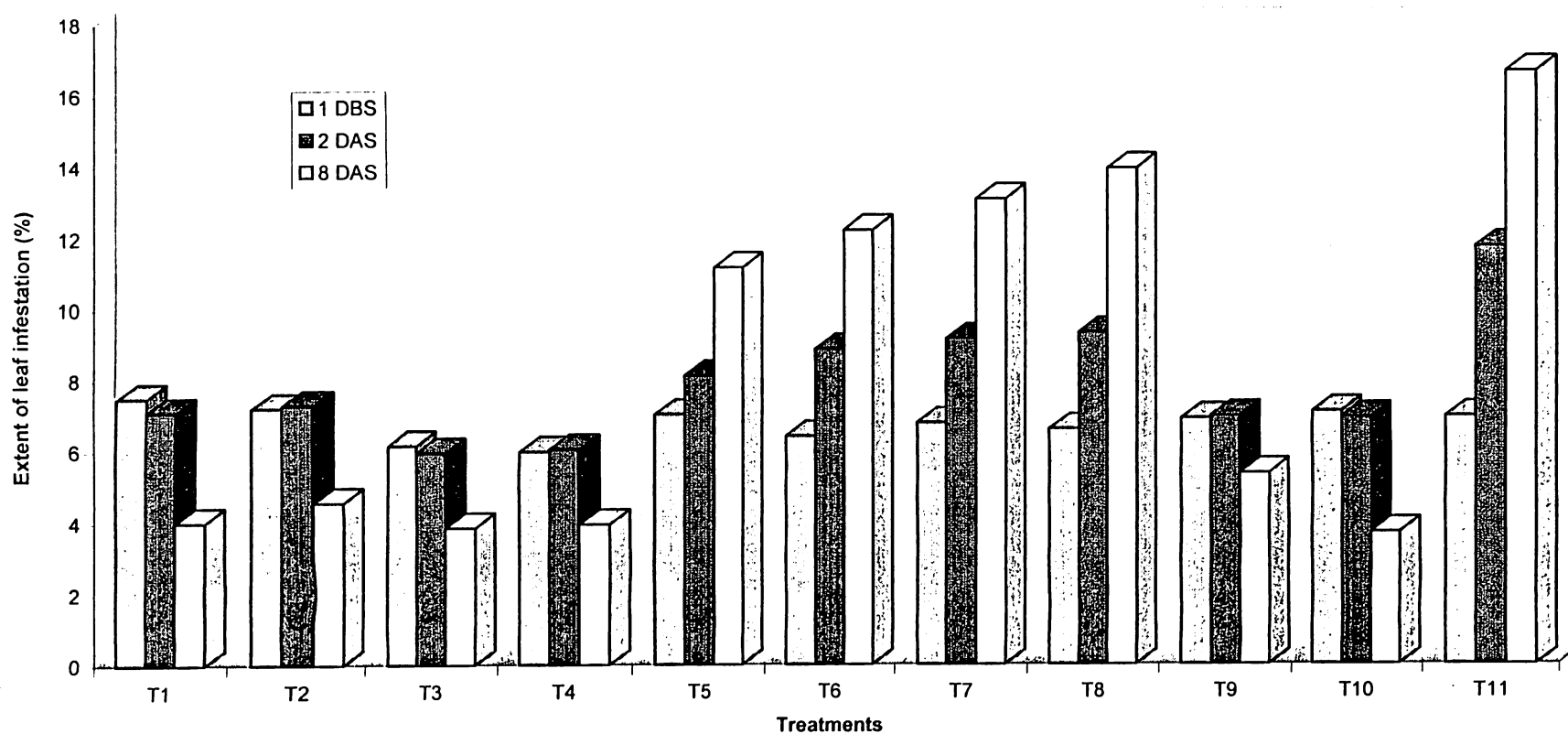
**Table 11. Efficacy of certain insecticides against rice leaf folder
(Var.- Jaya, Summer, 1998)**

Treatments	Dose (kg a.i/ha)	Extent of leaf infestation (%)*		
		1 day before spraying	2 DAS	8 DAS
Quinalphos 25 EC	0.5	7.50 (2.82)	7.10 (2.76)	4.01 (2.12)
Quinalphos 25 EC	0.25	7.23 (2.77)	7.31 (2.79)	4.58 (2.25)
Chlorpyrifos	0.5	6.18 (2.58)	5.98 (2.54)	3.88 (2.09)
Chlorpyrifos	0.25	6.02 (2.54)	6.08 (2.56)	3.98 (2.12)
Fortune Aza	1500 ppm	7.07 (2.74)	8.18 (2.95)	11.21 (3.42)
Fortune Aza	750 ppm	6.46 (2.63)	8.92 (3.07)	12.25 (3.57)
Nivaar	1500 ppm	6.83 (2.70)	9.21 (3.12)	13.12 (3.69)
Nivaar	750 ppm	6.66 (2.66)	9.39 (3.14)	13.98 (3.80)
Ethofenprox	0.1	6.96 (2.72)	7.02 (2.74)	5.42 (2.43)
Monocrotophos	0.5	7.16 (2.76)	6.99 (2.74)	3.75 (2.06)
Untreated Check	-	7.02 (2.65)	11.82 (3.51)	16.70 (4.15)
F-test		NS	Sig.	Sig.
SE (m) _±		-	0.013	0.042
CD _(0.05)		-	0.038	0.123

* Mean of three replication.

DAS = Days after spraying

Figures in the parentheses are the transformed ($\sqrt{X+0.5}$) values.



DBS - Days before spraying
DAS - Days after spraying

T1 - Quinalphos 25 EC (0.05 kg a.i./ha)
T2 - Quinalphos 25 EC (0.25 kg a.i./ha)
T3 - Chlorpyrifos (0.5 kg a.i./ha)
T4 - Chlorpyrifos (0.25 kg a.i./ha)
T5 - Fortune Aza (1500 ppm)
T6 - Fortune Aza (750 ppm)

T7 - Nivaar (1500 ppm)
T8 - Nivaar (750 ppm)
T9 - Ethofenprox (0.1 kg a.i./ha)
T10 - Monocrotophos (0.5 kg a.i./ha)
T11 - Untreated check

Fig 7. Efficacy of insecticides against rice leaf folder

The leaffolder infestation declined in most of the protected plots except neem based pesticides at eight days after spraying. In the neem pesticides the infestation level increased by them 37.04 to 48.88 per cent. Among the other chemicals monocrotophos, chlorpyriphos and quinalphos all at 0.5 kg a.i./ha remained significantly effective against leaffolder infestation. In untreated check the level of infestation was as high as 16.70 per cent which varied significantly from all other treatments.

4.7 Effect of insecticidal treatment on larval recovery :

The effect of insecticidal treatment on larval recovery of rice leaffolder was studied during the summer season of 1998. The presence of the larvae on the rice plants was estimated one day before and two and eight days after insecticidal application. The insecticides were sprayed on 60 day old transplanted crop.

The larval population per 10 clumps varied from 10.0 to 13.0 numbers just one day before application of insecticides. Spraying with different insecticides drastically reduced the larval population in almost all the synthetic chemicals but the reduction was marginal in plots receiving neem based pesticides. The population varied between 3.0 and 10.0 in different insecticides as against 13 number in untreated control. A significant decrease in the larval population was recorded in plots treated with monocrotophos, quinalphos and chlorpyriphos at the rate of 0.5 kg a.i./ha. The neem based pesticide remained significantly inferior than the synthetic chemicals but proved significantly better than untreated check (Table 12).

At eight days after spraying the larval population further declined in almost all the treatments except control. The chemicals quinalphos, chlorpyriphos

Table 12. Effect of insecticidal treatment on larval recovery (Var.-Jaya, Summer, 1998).

Treatments	Dose (kg a.i./ha)	Number of live larvae recovered from 10 hills *		
		1 day before spraying	2 DAS	8 DAS
Quinalphos	0.5	12.0(3.52)	3.0(1.86)	0.0(0.70)
Quinalphos	0.25	10.0(3.25)	3.0(1.86)	1.0(1.17)
Chlorpyriphos	0.5	11.0(3.38)	4.0(2.11)	0.0(0.70)
Chlorpyriphos	0.25	12.0(3.52)	5.0(2.34)	2.0(1.56)
Fortune Aza	1500 ppm	10.0(3.24)	7.0(2.73)	6.0(2.54)
Fortune Aza	750 ppm	13.0(3.66)	10.0(3.24)	9.0(3.08)
Nivaar	1500 ppm	11.0(3.38)	8.0(2.91)	7.0(2.73)
Nivaar	750 ppm	12.0(3.51)	8.0(2.91)	8.0(2.73)
Ethofenprox	0.1	10.0(3.23)	5.0(2.34)	2.0(1.56)
Monocrotophos	0.5	11.0(3.38)	3.0(1.86)	0.0(0.70)
Untreated	-	12.0(3.52)	13.0(3.67)	14.0(3.81)
Check				
F-test		NS	Sig.	Sig.
SE (m)±		-	0.126	0.132
CD _(0.05)		-	0.372	0.390

* Mean of three replications

DAS- Days after spraying.

Figures in the parentheses are the transformed ($\sqrt{X + 0.5}$) values.

and monocrotophos at the rate of 0.5 kg a.i./ha each killed cent per cent larvae at eight days after treatment. The population in the lower doses of quinalphos chlorpyriphos as well as 0.1 kg a.i./ha of ethofenprox dwindled between one and two larvae per 10 clumps. However the population varied from seven to nine larvae per 10 clumps in plots treated with neem based pesticides. The corresponding population in untreated check was 14 larvae/10 clumps which varied significantly from rest of the treatments.

4.8 Chemical control of rice leaffolder and its effect on yield :

The efficacy of ten commonly recommended insecticides was tested against rice leaffolder during the summer season of 1998. The extent of leaf infestation at eight days after spraying and its effect on grain yield was estimated.

It is evident from the data in Table 13, that the insecticidal treatment restricted the percentage leaf infestation to less than 14.0 per cent as against 16.70 per cent in untreated control. Most of the synthetic chemicals were quite effective and the leaf infestation was limited to less than 5.5 per cent. On the contrary the neem based pesticides namely Fortune Aza and Nivaar proved less effective against this defoliator and the infestation level varied from 11.21 to 13.98 per cent.

The grain yield varied from 2.94 to 4.00 t/ha in different insecticidal treatment as against 2.86 tonnes in untreated control. Highest grain yield of 4.00 t/ha was obtained from the plots treated with 0.5 kg a.i./ha of monocrotophos closely followed by similar dose of chlorpyriphos and quinalphos. The yield level varied from 2.94 to 3.17 t/ha in plots receiving neem based pesticides.

Table 13. Chemical control of rice leaffolder and its effect on yield (Var.-Jaya, Summer, 1998).

Insecticidal	Dose (kg a.i./ha)	Extent of leaf infestation(%)* at 8 DAS	Yield (t/ha)*
Quinalphos	0.5	4.01 (2.12)	3.83
Quinalphos	0.25	4.58 (2.25)	3.60
Chloryriphos	0.5	3.88 (2.09)	3.91
Chlorpyriphos	0.25	3.98 (2.12)	3.71
Fortune Aza	1500 ppm	11.21 (3.42)	3.17
Fortune Aza	750 ppm	12.25 (3.57)	3.11
Nivaar	1500 ppm	13.12 (3.69)	3.08
Nivaar	750 ppm	13.98 (3.80)	2.94
Ethofenprox	0.1	5.42 (2.43)	3.47
Monocrotophos	0.5	3.75 (2.06)	4.00
Untreated Check	-	16.70 (4.15)	2.86
F-test		Sig	Sig
SE (m)±		0.042	0.04
CD _(0.05)		0.123	0.117

DAS - Days after spraying.

* Mean of three replications.

Figures in the parentheses are the transformed ($\sqrt{X + 0.5}$) values.

Table 14. Benefit cost analysis of insecticidal treatments (Var.-Jaya, Summer, 1998)

Insecticidal	Dose (kg a.i./ha)	Average Yield (t/ha)	Increased yield over control(t/ha)	Cost of increased yield over control (Rs/ha)	Plant protection cost (Rs/ha)	Net profit (Rs/ha)	Benefit : Cost ratio
Quinalphos	0.5	3.83	0.97	3686.00	795.00	2891.00	3.63 : 1
Quinalphos	0.25	3.60	0.74	2812.00	440.00	2372.00	5.39 : 1
Chlorpyriphos	0.5	3.91	1.05	3990.00	915.00	3075.00	3.36 : 1
Chlorpyriphos	0.25	3.71	0.85	3230.00	496.00	2734.00	5.51 : 1
Fortune Aza	1500 ppm	3.17	0.31	1178.00	747.00	431.00	0.58 : 1
Fortune Aza	750 ppm	3.11	0.25	950.00	415.00	535.00	1.29 : 1
Nivaar	1500 ppm	3.08	0.22	836.00	675.00	161.00	0.24 : 1
Nivaar	750 ppm	2.94	0.08	304.00	378.00	-74.00	-0.20 : 1
Ethofenprox	0.1	3.47	0.61	2318.00	980.00	1338.00	1.36 : 1
Monocrotophos	0.5	4.00	1.14	4332.00	615.00	3717.00	6.04 : 1
Untreated Check	-	2.86					

Cost of paddy calculated @ Rs 3800/tonne.

Cost of labour @Rs 40.00/man day @ 2 labourers/ha of spraying.

Cost of Quinalphos, Chlorpyriphos, Fortune Aza, Nivaar, Ethofenprox and monocrotophos are Rs. 375.00, Rs.350.00, Rs 280.00, Rs 250.00, Rs. 900.00 and Rs. 400.00 per litre respectively.

The grain yield obtained from plots receiving 750 ppm of Nivaar was at par with the grain yield of untreated check.

4.9 Benefit cost analysis of insecticidal treatments :

The benefit cost analysis data of various spraying schedules against rice leaffolders has been presented in Table 14. Based on the yield data of the insecticidal treated plots against those in untreated check, the increase in yield in the protected plots were calculated. The cost of plant protection (Insecticidal cost + labour charges) was calculated at the prevailing local rate. The net profit and benefit cost ratio was calculated from the cost of increased yield over control.

It is evident from the data that maximum net benefit or Rs. 3075.00 per hectare was obtained from plots treated with chlorpyrifos at the rate of 0.5 kg a.i./ha at 60 DAT followed by similar treatment with quinalphos (Rs.2891.00/ha). Highest benefit cost ratio of 6.04 :1 was obtained by spraying monocrotophos at the rate of 0.5 kg a.i/ha closely followed by chlorpyrifos and quinalphos (0.25 kg a.i./ha). The neem based pesticides except fortune Aza (750 ppm) are least remunerative.

CHAPTER V

DISCUSSION

DISCUSSION

The rice leaffolder complex has assumed major pest status in India as a result of improved practices associated with rice production. Very frequent population outbreaks are favoured by multiple rice cropping with high yielding rice varieties, use of nitrogenous fertilizers and insecticides induced resistance. At present leaffolders are chronic pests of high yielding rice varieties and occur in all the rice environments throughout the year. In Orissa medium-and low land rice crops having irrigation facilities of both wet-and summer seasons are often devastated by this pest. The chemical control methods developed for rice leaffolders based on its bionomics, host range, natural enemy associations and chemical control schedules, all need to be re-evaluated. Keeping this in view field experiments were conducted during wet-and summer seasons of 1997 and 1998 with the following objectives.

- (i) To study the seasonal activity of rice leaffolders under natural infestation condition.
- (ii) To study the reaction of some rice varieties against leaffolder.
- (iii) Management of rice leaffolders through application of selective insecticides.

5.1 The activity of rice leaffolders in the transplanted Jaya rice grown under natural infestation conditions was monitored at 10-days interval starting from 30 DAT of both season crops. Leaffolder activity was first noticed at 30 DAT of both wet and summer crops. The incidence gradually increased upto 60 DAT and thereafter its population declined and completely seized towards 90 DAT. In wet season of 1997 the incidence was vary mild and maximum

infestation of 3.29 per cent was noticed at 60 DAT. The low infestation of leaffolders in wet season 1997 was mainly due to the activity of natural enemies prevailed in the experimental plots. However in the summer crop of 1998 leaffolder activity was moderate and the level of infestation varied from 0.76 to 15.08 per cent. A maximum of 15.08 per cent leaf damage was recorded at 70 DAT. Working on the bioecology of rice leaffolders Viswakanthaih (1972), Velusamy *et al.*, (1973) and Kuruppuchamy and Gopalan (1986) reported that the rice crop transplanted in July showed maximum leaffolder infestation in September. But in our present crop of wet season the incidence remained very low.

5.2 In addition to the extent of leaf infestation by rice leaffolders under natural infestation condition, the larval recovery was also estimated during both wet season and summer crops. As the infestation level was very mild, the larval recovery too remained very low ranging from 0.00 to 2.10 larvae/m² during the wet season of 1997. Similarly the larval recovery varied from 0.00 to 3.80 numbers/m² in the summer crop. During field observations it was found that most of the infested leaves did not contain the larvae. It may be just possible that the natural enemies that predominated in the rice environment might have preyed upon the larvae or the larvae themselves have migrated to conceal themselves in some other parts of the rice plants. In the available literature very little has been mentioned on larval recovery per square meter area. In this context Shen and Liu (1984) reported that 0.75 to 1.4 3rd instar larvae per hill at tillering stage of rice and 0.5 to 0.75 larvae at early tillering stage are the threshold values for rice leaffolders. Further Reissig *et al.*, (1986) reported that greater leaffolder damage was tolerated at vegetative

stage (15 per cent damaged leaves) than reproductive and ripening stages (5 per cent damaged leaves). In our present study the infestation level based on percentage leaf damage as well as larval count remained much below the economic threshold level during the wet season of 1997. However during summer, 1998 the percentage leaf damage reached close proximity of ETL (specified above) and it influenced the grain yield.

5.3 In the present strategy of pest management varietal resistance as well as need based application of selective insecticides play a vital role. Host plant selection by phytophagous insects is a complex phenomena. It is difficult to ascertain why some varieties are more susceptible than other under similar environmental condition. In our present study the interaction of four varieties of rice namely IR 36, Tapaswini, Bhubana and TN I and five insecticides like monocrotophos, carbaryl, endosulfan, deltamethrin and imidacloprid as well as untreated control was studied under field conditions. The results revealed that irrespective of the insecticidal treatment percentage leaf infestation varied from 9.25 to 13.48 per cent between the varieties. In contrast the infestation level ranged between 13.13 and 25.76 per cent in plots receiving no insecticides. Similarly irrespective of the varieties spraying of different chemicals restricted the leaf folder infestation to less than 11.56 per cent as against 19.43 per cent in untreated check. However the interaction between variety and insecticides remained non significant.

The reaction of several rice varieties were evaluated against rice leaf folder in India and abroad. The note worthy findings of these studies were as follows. According to Heinrichs *et al.*, (1985) the donors from 10 countries were evaluated and 35 cultivars mostly from Bangladesh and Indian origin were

found resistant. Based on these recommendation plant breeder selected W 1263, Tkm 6, Muthumenikan, Ptb 33 and GEB 24 as donors against leaffolder resistance. Rajendran (1985) screened some rice accessions for leaffolder resistance and found that IET 8100 and IET 8105 as resistant against leaffolders. Similar studies were conducted by Joshi *et al.*, (1986) who reported that IR 40 as least susceptible to leaffolders. In our present study the variety Bhubana proved least susceptible against rice leaffolders in summer rice.

5.4 It has already been reported that rice leaffolder infestation in the flag leaf affected the grain yield to varying degrees (Murugesen and Chelliah, 1983). In fact the photosynthetic activity of the flag leaf as well as the subsequent two leaves is much higher as compared to the other older leaves. Due to chlorophyll defoliation by rice leaffolders the photosynthetic activity of these three leaves are greatly reduced and the photosynthates of the affected leaves could not be available for grain filling. This was the reason probably for decrease in the number of filled grains per panicle at this crucial stage of crop growth.

Studies related to the interaction between the rice varieties and insecticides against rice leaffolder infestation in the top three leaves revealed that the infestation in the top three leaves i.e. flag leaf, penultimate leaf and the third leaf from the top recorded 21.34 to 32.74 per cent infestation in the four test rice varieties. Amongst them IR 36 remained most susceptible. Similarly among insecticides lowest infestation level of 19.14 per cent was recorded in plots treated with imidacloprid at the rate of 0.02 kg a.i/ha. The level of infestation in the carbaryl (1.0 kg a.i/ha) treatment was 36.96 per cent which was more than the level of infestation in untreated check.

5.5 It is an established fact that increase in the leaffolder damage in flag leaf has a direct bearing on grain filling. In order to find out the relation between extent of flag leaf infestation and its effect on number of filled grains/panicle, a field study was conducted during wet season, 1997 and summer season of 1998. The studies revealed that irrespective of the season increase in flag leaf area infestation decreased the number of filled grains per panicle. When the leaf area infestation was restricted to 10 per cent the number of filled grains/panicle varied between 118.50 to 135.20 irrespective of the season. When the leaf area damage ranged between 51-60 per cent the filled grains per panicle decreased and varied from 88.9 to 103.8. A corresponding increase in the unfilled grains was recorded. Complete defoliation of the flag leaf brought about 35.50 to 38.73 per cent decrease in filled grains and 84.0 to 85.21 per cent increase in unfilled grains per panicle. In this context Singh and Ghosh (1981) mentioned that flag leaf played an important role in assimilation and translocation of assimilates in the rice plant, thus ultimately influence the grain yield. A significant variation in the yield was reported when the flag leaves of rice plant were defoliated at zero-day, seven-day and 14-day after emergence and in the plants with intact flag leaves, the yield was highest. Further Barrion *et al.*, (1991) reported a positive linear relationship between yield loss and both percentage damage leaves and leaf area consumed. Our present findings are in agreement with that of the above workers.

5.6 In the present strategy of pest management, control operations should not be carried out unless it is well known that the pest is present in sufficient number to cause economic loss. Insecticidal treatments below this threshold results financial loss as well as environmental pollution. Despite of

the fact that leaffolders have already assumed the status of major pests of rice in India, sound and well proven threshold values are not available against this pest. Based on assumptions from past experiments as well as experience 5.0 per cent damaged leaves/1-2 freshly damaged leaves per hill is considered as threshold value for rice leaffolder (Reissig *et al.*, 1986 and AICRIP, 1987).

In our present study insecticidal protection with six commonly recommended insecticides (with some of them at two doses) were evaluated against rice leaffolders under field conditions. Before spraying the population marginally exceeded the threshold level and the percentage infested leaves varied from 6.02 to 7.5 per cent including untreated check. Two days after spraying of insecticides the infestation levels declined in the insecticides like quinalphos, chlorpyrifos and monocrotophos while it increased in the neem based pesticides as well as ethofenprox. Similar trend was observed for neem pesticides at 8 DAT. Among the insecticides monocrotophos, chlorpyrifos and quinalphos proved most effective against rice leaffolders. Working on the chemical control of rice leaffolders Kareem and Viswanath, (1981); Hirao, (1982); Jain *et al.*, (1987); Raju *et al.*, (1988); and Jena *et al.*, (1992); reported chlorpyrifos as an effective insecticide against rice leaffolders while Saroja (1989); CRRI, (1989) and Jena *et al.*, (1992) reported monocrotophos as an effective insecticide against rice leaffolders. Our present findings are in agreement with that of the above workers.

5.7 The effect of insecticidal spraying on larval recovery was recorded in the summer rice crop grown during 1998. One day before insecticidal application the larval recovery from 10 randomly selected hills varied from 10.0 to 13.0 numbers. Its population declined varying from 3.0 to 10.0 numbers

two days after spraying of insecticides. More than 50.0 per cent reduction in larval population was recorded from plots sprayed with quinalphos, chlorpyrifos, monocrotophos and ethofenprox while neem based pesticide marginally decreased the larval population. At eight days after spraying the plots receiving monocrotophos, quinalphos and chlorpyrifos at the rate of 0.5 kg a.i/ha killed cent per cent larvae but neem based pesticides harboured 6.0 to 9.0 larvae per 10 hills. This clearly indicates that neem based pesticides are less effective against leaffolder larvae as compared to conventional insecticides like chlorpyrifos, quinalphos and monocrotophos. Working on the management of rice leaffolders Maharana (1991) and Panda (1992) have reported that one round spraying of monocrotophos between 35 and 47 DAT was most effective against rice leaffolders. In our present study different test chemicals were sprayed at the peak infestation level (60 DAT) in order to obtain concrete results.

5.8 The chemical control of rice leaffolders and its effect on grain yield was studied during summer, 1998. Six commercial preparations of insecticides commonly recommended were evaluated against rice leaffolders. Spraying with different chemicals (Except neem preparation) drastically reduced the leaffolder infestation at eight days after spraying. The grain yield varied from 2.94 to 4.00 t/ha from plots receiving different chemicals as against 2.86 t/ha from untreated check. Plots receiving monocrotophos at the rate of 0.5 kg a.i/ha at 60 DAT limited the leaf infestation to less than four per cent and at the same time gave highest yield of 4.0 t/ha closely followed by similar treatment with chlorpyrifos (3.91 t/ha). Neem based pesticides being less effective against leaffolder (11.21 to 13.98 per cent leaf infestation) yielded 2.94 to 3.17 t/ha which remained significantly inferior to treatment with

conventional pesticides. Even Nivaar application at the rate of 750 ppm proved least effective against leaffolder and the grain yield from this treatment was at par with the yields obtained from untreated check. Working on the chemical control of rice leaffolders Maharana (1991) and Panda (1992) reported that monocrotophos was most effective against rice leaffolders and at the same time gave highest grain yield. Our present findings are in agreement with that of the above workers.

5.9 The ultimate objective of any pest control schedule is to obtain more yield with minimum expenditure on pesticides. Sometimes insecticides are very effective against insect pests but at the same time the cost involvement is extremely high and beyond the reach of a marginal farmer. Therefore, benefit cost analysis is an important criteria in any pest management system. The benefit cost analysis of leaffolder control revealed maximum net benefit of Rs.3075.00 per hectare by spraying chlorpyriphos at the rate of 0.5 kg a.i/ha closely followed by similar dose of quinalphos. However, on the basis of benefit cost analysis monocrotophos at the rate of 0.5 kg a.i/ha was most cost effective (6.04 :I) followed by chlorpyriphos as well as quinalphos at the rate of 0.25 kg a.i/ha. With every rupees spent on plant protection there was net benefit of rupees 5.39 to 6.04 in quinalphos, chlorpyriphos and monocrotophos treatment. Spraying with neem based pesticides were least cost effective and except fortune Aza, (750 ppm) the other neem based pesticide for every rupees spent on plant protection the net return was Rupees(-) 0.20 to 0.58. Working on the benefit cost analysis Maharana (1991) reported that spraying of monocrotophos at 42 DAT was most cost effective (3.75 :I) followed by similar

treatment at 49 DAT (3.43:I) while Panda (1992) reported a benefit cost ratio of 2.27:I by spraying monocrotophos at 47 DAT. In our present study monocrotophos spraying at the rate of 0.5 kg a.i/ha at 60 DAT was most cost effective (6.04:I).

CHAPTER VI
SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

In order to study the bioecology, host plant resistance, yield loss assessment and effective insecticidal protection against rice leaffolders, field experiments were conducted during wet season of 1997 and summer, 1998 at the Central Research Station of Orissa University of Agriculture and Technology, Bhubaneswar. The salient findings obtained and conclusions derived thereof are summarised below.

In the wet season of 1997, rice leaffolder infestation in Jaya commenced from 30 DAT and continued upto 90 DAT with peak incidence at 60 DAT. In general leaffolder incidence was quite mild during wet season and the extent of leaf infestation varied between 0.73 and 3.29 per cent.

During summer, 1998 similar observations on leaffolder infestation revealed that 4.50 to 5.16 per cent leaf damage was recorded at 50 DAT. But the infestation level reached 15.08 per cent leaf damage at 70 DAT. The leaffolder activity gradually declined thereafter. Temperature ranging between 24.2°C and 38.2°C coupled with relative humidity of 68.0 to 69.0 per cent favoured the build up of rice leaffolders in summer rice.

The estimation of larval population from a square metre area was recorded from August 27th to 11th Nov, during the wet season of 1997. Maximum recovery of 2.1 larvae/m² was recorded in the 37th standard week i.e., Sept. 10th to 16th. During summer 1998, larval presence was recorded between 11th and 16th standard week i.e., Mar. 12th to April, 22nd. As high as 3.80 larvae/m² was recorded in the third week of April, 1998.

The interaction between variety and insecticide on incidence of leaffolder in summer rice revealed that the percentage leaf infestation varied from 9.25 to 13.48 per cent in the varieties IR 36, Tapaswini, Bhubana and TN 1. Among them Bhubana remained least susceptible while IR 36 significantly susceptible.

Among the insecticides imidacloprid at the rate of 0.02 kg a.i./ha proved most effective (7.13 per cent leaf infestation) against rice leaffolder closely followed by endosulfan 0.5 kg a.i./ha (8.08 per cent infestation). A significantly higher infestation of 19.43 per cent damaged leaves was recorded from plots receiving no insecticides.

Studies related to the effect of insecticidal treatment on leaffolder infestation in the top three leaves indicated that 21.34 to 32.74 per cent infestation in the four test varieties of rice mentioned above. Maximum infestation of 32.74 per cent was recorded in IR 36. The insecticide imidacloprid proved significantly superior to other insecticides in checking the leaffolder infestation while carbaryl treatment was least effective (36.96 per cent infestation). The interaction between rice variety and insecticides revealed that Bhubana sprayed with 0.5 kg a.i./ha of endosulfan drastically limited the leaf infestation to 11.32 per cent as against 42.10 per cent infestation in IR 36 receiving carbaryl of the rate of 1.0 kg a.i./ha.

The effect of flag leaf infestation on grain filling revealed that increase in flag leaf area damage decreased grain filling to varying degrees. In the wet season crop flag leaf area damage upto 10 per cent produced 135.20 filled grains/panicle while it was decreased to 87.20 numbers when the damage ranged between 90-100 per cent. A simultaneous increase in the number of unfilled grains was recorded which varied from 35.00 to 64.40 numbers at

graded levels of flag leaf infestation. A similar trend was recorded in summer rice.

The efficacy of certain selective insecticides against rice leaffolders was carried out during summer, 1998. The results revealed that the extent of leaf infestation varied from 6.02 to 7.50 per cent one day before spraying. A marginal increase in the infestation level was recorded two days after spraying particularly in plots receiving neem based pesticides. Among the test chemicals chlorpyrifos @ 0.5 kg a.i./ha restricted the leaf infestation to less than 6.0 per cent. Both quinalphos and monocrotophos proved equally effective against leaffolders. The neem based pesticides proved less effective (8.18 - 9.39 per cent infestation) as compared conventional insecticides but superior to untreated check. The infestation level at eight days after spraying increased ranging from 37.04 to 48.88 per cent in plots receiving neem pesticides while the chemicals like monocrotophos, chlorpyrifos and quinalphos all at 0.5 kg a.i./ha remained significantly effective against rice leaffolders and restricted the damage level to less than 5.0 per cent.

The effect of insecticidal treatment on larval recovery was estimated one day before and two and eight days after spraying from the rice crop grown during summer, 1998. The larval population varied from 10.0 to 13.0 at one day before spraying and was 3.0 to 10.0 numbers at two days after spraying in different insecticidal treatments as against 13.0 numbers in untreated check. The insecticides monocrotophos, quinalphos and chlorpyrifos drastically reduced (three to five insects per 10 hills) the larval population while all the test neem pesticides proved significantly inferior than the synthetic chemicals. Similar trend was observed at eight days after spraying.

The effect of 10 commonly recommended insecticides on leaffolder infestation and grain yield was studied during summer, 1998. Insecticidal treatments restricted the leaf infestation to less than 14.0 per cent as against 16.70 per cent in untreated check. The conventional insecticide further limited the infestation to less than 5.5 per cent. While it was 11.21 to 13.98 per cent in plots receiving neem based pesticides.

The rough rice yield varied from 2.94 to 4.00 t/ha in plots receiving different insecticides as against 2.86 t/ha from untreated check. Monocrotophos applied @0.5 kg a.i./ha contributed towards highest grain yield of 4.0 t/ha closely followed by similar treatments with chlorpyrifos and quinalphos (3.91 and 3.83 t/ha). The yields from neem pesticides treated plots was marginally higher (2.94 to 3.17 t/ha) than untreated check (2.86 t/ha).

The benefit cost analysis of various spraying schedules against rice leaffolders revealed that maximum net benefit of Rs. 3075.00 per hectare was obtained from plots receiving chlorpyrifos @ 0.5 kg a.i./ha at 60 DAT followed by similar treatment with quinalphos (Rs. 2891.00/ha). However, highest benefit cost ratio of 6.04:1 was obtained by spraying monocrotophos @0.5 kg a.i./ha closely followed by 0.25 kg a.i./ha each of chlorpyrifos and quinalphos. The neem based pesticides were least cost effective.

BIBLIOGRAPHY

BIBLIOGRAPHY

- AICRIP, 1978. Annual Report (*Kharif*). All India Co-ordinated Rice Improvement Project, Rajendranagar, Hyderabad, India.
- AICRIP, 1979. Annual Report (*Kharif*). All India Co-ordinated Rice Improvement Project, Rajendranagar, Hyderabad, India.
- AICRIP, 1980. Annual Report (*Kharif*). All India Co-ordinated Rice Improvement Project, Rajendranagar, Hyderabad, India.
- AICRIP, 1990. Annual Report (*Kharif*). All India Co-ordinated Rice Improvement Project, Rajendranagar, Hyderabad, India.
- AICRIP, 1991. Annual Report (*Kharif*). All India Co-ordinated Rice Improvement Project, Rajendranagar, Hyderabad, India.
- AICRIP, 1992. Annual Report (*Kharif*). All India Co-ordinated rice improvement project. Rajendranagar, Hyderabad, India.
- AICRIP, 1993. Annual Report (*Kharif*). All India Co-ordinated Rice improvement project. Rajendranagar, Hyderabad, India.
- AICRIP, 1994 Annual Report (*Kharif*). All India Co-ordinated Rice improvement project. Rajendranagar, Hyderabad, India.
- Balasubramanian, N.M. and Michael, R.K.P.M., 1976. Effect of quinalphos and certain other granular pesticides on pests of rice. *Madras Agric. j.* 63:288-91.
- Barrion, A.T. and Litsinger, J.A., 1987. Meadow grasshopper *Conocephalus longipennis* (de Hann) damage to rice spikelets. *IRRN* 12(1) :18.
- Barrion, A.T., Litsinger, J.A., Medina, E.B., Aguda, R.M., Bandong, J.P., Pantua, P.C. Jr., Viajante, V.D., dela Cruz, C.G., Vega, C.R., Soriano, Jr. Ja., Camnag, E.E., Saxena, R.C., Tryon, E.H. and Shepard, B.M. 1991. The rice *Cnaphalocrocis* and *Marasmia* (Lepidoptera : Pyralidae), Leaf folder complex in the Philippines : Taxonomy, Bionomics and control. *Philippines Ent.* 8(4) :987-1074.

- Bautista, R.C., Heinrichs, E.A., and Rajesus R.S., 1984 Economic injury levels for the rice leaffolder *Chaphalocrocis medinalis* (Lepidoptera): Pyralidae : Insect infestation and artificial leaf removal. *Environ. Entomol.* **13** : 439-43.
- Bentur, J.S. and Kalode, M.B. (1989) Evaluation of rice germplasms against rice leaffolder (LF) in green house. *Int. Rice Res. Newsl.* **14**(1):14.
- Biswas, A.K. and Mandal, S.K., 1992. Evaluation of prophylactic insecticidal measures against insect pests of paddy seed bed. *Rev. of appld. Entomol* **8**(9) : 818.
- Bradley, J.D. 1981. *Marasmia patnalis* on rice in South East Asia. *Bulletine on Entomological Research.* **71**(2) :323-7.
- Chang, S.S., Lo., Z.C., King, C.G., Li, G.Z., Chem, X.L. and Wu, X.W. 1980. Studies on the migration of the rice leaffolder. *C. medinalis Guenee Aota Entomologica Sinica.* **23**(2) : 130-40.
- Chantarapha. N., Katanyukul, W., Semapetch, U. and Seetanun, W. 1980. Influence of ammonium phosphate levels on rice leaf roller incidence. *IRRN* **5**(5) :21.
- Chatterjee, P.B., 1979. Rice leaffolder attack in India. *IRRN* **4**(3) :21.
- Chatterjee P.B.. 1987. Rice leaffolder infestation in West Bengal. *IRRN* **12**(4):44.
- Chatterji, S.M., Kulashreshtha, J.P. and Rajamani, S. 1977. Recent advances in the management of rice pests in India. *Indian farmers Digest*, **10**(7):9-12.
- Chen, C.C. and Chiu, S.C. 1985. Ecological studies on egg parasitoid *Trichogramma chilonis* with special reference to ovipositional habits. *J. of Agric. Res. of China.* **34**(2) : 207-12.
- Chhabra, K.S., Sajjan, S.S. and Singh, J. 1976. Light trap catches at the rice research station at Kapurthala, Punjab, India. *Rice Ent. Newsl.* **4** : 38.
- Chhabra, K.S. and Singh, J. 1979. Rice pest situation in Punjab during 1975. *Indian J. of Plant Protection.* **7**(1) : 73-6.

- Chiranjeevi, Ch. and Rao, G.M. 1991. Population fluctuation of leaffolder (LF) at different planting times in some rice varieties. *IRRN* 16(6):22.
- C.R.R.I., 1980. Central Rice Research Institute. Annual Report for 1980.
- C.R.R.I., 1981. Central Rice Research Institute. Annual Report for 1981.
- C.R.R.I., 1982. Central Rice Research Institute. Annual Report for 1982.
- C.R.R.I., 1989. Central Rice Research Institute, Annual Report for 1989.
- Custodio, H.A. 1980. Integrated pest control programme in Rice in Philippines pp. 45-59.
- Das, N.M. and Nair, M.R.G.K., 1974. Relative field susceptibility of rice varieties to infestation by rice leaffolder *C. medinalis* Guenee. *Agric. Res. J. Kerala*, 12(2):194-6.
- De Datta, S.K. 1981. Principles and practices of rice production, John Willey, New Work, 618 pp.
- Endo, S., and Masuda, T. 1981. Cartap concentration in rice plants treated with three formulations types and toxic effects to the rice leaf roller, *Cnaphalocrocis medinalis* Guenee. *Journal of Pesticide Science* 6(3) : 287-92.
- Escalado, M.M. and Heong, K.L. 1992. Early spraying by rice farmers in Leyte, Philippines. *IRRN* 17(6) : 27-8.
- Fernado, M.H.J.P. 1980. Control of insect pests of Rice in Sri Lanka. A paper presented in the cropping systems conference, 3-7 March, 1980. *Int. Rice Research Institute* Los Banos, Laguna, Philippines, pp 66-73.
- Fraenkel, G., Fallil, F. and Kumarsinghae, K.S. 1981. The feeding behaviour of rice leaffolder, *Cnaphalocrocis medinalis*. *Ent. Exp. appl.* 26:147-61.
- Gargav, V.P. and Katiyar, O.P. 1985. Host plants of *Cnaphalocrocis medinalis* Guenee and its incidence on paddy at Raipur, Madhya Pradesh, *Oryza*. 8(1) :109-10.

- Godase, S.K. and Dumbre, R.B. 1985. Chemical control of rice leaffolders *C. medinalis*. *Pesticides*. 19(2):38.
- Gomez, K.A. and Gomez, A.A. 1976. A text book of Statistical Procedures for Agricultural Research. The IRRI, Los Banos, Laguna, the Philippines, pp.183-201.
- Gouda, C. 1990. Estimation of economic threshold levels for stem borer and leaffolders of rice. M.Sc.(Ag.) thesis submitted to Orissa University of Agril. and Tech. Bhubaneswar, India.
- Gunathilagaraj, K. and Gopalan, M. 1986. Rice leaffolder complex in Madurai, Tamil Nadu, India. *IRRN* 11(6):24.
- Harinkhere, J.P., Kandalkar, V.S., and Bhowmick, A.K., 1998. Seasonal abundance and association of light trap catches with field incidence of rice leaffolder (*Cnaphalocrocis medinalis* Guenee). *Oryza*. 35(1) : 91-92.
- Heinrichs, E.A. and Valencia, S.L. 1980. Evaluation of insecticides applied as foliar sprays for rice leaffolder control. *Sectic. Acaric Tests*. 5 :145-6.
- Heinrichs, E.A., Bautista, R.C. and Rejesus, R.S. 1984. Economic injury level for rice leaffolder *C. medinalis* Guenee (Lepidoptera: Pyralidae): insect infestation and artificial leaf removal. *Environ. Ento.* 13 : 439-443.
- Heinrichs, E.A., Camnag, E. and Romena, A. 1985. Evaluation of rice cultivars for resistance to *Cnaphalocrocis medinalis* Guenee. (Lepidoptera: Pyralidae). *Journal of Eoc. Ent.* 78:274-8.
- Heinrichs, E.A., Mendrano, F.G. and Rapus, H.R. 1985. Genetic evaluation for insect resistance in Rice. Chapter 23. IRRI, Los Banos, Philippines.
- Hirao, J. 1981. Wide spread out breaks of immigrating leaffolder and white backed plant hoppers in South Western Japan. *IRRN* 6(5):18.
- Hirao, J. 1982. Ecology and chemical control of the rice leaf roller. *Japan Pestic.*

- Jena, Mayabini, Dani. R.C. and Rajamani, S. 1992. Effectiveness of insecticides against the rice leaffolder. *Cnaphalocrocis medinalis* (Guenee) *Indian J. Plant Prot.* 20 : 43-46.
- Joshi, R.C., Medina, E.B. and Heinrichs, E.A. 1986 b. Screening of IR Varieties for resistance to the rice leaffolder, *Marasmia patnalis* Bradley,. *J. Ent. Res.* 10 :112-114.
- Kalode, M.B. 1976. Current status of research on rice pest control. National seminar on control of pest of rice and jowar. AICRIP. Rajendranagar Hyderabad, India. pp.12-13.
- Kareem, A.A. and Viswanathan, T. 1981. Efficacy of chlorpyrifos (coroban) 5 and 10G against two major rice pests in Tamilnadu. *Int. Rice Res. Newsl.* 6(1):15
- Karuppuchamy, P. and Gopalan, M. 1986. Influence of time of planting on the incidence of rice pests. *Madras Agric. Journal* 73(II):606-9.
- Khan, Z.R., Barrion. A.T., Litsinger, J.A., Castilla, N.P. and Joshi, R.C. 1988. A bibliography of rice leaffolders (Lepidoptera:Pyralidae). *Insect science and its application*, 9 : 129-174.
- Khan, Z.R. and Joshi. R.C. 1990. Review of varietal resistance to *Cnaphalocrocis medinalis* (Guenee) in rice. *Crop Protection.* 9:243-51.
- Kushwaha, K.S. and Sharma, S.K. 1983. Relationship of date of transplanting, spacing and levels of nitrogen on the incidence of rice leaffolder in Haryana. *Indian Journal of Entomology*, 43(3):338-9.
- Lever, R.J.A.W. 1946 b. The rice leafroller *Marasmia venialialis*(Sic.) *Agric. J. Fiji*, 17.11.
- Li, L.Y. 1978. The control of Agricultural and Forest insect pests by using Trichogrammatid egg parasites:Institute of Entomology, Kwantung, China.
- Lim, G.S., Ooi, A.C. and Low, W.M. 1980. Integrated pest control programmes in Malaya with special reference to rice, pp. 31-4.

- Litsinger, J.A., Canapi, B.L., Bandong, J.P., dela Cruz, C.G., Apostoi, R.F., Pantua, P.C., Lumaban, M.D., Alviola III A.L., Raymundo, F., Libetario, F.M., Leevinshon, M.E. and Joshi, R.C. 1987. Rice crop loss from insect pests in wetland and dryland environments of Asia with emphasis on the Philippines. *Insect Sci. Applic.* 8:692-9.
- Maharana, S. 1991. "Studies on ecology and estimation of economic threshold for rice leaffolder in wetseason," M.Sc. (Ag) Thesis presented to Orissa University of Agriculture and Tech. Bhubaneswar, India.
- Mathew, G. and Menon, M.G.R. 1984. The pyralid fauna (Lepidoptera: Pyralidae:Pyralidina) of Kerala (India). *Journal of Entomological Research* 8:5-13.
- Mathew, G. and Menon, M.G.R. 1986. Identification of some leafrollers belonging to the genera *Bradina*, *Marasmia* and *Cnaphalocrocis* (Lepidoptera:Pyraustidae). *Entomon*, 11: 311-317.
- Miyahera, Y. 1981. Occurrence of the rice leaffolder in Japan. *JARQ*, 15(2) : 100-105.
- Mishra, B.K. 1995. Bio-ecology and management of rice leaffolders in the coastal belt of Orissa. Ph.D., thesis Orissa University of Agriculture and Technology.
- Mochida, O., Joshi, R.C. and Litsinger, J.A. 1987. Climatic factors affecting the occurrence of insect pests. In the proceedings of the International workshop on impact of weather parameters on growth and yield of rice. IRRI, Los banos, laguna, the Philippines. pp.149-64.
- Murugesan, S. and Chelliah, S. 1983. Rice yield losses caused by leaffolder damage at tillering stage. *IRRV* 8(4):13.
- Murugesan, S. and Chelliah, S. 1983. Rice yield losses caused by leaffolder damage to the flag leaf. *IRRV* 8(4):14.
- Murugesan, S. and Chelliah, S. 1986. Yield loss and economic injury by rice leaffolders. *Indian J. of Agric Sci.* 56(4):282-5.

- Nair, M.R.G.K. 1986. Insects and mites of crops of India (ICAR), p.13.
- Natarajan, K., Rajamani, S. and Mathur, K.C. 1978. *Brachmia arotraea*, a leaffolder of rice in India. *IRRN* 3(3):16.
- Nguyen, C.T. 1982. Rice insect pests in Vietnam. *IRRN* 7(2):10-11.
- Nodarajan, L. and Nair, N.R. 1983. Screening for leaffolder resistance. *IRRN* 8(3):5.
- Nodarajan, L. and Nair, N.R., 1987. A new rice leaffolder in Kerala. *IRRN* 12(5):23.
- Panda, M. 1992. Studies on ecology and management of rice leaffolders. M.Sc.(Ag.) thesis presented to Orissa Univ. of Agric. and Tech. Bhubaneswar, India.
- Panda, S.K. and Shi. N. 1989. Carbofuran induced rice leaffolder resurgence. *IRRN* 14(1):30.
- Pangtey, V.S. and Sachman, J.N. 1982. Leaffolder outbreak in Kohima district, Nagaland, India. *IRRN*. 7(2):10-11.
- Patel, R.K., Jamproa, M.P. and Bhowmik, A.K. 1987. Leaffolder population on rice under drought. *IRRN* 12(3):30.
- Pathak, M.D. 1977. Insect pests of rice. 4th reprint. International Rice Research Institute. Los Banos, Laguna, the Philippines, pp.62.
- Pathak, M.D. and Dhaliwal, G.S. 1981. Trends and strategies for rice insect pest problems in tropical Asia. *International Research paper Series* No 64, 15pp.
- Pillai, K.B. and Nair, M.R.G.K. 1984. Use of insecticides applied as granules in soil for control of *C. medinalis* and other lepidopteran insects of rice. *Entomon*, 9(4):275-8.
- Pradhan, S.B. and Shai, B.B. 1983. Leaffolder outbreak in Terai belt of Nepal. *IRRN* 8(2):13.
- Raghunath, T.A.V.S. and Ramakrishana, T.A.V.S. 1979. Studies on the biology of *Marasmia trapezalis* Guenee (Pyralidae:Lepidoptera) on sugar cane. *Indian Sugar* 29: 19-21.

- Rajendran, R. 1985. A technique to screen rice accessions for resistance to rice leaffolder. *Madras Agric. J.* 72(II) : 650-651.
- Raju, N., Gopalan, N. and Balasubramanian, G. 1988. Effect of insecticides on rice leaffolder eggs. *Int. Rice Res. News L.* 13(3) :33.
- Rao, M.V., Reddy, P.S. and Rao, V.L.V.P. 1982. Multiple tolerance to insect pests in certain rice cultures at Warangal. *Oryza*, 19(314) : 208.
- Ray, S., Singh, M. and Singh, G. 1993. Field screening of rice cultivars for resistance to leaffolder (LF), (*C. medinalis* Guenee) and Stem borer(SB) (*Sesamia inferens* Walker). *IRRN* 18(4):12.
- Reissig, W.H., Heinrichs, E.A., Litsinger, J.A., Mody, K., Fielder, L., Mew, T.W. and Barrion, A.T. 1986. Illustrated Guide to Integrated Pest Management in rice in Tropical Asia. IRRI, Philippines. P. 411.
- Sachan, S.K. 1992. Rice leaffolder (LF) outbreak in Valleys of Uttar pradesh, India. *IRRN*, 17(6):25-6.
- Sachan, S.K. and Garg, D.K. 1992. Field pests of rice in the hills of UP Short communication. *Oryza*, 29:81-3.
- Salim, M., Rehman, A. and Ramzan, M. 1991. Leaffolder(LF) outbreak in Punjab, Pakistan. *IRRN*, 16(1):22.
- Saroja, R. 1989. Comparative efficiency of insecticides for the control of rice leaffolder *C. medinalis*. *Madras Agricultural Journal.* 76(9):490-493.
- Saroja, R. and Raju, N. 1982. Effect of foliar insecticides on stem borers and leaffolders. *IRRN* 7(3) : 14.
- Saroja, R. and Raju, N. 1983. Influence of planting time on rice leaffolder incidence. *IRRN*, 8(6):17.
- Saroja, R., Nazeer, S. and Raju, N. 1981. Effects of method of nitrogen application on the incidence of rice leaffolder. *IRRN*, 6(4):15.
- Sen P. and Chakravarty, S. 1970. A preliminary observation on rice pests occurring in Haringhata (West Bengal) *Indian Agric.* 14 :63.

- Shen, C.Y. and Lü, Z.C. 1984. Yield loss of rice caused by rice leaf roller and the threshold of economic injury. *Acta Entomologica Sinica*, 27:384-391.
- Singh, J and Sinha, M.M. 1978. Studies on the occurrence of different paddy pests under North Bihar conditions. *Science and Culture*, 44(11):508-9.
- Smith, J., Litsinger, J.A., dela Cruz, C.G. and Lumaban, M.D. 1988. Economic thresholds for insecticide application to rice profitability and risk analysis to Filipino farmers. *J. Pl. Prot. Trop.*, 6:67-87.
- Srivastava, S.K. 1989. Leaffolder (LF) damage and yield loss in some selected rice varieties. *Int. Rice Res. Newsl.* 14(6) :10.
- Subramanian, R. and Balasubramanian, M. 1976. Effect of potash nutrition on the incidence of certain insect pests of rice. *Madras Agricultural Journal*, 63:561-4.
- Teng, Poul, S., Heong, K.L. and Moddy Keith. 1993. Advances in tropical rice integrated pest management research. In *New Frontiers in Rice Research* (Eds) K. Muralidharan and E.A. Siddiq. Directorate of Rice Research, Rajendranagar, Hyderabad, India - PP.241-55.
- Thangamuthu, G.S., Murugesan, S. and Subramanian, S. 1982. Effect of spacing on leaffolder *C. medinalis*, Guenee infestation in rice. *IRRN* 7(5):21.
- Tomar, J.B., Prasad S.C., Singh, M.P. and Tomar, S.D. 1990. Evaluation of rice cultivars for resistance to leaffolder. *Int. Rice Res. News L.* 15(4):12
- Tunga T.K. 1989. Studies on the seasonal incidence of rice leaffolders and their biocontrol agents, M.Sc. (Ag) thesis, Orissa University of Agriculture and Technology.
- Upadhyay, V.R., Shah, A.H. and Desai, N.D. 1981. Influence of levels of nitrogen and rice varieties on the incidence of rice leaffolder *C. medinalis* Guenee. *Gujarat Agric. Univ. Res. J.*, 1 : 115-17.
- Velusamy, R., Janaki, J.P. and Subramanian, T.R. 1973. Varietal susceptibility of rice to the rice leaf roller *C. menanalis* Guenee. *Madras Agric. Journal.* 60 : 1806-8.

- Velusamy, R. and Subramanian, T.R. 1974. Bionomics of the rice leaffolder. *C. medinalis* Guenee. *Indian j. of Entomol.* 36(3):185-9.
- Verma, S.K., Pathak, P.K., Singh, B.N. and Lal, M.N. 1979. Leaffolder outbreak in Terai and hill region of Uttar Pradesh, India. *IRRN.*, 4(3):20.
- Wada, T and Kobaysahi, M. 1980. Distribution pattern and sampling technique of the rice leaf roller *Cnaphalocrosis medinalis* in a paddy field.
