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4 MISUSE OF PESTICIDES AMONG RICE FARMERS IN LEYTE, PHILIPPINES

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4.1. Introduction

The market value of pesticides used in rice was estimated to be U.S. $2.4 billion in 1988 (Woodburn, 1990). Japan was the largest consumer, accounting for 59 percent of the market, followed by South Korea (10 percent) and China (6 percent). The Philippine market was about U.S. $48 million in 1988, with insecticides and herbicides accounting for 58 percent and 35 percent, respectively.

Large estimates of crop losses in tropical rice are often cited in the literature, and on average more seem to be lost to pests than was harvested (Teng, Torres, Nuque, and Calvero, 1990). Although these figures might only represent magnitudes of loss under abnormal and rare conditions, they nevertheless continue to be used by researchers and policymakers. Without corresponding information on the probabilities of occurrence and attainable yields, these figures are meaningless (Zadoks, 1992).

Farmers' pest management practices generally reflect their perceptions of pests (Tait and Napompeth, 1987; Mumford and Norton, 1984; Rola and Pingali, 1993). Most farmers believe that pests are major constraints to high yields (Litsinger, Price, and Herrera, 1980; Heong, 1984; Heong, Ho, and Jegatheesan, 1985; Rola and Pingali, 1993). They tend to spray pesticides to keep pests off their rice crops rather than to prevent yield loss. Such attitudes would lead to pesticide misuse.

In this paper, we analyzed the types of chemicals farmers used in Leyte during the wet season, the pest targets, and the timing of sprays, to assess misuse. Approaches to improve current practices are discussed.

4.2. Methods

Leyte is an island located in the Eastern Visayas region of the Philippines. It has a total land area of 6,270 square kilometers with a population of about 1.5 million. Agriculture is a major economic activity with coconut, rice, sugar, and corn as principal crops. Of the 98,000 hectares cultivated to rice, about 72 percent is irrigated, 23 percent rainfed, and the remaining 5 percent upland rice.

Data on farmers' pesticide use were obtained using structured personal interviews. The survey questionnaire was translated into Cebuano and Waray, the two local languages spoken in Leyte. It was pretested on twenty-five farmers, and the questionnaires were modified. The modified questionnaire was then further tested on another ten farmers before the final version was prepared. The survey was conducted with the assistance of three students of Development Communication trained in basic survey techniques. All the interviews were conducted in May 1991. In addition, personal interviews with farmers were conducted by the authors, in which answers were further examined.

Three hundred farmers from eight municipalities in Leyte were selected for the interviews. From a list of rice growing villages in the municipalities, thirty villages were randomly selected, and from each village, ten farmers were randomly chosen. To ensure accuracy in the pesticides used, farmers were requested to show the interviewers used bottles of the pesticides.

The questionnaire data were coded and entered into a spreadsheet program using a microcomputer. After validation, the data file was uploaded to the mainframe IBM 4361 at the International Rice Research Institute. Frequency tables were generated using the FREQ procedure available in Statistical Analysis Systems (SAS, 1985).

4.3. Results

About 88 percent of the farmers interviewed sprayed at least once during the season. Almost half (45 percent) of the farmers sprayed two or three times a season, and another third (33 percent) sprayed more than three times. About 12 percent did not use any pesticides, while 10 percent used once. Most (78 percent)

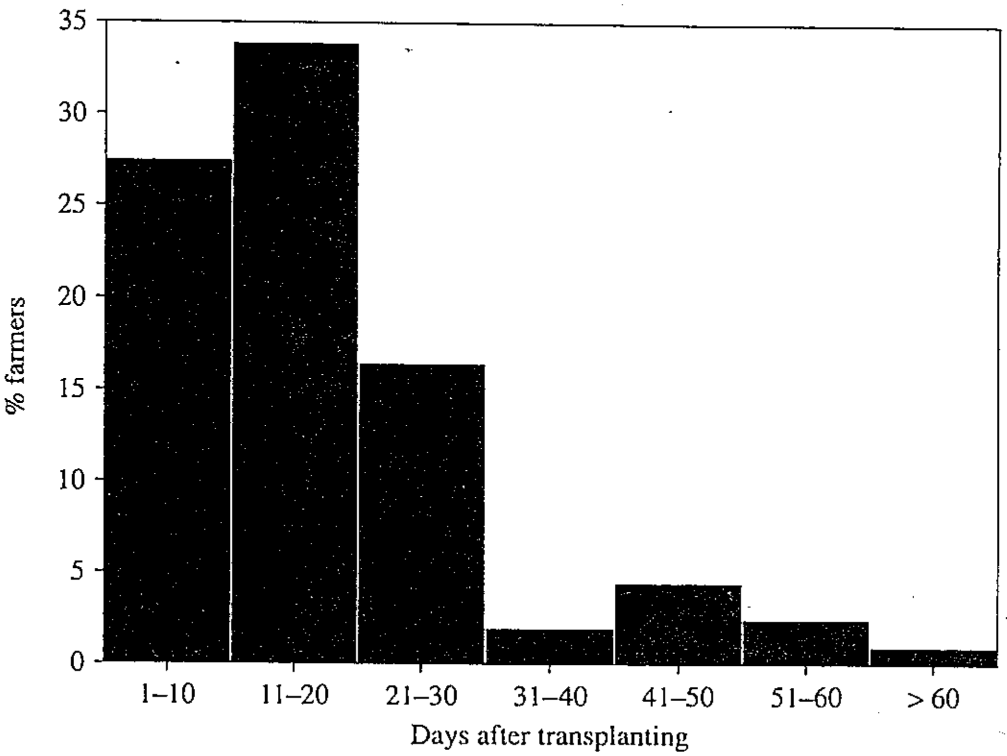

Figure 4.1. Distribution of Rice Farmers' First Pesticide Sprays in Leyte, Philippines

of the farmers applied their first pesticide sprays in the first thirty days after transplanting (DAT) (Figure 4.1).

The 300 farmers interviewed applied a total of 841 sprays. The average sprays per farmer was 2.8. Table 4.1 shows the variety of pesticides used in the different crop stages. At seedling and tillering stages, endosulfan was most commonly used, followed by monocrotophos. At booting, flowering and milky stages, methyl parathion was most common followed by cypermethrin.

Most of the pesticides (92 percent) used were insecticides. Only 4.1 percent and 3.9 percent of the applications were fungicides and herbicides, respectively. Of the insecticides, five chemicals constituted 84 percent of the total sprays. These were endosulfan (21 percent), methyl parathion (21 percent), cypermethrin (17 percent), monocrotophos (13 percent), and chlorpyrifos (11 percent). Using hazard classifications of the World Health Organization (WHO), 17 percent of the chemicals used by the farmers were in category la (extremely hazardous), 20 percent in category lb(highly hazardous), and 59 percent in category II (moderately hazardous).

The intended target pests of the pesticide sprays by the farmers are shown in

Table 4.1. Pesticides Used by Rice Farmers at Particular Crop Stages in Leyte, Philippines

Pesticides	Total Sprays	*Percentage of Sprays of Each Pesticide Used at Crop Stages* Nursery	Early Tillering	Late Tillering	Booting	Flowering	Milky	Soft Dough
Insecticides:								
Organochlorines:								
Endrin	2	1.2%	0.0%	0.0%	0.0%	1.0%	0.0%	0.0%
Endosulfan	165	41.7	23.3	18.9	16.1	12.1	10.4	17.4
Organophosphates:								
Chlorpyrifos	86	8.3	12.3	11.0	9.5	15.2	6.0	5.8
Methyl parathion	166	9.5	10.3	18.3	21.3	25.3	34.3	29.0
Monocrotophos	102	8.3	18.5	17.7	10.9	6.1	6.0	8.7
Azinphos-ethyl	14	0.0	1.4	1.2	2.8	1.0	3.0	1.4
Cyhalothrin	14	1.2	0.0	1.2	1.9	2.0	3.0	4.3
Malathion	7	0.0	1.4	1.2	1.4	0.0	0.0	0.0
Triazophos	3	0.0	0.7	0.0	0.5	0.0	0.0	0.0
Methamidophos	5	0.0	1.4	0.6	0.9	0.0	1.5	0.0
Carbamates:								
MIPC	20	3.6	2.1	2.4	2.4	1.0	3.0	2.9
BPMC	7	0.0	1.4	1.2	0.9	1.0	0.0	0.0
Carbosulfan	1	0.0	0.0	0.0	0.5	0.0	0.0	0.0
Pyrethroids:								
Cypermethrin	134	9.5	14.4	14.0	15.6	24.2	22.4	14.5
Mixtures:								
Cypermethrin + Monocrotophos	102	8.3	18.5	17.7	10.9	6.1	6.0	8.7
Fungicides:								
Fentin chloride	17	13.1	2.7	1.2	0.0	0.0	0.0	0.0
Fentin acetate	3	1.2	0.7	0.0	0.0	0.0	0.0	0.0
Edifenphos	14	0.0	3.4	1.2	1.4	2.0	1.5	1.4
Others (including herbicides and foliar fertilizers)	33	2.4	2.1	6.1	3.3	4.0	3.0	7.2
Totals	841	84	146	164	211	99	67	69
Percent of total	100.0%	10.0%	17.4%	19.5%	25.1%	11.8%	8.0%	8.2%

Table 4.2. For rice bugs, farmers used methyl parathion (27 percent), cypermethrin (19 percent), and endosulfan (15 percent), while for snail control, endosulfan was most common (67 percent) and some (29 percent) used a fungicide, fentin chloride. To control leaffolders and other lepidopterous larvae, farmers mainly used methyl parathion (15 percent), monocrotophos (17 percent), endosulfan (19 percent), and cypermethrin (15 percent). Farmers did not consider leaf and planthoppers to be important, but about 6 percent of the sprays were targeted at them. The main chemicals used were chlorpyrifos, methyl parathion, cypermethrin, and monocrotophos, which accounted for 73 percent of all the sprays used for these pests. Only a few (6 percent) used carbamates. About 10 percent of the farmers reported spraying against ladybird beetles, and these accounted for 4 percent of sprays used. The main insecticides used were methyl parathion, endosulfan, cypermethrin, and monocrotophos.

Table 4.3 shows the proportion of sprays used against the main pests at different crop stages. A large proportion of the spraying for snail control was carried out in the nursery (73 percent) and at early tillering (20 percent). For rice bugs, most of the sprays were carried out at the booting (35 percent) and flowering (24 percent) stages, while only a third were used in the milky (17 percent) and soft dough (17 percent) stages. Most of the sprays for leaffolder control were carried out in the early tillering (36 percent), late tillering (31 percent), and booting (21 percent) stages, while some (10 percent) were used in the nursery. Similarly, the control of other lepidopterous larvae were also done during the early tillering (34 percent), late tillering (27 percent), booting (15 percent), and nursery (17 percent) stages. For stemborer control, most sprays were carried out in the early tillering (23 percent), late tillering (44 percent), and booting (21 percent) stages.

4.4. Discussion

Misuse is defined as the "improper or incorrect use" (*New Lexicon Webster's Dictionary*, 1991). Thus, when a pesticide is used for the wrong target pest or at the wrong time or both, it can be considered to be misused. However, farmers tend to use pesticides as killing agents, which is perhaps the main reason farmers use methyl parathion, endosulfan, monocrotophos, cypermethrin, and fentin chloride. These chemicals are extremely toxic not only to pests but to humans as well. Methyl parathion, for instance, has a mammalian toxicity of less than 15 mg/kg and is classified by WHO as extremely hazardous. About 60 percent of this insecticide had been used for rice bug control. Rice bugs (*Leptocorisa* spp.) commonly colonize ricefields in the tillering and ripening stages, but they are pests only during the milky stage, which lasts seven to ten days. However,

Table 4.2. Pest Targets of Pesticides Used by Rice Farmers in Leyte, Philippines

Pesticides	*Percentage of Sprays of Each Pesticide Used for Each Pest*												
	Rice Bug	*Ladybird Beetle*	*Golden Apple Snail*	*Tungro*	*Rice Leaf Folder*	*Mole Cricket*	*Stem Borer*	*Blast*	*Cut Worm*	*Whorl Maggot*	*Lepidopterous Leaf Feeder*	*Green Leaf Hopper*	*Brown Plant Hopper*
Insecticides:													
Organochlorines:													
Endrin	0.3%	0.0%	0.0%	0.0%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Endosulfan	15.2	16.7	66.7	41.7	7.3	0.0	16.3	33.3	50.0	0.0	30.0	8.6	7.1
Organophosphates:													
Chlorpyrifos	9.0	2.8	0.0	16.7	12.7	0.0	10.5	0.0	0.0	66.7	10.7	20.0	28.6
Methyl parathion	26.5	36.1	0.0	8.3	16.4	100.0	16.3	0.0	0.0	0.0	13.3	17.1	21.4
Monocrotophos	8.2	16.7	0.0	8.3	12.7	0.0	17.4	11.1	50.0	0.0	20.8	28.6	0.0
Azinphos-ethyl	1.4	0.0	0.0	0.0	3.6	0.0	4.7	0.0	0.0	0.0	0.0	2.9	0.0
Cyhalothrin	2.5	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0
Malathion	0.6	0.0	0.0	0.0	0.9	0.0	3.5	0.0	0.0	0.0	0.8	0.0	0.0
Triazophos	0.3	0.0	0.0	0.0	0.9	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0
Methamidophos	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carbamates:													
MIPC	2.5	0.0	0.0	8.3	2.7	0.0	2.3	0.0	0.0	0.0	1.7	2.9	14.3
BPMC	0.6	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0
Carbosulfan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0
Pyrethroids:													
Cypermethrin	19.2	16.7	0.0	0.0	17.3	0.0	17.4	33.3	0.0	0.0	12.5	8.6	21.4

Mixtures:													
Cypermetrin + monocrotophos	0.6	0.0	0.0	0.0	0.9	0.0	1.2	0.0	0.0	0.0	0.8	2.9	0.0
Fungicides:													
Fentin chloride	0.0	0.0	29.4	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0
Fentin acetate	0.0	0.0	2.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Edifenphos	1.7	0.0	2.0	8.3	0.9	0.0	1.2	11.1	0.0	0.0	0.8	0.0	7.1
Others (including herbicides and foliar growth stimulants)	3.7	0.0	0.0	0.0	5.4	0.0	7.0	11.1	0.0	33.3	3.3	5.7	0.0
Total sprays	355	36	51	12	110	1	86	9	2	3	122	35	14
Percent of total	42.5%	4.3%	6.1%	1.4%	13.2%	0.1%	10.3%	1.1%	0.2%	0.4%	14.6%	4.2%	1.7%

Table 4.3. Main Pest Targets of Rice Farmers' Sprays at Different Crop Stages in Leyte, Philipines

Main Pests	*Number of Sprays*	*Percentage of Sprays Against Each Pest*						
		Seedling	*Early Tillering*	*Late Tillering*	*Booting*	*Flowering*	*Milky*	*Soft Dough*
Rice bugs	355	0.6%	1.4%	5.3%	34.9%	23.7%	17.0%	17.2%
Leaffolders	110	10.0	36.4	30.9	20.9	1.8	0.0	0.0
Other lepidopterans	122	17.2	34.4	27.0	14.8	3.3	1.6	1.6
Stemborers	86	5.8	23.3	44.2	20.9	3.5	1.2	1.2
Ladybird beetles	36	2.8	8.3	30.6	33.3	2.8	8.3	13.9
Snails	51	72.6	19.6	7.8	0.0	0.0	0.0	0.0
Green leafhoppers	35	8.6	42.9	28.6	20.0	0.0	0.0	0.0
Brown planthoppers	14	7.1	42.9	28.6	7.1	7.1	7.1	0.0

only 34 percent of the sprays were applied in the milky or soft dough stages. Rice bugs are highly mobile and tend to move between fields (Rothschild, 1970). Thus, spraying for rice bugs at the nursery, tillering, and flowering stages has no impact on crop protection.

Similarly, using insecticides to control leaf-feeding insects at the early crop stages generally do not increase yields. The most common species that infest the rice crop at these stages is the rice leaffolder, *Cnaphalocrocis medinalis*. Crops with as much as 67 percent damaged leaves did not suffer any loss (Miyashita, 1985). Although the economic threshold was estimated to be 1.5 larvae per hill by Bautista, Heinrich, and Rejesus (1984), it was grossly overestimated by at least four times (Heong, 1990) and should be adjusted to five to six larvae (Heong, 1993). Such densities are extremely rare. In the Philippines, the average density observed is less than one larva per hill (Guo, 1990). Ladybirds, *Micraspis sp.*, are common predators and pollen feeders in ricefields, but farmers mistake them for pests and spray against them. Generally, the hoppers *Nilaparvata lugens* and *Nephotettix virescens* are found in ricefields at low densities in the early crop stages (Heong, Aquino, and Barrion, 1991) and do not cause any crop loss. However, farmers spray to get rid of them. The golden apple snail, is a relatively new pest problem in the Philippines (Adalla and Rejesus, 1988). There was no molluscicide suitable for ricefields available in the Philippines, and most farmers used chemicals that would kill snails, like organotin fungicides, fentin chloride, and fentin acetate. Another commonly used chemical was endosulfan, an insecticide with adverse effects on aquatic fauna. These were clearly misuses of pesticides.

Of the 841 sprays, only 190 or 23 percent may be considered to be applied at the appropriate time for the intended targets. Out of this, only 160 or 19 percent have used a chemical that can affect the intended pests and in some way prevented yield loss. Thus more than 80 percent of the sprays applied by farmers in Leyte during the 1991 wet season can be considered to be misuse of pesticides.

In the early crop stages, the rice ecosystem is usually inhabited by species that are herbivores, predators, and detritivores (Heong, Aquino, and Barrion, 1991). Among the herbivores, plant and leaf hoppers are usually predominant, but they do little damage to the crop. The most visible injuries in the crop are often due to a few lepidopterous species. Thus, during these early crop stages, insecticide sprays were unnecessary. Yet 78 percent of the farmers applied their first sprays in the first thirty DAT. Insecticide inputs at these early crop stages are not only wasteful but can be damaging to the predator-prey balance that may lead to secondary pest outbreaks, like the brown planthopper (Heinrichs and Mochida, 1984; Heong, 1991).

Highly visible and colorful species, such as the rice bug, golden apple snail, ladybird, and lepidopterous larva, are often perceived to be damaging and farmers tend to overreact toward them (Bentley, 1989; Bentley and Andrews, 1991; Escalada and Heong, 1993). These species were the targets of 80 percent of the sprays in Leyte. It thus seems that indigenous attitudes, such as a belief that insects, particularly worms (or ulod) and snails are harmful, tend to make farmers become victims of pesticide abuse (Bentley, 1989).

As pesticide misuse is high, programs that focus on eliminating misuse may be beneficial to farmers. Misuse may be due to widespread gaps in farmers' perceptions of rational pest management (Escalada and Heong, 1993). To bridge these gaps and improve farmers' pest management practices, several communication approaches have been employed. They generally utilize either mass media or interpersonal channels or a combination. The choice of which communication approach to employ will depend on project objectives and resources. Among the extension and communication approaches used in rice pest management, strategic extension campaigns (Escalada and Kenmore, 1988), radio-based campaigns (Pfuhl, 1988), farmer field schools (Kenmore, 1991), and farmer participatory research (Escalada and Heong, 1993) stand out in bringing about changes in farmer practices. While extension and radio-based campaigns have greater reach, farmer participation methods, like the farmer field schools and farmer participatory research, may have more impact through experiential learning. Because of their experiential character, learning from participatory approaches that eventually impact on changes in practices may tend to be more sustainable. As pointed out by Minnick (1989), individuals generally retain 70 percent of the information taught if they learn it by seeing and doing.

Several human and social factors influences farmers' deeply entrenched perceptions of pests and pesticide use. These include the association of pesticides with medicine, risk aversion, media messages, and pesticide promotion campaigns (Escalada and Heong, 1993). To initiate changes in pest management decision making would require learning of basic concepts and applying them. Farmer participatory approaches, like the farmer field schools and farmer participatory research, would have greater impact in changing attitudes and practices.

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References

Adalla, C.B., and B.M. Rejesus. 1988. The golden apple snail, Pomacea sp.: A serious pest of lowland rice in the Philippines. In Ian Henderson (ed.), *Slugs and Snail in World Agriculture* (pp. 417–422). Thornton Heath, U.K.: British Crop Protection Council No. 41.

Bautista, R.C., E.A. Heinrichs, and R.S. Rejesus. 1984. Economic injury level for the rice leaffolder, *Cnaphalocrosis medinalis* (Lepidoptera: Pyralidae): Insect infestation and artificial leaf removal. *Environmental Entomology* 13: 439–443.

Bentley, J.W. 1989. What farmers don't know can't help them: The strengths and weakness of indigenous technical knowledge in Honduras. *Agriculture and Human Values* 6: 25–31.

Bentley, J.W., and K.L. Andrews. 1991. Pests, peasants, and publications: Anthropological and entomological views of an integrated pest management program for small-scale Honduran farmers. *Human Organization* 50: 113–122.

Escalada, M.M., and K.L. Heong. 1993. Communication and implementation of change in crop protection. In *Crop Protection and Sustainable Agriculture* (pp. 191–207). Chichester: Wiley Ciba Foundation Symposium.

Escalada, M.M., and P.E. Kenmore. 1988. Communicating integrated pest management to rice farmers at the village level. In P.S. Teng and K.L. Heong (eds.), *Pesticide Management and Integrated Pest Management in Southeast Asia* (pp. 221–228). College Park, Md., USA.: Consortium for International Crop Protection.

Guo, Y. 1990. Larval parasitization of rice leaffolders (Lepidoptera: Pyralidae) under field and laboratory conditions. Ph.D. dissertation, University of the Philippines at Los Baños, College, Laguna, Philippines.

Heinrichs, E.A., and O. Mochida. 1984. From secondary to major pest status: The case of insecticide-induced rice brown planthopper, *Nilaparvata lugens*, resurgence. *Protection Ecology* 7: 201–218.

Heong, K.L. 1984. Pest control practices of rice farmers in Tanjung Karang, Malaysia. *Insect Science and Applications* 5: 221–226.

Heong, K.L. 1990. Feeding rates of the rice leaffolder, *Cnaphalocrosis medinalis* (Lepidoptera: Pyralidae), on different plant stages. *Journal of Agricultural Entomology* 7: 81–90.

Heong, K.L. 1991. Management of the brown planthopper in the tropics. In *Proceedings of the Symposium on Migration and Dispersal of Agricultural Insects*, September 25–28, National Institute of Environmental Sciences, Tsukuba, Japan.

Heong, K.L. 1993. Rice leaffolders: Are they serious pests? In *Research on Rice Leaffolder Management in China* (pp. 8–11). Proceedings of the International Workshop on Economic Threshold for Rice Leaffolder in China, March 4–6, 1992, Beijing. Hangzhou, China: China National Rice Research Institute.

Heong, K.L., G.B. Aquino, and A.T. Barrion. 1991. Arthropod community structures of rice ecosystems in the Philippines. *Bulletin of Entomological Research* 81: 407–416.

Heong, K.L., N.K. Ho, and S. Jegatheesan. 1985. The perception and management of pests among rice farmers in the Muda Irrigation Scheme, Malaysia. MARDI Report No. 105. Malaysian Agricultural Research and Development Institute, Kuala Lumpur.

Kenmore, P.E. 1991. *Indonesia's integrated pest management: A model for Asia.* Manila, Philippines: FAO Intercountry IPC Rice Programme.

Litsinger, J.A., E.C. Price, and R.T. Herrera. 1980. Small farmer pest control practices for rainfed rice, corn and grain legumes in three Philippine provinces. *Philippine Entomology* 5(1–2): 65–86.

Minnick, D.R. 1989. *A guide to creating self-learning materials.* Los Baños, Laguna, Philippines: International Rice Research Institute.

Miyashita, T. 1985. Estimation of the economic injury level in the rice leaf roller, *Cnaphalocrosis medinalis* Guenee (Lepidoptera: Pyralidae). I. Relations between yield loss and injury of rice leaves at heading or in the grain filling period. *Japanese Journal of Applied Zoology* 29: 73–76.

Mumford, J.D., and G.A. Norton. 1984. Economics of decision making in pest management. *Annual Review of Entomology* 29: 157–174.

New Lexicon Webster's Dictionary. 1991. New York: Lexicon Publication.

Pfuhl, E.H. 1988. Radio-based communication campaigns: A strategy for training farmers in IPM in the Philippines. In P. S. Teng and K.L. Heong (eds.), *Pesticide Management and Integrated Pest Management in Southeast Asia* (pp. 251–255). College Park, Md., USA: Consortium for International Crop Protection.

Rola, A.C., and P.L. Pingali. 1993. *Pesticides, rice productivity, and farmers' health: An economic assessment.* Washington, D.C.: World Resources Institute and Los Baños, Laguna, Philippines: International Rice Research Institute.

Rothschild, G.H.L. 1970. Observations on the ecology of the rice-ear bug, *Leptocorisa oratorius* (F.) (Hemiptera: Alydidae) in Sarawak (Malaysian Borneo). *Journal of Applied Ecology* 7: 147–167.

Statistical Analysis System (SAS). 1985. *SAS user's guide: Statistics.* Version 5 Edition. Cary, N.C., USA: SAS Institute.

Tait, J., and B. Napompeth (eds). 1987. *Management of pests and pesticides: Farmers' perceptions and practices.* Boulder, Color., USA: Westview Press.

Teng, P.S., C.Q. Torres, F.L. Nuque, and S.B. Calvero. 1990. Current knowledge of crop losses in tropical rice. In *Crop Loss Assessment in Rice* (pp. 39–53). Los Baños, Philippines: International Rice Research Institute.

Woodburn, A. 1990. The current rice agrochemical Market. In B.T. Grayson, M.B. Greene, and L.G. Cropping (eds.), *Pest Management in Rice.* London: Elservier Applied Science.

Zadoks, J.C. 1992. The costs of change in plant protection. *Journal of Plant Protection in the Tropics* 9(2): 151–159.