STUDIES ON THE MANAGEMENT OF THE YELLOW STEM BORER, *Scirpophaga incertulas* (Walk.) IN DEEPWATER RICE

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THE ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, BHUBANESWAR
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FOR THE DEGREE OF

MASTER OF SCIENCE IN AGRICULTURE
(ENTOMOLOGY)

BY
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1990

THESIS ADVISOR

Dr. B. SENAPATI

Dedicated

to

My Beloved Parents

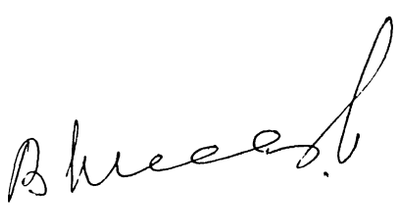
Dr.B. Senapati, Ph.D.,
Professor and Head,
Department of Entomology,
College of Agriculture,
Orissa University of
Agriculture and Technology,
Bhubaneswar 751 003.

CERTIFICATE - I

This is to certify that the thesis entitled **"STUDIES ON THE MANAGEMENT OF THE YELLOW STEM BORER, Scirpophaga incertulas (Walk.) IN DEEPWATER RICE"** submitted by Sri Biranchi Narayan Sahoo 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)** is a faithful record of bonafide research carried out by him under my guidance and supervision. No part of the thesis has been submitted for any other degree or diploma or published in any other form. It is further certified that such help and assistance availed during the course of this investigation have been duly acknowledged by him.

Bhubaneswar

Dated the 28th February, 1991.



(B. SENAPATI)

CERTIFICATE - II

This is to certify that the thesis entitled **"STUDIES ON THE MANAGEMENT OF THE YELLOW STEM BORER, Scirpophaga incertulas (Walk.) IN DEEPWATER RICE"** submitted by Sri Biranchi Narayan Sahoo to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE IN AGRICULTURE (ENTOMOLOGY)** has been approved by the Advisory Committee after an oral examination on the same in collaboration with an External Examiner.

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EXTERNAL EXAMINER

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CHAPTER I

INTRODUCTION

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

About 90 per cent of the World's rice production is harvested and consumed in Asia Where it is the staple food of 300 million people. This crop is grown in diverse situations having varied topography, soil, weather, water regime and socio-economic conditions. Less favourable rainfed rice ecosystems which currently account for almost 50 per cent of the harvest area produce only 20 to 25 per cent of the World's rice. During the last three decades commencing from 1960 improvement of rice production technologies has mainly revolved around the development of high yielding varieties devised mainly for homogenous irrigated environments. It has now become essential to increase rice productivity in heterogenous difficult ecosystems through technological changes along with the efforts for further yield increase in the favourable situations. During a period of coming 30 years i.e., by the year 2020 rice production has to be expanded from the current level of production of 508 million tonnes to 758 million tonnes, which is almost a 50 per cent increase. For maintaining lower rice prices for the consumers, achieving national food security in developing countries and sustaining and improving incomes of disadvantaged farming communities adequate atention of the rice scientists has to be given to these 50 per cent unfavourable areas.

Deepwater rice (DWR), one of the less favourable ecosystems,is adopted to about 10 million hectares in the

flood plain and deltaic regions where water depth of 0.5 to 3.5 metres during monsoon is observed (Catling, 1987). In India DWR constitutes 11.4% (4.446 million hectares) of the total wet season rice and is mainly cultivated in eastern region of the country. In Orissa DWR is cultivated in about 1.2 lakh hectares and is mainly confined to the three coastal districts, Viz., Balasore, Cuttack and Puri.

DWR is an agro-ecosystem of great antiquity. Monocropping with long duration traditional varieties having long elongating thick stems with bigger stem lumens, large air spaces, development of nodal roots, aquatic environment for a long period during the growth stage of the crop, difficulty for normal intercultural, fertilizer application and even harvesting practices are some of the unique features associated with DWR cultivation. The various production constraints including the faunistic and floristic features in different areas of DWR have not been thoroughly indentified and thus, there is an inadequacy of understanding of this rice ecosystem which has resulted in stagnation of progress in technology development.

Insect pests of rice with a record of about 1000 species are known to bring about the yield loss of 18.3 per cent on global basis (Litsinger et al.,1987). An average yield difference of 30 per cent between plots with effective pest management and no management has been observed in India in recent years, particularly in high yielding varietis grown

Pest Management Programmes. According to the estimate of Catling (1987), 600 DWR varieties are grown in Bangladesh only and in India hundreds of DWR local varieties are cultivated in different States. Differences in their reaction to stem borers attack have become evident mainly under natural conditions of infestation (Catling et al.,1984-85; Tripathy, 1989). These diverse DWR germplasms need to be tested thoroughly to indentify the less susceptible and or tolerant varieties to the stem borers, particularly S. incertulas. Added to this, yield-infestation relationship in respect of the widely adopted varieties and those which have shown some prommise in preliminary trials against the stem borers is considered as another important field of study before successfully devising integrated management strategies against the borers.

With shallow deepwater situation that prevails in Orissa,the water level recedes significantly in the booting/flowering stage of the crop during the period from the 2nd fortnight of October to 1st week of November, making the foliar application of insecticides feasible. Further, in the heading stage of the crop high level of borer incidence is manifested with the expression of white heads and causes enormous yield loss. This envisages the application of effective insecticide. However, our knowledge on the performance of insecticidel application under DWR conditions, its number, time, frequency and cost worthiness is quite inadequate.

Keeping the above objectives in view the present investigation was undertaken on the following aspects.

1. Seasonal incidence of stem borers in relation to flooding pattern in DWR areas and their off-season activities,
2. composition of different species of stem borers in DWR,
3. Screening of DWR varieties for their resistance/tolerance reactions,
4. Tolerance reaction of some selected varieties to stem borers under natural infestation condition and determination of yield-infestation relationship,
5. Effect of some insecticial application schedules on incidence of borers at heading stage and grain yield.

The results obtained from these studies provide some valuable information on the ecology of rice stem borers in DWR ecosystem, their reaction to a good number of varieties, yield-infestation relationship in 11 DWR varieties and their insecticidal control. These informations are no doubt of practical utility in developing suitable and effective stem borer management strategy under this less favourable rice ecosystem.

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CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Research on deepwater rice started in 1934 with the inception of the Deepwater Rice Research Station at Habiganj, Bangladesh (Swaminathan, 1979). In the beginning effeorts were made for isolation of certain promising pure line selections of DWR and since 1975, development of DWR varieties having yield stability received priority attention of Plant Breeders in India. However, the DWR Entomological research work, although started in late 1970s, particularly in Bangladesh, Thailand and India, have not made much progress in finding solutions to the pest problems in this difficult ecosystem. Thus, information documented on various aspects of DWR pests are quite inadequate.

2.1 PEST COMPLEX OF DEEPWATER RICE

Catling et al., (1978) recorded the yellow stem borer, Scirpophaga (Tryporyza) incertulas (Walker) as the most destructive and major rice pest in Asia and is a key pest in Bangladesh under deepwater situation. In other countries of Asia like India, and Thailand this species had also been reported to have assumed major pest status (Catling et al., 1988).

According to Catling and Islam (1979) although yellow stem borer (YSB) was listed as the major DWR pest first in 1975 in Bangladesh its true status was not discovered till 1977 when systematic pest survey in elongating DWR was undertaken.

The yellow rice borer (YSB) has been recognised as a majore rice pest in Asia and thus, one of the most damaging insect pest in India, Bangladesh, Thailand, Burma, Pakistan, Vietnam, Indonesia, Philippines, Taiwan, Malaysia, South China and Japan (Commonwealth Agricultural Bureaux, 1980).

The survey reports of Huynh Van et al., (1980) revealed that in Mekong delta areas of Vietnam, rice hispa (Dicladispa armigera), cricket (Grylotalpa africana) and thrips (Stenchaetothrips biformis) occurred in DWR in preflooding stage and BPH (Nilaparvata lugens), WBPH (Sogatella furcifera), GLH (Nephotettix virescens) and striped borer (Chilo spp.) having sporadic occurrence were of minor importance. YSB occurred in pre-flooding, flooding as well as post flooding stages of the crop.

Hillee et al., (1981) recorded the sporadic occurrence of GLH, Mealybug, thrips and root aphid in DWR in Bangladesh and these pests were of minor importance. In the same country rice hispa was also recorded in the late planted crop.

Nine insect pests, viz., grasshoppers (Hieroglyphus banian F. and Oxya sp.), leaf folder (Cnaphalocrocis medinalis Guen.), hispa (D. armigera), whorl maggot (Hydrellia philippina Fer.), WBPH (S. furcifera) and three species of stem borers (S.incertulas, Chilo supressalis Walk. and Sesamia inferens Walk.) were recorded infesting DWR in Orissa in 1989 (Tripathy, 1989).

2.2 INCIDENCE OF STEM BORERS

Five species of stem borers, viz., S.incertulas, C. supressalis, C.auricilius, C.polychrysus (Meyr.) and S.inferens have been reported to attack DWR in different countries of Asia. Of these the former species has been recognised as the dominant one over time and space.

2.21 Relative abundance of borer species

Islam (1977) stated that the YSB was the most abundant stemborer of deeply flooded rice in Bangladesh.

Catling (1979,1981) repored that in Bangladesh, S.incertulas was the dominant borer species in DWR causing 25.3% stem damage and the darkheaded borer, C.auricilius was observed in shallow deepwater situation. In Thailand YSB comprised more than 95% of the borer population. Further studies by the author (1984) revealed that S.incertulas usually comprised more than 90% of the borer population and was almost exclusively present during the main flooding period. C. polychrysus comprised 11% and S. inferens 6% of the population in the pre-flood and ripening stages.

According to the report of Hussain and Begum (1985) in Mymensingh area of Bangladesh, S. incertulas constituted 60-97% of the total borer population from July - October and Chilo polychrysus and C. auricilius constituted 19-85% during

the period from November - May. The pink borer, S. inferens which maintained low population in the beginning increased from November - May because of availability of its alternate host, wheat in the fields.

Barrion and Litsinger (1987) reported that the relative abundance of different borer species in DWR fields in Philippines was in the order of S. incertulas > Chilo auricilius > C. supressablis > S. inferens.

According to Rai et al.,(1989) stem borer complex in DWR under North Bihar (India) conditions mainly consisted of S. incertulas S. inferens C. supressalis and C. polychrysus the proportion of their larval population being 3 to 89%, 12 to 81%, 8% and 2 to 28% respectively in cultivar Janki during different crop growth stages in 1983. Population of C. supressalis was the highest in the Ist fortnight of November and remained maximum till July. The YSB and PSB were predominant on the wet season rice.

Extensive field surveys conducted by Senapati et al.,(1990) in Orissa during 1986 through 1988 indicated that, of the three species of stem borers (S.incertulas, C. supressalis and S. inferens) the YSB which constituted 66.67 - 100% of the larval population in dissected stems in the grain ripening stage was the predominant species. SSB and PSB comprised 0.00-11.11 and 0.00-22.22% of the total larvae recovered. Further studies in the State also revealed almost

the same trend, the mean larval population being 97.14, 2.86 and 0.00% in vegetative and 85.11, 10.64 and 4.25% in the heading stage of the YSB, SSB and PSB respectively (Tripathy, 1989).

2.22 Extent of crop damage and yield loss

YSB had been reported to inflict 20-40% stem damage in DWR in Bangladesh and Thailand (Catling, 1979; Catling and Pattrasudhi, 1981).

Catling and Islam (1979) and Catling (1981) conducted a series of crop loss assessment experiments in Bangladesh and reported 20-40% yield loss in DWR by YSB. In field experiments a 20-40% yield loss was related to 33% damaged stems thus, having a damaged stems to yield loss ratio of 1:1. Results of pot culture experiments of Catling and Islam (1979) revealed that the panicles borne in the compensatory tillers were 27-30% lighter in weight. In other experiments Catling (1981) observed 15-25% infestation in the stem elongation stage during July to September and 15-30% yield loss due to YSB larval feeding in the grain ripening stage.

In Prachin area of Thailand Catling (1981) recorded an exceptionally high stem damage of 71% due to S. incertulas in ripening stage. However, the mean stem damage of 3% in early elongation stage of the crop increased to 37% at harvest.

Observatons of Huynh Van et al.(1983) in Mekong delta area of Vietnam showed that YSB caused 30-38, 32-38 and 34-44% stem damage in flowering, hard dough and full grain ripening stages of DWR respectively.

Rice stem borers had been reported as relatively unimportant in the pre-flood period and with flooding, the YSB was found active for three successive generations causing on an average, 23% damaged stems by the flowering stage and 38-44% at the late ripening stage in Thailand (Catling et al.,1984-85).

Yield loss assessment studies conducted by Catling et al.(1987) in Bangladesh and Thailand revealed 27-34% yield reduction due to stem borers and there was 1% yield loss with each 2% damaged stems at harvest. Yield loss was mainly due to a loss of bearing stems and lighter panicles borne by compensatory nodal tillers.

Prasad et al. (1988) recorded grain yield of 3.6 g/panicle from stem with 0-20% damage and that than 2.8 g/panicle from stem with more than 60% damage in DWR. In this case the yield reduction was estimated to be 32 per cent.

Senapati et al. (1990) reported that in Orissa the incidence of DH and WH in different areas ranged from 0.00 - 3.46% and 11.42-40.09% respectively and dissection of stems,

aparently looking healthy revealed 0.00-17.48% damaged stems in the vegetative stage and 13.95-54.76% in the heading stage of DWR.

A recent report from Bangladesh indicated 17% yield loss in DWR due to the attack of S.incertulas during the last 11 weeks (from flooding to crop maturity stage) of the crop growth period (Islam, 1990).

2.23 Seasonal fluctuation in borer incidence

There is strong evidence that the YSB has high moisture requirements and hence it shows preference to areas having poor drainage. The larvae always bore downwards (Yasumatsu, 1976).

S. incertulas has been reported to be highly adapted to deeply flooded rice in Bangladesh. On the contrary, high temperature and low humidity before flooding were known to reduce its population severely due to low rate of egg laying and high mortality of eggs by desication (Catling, 1981).

Catling et al. (1984) were of the opinion that in Bangladesh and Thailand the low YSB activity in the early part of the season was due to mainly a low nucleus population, the synchronous planting of DWR, severe moisture stress, high temperatures in the pre-flood period, longer pre-flood period and the lack of an intervening rice crop in the dry season. The borer activity had been observed to increase steadily

during the first three to four months of flooding and caused, on an average, 23% damaged stems by the flowering stage. The activity of the borers continued at about the same level as the water receded and reached the maximum annual levels of 38-44% damaged stems at the late-ripening stage. At harvest in 60% of the fields more than 40% damaged stems were recorded.

According to Datta et al. (1985) during July - September, when almost all the stems were submerged, a few plants were infested by stem borers. They recorded peak infestation in October when the plants were in pre-flowering stage and with the decrease of water level the extent of infestation increased. Stem damage was substantially higher in the last three internodes at harvest.

Effect of prevailing temperature and humidity on the survival of eggs and first instar larvae of S. incertulas was studied by Suwongwan and Catling (1987) who observed that survival of eggs was three times lower in hot - dry pre-flood period (April - June) than in milder conditions of flooded rice during September - October. There was a negative co-rrelation between the survival of eggs and maximum daily temperature and minimum RH. High mortality was observed when the maximum daily temperature was above 33^{o}C and the relative humidity was less than 70%.

In Philippines, the YSB moths were attracted to the rice plants at tillering and late tillering stages for oviposition which was absent in plants at pre-booting, heading and ripening stages (Kumhof, 1987). The author further observed that the larval population increased from tillering and late tillering stage to milk stage. There were low levels of infestation and increased levels of mortality in plants at panicle initiation, beginning of stem elongation and dough stages. The susceptibility of the plants for infestation during tillering and reproductive stages were altered because at the vegetative stage the plants were able to tolerate infestation by producing more compensatory tillers.

According to the report of Rao and Padhi (1988), brood emergence of YSB in outbreak years was higher than that in normal years and relatively greater solar radiation was recorded during outbreak years. Further, the rainfall during August - November and rainy days during October - November were significantly negetively co-rrelated with the infestation. The authors were of the opinion that the mean sunshine hours/day and maximum temperature in September - October were also related to infestation.

In Orissa, stem borer incidence was first observed in August first fortnight, gradually increased to an average of 21.58% infestation in the 2nd fortnight of September, with a decline in October to 10.97% in the vegetative stage. In the

flowering and grain ripening stages during November and December, WH and DS accounted for, on an average, 16.92-22.90 and 49.16-51.61% respectively (Tripathy, 1989).

2.24 Off-season activities of stem borers

As per the report of Kawada et al.(1934) the matured YSB larvae passed the winter inside the rice stubbles in a state of diapause until the warm weather begins in April - May when they underwent pupation. Migration of the larvae to the base of the stubbles was also observed by the authors.

Mervyn and Edwin (1968) in their studies on the effects of seasonal fluctuation and abundance of various rice stem borers in Philippines observed that S.incertulas was the dominant species in the standing crop constituting about 70% of the borer population, but after harvest of the crop, C. supressalis was dominant in stubbles and the YSB population declined.

The stubbles of the rice variety, 'CR 303' had been reported to harbour 35.6% of the stem borer larvae and the dominant species recovered were S. incertulas (74.2%), S. inferens (13.3%) and C. supressalis (12.5%) (Israel, 1969).

Israel et al. (1967) Saha and Saharia(1970) reported that the immature larvae harbouring in the stubbles ranged from 1.61-12.7% with an average of 6.33% in different

treatment combinations of dates of transplanting and levels of nitrogenous fertilizer application.

Results of the study on the relative abundance of lepidopterous stem borers in rice stubbles conducted by Panda et al. (1974) revealed that YSB and SSB were distributed in equal proportions in the upland and medium land rice stubbles, where as the SSB was more abundant in low land rice stubbles during rainy season. Higher populations of Chilo sp. (52.3-65.98%) were recorded from stubbles of winter rice crop which also harboured pink borer (4.5-13.01%) irrespective of the land type.

Parida (1979) recorded 4.1-7.02% tillers having borer damage and 2.56-5.26% stubble tillers contained borer larvae in rice variety 'Jaya'. In case of the variety 'Shakti', 3.83-4.28% tillers were infested by borers and the larvae were recorded from about 3.28% of the stubble tillers.

In December and January the entire YSB population was known to be confined to stubbles in the field in Bangladesh (Catling, 1981).

Zafar (1983) conducted field studies on the hibernation of stem borers (Scirpophaga and Sesamia) in the stubbles of the harvested field left over as ploughed and upploughed fallow in Pakistan and reported that on an average,

4.1 and 1.6 number of larvae were observed per stubble from the ploughed and upploughed fallow respectively.

Deng et al. (1984) observed that in China the number of overwintering SB larvae was higher in hybrid rice stubbles and body weight and fat content of the larvae recovered from hybrid rice were also higher.

As per the report of Shen (1985) the overwintering population of stemborer larae in the stubbles had co-rrelation with the subsequent number of adults observed and the factors influencing the overwintering population were mainly temperature and relative humidity.

Observations on the off-season behaviour of stemborer diapausing larvae in DWR stubbles at Perapur in West Bengal during 1989 revealed 72-90% YSB, 7-19% PSB and 3-9% dark headed stem borer (DHSB) in January and 42% YSB, 42% PSB and 16% DHSB in February (Anon, 1989).

2.3 RESISTANCE/TOLERANCE OF DWR VARIETIES TO STEM BORERS

Certain specific plant characters like long, wide and healthy stems favouring oviposition, larger sheath groove and low percentage of dry matter making them more socculent, presence of high proportion of air passages and poor development of schlerenchymatous tissues and elongating stems favouring the penetration of first instar larvae of stem

borers had been reported to be associated with higher level ofborer incidence inrice (Israel, 1967; Chaudhury and Zamal, 1970; Manwan, 1975; Fang, 1977 and Datta and Banerjee, 1979).

During the late 1970's and 1980's a large number of DWR varieties were screened under natural conditions of infestation in Bangladesh, India and Thailand. According to the report of Catling (1979), 16 entries (10 Bangladesh indigenous varieties, 1 Rayada strain and 5 advanced breeding lines) were screened for resistance to the YSB in Bangladesh in 1978. On an average 17% (9-25%) stems were damaged by the borer in the indigenous entries as against 25% (13-29%) in advanced breeding lines in the stem elongation stage. Varieties having thicker stems were more severely damaged by the pest.

Catling (1979) also screened 21 entries at three sites in Bangladesh. He observed that the stem borer activity was low in pre-flood period with 0.4-2.9% DH at deeply flooded sites and 0.6% DH at shallow deep water sites. Varieties like Mura Bajal and BR 222-B-358 were most severly infested. On an average, 10-20% DS were observed in eight entires and 11 entries had less than 10% DS None of the entires showed below 5% damage indicated possible resistance. There was similarity between the overall level of damage in shallow water sites and that of deeply flooded sites, but no entry had more than 20% DS. Varietal reaction in this situation differ from that in deeply flooded sites, the reasons of which were ascribed by

the author to be shorter stems, different growth habit of the plants and greater activity of daskheaded borer (C. polychrysus).

Out of the 51 entries successfully screened in Bangladesh in 1979, 12 had less than 5% DS in the heading stage and the rest having 6-30% DS were considered as susceptible (Catling, 1979).

Of the 72 entries (7 Bangladesh pureline selections, 45 Bangladesh indigenous varieties, 5 foreign varieties and 15 advanced breedling lines including 2 from Thailand) screened for reaction to YSB, only one entry, 'Shulpan' showed less than 5% stem damage. In farmers' field surveys another 13 varieties (Barracha, Bashi Raj, Bhadoia, Dudh Moni, Guda Lokhi, Haroli, Hijaldigha, Horigachi, Jhaolath, KalaAman, Kalaharsal, Kusta and Bawalia) were also found to show less than 5% stem damage which were suggested for further screening (Catling, 1981).

In screening trials for resistance to stemborers in Uttar Pradesh during wet season of 1978, 79 and 80, Chaudhury et al. (1985) observed 23 (Out of 61) flooded rice cultivars and 11 (out of 37) DWR cultivars to have shown resistance reaction to YSB with less than 1% incidence. The 11 resistant cultivars were Agahani, DW 3,DW 20, DW 23, DW 88, DW 91, GMS 12, GT 118, Kalamdan and Turhia. Moderately resistant

varieties (Aalaungi, Aaranga, Aariawa, Anandi, Anjani, Bhainslet, DW 48, Gonth, GT 95, GT 103, GT 117, Jaisuria, Latamangri, Mansera, Rajal, Sengar, Suapankhi and Usha) with 1-5% pest incidence were 18 in number. Aalangi, Dhania, Ghoghari, Jalmagan, Jarhan, Kangra, Latera and Singhara were the eight susceptible varieties which had 6-50% incidence.

During 1989, 133 DWR varieties including Patani-23 as the susceptible check collected from different States (Assam 34, Bihar 10, Orissa 50, UP 23 and WB 16) were screened at Chinsura, West Bengal. Lowest incidence of stem damage (2%) in the grainripening stage was recorded in three varieties. viz. Herepi and Laodubi from Assam and TCA-12 from Bihar, as against highest incidence of 39.5% in the West Bengal Variety, CN 570-661-48-3. Further, less than 5% stem damage was observed in 15 varieties (8 from Assam, 2 from Bihar and 5 from Orissa). The varieties from Orissa recording low borer incidence were Champa, Kalapakhira, Madankhatia, Matia and Mayurkantha (Anon,1989).

Of the 42 varieties screened under field conditions by Tripathy (1989), 26 and 21 varieties had less than 5% DH and WH respectively. Taking into account the low incidence of WH and total infestation as well as high tolerance ratio, 9 varieties, viz., Achuwabayahonda, Bayahonda, Hendakadala, Kakudimanji, Kalamahipal, Kalapakhira, Moogey, Patani and Sapadidhan were considered less susceptible to the stem borers.

2.4 INSECTICIDAL CONTROL OF STEM BORERS IN DWR

A considerable number of experiments both in field and laboratory have been conducted in different parts of India and other countries to evaluate various insecticides against the YSB of rice under medium and low land situations. Results of these experiments suggested that amongst the different granular insecticides carbofuran, phorate, cartap and of the sprayable compunds monocrotophos, phosphamidon, quinalphos, acephate, carbofuran, chlorpyriphos, fenvalerate, chlordimeform, fenthion, cypermethrin were effective against this pest (Fukuda, 1966; Dhaliwal et al., 1982; Saroja and Raju, 1982; Rizvi et al., 1983; Prasada Rao et al., 1984; Murugesan and Chelliah, 1984; Krishnamurthy and Ramsubbaiah, 1986; Ukwungwu, 1986; Pandya et al. 1987; Dubey et al., 1987; Balasubramanian et al., 1987; Murthy et al., 1988, Rajamani, 1988; Peter and David, 1988; Purohit et al., 1988; Singh and Verma, 1988 and Dhaliwal and Singh, 1988). According to Rajamani (1984) quinalphos in vegetative stage and monocrotophos in heading stage @ 0.5kg a.i./ha as foliar spray afforded excellent control of YSB in low land rice. However, information documented show that very few experiments had been conducted on DWR to evolve insecticidal control strategy against the stemborers.

Results of experiments conducted at Ghaghraghat (UP) revealed that basal application of Carbofuran granules at 1.5 kg a.i./ha at sowing followed 25 days later by three sprayings

of 0.05% phosphamidon at three week intervals reduced stemborer incidence from 3% to 1.1% in 1979 and from 35.6% to 11.6% in1980 (Singh, 1981).

Catling (1981) reported from his insecticidal trials in 1978 conducted in Bangladesh onDWR that 22 applications of insecticides (granular carbofuran twice before flooding and 20 sprays of diazinon at 6-7 days interval) could not give total protection from YSB attack. Stem infestation in treated plots was 9% as against 33% in untreated plots. Results of similar experiments of the author in 1979 with 20 sprays of diazinon showed that there was 13.5% infestation in treated plots as against 33.2% in the untreated check plots.

According to Taylor and Islam (1982) spraying of monocrotophos @ 250g a.i./ha in mid-August reduced infestation significantly and increased grain yield by 7.3-10% over control.

Pandey et al. (1983) evaluated several insecticidal combinations against YSB in deepwater conditions during wet season (1979-80) and observed that casbofuran 3G at 1.5 kg a.i./ha + phosphamidon spray at 0.05% was most effective in controlling the pest and increasing the yield.

Some low toxic insecticdes and neem oil were evaluated for their effectiveness against stem borer in DWR during 1988

in West Bengal. The results showed that cartap hydrochloride (Padan 50SP) @ 0.5 kg a.i./ha resulted in least WH incidence and fenitrothion (Sumithion 50 Ec) @ 0.5 kg a.i./ha, fenitrothion + Entice (an US made feeding stimulant for lepidopterous insects @ 20 ml/l) @ 0.5 kg a.i./ha and phosphamidon (Dimecron 85 WSP) @ 0.3 kg a.i./ha were at par (Anon,1989).

A recent field experiment conducted in Orissa revealed that application of monocrotophos @ 0.5 kg a.i./ha twice at boot leaf/flowering stage either at 7 or 14 days interval in DWR (Var. Panikoili) resulted in significant reduction of WH and DS and increase of grain yield of 5.02-6.22 q/ha over control. However, the three spraying schedule had no significant additional advantage over the two spraying schedules (Anon,1990).

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CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

Investigations on the ecology of rice stem borers in deepwater rice ecosystem, screening of deepwater rice (DWR) varieties for resistance/tolereance to stem borers and their insecticidal control were carried out during the year, 1990. This chapter describes the various materials used and methods adopted for these studies.

3.1 EXPERIMENTAL SITES AND SEASON

The studies on the stem borer complex of rice, seasonal fluctuation in their incidence and their association with other insect pests under deepwater situation were undertaken during the wet season of 1990 in Bramhagiri block of Puri district and Patamundai block of Cuttack district which are the typical DWR areas in Orissa. These ecological studies along with varietal screening for resistance/tolerance to the stem borers and their insecticidal control were conducted at the Central Agricultural Research Station of Orissa University of Agriculture and Technology, Bhubaneswar during the same season. Besides, field experiments on tolerance of some selected DWR varieties to stem borers and a second trial on their insecticidal control were also conducted in the Government Agricultural farm located at Pipili. Off- season activities of stem borers were also studied in the above Government farm during the period from January to June, 1990.

3.2 STUDIES ON PEST COMPLEX AND THEIR SEASONAL FLUCTUATION

3.21 Sequential survey

During the cropping period from June-December 1990, sequential studies on occurrence of different insect pests, extent of infestation and flooding patterns were made at three locations, viz.,one village of Bramhagiri block in Puri district and one village of the Patamundai block in Cuttack district and Central Agricultural Research Station, Bhubaneswar. In each of the two blocks two plots and in the latter location one plot of 0.2 - 0.4 ha area were selected for recording observations during the entire course of study. In Bramhagiri and Patamundai the plots were visited once in every fortnight where as that in Bhubaneswar once in a week. The detail information on the villages included in the survey programme and the varieties examined are given in Table 1.

Table. 1 Blocks, villages and varieties involved in the sequential survey programme in Orissa during the wet season of 1990

District	Block	Village/ location	Variety	
			Plot-I	Plot -II
Cuttack	Patamundai	Mulabasanta	Kalakhuda	Banash.ali
Puri	Bramhagiri	Goruala	Laxmi Kajal	Kalasura
	Bhubaneswar	Central Agril. Research Station,OUAT.	Panikoili	-

Square metre sampling technique was adopted for recording the extent of infestation and the population of the concerned pests. For this purpose a wooden quadrat of 1m X 1m was used. In each field five stratified random samples were taken each time and incidence of deadhearts (DH) at vegetative stage and white earheads (WH) at heading stage was recorded by counting the total number of tillers and DH and WH per square metre area respectively. The percentages of DH and WH were computed. In addition to this, 50 tillers appearing outwardly healthy were collected from each field in vegetative stage and 50 ear bearing tillers in the heading stage and were dissected to findout the extent of stem damage by different species of stem borers. The larval population density of different borer species and their relative abundance were assessed.

The extent of leaf damage inflicted by the different species of foliage feeders like leaf folders (LF), grasshoppers (GH), cricket and hispa was also estimated by.counting the total number of leaves and infested leaves in 10 clumps oneach day of observation in each field.

Water level in each sequential study plot was measured with the help of a metre scale on each day of observation with a view to study the flooding pattern during the season.

3.22 Studies on the off-season activities of stem borers

With a view to study the off-season behaviour of the stem

borers, stubbles of 20 clumps of the DWR variety, 'Panikoili' grown during the wet season of 1989 in the Government Agricultural Farm located at Pipili were collected randomly at 7 days interval from the first week of January to last week of March, 1990. The stubbles were dissected in the laboratory and number of larvae/pupae of different borer species as well as the extent of infestation caused by them were recorded. The percentage stubble infestation by different borer species and their relative abundance were calculated. In order to identify the larvae/pupae of different borer species, the book entitled "Illustrated Guide to Integrated Pest Management in Rice in Tropical Asia" and published by the International Rice Research Institute, Philippines was used as reference.

3.3 SCREENING OF DWR VARIETIES FOR RESISTANCE/TOLERANCE TO STEM BORERS

Two sets of field experiments were conducted to screen the DWR varieties against the stem borers under natural conditions of infestation. In the first set sixty varieties collected from different locations of Orissa, Assam and West Bengal were grown in the wet season on 1990 in the Central Agricultural Research Station, Bhubaneswar in observation strips. The different varieties included in the test programme and their sources of collection are given in Table 2. For getting healthy seedlings, the seeds of the varieties were sown

Table 2. DWR varieties used for screening against stem borers and their source of collection

Sl. No.	Variety	Source of collection			
		Village	Block	District	State
1	2	3	4	5	6
01.	Kanthapakhira	Jagauallipur	Tirtol	Cuttack	Orissa
02.	Talamula	-do-	-do-	-do-	-do-
03.	Katakichandi	Siha	Ersama	-do-	-do-
04.	Athagarbangi	-do-	-do-	-do-	-do-
05.	Badakantamal	-do-	-do-	-do-	-do-
06.	Matia	-do-	-do-	-do-	-do-
07.	Raspanjar	-do-	-do-	-do-	-do-
08.	Kalamahipal	-do-	-do-	-do-	-do-
09.	Khajira	Jajanga	Kendrapara	-do-	-do-
10.	Panisanar	-do-	-do-	-do-	-do-
11.	Harisankar	-do-	-do-	-do-	-do-
12.	Pakhia	Seraei	Knas	Puri	-do-
13.	Kalashira	-do-	-do-	-do-	-do-
14.	Ghodatapua	Sarada	Gop	-do-	-do-
15.	Champa	Musunpur	Nimapara	-do-	-do-
16.	Mayurkantha	Musunpur	-do-	-do-	-do-
17.	Sapadidhan	Pattangi	Pattangi	Koraput	-do-
18.	Achuwabayahonda	Gadiakhola	Gunpur	-do-	-do-
19.	Champeisiali	baiganbadia	Jaleswar	Balasore	-do-
20.	Dhulia	-do-	-do-	-do-	-do-
21.	Kakhuria	-do-	-do-	-do-	-do-
22.	Madankhatia	-do-	-do-	-do-	-do-
23.	Patani	-do-	-do-	-do-	-do-
24.	Moogey	-do-	-do-	-do-	-do-
25.	Desichampa	Badakundura	Gop	Puri	-do-
26.	Baunsagaja	Jaguliapada	Rajkanika	Cuttack	-do-
27.	Hendakadala	Kalyanpur	Binjharpur	-do-	-do-
28.	Rebati	Jaguliapada	Rajkanika	-do-	-do-
29.	Birijana	Kalyanpur	Binjharpur	-do-	-do-
30.	Madua	Jaguliapada	Rajkanika	-do-	-do-

Contd.....

Contd.....Table 2.

1	2	3	4	5	6
31.	Ravana	Jaguliapada	Rajkanika	Cuttack	Orissa
32.	Khura	Kalyanpur	Binjharpur	-do-	-do-
33.	Panikoili	Chapalli	Mahakalapada	-do-	-do-
34.	Panidhan	Central Rice Res. Institute		-do-	-do-
35.	Bayahonda	Pattangi	Pattangi	Koraput	-do-
36.	Malbhog	Regional Agril.Research Station			Assam
37.	Panikekua	-do-			-do-
38.	Amona	-do-			-do-
39.	Acc^{n} 7/21-2	-do-			-do-
40.	Tulasibau	-do-			-do-
41.	Rupahi	-do-			-do-
42.	Sarsuri	-do-			-do-
43.	AR 14	-do			-do-
44.	Laldhepa	-do-			-do-
45.	TCN	-do-			-do-
46.	Moimansingiabao	-do-			-do-
47.	Kajalibao	-do-			-do-
48.	Harkana	-do-			-do-
49.	Jalbao	-do-			-do-
50.	Rangabalam	-do-			-do-
51.	IRDWON 53	-do-			-do-
52.	Itkhulig	-do-			-do-
53.	Dalbao	-do-			-do-
54.	Maguri	-do-			-do-
55.	Negheribao	-do-			-do-
56.	Kekua	-do-			-do-
57.	Katisali	-do-			-do-
58.	IRDW 10	Chinsura Research Station			West Bengal
59.	IRDW 11	-do-			-do-
60.	IRDW 12	-do-			-do-

in raised nursery beds in lines on June 13, 1990. FYM was applied to the nursery bed at the time of sowing. However, no chemical fertilizer was applied to the nursery beds. On 26th July, 1990, the seedlings of each variety were transplanted in the main field prepared earlier for the purpose. The seedings were transplanted with a spacing of 30 cm X 20 cm. For each variety there were 4 rows, each being 2.8 m in length. Only one seedling per hill was planted and there were 56 plants plot for each variety. A gap of 60 cm was given between two test varieties (Fig. 1). At the time of transplanting fertilizers were applied @ 30 : 20 : 20 kg of N, P_2O_5 and K_2O as urea, SSP and MOP respectively.

Reaction of the varieties to stem borers was studied by observing the incidence of DH and WH at vegetative and heading stages respectively. The middle two rows in each variety were examined for the purpose. In addition to this tillers of 10 randomly selected clumps from the middle two rows of each variety were dissected both at vegetative and grain ripening stages (two days before harvest) to study the extent of stem damage here after referred as damaged stems (DS). A record of the incidence and intensity of larvae and/or pupae of different borer species present in each variety dissected was also kept. The tolerance ratio was calculated at both the stages by using the following formula.

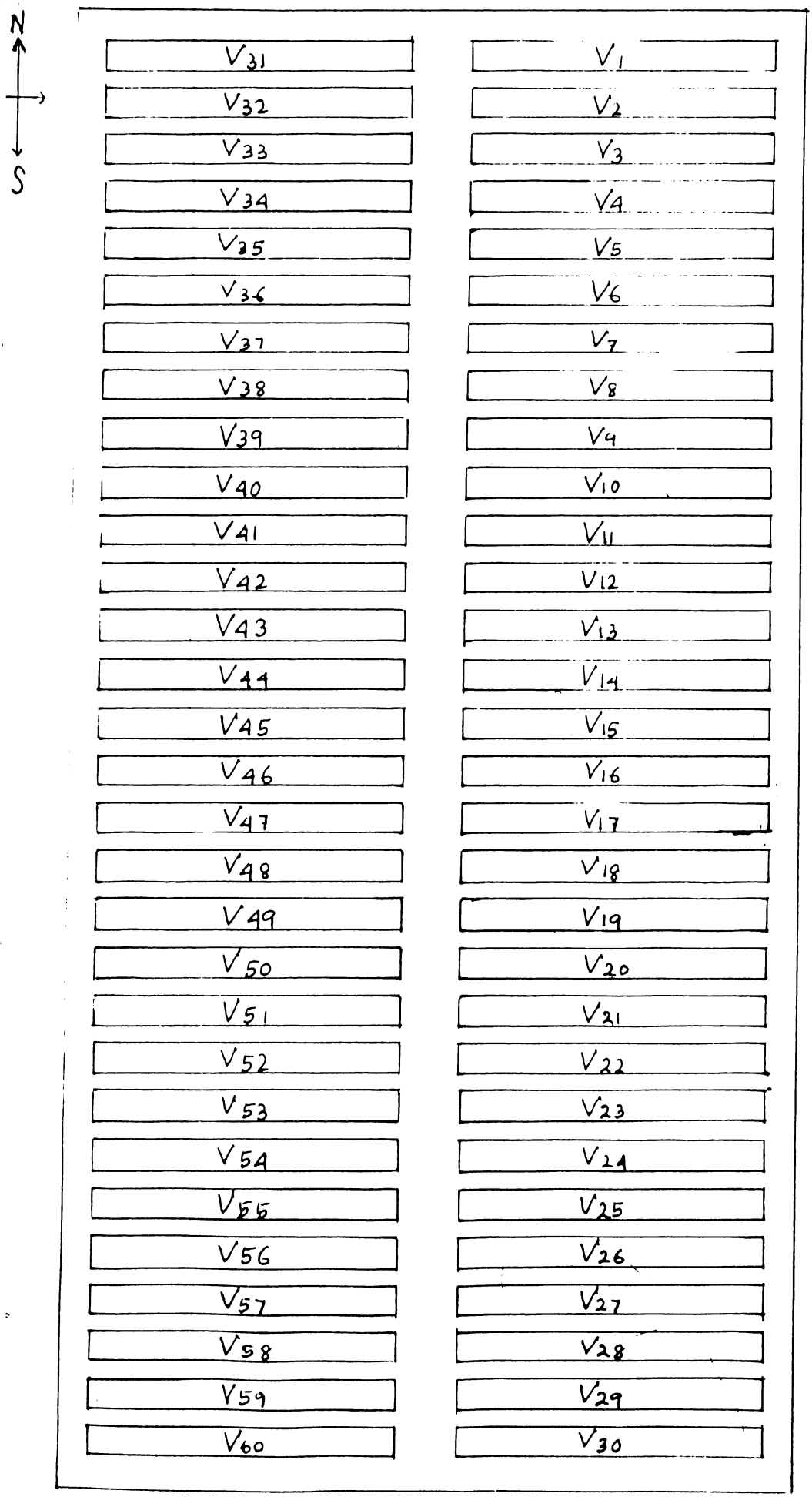

FIG. 1. PLAN OF LAY OUT OF THE VARIETAL SCREENING TRIAL AT BHUBANESWAR

$$\text{Tolerance ratio (TR)} = \frac{\text{Percentage TI}}{\text{Percentage DH/WH}}$$

Where TI = Total infestation (i.e., DH/WH + DS)

DH = Dead hearts

WH = White heads

DS = Damaged stems

Nine DWR varieties, Viz., Achuwabayahonda, Bayahonda, Champeisiali, Hendakadala, Kalamahipal, Mayurkantha, Moogey, Patani and Sapadidhan which were found less susceptible in 1989 screening trial along with two new entries such as Panidhan and Panikoili (the standard check) were field evaluated for their tolerance reaction to stem borers under natural condition of infestation. The experiment was laid out in RBD with three replications in Government Agricultural Farm, Pipili. Seeds were sown in nursery on June 7, 1990 and 57 days old seedlings were transplanted on August 3, 1990 at a spacing of 30 cm X 20 cm. Each plot measured 12 sqm (4 m X 3 m) and gaps of 60 cm between two plots and 100 cm between two replications were maintained (Fig.2). There were 200 hills (each with two plants) in 10 rows in each plot. FYM @ 5 t/ha was applied during land preparation. No fertilizer was applied to the crop.

The sampling techniques for recording the incidence of DH, WH and DS by the stem borers were the same as described in section 3.21.

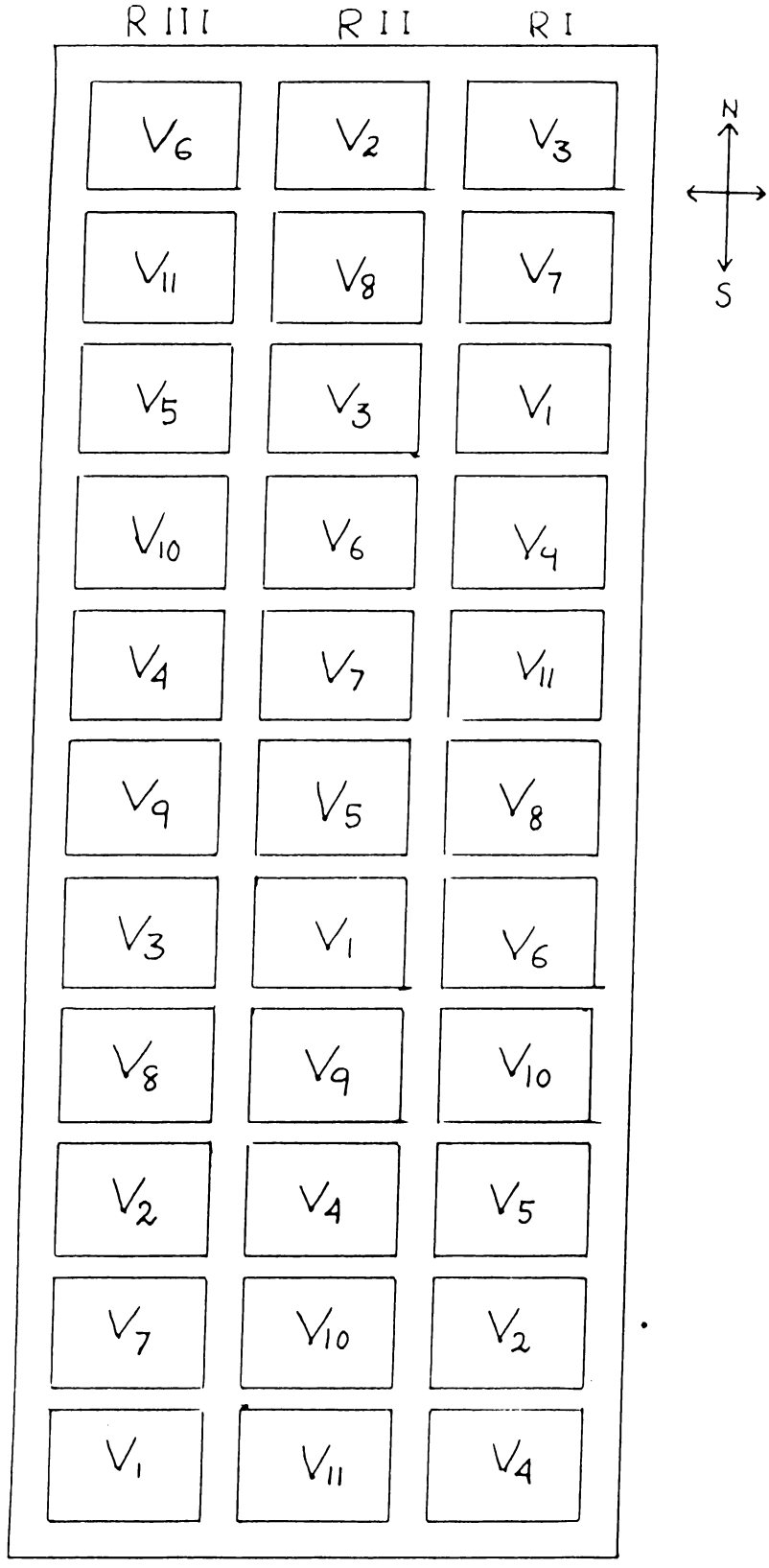

FIG. 2. PLAN OF LAY OUT OF THE VARIETAL SCREENING TRIAL FOR TOLERANCE TO SB.

While assessing the extent of DS heading stage through stem dissection the panicles of healthy plants and those of plants showing stem damage were separated and observations on panicle length, number of grains/panicle percentage chaffy grains, 1000 grains weight and grain yield/panicle were recorded. For each variety in each replication 10 panicles, each of healthy and infested plants were taken. Percentage reduction/increases for each of the above traits and per cent yield loss due to stem damage was computed as indicated below.

$$\text{Percentage reduction of panicle length} = \frac{\text{Mean panicle length in healthy plants} - \text{Mean panicle length in infested plant (showing stem damage)}}{\text{Mean panicle length in healthy plants}} \times 100$$

$$\text{Percentage reduction of number of grains/panicle} = \frac{\text{Mean number of grains/panicle in healthy plants} - \text{Mean number of grains/panicle in infested plants}}{\text{Mean number of grains/panicle in healthy plants}} \times 100$$

$$\text{Percentage reduction of 1000 grain weight} = \frac{\text{Mean weight of 1000 grains obtained from healthy plants} - \text{Mean weight of 1000 grains obtained from infested plants}}{\text{Mean weight of 1000 grains obtained from healthy plants}} \times 100$$

$$\text{Percentage increase of chaffy grains} = \frac{\text{Mean \% chaffy grains in panicles obtained from infested plants} - \text{Mean \% chaffy grains in panicles obtained from healthy plants}}{\text{Mean \% chaffy grains obtained from panicles obtained from healthy plants}} \times 100$$

$$\text{Percentage yield reduction (PYR)} = \frac{\text{Mean grain yield/panicle obtained from healthy plants} - \text{Mean grain yield panicle obtained from infested plants.}}{\text{Mean grain yield/panicle obtained from healthy plants}} \times 100$$

$$\text{Percentage yield loss due to stem damage} = \frac{\text{Percentage DS X PYR}}{100}$$

3.4 INSECTICIDAL CONTROL OF STEM BORERS

Two field trials on insecticidal control of stem borers in the heading stage were conducted in the wet season of 1990, one in the Government Agricultural Farm, Pipili and the other at Bhubaneswar. Panikoili, an extensively grown DWR variety in Mahakalapada and Marshaghai areas of Cuttack district was taken as the test variety in both the trials. In the trial conducted at Pipili there were five treatments with four replications

arranged in a simple RBD. A total of 20 plots each measuring 21 sqm (7 m X 3 m) were prepared for the purpose (Fig.3). Healthy seedlings of the said variety sown on the raised nursery beds on June 2, 1990 were transplanted in the puddled plots on August 2, 1990. No fertilizer was applied to the crop. Details of the treatments are presented in Table 3a. Dimedon, the commercial preparation of phosphamidon supplied by E.C.I. Agrochemicals (Private) Limited, Calcutta was used @ 0.3 Kg a.i./ha as the test insecticide in this experiment and the spray liquid applied @ 500 l/ha.

In the trial conducted at Bhubaneswar, Guardian 36 SL, the commercial preparation of monocrotophos supplied by Gharda Chemicals Ltd., Bombay was used @ 0.5 Kg a.i./ha in place of phosphamidon and there were six insecticidal treatments as presented in Table 3b. There were 24 plots, each measuring 5.1 X 4 sqm area (Fig. 4). Urea, SSP and MOP were applied to provide @ 30 : 20 : 20 Kg of N, P_2O_5 and K_2O/ha respectively. Healthy seedlings from the nursery bed sown on June 9, 1990 were transplanted in the main field on July 24, 1990 at a spacing of 30 cm X 20 cm. There were 17 rows/plot, each with 20 hills. There were gaps of 60 cm between two treatments and 100 cm between two replications.

The incidence of WH and DS was recorded at grain maturity stage of the crop in the 3rd week of December, 1990. The square metre sampling

Table 3 a. Insecticidal treatment schedules tested against stem borers of DWR in heading stage at Pipili during the wet season of 1990

Sl.No.	Treatment	Description of the treatment	Date of spraying
1.	T_o	Untreated check	-
2.	T_1	One spraying with phosphamidon @ 0.3 kg a.i./ha, at boot leaf stage.	26.10.90
3.	T_2	Two sprayings with phosphamidon @ 0.3 kg a.i./ha, once at boot leaf stage and the second at 7 days later.	26.10.90 and 2.11.90
4.	T_3	Two sprayings with phosphamidon @ 0.3 kg a.i./ha, once at boot leaf stage and the second at 14 days later.	26.10.90 and 9.11.90
5.	T_4	Three sprayings with phosphamidon @ 0.3 kg a.i./ha, once at boot leaf stage, other two at 7 days interval.	26.10.90, 2.11.90 and 9.11.90

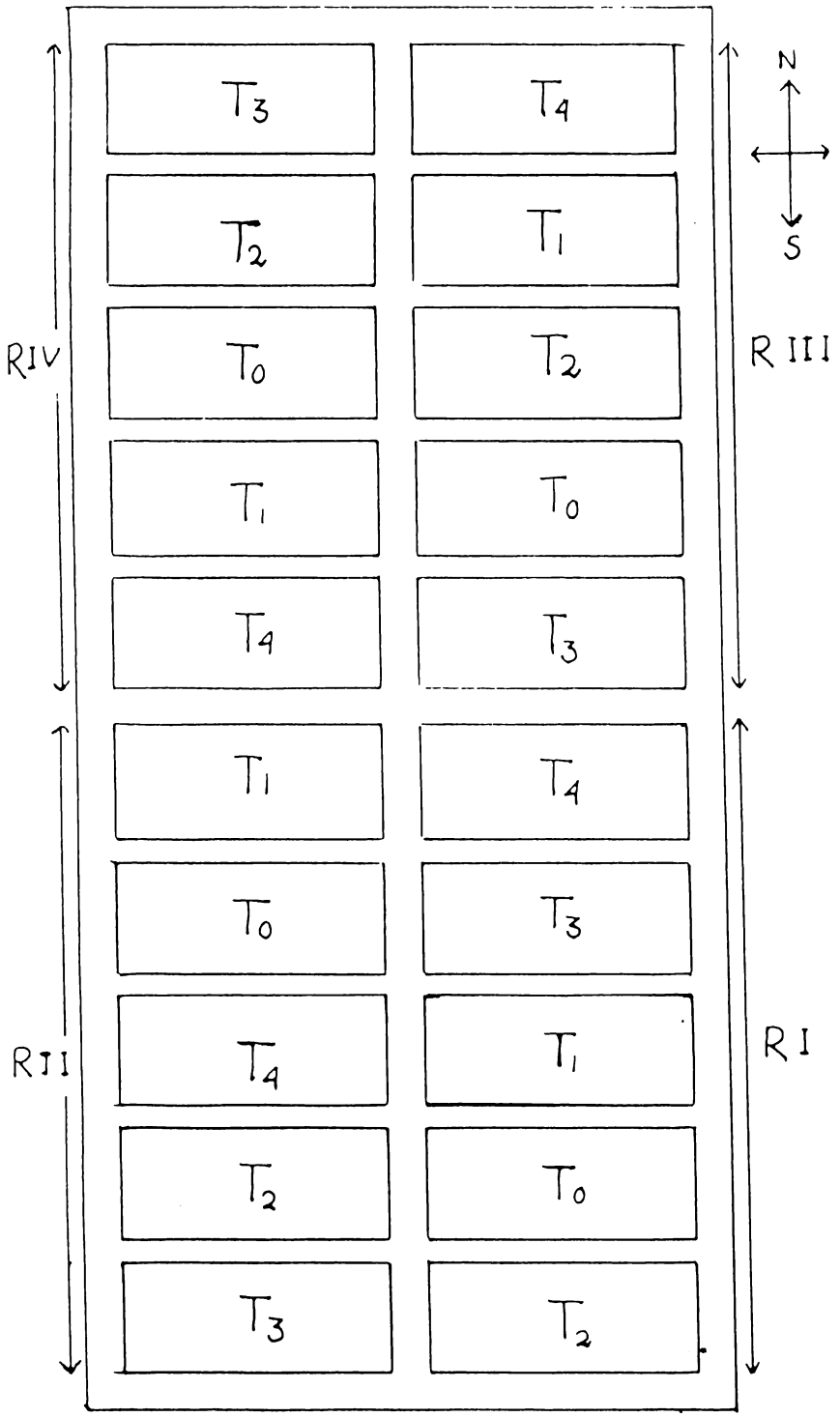

FIG. 3. PLAN OF LAY OUT OF THE TRIAL ON INSECTICIDAL CONTROL OF STEM BORER IN HEADING STAGE OF DWR AT PIPILI

Table 3b. Insecticidal treatment schedules tested against stem borers of DWR in heading stage at Bhubaneswar during the wet season of 1990

Sl.No.	Treatment	Description of the treatment	Date of spraying
1.	T_o	Untreated check	-
2.	T_1	One spraying with Monocrotophos @ 0.5 kg a.i./ha, at boot leaf stage.	27.10.90
3.	T_2	Two sprayings with Monocrotophos @ 0.5 kg a.i./ha, once at boot leaf stage and the second at 7 days later.	27.10.90 and 3.11.90
4.	T_3	Two sprayings with Monocrotophos @ 0.5 kg a.i./ha, once at boot leaf stage and the second at 14 days later.	27.10.90 and 10.11.90
5.	T_4	Three sprayings with Monocrotophos @ 0.5 kg a.i./ha, once at boot leaf stage and the other two at 7 days interval.	27.10.90, 3.11.90 and 10.11.90
6.	T_5	Need basis application of Monocrotophos @ 0.5 kg a.i./ha, (one spraying at early boot leaf stage) .	20.10.90

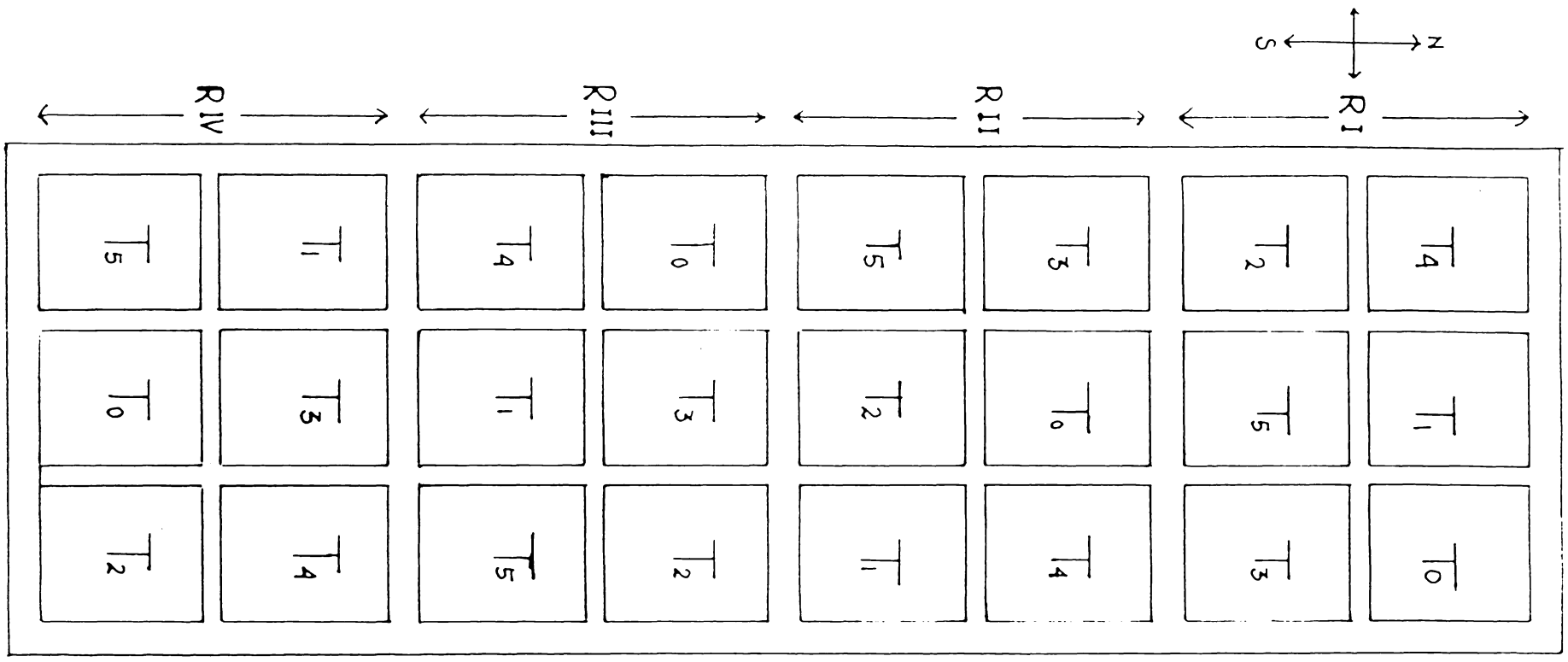

FIG. 4. PLAN OF LAY OUT OF THE TRIAL ON INSECTICIDAL CONTROL OF STEM BORERS IN HEADING STAGE OF DWR AT BHUBANESWAR

(Quadrat count) technique was followed for recording the incidence of WH in each treatment. The extent of DS was estimated by dissecting the effective tillers (looking apparently healthy) of randomly selected 10 clumps from each plot. The percentages of WH, DS and total infestation (TI) were computed.

3.5 STATISTICAL ANALYSIS

The data recorded on different aspects of the study were subjected to statistical analysis in order to derive conclusions. The percentages of DH, WH, DS and TI as well as percentage incidence of different borer larvae were transformed to angular values (Arc Sin $\sqrt{\text{percentage}}$) and then analysed.

The data on various yield contributing traits of the healthy plants and the plants showing stem damage of each variety were subjected to 't' test for comparision.

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CHAPTER IV

RESULTS

R E S U L T S

With a view to develop ecologically and economically sound intergrated management strategies against the stem borer complex of rice under deepwater situation sequential studies on flooding patterns, fluctuation in the incidence of various stem borer species in different growth stages of the crop, screening of DWR vavieties for their resistance/tolerance to the borers and their insecticidal control in the heading stage were undertaken during the wet season of 1990.

4.1 INSECT PESTS RECORDED IN DWR

Eight species of insect pests, viz., three species of stem borers (Scirpophaga incertulas, Chilo supressalis and Sesamia inferens), grasshopper (Oxya nitidula), leaffolder (Cnaphalocrocis medinalis), whorlmaggot (Hydrellia philippina), hispa (Dicladispa armigera) and cricket (unidentified) were recorded in different growth stages of DWR in Orissa during wet season of 1990 (Table 4). The incidence of stem borers was observed in all the three blocks, i.e., Bramhagiri and Bhubaneswar of Puri district and Patamundai of Cuttack district. Incidence of leaffolder, whorl maggot and hispa was mild, where as that of grasshopper and cricket was moderate (Table 5). Regional variation in extent of damage by the foliage damaging pests was also observed. The different periods of occurrence of various foliage damaging pests, viz., grasshopper, leaffolder, whorlmaggot, cricket and hispa were

August to November, July to November, August, September to November and August with the extent of leaf infestation ranging from 1.1 to 30.0, 0.0 to 25.6, 0.0 to 4.8, 0.0 to 48.4 and 1.6 to 14.9% respectively.

Table 4. Insect pests recorded on DWR in Orissa during 1990

Sl.No.	Common Name	Scientific Name	Period of occurrence
1.	Yellow stem borer	Scirpophaga incertulas	Aug. - Dec. Jan. - June.*
2.	Striped stem borer	Chilo supressalis	Jan. - March**
3.	Pink stem borer	Sesamia inferens	Jan. - Feb.**
4.	Grasshopper	Oxya nitidula	Aug. - Nov.
5.	Leaffolder	Cnaphalocrocis medinalis	July - Nov.
6.	Whorl maggot	Hydrellia philippina	August
7.	Hispa	Dicladispa armigera	August
8.	Cricket	Unidentified	Sept. - Nov.

* In stubbles and ratoon plants

** In stubbles

4.11 Rainfall in Orissa during 1990 and flooding patterns in sequential study plots

In Orissa, the premonsoon, monsoon and post monsoon rains were abonormally high and DWR cultivation was affected to

Table 5. Seasonal incidence of some foliage damaging pests in DWR in Orissa during 1990

Month	Fortnight	Leaf Infestation (%)				
		GH	LF	LF	CRICKET	WM	HISPA
July	I	-		0.5 (0.0-2.0)	-	-	-
	II	-		0.0	-	-	-
August	I	16.4 (9.0-24.0)		7.3 (0.0-25.6)	-	1.1 1.1	9.5 9.5
	II	9.6 (4.8-19.9)		3.2 (0.0-12.8)	-	1.2 (0.0-4.8)	2.6 (1.6-3.5)
September	I	7.9 (6.0-9.7)		3.7 (6.5-8.4)	11.3 (0.0-35.9)	-	-
	II	10.1 (6.5-15.7)		1.0 (0.0-2.1)	6.0 (0.0-19.1)	-	-
October	I	13.5 (5.1-18.1)		2.8 (0.2-5.9)	3.2 (0.0-12.6)	-	-
	II	12.6 (1.6-30.0)		2.0 (0.0-4.2)	5.9 (0.0-15.0)	-	-
November	I	10.1 (1.1-18.5)		5.0 (2.1-9.2)	16.7 (0.0-48.4)	-	-
	II	9.5 (5.6-15.5)		8.3 (0.0-22.2)	15.3 (1.5-40.6)	-	-
December	I	7.85 (5.56-9.09)		12.20 (1.05-22.22)	17.91 (1.51-46.67)	-	-
	II	-		-	-	-	-

a significant extent during the wet season of 1990. During the premonsoon period (February-May) a total rainfall of 434.9 mm (Annexture -I) was received in 34 rainy days. During monsoon (June-September) and post monsoon (October-December) periods there were 73 and 18 rainy days during which 1206 and 411.8 mm rainfall respectively was received in the State. Thus, a total rainfall of 2052.6 mm was received in 125 rainy days during 1990 in Orissa. Abnormally heavy rains in May-June (335.5 mm) hampered the normal seeding practices (direct seeding) of DWR in majority areas and those sown were spoiled due to water logging in the DWR fields. However, a considerable hectarage of DWR was transplanted during July and August, 1990. Heavy rainfall (246.6 mm) in the first week of November resulted in high water level in the heading stage of the crop for quite a long period (Table 6).

In the sequential survey plots at Patamundai and Bramhagiri the water levels varied from 0-82 cm and 2-85 mm respectively during the period from July to December, 1990. In Bramhagiri, the water level remained above 50 cm in both the plots for three months (September - November), where as in Patamundai only one of the two plots had more than 50 cm water for three and half months (from second fortnight of August to end of November) and in other plot the water level above 50 cm was there for a short period of 15 days only (Ist fortnight of November) (Table 6).

Table 6. Flooding pattorns in sequential survey plots in Orissa during 1990

Month	Fortnight	Water level (cm)			
		Bramhagiri		Patamundai	
		Plot I	Plot II	Plot I	Plot II
June	I	0.0	0.0	0.0	2.0
	II	0.0	2.0	15.0	5.0
July	I	2.0	5.0	18.0	7.0
	II	16.0	11.0	43.5	20.0
August	I	19.0	18.0	60.0	24.0
	II	20.0	39.0	65.0	30.0
September	I	50.0	65.0	65.0	29.0
	II	52.0	63.0	55.0	38.0
October	I	55.0	65.0	70.0	42.0
	II	52.0	55.0	65.0	35.0
November	I	63.0	85.0	82.0	52.0
	II	43.0	52.0	51.0	5.0
December	I	38.0	48.0	20.0	0.0
	II	22.0	32.0	12.0	0.0

In Bhubaneswar, the water level during August to December varied from 0-30 cm only, and thus, deepwater situation did not prevail in the sequential survey plot (Table 7).

Table 7. Flooding pattern in sequential survey plot at Bhubaneswar during wet season of 1990

Month	Week	Water level (cm)
August	I	15.0
	II	25.0
	III	19.0
	IV	30.0
September	I	22.0
	II	28.0
	III	27.0
	IV	24.0
October	I	18.0
	II	15.0
	III	13.0
	IV	9.0
November	I	7.0
	II	8.0
	III	3.0
	IV	1.0
	V	1.0
December	I	0.0
	II	0.0
	III	0.0
	IV	0.0

4.12 Incidence of stem borers and their seasonal fluctuation

4.121 Bramhagiri and Patamundai locations

Incidence of stem borers was first observed in the first fortnight of August in Patamundai block and in the second fortnight of the same month in Bramhagiri block. In the vegetative stage (July - October) the extent of DH and damaged stems (DS) ranged from 0.00-11.11 and 0.00-11.54% in Patamundai (Table 8 & Fig.5) and 0.00-13.04 and 0.00-15.15% in Bramhagiri (Table 9 & Fig.6) respectively. The total infestation (DH + DS) in Patamundai and Bramhagiri survey plots varied from 0.00-13.89 and 0.00-17.25% respectively. However, the mean incidence of DH, DS and total infestation (TI) over the two locations (Table 10 & Fig.7) during the period from August to October was low (0.00-5.29%, 1.02-1002% and 3.85-1055% respectively). The data in Table 10 further indicate that August brood caused more of DH where as the October brood caused more of DS without DH expression. In the early heading stage of the crop during November the white head (WH), DS and TI over two location ranged from 6.98-15.31, 3.01-24.0 and 4.35-36.00% respectively, where as in December higher levels of WH (5.38-18.96%), DS (4.03-24.07%) and TI (13.01-41.93%) were recorded.

4.122 Bhubaneswar location

Results of sequential surveys conducted at Bhubaneswar indicated 0.00-12.57, 0.00-10.71 and 2.71-23.28% DH, DS and TI

Table 8. Incidence of stem borers in DWR in different months in Orissa (Patamundai Block, Cuttack district) during 1990

Month	Fort-night	Plot I			Plot II			Mean		
		DH/WH (%)	DS (%)	Total (%)	DH/WH (%)	DS (%)	Total (%)	DH/WH (%)	DS (%)	Total (%)
July	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug.	I	11.11	2.78	13.98	5.13	1.28	6.41	8.12	2.03	10.15
	II	0.00	0.00	0.00	0.00	2.00	2.00	0.00	1.00	1.00
Sept.	I	0.00	0.00	0.00	0.00	1.75	1.75	0.00	0.88	0.00
	II	0.00	0.00	0.00	0.00	3.13	3.13	0.00	1.57	1.57
Oct.	I	0.00	0.00	0.00	3.33	6.67	10.00	1.67	3.34	5.01
	II	0.00	9.52	9.52	0.00	11.54	11.54	0.00	10.53	10.53
Nov.	I	0.00	4.35	4.35	1.79	12.50	14.29	8.90	8.43	10.33
	II	12.00	24.00	36.00	10.00	17.00	27.00	11.00	20.75	31.75
Dec.	I	18.86	21.63	40.59	10.00	12.45	22.45	14.48	17.04	31.52
	II	17.53	21.48	39.01	11.61	14.50	26.11	14.57	17.99	32.56

DH = Dead hearts WH = White heads

DS = Damaged stems Total = DH/WH + DS

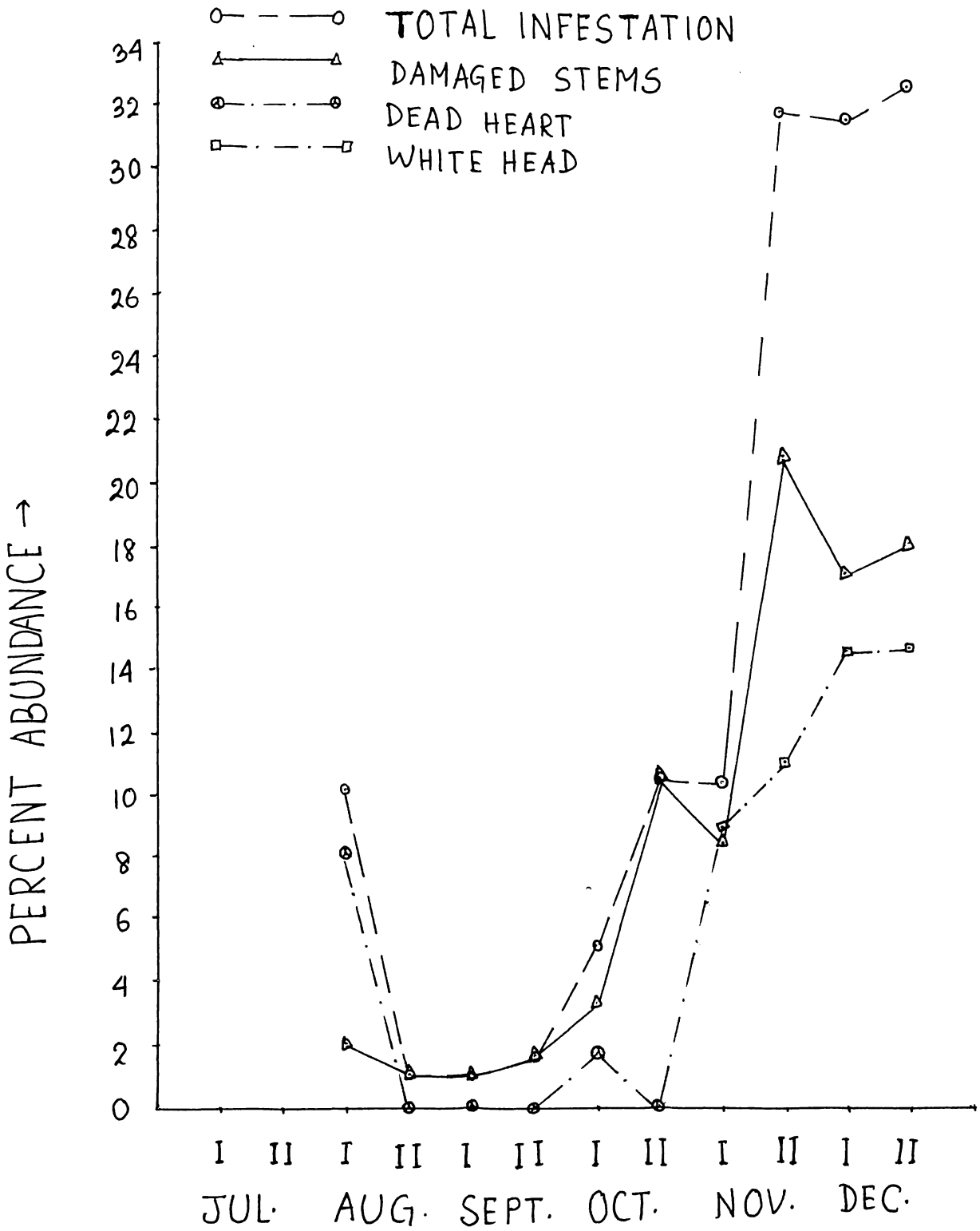

FIG. 5. INCIDENCE OF STEM BORERS IN DWR IN SEQUENTIAL STUDY PLOTS IN PATAMUNDAI BLOCK (CUTTACK)

Table 9: Incidence of stem borers in DWR in different months in Orissa (Bramhagiri Block, Puri District) during 1990

Month	Fort-night	Plot I			Plot II			Mean		
		DH/WH (%)	DS (%)	Total (%)	DH/WH (%)	DS (%)	Total (%)	DH/WH (%)	DS (%)	Total (%)
July	I	-	-	-	-	-	-	-	-	-
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug.	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	13.04	1.69	14.73	8.11	2.70	10.81	10.58	2.20	12.78
Sept.	I	0.00	10.71	10.71	3.44	3.44	6.88	1.72	7.08	8.80
	II	0.00	7.31	7.31	2.41	3.54	5.95	1.20	5.43	6.63
Oct.	I	0.00	5.41	5.41	0.00	0.00	0.00	0.00	2.71	2.71
	II	2.10	15.15	17.25	0.00	3.85	3.85	1.05	9.50	10.55
Nov.	I	0.00	8.11	8.11	6.67	6.67	13.34	6.67	7.39	14.06
	II	6.98	3.01	9.99	15.31	14.29	29.60	11.15	8.65	17.80
Dec.	I	8.98	4.03	13.01	16.32	15.39	31.71	12.65	9.71	22.36
	II	5.38	15.38	20.76	17.86	24.07	41.93	11.62	19.73	31.35

DH = Dead hearts WH = White heads

DS = Damaged stems Total = DH/WH + DS

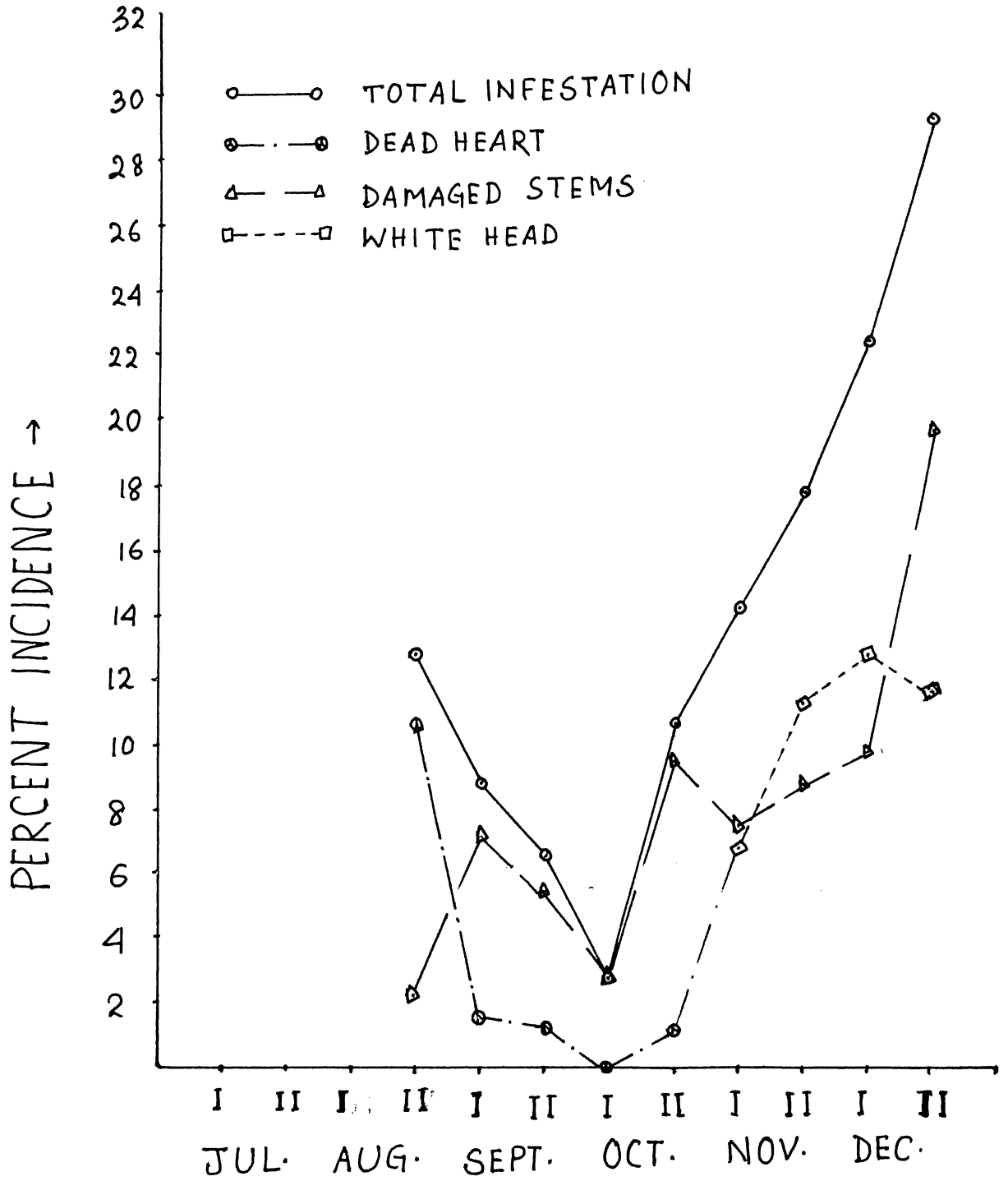

FIG. 6. INCIDENCE OF STEM BORERS IN DWR IN SEQUENTIAL STUDY PLOTS IN BRAHMAGIRI BLOCK (PURI)

Table 10. Mean incidence of stem borers in DWR in different months in Orissa during 1990

Month	Fort-night	DH/WH	DS	Total
July	I	0.00	0.00	0.00
	II	0.00	0.00	0.00
Aug.	I	4.06 (0.00 - 11.11)	1.02 (0.00 - 2.78)	5.08 (0.00 - 13.89)
	II	5.29 (0.00 - 13.04)	1.60 (0.00 - 2.70)	6.89 (0.00 - 14.73)
Sept.	I	0.86 (0.00 - 3.44)	3.98 (0.00 - 10.71)	4.84 (0.00 - 10.71)
	II	0.60 (0.00 - 2.4)	3.50 (0.00 - 7.31)	4.10 (0.00 - 7.31)
Oct.	I	0.83 (0.00 - 3.33)	3.02 (0.00 - 6.67)	3.85 (0.00 - 10.00)
	II	0.53 (0.00 - 2.10)	10.02 (3.85 - 15.15)	10.55 (3.85 - 17.25)
Nov.	I	2.12 (0.00 - 6.67)	7.91 (4.35 - 12.50)	10.03 (4.35 - 14.29)
	II	11.07 (6.98 - 15.31)	14.70 (3.01 - 24.0)	25.77 (9.99 - 36.00)
Dec.	I	13.57 (8.98 - 18.96)	13.37 (4.03 - 21.63)	26.94 (13.01-40.59)
	II	13.09 (5.38 - 17.86)	18.86 (14.50 - 24.07)	31.95 (20.76-41.93)

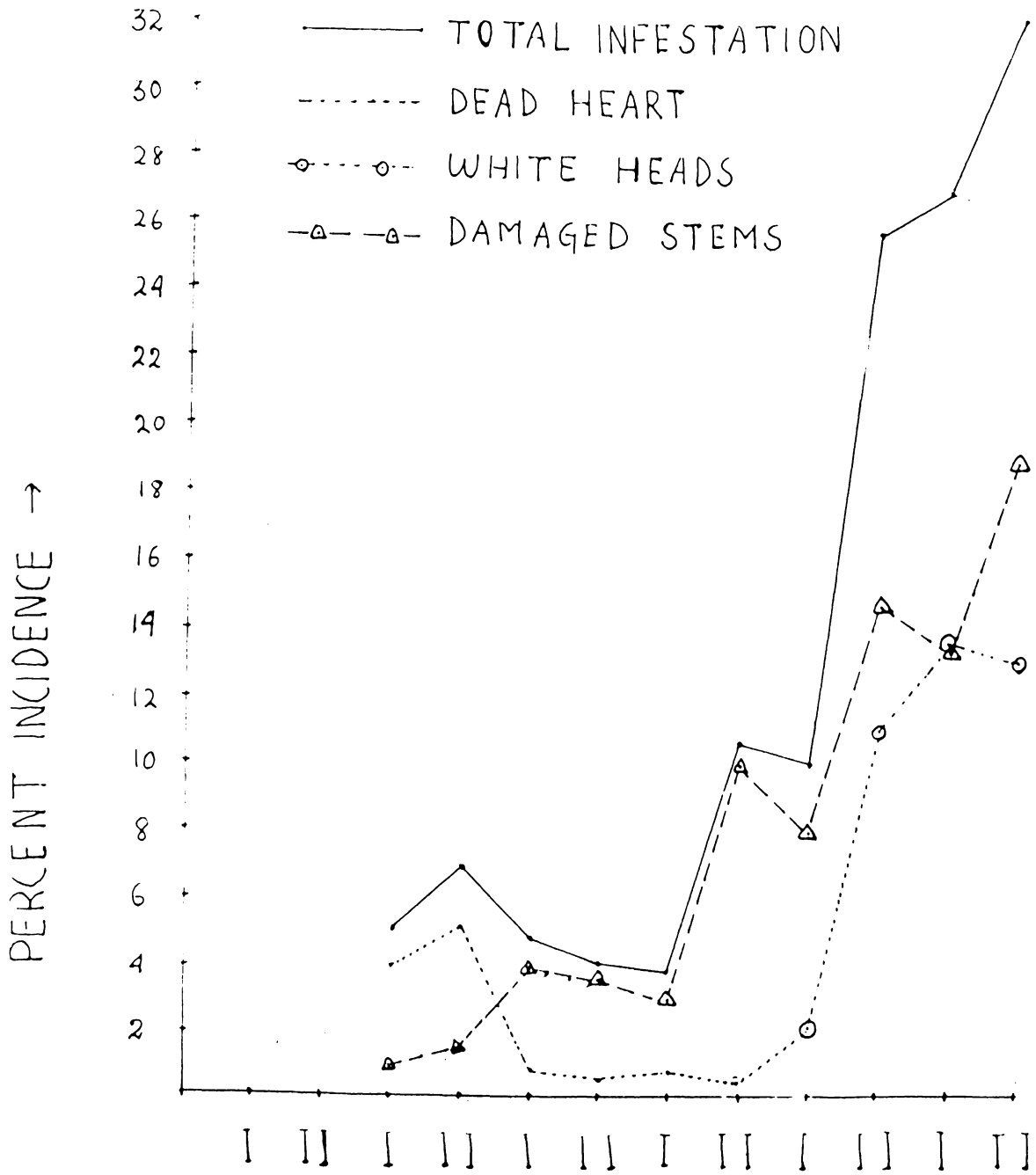

FIG. 7.

MEAN INCIDENCE OF STEM BORERS IN SEQUENTIAL STUDY LOCATIONS

respectively in the vegetative stage of the crop (Table 11 & Fig.8). In the heading stage (November-December) the incidence of WH, DS and TI varied from 2.99-20.00, 8.00-40.00 and 11.81-59.22% respectively.

4.13 Ratio of DH/WH to TI

There was a great deal of variation in the ratio of DH/WH to TI in different periods of growth of the crop. During the period from August to December 1990 the ratio varied from 1: 1.25 to 1 : 20.08 (Table 12 & Fig.9). In early tillering stage of the crop borer infestation was manifested as DH and in heading stage as WH. The higher ratios (1:4.63 to 1:20.08) were observed during the period from September and October as compared to that recorded in August, November and December.

In Bhubaneswar, the ratio of DH/WH to TI during August to December, 1990 was observed to vary from 1:1.00 to 1:4.10 (Table 13 & Fig.10).

4.14 Off-season activities of stem borers

Observations recorded on the stubbles of the DWR variety Panikoili at 7 days interval during the period from January to mid-March, 1990 revealed 15.38-22.09% borer incidence (Table 14). Of the infested stubbles 71.43-76.92% were found to harbour the borer larvae during the first three weeks of January

Table 11. Incidence of stemborers in DWR (Var. Panikoili) at Bhubaneswar during wet season of 1990

Month	Week	Incidence of stem borers (%)		
		DH/WH	DS	TI
August	I	0.00	0.00	0.00
	II	0.00	0.00	0.00
	III	0.00	0.00	0.00
	IV	2.71	0.00	2.71
September	I	2.82	0.00	2.82
	II	4.98	8.82	13.80
	III	7.72	10.00	17.72
	IV	9.95	9.75	19.70
October	I	5.01	5.55	10.56
	II	5.04	8.16	13.20
	III	5.49	10.71	16.20
	IV	12.57	10.71	23.28
November	I	4.61	8.00	12.61
	II	2.99	8.82	11.81
	III	10.54	13.58	24.12
	IV	16.11	21.27	37.38
	V	11.18	34.69	45.87
December	I	20.00	39.22	59.22
	II	17.93	40.00	57.93
	III	-	-	-
	IV	-	-	-

DH = Deadheart
WH = Whitehead
DS = Damaged stems
TI = Total infestation

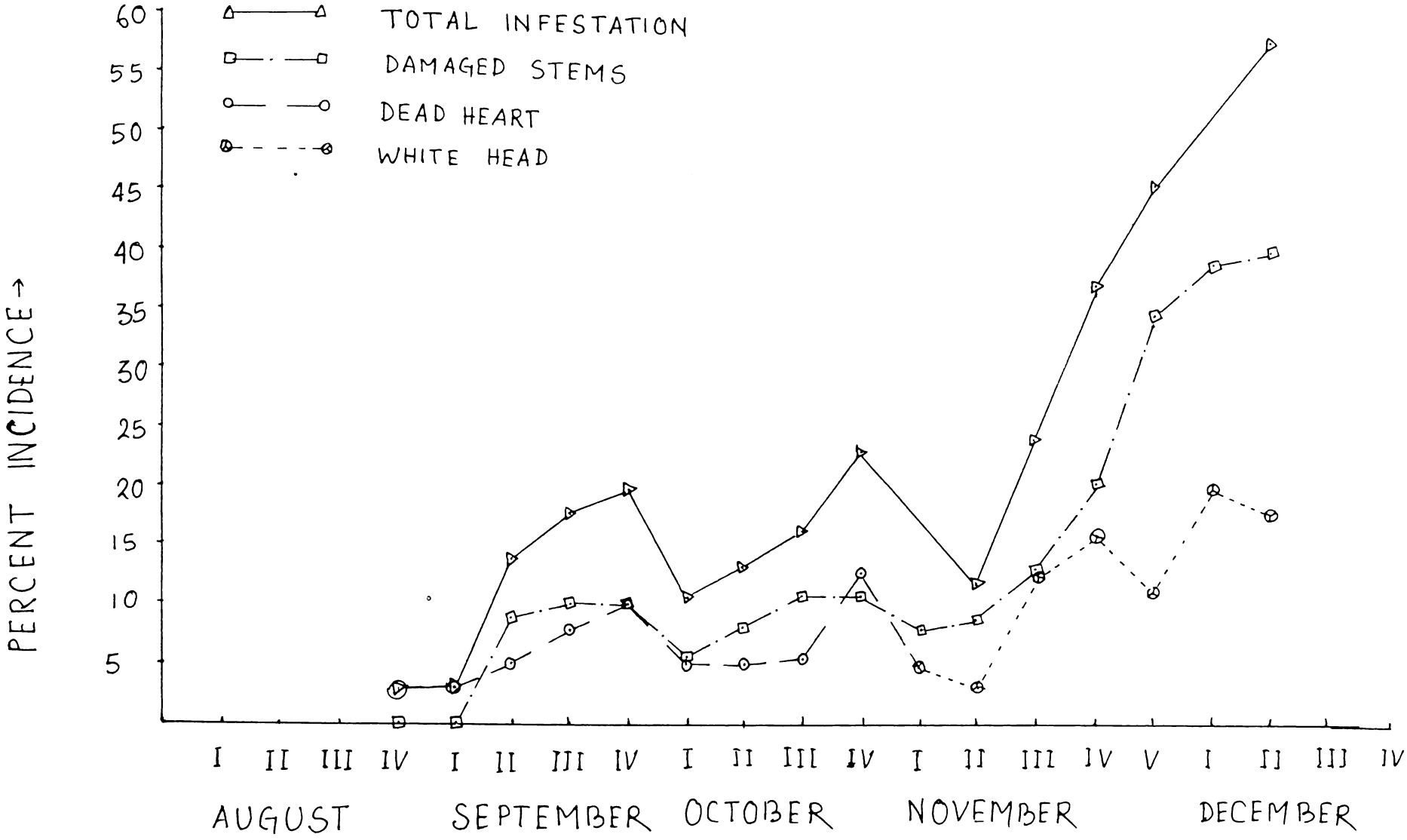

FIG. 8. INCIDENCE OF STEM BORERS IN DWR AT BHUBANESWAR DURING WET SEASON OF 1990

and from the last week of January the population of larvae and pupae gradually declined upto the first week of March when only 5.55% of the stubbles were found to contain the pupae. In March second week no immature stage of the borers was found in the stubbles. Pupal exuviae observed from mid-Feburary unwards indicated that the emergence of stem borer moths occurred during the period from mid-February to 1st week of March in 1990.

Further study on the DWR ratoon plants developed from the stubbles indicated that, the ratoon plants harboured stem borers and there was 9.41 to 15.38% DH incidence in Bramhagiri and Patamundai areas during June, 1990.

4.15 Composition of stem borer species in DWR ecosystem

Three borer species, viz., S. incertulas C. supressalis and S. inferens were recorded in DWR stubbles during the period from January to March, 1990. YSB constituted 48.00-83.33% of the larval population and was the dominant species followed by SSB and PSB which accounted for 0.00-52.00% and 0.00-50.00% larval population in the stubbles (Table 14).

Results of the sequential survey in Patamundai and bramhagiri revealed that, only YSB occurred during August to first fortnight of November, 1990 (Table 12 and Plate 1) and occurrenced of SSB and PSB larvae was observed in the dissected stems from the second fortnight of November and December

Table 12 . Ratios of DH/WH : TI and relative abundance of different borer species in DWR during 1990 in Orissa

Month	Fortnight	DH/WH : TI	Percentage abundance of		
			YSB	SSB	PSB
July	I	-	-	-	-
	II	-	-	-	-
Aug.	I	1 : 1.25	100.00	0.00	0.00
	II	1 : 1.30	100.00	0.00	0.00
Sept.	I	1 : 5.63	100.00	0.00	0.00
	II	1 : 6.83	100.00	0.00	0.00
Oct.	I	1 : 4.63	100.00	0.00	0.00
	II	1 : 20.08	100.00	0.00	0.00
Nov.	I	1 : 4.73	100.00	0.00	0.00
	II	1 : 2.33	85.71	14.29	0.00
Dec.	I	1 : 1.99	100.00	0.00	0.00
	II	1 : 2.44	80.00	10.00	10.00

respectively. The SSB population in the dissected stems was 10.00-14.29% where as that of PSB 10% only (Table 12 and Plates 2 and 3). However, in Bhubaneswar only YSB occurred during second week of September to second week of November and larvae of SSB and PSB were observed in the dissected stems from the third week and last week of November respectively (table 13 & Fig. 10).

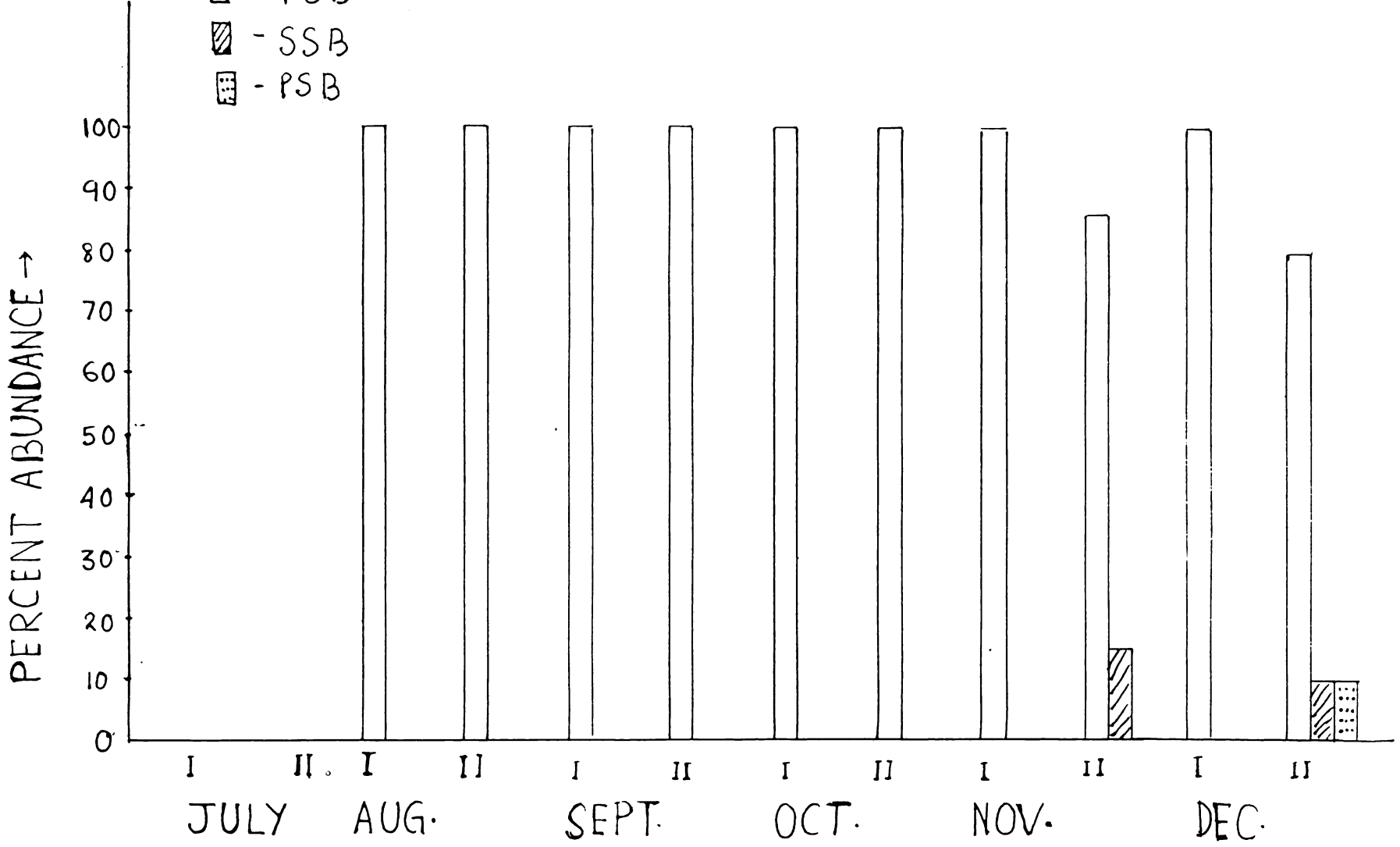

FIG. 9. RELATIVE ABUNDANCE OF DIFFERENT BORER SPECIES IN SEQUENTIAL STUDY PLOTS (MEAN OF TWO LOCATIONS)

Table 13. Ratios of DH/WH : TI and relative abundance of different borer species on DWR(Var. Panikoili) at Bhubaneswar, during 1990

Month	Week	DH/WH:TI	Percentage abundance of		
			YSB	SSB	PSB
August	I	-	0.00	0.00	0.00
	II	-	0.00	0.00	0.00
	III	-	0.00	0.00	0.00
	IV	1:1.00	0.00	0.00	0.00
September	I	1:1.00	0.00	0.00	0.00
	II	1:2.77	100.00	0.00	0.00
	III	1:2.30	100.00	0.00	0.00
	IV	1:1.98	100.00	0.00	0.00
October	I	1:2.11	100.00	0.00	0.00
	II	1:2.62	100.00	0.00	0.00
	III	1:2.95	100.00	0.00	0.00
	IV	1:1.85	100.00	0.00	0.00
November	I	1:2.74	100.00	0.00	0.00
	II	1:3.95	100.00	0.00	0.00
	III	1:2.29	66.67	33.33	0.00
	IV	1:2.32	50.00	50.00	0.00
	V	1:4.10	75.00	0.00	25.00
December	I	1:2.96	20.00	40.00	40.00
	II	1:3.23	50.00	50.00	0.00
	III	-	-	-	-
	IV	-	-	-	-

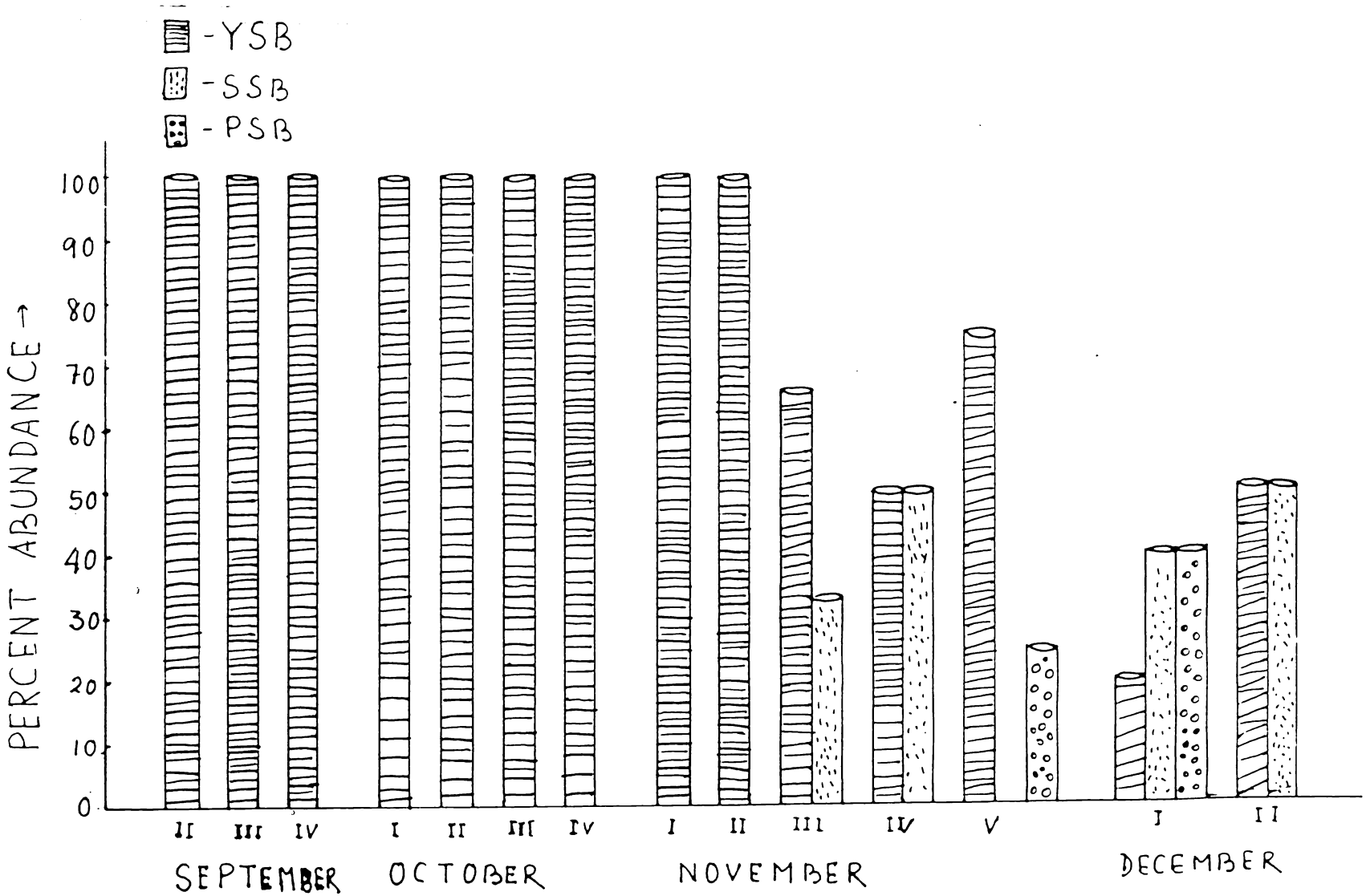

FIG. 10. RELATIVE ABUNDANCE OF DIFFERENT BORER SPECIES IN SEQUENTIAL STUDY PLOT AT BHUBANESWAR

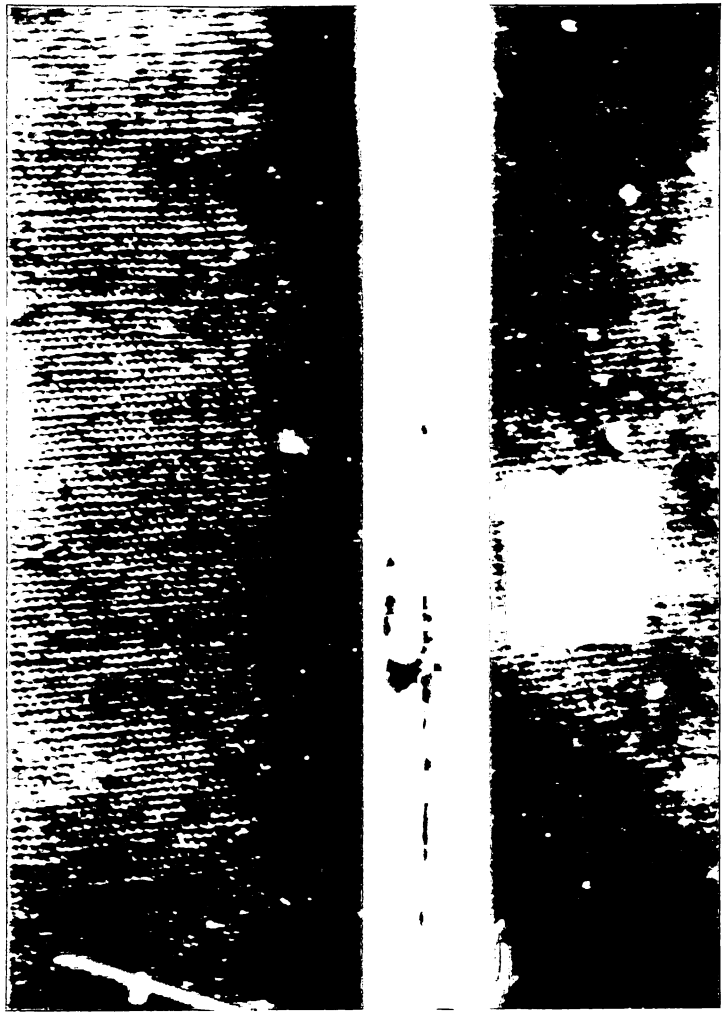

PLATE 1

DISSECTED INTERNODE
SHOWING LARVA OF
YSB (S. incertulas)

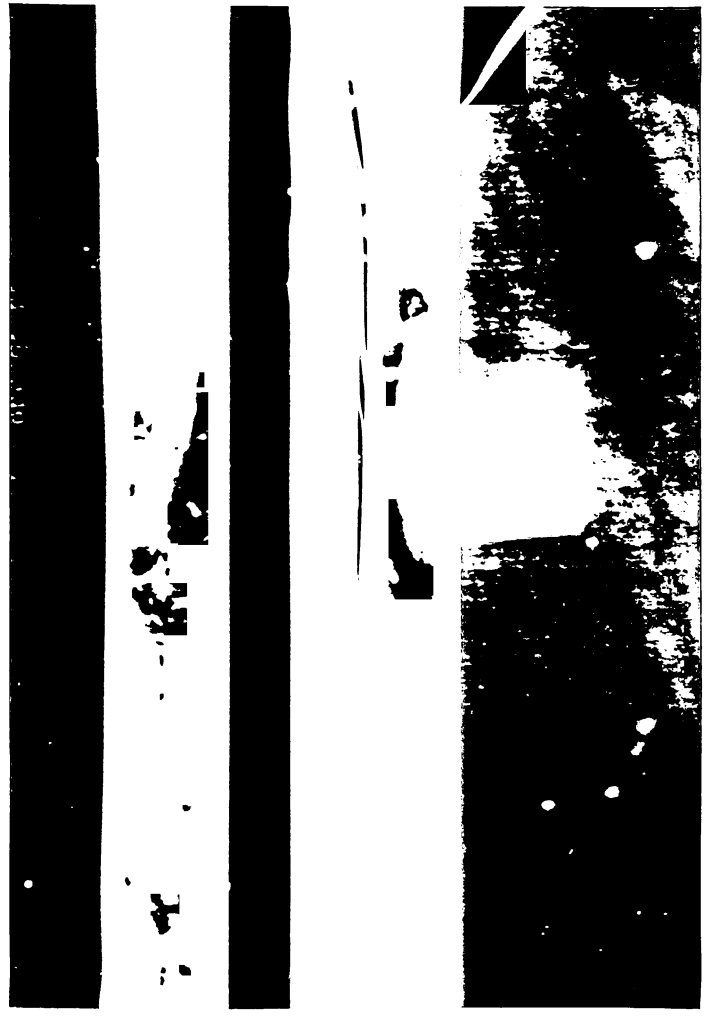

PLATE 2

DISSECTED INTERNODES
SHOWING LARVAE OF
SSB (C. supressalis)

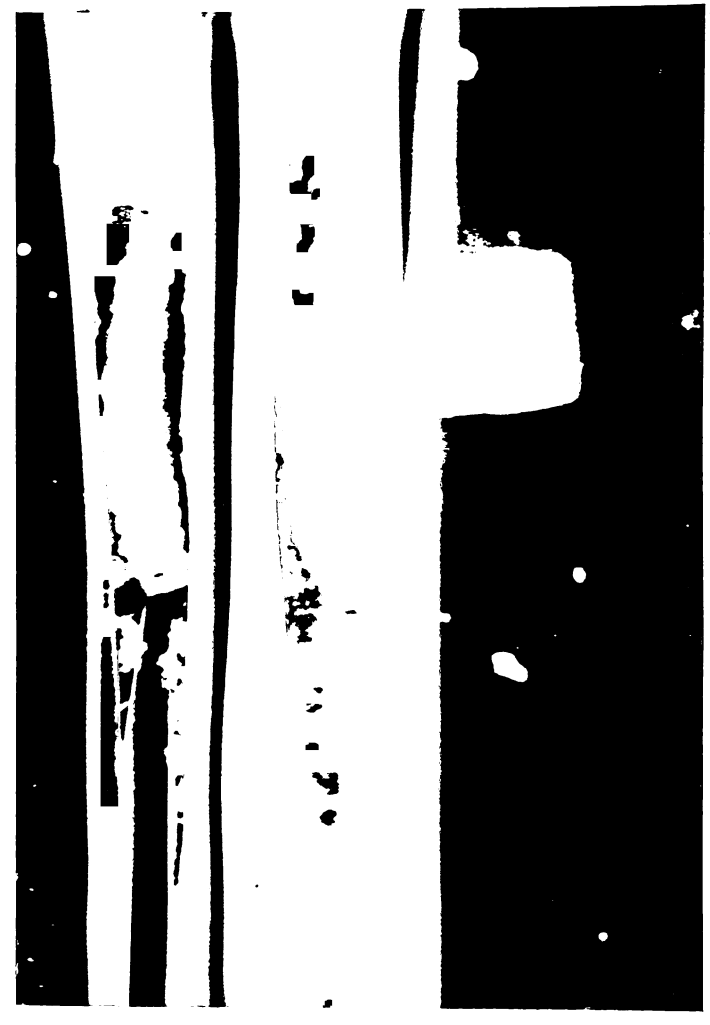

PLATE 3

DISSECTED INTERNODES
SHOWING LARVAE OF
PSB (S. inferens)

Table 14. Extent of stem borer incidence in DWR stubbles in Orissa during 1990

Month	Week	No. of stubbles examined	Infested stubbles (%)	Infested stubbles harbouring borer larvae and pupae (%)	Composition of borer species (%)		
					YSB	SSB	PSB
Jan. 90	I	76	17.10	76.92	80.00	20.00	0.00
	II	78	15.38	75.00	77.30	22.70	0.00
	III	84	16.66	71.43	66.33	27.27	6.40
	IV	72	16.66	50.00	66.66	16.67	16.67
Feb. 90	I	87	19.54	29.41	80.00	0.00	20.00
	II	85	16.47	42.85	83.33	16.67	0.00
	III	86	19.76	23.53	75.00	25.00	0.00
	IV	86	22.09	10.53	50.00	0.00	50.00
March 90	I	83	21.68	5.55	48.00	52.00	0.00
	II	88	19.31	0.00	-	-	-

4.2 FIELD-SCREENING OF DWR VARIETIES FOR RESISTANCE/ TOLERANCE TO STEM BORERS

Reaction of 60 rice varieties to stem borers was studied under field conditions during the wet season of 1990. Observations on the incidence of DH in vegetative stage and WH in heading stage and that of DS in both the stages were recorded. Extent of DH and DS in the vegetative stage ranged from1.92-19.23% and 4.17-21.74% respectively in different varieties tested (Table 15). Of the 60 varieties 10 varieties with less than 5%, 25 with 5-10% and rest 25 with more than 10% DH were recorded, the lowest and highest being in Achuwabayahonda and Khajira respectively (Table 16). On the contrary, Champa and Rupahi recorded the lowest and highest incidence of DS respectively. Total infestation (DH + DS) in the vegetative stage ranged between 7.11 and 37.72%. The total infestation (TI) was comparatively low (7.11-8.25%) in varieties like Achuwabayahonda, Champa and Kanthapakhira and was at a higher order (32.01-37.72%) in IRDW 12, IRDW 11, Khajira, Jalbao, Moimansingiabao, Katisali, Kekua, Kajalibao, Dalbao, Maguri and Khura.

The tolerance ratio (TR) in the vegetative stage calculated taking into account the TI and DH incidence indicated wide variation between the varieties (1.50 : 1 - 5.51:) (Table 15). The TR was comparitively high (3.43 : 1-5.51 : 1) in 13 varieties viz., Panidhan, Kalamahipal, Patani,

Table 15. Reaction of DWR varieties to stem borers in the vegetative stage of the crop and relative abundance of different borer species during kharif, 1990

Variety No.	Variety Name	Incidence of stem borers (%)			Tolerance Ratio(TR)	No.of stems dissected	Borer larvae recorded			Relative abundance(%) of borer larvae		
		DH	DS	TI			YSB	SSB	PSB	YSB	SSB	PSB
1	2	3	4	5	6	7	8	9	10	11	12	13
01.	Kanthapakhira	3.70	4.55	8.25	2.23	45	1	0	0	100.00	-	-
02.	Talamula	7.89	11.11	19.00	2.41	57	3	0	0	100.00	-	-
03.	Katakichandi	5.11	14.76	19.87	3.89	48	1	0	0	100.00	-	-
04.	Athagarbangi	8.33	9.09	17.42	2.09	44	2	0	0	100.00	-	-
05.	Badakantamal	13.51	16.67	30.18	2.33	54	4	0	0	100.00	-	-
06.	Matia	5.88	14.29	20.17	3.43	56	1	0	0	100.00	-	-
07.	Raspanjar	16.67	8.33	25.00	1.50	48	6	0	0	100.00	-	-
08.	Kalamahipal	3.85	12.50	16.35	4.25	54	0	0	0	0.00	-	-
09.	Khajira	19.23	13.23	32.46	1.69	45	5	0	0	100.00	-	-
10.	Panisanar	8.70	14.29	22.99	2.64	35	3	0	0	100.00	-	-
11.	Harisankar	8.33	20.00	28.33	3.40	45	1	0	0	100.00	-	-
12.	Pakhia	5.13	8.70	13.83	2.70	46	1	0	0	100.00	-	-
13.	Kalashira	12.50	6.67	19.17	1.53	45	6	0	0	100.00	-	-
14.	Ghodatapua	8.33	11.11	19.44	2.33	45	4	0	0	100.00	-	-
15.	Champa	2.94	4.17	7.11	2.42	57	2	0	0	100.00	-	-
16.	Mayurkantha	3.70	10.53	14.23	3.85	45	0	0	0	0.00	-	-
17.	Sapadidhan	7.41	18.75	26.16	3.53	54	0	0	0	0.00	-	-
18.	Achuwabaya-honda	1.92	5.77	7.69	4.00	54	2	0	0	100.00	-	-

Contd.....

Contd..... Table 15

1	2	3	4	5	6	7	8	9	10	11	12	13
19.	Champeisiali	2.78	7.69	10.47	3.77	52	0	0	0	0.00	-	-
20.	Dhulia	6.25	9.09	15.34	2.45	44	3	0	0	100.00	-	-
21.	Kakhuria	5.56	11.11	16.67	3.00	45	1	0	0	100.00	-	-
22.	Madankhatia	8.57	12.50	21.07	2.46	48	3	0	0	100.00	-	-
23.	Patani	3.22	10.00	13.22	4.11	44	0	0	0	0.00	-	-
24.	Moogey	2.94	7.14	10.08	3.43	56	0	0	0	0.00	-	-
25.	Desichampa	9.52	10.00	19.52	2.05	40	3	0	0	100.00	-	-
26.	Baunsagaja	7.69	14.29	21.98	2.86	45	2	0	0	100.00	-	-
27.	Hendakadala	3.70	10.53	14.23	3.85	51	0	0	0	0.00	-	-
28.	Rebati	9.76	5.88	15.64	1.60	45	5	0	0	100.00	-	-
29.	Birijana	9.09	14.29	23.38	2.57	44	4	0	0	100.00	-	-
30.	Madua	12.12	13.04	25.16	2.08	56	8	0	0	100.00	-	-
31.	Ravana	11.11	15.38	26.49	2.38	52	7	0	0	100.00	-	-
32.	Khura	16.67	21.05	37.72	2.26	44	4	0	0	100.00	-	-
33.	Panikoili	8.33	20.00	28.33	3.40	57	2	0	0	100.00	-	-
34.	Panidhan	3.45	15.56	19.01	5.51	54	0	0	0	0.00	-	-
35.	Bayahanda	7.41	18.75	26.16	3.53	51	2	0	0	100.00	-	-
36.	Malbhog	5.88	14.29	20.17	3.43	51	2	0	0	100.00	-	-
37.	Panikekua	12.50	18.18	30.68	2.45	42	3	0	0	100.00	-	-
38.	Amona	8.11	11.76	19.87	2.45	44	1	0	0	100.00	-	-
39.	ACC^{n} 7/21-2	9.96	19.95	29.91	3.00	46	4	0	0	100.00	-	-
40.	Tulasibau	8.47	18.18	26.65	3.15	45	1	0	0	100.00	-	-
41.	Rupahi	9.68	21.74	31.42	3.25	57	3	0	0	100.00	-	-

Contd.....

Contd.....Table 15

1	2	3	4	5	6	7	8	9	10	11	12	13
42.	Sarsuri	10.87	15.00	25.87	2.38	40	4	0	0	100.00	-	-
43.	AR 14	13.79	16.67	30.46	2.21	45	4	0	0	100.00	-	-
44.	Laldhepa	10.34	12.00	22.34	2.16	50	5	0	0	100.00	-	-
45.	TCN	12.24	19.05	29.29	2.39	42	4	0	0	100.00	-	-
46.	Moimasngi-abao	11.53	21.43	32.96	2.86	56	3	0	0	100.00	-	-
47.	Kajalibao	15.38	18.75	34.13	2.22	48	0	0	0	100.00	-	-
48.	Harkana	7.89	18.52	26.41	3.35	54	2	0	0	100.00	-	-
49.	Jalbao	11.54	21.05	32.59	2.82	57	3	0	0	100.00	-	-
50.	Rangabalam	8.77	11.43	20.20	2.30	53	4	0	0	100.00	-	-
51.	IRDWON 53	11.43	14.81	26.24	2.30	54	4	0	0	10.00	-	-
52.	Itakhulig	11.76	18.18	29.94	2.55	44	3	0	0	100.00	-	-
53.	Dalbao	13.33	21.43	34.76	2.61	56	3	0	0	100.00	-	-
54.	Maguri	14.29	20.00	35.29	2.47	40	0	0	0	0.00	-	-
55.	Negheribao	12.50	17.24	29.94	2.40	58	4	0	0	100.00	-	-
56.	Kekua	14.71	19.05	33.76	2.30	42	4	0	0	100.00	-	-
57.	Katisali	13.85	19.81	33.66	2.43	56	3	0	0	100.00	-	-
58.	IRDW 10	14.29	16.00	30.29	2.12	50	5	0	0	100.00	-	-
59.	IRDW 11	15.63	16.67	32.30	2.07	48	6	0	0	100.00	-	-
60.	IRDW 12	11.11	20.90	32.01	2.88	40	0	0	0	100.00	-	-

DH = Dead heart, DS = Damaged stems, TI = Total infestation

TR = Tolerance ratio $\frac{\text{Percentage TI}}{\text{Percentage DH}}$

Achuwabayahonda, Katakichandi, Mayurkantha, Hendakadala, Champeisiali, Sapadidhan, Bayahonda, Matia, Moogey and Malbhog, where as in rest varieties the ratio was quite low (1.5 : 1 - 3.4 : 1).

Incidence of WH, DS and TI in grain ripening stage ranged from 4.11 to 33.08, 12.16 to 55.17 and 19.00 to 76.22% respectively in different test varieties (Table 17). Moogey and Ghodatapua recorded the lowest incidence of WH and DS respectively, the former variety having the lowest level of TI. Higher levels of WH ($>$ 20%), DS ($>$ 20%) and TI ($>$ 40%) were observed in 12, 54 and 36 varieties respectively. On the contrary, less than 5% WH in two varieties (Moogey and Panidhan) and less than 15% DS in three (Ghodatapua, Pakhia and Moogey) varieties were recorded. Twelve varieties had 5-10% WH incidence (Table 18).

The TR calculated in the heading stage taking into account the TI and WH also indicated wide variation (1.72 : 1 to 7.56 : 1) between the varieties, the lowest and highest being in Khajira and Panidhan respectively. Sixteen varieties with a comparatively high TR of 4.00 : 1-7.56 : 1 were Panidhan, Kalamahipal, Patani, Champeisiali, Katakichandi, Moogey, Hendakadala, Mayurkantha, Achuwabayahonda, Malbhag, Panikili, Bayahonda, Negheribao, Kakhuria, Maguri and Dhulia. The rest 44 varieties were with a low TR of 1.72 : 1 - 3.94 : 1.

Table 10. BWR varieties with different levels of stem borer infestation in vegetative stage

Infestation level (%)	DH		DS	
	No. of varieties	Name of the varieties	No. of varieties	Name of the varieties
0.00-5.00	10	Achuwabayahonda, Champa, Champe-isiali, Hendakadala, Kalamahipal, Kanthapakhira, Mayurkantha, Moogey, Panidhan, Patani.	2	Champa, Kanthapakhira
5.01-10.00	25	ACC^{n} 7/21-2, Amona, Athagarbangi Baunsegaja, Bayahonda, Birijana, Desichampa, Dhulia, Ghodatapua, Harisankar, Harkana, Kakhuria, Katakichandi, Madankhatia, Malbhag, Matia, Pakhia, Panikoili, Panisanar, Rangabalam, Rebati, Rupahi, Sapadi-dhan, Talamula, Tulasibau.		Achuwabayahonda, Athagarbangi, Champeisiali, Desi-champa, Dhulia, Kalashira, Moogey, Pakhia, Patani, Raspanjar, Rebati.
10.01-15.00	20	AR 14, Badakantamal, Dalbao, IRDW 10, IRDW 11 IRDWON 53, Itakhulig, Jalbao, Kalashira, Katisali, Kekua, Laldhepa, Madua, Maguri, Moimansingiabao, Negheribao, Panikekua, Ravana, Sarsuri, TCN.	19	Amona, Baunsagaja, Birijana, Ghodatapua, Hendaka-dala, Kakhuria, Kalamahipal, Katakichandi, Khajira, Laldhepa, Madankhatia, Madua, Malbhag, Matia, Mayurkantha, Panisanar, Raspanjar, Sarsuri, Talamula.
15.01-20.00	5	IRDW 11, kajalibao, Khajira, Khura, Raspanjar.	22	ACC^{n} 7/21-2, AR 14, Badakantamal, Bayahonda, Harisankar, Harkana, IRDW 10 IRDW 11, IRDWON 53, Itakhulig, Kajalibao, Katisali, Kekua, Maguri, Negheribao, Panidhan, Panikekua, panikoili, Ravana, Sapadidhan, TCN, tulasibau.
> 20.00	0	-	6	Dalbao, IRDW 12, Jalbao, Khura, Moimangiabao, Rupahi.

Table 17. Reaction of DWR varieties to stem borers in the heading stage of the crop and relative abundance of diff borer species during kharif, 1990

Variety		Incidence of stem borers (%)			Tolerance Ratio(TR)	No.of stems dissected	Borer larvae recorded			Rel. abundance (%) of borer larvae		
No.	Name	WH	DS	TI			YSB	SSB	PSB	YSB	SSB	PSB
1	2	3	4	5	6	7	8	9	10	11	12	13
01.	Kanthapakhira	10.34	29.03	39.37	3.81	95	2	0	0	100.00	-	-
02.	Talamula	15.94	44.12	60.06	3.76	74	2	0	0	100.00	-	-
03.	Katakichandi	8.03	31.98	40.01	4.98	86	1	1	0	50.00	50.00	-
04.	Athagarbangi	18.87	33.78	52.65	2.79	84	5	0	0	100.00	-	-
05.	Badakantamal	17.78	29.47	47.25	2.65	125	3	1	0	75.00	25.00	-
06.	Matia	14.49	34.48	48.97	3.38	97	0	2	0	0.00	100.00	-
07.	Raspanjar	10.81	17.07	27.88	2.58	119	3	0	1	75.00	-	25.00
08.	Kalamahipal	5.88	25.96	31.84	5.41	83	0	2	1	0.00	66.67	33.33
09.	Khajira	27.78	20.00	47.78	1.72	88	4	5	2	36.36	45.46	18.18
10.	Panisanar	24.69	41.90	66.59	2.69	89	0	2	0	0.00	100.00	-
11.	Harisankar	21.92	37.40	59.32	2.71	86	7	0	0	100.00	-	-
12.	Pakhia	8.60	13.04	21.64	2.52	94	6	0	0	100.00	-	-
13.	Kalashira	21.05	55.17	76.22	3.62	89	4	0	1	80.00	-	20.00
14.	Ghodatapua	15.38	12.16	27.54	1.79	123	2	0	1	66.67	-	33.33
15.	Champa	13.22	37.78	51.00	3.85	140	0	3	0	0.00	100.00	-
16.	Mayurkantha	8.33	28.83	37.16	4.46	95	2	2	0	50.00	50.00	-
17.	Sapadidhan	9.52	27.95	37.47	3.94	74	1	0	0	100.00	-	-

Contd.....

1	2	3	4	5	6	7	8	9	10	11	12	13
18.	Achuwabaya-honda	7.89	26.00	33.89	4.30	61	2	1	0	66.67	33.33	-
19.	Champeisiali	5.51	22.31	27.82	5.05	99	2	1	2	40.00	20.00	40.00
20.	Dhulia	16.67	50.00	66.67	4.00	66	0	1	1	0.00	50.00	50.00
21.	Kakhuria	15.63	48.42	64.05	4.10	95	0	3	2	0.00	60.00	40.00
22.	Madankhatia	12.50	22.00	34.50	2.76	100	1	0	1	50.00	0.00	50.00
23.	Patani	6.10	25.30	31.40	5.15	79	3	2	1	50.00	33.33	16.67
24.	Moogey	4.11	14.89	19.00	4.62	84	2	2	0	50.00	50.00	0.00
25.	Desichampa	28.46	37.27	65.73	2.31	85	4	2	2	50.00	25.00	25.00
26.	Baunsegaja	27.78	28.57	56.35	2.03	113	6	0	4	60.00	-	40.00
27.	Hendakadala	7.73	27.63	35.36	4.57	86	2	4	2	25.00	50.00	25.00
28.	Rebati	18.18	21.74	39.92	2.20	83	7	3	3	53.84	23.08	23.08
29.	Birijana	24.14	29.03	53.17	2.20	88	6	7	5	33.33	38.89	27.78
30.	Madua	18.87	44.61	63.48	3.36	85	11	2	7	55.00	10.00	35.00
31.	Ravana	17.73	43.27	61.00	3.44	69	0	2	9	0.00	18.18	81.83
32.	Khura	13.22	37.78	51.00	3.86	65	2	1	1	50.00	25.00	25.00
33.	Panikoili	13.95	44.16	58.11	4.17	64	5	3	2	50.00	30.00	20.00
34.	Panidhan	4.48	29.41	33.89	7.56	87	2	2	0	50.00	50.00	0.00
35.	Bayahonda	15.63	48.42	64.05	4.10	90	3	0	2	60.00	0.00	40.00
36.	Malbag	9.38	30.16	39.54	4.22	104	3	3	1	42.86	42.86	14.28
37.	Panikekua	14.48	29.42	43.90	3.03	85	1	1	2	25.00	25.00	25.00
38.	Amona	8.60	20.71	30.31	3.52	129	2	1	1	50.00	25.00	25.00

Contd.....

Contd..... Table 17

1	2	3	4	5	6	7	8	9	10	11	12	13
39.	ACC^{n} 7/21-2	19.38	30.16	49.54	2.56	63	0	2	1	0.00	66.67	33.33
40.	Tulasibau	11.76	21.69	33.45	2.84	83	2	0	3	40.00	0.00	60.67
41.	Rupahi	12.50	15.67	28.17	2.25	134	0	1	2	0.00	33.33	66.67
42.	Sarsuri	10.17	23.38	33.55	3.30	178	1	2	2	20.00	40.00	40.00
43.	AR 14	14.52	27.95	42.47	2.92	161	1	1	2	25.00	25.00	50.00
44.	Laldhepa	15.51	22.31	37.82	2.44	130	0	3	0	0.00	100.00	0.00
45.	TCN	18.33	28.83	47.16	2.57	111	4	-	-	100.00	0.00	0.00
46.	Moimansi-ngiabao	28.21	43.90	72.11	2.56	82	3	2	1	50.00	33.33	16.67
47.	Kajalibao	13.33	31.91	45.24	3.39	94	7	4	2	53.86	30.76	15.38
48.	Harkana	24.14	30.68	54.82	2.27	88	5	1	3	55.56	11.11	33.33
49.	Jalbao	15.00	27.66	42.66	2.84	67	8	1	1	80.00	10.00	10.00
50.	Rangabalam	13.95	33.93	47.88	3.43	56	9	0	1	90.00	0.00	10.00
51.	IRDWON 53	10.34	29.03	39.37	3.81	62	0	4	0	0.00	100.00	0.00
52.	Itakhulig	14.29	39.13	53.42	3.74	66	4	2	2	50.00	25.00	25.00
53.	Dalbao	14.49	39.02	53.51	3.69	61	7	5	1	53.85	38.46	7.69
54.	Maguri	9.23	28.33	37.56	4.07	60	8	2	2	60.06	16.67	16.67
55.	Negheribao	16.10	53.16	69.26	4.30	57	3	7	0	30.00	70.00	0.00
56.	Kekua	33.08	43.91	76.99	2.33	63	4	2	1	57.16	28.56	14.28
57.	Katisali	22.00	47.50	69.50	3.16	64	3	3	2	37.50	37.50	25.00
58.	IRDW 10	18.00	33.96	57.96	2.89	53	2	1	1	50.00	25.00	25.00
59.	IRDW 11	12.89	26.00	38.89	3.02	50	3	0	2	60.00	0.00	40.00
60.	IRDW 12	30.96	37.14	68.10	2.20	56	1	2	3	16.67	33.33	50.00
								Mean		47.18	31.19	21.63

WH = White head DS = Damaged stems, TI = Total infestation TR = Tolerance ratio(% TI / % DH)

Table 2. Rice varieties with different levels of stem borer infestation in heading (Grain ripening) stage

Infestation level (%)	WH		DS	
	No. of varieties	Name of the varieties	No. of varieties	Name of the varieties
0.00-5.00	2	Moogey, Panidhan	0	NIL
5.01-10.00	12	Achuwabayahonda, Amona, Champeisiali, Hendakadala, Kalamahipal Katakichandi, Maguri, Malbhog, Mayurkantha, Pakhia, Patani, Sapadidhan.	0	NIL
10.01-15.00	19	AR 14, Champa, Dalbao, IRDW 11, IRDWON 53, Itakhulig, Jalbao, Kajalibao, Kanthapakhira,Khura, Madankhatia, matia, Panikekua, Panikoili,Rangabalam,Raspanjar, Rupahi, Sarsuri, Tulasibau.	3	Ghodatapua, Moogey, Pakhia.
15.01-20.00	15	ACC^{n} 7/21-2, Athagarbangi, Badakantamal, Bayahonda,Dhulia, Ghodatapua, IRDW 10,Kakhuria, Laldhepa, madua, Negheribao, Ravana, Rebati, Talamula, TCN.	3	Khajira, Raspanjar, Rupahi
20.01-25.00	6	Birijana,Harisankar,Harkana,Kalashira, Katisali,Panisarar.	7	Amona, Champeisiali,Laldhepa, Madankhatia, Rebati, Sarsuri,Tulasibau.
25.01-30.00	4	Baunsagaja, Desichampa, Khajira, Moimansingiabao	19	Achuwabayahonda, AR 14, badakantamal, Baunsagaja, Birijana, Dhulia, Hendakadala, IRDW 11, IRDWON 53, Jalbao, Kalamahipal, Kanthapakhira, Maguri, Mayurkantha, Panidhan, Panikekua, Patani, Sapadidhan, TCN.
> 30.00	2	IRDW 12, Kekua	28	ACC^{n} 7/21-2, Athagarbangi, bayahonda,Champa, Dalbao Desichampa, Harisaukar, Harkana, IRDW 10, IRDW 12, Itakhulig, Kajalibao, Kakhuria, Kalashira, Katakichandi, Katisali, Kekua, Khura, madua, Malbhag, Matia Moimansingiabao, Negheribao, Panikoili, Panisanar, Rangabalam, Ravana, talamula.

Table 19. Reaction of DWR varieties to stem borers under field condition in vegetative stage in Orissa during 1990

Variety		Incidence of stem borer(%)			Tolerance ratio(TR)
No.	Name	DH	DS	TI	
01.	Moogey	1.84 (7.69)	9.03 (17.20)	10.87 (18.94)	5.91
02.	Mayurkantha	7.60 (15.42)	6.30 (17.60)	13.90 (21.40)	1.93
03.	Panidhan	6.49 (12.72)	5.16 (14.82)	11.65 (19.08)	1.80
04.	Champeisialli	5.08 (12.75)	9.92 (14.82)	13.00 (20.46)	2.56
05.	Bayahonda	11.88 (19.74)	20.68 (27.03)	32.66 (34.88)	2.73
06.	Kalamahipal	7.97 (15.99)	14.51 (22.41)	22.48 (28.23)	2.82
07.	Sapdidhan	5.14 (10.65)	10.93 (18.40)	16.07 (23.59)	3.13
08.	Hendakadala	6.49 (14.32)	9.14 (17.10)	15.63 (23.02)	2.41
09.	Patani	7.82 (15.83)	9.11 (10.44)	16.93 (23.00)	2.16
10.	Achuwabayahonda	4.00 (11.00)	10.13 (17.56)	14.13 (21.02)	3.53
11.	Panikoili(check)	2.33 (8.74)	4.56 (11.96)	6.89 (15.10)	2.96
	S.E. (m)	3.03	4.01	3.80	
	C.D. (0.05)	NS	NS	NS	

DH - Deadhearts, DS - Damaged stems

TI - Total infestation, TR - Tolerance ratio = $\frac{\% \text{ TI}}{\% \text{ DH}}$

Figures in parentheses are the means of Arc Sin $\sqrt{\text{percentage}}$

Table 20. Reaction of DWR varieties to stem borers under natural infestation conditions in heading stage (at maturity) and grain yield in Orissa during 1990

Variety		Incidence of stem borers(%)			Tolerance ratio(TR)	Grain yield (q/ha)
No.	Name	WH	DS	TI		
01.	Moogey	20.87 (27.21)	36.28 (37.03)	57.15 (49.12)	2.74	16.67
02.	Mayurkantha	24.79 (29.86)	34.94 (36.23)	59.73 (50.61)	2.41	16.81
03.	Panidhan	5.43 (13.48)	20.01 (26.59)	25.44 (30.31)	4.69	28.33
04.	Champeisiali	15.92 (23.52)	27.87 (31.86)	43.79 (41.44)	2.75	16.11
05.	Bayahonda	28.55 (32.30)	37.58 (37.80)	66.13 (54.43)	2.32	11.67
06.	Kalamahipal	6.27 (14.46)	23.62 (29.08)	29.89 (33.15)	4.77	19.72
07.	Sapadidhan	33.97 (35.65)	41.58 (40.55)	75.55 (60.35)	2.22	13.19
08.	Hendakadala	12.14 (20.38)	25.80 (30.55)	37.94 (38.02)	3.13	15.00
09.	Patani	28.69 (32.39)	31.91 (34.41)	60.61 (51.13)	2.11	14.69
10.	Achuwabaya-honda	28.12 (32.09)	36.45 (37.13)	64.57 (53.43)	2.30	13.61
11.	Panikoili (Check)	38.25 (38.19)	38.11 (38.12)	76.36 (60.71)	2.00	12.50
	S.E. (m)	0.40	0.34	0.46	-	0.50
	C.D. (0.05)	1.18	1.00	1.36	-	1.47
	C.D. (0.01)	1.61	1.37	1.85	-	2.01

WH - Whiteheads, DS - Damaged stems

TI - Total infestation, TR = $\frac{\% \text{ TI}}{\% \text{ WH}}$

Figures in parentheses are the means of Arc Sin $\sqrt{\text{percentage}}$

incidence of WH, DS and TI varied from 5.43 - 38.25, 20.01 - 41.58 and 25.44 - 76.36% respectively (Table 20). Panidhan followed by Kalamahipal had the lowest incidence of WH, DS and TI and both the varieties were at par as regard to WH incidence. Higher levels of WH (28.12 - 38.25%) and DS (31.91 - 41.58%) were recorded in Panikoili, Sapadidhan, Patani, Bayahonda and Achuwabayahonda. High level of stem damage was also recorded in varieties like Moogey and Mayurkantha. Both the varieties, Panidhan and Kalamahipal had higher ration of TI : WH (4.69 : 1) and 4.77 : 1 respectively). So far as grain yield was concerned all varieties except Achuwabayahonda produced significantly higher yield than the check variety Panikoili. Grain yield was the highest in the variety Panidhan (28.33 q/ha) followed by Kalamahipal (19.72 q/ha), Mayurkantha (16.81 q/ha), Moogey (16.67 q/ha) and Champeisiali (16.11 q/ha). The lowest yield of 12.5 q/ha was produced by Panikoili.

There were significant differences between the varieties for certain yield contributing characters like panicle length, number of grains/panicle, 1000 grain weight, percentage chaffy grains and grain yield/panicle both in respect of healthy plants and plants showing stem damage by stem borers (Table 21). Panidhan recorded the longest panicles with the highest number of grains/panicle, both in healthy and infested plants. The 1000 grain weight and grain yield/panicle were the highest in varieties Mayurkantha and Kalamahipal respectively. On the contrary, extent of chaffy grains was the least in Sapadidhan

Table 21. Effect of stem damage on yield contributing characters of DWR varieties during 1990 in Orissa

Variety No.	Name	Panicle length(cm)		No. of grains/ panicle		Chaffy grains(%)		1000 grain wt. (g)		Grain yield/ panicle (g	
		H	Inf.	H	Inf.	H	Inf.	H	Inf.	H	Inf
01.	Moogey	22.12	19.81	168	145	23.27 (28.81)	34.58 (36.00)	22.4	19.8	2.89	1.8
02.	Mayurkantha	26.52	23.84	174	147	27.61 (31.68)	44.06 (41.59)	28.9	24.7	3.65	2.0
03.	Panidhan	29.19	25.27	258	231	28.74 (32.38)	38.67 (38.36)	19.38	17.12	3.49	2.4
04.	Champeisiali	23.94	22.74	193	182	19.44 (26.17)	30.89 (33.74)	26.9	24.3	4.19	3.1
05.	Bayahonda	22.46	21.91	152	142	23.04 (28.65)	34.44 (35.95)	20.2	16.0	2.35	1.4
06.	Kalamahipal	25.60	24.21	196	184	25.83 (30.55)	31.03 (33.85)	28.3	24.0	4.30	3.0
07.	Sanadidhan	28.42	25.03	153	137	14.66 (22.46)	20.80 (27.11)	20.4	17.8	2.65	1.9
08.	Hendakadala	24.00	22.61	191	176	22.19 (28.07)	40.69 (39.62)	26.8	23.0	3.99	2.4
09.	Patani	26.40	24.66	171	154	22.20 (28.04)	33.31 (35.22)	24.6	23.7	3.25	2.4
10.	Achuwataya-honda	23.90	23.22	154	137	22.29 (28.16)	38.12 (38.10)	27.5	25.2	3.29	2.1
11.	Panikoili (Check)	24.81	22.30	165	152	20.52 (26.92)	40.37 (39.45)	26.7	24.0	3.59	2.2
	S.E. (m)	0.60	0.78	13.69	12.05	0.98	1.46	0.69	0.91	0.22	0.2
	C.D. (0.05)	1.77	2.30	40.38	35.54	2.89	4.31	2.04	2.68	0.65	0.7
	C.D. (0.01)	2.41	3.14	55.07	48.48	3.94	5.87	2.78	3.66	0.89	1.0

Figures in parentheses are the means of Arc Sin $\sqrt{\text{percentage}}$ H - Healthy, Inf. - Infested.

(14.66%) followed by champeisiali (19.44%). The analysis of variance for different characteristics showed the following results so far the significance of difference between varieties at (0.05%) was concerned.

1. Panicle length

(a) Healthy

$V_3\ V_7\ V_2\ V_9\ V_6\ V_{11}\ V_8\ V_4\ V_{10}\ V_5\ V_1$

(b) Infested

$V_3\ V_7\ V_9\ V_6\ V_2\ V_{10}\ V_4\ V_8\ V_{11}\ V_5\ V_1$

2. No. of grains/panicle

(a) Healthy

$V_3\ V_6\ V_4\ V_8\ V_2\ V_9\ V_1\ V_{11}\ V_{10}\ V_7\ V_5$

(b) Infested

$V_3\ V_6\ V_4\ V_8\ V_9\ V_{11}\ V_2\ V_1\ V_5\ V_{10}\ V_7$

3. Percentage chaffy grains

(a) Healthy

$V_7\ V_4\ V_{11}\ V_9\ V_8\ V_{10}\ V_1\ V_5\ V_6\ V_2\ V_3$

(b) Infested

$V_7\ V_4\ V_6\ V_9\ V_5\ V_1\ V_{10}\ V_3\ V_{11}\ V_8\ V_2$

4. 1000 grain weight

(a) Healthy

$V_2\ V_6\ V_{10}\ V_4\ V_8\ V_{11}\ V_9\ V_1\ V_7\ V_5\ V_3$

(b) Infested

$V_{10}V_2\ V_4\ V_6\ V_{11}\ V_9\ V_8\ V_1\ V_7\ V_3\ V_5$

5. Grain yield/panicle

(a) Healthy

$V_6\ V_4\ V_8\ V_2\ V_{11}\ V_3\ V_{10}\ V_9\ V_1\ V_7\ V_5$

(b) Infested

$V_4\ V_6\ V_9\ V_8\ V_3\ V_{11}\ V_{10}\ V_2\ V_7\ V_1\ V_5$

The results of 't' test clearly indicated that in all the varieties the differences between the healthy plants and plants showing stem damage in respect of percentage chaffy grains, 1000 grain weight, grain yield/panicle were significant (Table 22). In respect of panicle length except Champesiali, Bayahonda and Achuwabayahonda and that of number of grains/panicle except bayahonda the differences between healthy and infested plants were significant. Considerable reduction in panicle length, number of grains/panicle, 1000 grain weight and grain yield/panicle and higher percentage of chaffy grains in

Table 22. 't' test values for different yield contributing traits of the varieties having stem damage (infested) and no damage (healthy)

Variety No.	Name	Panicle Length (cm)	No.of grains/ panicle	Chaffy grains (%)	1000 grain weight	Grain yield/ panicle(gm)
01.	Moogey	3.370**	3.675**	6.758**	4.619**	12.631**
02.	Mayurkantha	3.014**	5.287**	5.776**	7.458**	14.993**
03.	Panidhan	6.271**	2.238**	3.832**	5.053**	4.954**
04.	Champeisiali	1.668	2.196*	9.154**	5.537**	6.621**
05.	Bayahonda	0.908	1.601	10.489**	8.089**	10.448**
06.	Kalamahipal	2.054**	2.641*	5.018**	7.711**	16.105**
07.	Sapadidhan	4.922**	3.184**	7.416**	5.909**	12.870*
08.	Hendakadala	2.192*	2.609*	20.694**	23.619**	13.616**
09.	Patani	2.600*	2.563*	9.425**	5.591**	6.479**
10.	Achuwabayahonda	1.055	3.505	13.824*	6.303**	20.908**
11.	Panikoili	4.228**	3.081**	24.318*	7.355**	10.864**
	Mean	3.817**	1.505	9.158*	4.888**	7.316**

* Significant at 5% level

** Significant at 1% level

plants having stem damage as compared to healthy plants in case of all the eleven varieties were observed. (Table 23). Percentage reduction in plants having damaged stems as compared to healthy ones in respect of panicle length, number of grains/panicle, 1000 grain weight and percentage increase of chaffy grains ranged from 2.45 - 13.43, 5.70 - 15.52, 3.66 - 20.79 and 20.13 - 96.73 respectively in different varieties (Table 23). All these figures indicated great deal of variations between varieties in respect of the effects of stem damage by the borer larvae. Further, taking these traits into consideration the yield reduction index computed was the highest in variety Panikoili (31.21%) followed by Hendakadala (27.80%), Mayurkantha (24.94%), Achuwabayahonda (23.32%) and the lowest in Kalamahipal (11.72%). The comparative study on grain yield/panicle obtained from healthy plants and that from plants showing stem damage revealed 23.87 to 44.11% reduction in yield due to stem damage in different varieties (Table 23). Varieties like Champeisiali (23.87%), Patani (25.23%), Sapadidhan (27.55%), Kalamahipal (28.84%) and Panidhan (31.23%) had less yield reduction than the others. The lowest grain yield loss of 6.25% due to stem damage was recorded in the variety Panidhan followed by Champeisiali (6.65%), Kalamahipal (6.81%) and Patani (8.05%) as compared to the highest (15.41%) in Mayurkantha (Table 24). Taking into consideration of the parameters like low incidence of WH, DH and yield reduction indices and extent of yield loss due to stem damage, the above mentioned four varieties were found to be promising so far as their tolerance

Table 23. Extent of reduction and increase in certain yield contributing traits and yield due to stem damage by stem borers

Variety No.	Name	Percentage reduction in Panicle length (A)	No.of grain/ panicle (B)	1000 grain weight (C)	Percentage increase chaffy grains (D)	Yield reduction index (%) $\frac{(A+B+C+D)}{4}$	Percentage yield reduction(PYR)
01.	Moogey	10.44 (17.81)	13.69 (21.69)	11.61 (19.43)	48.60 (44.07)	21.09	34.95 (36.15)
02.	Mayurkantha	10.11 (18.27)	15.52 (22.27)	14.53 (22.23)	59.58 (50.94)	24.94	44.11 (41.58)
03.	Panidhan	13.43 (21.46)	10.47 (18.33)	11.66 (19.39)	34.55 (35.34)	17.53	31.23 (33.97)
04.	Champeisialli	5.01 (11.21)	5.70 (12.85)	9.67 (17.22)	58.90 (50.15)	19.82	23.87 (27.78)
05.	Bayahonda	2.45 (8.91)	6.58 (13.82)	20.79 (26.89)	49.48 (44.82)	19.83	37.02 (37.39)
06.	Kalamahipal	5.43 (11.81)	6.12 (14.24)	15.19 (22.03)	20.13 (26.60)	11.72	28.84 (32.22)
07.	Sapadidhan	11.93 (19.61)	10.46 (17.02)	12.75 (18.99)	41.88 40.14)	19.26	27.55 (31.33)
08.	Hendakadala	5.79 (13.36)	7.85 (13.36)	14.18 (22.06)	83.37 (66.42)	27.80	39.35 (38.73)
09.	Patani	6.59 (14.52)	9.94 (16.60)	3.66 (10.08)	50.05 (48.06)	17.56	25.23 (29.92)
10.	Achuwabayahonda	2.85 (9.16)	11.04 (18.82)	8.36 (16.67)	71.02 (57.47)	23.32	35.26 (36.42)
11.	Panikoili	10.12 (17.95)	7.88 (15.55)	10.11 (18.52)	96.73 (79.67)	31.21	38.72 (37.47)
	S.E. (M)	3.44	4.12	4.22	5.29	-	3.96
	C.D. (0.05)	NS	NS	NS	15.60	-	NS
	C.D. (0.01)	NS	NS	NS	21.28	-	NS

Figure in parenters are the Are Sin $\sqrt{\text{percentage}}$

Table 24. Extent of grain yield loss due to stem damage by stem borers in Deepwater Rice verieties

Variety No.	Name	Percentage yield loss due to stem damage $\frac{(DS \times PYR^*)}{100}$	Percentage yield loss for 1 per-cent DS
01.	Moogey	12.68	0.3495
02.	Mayurkantha	15.41	0.4410
03.	Panidhan	6.25	0.3123
04.	Champeisiali	6.55	0.2386
05.	Bayahonda	13.91	0.3701
06.	Kalamahipal	6.81	0.2883
07.	Sapadidhan	11.46	0.2756
08.	Hendakadala	10.15	0.3934
09.	Patani	0.05	0.2523
10.	Achuwabayahonda	12.85	0.3525
11.	Panikoili	14.76	0.3873
	Mean	11.73	0.3328

$$* \text{ PYR} = \frac{\text{Grain yield/panicle obtained from healthy plants} - \text{Grain yield/panicle obtained from plants having stem damage}}{\text{Grain yield/panicle obtained from healthy plants.}} \times 100$$

to stem borer particularly to YSB attack was concerned.

4.3 INSECTICIDAL CONTROL OF STEM BORERS IN HEADING STAGE

The test chemical was phosphamidon (Dimedon 85 EC) in the trial conducted at Pipili and during the period of application (26.10.90 - 9.11.90) the water level in the field varied from 17.5 - 50.0 cm.

Observations on borer incidence recorded at grain maturity stage two days before harvest in the last week of December indicated that there was a significant reduction in stem borer incidence when phosphamidon was applied at boot leaf stage even for once (Table 25). Each of the treatments differed significantly from the other in respect of WH, DS, TI and yield. In the insecticide treated plots the incidence of WH, DS and TI ranged from 2.56 - 8.62, 15.48 - 24.26 and 18.04 - 32.88% as against 11.98, 27.40 and 39.38% in the untreated control plots respectively.

In the phosphamidon treated plots grain yield varied from 27.38 - 33.34 q/ha as against 23.81 q/ha in the untreated check plots, the highest being from three application schedule plots. However, grain yields obtained from all the treated plots were significantly higher over control.

The following relationships were observed amongst the different treatments in respect of incidence of WH, DS, TI and grain yield at 5% level.

Table 25. Effect of folior application of phosphamidon (0.3 Kg/ha) on stage and grain yield in DWR at Pipili during wet season of 1990

Treatment		(%) incidence of stem borers at heading stage			Grain yield
		WH	DS	TI	(q/ha)
T_0	Untreated check	11.98 (20.25)	27.40 (31.58)	39.38 (38.87)	23.81
T_1	Phosphamidon one spraying at boot leaf stage	8.62 (17.08)	24.26 (29.50)	32.88 (34.99)	27.38
T_2	Phosphamidon two sprayings at 7 days interval at boot leaf stage	3.68 (11.30)	17.05 (24.39)	20.91 (27.,34)	30.71
T_3	Phosphamidon two sprayings at 14 days interval at boot leaf stage	4.70 (12.52)	19.52 (26.22)	24.22 (29.49)	29.76
T_4	Phosphamidon three sprayings at 7 days interval at boot leaf stage	2.56 (9.22)	15.48 (23.19)	18.04 (25.16)	33.34
	S.E. (M)	0.28	0.27	0.30	0.27
	C.D. at 5%	0.86	0.83	0.92	0.83
	C.D. at 1%	1.21	1.17	1.30	1.17

WH = White heads, DS = Damaged stems, TI = Total infestation

Figures in parenthes are the means of Arc Sin $\sqrt{\text{percentage}}$

1. WH : $T_4 < T_2 < T_3 < T_1 < T_0$

2. DS : $T_4 < T_2 < T_3 < T_1 < T_0$

3. TI : $T_4 < T_2 < T_3 < T_1 < T_0$

4. Grain yield : $T_4 > T_2 > T_3 > T_1 > T_0$

In the second insecticidal control trial conducted at Bhubaneswar, monocrotophos was sprayed on the crop as per the schedules from 20.10.90 to 10.11.90 when the water level in the field varied from 8.0 - 13.0 cm. All the five insecticidal schedules resulted in significant reduction in the incidence of stem borers in the heading stage (Table 26). Incidence of WH, DS and TI in different treatments varied farm 13.78 - 18.67, 37.01 - 44.24 and 50.79 - 62.91% as against 20.89, 45.64 and 66.53% in untreated control respectively (Table 26). The grain yield in monocrotophos treated plots varied from 10.05 - 12.76 q/ha as against 8.85 q/ha in the untreated control plots, the highest being in three application schudule plots. The results of statistical analysis showed the following relationships between different treatments at 5% level.

1. WH : $T_4 < T_3 < T_2 < T_5 = T_1 < T_0$

2. DS : $T_4 < T_3 < T_2 < T_5 = T_1 < T_0$

3. TI : $T_4 < T_3 < T_2 < T_5 < T_1 < T_0$

4. Grain yield : $T_4 > T_2 = T_3 > T_5 = T_1 > T_0$

Table 26. Effect of monocrotophos (0.5 kg a.i./ha) spraying on the incidence of stem borers and yield in DWR (Var. Panikoili) in heading stage at Bhubaneswar during wet season of 1990

Treatment		(%) incidence of stem borers at heading stage			Grain yield
		WH	DS	TI	(Q/ha)
T_0	Untreated check	20.89 (27.21)	45.64 (42.49)	66.53 (54.63)	8.58
T_1	Monocrotophos one spraying at boot leaf stage	18.67 (25.61)	44.24 (41.70)	62.91 (52.48)	10.05
T_2	Monocrotophos two sprayings at days interval at boot leaf	16.04 (23.64)	39.57 (38.98)	55.61 (48.25)	11.76
T_3	Monocrotophos two sprayings at 14 days interval at boot leaf/flowering stage	14.89 (22.48)	38.53 (38.37)	53.42 (46.81)	11.40
T_4	Monocrotophos three sprayings at 7 days interval at boot leaf/flowering stage	13.78 (21.79)	37.01 (37.47)	50.79 (45.46)	12.76
T_5	Monocrotophos one spraying at boot leaf/flowering stage on need basis	18.08 (25.18)	43.74 (41.41)	61.82 (51.84)	10.29
	S.E. (M)	0.19	0.22	0.21	0.15
	C.D. at 5%	0.57	0.66	0.63	0.45
	C.D. at 1%	0.79	0.92	0.88	0.63

WH = White heads, DS = Damaged stems, TI = Total infestation

Figures in parenthes are the means of Arc Sin $\sqrt{\text{percentage}}$

Table 27. Cost : Benefit ratios of insecticidal control of stem borers in heading stage in DWR during the wet season of 1990

Treatment	Expenditure on spraying	Additional yield over control	Cost of additional yield	Profit due to spraying	Cost : benefit ratio
	Rs. P.	(q/ha)	Rs. P	Rs. P	
Phosphamidon @ o.3 kg a.i./ha per spraying					
One spraying	192.49	3.57	678.50	485.81	1:3.52
Two sprayings at 7 days interval	384.98	6.90	1311.00	926.02	1:3.41
Two sprayings at 14 days interval	384.98	5.95	1130.50	745.52	1:2.94
Three sprayings at 7 days interval	577.47	9.53	1810.70	1233.23	1:3.14
Monocrotophos @ 0.5 kg a.i./ha per spraying					
One spraying	419.47	1.47	279.30	-140.17	1:0.67
Two sprayings at 7 days interval	838.94	3.18	604.20	-234.74	1.0.72
Two sprayings at 14 days interval	838.94	2.82	535.80	-303.14	1:0.64
Three sprayings at 7 days interval	1258.41	4.18	794.20	-464.21	1:0.63
One spraying on need basis	419.47	1.71	324.90	-94.57	1:0.77

Computation of costworthiness of phosphamidon spraying revealed that a maximum profit of Rs.1233.23 was obtained from three spraying schedule followed by Rs.926.02 in two spraying schedule at 7 days interval (Table 27). However, the cost : benefit ratio was maximum (1 : 3.52) in the one spray schedule followed by two spray schedule at 7 days interval (1 : 3.4). On the contrary monocrotosphos spray resulted in moneytary loss of Rs.94.57 to Rs.464.21/ha in all the treatment schedules, the maximum being in three spary schedule followed by two spray schedule at 14 days interval (Rs.303.14) and the minimum in the need base application (one spraying in early booting stage). The cost : benefit ratios due to monocrotophos application were worked out to range from 1 : 0.63 to 1 : 0.77 (Table 27).

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CHAPTER V

DISCUSSION

DISCUSSION

5.1 PEST-COMPLEX OF DEEPWATER RICE AND THEIR RELATIVE ABUNDANCE

The agro-ecological conditions of a place, viz., crops, cropping patterns, soil, topography, water regime, crop varieties and weather conditions exert profound influence on the pest-complex of a crop and the magnitude of damage they cause to it. Inter-specific and intra-specific variation in insect pest population dynamics is a common phenomenon observed in DWR ecosystems in different parts of the world. However, according to Catling (1987) the insect fauna associated with DWR was almost the same as in low land rice. Fifteen species of insects are known to attack DWR in different parts of South and south-east Asia. Besides, four species of planthoppers and leafhoppers (Nilaparvata lugens, Sogatella furcifera, Nephotettix virescens and N. nigropictus) which had been reported to occur sporadically in Vietnam (Huynh Van et al., 1980) and Bangaladesh were considered as minor pests of rice in deepwater situation. But in all the countries of Asia the yellow stem borer (YSB), Scirpophaga incertulas has been reported as the major and most destructive pest of DWR (Catling, 1978; Catling and Islam, 1979; Huynh Van et al., 1983; Catling and Pattrasudhi, 1981 ; Catling et al., 1988 and Tripathy, 1989).

During the period of regular survey conducted from July to December, 1990 in two representative DWR areas of Orissa, i.e., Patamundai block of Cuttack district and Bramhagiri block of Puri district eight species of insect pests belonging to four different orders, viz., Lepidoptera (S. incertulas, Chilo supressalis, Sesamia inferens, Cnaphalocrocis medinalis), Orthoptera (Oxya nitidula, an unidentified cricket species), Diptera (Hydrellia philippina) and Coleoptera (Dicladispa armigera) were recorded. The occurrence of the leaf damanging insects like leaffolder, grasshopper and cricket, was observed from July-December, August-December and September-December with 0.5 to 25.6, 1.1 to 30.0 and 1.5 to 48.4% leaf infestation, where as the incidence of whorl maggot and hispa was confined to the month of August only with low extent of leaf damage (0.0 - 4.8 and 1.6 - 14.9%) respectively. All these insect species with varying degree of infestation have also been reported from other DWR areas of Asia. Besides, considering the regularity in occurrence, wide-spread distribution in the State and extent of damage, the YSB has been recognised as the most destructive pest of DWR and this is in agreement with the observations of all the past DWR Entomologists.

Variations in respect of pest species and extent of damage to DWR between 1989 and 1990 in the State were observed. In 1989 wet season the white backed planthopper, S. furcifera and the grasshopper, Hieroglyphus banian were recorded where as

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cricket incidence was not observed in DWR (Tripathy, 1989). On the contrary, in 1990 absence of the former two species and quite a considerable extent of leaf damage by the latter insect were remarkable. Further, although all the three borer species were recorded during both the years there was a great deal of variation in their relative abundance and extent of damage. These variations might be mainly due to differentia weather conditions particularly rainfall which was almost double (2054.6 mm) of that received during 1989 (996.6 mm). The changes in weather conditions ~~must~~ might have influenced the abundance of biocontrol agents directly and thus the pest population through their activities.

5.2 SEASONAL FLUCTUATIONS IN INCIDENCE OF YSB IN RELATION TO FLOODING PATTERNS AND GROWTH STAGES OF DWR

YSB, the most destructive and well-adapted species to deepwater situation is also greatly influenced to show its pestiferous activities by the changes in flooding pattern in different growth stages of the rice crop. As the flood water rises in the vegetative stage the growth of the rice plant is accelerated through stem elongation. The type of plant growth habit, flooding period and the prevailing temperature during the pre-flooding period coupled with the previous crops in the area are also known to determine the extent of YSB damage to DWR.

The present sequential studies revealed that the YSB incidence commenced either in first or second fortnight of August and remained at a low level upto the first fortnight of October in both Patamundai and Bramhagiri areas (Tables 8, 9 and 10 and Figs. 5 and 6). average incidence of DH and DS over the two locations ranged from 0.60 - 5.29 and 1.02 - 3.98% respectively in different fortnights during the above period. The maximum temperature during June and July was quite high (31.39 - 36.27^{o}C) which might have contributed to egg mortality, thus, affecting the initial population build up. Low borer incidence in vegetative stage might be partly ascribed to the effect of high temperature on egg survival preventing the population build up subsequently. According to the report of Suwongwan and Catling (1987) there was negative correlation of survival of eggs and first instar larvae of YSB with daily maximum temperature in Thailand. Reduction in egg-hatching has been observed above 32^{o}C and below 60% RH (Catling et al., 1984).

In Bramhagiri flooding commenced from mid - August and water level remained above 50 cm for a period of 10 - 11 weeks where as in Patamundai flooding started from mid-July and water level above 50 cm was observed for 16 weeks in one plot and 2 weeks in the other plot in which sequential studies were made. Flood water reached its peak in the first fortnight of November due to heavy rains (246.6 mm) during this period which was an unusual phenomenon in 1990. In Orissa recession of flooding

usually commences from October in DWR areas. Flooding in August-September accelerates stem elongation where as later part of flood receding period coincides with booting/flowering of DWR in the State. It has been observed in all the DWR areas that there is strong correlation between flooding, crop growth and incidence of stem brorers. During flooding period when water level was quite high amongst the stem borers only YSB was known to attack DWR. There is strong evidence that this borer species needs high moisture level in all its developmental period development (Nishida, 1967; Yasumatsu, 1976 and Tripathy, 1989). The present study revealed that during the monsoon and early part of the post-monsoon periods there was heavy rain (1371.9mm from June to October), there by leading to flooding for quite a long period during which only S. incirtulas incidence was recorded. High water level was quite unfavourable for other borer species.

In one of the sequential study plots at Patamundai for the major growth period of the crop and at Bhubaneswar, during 1990 deepwater situation did not prevail and on the contrary, there was low land situation. But in these plots upto the end of first fortnight of November YSB was the only borer which attacked the crop. This might be due to unsual heavy rain during this year. During 1989 incidence of stripped stem borer (SSB) was recorded in the vegetative stage of DWR in both Patamundai and Bramhagiri areas with the larval population constituting 5.54 to 27.28% during the period from August to

October, 1989 (Tripathy, 1989). However, at Bhubaneswar the borer incidence level in the vegetative stage was at a higher order with the mean DH and DS stem ranging from 2.71 - 12.57 and 8.82 - 10.71% respectively in different weeks (Table 11).

From the results of earlist workers it is evident that water receding phase coincides with the booting/flowering stage of DWR and increase of borer incidence (Catling, 1984-85 and Tripathy, 1989). During 1990 DWR came to booting/flowering in the first fortnight of November, but flooding started receding from the second fortnight of the month both at Bramhagiri and Patamundai (Table 6). The mean borer incidence in the first fortnight of November weas almost at the same level (10.03% TI). In the second fortnight of November coinciding with the recession of flooding borer incidence abruptly increased from 2.12, 7.91 and 10.03% to 11.07, 14.70 and 25.77% WH, DS and TI respectively. These data conclusively proved that there was a strong correlation between the water receding phase or in other words low water level and higher activity of borers. Further, in the grain maturity and ripending stage which occurred in December when water level was considerably low (Table 6) activity of borers was accelerated and infestation reached the maximum levels of 32.56 and 31.35% (TI) at Patamundai and Bramhagiri respectively in the second fortnight oif the month (Table 8 and 9; Figs. 6 and 7). The conditions prevailed in december was quite favourable for the other two borer species, viz., C. supressalis and Sesamia inferens which accounted for 10.00% of the larval population (Table 12). Hence, it is

believed that the activity of these two species added to the damage caused by YSB and due to combined infestation of the three borer species in the grain maturity/ripening stage such high incidence of WH and DS was resulted in. High incidence of stem borers in DWR in the grain ripening stage has also been recorded by Huynh Van et al. (1983) in Vietnam, Catling et al. (1981 and 1984) in Bangladesh and Thailand and Tripathy (1989) in Orissa (India). Further studies of Catling et al. (1984, 1985) also revealed high incidence of S. incertulas and C. polychrysus in grain ripening stage of DWR and reached the maximum seasonal level of 44% DS in Bangladesh and 38% in Thailand.

5.21 DWR stubbles as the habitat of YSB and its impact on damage of subsequent crop

During the period from January to mid-march, 1990, 15.38 - 22.09% DWR stubbles were found intested by borers and in the first three weeks of January 71.43 to 76.92% infested stubbles were recorded to harbour the borer larvae. Thereafter, there was a gradual decline in the recovery of larval and pupal population in the dissected stubbles which indicated pupation and moth emergence from 4th week of January onwards till the second week of March where no immature stage of the borers was observed. Considerably low percentage of infested stubbles having borer larvae and pupae during the second fortnight of February and presence of pupal exuviae during this period indicated majority of the borer moth emergence during this period.

The average weekly atmospheric maximum and minimum temperatures that prevailed in January 4th week were 32.5^{o} and 17.1^{o}C respectively. Although the maximum temperature from January 4th week to mid-March fluctuated between 29.76 to 32.83^{o}C there was a steady increase in the minimum temperature during the above period and reached 21^{o}c during the first fortnight of March. These temperatures were quite favourable for pupation and adult emergence of S. incertulas which was also the dominant borer species in stubbles.

Overwintering of YSB in larval stage in DWR stubbles during December to February has been observed in Bangladesh (Catling, 1981), China (Deng et al., 1984), India (Anon, 1989a, 1989b). In an earlier study on off-season activity of stem borers during 1989 borer moth emergence was mostly confined to the first fortnight of February which was a deviation from the 1990's observation. Because of lack of winter rainfall, particularly early February 1989 the almospheric temperature was higher (33.7^{o} - 33.8^{o}C maximum and 18.9 - 19.6^{o}C minimum) than that prevailed in 1990 during the same period. The higher soil and atmospheric temperatures must have been the main reason of early pupation and moth emergence during 1989.

The overwintering YSB larvae in stubbles are largely responsible for population build up in subsequent generations in the summer paddy crop which comes up in the field from December onwards either in the nursery beds or main fields. Later, the

summer paddy crop acts as a source of YSB infestation for the subsequent wet season rice mostly in the low land and deepwater situations. Thus, destruction of stubbles in late January or early February is likely to reduce stem borer menace both in summer and wet season rice in the State. This conclusion is in partial agreement with the observations of Shen (1985) who reported that the over-wintering population of stem borer larvae in stubbles had correlation with subsequent number of larvae observed and temperature and RH were the main factors that influenced the overwintering population.

5.22 Composition of different borer species and status of YSB in DWR ecosystem

In Orissa three stem borer species, viz., S. incertulas, C. Supressalis and S. inferens with varying proportions in their population in different cro growth periods were recorded in DWR both in 1989 (Tripathy, 1989) and 1990. However, the former species has been recognized as the most abundant and destructive species over time and space in DWR ecosystem. In Bangladesh, Thailand, Vietnam, Philippines, Burma and India this insect has been reported to cause high level of damage to DWR and considered as the dominant borer species (Catling, 1979; Catling and Pattrasudhi, 1981; Huynh Van et al., 1983; Hussain and Begum, 1985, Barrion and Litsinger, 1987; Rai et al., 1989, Senapati et al., 1990). In the present study it was observed that YSB constituted 100% from August to mid-November where as in the grain maturity and ripening stages (from mid-November to

end of December) SSB and PSB comprised of 10.00 - 14.29 and 10.00% respectively (Table 12) at P atmundai and Bramhagiri areas where deep flooding continued upto mid-November. On the other hand, at Bhubaneswar where water depth was at a very low level (1.0 - 8.0 cm) in November and nil in December SSB and PSB larval populations were at a higher plateau (25.00 - 50.00%) during late heading stage. But during the period from September to mid-November only YSB was recorded. S. incertulas is restricted to Oryza spp. and is well adapted to aquatic environment. Elongating stem, long growth period of DWR and special biological adaption for protection of the pupae in the stem during submergence period by preparing water proof memberane provide favourable conditions for survival and successive brood development of this species. These are definite advantages for YSB over the other two species, viz., C. supressalis and S. inferens which are the polyphagous species having no adaptation to aquatic environment. They, therefore, confine their attack to the grain ripening stage.

5.23 VARIATION IN RATIO OF DH/WH : TI

Stem damage by stem borers has been observed to show a great deal variation in developing symptoms of attack in different growth stages of the crops. In stem elongation to booting/flowering stage the mean ratio of DH/WH to TI during the period from September to mid-November was quite high (1 : 4.73 to 1 : 20.08) but in early flooding (August) and flood receding phase which coincided with grain maturity and ripening stage

(mid-November to December) the ratio was low (1 : 1.25 to 1 : 2.44) which was due to higher rate expression of symptoms of attack (Table 12). This phenomenon is usually observed in deepwater situation where with increasing water depth stem elongation is accelerated causing long internods with massive lumen and therefore, feeding in the stem does not cause of serverance of the central shoot. But stem damage in early growth stage of the crop when there are few internodes with thin stems and damage to terminal internodes in heading stage result in more of DH and WH respectively. Thus, in these stages the ratio becomes small. Plant elongations in response to flood water has been observed to show negative influence on prodution of damaged symptoms in Bangaladesh (Islam, 1990). Higher ratio of DH to DS and WH to DS in stem elongation and booting/flowering stage has also been observed in earlier studies in Thailand and Bangladesh (1 : 13) by Catling et al. (1984/85), in Bangladesh (1 : 16) by Islam (1990) and in Orissa by Tripathy (1989).

Another point of interest emerged when DH/WH to TI ratio observed under typical deepwater situation (at Bramhagiri and Patamundai) were compared with those recorded under lowland condition with DWR variety 'Panikoili' at Bhubaneswar. The ratios at Bhubaneswar varied from 1 : 1 to 1 : 4.10 which was much less than that observed at Bramhagiri and Patamundai. The reason of this can be ascribed mainly to low rate of stem elongation and small stem lumen due to lack of flooding.

5.3 VARIETAL REACTIONS TO STEM BORERS ATTACK

Although true genetic resistance to YSB in none of rice germplasms has been observed yet at the global level, DWR varieties are known to show differential reactions to borer attack in Bangaladesh and Thailand (Catling, 1979; 1981; 1984/85); Uttar Pradesh (Chaudhury et al., 1985 and Gupta et al., 1989), West bengal (Anon, 1989) and Orissa (Tripathy, 1989). In the present study a great deal of variation between varieties in respect of incidence of DH, WH, DS and ratio of DH/WH to TI was observed (Tables 15, 16, 17 and 18). Of the 60 varieties screned in the field under natural conditions of infestation only 10 and 2 varieties had less than 5 and 2% DH (Achuweabayahonda, Champa, Champeisiali, Hendakadala, Kalamahipal, Kanthapakhira, Mayurkantha, Moogey, Panidhan and Patani) and DS (Champa and Kanthapakhira) respectively where as 45 varieties had moderate level of incidence which ranged from 5.01 to 15.0% DH. Low incidence of both DH and DS ($\leq$ 5%) was observed only in two varieties, viz., Champa and Kanthapakhira. Comparatively high tolerance ratios (TI : DH) of above 4.0 were found in favour varieties like Kalamahipal, Achuwabayahonda, Patani and Panidhan in the vegetative stage (Table 15).

In grain ripening stage WH incidence within 5% was recorded only in two varieties (Moogey and Panidhan), but none of the varieties tested could remain within this level so far DS was concerned (Table 18). However, 15 varieties had high tolerance ratios (TI : WH) of 4.00 - 7.56, the highest being observed in Panidhan (Table 17). None of the varieties

satisfied all the favourable traits like low level of DH, WH, DS and high tolerance ratio. However, considering three or four above traits out of five Panidhan, Moogey, Kalamahipal, Achuwabayahonda and Patani showed promise against the borer attack. This conclusion confirmed the observations of Tripathy (1989) who reported that the latter four varieties were found less susceptible to the stem borer attack under field conditions during 1989. The former variety (Panidhan) was not included in Tipathy's screening trial.

5.31 Varietal differences in tolerance to stem borers infestation

Results of a replicated field trial on tolerance study to stem borers attack (predominantly S. incertulas) showed wide variations between 11 varieties in respect of extent of DH, WH, DS and TI. In the vegetative stage although the differences between varieties in respect of the above traits were not significant the tolerance ratio (TR) went in favour of Moogey (5.91) followed Achuwabayahonda (3.53) and sapadidhan (3.13), Moogey, Panikoili, Achuwabayahonda, and Panidhan had lower borer incidence as compared to the rest of the varieties (Table 19).

In heading stage varieties like Panidhan and Kalamahipal recorded significantly lower incidence of WH (5.43 and 6.27%) and DS (20.01 and 23.62%) with higher tolerance ratios (4.69 and 4.77) than rest of the varieties (Table 20).

5.311 Components of yield loss and yield-stem damage relationship

The various components which attribute towards grain yield loss in rice particularly under deepwater situation due to stem borer infestation are (i) production of DH in vegetative stage, (ii) reduction in plant density mostly in the flooding period, (iii) adverse effects of stem damage in plants apparently looking healthy and (iv) production of white heads in the heading stage. Severance of the central shoots due to feeding of the borer larvae causes DH and WH in the vegetative and reproductive stages respectively. But a major proportion of damage stems do not express the symptoms of infestation and look outwordly healthy. Larval feeding is likely affect the translocation of nutrients and water to the developing panicles, thereby affecting grain filling.

In the present study however, effect of stem borer damage on plant density has not been taken into account and emphasis has been given on the effect of stem damage, in those plants showing no symptoms of attack, on yield contributing characteristics and finally yield in 11 DWR varieties. The results of present investigation revealed significant reduction in panicle length, number of grains/panicle, 1000 grain weight and grain yield/panicle and significant increase in grain sterility in infested but apparently healthy lants as compared to healthy plants in almost all the varieties. There was

variation between varieties in showing reduction/increase of the above traits, but only in percentage increse in chaffy grains the differences were statistically significant (Table 23).

The percentage yield reduction (PYR) computed taking into account the yields of individual panicles ranged from 25.23 to 44.11 in different varieties, but the differences between varieties were not significant. However, the yueld reduction indices calculated taking all the above parameters into contideration ranged from 11.72% in Kalamahipal to 31.21% in Panikoili which indicated wide variation between varieties.

Extent of yield reduction depends upon the percentage damaged stems and extent of yield loss due to each unit of damage stems, which is again likely to show varietal variations. In the present study considering the extent of damaged but apparently healthy looking stems and PYR the yield loss has been worked out to range from 6.25 to 15.41% and extent of yield loss/each one per cent of DS from 0.2386 - 0.4410% (Table 24). Panidhan, Champeisiali, Kalamahipal and Patani recorded low level of yield loss (6.25 - 8.05%) due to stem damage as compared to other varieties. The findings of this study established that, on an average, one per cent damaged but apparently healthy stem resulted in 0.3328% yield loss. Low level of yield loss in Panidhan, Kalamahipal and Champeisiali was mainly due to low percentage of stem damage (20.01, 23.62, 27.87% respectively) where as in case of Patani it was mainly

due to low rate of yield loss (0.2523%) per each one per cent of damaged stems, even though there was fairly high percentage (31.91%) of DS prevailed in the heading stage.

The yield loss due to damaged but aparently healthy looking stems in DWR is less understood. In a recent study Islam (1990) reported from Bangladesh that stem damage significantly reduced filled grain numbers and panicle weights and increased grain sterility in two varieties such as Chamara and Khama. In the former variety significant grain weight reduction was also observed by the author. Catling et al. (1987) also observed 1% yield loss with 2% DS at harvest in DWR. Further, varietal differences in reduction of the above traits and increase in grain sterility are likely to depend on the severity of damage and position of damage in the stems. Relatively short statured varieties are expected to suffer from more yield loss than the tall varieties having long internodes. When the top internodes are damaged yield loss is more pronounced. Such type of opinions have given by Taylor and Islam (1984), Datta et al. (1985) and Taylor (1988). Although in the present study position and length of stem damage have not been taken into account the varietal differences observed on yield loss due to stem damage might be partly due to the above damage criteria.

Higher yields of 16.11 - 28.33 q/ha obtained from Panidhan, Kalamahipal, Mayurkantha, Moogey and Champeisiali indicated their better adaptability to DWR situation and less damage due to stem borers.

5.4 EFFECT OF INSECTICIDES ON BORER INCIDENCE AND GRAIN YIELD

In Orissa, shallow deepwater situation usually prevails in DWR ares and flood water starts receding from October unwards. But during the year 1990 due to heavy rainfall in the Ist week of October and that of November water level in the insecticidal trial plot ranged from 17.5 - 50 cm during the period (26.10.90-9.11.90) when phosphamidon was applied. In this water level although insecticide application was little difficult put found feasible.

Phosphamidon application @ 0.3 kg a.i./ha at the boot leaf/flowering stage resulted in reduction of WH incidence by 28.05-78.63, DS 11.46-43.50 and TI 16.51-54.19% respectively and a yield increase of 3.57-9.53 g/ha which came to 14.99-40.03% over untreated control (Table 28) each additional one application prooved significantly better in reducing the borer incidence and increasing the grain yield. However, the cost effectiveness of one application was the highest (1:3.52) followed by two applications at 7 days interval (1:3.41) at bootleaf stage of the crop. Although highest profit of Rs.1230.23 was acrued from three spraying schedule the cost effectiveness was in the third position. Thus, from the present results it is reasonable to conclude that two foliar applications of phosphamidon at the boot leaf stage at 7 days interval could afford effective control of stem borers in

Table 28. Mean percentage reduction of stem borer incidence and percentage increase in yield due to insecticidal treatments at Pipili

Sl.No.	Treatment	Percentage reduction			Percentage increase in yield
		W H	D S	T I	
1.	T_1-Phosphamidon one spraying at boot leaf stage	2.05	11.46	16.51	14.99
2.	T_2-Phosphamidon two sprayings at 7 days interval at boot leaf stage	69.28	37.77	46.90	28.98
3.	T_3-Phosphamidon two sprayings at 14 days interval at boot leaf stage	60.77	28.76	38.50	24.99
4.	T_4-Phosphamidon three sprayings at 7 days interval at boot leaf stage	78.63	43.50	54.19	40.03

Table 29. Mean percentage reduction of stem borer incidence and percentage increase in yield due to insecticidal treatments at Bhubaneswar

Sl.No.	Treatment	Percentage reduction			Percentage increase in yield
		W H	D S	T I	
1.	T_1-Monocrotophos one spraying at boot leaf stage	10.63	3.07	5.44	17.13
2.	T_2-Monocrotophos two sprayings at 7 days interval at boot leaf stage	23.22	13.30	16.41	37.07
3.	T_3-Monocrotophos two sprayings at 14 days interval at boot leaf/ flowering stage	28.72	15.58	19.71	32.87
4.	T_4-Monocrotophos three sprayings at 7 days interval at boot leaf/ flowering stage	34.04	18.91	23.66	48.72
5.	T_5-Monocrotophos one spraying atboot/flowering stage on need basis	13.45	4.16	7.08	19.93

heading stage with significant yield advantage. Further, the second insecticide trial conducted at Bhubaneswar clearly indicated that application of monocrotophos once at ETL coinciding with one egg mass or one moth per squre metre in the boot leaf stage could afford better result in reducing borer incidence and increasing grain yield over arbitrary application of insecticide once (Table 26 and 29).

Earlier studies conducted by Catling et al. (1987) revealed that total protection from YSB infestation was not possible even after applying insecticides for 20-22 times. But such treatments could reduce the WH and DS by 73.00 and 62% respectively and increased the yield by 21%. Toylor et al. (1981) were of the opinion that insecticide application although could not be the whole solution for the YSB problem under DWR situation but it could find a genuine place in the pest management programmes. Tripathy (1989) reported that two applications of monocrotophos @ 0.5 kg ai/ha at booting/flowering stage afforded statisfactory control of stem borer in heading stage with considerable yield increase and reasonable cost effectiveness. The results of the present study also clearly indicated that application of phosphamidon/ monocrotophos in booting/flowering stage could contribute substantially in the management of stem borers in deepwater rice.

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CHAPTER VI

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

Investigations were undertaken to study some aspects of ecology of stem borer complex of rice, varietal reactions to stem borers attack and their insecticidal control in the heading stage under deepwater situation during 1990. The main objective of this study was to find out some effective individual control components, viz., varietal tolerance, time, frequency and number of insecticidal application in order to develop a suitable, effective stem borer management strategy in DWR with reasonable cost-effectiveness. The results of these studies and the conclusions derived there of are summarised below.

Sequential studies conducted in two typical deepwater rice areas i.e., Patamundai and Bramhagiri blocks of Cuttack and Puri districts respectively revealed the association of eight insect species namely the yellow stem borer (Scirpophaga incertuals), striped borer (Chilo supressalis), pink borer (Sesamia inferens) leaffolder (Cnaphalocrocis medinalis), grasshopper (Oxya nitidula), cricket (unidentified), whorl maggot (Hydrellia philippina) and hispa (Dicladispa armigera) with deepwater rice during the different growth stages of the crop from July to December, 1990. The incidence of YSB was severe, where as that of grasshopper and cricket moderate and the other species mild. Sequential survey was also conducted on the stem borer activities at Bhubaneswar during the same period. The water level in sequential study plots ranged from 2-85, 0-82 and 0-30 cm at Patamundai, Bramhagiri and Bhubaneswar respectively.

The stem borer incidence was first observed in the 1st or 2nd fortnight of August and the level of infestation was low in the vegetative stage of the crop (upto the end of October). The mean incidence of DH and DS ranged from 0.53 -5.29, and 1.02-10.02% in Patamundai and Bramhagiri areas where as at Bhubaneswar the corresponding figures ranged from 2.8-12.57 and 5.55-10.71% respectively in different fortnights. The incidence was comparatively at a higher level during the 2nd fortnight of October in all the three locations. Coinciding with the flood receding phase in 2nd fortnight of November the total borer incidence increased, on an average, to 25.77% with 11-07% WH in the flowering stage of the crop. Subsequently, in the grain maturity and ripening stage in December the mean incidence of WH, DS and TI were 13.09, 18.86 and 31.95% respectively. These results conclusively proved that the water receding phase which usually coincides with the flowering stage is very critical from the point of view of borer attack. borer in-festation at Bhubaneswar was at a higher level than at Patamundai and Bramhagiri.

Amongst the three stem borer species recorded S. incertulas was the dominant one followed by C. supressalis and S. inferens, the former species constituting 100% upto first fortnight of November and 85.71 - 90% at Bramhagiri and Patamundai areas and 20-75% at Bhubaneswar. The striped and pink borers constituted 10.00-14.29 and 0.00-10-00% at the former two locations and 40-50, and 25-40% at Bhubaneswar respectively.

Studies on the activities of the stem borers on the DWR stubbles also indicated the association of the above three species, YSB followed by SSB and PSB being the dominant one. The emergence of borer moths from the stubbles was mainly confined to the 2nd fortnight of February in 1990.

Of the sixty DWR varieties screened under natural infestation conditions only 10 varieties (Achuwabayahonda, Champa, Champeisiali, Hendakadala, Kalamahipal, Kanthapakhira, Mayurkantha, Moogey, Panidhan and Patani) had low incidence (within 5%) of DH where as two varieties (Champa and Kanthapakhira) had low incidence of DS. On the heading stage, however, extent of WH incidence was within 5% in Moogey and Panidhan. Considering the incidence of DH, DS, WH and tolerance ratio (TR) five varieties (Panidhan, Moogey, Kalamahipal, Achuwabayahonda and Patani) were considered less susceptible to the attack of stem borer, particularly S. incertulas which was the predominant species.

Effect of stem damage in plants looking outwardly healthy was manifested in reduction of 2.45 - 13.43% in panicle length, 5.70 - 15.52% in number of grains/panicle, 3.66 - 20.79% in 1000 grain weight and 20.13 - 96.73% increase in grain sterility with 25.23 - 44.11% grain yield reduction in 11 DWR varieties evaluated in a RBD trial. The extent of stem damage without expression of symptoms ranged from 20.01 - 41.58% in different varieties. Computation of these results indicated

that per each one percent of stem damage there was an yield reduction of 0.2386-0.4410% with the total reduction of 6.25 - 15.41% in different varieties, the average being 0.3328 and 11.73% respectively. Considering the extent of WH, DS and extent of yield loss due to stem damage and grain yield, Panidhan was considered as the most tolerant variety and was followed by Kalamahipal and Champeisiali. Panidhan recorded the highest grain yield of 28.33 q/ha followed by Kalamahipal (19.72 q/ha), Mayurkantha (16.81 q/ha), Moogey (16.67 q/ha) and Champeisiali (16.11 q/ha).

Application of Phosphamidon @ 0.3 Kg. or monocrotophos @ 0.5 Kg a.i./ha at booting/flowering stage reduced the borer incidence and increased the grain yield significantly. The incidence of WH and DS ranged from 2.56 - 8.62 and 15.48 - 24.26 with the grain yield of 27.38 - 33.34 q/ha in the phosphamidon treated plots as against 11.98 and 27.48% with grain yield of 23.81 q/ha in untreated control plots respectively. The cost : bendit ratio with phosphamidon treatment was wcrked out to range from 1 : 2.94 to 1 : 3.52, the highest being in one spray schedule. In Monocrotophos treated plots the incidence of WH and DS ranged from 13.78 - 18.67 and 37.01 - 44.24% as against 20.89 and 45.64% in untreated check plots respectively. Due to low yield in the experimental plot the cost-effectiveness of the monocrotophos treatment was not encouraging.

The results of present study led to the conclusion that YSB was the most destructive insect pest perticularly in the heading stage of DWR and the varieties like Panidhan, Kalamahipal and Champeisiali showed tolerance reaction to its infestation. Further, application of phosphamidon in the booting/flowering stage twice at 7 days interval could afford satisfactory control of the borer and resulted in significant increase in grain yield. However, better results are expected if the varietal tolerance factor is integrated with the insecticidal approach.

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APPENDIX

Annexture I Meteorological data in Orissa during 1990

Month	Fort-night	Temperature in °C		Rainfall (mm)	No.of rainy days.	Mean RH(%)	Sunshine hours
		Max.	Min.				
Jan.-90	I	29.15	14.63	0.0	0	61.13	9.08
	II	32.19	16.36	0.0	0	60.94	9.53
Feb.-90	I	33.22	19.57	0.0	0	66.50	8.84
	II	29.76	19.40	59.8	7	77.86	7.42
March-90	I	30.21	21.00	112.7	5	79.27	7.70
	II	32.83	22.61	6.8	2	74.50	8.61
April-90	I	33.81	23.38	77.9	5	76.73	8.75
	II	35.13	26.16	52.8	2	75.27	7.92
May.-90	I	33.25	24.14	76.9	8	68.67	5.61
	II	36.27	26.43	48.0	5	61.38	8.56
June-90	I	35.49	25.97	64.7	5	76.53	6.21
	II	32.98	25.29	145.9	11	82.67	4.09
July-90	I	31.39	24.61	163.4	11	85.93	0.77
	II	32.18	25.97	126.1	7	80.75	3.96
Aug.-90	I	33.70	26.01	172.5	9	82.53	6.62
	II	32.11	26.01	296.0	13	85.06	5.00
Sept.-90	I	31.91	25.67	50.1	12	85.60	1.69
	II	33.27	25.39	188.0	5	83.20	1.54
Oct.-90	I	31.49	24.81	163.5	10	87.33	4.82
	II	31.56	21.03	1.7	2	72.38	7.43
Nov.-90	I	30.17	21.87	246.6	6	74.13	5.76
	II	31.16	19.05	0.0	0	69.87	8.18
Dec.-90	I	29.97	16.87	0.0	0	74.10	7.87
	II	28.50	14.40	0.0	0	65.82	9.26