1. RECENT PROGRESS IN RICE INSECT RESEARCH IN INDIA

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Introduction

India is the largest rice growing country in the world cultivating about 90 million acres, and annual production is about 37 million tonnes. About 25 million acres rice is grown with artificial irrigation. The crop is grown in almost all states of India but about 97% of the country's production is concentrated on the river-valley-deltas and low-lying coastal areas of north-eastern and southern states. Nearly 3,000 varieties differing in morphological and agricultural characteristics are in cultivation (Anonymous 1967). In tropical and sub-tropical conditions, as in southern India, rice can be grown practically throughout the year. In temperate regions and at high altitudes, the crop is grown only in warm part of the year. In spite of the large acreage under rice cultivation, our country is deficient in rice. It has been estimated that the rice crop suffers damage due to pests and diseases, to the tune of Rs. 100 crores annually out of which the share of paddy stem borer alone is Rs. 10 crores (Mehta & Varma 1968).

In India the Green Revolution in rice growing is not very far and this is due to the introduction of high-yielding varieties from Far East such as Taichung Native I, IR 8, IR 5 and other locally evolved varieties. Although the cultivators have realized the importance of timely control of pests and diseases in rice crop, there are 25 insect pests of paddy of major significance causing economic loss to crop that attack all parts of the plant from seedlings to mature stages. These pests have been reviewed from time to time by Banerjee and Pramanik (1964), Banerjee (1964, 1969) with regard to their ecology and bionomics by Kulshreshtha *et al.* (1970), Israel (1966), Rai and Zutshi (1969 & 1971), Nair and Nagalingam (1969) and Venkataraman *et al.* (1971) on ther control and Seth *et al.* (1969) about the losses. With the introduction of high yielding varieties the so-called minor pests like Gall fly (*Pachydiplosis oryzae*) and the hoppers (*Sogatella furcifera; Nilaparvata lugens*) are assuming alarming proportions in some areas (Rai & Zutshi 1969). The infestation of *P. oryzae* is reported to cause 80% (Pathak *et al.* 1967) or even hundred per cent (Zutshi 1958) reduction in yield. The potent threat posed by green leaf hoppers (*Nephotettix* spp.) in transmitting tungro and other rice viruses should lead to a wider recognition of their importance. Further, due to irrigation facilities there is double and triple cropping in major rice growing tracts of the country which provides a continuous host for pests and diseases. As a result pest problem become more and more acute day by day.

This article is an attempt to review the recent progress in rice insect research with special reference to the use of newer pesticides against various rice pests in India.

Paddy Tissue Borers

The paddy crop is affected by seven tissue borers in India, viz., *Tryporyza incertulas* Wlk., *Sesamia inferens* Wlk., *Chilo simplex* Bult., *Scirpophaga innotata* Wlk., *Chilotrea*

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infuscatellus Snell., *Proceras indicus* Kap., *Chilo zonellus* Swin.

In Asia the yellow borer (*Tryporyza incertulas*) and striped stalk borer (*Chilo suppressalis*) are major pests of rice and are distributed widely from India to Japan. The most important and widely distributed borer in India is yellow borer. So far no alternate host has been noted by workers in India and the absence of alternate host and the peculiar boring habit of the larvae makes the insect more difficult to control. The insect is distributed throughout India. It is a serious pest in Assam, Andhra Pradesh, Bihar, Jammu, Kashmir, Kerala, Maharashtra, Mysore, Madhya Pradesh, Orissa, Punjab, Tamil Nadu and Wet Bengal. The estimated total loss caused by all stem borers in India is 20% or 7.4 million metric tonnes (Lever 1969). However, more logical explanation has been put forward by Israel *et al.* (1962) on the basis of regression formula. They found that the loss in yield due to infestation at the early seedling stage was 21.57% while the loss in the ear-head stage was 26.99%. The cumulative loss sustained by the crop at both the stages was 44.25%.

Three broods have been observed in a year in West Bengal while in Orissa there are two broods. In Andhra Pradesh there are three broods in rabi season; in Tamil Nadu 5 broods while in Punjab there are 4 or 5 generations in a year (Banerjee 1964).

The affected plants turn yellow and grain formation is prevented. The ear heads appear white and chaffy. Small punctures at the lower portions of the stem is an evidence of the borer attack.

The control of the stem borer is difficult as the larvae can be within the plants soon after hatching. The entire larvae and pupal period are spent within the stem. From 1959 onwards detailed experimental work with light trap in West Bengal revealed interesting observations concerning control of stem borer (Banerjee and Pramanik 1964). In India three fortnightly sprays of endrin 0.04% or parathion 0.04% or four applications of a mixture of 0.05% diazinon and 0.75% actual endrin per acre reduce the infestation considerably (Srivastava and Saxena 1960). Although encouraging results on the control of this pest have been achieved by the use of the above mentioned chemicals but more potent and safer chemicals are yet to be found out.

During 1970 Indian Council of Agricultural Research (Anonymous 1970) tried the efficiency of 15 promising newer insecticides against stem borer (Appendix 1). It was observed that carbofuran, Dursban, SD 6626, phorate, fenthion and diazinon are effective for controlling stem borer at the vegetative stage. It was also observed that the toxicity of diazinon granules persist effectively for 15 days against just hatched larvae of *Tryporyza incertulas* in the treated plants when applied through irrigation water.

Maximum Protection Trial

In India recently the maximum protection trial against borers was also conducted by Indian Council of Agricultural Research (Anonymous 1970). Trials were laid at 4 locations and the varieties like Jaya (TN1 × T141), Hamsa (HR12 × TN1), W1263 (MTU15 × Eswarakora) were tried in experiments. Mainly diazinon granules at 1.5 kg (active ingredient) per hectare at 15 days intervals beginning from 5 days after planting till maturity were used. It was found in all locations that the protective measures would enable a substantial yield increase, which otherwise would have been lost on account of insect pest. Under Indian conditions response of different varieties to the protection was quite discernible. Jaya, IR 8, and Hamsa, considered susceptible to the insect pest complex, produced yields of 3184, 3020 and 2812 kg per hectare respectively in some locations in India under protected conditions which accounted for a per cent increase of 174, 112 and 189 over unprotected situation (Appendix 5). In many other locations too Jaya and Hamsa responded to protection during 1970 (Anonymous 1970). In India recently from the point of view of grain yield carbofuran treatment has established

its superiority (Appendix 1).

Stem Borer Screening

The screening trial for stem borer resistance was conducted in India in many locations to detect the resistant lines from among the selections originating from crosses involving high-yielding and stem borer resistant parentage to explore the resistance in varieties resistant to other pests; also identify resistant types from the new germ plasm collections, primarily from Assam; and obtain an evaluation of varieties in the variety testing programme.

Seventy five entries were tested during rabi 1970. Out of these 23 were found to be borer resistant at the tillering and the flowering stages. The varieties like W1263 (MTU15 × Eswarakora) and W1251, W1253 and RPCBIB7078 (TN1 × TKM6) manifested resistance at both tillering and flowering stages at all locations. Jaya and IR 8 were rated as resistant at only flowering stage. The new selections like IET 400 (TN1 × C029) and IET 826 (TN1 × C029) were classified resistant at the tillering stage and none were resistant at the flowering stage (Appendix 5 and 6).

Rice Gall Midge/Paddy Gall Fly
(*Pachydiplosis oryzae*) (W. M.) Mani

The rice gall midge/paddy gall fly (*Pachydiplosis oryzae*) (W.M.) Mani has been reported in India as early as 1880 and remained as a minor pest. However, with the introduction of high yielding varieties this pest has become serious in some areas in our country (Rai and Zutshi 1969). The pest is particularly serious in Andhra Pradesh, Kerala, Mysore, Orissa and Tamil Nadu (Pathak *et al.* 1967).

Depending on the weather condition the peak of infestation fluctuates between August to the end of November. Number of brood varies from five to eight. The period of incidence is mid-August to October in West Bengal (Banerjee 1964) and from May to September in Bihar. In southern states the crop mainly suffers in the monsoon season and the maximum incidence is reached between 3rd week of August to 2nd week of September (Israel, *et al.* 1958).

The grub enters the stem and reaches the primordial cover where it develops. Due to some secretion or excretion of the maggot, some physiological disturbance takes place and the normal growth of the plant is hampered. The central leaf of the attacked plant becomes hollow and deformed and a little swelling or gall formation appears on the basal portion of the plant. The growth of the affected plant is stopped and the central leaf ultimately turns into a hollow out-growth giving a shining silvery colour. Hence the common name "the silver-shoot of paddy". The insect being an internal feeder is difficult to control by insecticides. However, organo-phosphorus insecticides like parathion and highly toxic chlorinated hydrocarbons like endrin have shown good promise in reducing the spread of the pest.

Spraying with 0.04 per cent parathion or with 0.02 per cent endrin has been found useful. While DDT and toxaphene proved ineffective, applications of dieldrin, chlordane and ethyl parathion significantly reduced the pest incidence. However, in many locations the insecticidal schedules apparently are providing erratic results.

At present the information available to us is meagre on the basic bionomics, factors affecting abundance and chemical control of this pest. In India during 1970 Indian Council of Agricultural Research (Anonymous 1970) tried the efficacy of 15 new insecticides against rice Gall midge at different locations. It was observed that none of the insecticides offered satisfactory level of protection (Appendix 3).

It has been noted in many locations that planting dates if adjusted can evade effectively the major Gall midge infestation. The general nature of Gall midge infestations

and the work in progress at some Research Stations in India suggests promising possibility for breeding varieties resistant to this pest but with good yield potentialities.

From the screening of the world genetic stock maintained at Central Rice Research Institute, two varieties, PTB 18 and PTB 21 from Pattambi were isolated as highly resistant. The variety, Eswarakora in Andhra Pradesh also found to be resistant in certain degree. Since all the above resistant varieties were tall, low yielder and very late duration they could not become popular among the farmers and necessitated further research work in this direction.

After the introduction of the high yielding varieties, number of crosses have been made using PTB 21, CR 56-17 and Leuang 152 as the resistant donors and IR 8 as the high yielding parents. The dwarf resistant selection from these crosses is being listed through All India Coordinated Rice Improvement Project. From the trials already conducted a few selections, viz.,

CR 57 – 26 CR 57 – 29	IR 8 × PTB 21
CR 58 – 35	TN 1 × PTB 21
CR 60 – 10	CR 56 – 17 × IR 8
CR 94 – 13	CR 55 – 36 × IR 8

were found to be highly resistant to Gall midge. (Roy *et al.* 1970). These varieties are also being tried in the Gall midge endemic areas for further performance.

In addition to this, studies at the Agricultural Research Station, Warrangal (Andhra Pradesh) identified several other resistant varieties, viz., HR 42, HR 63 and Siam 29, which exhibit less than one per cent incidence, under conditions when the popular local strain, HR 35 showed 50 per cent incidence (Shastry & Seshu 1971).

India at present the research work is going on regarding evolution of Gall midge resistant dwarf varieties as a priority item in the national programme (AICRIP), which consists of 3 aspects, viz.,

(a) search for new sources of resistance;
(b) screening of material originating from crosses involving different sources of resistance; and
(c) organization of yield trials with selections combining resistance as identified in GMS (Screening Trial for Gall Midge Resistance) with good plant type and grain characteristics (Shastry & Seshu 1971).

Paddy Bug

(*Leptocrixa acuta* Thun & *L. varicornis* Fab.)

In recent years this insect has assumed epidemic proportions. In the year 1952 seven to eight million acres of rice in Bihar, Madhya Pradesh, Orissa and Uttar Pradesh were affected. It is popularly known as Gundhi bug (Gundhi=bad smell which the insect possesses). *Leptocorixa varicornis* and *L. acuta* have distinct areas where they occur as a major or a minor pest. In the States of Assam, Bihar, Delhi, Kerala, Madhya Pradesh, Orissa, Rajasthan, Tamil Nadu and Uttar Pradesh *L. varicornis* is the major pest. *L. acuta* is a serious pest in parts of Kerala, Madhya Pradesh, Orissa, Tamil Nadu and West Bengal. From this distribution list it appears that two species of *Leptocorixa* are responsible for the damage to paddy crop.

The pest is active in West Bengal from May to the end of November (Banerjee 1964). In Bihar, its maximum period of activity is from the middle of September to the first week of October. They start breeding on "Sama" grass (*Panicum crusgalli*) and on the millets from June and then migrate to paddy.

In Uttar Pradesh the maximum population is reached in September and decreases with the advent of cold weather in the month of October.

It can be controlled by applying 5 per cent DDT or BHC dust. Spraying of aldrin or chlordane also prove beneficial. Insecticides should be applied before flowering. The success of control of this bug depends on timely action and treatment of contiguous araes. Varietal resistance in paddy to this insect has also been reported. Sona of Bihar, Sathia of Uttar Pradesh and Mundagakutty of Tamil Nadu are reported to be resistant to this bug (Israel *et al.* 1959).

Green Jassids

(*Nephotettix impicticeps & N. apicalis* Mots)

They are distributed in all the paddy growing tracts of India.

During the kharif season of 1969 the rice crop especially the varieties, Padma, Jaya, IR 8 and TN 1 in three States, viz., Bihar, Uttar Pradesh and West Bengal, was severely attacked by leaf hoppers, which also resulted in wide spread incidence of a new virus disease called Tungro. To safeguard against a similar situation developing in these States and the States adjoining them, viz., Madhya Pradesh and Orissa, in the kharif season 1970 the Directorate of Plant Protection, Quarantine and Storage in collaboration with Ford Foundation, Indian Council of Agricultural Research and the concerned States, conducted *ad hoc* rice surveys in the vulnerable areas of paddy by following prescribed survey routes. In all, 15 survey reports were issued and the concerned agencies were informed for taking further necessary action.

After completion of survey it was observed that at no period during the rice survey of 1970, did the population of *Nephotettix* spp. reach the levels existing in sections of Bihar, Uttar Pradesh and West Bengal during 1969. In Bihar and Uttar Pradesh the appearance of the vector, was three or more weeks later than in the previous seasons. Early rains in West Bengal appeared to be involved in earlier establishment of the leaf hopper than in other States, but still the vectors' appearance was approximately 2 weeks later in the 1969 season. Similar situations were observed in Orissa and eastern Madhya Pradesh, where *Nephotettix* spp. appeared later than usual and at the lower population levels. The Raipur area of Madhya Pradesh usually experiences high populations of *Nephotettix* spp. late in the season (October); however, in 1970 only pockets of moderate intensity were found (Lowe 1970).

The leaf hopper populations recorded during 1970 in Bihar and West Bengal were moderately high, but these populations were confined to isolated fields. The population did not reach the level existing over wide areas of these States in 1969 (Lowe 1970).

The occurrence of *Nephotettix* spp. in rice fields of the 5 State survey area during 1970 season was determined as follows:

State	First observation	Peak population	Intensity at peak
Bihar	July 21st	October 6th	8-10 adults/hill
Madhya Pradesh	September 2nd	November 1st	4-5 adults/hill
Orissa	August 4th	October 28th	3-5 adults/hill
Uttar Pradesh	August 3rd	October 7th	2 adults/hill
West Bengal	July 25th	October 28th	6-7 adults/hill

The leaf hopper population recorded during 1970 in Bihar and West Bengal were moderately high, but these populations were confined to isolated fields. The population did not reach the level existing over wide areas of these States in 1969 (Lowe 1970).

Pathak *et al.* (1967) while surveying paddy pests recorded low levels of the zigzag

leaf hopper, *Inazuma dorsalis* Mots (vector of orange-leaf virus diseases) from Burdwan (West Bengal), Patna (Bihar), Faizabad (U.P.) and Thanjavur (Tamil Nadu). In general the white black plant hopper, *Sogatella furcifera* Horvarth and brown plant hopper, *Nilaparvata lugens* Stal were more numerous. Damage caused by their direct feeding 'hopper burn' was observed in Andhra Pradesh, Maharashtra, Orissa and West Begal. IR 8 and TN 1 as well as local varieties showed this type of damage (Pathak *et al.* 1967.

Therefore it is important that adequate control measures be taken to protect these varieties from plant hoppers, particularly during the periods approaching crop maturity when these insects usually become more abundant (Pathak *et al.* 1967).

Recently at Rice Research Institute, Cuttack, use of granular insecticides, like Furadan, proved effective. Amongst the insecticides tested as foliar sprays at 0.05% concentration, Birlane and parathion proved very effective (Kulshreshtha 1971).

Rice Hispa

(*Hispa armigera* Olivier)

This insect is a serious pest in Andhra Pradesh, Assam, Bihar, Kerala, Madhya Pradesh, Orissa, Punjab, Tamil Nadu and West Bengal but is of minor importance in Himachal Pradesh, Jammu & Kashmir, Maharashtra and Uttar Pradesh. *H. aenescens* is also serious in Kerala and Punjab.

The pest is most serious on crops sown in June–July and January–February in Andhra Pradesh. In West Bengal both 'Boro' (January–March) and Aus (May to October) paddy are attacked. In Bihar it is serious only in Aus paddy (June–September). It has six generations in a year.

The adults feed by scraping out the green matter (chlorophyll) of the leaves but the larvae are leaf miner and feed on the tissue between the upper and lower epidermal layers. As a result of the attack the leaves turn whitish and memberanous and finally die. The average loss varies from 6 to 65 per cent. Studies on the assessment of damage were conducted in West Bengal (Banerjee 1964). According to him damage was 2.4 per cent in seedling stage; 4.06 per cent in the transplanting stage; 0.54 per cent in the flowering stage and 0.02 per cent in the grain stage of the crop and from sowing to harvest the damage was 6.76 per cent.

The pest can be controlled by applying BHC or DDT with or without pyrethrins. Use of parathion or endrin is reported to be more effective against grubs mining in the leaves (Banerjee 1964).

Discussion

K. G. Singh, Malaysia: How common are granular insecticides used by farmers in India to control stem borers? How widely is TN1 grown? Don't you think as it is a variety that is susceptible to all sorts of diseases, it should be replaced?

Answer: 1) Granular insecticides are recent introduction in India. So far India was importing this type of insecticides. Now we have started to manufacture. Last year in Andhra Pradesh, where there was high incidence of Gall midges, the farmers used this type twice. 2) TN1 is gradually being replaced by varieties developed in India.

T. Hidaka, Japan: 1) What is the most important factor affecting population density of the rice gall midge? 2) PTB 18 and PTB 21 were susceptible against the rice gall midge in Thailand. How about in India?

Answer: 1) It has not been worked out. But we are now working on it. 2) In India they are resistant according to the study in the Central Rice Research Institute, Cuttack, India.

K. Kiritani, Japan: It seems that in India you use widely chlorinated hydrocarbons against insect pests of rice. According to the WHO report, human fat of Indian people contains higher amount of DDT than that of any other nations. Is the application of these insecticides to the paddy field related to this facts? Are you making any attempt to counteract this problem?

Answer: We have restricted the use of DDT for agricultural purpose. Lindane is being used. We are restricting Endrin from this year.

Soenardi, Indonesia: Will Thiodan be used in rice although it is highly toxic to fish?

Answer: Where there is fish culture we do not recommend it.

R. Kishimoto, Japan: In India do you have often outbreaks of the brown and white-backed plant hopper (*Sogatella furcifera*) on a large scale? And if any, when?

Answer: In 1951 (Bihar and West Bengal).

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Appendix. 1. Summary of Grain Yield (Kg/ha) obtained in the New Insecticide Trial During Rabi 1970*

Insecticide	Formulation	Grain yield (kg/ha)	
		Cuttack	Maruteru
Carbofuran	Granules	$4792^{+=}$	5704^{++}
Cytrolane	〃	—	$5605^{+=}$
Dursban	〃	$4375^{+=}$	$5459^{+=}$
SD 6626	〃	$4732^{+=}$	$5158^{+=}$
Birlane	〃	—	$5011^{+=}$
Thimet+BHC	〃	$4792^{+=}$	$4912^{+=}$
Sevidol	〃	$3929^{==}$	$4712^{+=}$
Azodrin	〃	$4286^{==}$	4166^{+-}
Lindane	〃	—	$3869^{+=}$
Fenthion (Lebaycid)	〃	$4730^{+=}$	$3571^{+=}$
BHC	〃	$4560^{+=}$	$3422^{+=}$
Fenitrothion (Folithion)	〃	$4136^{==}$	$3323^{+=}$
VCS 506	〃	$3929^{==}$	$2332^{==}$
Endosulfan	EC	—	$3869^{+=}$
Phosphamidon	EC	—	$4014^{+=}$
Diazinon	Granules	$4405^{+=}$	$4714^{+=}$
Diazinon (max. protection)	〃	4619^{+}	4960^{+}
No treatment		3839^{-}	2232^{-}

Experiment Mean
CD (0.05)

Note: The symbols following yield figures represent statistical significance of comparisons with 1) No treatment and 2) Diazinon (maximum protection). (+ indicate 'superior'; = indicates 'on par'; and - indicates 'inferior')

* Extracts taken from the Progress Report of the All India Coordinate Rice Improvement Project, Rabi 1970.

Appendix 2. Stem Borer Incidence in the New Insecticide Trial During 1970*

Insecticide	Formulation	Dead hearts				White ears			
		Maruteru		Cuttack		Maruteru		Cuttack	
		Per cent	Angular values	Per cent	Angular values	Per cent	Angular values	Per cent	Angular values
Carbofuran	Granules	4.15	$14.45^{==}$	0.07	$0.67^{+=}$	10.09	$16.82^{+=}$	0.15	$8.81^{+=}$
Cytrolane	〃	3.66	$13.54^{+=}$	—	—	13.91	$20.89^{+=}$	—	—
Dursban	〃	4.39	$14.54^{==}$	0.12	$8.82^{+=}$	20.72	$26.51^{==}$	3.87	14.25^{+-}
SD 6626	〃	2.46	$12.08^{+=}$	0.05	$8.67^{+=}$	18.62	$24.01^{==}$	3.24	$13.51^{+=}$
Birlane	〃	1.39	$11.59^{+=}$	—	—	16.93	$24.16^{==}$	—	—
Thimet+BHC	〃	3.23	$13.34^{+=}$	0.00	$8.53^{+=}$	21.75	$27.59^{==}$	2.19	12.17^{+-}
Sevidol	〃	3.43	$13.26^{+=}$	5.80	$16.37^{+=}$	21.22	$26.31^{==}$	4.73	$15.17^{+=}$
Azodrin	〃	2.64	$12.22^{+=}$	3.82	$13.43^{+=}$	28.78	$32.22^{==}$	1.78	$11.13^{+=}$
Lindane	〃	2.24	$11.94^{+=}$	—	—	19.94	$26.16^{==}$	—	—
Fenthion (Lebaycid)	〃	3.57	$13.74^{==}$	1.21	$10.74^{+=}$	27.77	$31.29^{==}$	5.80	$16.43^{==}$
BHC	〃	2.59	$12.25^{+=}$	0.25	$9.04^{+=}$	36.33	$37.02^{==}$	2.85	$12.99^{+=}$
Fenitrithion (Folithion)	〃	3.09	$13.27^{+=}$	4.76	$15.19^{+=}$	31.36	$33.95^{=-}$	5.49	$16.09^{=-}$
VCS 506	〃	1.84	$11.57^{+=}$	8.59	$18.95^{+=}$	29.65	$32.97^{=-}$	7.69	$\%8.33^{==}$
Endosulfan (Thiodan)	E C	4.97	$14.94^{==}$	—	—	28.08	$31.94^{=-}$	—	—
Phosphamidon	E C	3.93	$13.89^{==}$	—	—	24.70	$29.59^{==}$	—	—
Diazinon	Granules	3.17	$13.61^{==}$	0.00	$8.53^{+=}$	21.62	$26.38^{==}$	2.33	12.26^{+-}
Diazinon (max. protection)	〃	4.06	$14.32^{=}$	0.19	8.91^{+}	10.88	19.27^{+}	0.35	9.23^{+}
No treatment		6.45	$16.98^{=}$	14.01	23.67^{-}	29.26	32.53^{-}	7.92	18.43^{-}
			3.93		3.40		9.91		2.49

CD (0.05)

Note: The symbols following the angular values indicate statistical comparisons with no treatment check and Diazinon (maximum protection) check in that order.

* Extract taken from the Progress Report of the All India Coordinated Rice Improvement Project, Rabi 1970.

Appendix 3. Gall Midge Incidence in the New Insecticidal Trial During Rabi 1970*

Insecticide	Formulation	Silver shoot Incidence			
		Maruteru		Cuttack	
		Per cent	Angular values	Per cent	Angular values
Carbofuran	Granules	6.91	17.42	0.22	8.93
Cytrolane	〃	4.91	15.10	—	—
Dursban	〃	4.66	15.13	0.00	8.53
SD 6628	〃	3.55	13.23	0.00	8.53
Birlane	〃	4.42	14.66	—	—
Thimet+BHC	〃	5.89	15.87	0.68	9.64
Sevidol	〃	3.54	13.60	0.78	9.96
Azodrin	〃	4.66	14.99	1.07	10.74
Lindane	〃	4.60	14.27	—	—
Fenthion (Lebaycid)	〃	6.47	16.90	0.17	8.91
BHC	〃	4.26	14.61	0.00	8.53
Fenitrothion (Folithion)	〃	6.49	17.17	0.54	9.59
VCS 506	〃	5.58	16.04	0.43	9.36
Endosulfan	E C	9.86	20.25	—	—
Phosphamidon	E C	6.10	16.57	—	—
Diazinon	Granules	4.41	14.80	0.00	8.53
Diazinon (max. protection)	〃	2.68	12.20	0.06	8.67
No treatment		5.36	15.91	1.24	10.59
			N S		1.42

CD (0.05)

* Extract taken from the Progress Report of the All India Coordinated Rice Improvement Project, Rabi 1970.

Appendix 4. Summary of Grain Yield (kg/ha) in the Maximum Protection Trial During Rabi 1970.*

Location		Grain yield in kg/ha						Local variety	
		IR 8	Jaya	Hasma	W 1263	CR 44-93	Local	Used	Mean
Maruteru	Protected	5583	5021	4229	3854	5334	3261	SLO 16	4547
	Unprotected	2563	1834	1417	1954	3250	1698		2119
	Difference	3020	3184	2812	1900	2084	1563		2428
	% increase	118	174	198	97	64	92		115
Cuttack	Protected	—	5310	3807	3633	4417	4267	Padma	4287
	Unprotected	—	3527	2250	3510	3583	3083		3191
	Difference	—	1783	1557	123	834	1184		1096
	% increase	—	51	69	4	23	38		34
Coimbatore	Protected	—	5029	3489	3113	3900	3148	Co 29	3736
	Unprotected	—	4139	2908	3215	3761	3114		3433
	Difference	—	890	581	−102	139	34		30
	% increase	—	22	20	−3	4	1		9

CD (0.05) between:	Maruteru	Cuttack	Coimbatore
Protected and unprotected for one variety	533	275	NS
Protected and unprotected over all varieties	400	531	NS
Two varieties within either protected or unprotected	592	929	NS
Two varieties over protected and unprotected	419	657	753

* Extract from the Progress Report of the All India Coordinated Rice Improvement Project, Rabi 1970.

Appendix 5. Resistance Rating to Stem Borer in Stem Borer Screening Trial Conducted During Rabi 1970.*

Designation	Cross	Resistance rating for					
		Dead heart incidence at			White ear incidence at		
		CRRI	Maruteru	Rajendra-nagar	CRRI	Maruteru	Rajendra-nagar
1	2	3	4	5	6	7	8
IR 8		0.56	1.60	1.13	0.78	0.62	—
CR 44-1	TKM 6×IR 8	0.15	0.22	1.08	1.11	0.65	1.26
Ratna	〃	0.51	0.47	1.10	0.94	2.14	0.92
CR 44-32	〃	0.29	0.84	0.91	0.46	1.18	1.90
CR 44-35	〃	0.43	0.47	1.54	0.70	0.73	1.23
CR 44-38-173	〃	0.76	—	0.53	0.37	0.74	2.81
CR 44-80	〃	0.84	1.23	1.37	0.97	0.81	1.25
CR 44-93	〃	0.10	0.60	0.95	0.80	0.79	1.66
CR 44-98	〃	0.35	0.91	0.95	1.09	1.10	2.25
CR 44-101	〃	0.37	0.75	0.88	0.97	1.33	3.61
CR 44-114-5	〃	1.08	1.03	0.94	0.18	0.97	1.10
CR 44-125	〃	—	1.03	2.15	0.91	0.97	3.08
CR 44-126	〃	0.65	1.49	1.26	0.48	1.97	—
CR 52-3	(TKM 6×CB 1)×IR 8	0.91	0.56	0.58	0.45	1.86	5.38
Pusa 2-12	IR 8×TKM 6	0.22	0.66	0.80	1.01	1.95	2.87
Pusa 2-21	〃	0.52	0.42	1.60	1.33	1.14	0.35
Pusa 2-90	〃	0.49	0.82	0.53	0.93	1.22	1.00
Pusa 2-94	〃	1.09	0.55	2.47	0.91	1.38	0.57
Pusa 2-103	〃	0.35	1.90	1.63	1.06	1.16	0.85
T (N) 1		0.46	0.81	1.71	0.50	2.51	2.31
CR 43-3	TKM 6×T(N)1	0.13	1.35	0.97	0.58	0.74	4.18
CR 43-30	〃	1.41	0.94	0.81	0.78	1.47	0.87
CR 43-63	〃	0.18	0.28	0.99	1.04	1.55	4.33
CR 43-75	〃	1.22	1.07	1.32	0.81	1.87	6.86
CR 43-127	〃	0.31	0.53	0.86	0.20	1.56	3.50
CR 43-128	〃	1.16	0.54	1.00	1.37	1.14	—
Cauvery	〃	0.23	0.57	1.18	1.28	1.13	3.28
RBCB1B-295	T(N)1×TKM 6	0.75	1.16	1.49	0.83	0.90	*
RPCB 1-3387	〃	0.53	0.61	—	1.57	1.42	—
RPCB1B-7078	〃	0.69	0.75	—	0.62	0.91	—
IET 963	〃	0.26	0.59	1.01	1.21	0.78	5.46
IR 20	IR 262×TKM 6	0.80	1.37	1.54	0.27	0.73	—
IR 532 E 247	〃	0.39	1.03	0.77	0.17	0.97	—
IR 532 E 284	〃	0.50	0.94	0.99	0.52	1.07	2.70
IR 532 E 285	〃	0.32	0.85	0.48	0.83	1.50	4.10

* Extract from the Progress Report of the All India Coordinated Rice Improvement Project, Riace 1970.

Appendix 5. (Contd.)

Designation	Cross	Resistance rating for					
		Dead heart incidence at			White ear incidence at		
		CRRI	Maruteru	Rajendra-nagar	CRRI	Maruteru	Rajeudra-nagar
1	2	3	4	5	6	7	8
IR 532 E 293	〃	0.78	1.02	0.88	1.47	0.98	1.23
IR 532 E 527	〃	1.15	1.10	1.61	1.16	0.91	*
IR 532-1-218	〃	1.97	1.01	0.68	1.44	0.99	0.32
IR 532 RP 838	〃	0.63	0.73	1.42	0.29	1.14	*
IR 532 RPCB	〃	0.46	0.72	—	0.33	1.30	—
IR 528-1-32	IR 262×ADT 27	0.78	0.72	1.23	2.27	1.40	2.72
IR 506 RP2B	IR 8×(B 589A4-18/2×T(N)1)	0.71	1.30	0.68	0.16	0.77	2.52
IR 506 RP4B	〃	0.75	0.97	1.89	*	1.05	0.38
IR 506 RP5B	〃	0.86	0.71	1.71	0.28	1.01	0.85
IR 506 RP9B	〃	0.52	1.14	1.45	0.07	1.05	0.54
IR 644 RP2B	IR 8/2×(B589A4-18/2×T(N)1)	1.14	1.37	1.61	*	0.73	0.94
IR 661-1-140-3	IR 8×IR 127-2-2	0.61	0.82	2.19	0.95	1.17	1.22
CR 10-41-4128	T-90×IR 8	0.82	1.26	0.94	*	0.79	5.10
Vijaya	〃	1.21	1.19	1.14	0.96	0.84	0.77
CR 51-3	IR 8×(IR 8-24×Lalnakanda)	0.36	1.05	1.30	0.65	1.70	1.70
W 884	IR ×W 1263	0.37	0.36	0.76	0.78	2.17	4.08
W 1776	〃	0.90	0.46	2.44	0.79	1.03	*
Hamsa	HR 12×T(N)1	0.41	0.46	1.95	0.76	0.85	3.92
Padma	T 141×T(N)1	0.18	0.52	1.36	2.19	0.39	1.16
Sabarmati	Basmati 370/5×T(N)1	0.67	0.97	0.75	0.39	2.22	2.16
Krishna	GEB 24×T(N)1	—	1.04	1.96	0.78	0.97	1.36
IET 546	C 279×T(N)1	0.58	0.80	0.98	0.80	1.04	1.43
CR 23-4736	Sigadis×T(N)1	0.82	0.91	1.92	0.32	1.05	1.18
CR 24-4560	T(N)1×MIFB 322-1	0.70	0.63	1.73	0.67	1.39	0.89
Jaya	T(N)1×T 141	0.16	0.37	1.64	0.32	*	0.33
IET 714	〃	0.86	0.80	1.13	*	1.25	*
IET 400	T(N)1×Co 29	0.35	0.68	0.53	0.10	1.47	0.53
IET 826	〃	0.33	0.74	0.51	1.05	1.28	1.09
CR 66-56	T(N)1×(CH 45)×(Rikuu 132×N22)	1.03	0.88	1.07	1.01	1.29	5.02
CR 82-10	T(N)1×W 418	0.90	0.88	1.32	0.36	—	—
CR 100-32	Irradiated T(N)1×N 136	1.84	1.25	1.00	0.59	0.80	0.28
Ptb 18	〃	0.41	0.74	1.64	*	*	*
Ptb 21	〃	1.00	0.81	0.94	*	*	*
IR 5	T. Rotan×Peta	1.84	1.75	1.85	*	*	*
Eswarakora	0.60	0.60	0.45	2.16	*	*	*

Appendix 5. (Contd.)

Designation	Cross	Resistance rating for					
		Dead heart incidence at			White ear incidence at		
		CRRI	Maruteru	Rajendra-nagar	CRRI	Maruteru	Rajendra-nagar
1	2	3	4	5	6	7	8
W 1251	MTU 15×Eswarakora	0.42	0.43	0.56	0.47	0.97	0.66
W 1253	〃	0.98	0.23	0.97	0.43	0.92	0.81
W 1263	〃	**5.94	0.31	0.48	0.27	0.67	0.39
ARC 6114	0.93	0.93	1.22	—	*	1.03	—
ARC 11214		R0.75	1.16	—	*	1.48	—

** This reading has been ignored since it widely deviates from the known reaction of this variety at several locations including CRRI in different trials.

Appendix 6. Varieties Exhibiting Resistance to Stem Borer.†

At tillering during		At flowering during	
Rabi 1970	Kharif 1969 and Rabi 1970	Rabi 1970	Kharif 1969 and Rabi 1970
CR 44-38-173	CR 44-32	IR 8+	Jaya
CR 44-93	CR 52-3	RPCB1B 7078*+	W 1263*
CR 44-98	W 1263	IR 20+	
CR 44-101		IR 532 E 247+	
Pusa 2-12		IR 664-RP2B	
Pusa 2-90		Vijaya	
CR 43-63		CR 100-32	
CR 43-127		W 1251*	
RPCBI-3387+		W 1253*	
RPCB1B-7078**			
IR 532 RPCB			
IR 532 E 284			
IR 532 E 285			
W 884			
Sabarmati			
IET 546			
IET 400			
IET 826			
Ptb 21			
W 1251*			
W 1253*			

+ Data available from two locations.
** Resistant at tillering and flowering.
† Extract from the Progress Report of the All India Coordinated Rice Improvement Project, Rabi 1970.