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Integrated pest management practices for rice crops: Review of Indonesia and Taiwan

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Abstract. One of the new strategies to control rice pests that are at the same time more environmentally friendly is integrated pest management (IPM). IPM employs such methods as biological and mechanical controls, and botanical pesticides. National and international resources have been used to developed IPM programs in some countries. Indonesia and Taiwan have used such programs to control rice pests. Biological control, botanical pesticides and some mechanical control have been conducted in IPM program in both countries. However, assessing and comparing the effects of IPM programs are difficult because of the heterogeneity of the data due to differences in regions (e.g., climate, rainfall, soil structure), time periods, pest classes (e.g., insects, plant pathogens, weeds), and types of crops researched. In Indonesia using the recommended pesticides still be the last option for controlling the pests that reach an economic threshold. In 2011, recommended pesticides are applied about 981,628 ha of all rice crops. Other controls are the second pests control choosen in Indonesia. Other controls are consists of biological control (using parasitoids and predators), microbial control (fungi, virus and bacteria) and natural plant extraction. Other controls reach about 464,854 ha of total rice crops in Indonesia. Mechanical controls are less applied than recommended pesticides and other controls. Mechanical controls are including all controls before rice planting, such as harrowing land, killing rats, applying organic fertilizer, planting good varieties and cropping pattern. Mechanical controls reach about 84,920 ha of total rice crops in Indonesia. Taiwan also have similar development of rice IPM like Indonesia. In different counties, the farmers applied different IPM techniques. More farmers are independent to set up their rice pest control. Now, Taiwan have a significant progress in organic rice.
Keywords: Integrated pest management (IPM), Rice pests, biological controls, cultural controls,recommended pesticide use, Indonesia, Taiwan.

Introduction

Rice is the world's most important staple food crop. More than half of the world's population relies on rice as the major daily source of calories and protein (Kasmaprapruet, Paengjuntuek, Saikhwan, & Phungrassami, 2009). Like other plants, rice is also attacked by pests. The brown plant hopper (BPH), Nilaparvata lugens (Stal), white stem borer (WSB), Scirpophaga innotata and yellow stem borer (YSB) Scirpophaga incertulas are major insect pests of irrigated rice in large areas of South East Asia (Claridge, 1998). To solve these pest problems, chemical pesticides have been used to and their use will probably continue at least into the near future (Magallona, 1989). Ooi (2005) contends that the effectiveness of chemical pesticides in protecting crops, however, has masked the negative impacts associated with their use. For farmers, the most serious impacts are the acquisition of pest resistance to the chemicals, secondary pest outbreaks, and health hazards associated with the application of chemicals. For consumers, the main problems are pesticide residues in food and environmental degradation. One of the new strategies to control rice pests that are at the same time more environmentally friendly is integrated pest management (IPM). IPM employs such methods as biological and mechanical controls, and botanical pesticides (Borkhani, Rezvanfar, Fami, & Pouratashi, 2010).

National and international resources have been used to developed IPM programs in some countries. Assessing and comparing the effects of IPM programs is difficult because of the heterogeneity of the data across regions, time, pest classes (insects, plant pathogens, weeds), and types of crops grown (Fernandez-Cornejo & Ferraioli, 1999). The purpose of this paper is to investigate the impacts of adopting a wide variety of Indonesian and Taiwanese IPM strategies for rice pest management. By reviewing past studies, some advantages and disadvantages from different tactics of IPM programs in Indonesia and Taiwan will be assessed and compared. The outcome of this examination will be to more comprehensively understand diverse IPM programs with regard to rice, and to apply this knowledge to IPM programs involving other crops.

Materials and Methods

During the preparation of this paper, a number of sources will be used to required. These sources will include peer reviewed journals, review articles, workshop papers, proceedings, and IPM books.

Interview had taken with different farmers and researchers in Taiwan. Some data also taken from the website of from organic agriculture in Taiwan and council of agriculture (COA). Some questions of interview had been provided in three languages, English, Mandarin and Indonesia. All questions included all about rice pest management. Interview questions on integrated pest management (IPM) were collected in direct interview for three sections, they are : IPM role and responsibilities, procedures and plans, and evaluation.

The same way also conducted in Indonesia. Data collection came from different plant protection laboratories in Aceh. Interviews for some researchers were conducted directly in Aceh and Jakarta. To assess the development of IPM from all provinces in Indonesia, some sample data were collected from the office center of plant protection that located in South Jakarta. The recent data were obtained about four years (2008 – 2011).

Results and Discussion

Development of IPM in Indonesia

The Main Rice Pests

From interviewed section, some researchers informed that there have been a lot of pests and diseases in rice crops. They are rat, bird, apple snail, rice bug, stem borer, rice leafroller, bacterial leaf blight, rice blast, and brown planthopper. Recently, the main rice pests in Indonesia are rice bug, stem borer and rat. For the main rice deseases are Tungro, rice blast and bacterial leaf blight. In other reference, Supriatna (2003) explained that the average annual loss of lowland rice was around 1.32 ton of paddy due to attacks of brown planthopper (40%), rats (17.60%), gall midge (14.60%), stem borer (9.70%), stink bug (8.10%), leaf folder/roller (3.30%), armyworm (1.40%), and others (5.30%).

Pest attacks are different for rice age and season. For example, rats usually attack the rice on July – August, brown planthopper attacks on March – April, rice bug attacks when the age of rice reach more 75 days, and armyworm attacks rice when the rice almost reach harvest time (usually on May). A periodic observation have been performed for pests monitoring. The purposes of this observation are to know pest population density, natural enemy and attack intensity. Budiyanto (2011b) informed that observation does for 4 days every week. Observation pattern used is diagonal. This pattern is used to take sample of pests in the field.

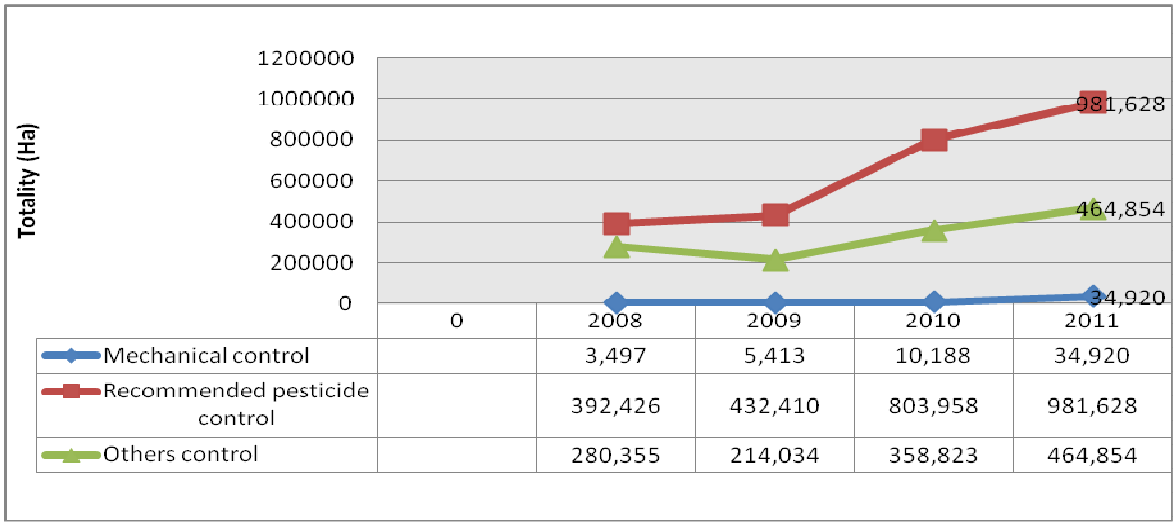
Direct monitoring have been carried by field workers. They make a plot to determine and count some pests and deseases. In each plot, pest observation is conducted in 10 rice crops. They will create pest attack intensity categories for each observation. There are 3 categories : low attack, medium attack and high attack. (Budiyanto, 2011a) explained that there are some pest attack categories, guidelines used is;

- Low attack is ≤ 25%
- Medium attack is 25% – ≤ 50%
- High attack is > 50% - ≤ 85%

IPM Techniques

In Indonesia, more farmers use recommended chemical pesticides as the last option for pests controlling. The usage of recommended chemical pesticides in Indonesia increases from 2008 to 2011 (Figure 1). There are some reasons the farmers still use recommended chemical pesticides : (1) knowledge about IPM is limited, (2) some techinques of IPM indicate slow impact to the pest attack, and (3) using pesticides is easier than IPM techniques (for example using biological control). The highest number of province that using pesticides is Central Java. It reaches 309.133 hectare (ha) in 2011 (Figure 2). In Central Java, the farmers are more understand about the effect of chemical pesticides to environment and natural enemies. They know the rules of using chemical pesticides from IPM farmers' field school (IPMFFS). In this school, some researchers give all information about IPM. Therefore, they know how to control the pest by using chemical pesticides that environmentally friendly.

Most provinces use chemical pesticides. The reason of using chemical pesticides is because of its low price and sometime they gain a good reward when they buy the pesticides. In several regions, the farmers use illegal chemical because they want to kill the pest quickly.



	0	2008	2009	2010	2011
Mechanical control		3,497	5,413	10,188	34,920
Recommended pesticide control		392,426	432,410	803,958	981,628
Others control		280,355	214,034	358,823	464,854

Figure 1. The totality of different pest controls in Indonesia
(Source : Directorate General for Food Crop Protection 2011)

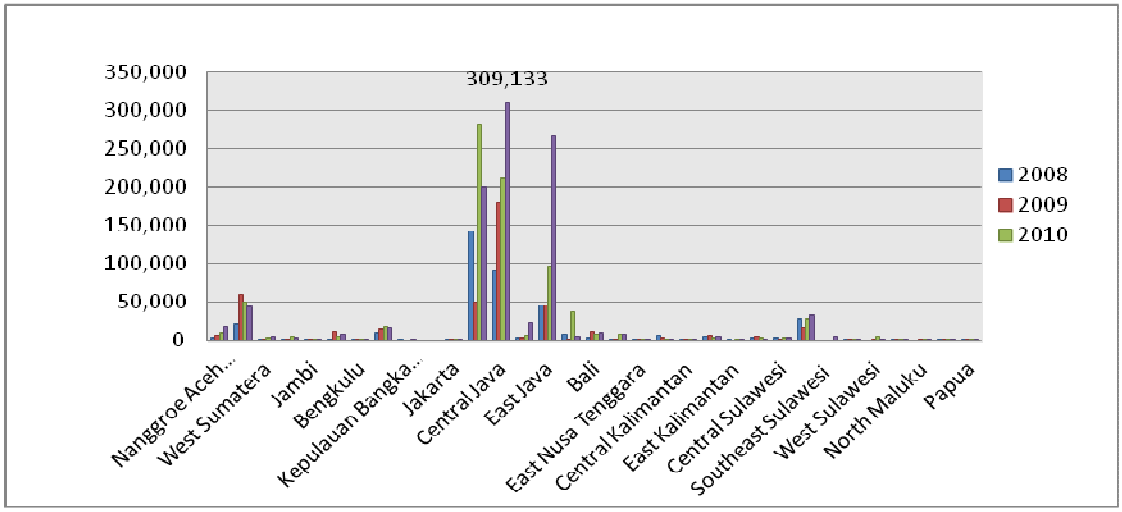


Figure 2. The recommended chemical pesticide control of rice in Indonesia.
(Source : Directorate General for Food Crop Protection 2011)

Other control is the second highest pest control that farmers use for rice. Other controls are consist of using plant extraction (natural pesticides) and biological control (parasitoid, predator, fungi, bacteria and virus). In 2011, using other controls reached 464.854 hectare (ha) (Figure 1). In Aceh, more farmers apply plant extraction (natural pesticide) for rice crop as a pest suppression before the population of pest reach economic threshold. Fungi and bacteria extraction are also used. The problem of using fungi or bacteria is the farmers do not have sufficient knowledge on how to make the pure cultures of fungi or bacteria before spraying in the field. Parasitoid and virus are not also using in Aceh's rice crops. For plant extraction, the farmers can make the extraction by themselves, and for fungi or bacteria extraction, the farmers obtain them from the laboratory of pest observation.

The highest number of province that use other control is West Java (255.343 ha) (Figure 3). In Java, biological controls are almost generally applied in all rice fields. They applied plant extraction, fungi and bacteria extraction, or natural enemies (parasitoid and predator)

as the rice pests control before population of the pests reach economic threshold. More farmers have good knowledge about pests control and can be a teacher for other farmers.

Mechanical methods are used to control field rats (jelantik Oka, 2003). Then, jelantik Oka (2003) informed that in areas with synchronized planting and crop rotation, the farmers usually organize a hunt for field rats a few days before planting. Figure 1 shows that the mechanical controls are less applied than recommended pesticides and other control. It is caused by the more information which farmers know about some physical/mechanical controls of rats attack. Singleton, Sudarmaji, Tan, and Hung (1999) mentioned that there are physical controls of rats such as using bamboo tubes, digging of burrows to kill rats in situ, stalking at night with a kerosene light and a net at the end of a long handle, physical barriers (consist of plastic or metal sheeting), using metal rat guards and scaring devices (white cloth or plastic is attached to a bamboo pole).

East Java is Province that applied mechanical control highest than other provinces in 2011 (Figure 4). East java is one of the six Provinces in Java Island which is known as natural producer of rice. Over 16% of national rice is expected produced by East Java Province (Wicaksono & Nakagoshi, 2009). The major pests which frequently affect rice production are the brown plant hopper (BPH), rice stem borer and rats (Wicaksono & Nakagoshi, 2009). Rats attack mostly in organic rice fields. Before the rats attack rice-field in East Java; they also attack other rice fields in some provinces. Sudarmaji, Brown, Jacob, and Herawati (2010) informed that West Java, Central Java and South Sulawesi are three of the four highest rice-producer provinces. These provinces were also ever damaged by rats in the highest number. Nowadays, East Java applies mechanical control for rats killing.

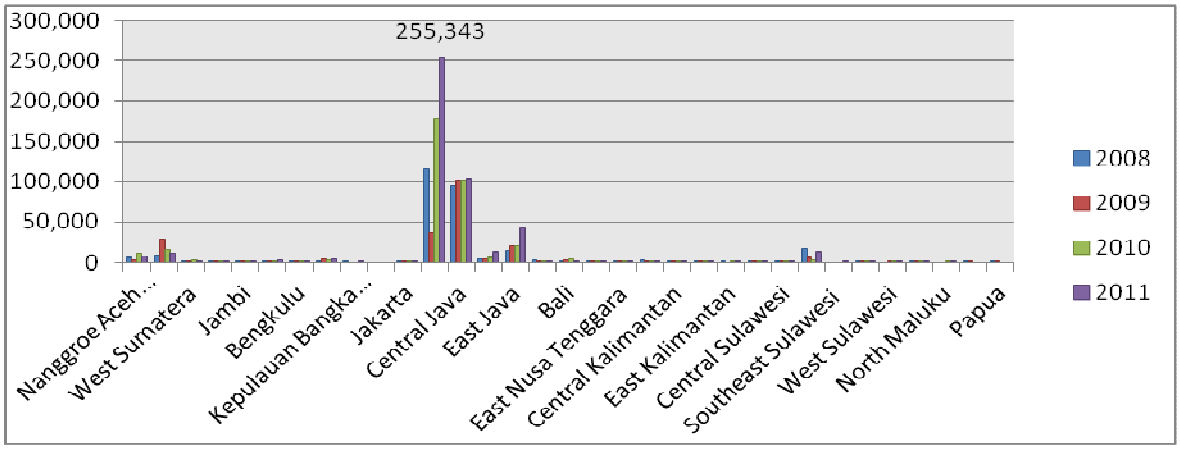


Figure 3. Other controls of rice in Indonesia
(Source : Directorate General for Food Crop Protection 2011)

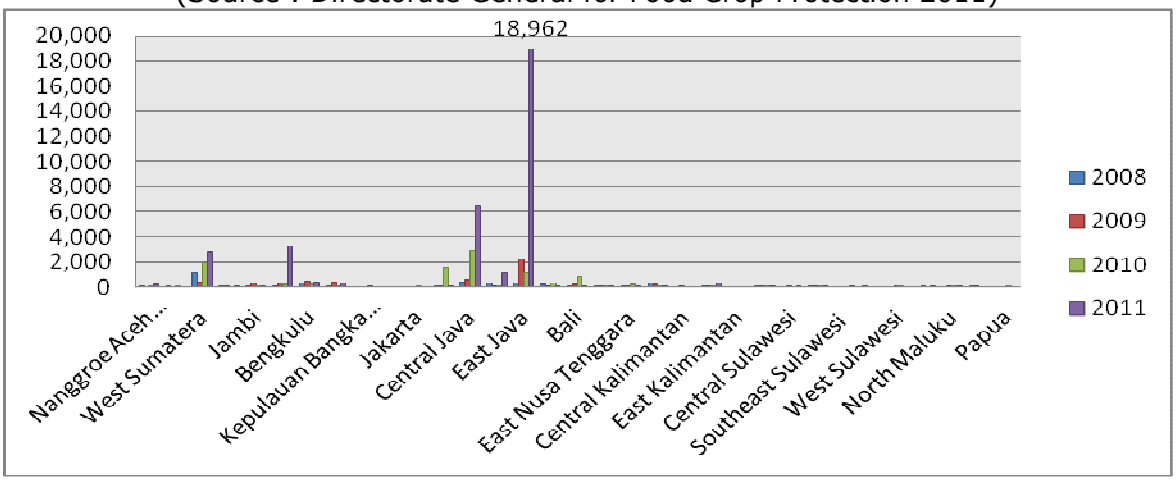


Figure 4. Mechanical controls of rice in Indonesia.(Source : Directorate General for Food Crop Protection 2011)

Development of IPM in Taiwan

The Main Rice Pests

Taiwan is located in the subtropical nearby the tropical region. Rice is also the staple food grain in Taiwan. Rice productions also increase year by year. In 2010, rice production is 1,167,972 million ton (M.T), then in 2011 increase up to 1,347,767 million ton (Council of Agriculture (COA), 2012). The major rice insect pests in Taiwan include the native species, immigrant species and invasive species. The yellow stem borer (*Scripophaga incertulas* Walker), striped rice borer [*Chilo suppressalis* (Walker)], pink borer [*Sesamia inferens* (Walker)], smaller brown planthopper [*Laodelphax striatella* (Fallen)], green rice leafhopper [*Nephotettix cincticeps* (Uhler)], rice hispa [*Dicladispa armigera* (Olivier)] and rice leaf beetle [*Oulema oryzae* (Kuwayama)] are the native species. The immigrant species, such as brown planthopper (*Nilaparvata lugens* Stål), whitebacked planthopper (*Sogatella furcifera* Horváth) and rice leaffolder [*Cnaphalocrocis medinalis* (Guenée)], can overwinter with a low population in Taiwan, but the population abundance mainly depend on the number of immigrants. The invasive species, such as rice water weevil (*Lissorhoptrus oryzophilus* Kuschel), invade into Taiwan mostly through international trade. (Huang, Cheng, & Wu, 2010).

The brown planthopper has been one of the most important insect pests of rice in Taiwan although it had been a sporadic pest before 1960. According to statistics, more than 100.000 hectares of rice field in Taiwan have been infested every year by this pest during the last decade (C. H. Cheng, 1983).

IPM Techniques

Various techniques of IPM are also applied for controlling rice pests in Taiwan. X. Cheng, Chang, and Dai (2010) informed that varietal resistance, Bt rice, cultural practices, insecticides and biological control, have been used to control rice stem borers, while insecticides are still preferred by farmers. To control the main rice pest, brown planthopper, Wang and Ku (1985) reported that use organophosphates and carbamates still are familiar practiced since 1960 in Taiwan. As Indonesia, using the recommended pesticides is also be the last option for controlling rice pests in Taiwan. Table 2 shows some recommended insecticides that still applied on rice in Taichung county, Taiwan. This table indicates that in IPM program, controlling pest is not only carried out by using biological control, plant extraction or mechanics controll, but also using chemical pesticide.

For decreasing chemical fertilizer and insecticide usage, Taiwanese farmers try to find some ways for controlling pests. Nature farming is one of the most effective ways to avoid environmental pollution (Lin, 1991). In nature farming, farmers applied using microorganism and natural enemies to solve pest problem. The EM treatment made the stems and the leaves of the paddy rice stronger, straighter and heavier than conventionally grown rice (Lin, 1991).

Besides using microbial control, Taiwanese farmers also applied biological control such as parasitoid and predator. Taiwan Agricultural Research Institute (TARI) expanded its investigation to cover the insect pests and their natural enemies. Totally, 21 parasitoids and 17 predators were found. Two egg parasitoides (*Anagrus* sp. and *Gonatocerus* sp., (Hymenoptera: Mymaridae) and two predatory spiders (*Lycosa pseudoannulata* Boes. & Str. (Araneae: Lycosidae) and *Oedothorax insecticeps* (Boes. & Str.) (Araneae: Micryphantidae) are the most common and important natural enemies for rice green leafhopper and brown planthopper. Among parasitoides, *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae) and *Apanteles* sp. (Hymenoptera: Braconidae) were found to be more abundant in paddy fields (Lee, Lin, Lu, & Wang). Taiwan has made significant progress in the development and application of IPM in their rice field.

Conclusions

Integrated pest management had been developed in Indonesia and Taiwan. Different techniques have been applied in rice field. In 2011, Indonesia used the recommended pesticides higher than mechanical controls and other controls (e.g. natural pesticides, biological control, and microbial control). Data from Taichung shows that the farmer still use recommended pesticides to control some pests. Nature farming or organic farming is one way

to reduce chemical pesticide in Taiwan. More progress had been done by farmer in Taiwan to control their rice pests under IPM program.

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References

Borkhani, F. R., Rezvanfar, A., Fami, H. S., & Pouratashi, M. (2010). Investigating the Major Barriers to Adoption of IPM Technologies by Paddy Farmers. *American-Eurasian Journal of Toxicological Sciences 2*, 146-152.

Budiyanto, E. (2011a). Pedoman Pengamatan dan Pelaporan Perlindungan Tanaman Pangan (pp. 1-86). Jakarta: Kementerian Pertanian, Direktorat Jenderal Tanaman Pangan, Direktorat Perlindungan Tanaman Pangan.

Budiyanto, E. (2011b). *Pedoman Rekomendasi Pengendalian Organisme Pengganggu Tumbuhan (OPT) Tanaman Serealia*. Jakarta: Direktorat Perlindungan Tanaman Pangan, Direktorat Jenderal Tanaman Pangan.

Cheng, C. H. (1983). Studies on Integrated Control of Brown Planthoppers, Nilaparvata lugens (Stai) in Taiwan1. *A paper submitted to Tokyo University for Dactor of Agriculture*, 335.

Cheng, X., Chang, C., & Dai, S. M. (2010). Responses of striped stem borer, Chilo suppressalis (Lepidoptera: Pyralidae), from Taiwan to a range of insecticides. *Pest management science, 66*(7), 762-766.

Claridge, M. F. U. (1998). Integrated strategies for the biological control of major insect pests of rice in South East Asia.

Fernandez-Cornejo, J., & Ferraioli, J. (1999). The environmental effects of adopting IPM techniques: the case of peach producers. *Journal of Agricultural and Applied Economics, 31*(3), 551-564.

Huang, S. H., Cheng, C. H., & Wu, W. J. (2010). Possible impacts of climate change on rice insect pests and management tactics in Taiwan. *Crop Environ Bioinfo, 7*, 269-276.

jelantik Oka, I. P. G. N. (2003). Integrated Pest Management in Indonesia: IPM by Farmers. *Integrated pest management in the global arena*, 223.

Kasmaprapruet, S., Paengjuntuek, W., Saikhwan, P., & Phungrassami, H. (2009). Life cycle assessment of milled rice production: case study in Thailand.

Lee, C. F., Lin, F. C., Lu, C. T., & Wang, C. L. Natural enemies and their use in the bio-control of insect pests in Taiwan.

Lin, D. (1991). *Nature farming in Taiwan: Effect of EM on growth and yield of paddy rice.* Paper presented at the Proceedings of the First International Conference on Kyusei Nature Farming. US Department of Agriculture, Washington, DC, USA.

Magallona, E. (1989). Effects of insecticides in rice ecosystems in Southeast Asia. *Ecotoxicology and climate: with special reference to hot and cold climates. Wiley, Chichester*, 265-297.

Ooi, P. A. C. (2005). Non Pesticide Methods for Controlling Diseases and Insect Pests. *Nonpesticide Methods for Controlling Diseases and Insect Pests*, 179.

Ooi, P. A. C., & IIED. (1998). *Beyond the farmer field school: IPM and empowerment in Indonesia*: IIED.

Singleton, G. R., Sudarmaji, J., Tan, T. Q., & Hung, N. Q. (1999). Physical control of rats in developing countries. *Ecologically-based management of rodent pests. ACIAR Monograph*(59), 178-198.

Sudarmaji, G. R. S., Brown, P. R., Jacob, J., & Herawati, N. (2010). Rodent impacts in lowland irrigated intensive rice systems in West Java, Indonesia. *Rodent Outbreaks: Ecology and Impacts*, 115.

Supriatna, A. (2003). Integrated pest management and its implementation by rice farmer in Java. *Jurnal Litbang Pertanian, 22*(3), 109.

Wang, S. C., & Ku, T. Y. (1985). *Development of Insecticide Resistance of Brown Planthoppers in Central Taiwan.* Paper presented at the Proceedings of ROC-Japan Seminar on the Ecology and Control of the Brown Planthopper.

Wicaksono, K. P., & Nakagoshi, N. (2009). Agriculture profile and sustainability in Okinawa Prefecture Japan and East Java Province of Indonesia and its future development.