The brown planthopper problem

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The brown planthopper *Nilaparvata lugens* (Stål) recently increased in abundance and caused severe yield losses in several tropical countries of Asia. It is rather widely distributed but is found mainly in South, Southeast, and East Asia. It damages the rice plant by directly feeding on it and by transmitting the grassy stunt disease.

Some damage by the brown planthopper has been reported in Bangladesh, Brunei, China, Fiji, Korea, Malaysia, Papua New Guinea, Solomon Islands, Sri Lanka, Thailand, and Vietnam. But according to available data, the most extensive losses from the insect and the disease have occurred in India (estimated at US$20 million), Indonesia (US$100 million), and the Philippines (US$26 million). Losses from the insect alone are US$100 million in Japan and US$50 million in Taiwan.

The estimated losses due to the brown planthopper and the grassy stunt disease total more than US$300 million. That is a conservative estimate; it includes only losses from reporting countries and excludes expenditures for control operations. A pest management strategy that is compatible with modern rice technology is urgently needed to solve this serious pest problem.

THE BROWN PLANTHOPPER (BPH) *Nilaparvata lugens* (Stål) has in recent years caused extensive damage to the rice crop in Asia. Although an important pest in Japan for many years, it was formerly only a minor pest in most tropical countries of Asia. In the past 5 years, however, the BPH populations have greatly increased and caused severe yield losses in several countries. Large-scale damage by the insect has been reported in India, Indonesia, the Philippines, and Sri Lanka, and infestations of varying degrees are now commonly observed in many countries. Many regard the BPH as the number-one insect pest of rice in Asia today, primarily because of the unpredictability of the infestation and the dramatically severe damage it causes.

The pest feeds directly on the growing plant, reducing its yield potential. If the pest density is high, the plant dies and a condition known as hopperburn

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results. The insect may also transmit the grassy stunt disease, which can further reduce yield. Epidemics of grassy stunt have followed major pest outbreaks in India, Indonesia, and the Philippines.

This paper summarizes the few scattered reports of crop damage and loss caused by the BPH, primarily in tropical countries. Also, to give perspective to the importance of the insect, an attempt is made to estimate the monetary value of the pest problem.

DISTRIBUTION

Nilaparvata lugens is widely distributed; it is found in South, Southeast, and East Asia; the South Pacific islands; and Australia (Fig. 1). Earlier reviews have listed specific countries where the pest has been found, but it is now thought that the BPH area extends from Pakistan to Japan, and many islands in Southeast Asia, Micronesia, and Melanesia. The insect is found throughout the year, mainly on rice, except in Japan and Korea where adult pests migrate into the country each summer.

HISTORICAL RECORD OF INFESTATIONS, DAMAGE, AND YIELD LOSSES

Bangladesh

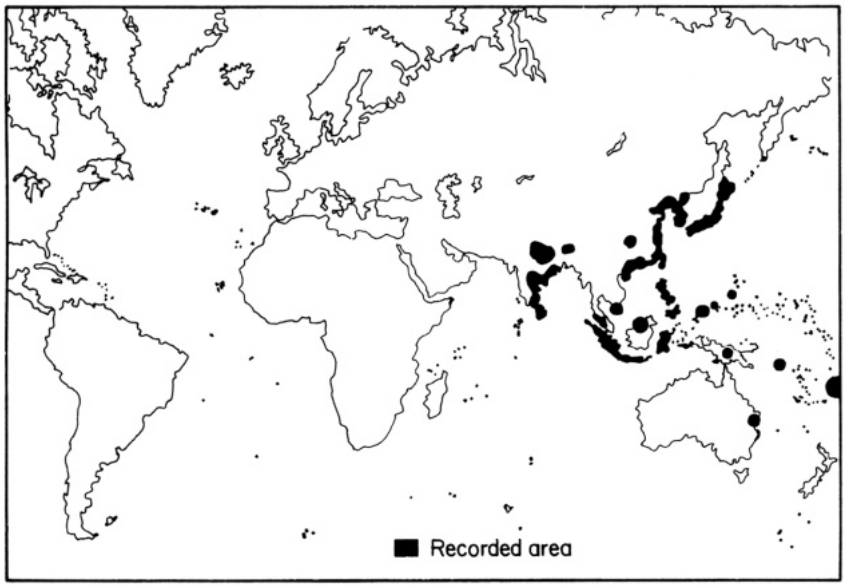
The BPH was first officially recorded in Bangladesh in 1969, but there are earlier records using synonyms of *N. lugens* in 1957 and in 1917. Catches in light traps near Dacca show that the insect population has gradually increased since 1970. The catch in 1976, especially in November, was very large (pers. comm. with S. Alam, Bangladesh Rice Research Institute, Joydebpur, Dacca, Bangladesh). The BPH was only a minor pest until high densities developed on crops in two areas near Dacca in 1976. The total area damaged was about 4 ha, with some patches hopperburned. That is the first confirmed case of hopperburn due to the BPH in Bangladesh (Alam and Karim 1977).

Brunei

Nilaparvata lugens occurs in Brunei, but it has not been identified as a pest. There is, however, a report of some hopperburn occurring a few months ago (pers. comm. with D. J. McCrae, Jabatan Pertanian, Department of Agriculture, Brunei).

China

Recent visitors to China have reported that the BPH is a pest there. Research in Japan and Korea. showing that planthoppers migrate to those countries from the southwest with weather systems, suggests some infestation each year in China. But data on crop damage and yield losses attributable to BPH are not available.



1. Distribution of the brown planthopper *Nilaparvata lugens* (Stål). shown by blackened areas (source: R. C. Saxena, IRRI).

Fiji

Hinckley (1963b) regarded planthoppers, including both *N. lugens* and *Sogatella furcifera* (Horvath), as the most important insect pests of rice in Fiji. The insects can kill rice in large patches and in entire fields. Infestations in 1959 occurred throughout the areas with standing rice (Hinckley 1963a). According to a report by Watson (1960) and Hinckley (1963a), about US$500,000 was lost when planthoppers destroyed 22% of the rice crop, or about 2,800 ha. Today the BPH still appears to be a major constraint on rice production in Fiji.

India

The most severe outbreak of the BPH in India occurred in Kerala state at the end of 1973 and early in 1974 (Koya 1974; Nalinakumari and Mammen 1975). Even though the pest had occurred sporadically in 1958 and 1962, the outbreak of 1973–74 was the first major one in Kerala. It occurred in the 'Kole' lands of Trichur district and Kuttanad area in Kottayam and Alleppy districts. The insect outbreak caused economic damage on about 50,000 ha of rice fields (Freeman 1976). About 8,000 ha was almost completely wiped out (Gopalan 1974). Hopperburn frequently developed in patches and sometimes covered

whole fields. Most crops showing damage had already headed (Kulshreshtha 1974), although crops suffered some damage at all growth stages (Mammen and Das 1973). In many fields the damage was so great that growers abandoned the crop (Das et al 1972). The loss in grain yield ranged from 10% in moderately affected fields to 70% in those severely affected (Kulshreshtha et al 1974). The damage to the standing crop sometimes reached 100%. Table 1 shows the area equivalent to that which experienced total loss of the rice crop in recent years; the estimate was arrived at by adding losses of various degrees in different areas. The estimated losses in Kerala from 1973–74 to 1975–76 total almost US$12 million.

Other states of India have also reported BPH infestations and damage. Ghose et al (1960) noted that *N. lugens* was a minor pest in Andhra Pradesh. The insect has since become a serious pest. In the 1976 dry season in East Godavari, A. P., about 200 ha was hopperburned and 3,250 ha was severely infested (Prakasa Rao et al 1976). During 1973 several thousand hectares were affected in Orissa (pers. comm. with B. C. Misra, Central Rice Research Institute, Cuttack—753006, India). Chatterjee (1969) reported that the formerly minor insect *N. lugens* had assumed serious proportions on rice in two northern districts of West Bengal. It caused serious damage to both autumn and winter crops. There was an outbreak in one district of West Bengal in 1975, and in several cases the crop was destroyed (Anonymous 1975e). Hopperburn occurred in two districts of Himachal Pradesh in 1973 and 1974 (Bhalla and Pawar 1975). Chelliah and Subramanian (1972–73) mentioned that the BPH occurs in epidemic form once every few years in Tamil Nadu and causes extensive damage. The incidence of the pest was especially high in 1969 and 1971, and Das et al (1972) reported a devastating outbreak in 1972. In Coimbatore district in the 1975 wet season, about 200 ha of rice fields was severely infested, and some hopperburn occurred (Velusamy et al 1975).

Numerous comments in recent literature indicate that the BPH is becoming

Table 1. Damage to the rice crop caused by the brown planthopper in Kerala, India, in recent years.

Crop year	Season	Affected area		Degree of damage (%)	Estimated equivalent area of total crop loss (ha)	Approximate value of crop loss[a] (US$)
		Ha	% of total rice area			
1973–74	Mundakan (Aug.–Jan.)	19,002	5.8	50–100	14,250	4,275,000
	Puncha (Dec.–Apr.)	48,910	63.4	10–100	19,800	5,940,000
1974–75	Mundakan	17,150	5.2	0–100	820	246,000
	Puncha	5.148	6.7	0–100	560	168,000
1975––76	Mundakan	6,087	1.9	0–30	480	144,000
	Puncha	27,356	35.4	0–100	3,230	969,000
Total						11,742,000

[a]Assuming an expected yield of 2.0 t/ha and a rough rice price of US$150/t.

an increasingly damaging pest in as many as 10 states in India, including Uttar Pradesh, Bihar, Haryana, and Punjab (Kalode 1974, 1976; Diwakar 1975; Pawar 1975; Freeman 1976; B. C. Misra, pers. comm.). The amount of grain lost because of BPH infestation in the whole of India has never been estimated, but it must be worth at least US$20 million. That figure is miniscule when compared with one arrived at using Cramer's (1967) calculations. He estimated that 1.8 million tons of rice was lost annually in only three states—Andhra Pradesh, Tamil Nadu, and Orissa. At US$150/t that would be worth more than US$277 million.

Indonesia

Observations in Java as early as 1931, 1939, and 1940 suggested that sucking insect pests were causing direct plant damage in the field (Kalshoven 1950; Mochida et al 1977). Until 1951, 50 to 150 ha of rice in Java was only occasionally infested by leafhoppers and planthoppers (Soehardjan 1973). Crop damage was negligible. The real pest problem first became evident in the 1968–69 crop. Thereafter, larger areas were infested and damage became more severe until the 1974–75 season, when tremendous losses occurred. The severe problem, which continued until at least the 1975–76 season, was compounded by grassy stunt disease. At the height of the epidemic more than 200,000 ha of rice was damaged by the insect and the disease (Table 2; pers. comm. with I. N. Oka, Central Research Institute for Agriculture, Merdeka 99, Bogor, Indonesia; Soehardjan 1973; Anonymous 1975c; Mochida and Suryana 1975; Sama and Halteren 1975; Sastrowidjoyo 1976; Mochida and Dyck 1976; Mochida et al 1977; Oka 1976; Partoatmodjo 1976; Sukarna and Mochida 1976).

BPH damage and grassy stunt infection resulted in great yield losses in

Table 2. Area damaged by the brown planthopper and grassy stunt disease in Indonesia by crop year and region.[a]

Crop year	Area (ha) damaged					
	Sumatra	West Java	Central Java	East Java	Other islands	Total
1968	–	50,000?	2,000	–	–	52,000[b]?
1969	–	?	1,633	–	–	10,000 ?
1969–70, 1970	–	13,443	755	391	–	14,589
1970–71, 1971	672	12,183	4,046	534	–	17,435
1971-72, 1972	3,724	19,881	1,885	9,969	–	35,459
1972–73, 1973	5,411	15,165	2,749	9.568	100	32,993
1973–74	3,199	14,980	4,922	7,039	158	30,298
1974	22,838	–	15,998	–	–	38,836
1974–75	114,193	59,946	23,927	62,589	23,233	283,888
1975	23,915	3,233	37,473	8,966	20,000	120,000 ?
1975–76	17,115	17,671	104,000	70,000	33,641	242,427
1976	400	–	–	–	–	8,000 ?

[a]Data from L N Oka (pers. comm.), Soehardjan (1973). Anonymous (1975c). Mochida and Suryana (1975). Sama and Halteren (1975). Sastrowidjoyo (1976). Mochida and Dyck (1976). Mochida et al (1977). Oka (1976). Partoatmodjo (1976). and Sukarna and Mochida (1976). [b]Caused by planthoppers and leafhoppers

Table 3. Damage to the rice crop by the brown planthopper and grassy stunt disease in Indonesia.[a]

Crop year	Damaged area (ha)	Degree of damage (%)	Estimated equivalent area of total crop loss (ha)	Approximate value of crop loss [b] (US$)
		All islands		
1974–75	248,819	20–100	99,830	46,907,620
1975	95,272	20–100	49,054	23,049,250
Total				69,956,870
		N. Sumatra		
1974	5,076	100	5,076	2,385,080
1975–76	1,402	100	1,402	658.760
Grand total				73,000,710

[a] Basic data from I. N Oka (pers. comm.), Anonymous (1975d), Oka (1976). and Sukarna and Mochida (1976). [b] Based on expected yield of 3.75 t/ha and rough rice price of $125.30/t.

Indonesia in recent years. Yield loss estimates were made for the whole country for the 1974–75 and 1975 crop years (I. N. Oka, pers. comm.; Anonymous 1975d; Oka 1976; Mochida and Suryana 1975, 1976a,b). Within that 12-month period the estimated value of crops lost ranged from about US$30 million to US$70 million (Table 3). With additional data from Sumatra, the maximum total crop loss could amount to US$73 million (Table 3; Sukarna and Mochida 1976). Considering the losses in other years (Anonymous 1975c) not estimated in Table 3, the total amount of grain lost to the BPH and the associated grassy stunt disease would undoubtedly be more than US$100 million. The figure excludes the cost of crop protection, which might reach US$1 million/year. Indonesia has probably suffered more from the BPH than has any other tropical country.

Japan

The BPH has evidently been a pest of rice in Japan since ancient times. Outbreaks date back to AD 697 or 701 (Miyashita 1963; Grist and Lever 1969; Mochida et a1 1977). Since then there have been numerous records of outbreaks, many covering large areas, and some causing severe famine (Miyashita 1963 ; Kuno 1964; Kisimoto 1968, 1971). In 1897, 960,000 tons of rice was lost. That was equivalent to a loss of 18.49% for all of Japan (pers. comm. with R. Kisimoto, Central Agricultural Experiment Station, Konosu, Saitama, 365 Japan; Kuno 1964). Crop damage from *N. Iugens* usually occurs in the same year as that from *Sogatella furcifera,* but *S. furcifera* reaches its peak before *N. lugens*– early in the crop season (Kisimoto 1976a). The latter species may do more damage, since it is most dense during the reproductive period (Kuno 1964).

In this century. outbreaks occurred rather frequently in 1912, 1926, 1929, 1935, 1940, 1944, 1948, 1960,1966, and 1969 (Kono et a1 1961; Miyashita 1963; Kuno 1964; Mochida 1964; Kisimoto 1968, 1976a,b; Kiritani 1976). In 1940 the planthoppers destroyed 240,000 t of rice (Kawada et a1 1954). Kuno (1964)

wrote that such damage never recurred because of extensive crop protection measures, particularly the use of insecticides. However, the infestations in 1966 and 1969 were very serious despite chemical applications; more than one-third of the total paddy-field area was seriously damaged. Yield losses were 349,000 t in 1966 and 176,500 t in 1969 (Kisimoto 1976a).

Mochida (1974) observed that over a 10-year period in Kyushu, the yield losses due to insects and diseases in untreated experimental plots averaged 53% (28-100%). The greater part of the loss was attributed to insects, especially to *N. lugens*. Severe hopperburn occurred in 1967 and in 1969 when light-trap catches were high. The correlation coefficient between the occurrence of *N. lugens* in light traps and yield was –0.637 ($0.10 > P > 0.05$). Thus the BPH appeared to be the major cause of the yield losses due to pests.

In 1973, when infestation by the BPH was moderate, losses totaled 83,700 t (Japan 1973).

Rice losses due to the BPH in Japan could be a1 least 1 million t. or probably higher. That much rice may be worth US$100 million.

Korea

In ancient Korean records, 36 out of 167 references to insect infestations can possibly be attributed to planthoppers. Hopper damage was reported as early as 18 AD. Since 1912 the BPH has been authentically recorded four times, and about 10 outbreaks probably have occurred. The pest infested fields in many provinces in 1912; infestations also occurred in 1921, 1922, and 1923. The BPH problem has increased during the last 10 years, although the severity of outbreak varies with season. Some damage occurred in 1965, 1966, 1967, 1969, and 1970 (Lee and Park 1977: Paik 1977).

BPH outbreak was most severe in 1975 in the southwestern part of Korea; it mainly affected the late-maturing local varieties. The insect fed extensively. on plants past the heading stage (Lippold 1976; Paik 1977; Park and Lee 1976). Planthoppers and leafhoppers infested 1.745 million ha of rice in 1975, but only 200,996 ha in 1973 and only 497.507 ha in 1974. The yield loss in 1975 ranged from 24 to 38% in hopperburned areas, and from 2 to 20% in fields that were infested but not hopperburned (Lee and Park 1977). It may be valued at US$10 million.

Malaysia

The BPH used to be a minor pest in Malaysia. In Sarawak, no outbreak has ever been recorded: nor has the pest alone caused appreciable crop damage (pers. comm. with B. H. Voon, Agricultural Research Centre, Semongkok, Department of Agriculture. P.O. Box 977. Kuching, Sarawak, Malaysia). But in 1967 the BPH and *Sogatella furcifera* together attacked and destroyed more than 5,000 ha of paddy fields in West Malaysia (Lim 1971). Losses were about US$1 million. A little hopperburn, affecting about 8 ha, was seen in 1968. More recently, in 1975, a few areas reported outbreaks of the BPH and a few

hectares were hopperburned (Anon. 1975b; Heong 1975; pers. comm. with P. A. C. Ooi, Crop Protection Division, Department of Agriculture, Jalan Gallagher, Kuala Lumpur, Malaysia).

Nepal

N. lugens, reported in Nepal in 1965, apparently caused no serious infestations (pers. comm. with K. C. Sharma, Ministry of Food, Agriculture and Irrigation, Agriculture Department, Khumaltar, Lalitpur, Nepal).

Papua New Guinea

Recently small outbreaks of the BPH on New Ireland, New Britain, and the New Guinea mainland, with a few hectares hopperburned, were reported (pers. comm. with P. R. Hale, Department of Agriculture, Stock and Fisheries, Department of Primary Industry, P.O. Box 101, Kavieng, N.I.P., Papua New Guinea). Hale and Hale (1975) noted that in New Ireland the pest caused complete loss of the crop in several fields, and damaged other fields.

Philippines

The earliest recorded damage by the BPH in the Philippines occurred in Calamba, Laguna, in 1954 (Varca and Feuer 1976). Cendaña and Calora (1967) mentioned that an attack by the pest in 1959 in the same town destroyed all fields planted to the variety Milfor. In Ilocos Norte province in the wet season of 1957-58, the BPH caused extensive damage to irrigated lowland rice; even seedbeds were destroyed (pers. comm. with H. A. Custodio, Pest and Disease Division, Bureau of Plant Industry, San Andres, Manila). Some plots on the IRRI farm were hopperburned in 1964. Since 1966 catches of BPH in IRRI light traps gradually increased and reached a peak in 1973 (IRRI 1975). Probably BPH incidence similarly increased in many parts of the country, since serious outbreaks occurred in numerous provinces in 1973 (Bureau of Plant Industry (BPI) et al 1974).

The 1973 infestation affected most rice-producing provinces (Varca and Feuer 1976). BPI et al (1974) list 21 provinces with serious infestations and 14 provinces with moderate infestations. Pest populations reached "explosive" levels, and hopperburn was a common sight. The actual yield losses in the infested provinces were not reported. But Cramer's method (1967) for calculating losses (5% loss for severe infestation and 2% for moderate infestation) estimates the 1973 yield loss for the country as a whole to be about 150,000 t, worth about US$20 million.

Probably the worst infestation in 1973 occurred in Laguna province, where thousands of hectares were infested. BPH and the grassy stunt disease damaged 85% of the province's rice fields. In some towns the pest destroyed the crop (Anon. 1975a). About 700 ha was hopperburned, and the yield worth more than US$200,000 was lost.

In general, the pest problem was much reduced in 1974, although infestations and some damage were reported (Dyck 1974; Anon. 1975c; IRRI 1975). In 1975 the BPH infested a thousand or so hectares in Nueva Ecija province, and a few hectares were hopperburned (Anon. 1975a,b). In 1976, damage, especially by BPH biotype 2, was reported in Mindanao. IRRI light-trap catches of BPH in 1976 showed insect resurgence. In the Philippines the BPH infested a total of 50,000 ha in late 1976 and caused a yield loss of about 20%. About 1,000 ha was hopperburned. The national loss incurred, about 0.75%, was worth US$6 million (pers. comm. with R. Feuer, IRRI). The BPH continues to be a threat—possibly the major insect threat—to rice production in the Philippines.

Solomon Islands

When rice was first grown in the Solomon Islands in the early 1960's, the BPH was a serious pest (MacQuillan 1974). Difficulties in controlling the insect stopped rice production for some time. After production was resumed, the pest was controlled effectively for a few years. But an outbreak in 1974 caused some hopperburn and a total crop loss amounting to about US$120,000 (pers. comm. with J. H. Stapley, ILO Research Station, Dodo Creek, Honiara, Solomon Islands). Although an outbreak has not recurred, some damage was again reported in 1975 (Anon. 1975b).

Sri Lanka

Some authors regard planthoppers as very important insect pests of rice in Sri Lanka (Otake et al 1975). Over the past 10 years BPH have appeared in large numbers in several parts of the country, and occasionally have caused hopperburn. In Ampari district the pest became serious in recent years. In 1974 about 16,200 ha was attacked to some degree, and 2,800 ha of rice was destroyed (Fernando 1975). Yield loss amounted to about US$1 million.

Taiwan

Before 1960, the BPH occurred only sporadically (Yen and Chen 1977). In Taiwan since 1960 it has been a major insect pest. It is generally considered as the principal insect pest of rice (Hsieh 1977). Now it is widely distributed and destructive. Outbreaks occurred in central and southern Taiwan during the second crop seasons of 1966, 1967, 1970, 1974, and 1975. The insects infested more than 100,00 ha of rice fields, about 25% of the total area under rice. It also caused severe damage in some parts of southern Taiwan during the first crop seasons of 1966 and 1969 (Table 4; Hsieh 1977). In spite of the extensive use of insecticides, the rice yield annually lost to BPH in 1972–75 ranged from 16,140 to 55,584 t (0.6 to 2.24% of total rice production). In 1975 the estimated value of the lost crop was US$9,715,000. The amount excludes US$28,701,298 that farmers spent to control the insect (Hsieh 1977).

Table 4. Area infested by the brown planthopper in Taiwan, 1966–75.[a]

Year	Infested area			
	In first crop		In second crop	
	Ha	% of total rice area	Ha	% of total rice area
1966	59,543	17.5	104,767	23.3
1967	17,379	5.1	137,419	30.5
1968	6,339	2.0	88,550	19.7
1969	61,172	17.8	79,399	17.3
1970	23,149	6.8	102,680	23.6
1971	16,969	5.1	53,207	12.7
1972	9,479	2.9	56,510	13.7
1973	14,908	4.6	47,827	11.9
1974	12,972	3.7	101,708	23.5
1975	20,886	5.8	110,570	25.6

[a] Data from Hsieh (1977) and the Provincial Department of Agriculture and Forestry, Taiwan.

Yen and Chen (1977) mentioned that US$45/ha was spent in each crop season in 1975 to control the BPH; that is 23% of the total spent in rice crop protection.

The grain lost to the BPH in the last decade or so may be valued at about US$50 million. Adding to this the amount spent on pest-control measures would make the monetary value of the pest problem enormous.

Thailand

No damage from the BPH was noticed in Thailand before 1974. But in that year's dry season the pest population in the Central Plain area became very high. The insects spread throughout the Central Plain and caused hopperburn (Tirawat 1975). A small outbreak developed west of Bangkok (Otake and Hokyo 1976). Some pest problem occurred in 1975 and insecticides were applied to control it (Anon. 1975c).

Vietnam

In 1971 Ngoan reported that planthoppers and leafhoppers were causing more damage in Vietnam than they did before 1967. Damage by planthoppers seemed to be the major insect-limiting factor in rice production. *N. lugens,* which has become increasingly abundant every year, has formed outbreaks. Hopperburn is caused mostly by *N. lugens,* not by *Sogatella furcifera,* Thousands of hectares have been destroyed every year (Ngoan 1971), and yields possibly worth US$3 million have been lost.

According to Huynh (1975), the BPH has been the most serious insect pest of rice in Vietnam since 1970. Hopperburn occurred in 1975 at several locations in the Mekong Delta area.

Table 5. Summary of approximate total monetary loss caused in recent years by brown planthopper and grassy stunt damage to rice.[a]

Country	Loss (million US$)
Fiji	0.50
India	20.00
Indonesia	100.00
Japan	100.00
Korea	10.00
Malaysia	1.00
Philippines	26.00
Solomon Islands	0.12
Sri Lanka	1.00
Taiwan	50.00
Vietnam	3.00
Total	311.62

[a] Calculated from available records.

CONCLUSIONS

Adding up the estimated losses due to the BPH and the grassy stunt disease in most of the countries where the insect is found gives a total of more than US$300 million (Table 5). No doubt that is a conservative estimate. It does not generally include losses during years of moderate or low infestations, or losses in several countries for which information is lacking, or expenditures for control. The estimate would be much higher if all losses everywhere could be totaled.

The BPH will probably remain as a major pest for two reasons. One is that modern agronomic practices and high yielding varieties may themselves be related to the causes of the problem. Another is that present control measures are not entirely satisfactory.

We must improve our pest-control technology, and devise a pest-management strategy that is compatible with modern rice technology. If we are to make further advances in rice science in the rice bowl of the world, the BPH pest problem must be solved.

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