3. RECENT PROGRESS IN RICE INSECT RESEARCH IN MALAYSIA*

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Introduction

Insect pests of rice have been of considerable importance in West Malaysia. Several early accounts (13, 14) have been given regarding the biology of some of these. However, owing to the practice of adopting pure bred varieties, closer planting, and high levels of application of nitrogenous fertilizers, more reports of damage caused by pests are being recorded.

In West Malaysia the area under wet rice has been increasing steadily and Table 1 indicates the total acreages under rice for the 1969/1970 Main-season crop.

Table 1. Acreage of padi planted in the States of Malaya.

State	Acreage ptanted
Perlis	65,631
Kedah	295,090
Kelantan	188,871
Trengganu	92,432
Penang	40,308
Pahang	59,937
Perak	126,369
Selangor	47,713
Negri Sembilan	31,831
Malacca	33,100
Johore	13,189
Total	994,471

This consists of 941,036 acres of wet padi, 26,755 acres under upland padi and 26,680 of lowland dry padi.

Although in Malaysia more than 160 species of insect pests have been recorded (2), only some are of major economic importance causing serious damage directly, acting as vectors of virus diseases or combining both these functions.

Yunus and Rothschild in 1963 (3) gave a comprehensive list of all the insects pests of rice. Although substantially the main pests recorded by these workers remain the same, some emphasis has to be given to others in light of recent work. The major pests of the rice plant in Malaysia can be grouped as follows:

Stem Borers
Leaf Feeders

* Covers investigation work done in West Malaysia only.

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Sucking Hemipterous Bugs
Storage Insects
Other Minor Insects

Stem Borers

Five species of stem borers have been known to occur in Malaysia. These are: *Chilotraea polychrysa* Meyr., *Tryporyza incertulas* Wlk., *Sesamia inferens* Wlk., *Chilo suppressali* Wlk. and *Tryporyza dodatellus* Wlk.

Alternate hosts

Apart from the rice plant, other hosts of stem borers are known and these are given in Table 2.

Table 2. Alternate hosts of stem borers in West Malaysia.

Echinochloa colona Link.
Eleusine indica Gaertn.
Eliochloa annulata Kunth.
Hymenachne myuros Beauv.
Ischaemum timorense Kunth.
Oryza latifolia Desv.
Panicum auritum Presl.
Panicum repens L.
Paspalum orbiculare Forst.
Paspalum punctatum Burm.
Saccharum officinarum L.
Sacciolepis myosuroides Ridley
Scripus grossus L.
Setaria rubiginosa Mig.
Vetiveria odorata Virey
Zea mays L.

Light trap investigation

In light trap catches (6) during 1959–1960, *T. incertulas* was caught in larger numbers than *C. polychrysa* (Fig. 1). Recent data for the year 1969, has further shown that *T. incertulas* still predominates over the other species (Table 3).

The distribution and abundance of the major species in the field differs from locality to locality. In Province Wellesley, *T. incertulas* is the dominant species whereas in the neighbouring Krian District, *C. polychrysa* and *T. incertulas* predominate. In the East Coast States of Kelantan and Trengganu *S. inferens* is commonly found and in Tanjong Karang (Selangor) both *C. polychrysa* and *C. suppressalis* may occur in abundance. For West Malaysia the two most important species, however, are *C. polychrysa* and *T. incertulas*. *T. dodatellus* is of little economic importance.

Several workers have studied the bionomics of *C. polychrysa* and *T. incertulas* in the Krian District (6, 7). Koyama (7) from his studies showed that five peaks occurred at about monthly intervals beginning in October. The second peak in November caused the most extensive damage to the crop and corresponded in the field to the flowering stage of the rice plant. *T. incertulas* began to build up its population in early

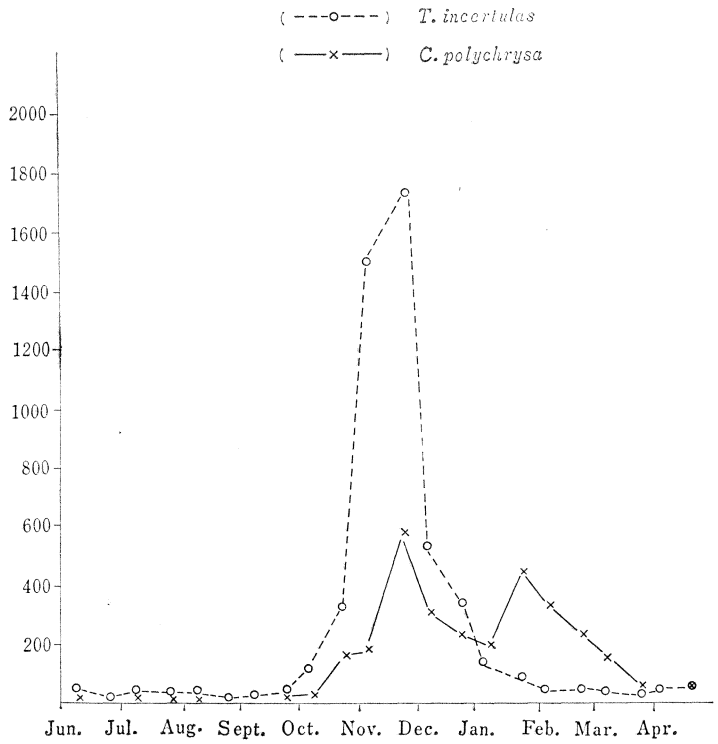

Fig. 1. Moth catches (1959–1960) of *T. incertulas* and *C. polychrysa* at Simpang Tiga Padi Test Station, Krian.

Table 3. Light trap catches of stem borers for 1969.

Padi Experiment Station	Species		
	C. polychrys	T. incertulas	S. inferens
Titi Serong	3,368	4,114	112
Simpang Tiga	2,493	2,857	113
Bukit Merah	139	3,323	11

November reaching its maximum population by mid-December. *C. polychrysa* reached its maximum population in mid-January and *S. inferens* showed an increase in population towards harvest in February or March. The numbers of *S. inferens* in the field were, however, insignificant when compared with the other two species.

Losses in yield

Losses caused vary from field to field depending upon the intensity of attack. Wyatt (23, 24) recorded losses in yield in the region of 26 per cent. Trials conducted have shown that yields may be increased considerably per acre if borers are controlled effectively by insecticidal spraying.

Varietal resistance

A few varieties have been screened against *C. polychrysa* and these are: IR-356-1-20, IR-356-3-12, Yabami Montakhab, IR-356-3-3 IR-356-1-40, IR-356-2-7, Malinja, Rexoro, IR-356-1-24, IR-8-288-3 (Ria), IR-356-1-37, IR-356-2-10 and Mahsuri.

Field observations indicate that none of the other varieties grown by farmers appear to possess any resistance to stem borers.

Control

Padgen (13, 14) was one of the early workers who attempted to find biological agents for controlling these pests. He recorded five parasites of *C. polychrysa*, three hymenoptera from the ova, a braconid from the larvae and a chalciodid from the pupae. From *T. incertulas*, two parasites were noted and none was found on *S. inferens*.

Millions of the parasite *Trichogramma Japonicum* Ahsm were bred and released in the field, without much success of their recovery. Lever (8) obtained *Paratheresia claripalpis* van der Wulp. from Trinidad and released them in Province Wellesley. He failed to recover any of the tachinid flies. No success was obtained even with *Metagonistylum minense* Tow.

Koyama (7) found BHC superior to Dieldrin and Dipterex. However, to produce high larval mortality the treatment had to begin a month before flowering. Kimura (6) from his studies concluded that application of three treatments were effective. The chemicals had to be applied first at intervals of three weeks and one week before flowering, followed by a final application at one week after flowering, to get significant increases in yields.

In recent years several insecticides have been tested in pot and field experiments against the two major species of stem borers. Granular insecticides have become popular and farmers are able to realize their advantages easily. Current recommendations for controlling the pest in the field include three applications of BHC 6% granules at the rate of 25–30 lbs./acre spread out at weekly intervals, five weeks before flowering. Endosulfan (Thiodan 35E), BHC 20 EC at 0.1% a.i. have also been found to be effective.

Leaf Feeders

Although there are several leaf-eating insects damaging rice, the three species are considered as serious pests are, *Spodoptera mauritia* Bois., *Cnaphalocrocris medinalis* Guen and *Nymphula depunctalis* Guen.

These pests in the caterpillar stage cause considerable damage to the nursery or the freshly transplanted plants. Losses caused are relatively minor unless outbreaks occur and effective control is obtained by spraying at 0.1% a.i. Carbary 1 (Sevin), BHC, Diazinon, Dieldrin and Fenitrothion.

Sucking Hemipterous Bugs

Leaf and plant hoppers*

Of the several different species of pests infesting and feeding on rice, the leaf and plant hoppers can be considered of major importance in some countries. In West Malaysia the species which have been recorded occurring in rice fields are: *Nephotettix apicalis* Ishihara, *Nephotettix impicticeps* Motsch., *Nephotettix malayanus* Kawase & Ishihara, *Nephotettix parvus* Kawase & Ishihara, *Recilia dorsalis* Motsch., *Nilaparvata*

* Recent revision of genus *Nephotettix* matsumura; *Nephotettix virescens* (Distant)=*N. impicticeps* Ishihara; *N. nigropictus* (Stål)=*N. apicalis sensu* Ishihara.

lugens Stal., *Nilaparvata sordiscens* Motsch, *Sogatella furcifera* Horv.

In the Krian District, light trap investigations have indicated that *Nephotettix* spp. are dominant. In Central Province Wellesley and Perlis, 60–70 percent of the leafhopper population consists of *N. apicalis*. *N. malayanus* and *N. parvus* have been recorded only in 1968 from the Krian District and their combined field population is less than 4 percent (5).

Hopper-burn caused by excessive feeding by *Sogatella* spp. has been observed to occur in this country, since several decades ago (3). In recent years, however, hopperburn attributed to the rice green leafhoppers has been noticed in the Krian, Province Wellesley and Perlis regions (18). Fortunately, fields damaged have been estimated to be not more than 50 acres in each region.

Population fluctuation

Light trap catches over a number of years from three experimental stations (Titi Serong, Simpang Tiga and Bukit Merah) have indicated that there is a seasonal fluctuation in the rice green leafhopper population (1). The population begins to build up during sowing and at the time of transplanting in August, has already reached a high level. It keeps on increasing as the crop in the field is growing and around October onwards it begins to fall (15).

During certain years there appears to be a corelation between incidence of the virus disease 'penyakit merah' and numbers of rice green leafhoppers caught. In the 1969 severe outbreak, the disease was reported from several farmers fields in the Krian District and the States of Kedah and Perlis. The numbers of *Nephotettix spp.* caught (Table 4) were much higher than in 1967 or the subsequent years (Fig. 2).

Table 4. Light trap catches of Nephotettix spp. for 1967 & 1969.

Station	Jan.–Mar.		April–June		July–Sept.		Oct.–Dec.		Total	
	1967	1969	1967	1969	1967	1969	1967	1969	1967	1969
Titi Serong	4,031	9,075	15,500	6,193	58,935	358,727	15,368	56,971	93,834	430,966
Simpag Tiga	2,353	4,954	2,186	6,171	16,566	86,655	5,605	103,813	26,710	201,593
Bukit Merah	5,959	1,617	8,126	1.840	5,727	94,990	604	3,361	20,416	101,808

Leafhoppers as vectors of diseases

Apart from the direct feeding damage caused by this group of insect pests, leafhoppers are also known to be vectors of several virus diseases of rice. In view of recent information obtained and to maintain continuity of the subject, a brief discussion is essential.

Penyakit merah virus

Nephotettix impiciticeps has been known to be the vector of the 'penyakit merah' virus (PMV) disease of rice. During the Mainseason 1969–70 approximately 23,000 acres of padi were affected mainly in the States of Perak, Kedah and Perlis. Several early accounts (10, 15, 16, 17, 21, 22) mentioned that Nephotettix impicticeps Ishihara was the only vector of PMV. It would, however, appear from Table 5 that even small numbers of *N. apicalis* can transmit the disease (21).

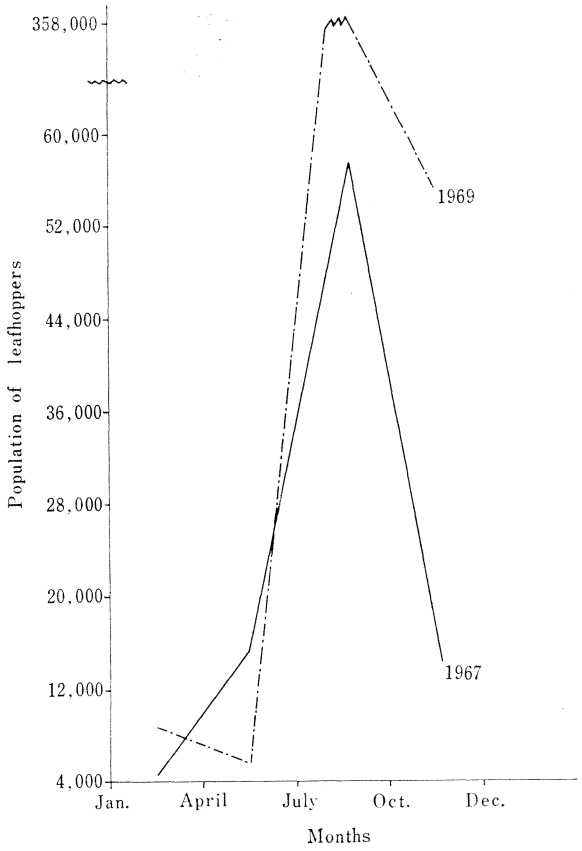

Fig. 2. Light Trap Catches of *Nephotettix spp.* at Padi Experiment Station, Titi Serong, Krian for 1967 and 1969.

Table 5. Transmission of PMV by Nephotettix apicalis.

Test No.	Locality hoppers collected from	No. of seedlings inoculated	Vector		No. of seedlings infected	Infection (%)
			Male	Female		
1	Padi Expt. St. Bulkit Merah, Penang	63	Mixed	Colony	7	11.1
2	〃	100	M	Nil	Nil	0
3	〃	90	M	Nil	Nil	0
4	〃	100	M	Nil	2	3.0
5	〃	115	M	Nil	Nil	0
6	〃	29	M	Nil	Nil	0
7	〃	293	M	Nil	6	2.1
8	Rice Production and Training Centre, Bumbong Lima, Penang	33	Mixed	Colony	2	6.6
9	〃	30	M	Nil	0	0

The following generalizations emerge from the virus vector interaction studies of this disease.

(a) The disease is not transmitted mechanically or through seeds.

(b) Transmission by *N. apicalis* is rare. *Sogatella furcifera* (Horv.), *Tettigella spectra* (Dist.), *Scotinophora coarctata* F. and *Recilia dorsalis* Motsch. do not appear to transmit the disease.

(c) The penyakit merah virus is non/semi-persistent in the vector with more than 50% of adult *N. impicticeps* being unable to retain the virus after 48 hours of acquisition, indicating that there is a gradual decrease in infectivity with enlapsed time.

(d) Insects given an acquisition period of 5 minutes and an inoculation period of 10 minutes are able to transmit the disease. There is a decrease in infectivity with elapsed time from acquisition.

(e) On moulting, the nymphs loose the ability to transmit the disease but are able to reacquire the virus on feeding from a diseased plant. The leafhoppers are able to retain the virus for a maximum period of five days.

(f) Preliminary fasting has a positive effect on PMV transmission efficiency of the vector and post-aquisition fasting a detrimental effect.

(g) Most of the local indigenous varieties are susceptible and high resistance appears to be found in Pankhari 203, Sigadis, Tjeremas, Latisail, Mas, Bengawan etc.

Table 6. Some properties of tungro (RTV. Philippines), leaf yellowing (LY) and tungro (India), mentek (Indonesia), penyakit merah (Malaysia) and yellow orange leaf (Thailand).

	RTV	LY	RTV	Mentek	PMV	YOLV
1. Vector	N. apicalis	—	—	—	do	do
	N imp.	do	do	do	do	do
	I. dorsalis	—	—	—	Nil	do
2. Mechanical transmission	Nil	—	Nil	Nil	Nil	Nil
3. Minimum acquisition feeding period	30 mins.	5 days	30 mins.	6 hours	5 mins.	20 mins.
4. Minimum inoculation feeding period	15 mins.	—	15 mins.	1 hour	10 mins.	15 mins.
5. Effect of preliminary fasting on vector efficiency	>	—	>	—	>	—
6. Effect of post acquisition fasting on vector efficiency	<	—	—	—	<	—
7. Incubation of the virus in the vector	Nil	—	Nil	—	Nil	Nil
8. Persistence of the virus in the vector	1–5 days	—	2 days	3 days	1–5 days	1–6 days
9. Retention on ecdysis	Nil	—	Nil	—	Nil	Nil
10. Retention in the insects	5 days	—	—	—	5 days	6 days
11. Varietal resistance very susceptible	T(N)1 etc.	—	T(N)1 etc.	T(N)1 etc.	T(N)1 etc.	T(N)1 etc.
Resistant	Pankhari, etc.	—	Pankhari, etc.	Pankhari, etc.	Pankhari, etc.	Pankhari, etc.

>Beneficial <detrimental

From the available information, a close relationship is indicated between PMV and viruses of the 'tungro' group (Table 6).

'Padi Jantan'

The disease, known locally as 'padi jantan' meaning male rice, is of minor importance and has been recorded mainly from the Krian District (Perak) and Province Wellesley. The disease is transmitted by *N. impicticeps* and *N. apicalis*.

It was believed earlier (9) that 'padi jantan' was a virus disease. However, ultra-thin sections of the affected rice leaves, have shown mycoplasma-like bodies. Diseased plants have responded to the rapeutics treatment with the antibiotic aureomycin. Consequently, 'padi jantan' is considered similar to the rice yellow dwarf disease (19).

Orange leaf virus

This disease was first recorded in 1969 (20) from Province Wellesley and has been known to occur in the States of Perak and Kedah, as well. It is transmitted by the zig-zag leafhopper *Recilia dorsalis* Motsch. Information (20) obtained so far indicates that a minimum period of 3 hours of acquisition and an inoculation period of the same duration is sufficient to bring about infection. It has been found that some insects are able to transmit the virus immediately after having been given a 24-hour period of acquisition, whereas the majority require an incubation period of 4 or more days. Only a small number of insects (17%) from the natural population are able to transmit the disease. In laboratory experiments, of the 120 adults tested only 12 (10%) were found to be transmitters. Infective insects have been found to retain the virus for 23 days when given successive transfers daily (Table 7).

Table 7. Behaviour of adult Inazuma dorsalis in transmitting orange leaf virus.

\+ transmitter — non-transmitter D Death of insect

Insect No.	Serial Inoculation (days)																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	+	+	−	−	−	−	+	D	
2	−	−	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	D					
3	−	−	−	−	−	+	−	−	−	−	−	D													
4	−	−	−	−	−	−	−	−	−	−	−	+	−	D											
5	−	−	−	−	−	+	−	+	−	−	−	+	+	D											
6	−	+	−	−	−	−	−	−	−	D															
7	−	−	−	−	−	−	−	−	+	+	−	+	D												
8	−	−	−	−	+	−	−	+	+	+	+	+	+	+	+	+	+	+	+	−	+	+	+	D	
9	−	−	−	−	−	−	−	−	−	+	+	+	+	+	−	+	−	+	+	−	+	+	−	D	
10	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+	+	+	+	−	−	−	−	+	+	D
11	−	+	+	D																					
12	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+D						

The disease is not transmitted mechanically or through seeds. It appears to be similar to the orange leaf virus disease known to occur in several other South-East Asian countries.

Control

Several insecticides (11) have been tested against hoppers and those recommended at 0.1% a.i. are Sevin 85 WP., Murfotox 68 E., Elsan 50% and Bidrin 24%. Dimecron 50 (Phosphamidon), Fenitrothion (Verthion 50%, Folithion 50%), Malathion 80% and Diazinon (Basudin 60 E) are effective at 0.05% a.i.

In areas where 'penyakit merah' virus disease is endemic, the first application of the insecticide should be made one week after sowing, followed by 4–5 other applications spread out at weekly intervals if the non-persistent insecticides are used, or 1–3 application at 12-day intervals with the president insecticides.

Other *Hemiptera*

Apart from the hoppers discussed above, there are a few sucking insects which are considered as important in rice cultivations. These are *Nezara viridula* Linn., *Scotinophora coarctata Fab.*, and *Leptocorisa acuta Thun.*

Damage by *S. coarctata* has been normally seen in the nursery and transplanted field. The adults have also been known to feed on the stems, resulting in poorly formed ears or ears with a few or partially filled grains. *S. bispinosa* Fab. and *S. cinerea* le. Guill. cause only very slight damage to the rice plant.

L. acuta is a common pest of padi in this country, especially, during the grain developing stage of the crop. Both the nymphs and the adults feed on the milky developing grains sucking the contents until only the empty seed coat remains.

N. viridula was first recorded as early as 1931, but outbreaks have been reported only recently (12). Acreages involved have been small and the affected rice fields were usually in patches of newly-cleared rubber or jungle land, or in areas where luxuriant growth of weeds occurred. Affected plants had shrivilled and unfilled grains.

Control

Outbreaks of these insects have occurred sporadically and effective control has been provided by using insecticides. In the case of the *S. coarctata* and *L. oratorius* insecticides which have proved effective at 0.1% a.i. are Lebaycid, Dipterex, Thiodan, Telodrin and Folithion. Bidrin at a concentration of 0.1% a.i. is effective against *N. viridula* owing to its residual period of at least 10 days. Several other chemicals (Sevin, DDT and Birlane) have also given control.

Storage Insect Pests

Apart from the insect pests of the rice plants, damage caused by insects to stored rice and padi has been considerable. In West Malaysia, freshly harvested padi has a moisture content of 13–23 per cent, depending of course on the weather conditions. Investigations (4) have shown that drying of padi in the bright sun for three hours reduces the moisture content to 12.4 per cent and further drying under favourable conditions could reduces this figure to 9 percent. However, at this stage, the grain would possibly crack if there is 90 per cent relative humidity. Moisture content of samples of padi taken from godowns in West Malaysia range from 7.5 to over 14 per cent. Some common pests of stores padi, rice and flour that have been reported (4) from West Malaysia are given in Table 8.

Milled rice sustains more damage than padi under stored conditions. High humidity is a conductive factor for increases in pest populations. The most serious pests are, *Sitophilus cryzae, Rhizopertha dominica, Lophocateres pusillus, Tribolium castaneum, Laemopholeus pusillus* and the moths *Tribolium castaneum, Corcyra cephalonica* and *Ephestia kuhniella* which become pests after milling.

Table 8. common pests of stored Padi and flour in west Malaysia.

Pest	Infestation
Sitophslus oryzae L.	Primary in rice
Revizopertha dominica F.	Primary in padi
Lophocateres pusillus Klug.	Primary in padi and rice
Oryzaephilus surinamensis L.	Secondary
Sitoroga cerealella Ol.	primary in padi
Tribolium castaneum Herbst.	Secondary in both padi and rice
Tribolium ferrugineun F.	Pest of stored rice
Tenebrioides mauritanicus L.	Pest of padi and rice
Ahasverus advena Walk.	Secondary
Laemophloeus pusillus Schon.	Secondary
Carpophillus sp. (probably *dimidiatus* F.)	Secondary
Procids	Found in rice accumulations
Ephestia cautella Walk.	Primary in rice
Ephestia lanica S.	Primary in rice
Doloessa viridis Zell.	Primary in rice
Trogoderma granarium	Pest of Rice
Alphitobius diaperinus Panz.	Rice and padi
Bostrychid indet	Rice and padi
Plodia interpunctella Herbst.	Rice and padi
Flour	
Tribolium castaneum Herbst.	—
Corcyra cephalonica Stn.	Secondary in flour
Ephestia leuhiriella	—

Trogoderma granarium (Khapra beetle) was recorded from rice imported from Burma in 1954, and since then it has not been found in this country.

Over the years several insecticides have been tested and used (4). Currently, spraying with Malathion, fumigation with methyl bromide, and fogging and spraying with Pybuthrin (mixture of pyrethrum and piperonyl butoxide) is being followed. Pybuthrin has a low order of toxicity to man but gives a quick 'knockdown kill' of insects and has very low residual effect.

Other Minor Insect Pests

Several other minor pests of the rice plant occur in West Malaysia but owing to their economic insignificance, not much attention has been paid to these. Since the publication of Yunus and Rothschild (3) *Scripophago nivella* F. and *Hystero neura* have been found to be feeding on the rice plant.

Future outlook and problems

It is not always easy to look into the crystal ball and predict accurately. It would appear that as far as insect pests of rice in Malaysia are concerned reports of damage caused would be on the increase. Intensive cultivation practices are increasingly being followed by the farmers who are keen to grow two crops of rice to further their sources of income. With the advent of new fertilizer responsive varieties and the use of potent

insecticides, pest problems need continuous vigilance. In certain region of West Malaysia, especially, in the Krian District, owing to the income derived from selling fish from the padi fields, farmers are reluctant to use insecticides which kill the fish. Other methods of pest control, therefore, have to be devised and adopted.

Special emphasis ought to be given for breeding for resistance against the major insect pests, stem borers and leaf and plant hoppers. Considerable scare has already been created by the phrase 'pollution of the environment' and as such it would appear that research on biological and/or integrated control measures needs to be further intensified.

Summary

In West Malaysia the major insect pests of the rice plant are stem borers, leaf eating caterpillars and leaf sucking insects. The species of stem borer, which causes serious damage is *C. polychrysa*. Attempts to find biological control measures of stem borers have not been successful. The leaf and plant hoppers cause considerable damage and are easily controlled by the timely application of insecticides. These hoppers, however, pose a problem as vectors of virus diseases. Storage pests which occur in large mills and godowns are becoming serious if rice is stored under high humidity conditions. The development of high yielding varieties coupled with the intensive cultural practices being followed by farmers to increase their yields contribute to outbreaks of pest damage which are on the increase and are problems limiting rice production. The introduction of granular insecticides has been a great boon to farmers. However, the application of chemicals have created special problems and research on biological and/or integrated control measures need to be emphasised.

Discussion

S. N. Banerjee, India: You have given a list of alternate hosts of borers. What is the basis of your statement? Have you noted eggs laying on these plants? Or is your statement on the basis of moths sitting on these plants?

Answer: Some work has been done on this aspect and from the literature it would appear that plants affected in the field showed the presence of the larvae or eggs. Certainly another setting on these plants was not the criteria used.

S. N. Banerjee, India: Do you have any information on host plants of those insects you mentioned in your paper?

Answer (G. S. Lim for K. G. Singh): There has been very little work done on the alternate host plants in Malaysia. However, the data obtained were from rearing on the alternate host plants in some cases. Most were recorded from infestations of the larvae in dissected stems of the alternative host plants made in field survey.

S. N. Banerjee, India: Are these borers *Tryporyza incertulas?*

Answer (G. S. Lim): No. These are *Chilotraea polychrysa*.

G. S. Lim, Malaysia (Comment): Dr. K. G. Singh has mentioned that the general infestation during outbreaks of *Nilaparvata lugens* is normally less than 50 acres in Malaysia. This is true. However, I would like to point out that there has been a severe outbreak of this species together with *Sogatella* spp. in 1967 when about 13,000 acres of padi were destroyed. Recently, there has been an increase of this pest in Malaysia and it will probably become more important in the near future. This may be due to the more intensive rice cultivation now practised in Malaysia.

Y. Ito, Japan: Did the density of *Nephotettix* increased recently? If so, what do you think is the factor contributing to it. I wonder if the wide-use of organic hydrocarbon insecticides results in the destruction of natural enemy faunna and becomes a factor of the increase of leaf and plant hoppers.

Answer: During certain years, the population of *Nephotettix* spp. was very large. And it was during these years when outbreaks of 'Penyakit Merah' virus disease occured on a wide scale. This was the case especially in the Main-season crop of 1969.

The use of organic hydrocarbons in Malaysian agriculture is only of recent date. While there is a possibility that the natural enemies of the leaf and plant hoppers could be destroyed by their use, there are also perhaps other factors which contribute to the build-up of the insect population. In this respect the ecology of the hoppers needs to be examined in detail in Malaysia and other tropical countries.

T. Iida, Japan: In rice orange leaf transmission trials, how were the symptoms caused by virus infection which was distinguished from phytotoxicity caused by the leaf hoppers feeding? How long did it take for the symptoms to appear?

Answer: Transmission studies were done by using individual insects. Although non-viruliferous hoppers were placed on the plant at the 3–4 leaf stage, the seedlings did not show any phytotoxicity and remained green and healthy.

The symptom appeared fourteen days after inoculation on the young seedlings.

M. D. Pathak, IRRI: Did you use viruliferous and non-viruliferous insects in your studies on transmission of orange leaf disease? This may further clarify the question raised by Dr. Iida.

Answer: Yes. Only a small percentage of insects transmit the disease. Effect of feeding toxicity has not been observed on the large number of seedlings which remained uninfected.

N. Kimura, Japan: Mechanically speaking, the resistance of rice to the stemborer depends upon the size of rice body. For instance, the diameter of Japanese rice stalk is about 4 mm, but that of a local variety in Malaysia is measured 10 mm. The size of stemborers, however, is the same and then, in case of Malaysia, mechanical damage is not so heavy. I suppose that so long as you take local rice varieties, there is no question about the rice stem borer. What you think about this problem?

Answer: I suppose the resistance to the rice stem borer depends upon the mechanical conditions in some measure. But it is also important to make new varieties of rice.

N. Kimura, Japan: I suppose that the most important thing to estimate the damage of stem borers is to provide stemborer free rice plant. And what do you think about this matter.

Answer: I suppose it is important and possible.

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