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TRENDS AND STRATEGIES FOR RICE INSECT PROBLEMS IN TROPICAL ASIA

M.D. PATHAK AND G.S. DHALIWAL

The International Rice Research Institute
P.O. Box 933, Manila, Philippines

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ABSTRACT

About 60% of the world's total rice area is in tropical Asia where population densities are high, landholdings and per capita income are small, and rice production per unit area is usually low. There is little scope for bringing additional land under cultivation and much of the increase in rice production must come from increases in yield per hectare and cropping intensity.

Rice insect pests in the tropics are more intense in fields with a thick crop stand and high cropping intensity. Thus, insect problems are likely to become more intense, and the change in rice plant type could bring about a shift in relative status of different pest species. Such changes are becoming apparent but are also greatly influenced by the varietal resistance to insect pests, agronomic practices, and adoption of integrated methods of pest control.

[1]By M. D. Pathak, director, Research Coordination and Training, and G. S. Dhaliwal, postdoctoral research fellow (Present address: Entomologist, Punjab Agricultural University, Regional Rice Research Station, Kapurthala 144 601, Punjab, India), International Rice Research Institute, P. O. Box 933, Manila, Philippines. A paper presented at the XVI International Congress of Entomology, Kyoto, Japan, August 1980, and revised and submitted to the IRRI Research Paper Committee April 1981.

TRENDS AND STRATEGIES FOR RICE INSECT PROBLEMS IN TROPICAL ASIA

Rice is the world's most important food crop. Of the 140 million ha grown to rice throughout the world, 125 million ha are in Asia. About 85% of those are in tropical Asia.

These and the fact that about 75% of the world's rice is consumed in tropical Asia emphasize the vital role rice plays in the economy of that region.

TRENDS AND POTENTIALS IN RICE PRODUCTION FOR TROPICAL ASIA

The area and yield of rice before modern varieties were introduced (1961-65) and the changes that have taken place from 1974 to 1979) are in Table 1. The average increase in hectarage was about 19%, average yield increase per hectare was 27%. These together effected a 52% increase in total production. However, most of the suitable land is already growing rice. Moverover, some prime rice-growing land is being lost to housing, roads, and industrial expansion. Therefore, much of the future increase in rice production must come from increases in yields per crop and in cropping intensity.

Prior to the development of the modern varieties, it was generally believed that high rice yields were not possible in the tropics. Now, potential yields are estimated at 13-15 t/ha (IRRI 1978). The maximum yield recorded at IRRI is 11 t/ha but many farmers in national crop yield competitions in tropical and subtropical Asia surpass this yield every year. Yields of 6 to 8 t/ha are commonly obtained at some experiment stations, and by progressive farmers. Average national yields in those regions, however, are about 2 t/ha.

Factors that limit rice yield in farmers' fields can be mainly grouped as physical, biological, and socioeconomic. Most of the physical constraints are either beyond control or require excessive cost for their removal:

- The lack of sufficient and timely rains, and the occurrence of floods can easily destroy a rice crop.
- Low solar radiation and high relative humidity which generally prevail in tropical rice-growing areas during the wet season do not favor high yield and also encourage pests and diseases.
- Likewise, in strongly acid sulfate soils the costs of reducing their acidity are a limiting factor.

The biological factors of the environment -- rodents, insects, diseases, weeds, soil fertility -- severely limit rice production in many areas.

Several socioeconomic factors, such as high cost of inputs, increased labor requirement, nonavailability of inputs, lack of credit facilities, and farmers' attitudes and educational levels, prevent farmers from achieving high yields (Gomez 1977, Barker 1979).

Table 1. Trends in rice production in major tropical Asian countries.[a]

Country	1961-65		Increase (%) during 1975-79[b] over 1961-65		
	Area (000 ha)	Yield (t/ha)	Area	Yield	Production
Bangladesh	8,967	1.68	12.2	10.5	24.1
Burma	4,722	1.64	7.6	14.0	22.5
India	35,626	1.48	9.6	23.7	35.8
Indonesia	7,036	2.04	21.4	35.6	64.6
Malaysia	531	2.15	44.4	18.2	69.7
Nepal	1,098	1.96	4.6	-2.8	11.3
Pakistan	1,287	1.42	42.8	69.6	142.2
Philippines	3,147	1.26	13.2	53.7	74.1
Sri Lanka	665	1.49	-2.4	62.5	66.9
Thailand	6,026	1.85	42.3	0.0	42.1
Vietnam	4,859	2.00	7.1	9.5	17.3
Av		1.72	19.3	26.8	51.9

[a]Calculated from yearly data compiled by Palacpac (1980). [b]1975-78 for Malaysia.

A striking example of the role of various constraints in yield differences is provided by two regions of India. In the flood-prone regions of eastern India, where performance of the currently available improved varieties and associated cultural practices is frequently unreliable because of water uncertainty, yields have remained more or less constant around 1.4 t/ha over the past 15 years. However, in the irrigated fields of northwestern India for which appropriate technology is available and where pest and disease problems are generally less severe, yields have shown a continuous rising trend (IRRI 1978).

An IRRI long range plan (IRRI 1979) estimates that about 48% of the future rice production could come from increased yields and about 52% from increased cropping intensities. Irrigated areas in tropical Asia would likely provide about 46% of the increased production, rainfed areas about 33% (Table 2). Therefore, in the next 10-15 years, about half of the total possible rice production gains from research would be realized in irrigated areas and about one-third in rainfed wetland areas (IRRI 1979).

Another important increase in production will come from cultivation of marginal agricultural lands. About 100 million ha of land suited to rice in South and Southeast Asia are uncultivated because of soil problems like salinity, alkalinity, acid sulfate, and peat (Ponnamperuma and Ikehashi 1979). Lands where the adverse soil conditions are not severe can be brought under rice cultivation by growing modern varieties tolerant of the adverse soils (Table 3). The soil in some areas can be reclaimed by water management or chemical amelioration.

These will allow profitable adoption of improved agronomic practices and thereby change the microclimate of rice fields of the areas. These and the increasing cropping intensity are expected to influence pest abundance.

CROP LOSSES DUE TO RICE INSECT PESTS

Insect pests proliferate in the warm and humid environment in which tropical rice is grown. More than 100 different species of insects are known as rice pests; of those about 20 are of major economic significance. Together, they attack all parts of the plant at all growth stages and some tansmit virus diseases. The vulnerability of rice crop to various insect pests was cited in the early 1970s as a major bottleneck to a breakthrough in rice production similar to that which occurred in wheat following the introduction of high-yielding varieties (Pradhan 1971).

Quantitative figures on rice crop damage due to insect pests are not widely available. However, various estimates have been made and, in specific cases, damage has been economically significant. There have been no systematic attempts to assess losses -- during several crops on a zonal basis

Table 2. Potential for increasing rice production in South and Southeast Asia.[a]

Environment	Rice area (%)		Yield (t/ha)		Crop intensity (Crop/ha per year)		Increase (%)
	1970s	1990s	1970s	1990s	1970s	1990s	
Irrigated 4-7 months	17	22	3.0	4.2	0.9	1.3	32
Irrigated >7 months	11	14	3.0	3.9	1.8	2.3	14
Rainfed, 4-7 months, >200 mm	30	25	1.8	2.6	0.7	1.0	24
Rainfed, >7 months, >200 mm	3	3	1.4	2.2	1.7	1.9	1
Rainfed, intermediate deep	15	12	1.5	2.5	0.8	0.9	8
Deepwater	8	8	1.0	1.5	0.9	1.0	3
Dryland	10	10	1.0	1.5	0.8	0.8	4
Arid, high temperature	4	4	3.0	4.5	0.8	1.2	11
Long day, low temperature	1	1	4.0	5.3	0.9	0.9	1
Av			2.2	3.1	1.0	1.3	

[a]Adapted from IRRI (1979).

Table 3. Resistance ratings of selected IRRI rice varieties.[a]

Variety	Insects: Brown planthoppper Biotype 1	Insects: Brown planthoppper Biotype 2	Insects: Brown planthoppper Biotype 3	Insects: Green leafhopper	Insects: Stem borer	Insects: Gall midge[b]	Diseases: Blast	Diseases: Bacterial blight	Diseases: Grassy stunt	Diseases: Tungro	Soil problems: Alkali injury	Soil problems: Salt injury	Soil problems: Zinc deficiency	Soil problems: Phosphorus deficiency
IR8	S	S	S	R	S	S	S	S	S	S	S	MR	S	MR
IR20	S	S	S	R	MR	S	MR	R	S	MR	S	MR	R	R
IR26	R	S	R	R	MR	S	MR	R	MR	MR	MR	MR	S	R
IR30	R	S	R	R	MR	S	MS	R	R	MR	MR	MR	R	MR
IR32	R	R	MR	R	MR	R	MR	R	R	MR	S	S	MR	S
IR34	R	S	R	R	MR	S	R	R	R	R	S	S	R	R
IR36	R	R	S	R	MR	R	R	R	R	R	R	MR	MS	S
IR38	R	R	S	R	MR	R	R	R	R	R	MR	MR	MR	S
IR40	R	R	S	R	MR	R	R	R	R	R	R	MR	MR	S
IR42	R	R	S	R	MR	R	R	R	R	R	MR	MR	MR	MR

[a]Rated in the Philippines. R = resistant, MR = moderately resistant, MS = moderately susceptible, and S = susceptible. [b]Rated in India.

within a country -- caused by insect pests to rice. The available estimates appear to be based on few experiments and those often involved treatments to provide the crop adequate protection from insects. Cramer (1967) estimated the loss of rice production in Asia (excluding mainland China) due to insect pests as 31.5% (Table 4).

Table 4. Rice crop losses due to insect pests in the world.[a]

Region	Loss (%)
Asia (excluding People's Republic of China)	31.5
People's Republic of China	15.0
Africa	14.4
South America	3.5
North and Central America	3.4
Europe	2.0
Oceania	2.0

[a]Adapted from Cramer 1967.

The magnitude of rice crop loss in tropical Asia can be illustrated from the data from 117 experiments during 1964-79 at IRRI. The average yield from plots protected with insecticides was 4.9 t/ha whereas that from unprotected plots was 3.0 t/ha, suggesting a loss of about 40%. The loss could be much more in areas where insect pests are endemic, as is evident from data from Maruteru in India, where only 0.6 t/ha was obtained without any insect protection as compared to 4.5 t/ha with protection (AICRIP 1972), suggesting a loss of about 86%. Because of intensive cropping, yield losses in unprotected plots at experiment stations are usually greater than those in farmers' fields.

In the mid-1970s a series of experiments in tropical Asia under an International Rice Agroeconomic Network coordinated by IRRI determined why rice yields in farmers' fields were not as high as those at research centers. The increase in yields from plots treated with improved agronomic and insect control practices over the farmers' method of crop production was 1.7 t/ha for the dry season crop and 0.9 t/ha for the wet season (Herdt 1979); 35 and 44% of those increases were due to insect control (Fig. 1). The network studies at three Philippine sites revealed an average yield gap of 1.8 t/ha in the dry season and an average of 1.0 t/ha in the wet season (De Datta et al 1979) with 29 and 45% of those increases due to insect control.

Status of insect pests

During the last two decades, the insect pest complex of the rice crop has changed tremendously. Several species that were considered minor pests have appeared in epidemic proportions, whereas the incidence of a few has declined somewhat:

- Increased severity: brown planthopper, whitebacked planthopper, green leafhopper, and gall midge.
- Some decline in importance: stem borers and rice hispa.
- Minor pests becoming major problem: leaf folder, thrips, caseworm, armyworms, and cutworms.
- New records in certain areas: smaller brown planthopper, leaf miners, aphids, and several other planthoppers, grasshoppers, and lepidopterous insects.
- New records as rice pests: sugarcane leafhopper and rusty plum aphid.

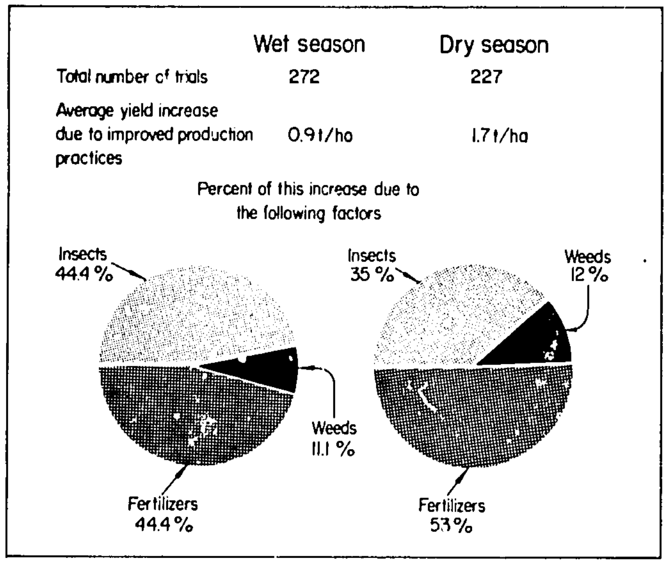

Fig. 1. Factors affecting differences in yields of the farmer's fields following his practices and improved production practices in 6 Asian countries, 1974-77 (Herdt 1979).

Certain insect species, known to attack rice during a particular crop season only, now occur throughout the year; others occur in expanded areas. This has given rise to new pest problems in several areas.

Brown planthopper

The brown planthopper (BPH) *Nilaparvata lugens* was a minor rice pest until the mid-1960s in much of tropical Asia. However, it assumed the status of the most destructive pest in the 1970s. Available data from India suggest that light-trap catches in several states have increased during the last decade (Kalode 1974 1976, Kalode and Kasiviswanathan 1976). There have been wide fluctuations in light-trap catches in Bangladesh since 1970, but the trend is toward the higher pest densities (Dyck et al 1979). Light-trap data at IRRI revealed a dramatic increase in its BPH population from 1966 to 1973, but the number has since declined considerably (Fig. 2).

During the 1970s, the BPH caused severe damage to the rice crop in many countries in tropical Asia (Dyck and Thomas 1979). Several outbreaks have occurred in the Philippines (Calora 1974), Solomon Islands (Stapley 1975), Thailand (Tirawat 1975), Sri Lanka (Fernando 1975), Vietnam (Huynh 1975), India (Kulshreshtha et al 1974), Malaysia (Ooi 1977), and Indonesia (Mochida 1979). In the Philippines, the BPH damaged at least 80,000 ha in 1973-74 (IRRI 1979). In Indonesia area damaged by BPH increased from only 4,000 ha in 1976-77 (Soenardi 1978).

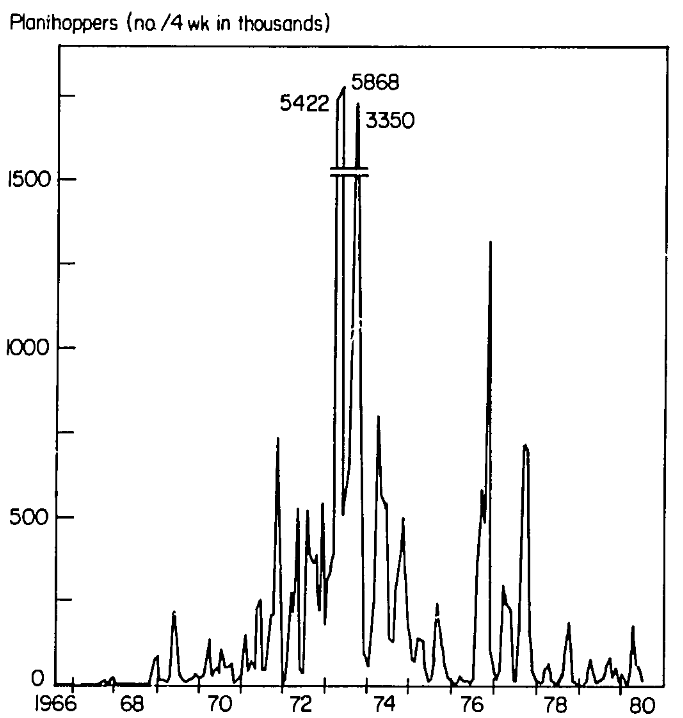

Fig. 2. Number of brown planthoppers, Nilaparvata lugens, caught in 3 light traps at IRRI, Philippines, 1966-80 (V. A. Dyck, IRRI, unpubl.).

Whitebacked planthopper

The whitebacked planthopper (WBPH), Sogatella furcifera, a minor pest until recently, has become increasingly important in Asia. In Pakistan, the insect was first observed in 1976 in Sind (Mahar et al 1978). In Punjab State, India, it was first reported to attack rice in 1967 (Atwal et al 1967) and since then has appeared regularly. The WBPH struck in epidemic proportions in 1978 (Majid et al 1979). Infestations were severe in 1972, 1975, and 1978 (Dhaliwal 1980). In Indonesia, it appeared recently in high population densities (Mochida et al 1979). Serious outbreaks of the WBPH have also been reported from Malaysia (Heong 1975), Vietnam (Huynh 1975), and Bangladesh (Alam and Alam 1977). It has recently occurred in high numbers at IRRI.

Green leafhopper

The green leafhopper (GLH), Nephotettix sp., appears to have increased over the last several years. It was only a sporadic pest in many parts of India until 1964 (Misra and Israel 1968), but soon became a chronic rice pest (Kulshreshtha et al 1970a). Light-trap data from different places in India reveal that buildup of the GLH has been high in recent years (Kalode and Kasiviswanathan 1976).

A great increase in GLH intensity has been recorded at IRRI since 1968-69 (Heinrichs 1979). Recent outbreaks of tungro disease associated with the increase of GLH were reported during 1969-75 from Bangladesh, India, Indonesia, Philippines, Malaysia, and Thailand (Ling 1976). In the Philippines, tungro virus, transmitted by N. virescens, destroyed 70,000 ha of rice in 1971 and 40,000 ha in 1972 (IRRI 1979).

Gall midge

The rice gall midge, Orseolia oryzae, is mainly distributed in Southeast Asian countries (Reddy 1967) and the severity of its damage has recently increased in Bangladesh, India, Indonesia, and Thailand. In Thailand it was known to occur until the early 1960s in the northern, northeastern, and eastern areas only but started attacking irrigated dry-season rice in the Central Plains in the mid-1970s (Chantaraprapha et al 1977, Hidaka et al 1978), and is further extending its distribution in the southern peninsula (Ya-klai et al 1978, Katanyukul et al 1980). In Indonesia the gall midge began to occur in coastal rice fields in Java during the late 1960s although before that it mainly occurred in Java's mountainous areas (Hidaka 1974).

Gall midge is also spreading on the Indian subcontinent. It was recorded for the first time in Uttar Pradesh in 1971 (Chaturvedi 1971) and occurred in severe proportions in 1978 (Rizvi and Singh 1980).

Gall midge was first known as a rice pest in the wet season only, but large infestations have been recorded in the dry season crop in Indonesia (Sochardjan 1973), several parts of India (Kalode 1974, Kalode and Kasiviswanathan 1976, Panda 1978), Bangladesh (Alam 1974), and Thailand (Hidaka et al 1970). It has been conventionally a pest of wetland irrigated rice, but it also infests deepwater rice (Venu Gopala Rao 1975). Also, gall midge infestation, which normally does not occur beyond the panicle initiation stage of crop growth, has recently attacked the crop at flowering (Rajamani et al 1979).

Stem borers

Until the 1960s, stem borers (Chilo suppressalis, Tryporyza incertulas, T. innotata, and Sesamia inferens) were generally considered the most serious rice pest throughout the tropics. Even though it is still a serious pest, stem borer damage seems to have somewhat declined in recent years -- in the Tanjong Karang area of Malaysia (Ooi 1976, Balasubramaniam and Ooi 1977), Pakistan (Ghouri 1977), Indonesia (Esa and Djalil 1975), Vietnam

(Ngoan 1971), and also at IRRI (Pathak 1979). However, in India the yellow stem borer continues to be widespread (Kalode 1974).

Whorl maggot

The rice whorl maggot Hydrellia spp. was generally not recorded in the tropical Asia until the early 1960s and even then the insects' identity was not established. Now it is a common pest in many parts of Asia, often causing extensive damage to the leaves of the young crop (IRRI 1966, Ferino 1968, Velayutham et al 1973, Basu 1979). IRRI experiments, however, have failed to show any significant yield loss by its infestations.

Other insect pests

There are many reports of several other insect pests becoming serious rice pests in many countries.

- The leaf folder, Cnaphalocrosis medinalis, has become a serious pest in several parts of India -- Punjab (Chaudhary and Bindra 1970), Tamil Nadu (Velusamy and Subramaniam 1974), Uttar Pradesh (Verma et al 1979); Malaysia -- Tanjong Karang region (Lim 1974) and peninsular region (Ooi 1977).

- The leaf roller, Susumia exigua, has become an important rice pest in Solomon Islands since 1975 (Stapley 1978).

- There have been severe outbreaks of thrips in India -- Bihar (Chand and Shaw 1975), Kerala (Mammen and Vasudevan Nair 1977), Punjab (Chaudhary and Ramzan 1971), Tamil Nadu (Chandramohan et al 1977, Mohansundaram et al 1978), and West Bengal (Nath and Sen 1978) -- and in China (Hsu et al 1978).

- Although several outbreaks of hispa, Dicladispa armigera, have occurred in certain parts of India in recent years (Kalode 1974, Rao and Muralidharan 1977a, Thakur et al 1979), its intensity appears to have considerably declined during the past few years.

- Outbreaks of rice bugs, Leptocorisa sp., have occurred in Malaysia (Ooi 1977) and several species of mealy bugs are emerging as serious rice pests in some parts of India (Mammen 1976) and Bangladesh (Alam et al 1979).

- There have been severe outbreaks of the green bug, Nezara viridula, in Malaysia (Lim 1970a) and black bug, Scotinophara coarctata, in India (Rao and Muralidharan 1977b) and Malaysia (Lim 1975).

- Armyworms, Cirphis compta and Pseudoletia separata, have become rice pests in India (Kulshreshtha et al 1979b), Bangladesh (Alam 1967), and Pakistan (Dar et al 1979).

Other pests that are becoming serious rice pests include caseworm, Nymphula depunctalis, (Litsinger et al 1979, Velusamy et al 1976), rice skipper, Parnara mathias (Purohit et al 1972), green horned caterpillar, Melanitis ledaismene (Katiyar et al 1976, Singh 1979), and rice root weevil, Hydronomodius molitor (Kushwaha and Sharma 1980).

In addition, there are records indicating the expansion of the area of occurrence of several insect pests. For example, the small BPH, Laodelphax striatellus, which is a serious rice pest in Japan and Korea, has been recorded in India (Shukla 1979) and the Philippines (Pawar 1974). A few other examples of such expansion of insect pests include a grasshopper, Shirakiacus shirakii, in Pakistan (Irshad 1977), rice leaf miner, Pseudonapomyza asiatica (Barrion and Litsinger 1979), Rivula sp. m. atimeta (Malabuyoc 1977), and a gryllid, Euscyrtus concinnus (Barrion and Litsinger 1980), in the Philippines, and a planthopper, Unkanodes sapporonus (Misra 1975), and an aphid, Tetraneura radicicola (Rai 1975), in India. The sugargane leafhopper, Pyrilla perpusilla, and rusty plum aphid, Carolinaia (Hysteroneura) setariae, have been recorded as rice pests in India (Sukhani 1971, Garg and Sethi 1976).

FACTORS AFFECTING INSECT PEST INTENSITY

It is difficult to say that pests have become more abundant since the advent of the so-called green revolution era in the tropics because even before the revolution pests often caused heavy crop losses. However, the intensity of several pest species generally increases in dense crop stands and intensive cultivation, while others find heavy-tillering, short-statured varieties as a better habitat. For example, the BPH and the gall midge have become more abundant in recent years and their incidence is more common in areas where modern varieties and improved production technology have been widely adopted.

Varieties

The traditional varieties in the tropics were tall and leafy, usually had a small number of tillers per unit area, and lodged beyond the panicle formation stage. The modern varieties are short, heavy tillering with moderately upright leaves, and are resistant to lodging. Thus, usually they have a denser crop stand than the old varieties and their lodging resistance makes them respond positively to fertilizer application and other improved agronomic practices, which rice farmers are progressively adopting. Thus, fields planted to modern varieties develop a distinctly different microclimate than those planted to traditional varieties. All other factors being the same, the semidwarf heavy tillering varieties are more susceptible to leafhoppers, planthoppers, and the gall midge, while less preferred by the stem borers. This is borne out by the relative change in the status of these pests in view of the cultivation of modern varieties in recent years. However, most of the newer varieties have genetic resistance to certain species of stem borers, leafhoppers, planthoppers and, gall midge, which is also significantly influencing their populations (Table 3).

The population growth of the BPH is greater on modern varieties without resistant genes than on some local varieties (Mochida 1978, Dyck et al 1979). In Indonesia, BPH epidemics took place on modern rices susceptible to BPH -- IR5, IR8, C4-63, Pelita I-1, and Pelita I-2, w' ch were planted from 1967 (Mochida and Suryana 1979).

In India, BPH and GLH became a serious problem only after the introduction of Taichung Native 1 in 1964 and IR8 in 1968 (Kulshreshtha et al 1970a). Similarly, the appearance of WBPH in Pakistan and northern India coincided with the large adoption of modern varieties.

In Indonesia, WBPH has been observed to be more severe in areas where BPH-resistant varieties are being grown. Replacement of BPH, on resistant varieties, by WBPH, to which these varieties are not resistant, may be a reason for the WBPH increase (Mochida et al 1979). Similarly, WBPH is reported to infest the variety TN73-2, which was introduced in Vietnam in 1973 as resistant to BPH (Huynh 1975).

The semidwarf high tillering varieties appear to be highly susceptible to the gall midge. However, similar varieties with resistance genes provide effective control. The gall midge infestation in new areas in Indonesia is considered to have followed the introduction and wide adoption of modern varieties (Hidaka et al 1978). In Bangladesh, gall midge damage on modern varieties is as high as o2% as compared to 6% on local varieties (Alam 1974). Similarly, leaf folder became important after the introduction of modern varieties (Dorge et al 1971). However, the introduction of the modern varieties is considered a factor for the decline in stem borer damage in Vietnam (Ngoan 1971), Malaysia (Esa and Djalil 1975), and the Punjab in India (Dhaliwal 1980).

The availability of improved plant type varieties, which are also resistant to insect pests, is significantly minimizing certain pest problems even in endemic pest areas. In many cases these resistant varieties, now grown on about 25 million ha, are providing control of certain pests. However, the development of biotypes of insects capable of attacking the resistant varieties, as in the case of the BPH, requires concerted efforts to investigate various sources of varietal resistance and to devise strategies such as the use of horizontal resistance or integrated pest management to minimize selection of biotypes within existing populations.

The first BPH-resistant variety, IR26, which incorporates a single dominant gene (Bph 1) for resistance, was released by IRRI in 1973. IR26 continued to be resistant until 1975 when the occurrence of biotype 2 was confirmed in the Philippines (Varca and Feuer 1976). During 1974-79, IR26 was also found susceptible in India and Sri Lanka (Kalode and Krishna 1979), Indonesia (Harahap 1979), Solomon Islands (Stapley 1974), and Vietnam (Huynh 1977). IR26 was soon replaced with varieties resistant to biotype 2. Although these latter varieties are susceptible to biotype 3 in greenhouse experiments, biotype 3 in large numbers has not been recorded in the field. So far only these three biotypes have been identified at IRRI, but the biotypes in India and Sri Lanka apparently differ (Heinrichs 1980). There are also reports of the occurrence of biotypes in GLH (Karim and Pathak 1979) and gall midge (Heinrichs and Pathak 1981).

Fertilizers and agronomic practices

Fertilizers often produce large succulent rice plants, which are more susceptible to insect attack than those grown at lower nutritional levels. High fertilizer rates are favorable to the development of populations of BPH (Kalode 1971, Dyck et al 1979), gall midge (Hidaka et al 1978), leaf folder (Dhaliwal et al 1979), WBPH (Majid et al 1979), and rice hispa (Dhaliwal et al 1980). In many tropical Asian countries, the amount of fertilizer applied to the rice crop has increased considerably in recent years. For example, in Indonesia, the consumption of urea mainly for rice was estimated at about 405 million t in 1971-72 but reached 919 million t in 1977-78 (Mochida 1978).

BPH population growth is greater on rice plants grown in pots or fields with standing water than on those in water-saturated soil but with no standing water (Dyck et al 1979, Mochida and Heinrichs 1981). The flooding of rice fields has often been cited as a factor for BPH outbreaks (Kulshreshtha et al 1974, Stapley 1975). Similarly irrigation favors increased infestation of gall midge (Kalode 1974, Hidaka et al 1978), whorl maggot, and caseworm (Pantua and Litsinger 1980).

Growing more than one rice crop a year influences the degree of pest problems. BPH, tungro, and grassy stunt epidemics have occurred on continuously cropped fields rather than on those with definite crop seasons (Mochida and Heinrichs 1980). Patha (1968) reported an increase in pest intensity in rice in multicropping areas. Since the introduction of double-cropping in rice in China, thrips have become a serious problem (Hsu et al 1978). Similarly, gall midge outbreaks in South China have become more common following a change in the cropping patterns to two or three rice crops per year (Chiu 1980).

On the other hand, double-cropping has largely been responsible for a decrease in the incidence of stem borers in Malaysia (Balasubramaniam and Ooi 1977) and Pakistan (Moiz and Rizvi 1971). With double-cropping, stem borers breed continuously throughout the year, which leads to overlapping of generations and favors the maintenance of an effective level of parasitism (Lim 1970b, Ooi 1976).

The closer spacing of rice plants results in a change in microclimate of the crop, which favors multiplication of insect pests. There are indications that the number of BPH nymphs/hill and the number of tillers/hill are often positively correlated (Mochida and Heinrichs 1981). There are also positive correlations between the number of nymphs and number of tillers/m^2, and between the number of nymphs and hill density/m^2 (Dyck et al 1979).

High plant population as a result of broadcast seeding rice at high rates has been cited as one of the reasons for BPH outbreaks in Kerala, India (Kalode 1974). The transplanting of rice at closer spacing is also more conducive to gall midge infestation than wider spacing (Prakasa Rao et al 1971, Katanyukul et al 1979).

Manwan (1975) recorded that spraying rice plants with 2, 4-D favored the survival and development of the yellow stem borer as compared to untreated plants.

Insecticides

Recent IRRI studies have shown that certain insecticides encourage resurgence of pest populations by rendering the treated plants more suitable to the insect pests and by stimulating insect reproduction. At IRRI BPH has developed resistance to carbofuran and diazinon (Heinrichs 1979). Methyl parathion sprays and diazinon granules caused BPH resurgence at IRRI (Chelliah and Heinrichs 1978). Insecticide-induced BPH resurgence has also been reported from Bangladesh (Alam and Karim 1977), India (AICRIP 1978), and Indonesia (Soekarna 1979). Based on these, it is suspected that resurgence due to insecticides in certain parts of tropical Asia was a factor for BPH outbreaks during 1972-75.

Studies under way at IRRI have demonstrated that certain insecticides such as carbofuran have a definite growth-stimulating effect on the rice plant (Venugopal and Litsinger 1980).

INSECT PEST PROBLEMS IN THE FUTURE

The urgency for producing more rice because of the expanding population, and the available and prospective production technology imply that rice production in tropical Asia is going to increase substantially within the next two decades. Insect pests will remain a major constraint to rice production, in certain cases becoming more serious than they are now. Therefore, it is important to design pest control programs that make better use of biological control organisms along with those other control methods that are inexpensive and environmentally safe.

The introduction of modern rice varieties in tropical Asia has provided an unprecedented potential for increasing rice production. Because the modern varieties must be provided with a number of inputs, including fertilizer and good water control, before their yield potential can be realized, they have caused significant changes in agriculture. As more land is brought under irrigation and concerted efforts are made to increase both per-hectare yield and cropping intensity, it is known that the pest problem, if not handled with great foresight and careful planning, can become more severe.

Fortunately, insect-resistant varieties, which became available only in the 1970s, are providing a practical method of control of several pests. Nevertheless, even these resistant varieties often produce significantly more rice when treated with insecticides, even when the apparent insect infestations are low. This, and the fact that resistance is available only to certain species of insect pests, implies that the rice crop, when well managed, will need at least one insecticidal treatment per crop. Thus, the use of about 0.3 kg pesticide/ha in most tropical Asian countries where rice predominates the proportion of cultivated area, as compared to 2 kg/ha for the United States or 10 kg/ha for Japan, is likely to increase at least 3-fold, even where integrated pest management programs are implemented.

Extreme precaution must be exercised by scientists and policy makers to ensure that this prospective increased use of insecticides is based on careful selection of chemicals, time of application, and formulation, and that insecticides should be used only when absolutely necessary.

The expansion of rice cultivation into saline soil areas appears imminent. There is some evidence that rice on saline soils becomes more susceptible to stem borers than that on other soils. This implies that salinity-tolerant varieties with genetic resistance for borers will be important as rice cultivation expands in those areas. It is also likely that the intensive rice cultivation in many areas will make certain species more abundant. For example, leafhoppers and planthoppers and certain insect species presently not infesting rice may adapt to it.

Little has been done to make biological control agents more effective. Most recent studies are of a survey and taxonomic nature. In general the tropical rice environment should be conducive to parasites, predators, and pathogens, exploitation of which is urgently needed to curb future growth of pest populations. Fortunately, the availability of resistant varieties, which minimizes insecticidal treatments, is helpful in the buildup of parasites and predators.

Recent research seems to lay more stress on varietal resistance whereas the emphasis on conventional chemical control is declining (Fig. 3). It is expected that the use of resistant varieties will become more common and genetic resistance to several of the common insect pests will be identified. However, the problem of the selection of biotypes capable of surviving on resistant varieties is likely to become more common and, therefore, future studies must emphasize the development of varieties with horizontal resistance or those with multigenic resistance.

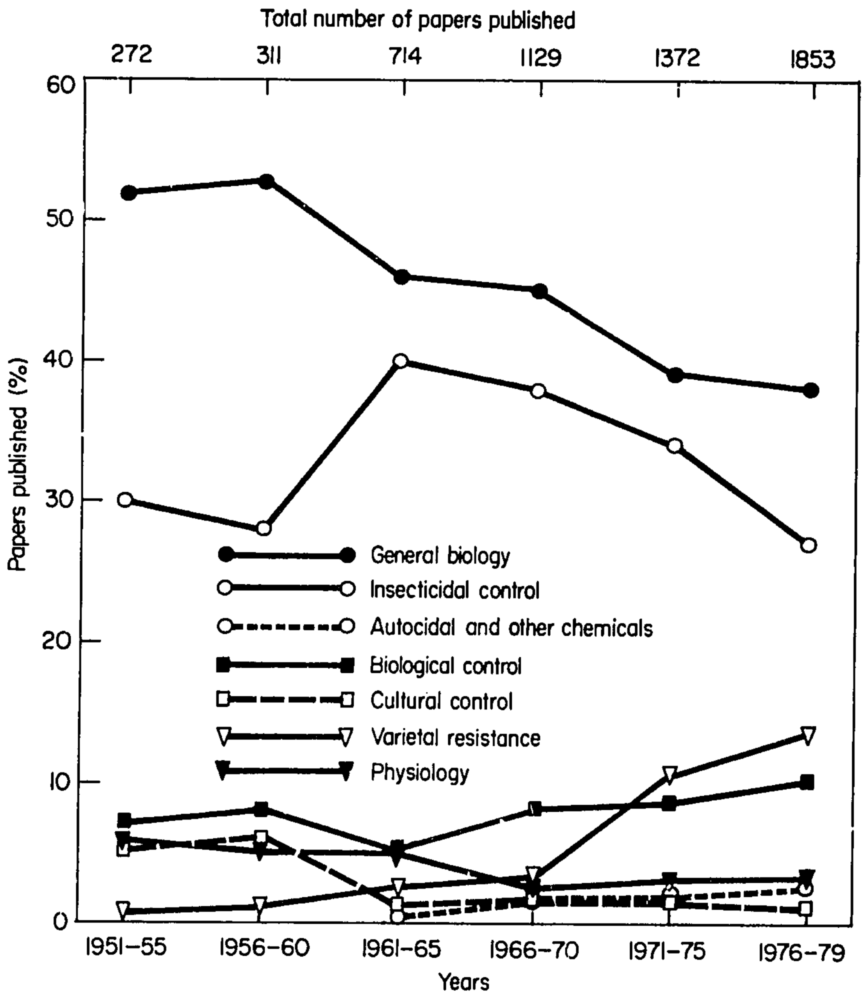

Fig. 3. Change in emphasis on different aspects of rice entomology, research on global basis, 1951-79. (Source: IRRI 1962 to 1979)

Future research on various pest control methods should emphasize their mutual compatibility. The pest problem should be handled through integrated management to avoid further worsening of the situation. Sound pest management systems, which integrate varietal resistance with other control measures, such as the judicious use of insecticides, biological control agents, and cultural practices, should be developed for different rice-growing regions in tropical Asia.

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