PRELIMINARY INSECTICIDE TESTS AND OBSERVATIONS FOR PREFLOOD CONTROL OF YELLOW RICE BORER IN DEEPWATER RICE

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SUMMARY

Starting with the hypothesis that insecticides could reduce the year's second brood of yellow rice borer, *Scirpophoga incertulas* (Walk.), and thus reduce the late season population potential in deepwater rice, trials of insecticides were made and a preliminary report of their efficacy is given. Stem dissections were made during the insecticide trials and the results, taken together with data from other trials and earlier work of the ODA/BRRI Deepwater Rice Pest Management Project, are used to examine the population structure of the yellow rice borer and to postulate a population dynamics model.

The existing evidence on rice yield loss due to yellow rice borer is re-examined and it is suggested that the most critical period of attack may be before flooding when basal and primary tillers are the only targets available for the pest.

The Deepwater Rice Pest Management Project, jointly funded by the Government of Bangladesh, through the Bangladesh Rice Research Institute (BRRI) and the Overseas Development Administration of the Government of the United Kingdom, entered a second phase in 1981 and aims to build on knowledge acquired or confirmed during 1977-80. Much of the first-phase work on stem borers, principally the yellow rice borer (or yellow stem borer), *Scirpophaga incertulas* (Walk.), was described by Catling and Islam (1979) and subsequently by Catling (1980, 1981).

During the first phase, relatively little work was done on actually controlling the yellow rice borer. Catling and others used basal applications of carbofuran at sowing time in 1979 but found that these gave little or no protection into the flooding period and there were no differences in yield between treated and untreated plots.

ODA/BRRI Deepwater Rice Pest Management Project, BRRI, Joydebpur, Bangladesh.

In 1978, the same workers attempted to compare the effect of intensive insecticide use with a no-treatment regime (Catling et al 1980). Although some 22 applications of insecticide (carbofuran granules twice before flooding and then 20 sprays of diazinon at intervals of 6-7 days) did not give total protection from yellow rice borer attack, stem infestation at harvest was only 9.0% in the treated area compared with 33.2% in the nonsprayed area. The yield from the treated area was 26.7% higher than that from the control area. In 1979, a similar experiment (with only 20 sprays of diazinon and no carbofuran) resulted in 33.2% infestation in the nonsprayed control area and 13.5% in the treated area. The yield improvement, however, was only 15.4%. Catling concluded that the trials showed the futility of trying to control yellow rice borer with insecticides alone (Catling 1981).

Much information was acquired, however, about the incidence of yellow rice borer, its importance as the major pest of deepwater rice in Bangladesh, and its population dynamics (Catling 1981). Catling postulated that there are six broods, or generations, of yellow rice borer each year. The first infestation of deepwater rice is by brood 2 in the preflood period (May to mid-June). Brood 3 tends to coincide with the onset of flooding (mid-June to the end of July). Brood 4 is at the height of flooding (August to late September), and brood 5 infests the rice at the heading stage, as the floods subside (late September to the end of October). The seasonal patterns, however, were variable in terms of density of infested stems and in numbers of larvae and pupae. In general, from Catling's conclusions, a typical year has a fairly high infestation in brood 3, a decline in the numbers in brood 4, and a peak in brood 5. The incidence of natural enemies of yellow rice borer, both predators and parasites, is highest in brood 5, relatively low in brood 3, and depressed probably by the onset of flooding in brood 4.

After reviewing Catling's findings, we decided that there could be scope for depressing brood 2 and, maybe, brood 3, and thus lower the late-season population potential. The use of insecticides in the early season would avoid the possible major problems of logistics and of contamination in spraying deeply flooded rice. Such a timing was also expected to have a minimal effect on the natural enemies of yellow rice borer.

A literature search showed that there has been little evaluation of insecticides for yellow borer control and almost none in deepwater rice areas. As a first step, we tested a range of insecticides to see which would control yellow rice borer. Particular emphasis was on trying to establish the effects on the egg and first-instar stages.

MATERIALS AND METHODS

The following insecticides were obtained:

Active ingredient	*Manufacturer's suggested dose (a.i./ha)*	*Trade name*
formothion (OP)	336-560 g	Anthio 25 EC
monocrotophos (OP)	250 g	Azodrin 40WSC

diazinon (OP)	1000-1500 g	Basudin 60 EC
dicrotophos (OP)	300-500 g	Bidrin 24WSC
dicrotophos (OP)	500-1000 g	Carbicron 50 WSC
propenofos (OP)	500-750 g	Curacron 50 EC
quinalphos (OP)	250-375 g	Ekalux 25 EC
methomyl (Carbamate)	250-500 g	Lannate 24 WSC
fenthion (OP)	500-1000 g	Lebaycid 50 EC
dimethoate (OP)	240 g	Perfekthion 40 EC
cypermethrin (Pyr.)	50-100 g	Ripcord 102 EC
fenvalerate (Pyr.)	100-200 g	Sumicidin 20 EC
fenitrothion (OP)	300-1000 g	Sumithion 100 EC
(experimental product)	750 g	G 24'480 EC

(OP) = organo-phosphorus; (Pyr.) = synthetic pyrethroid

The rates used were in the range suggested by the manufacturer — lower rates on young plants, higher rates as the tiller density increased. The spray volume used throughout was 600 liters/ha, applied with a knapsack sprayer.

Insecticide trial at Bastia, Manikganj

An insecticide trial was carried out in a farmer field in an area visited for population dynamics studies (Catling 1981). The field usually floods to a depth of 2-3 m. Stem infestation by yellow rice borer in 1977 and 1978 was more than 40% by the onset of flooding and reached 40-60% by late season in the four seasons 1977-1980.

The field was broadcast-seeded in early March with the deepwater variety Digha. Overall field dimensions were about 90 m × 30 m with a nearly rectangular shape, which made it convenient to make 36 plots 15 m × 6 m. Twelve treatments, including a nonsprayed control with three replicates of each, were possible.

The first insecticide application was made 13-14 May, when plant height was about 45 cm. Average tiller count on 13 May was 374 tillers/m^2.

Subsequent applications were on 27-28 May, 10-11 June, and 24-25 June. Plant height was about 50 cm on 27 May, and 110-125 cm on 24 June. Average tiller count on 4 June was 270/m^2.

Stem sampling by taking 34 stems from each plot, with the sampler moving along the diagonals of the plot and taking care to keep away from the edges, was done 21 May, 4 June, 17 June, and 1 July. On the last date flooding had started and there was about 30 cm of water in the field.

Following the practice adopted by Catling and Islam (1979), stem dissection was the main method of assessment. Stem samples were taken to the laboratory and each stem was split and examined for larvae, pupae, and evidence of infestation (frass, exit-holes). Deadhearts also were recorded. Table 1 presents data from stem dissections.

Insecticide trial in a deepwater tank, Joydebpur

Another trial was put in a 20 m × 20 m deepwater tank at BRRI, Joydebpur. The

Table 1. Results of stem dissections from insecticide trial at Bastia, Manikganj, Bangladesh, 1981.

Treatment[a]	Assessment dates	No./100 stems with Dead-hearts	No./100 stems with Frass or borer holes	Live stages found per 100 stems: Larval instars I	II	III	IV	V	VI	Pupae	Pupal skins
Control	22 May	18	19	0	0	3	2	2	2	1	0
	4 Jun	4	11	0	0	0	0	0	3	4	0
	17 Jun	2	6	0	0	0	0	0	0	0	5
	1 Jul	3	9	0	0	0	0	0	0	1	4
Anthio	22 May	7	11	0	0	1	2	1	1	1	0
	4 Jun	5	8	0	0	0	0	0	1	1	0
	17 Jun	5	10	0	0	0	0	0	1	0	4
	1 Jul	0	5	0	0	0	0	1	0	0	2
Azodrin	22 May	6	6	0	0	2	0	0	0	0	0
	4 Jun	1	3	0	0	0	0	0	0	2	0
	17 Jun	3	5	0	0	0	0	0	0	0	1
	1 Jul	0	1	0	0	0	0	0	0	0	1
Basudin	22 May	8	8	0	0	2	0	2	1	0	0
	4 Jun	2	2	0	0	0	0	0	1	0	0
	17 Jun	3	9	0	0	0	2	0	0	0	2
	1 Jul	0	2	0	0	0	0	0	0	0	1
Bidrin	22 May	10	13	0	0	1	0	0	3	0	1
	4 Jun	5	13	0	0	1	0	1	3	5	1
	17 Jun	1	6	0	1	0	0	1	0	0	1
	1 Jul	0	3	0	0	0	0	0	0	0	2
Cabicron	22 May	8	8	0	0	1	1	0	2	0	0
	4 Jun	1	2	0	0	0	0	0	0	1	0
	17 Jun	1	3	0	0	0	0	0	0	0	2
	1 Jul	0	4	0	0	0	0	0	0	0	1

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Treatment[a]	Assessment dates	No./100 stems with Dead-hearts	Frass or borer holes	Live stages found per 100 stems Larval instars I	II	III	IV	V	VI	Pupae	Pupal skins
Curacron	22 May	6	9	0	0	0	0	1	2	0	1
	4 Jun	1	2	0	0	0	0	0	0	0	1
	17 Jun	3	7	0	0	0	0	0	0	0	3
	1 Jul	1	2	0	0	0	0	0	0	0	3
Ekalux	22 May	2	5	0	0	0	0	1	2	0	0
	4 Jun	0	1	0	0	0	0	0	0	1	0
	17 Jun	1	1	0	0	0	0	0	0	0	0
	1 Jul	0	0	0	0	0	0	0	0	0	0
Perfekthion	22 May	4	5	0	0	0	0	2	4	0	0
	4 Jun	2	8	0	0	0	0	0	2	2	0
	17 Jun	3	5	0	0	0	0	0	0	0	2
	1 Jul	0	7	0	0	0	0	0	1	0	5
Ripcord	22 May	8	11	0	0	1	0	3	6	0	0
	4 Jun	3	7	0	0	0	0	0	1	3	0
	17 Jul	2	6	0	0	1	0	0	0	0	2
	1 Jul	0	5	0	0	0	0	0	1	0	1
Sumicidin	22 May	4	5	0	0	2	0	1	0	0	0
	4 Jun	4	4	0	0	0	0	0	0	1	1
	17 Jun	3	6	0	1	0	0	0	0	0	2
	1 Jul	0	3	0	0	0	0	0	0	0	2
Sumithion	22 May	8	11	0	0	0	0	2	1	0	0
	4 Jun	1	2	0	0	0	0	0	0	2	0
	17 Jun	3	7	0	0	0	0	0	0	0	5
	1 Jul	1	8	0	0	0	0	0	0	0	5

[a]Treatment dates: 13-14 May, 27-28 May, 10-11 June, 24-25 June.

tank was divided into 36 plots 3 m × 3 m and each plot individually bunded to prevent water movement between plots. Because of delays in land preparation, only 3 blocks were planted: Raja Mondal was planted in two blocks and Habiganj Aman IV in one block. These were not flooded and served as a simple insecticide trial with no possibility of yield data. As at Bastia, 12 treatments were arranged randomly within the blocks. Each treatment was replicated three times.

The first applications started 16 July but heavy rain interrupted work and the spraying was not completed until 19 July. Subsequent applications were made on 25 July, 5 August, 15 August, 29 August, and 9 September.

Sample of 20 stems/plot were taken 23 July, 7 August, 17 August, 22 August, 1 September, and 11 September. Data from stem dissections are in Table 2.

DISCUSSION AND CONCLUSIONS

Insecticide evaluation

We emphasize that the experiments we reported are not complete. For instance, we have not harvested the plots at Bastia and this may add considerably to the value of this season's work. Similarly, our results should not be taken as an endorsement or condemnation of any insecticide used.

A crude assessment, taking into consideration the number of live stages and the changes in stem infestation, suggests that the insecticides worth further evaluating are Azodrin, Basudin, Carbicron, Curacron, Ekalux, and Sumithion. Lannate was underdosed and a decision on it cannot be made until the season is complete.

While we agree with Catling that insecticides alone are unlikely to be the whole solution (Catling 1981) our 1981 results indicate that there may well be a genuine place for insecticide use in deepwater rice. The major questions are what product and when it should be used.

Observations on population dynamics

A side benefit of the regular dissections of stem samples during the two trials was the opportunity to analyze the population structure of the yellow rice borer during each year. Figure 1 shows the composition of the stem borer juvenile population on each date of our observations; additional points on the graph were derived from two sets of dissections of stem samples from agronomy trials, and from survey data obtained in previous years (where the latter showed a high enough infestation for analysis). The composition of the population on any one date is expressed as the percentage of the total juvenile stages, which falls into one of the six larval instars, pupae or pupal skins (the last possibly can be deceptive because pupal skins, unlike the other stages, tend to persist as relics).

Our first 1981 observations were on 22 May, whereas for 1977-1980 no data were obtained, at least not from the rapid surveys, prior to late June. In general, our summary of the population structure coincides with the thinking of Catling. The timing of the peak maturity in each brood, we feel, may be somewhat earlier than suggested by Catling (1981) especially brood 4. The population structure of brood 3 seems less clear than for broods 2 and 4. This is possibly because stem dissections in the middle of the growth and development cycle are liable to reveal a

Treatment[a]	Assessment dates	No./60 stems with: Dead-hearts	No./60 stems with: Frass or borer holes	Live stages found per 60 stems: Larval instars I	II	III	IV	V	VI	Pupae	Pupal skins
Control	23 Jul	2	4	2	0	0	0	0	0	0	0
	7 Aug	6	20	0	1	0	4	0	0	0	0
	17 Aug	8	10	0	0	0	0	0	1	2	0
	22 Aug	2	10	0	0	0	0	0	3	2	1
	1 Sep	2	17	0	0	0	0	0	0	0	10
Anthio	23 Jul	2	3	0	0	0	0	0	0	0	0
	7 Aug	6	21	0	0	0	0	2	2	0	0
	17 Aug	4	16	0	0	0	0	0	5	4	0
	22 Aug	0	13	0	0	0	0	0	0	2	2
	1 Sep	1	9	0	0	0	0	0	0	0	3
Azodrin	23 Jul	3	4	0	0	0	0	0	1	0	0
	8 Aug	1	5	0	0	0	0	0	1	0	0
	17 Aug	0	7	0	0	0	1	0	1	1	0
	22 Aug	0	3	0	0	0	0	0	0	0	0
	1 Sep	1	5	0	0	0	0	0	0	0	2
Basudin	23 Jul	2	5	0	0	0	1	1	0	0	0
	7 Aug	1	5	0	0	0	0	0	1	0	0
	17 Aug	1	3	0	0	0	0	0	0	0	1
	22 Aug	0	1	0	0	0	0	0	0	0	1
	1 Sep	1	1	0	0	0	0	0	0	0	0
Carbicron	23 Jul	3	6	0	1	0	1	0	0	0	0
	7 Aug	6	18	0	0	0	3	3	3	0	0
	17 Aug	2	3	0	0	0	1	1	0	0	0
	22 Aug	0	2	0	0	0	0	0	0	0	0
	1 Sep	0	2	0	0	0	0	0	0	0	2
Curacron	23 Jul	3	4	0	0	0	0	0	2	0	0
	7 Aug	2	6	0	0	0	0	0	1	0	0
	17 Aug	3	8	0	0	0	0	0	0	1	0
	22 Aug	0	1	0	0	0	0	0	0	0	0
	1 Sep	0	4	0	0	0	0	0	0	0	0

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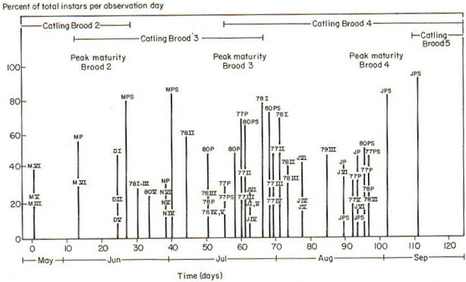
Table 2 continued

Treatment[a]	Assessment dates	No./60 stems with Dead-hearts	No./60 stems with Frass or borer holes	Live stages found per 60 stems: Larval instars I	II	III	IV	V	VI	Pupae	Pupal skins
Lannate	23 Jul	2	5	0	0	0	0	1	1	0	0
	7 Aug	4	16	0	0	1	0	0	6	0	0
	17 Aug	2	7	0	0	0	0	0	1	1	0
	22 Aug	0	5	0	0	0	0	0	1	2	0
	1 Sep	0	6	0	0	0	0	0	1	0	1
	1 Sep								0	1	0
Leybacid	23 Jul	2	5	1	0	0	0	1	1	0	0
	7 Aug	2	9	1	1	0	0	0	1	0	0
	17 Aug	0	6	0	0	0	0	0	0	0	3
	22 Aug	0	2	0	0	0	0	0	0	0	0
	1 Sep	1	10	0	0	0	0	0	1	1	2
Ripcord	23 Jul	1	2	0	0	0	0	0	0	0	0
	7 Aug	2	12	0	1	1	1	0	1	1	0
	17 Aug	4	10	0	0	0	0	1	4	0	1
	22 Aug	1	9	0	0	0	1	0	0	1	0
	1 Jul	2	7	0	0	0	0	0	0	0	2
Sumicidin	23 Jul	3	3	1	0	0	0	0	0	0	1
	7 Aug	2	14	0	0	0	0	2	3	2	0
	17 Aug	2	13	0	0	0	0	1	0	2	0
	22 Aug	1	8	0	0	0	0	1	0	2	0
	1 Sep	3	12	0	0	0	0	1	0	1	0
Sumithion	23 Jul	1	1	0	0	0	0	0	0	0	0
	7 Aug	0	4	0	0	0	0	1	0	0	0
	17 Aug	1	9	0	0	0	0	0	1	5	0
	22 Aug	1	5	0	0	0	0	0	0	0	0
	1 Sep	0	3	0	0	0	0	0	0	0	1
G24,480	23 Jul	2	5	0	0	0	0	1	0	0	0
	7 Aug	2	7	0	0	0	1	0	0	0	0
	17 Aug	1	6	0	0	0	0	0	2	2	0
	22 Aug	0	5	1	0	0	0	0	0	2	0
	1 Sep	1	2	0	0	0	0	0	0	0	1

[a]Treatment dates: 16-19 July, 25 July, 5 August, 15 August, 29 August.



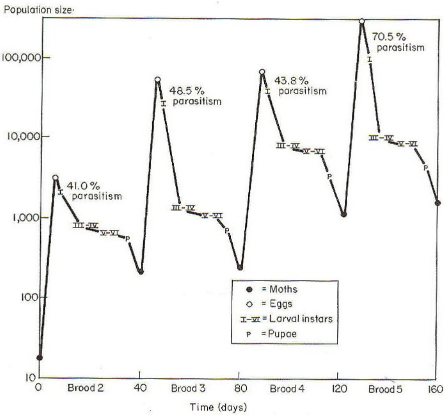
1. Population structure of yellow rice borer during the deepwater rice season in Bangladesh. Key: M = Bastia, Manikganj, 1981; N = Narsingdi, 1981; D = Daudkandi, 1981; J = Joydebpur (deepwater tank), 1981. 77, 78, 79, 80 = results from rapid survey dissections in 1977 to 1980. I-VI = larval instars; P = pupae; PS = pupal skins. Instars forming less than 10% of the total per observation day have been omitted. Catling Broods 2 to 5, after Catling (1981).

range of larvae of slightly different ages. Thus, on any one day there may be three instars present. Alternatively, it is conceivable that the so-called brood 3 actually does not exist and what is observed is late brood 2 individuals and the onset of brood 4. This would help to explain the anomaly between Catling's (1981) statement "Populations of yellow rice borer are always low before flooding (late June-early July)" and the fact that his light-trap catches showed no decline in numbers of adult moths at that time.

Timing of insecticide use

One of the difficulties that we faced in assessing the effectiveness of the insecticides used in the trials was that the numbers of live stages in the nontreated control appeared to decline with the passage of time, especially at Bastia (Table 1). One reason may have been replacement of infested stems by new tillers, thus altering the stem population being sampled. This was reflected in the apparent drop in stem damage. Another, possibly more important, reason is that, unlike many other insect pests, which have much shorter generation times or less well-defined broods, or both, the yellow rice borer populations can increase only at the start of a fresh brood — at four distinct points in each deepwater rice season.

Catling (1981) gave a good deal of information on moth numbers and egg parasitism. If his data are combined with the report by Rothschild (1970) on the mortality of different stages from egg to pupa, a model of the yellow rice borer population cycle can be derived. Figure 2 shows such a model. The numbers of



2. A population model for yellow rice borer in deepwater rice in Bangladesh.

moths are taken from Catling's data from light trapping; the number of eggs per moth is taken as 300, which, like the level of egg parasitism, is derived from Catling's studies. The intermediate mortalities are from Rothschild (with some adjustment to fit the egg to adult figures). The gross mortalities for the broods are 95.6% for brood 2, 99.6% for brood 3, 98.3% for brood 4, and 99.6% for brood 5. However, importance should not be attached to the accuracy of these figures, nor should the numerical values for brood size be taken as indicative of actual field numbers. What is important is that the greatest decline in potential numbers comes between the laying of eggs and the detection of third-instar larvae. A high level of control is exerted by the environment and by natural enemies particularly in broods 3 to 5.

Logistics, let alone environmental considerations, mitigate against use of insecticides after the onset of flooding. Therefore, our preseason thinking was that the use of insecticides against brood 2 would be the only feasible time, and such use might depress the size of subsequent broods. Figure 2, if correct, shows that brood 2 is the only brood in which the degree of natural control could realistically be enhanced. The model shows also that those larvae that penetrate into the stem are protected from outside influences and, thus, mortality is low. It seems possible, therefore, that one or two strategically timed applications of a suitable insecticide at the time of laying of the brood 2 eggs on deepwater rice seedlings might prove highly effective. Further applications at the time of laying of the brood 3 eggs, if not precluded by the onset of the floods, might be useful but the effect this would have on natural enemies still needs to be established.

Infestation and crop loss

Before starting our studies, we hypothesized that if it was possible to reduce the preflood brood of yellow rice borer and, thus, depress the size of subsequent broods there could be a consequent reduction in stem infestation in what Catling described as the critical period, June to September (Catling 1981). Although there seems to be little doubt that stem infestation is the best indicator of the numbers of stem borer larvae during June to September, it has still to be established whether or not such stem infestation is of prime importance in terms of actual crop loss.

What if loss of the main and primary tillers is the major cause of yield reduction? Setabutara and Vergara (1979) found that, in one variety, 90% of the total yield came from the main and primary tillers combined; in a second variety, their contribution was 77%. Similarly, Datta and Banerji (1979) found that, regardless of water regimes, grain yield and yield-contributing factors of basal tillers in both the varieties they studied were always greater than those of aquatic tillers. About 70-80% of the total grain production came from basal tillers.

Pot experiments carried out by Catling (1981) showed a loss of 27-30% in panicle weight if basal tillers were lost and replaced by aquatic tillers.

Crop loss studies in 1978 and 1979 with the variety Chota Bawalia (Catling 1981) showed that, although season-long insecticide use significantly reduced the stem infestation by yellow rice borer (as recorded at harvest) in both years and from identical levels the yield improvement was much less in 1979. The 1979 spraying of variety Lakshmidigha also gave a reduction in infestation but did not give a significant improvement in yield (in fact, only 3%). Not forgetting that 1979 was a poor year for crop establishment because of prolonged early drought, the major difference between the yield results in 1978 and 1979 may well have been that in 1979 yellow rice borer outbreaks did not occur until August and September. Therefore, in 1979 there could have been a lower than usual loss of basal tillers in the preflood period. Re-examining the field records of the 1978 study showed that no dissections were made in the early season but the deadheart level on 12 May was 14 times lower in the treated area than in the nontreated area ($0.5/m^2$ cf. $7.0/m^2$). There are few records, from 1977 to 1980, relating to yellow rice borer infestation before late June, but in 1978, at Agrakhola, deadhearts reached a peak of $11.0/m^2$ on 19 May.

This year, at Bastia, the nonsprayed control plots gave the following results: (of 100 stems examined and dissected)

22 May, 18% deadhearts and 19% infested;
4 June, 4% deadhearts and 11% infested;
17 June, 2% deadhearts and 6% infested;

1 July, 3% deadhearts and 9% infested.

Frame counts of tillers enabled us to estimate that there were 1.2 deadhearts/m^2 on 13 May and about 10.8 deadhearts/m^2 on 4 June.

From the limited data available, it seems that at the beginning of the season deepwater rice can be regarded the same as dryland rice and deadheart incidence will give a reasonable indication of infestation and damage by yellow rice borer. In the young plant, where there is little lumen development, the yellow rice borer larva is likely to cause much more damage to conducting tissues and to the apical meristem than in older plants. The elongated deepwater rice plant, with its massive stem lumens, probably provides a safe stable environment for the larva of the yellow rice borer, which feeds on the parenchyma tissue without damaging vascular tissue (Catling 1981). Thus, at this stage the yellow rice borer may achieve the status of the near-perfect parasite-host relationship. If correct, this would help to explain why the number of whiteheads at harvest represents less than 20% of the stem infestations recorded in the late season (Catling and Islam 1979).

FUTURE STRATEGY

By the end of this season, our experiments should give us a reasonable indication as to which insecticides are most likely to be suitable for further testing. We hope that the 1981 yield data from Bastia will add weight to the view that there is a distinct place for preflood use of insecticides.

The overall program of the Deepwater Rice Pest Management Project for 1982 is likely to be one of concentrating efforts on a few representative areas and laying down trials of agronomic practices in farmers' fields. These trials will be overlaid with trials of crop protection methods, including insecticide use.

In suitable areas, a practice that may prove ideal from the point of view of insecticide use is transplanting the deepwater rice. The protection of the young plants in a discrete area, such as a seedbed, would have obvious advantages.

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