
Rice Farmers' Adoption and Economic Benefits of Integrated Pest Management in South Sulawesi Province, Indonesia

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Bulkis, Sitti

Department of Agricultural Social and Economics,
Hasanuddin University, Makassar, Indonesia
Email: bulkisd@yahoo.com
+62-813-5549-1888

Rahmadanih, Rahmadanih

Department of Agricultural Social and Economics,
Hasanuddin University, Makassar, Indonesia
Email: rahmadanih.osek@yahoo.com
+62-821-8752-5498

Nasruddin, Andi

Department of Plant Pest and Disease,
Hasanuddin University, Makassar, Indonesia
Email: andinasruddin@yahoo.com
+62-822-9371-1859

Abstract

The study examined the adoption levels and economic benefits of IPM among rice farmers in South Sulawesi Province, Indonesia. The research was conducted in two main rice producing areas of the province, Soppeng and Maros Regencies. Simple random sampling was employed in selecting 20% of the total populations, resulting in sample sizes of 69 respondents in Soppeng and 52 respondents in Maros. A structured questionnaire was used in direct interview with the selected respondents to obtain data on their socio-economic profile, IPM implementation, and profit gained from IPM. Percentage was used to present the data. In both regencies, overall IPM adoption rates were high with most respondents were categorized as medium and high IPM adopters with adoption rates of 85.1% in Soppeng and 88.5% in Maros. The medium and high IPM adopters gained more economic profits of 26.9% in Soppeng and 16%% in Maros in comparison to the low IPM adopters. The high adoption rates indicated that although the nationwide IPM Program has ended in late 1990's, there was a continuous technological transfer from older farmers who participated in IPM-FFS to younger farmer generation. In order to improve IPM implementation by the younger farmers, they need to be provided with intensive extension support for IPM innovations.

Keywords: Integrated pest management, rice farmers, adoption, economic benefit

Introduction

Indonesia achieved a great success in increasing rice production by implementing the Green Revolution (Thorburn, 2014). However, dependence on high-yielding varieties and pesticide uses increase the risk of pest resurgence and pest resistance, including the brown rice planthopper, *Nilaparvata lugens* Stål (Hemiptera: Delphacidae) (Wu et al., 2018). Based on the National Law No. 12, 1992 on Plant Cultivation System, Indonesia has adopted integrated pest management (IPM) as a new pest control strategy (Indiati and Marwoto, 2017). Entomological Society of America (2017) defines the IPM as “a science-based approach that combines a variety of techniques. By studying their life cycles and how pests interact with the environment, IPM professionals can manage pests with the most current methods to improve management, lower costs, and reduce risks to people and the environment”. Adoption of IPM can help reduce dependence on pesticides without sacrificing crop yields (Peshin and Zhang, 2014, Settle et al., 2014).

To facilitate the implementation of IPM, a Presidential Decree No. 3 of 1986 was issued to ban the use of 57 insecticide formulations of 28 active ingredients in rice plantations. The banned insecticides had been proven to trigger pest resurgence due to the death of the natural enemies and the development of resistant pest populations against the insecticides (Indiati and Marwoto, 2017). To facilitate IPM technology transfer and decision making by farmers themselves in managing their plantations, Integrated Pest Management-Farmer Field School (IPM-FFS) models were introduced (Dani et al., 2016). Farmer field school (FFS) was first initiated by the Food and Agricultural Organization (FAO) in a small scale of Indonesian rice plantation in 1989 and then quickly spread to other countries in Asia and Africa (Friis-Hansen and Duveskog, 2014, FAO, 2019). Unlike the conventional top-down extension approaches, the FFSs were designed as a “bottom-up” approach and emphasized on both the training and the farmer-to-farmer diffusion of the management strategies (Larsen and Lilleør, 2014).

Farmer field school of IPM resulted in a tremendous improvement in rice management, for examples, reduction in insecticide applications (Pretty and Bharucha, 2015). Farmers participating in IPM-FFS also obtained higher yield and return than the non-participating farmers (FAO, 2019).

However, after the national political, social, and economic turmoil in 1998, support from the central and regional governments for nationwide IPM-FFS programs began to weaken. Now, rice farmers in many parts of the country tend to use more pesticides than before the IPM implementation in rice cultivation with the negative impact of pesticide use began to be seen with the increasing attack of brown planthopper at various rice producing areas in Java (Thorburn, 2014, 2015).

Information about current level of IPM adoption by rice farmers after over 20 years of the end of province wide IPM-FFS on rice plantations in South Sulawesi is not available. This information is very important for all relevant parties, including the local

and central government in making policies related to rice pest control in South Sulawesi. For this reason, this study determined:

- 1) the level of IPM adoption by rice farmers in South Sulawesi; and
- 2) economic benefits of IPM implementation among rice farmers in the province

Methodology

The study was conducted in two regencies, Maros (4° 43' – 5°11' S; 119° 20'– 119° 58' E) and Soppeng (4° 5' – 4° 32' S; 119° 42' – 120° 5' E) representing east coast and west coast of South Sulawesi Province of Indonesia, respectively. Both regencies are major irrigated rice-producing areas in the province. Because of year-round availability of sufficient water supply, farmers can intensively manage their farms to have up to five harvests in two years. In each regency, one sub regency with the largest rice plantation area was selected for sampling. In each sub regency, 20% of the rice farmers were randomly selected; thus, sample sizes used in Soppeng and Maros were 69 and 52 rice farmers, respectively.

A questionnaire was used to interview selected farmer. The respondents were asked to describe the extent of their knowledge and experience in implementing the integrated pest management in their farms. Respondents' scores were based on the frequency of rice IPM practices used, including cultivar rotation, crop rotation, recommended planting time, recommended pesticides, insecticide application based on pest scouting and action threshold, and biological control agents. Frequency values used were never = 0, sometimes = 1, often = 2, and always =3. The total survey score for each respondent was the sum of all frequency values. The results were then divided by total possible scores times 100% to determine percentage score for each respondent. Respondent percentage scores of 0-50% was categorized a low level of IPM implementation, 51-75% a medium level of IPM implementation, and 76-100% a high level of IPM implementation.

Further survey was conducted to compare economic benefits gained by respondents who were categorized low (0-50%) and medium and high IPM adopters (51-100%). They were asked with questions concerning economic aspects of their business, yield, yield price, farm income, and production material costs.

Results and Discussion

Level of Adoption of Integrated Pest Management

The adoption rate of IPM innovations was measured based on the application of the main IPM components, namely: (1) healthy cultivation technology, (2) utilization of natural enemies, (3) physical control, (3) mechanical control, and (4) chemical control. Table 1 shows that the IPM adoption rates by farmers in Soppeng and Maros regencies were mostly in the moderate and high adoption levels, 66.7% and 65.4%, respectively. In Soppeng Regency, 31.9% of the respondents was categorized as high IPM adopter while in Maros, only 23.1% was considered high

IPM adopter. This is due to the fact that more farmers were former IPM-FFS participants who understand and experience the principles and operationalization of IPM in Soppeng than in Maros. Although national scale of IPM-FFS has ended in 1999, local groups of IPM-FFS alumni are still active in many parts of the country, including in South Sulawesi. They continue to conduct experimentation, training, dissemination, and implementation of IPM innovations (Thorburn, 2014). However, the extension activities are conducted based on a participatory approach with a democratic process in which smallholder farmers are involved in decision-making (Cahyono and Agung, 2016). The approach was heavily promoted in Indonesia as a law enacted in 2006. As a policy, participatory extension is gaining popularity in developing countries as a democratic process of decision-making (Lindner and Dolly, 2012).

Table 1: Level of rice farmers' adoption of IPM

Adoption level	Soppeng Regency (%) (n=69)	Maros Regency (%) (n=52)
0 – 50%) Moderate	2.9	0.0
75%)	34.8	42.3
(> 76 –100%)	31.9	23.1
	69.6	65.4

Source: Field survey, 2018

Interestingly, there were about 30% and 35% of the respondents in Soppeng and Maros, respectively, who were moderate and high IPM adopters, and had not participated in any IPM-FFS. This suggests that there is a technological transfer from the farmers who had joined the IPM-FFS in the past to the younger farmers, although the Rice IPM-FFS is no longer undertaken in a large scale in the province since the end of 1990s.

The study results indicate that the size of the rice field managed by a farmer did not affect the farmer's level of IPM adoption because about equal numbers of farmers who are low and high IPM adopters managed small rice field (< 1 ha). Table 2 shows that most of the farmer respondents managed one ha or less of rice field. In Soppeng, 44.9 and 40.6% of the respondents adopting IPM in the category of low and high levels, respectively; owned 1 ha or less rice field. Similarly, in Maros, 44.2 and 32.7% of the respondents who were categorized as low and high IPM adopters, respectively, owned 1 ha or less rice field.

Table 2: Average rice farmers field with low and high IPM adoption rates in Soppeng and Maros Regencies

Rice field size (ha)	Number of farmers in Soppeng		Number of famers in Maros	
	% Low IPM adoption (n=69)	% High IPM Adoption (n=69)	% Low IPM adoption (n=52)	% High IPM Adoption (n =52)
≤ 0.5	20.3	21.7	23.1	15.4
0.51 – 1.0	24.6	18.8	21.1	17.3
1.1 – 1.5	4.3	2.9	1.9	1.9
1.6 – 2.0	2.9	4.3	7.7	11.5
> 2	0	0	0	0
Average	0.81 ha	0.82 ha	0.87 ha	0.85 ha

Source: Field survey, 2018

Rice Farmers' Economic Profiles

Economic profiles of farmers with low and high IPM adoption levels can be seen in Table 3. In both locations, higher yields were obtained by farmers adopting high IPM practices than those adopting low IPM practices. Yield discrepancies between low and high IPM adoption levels were 10.6 and 12.7% in Soppeng and Maros, respectively. The higher yield obtained by the high IPM adopters is mainly due to the use of good quality seed and effective pest and disease control.

The results also showed that the net profit gained by the farmers applying high IPM technologies was higher than those applying low IPM technologies. Profit increases due to the implementation of high IPM practices were IDR 3,242,219 or 26.9% in Soppeng and IDR 2,310,534 or 16% in Maros. This is in agreement with the reported finding that farmers participating in IPM gain higher yield and return than the non-participating farmers (Suharno et al., 2019).

Table 3: Economic profiles of farmers with low and high IPM adoption levels

Variable	Soppeng Regency		Maros Regency	
	Low IPM	High IPM	Low	High IPM
Plant productivity (kg/ha)	4,188	4,634	4,804	5,414
Workers' salary (IDR/ha)	394,338	405,094	392,449	385,714
Fertilization cost	696,088	620,386	782,885	756,776
Seed cost (IDR/ha)	394,500	417,775	339,535	380,022
Pesticide cost (IDR/ha)	407,957	357,472	568,462	474,408
Operational costs	3,170,290	3,092,899	5,254,462	4,677,058
Total cost (IDR/ha)	6,543,435	5,783,442	7,151,288	6,122,115
Revenue (IDR/ha)	18,647,059	21,738,461	21,617,308	24,363,461
Net profit (IDR/ha)	12,065,261	15,307,480	14,466,019	16,756,553

IDR = Indonesian Rupiah

Source: Field survey, 2018

The profit increase was obtained through the increased yield and reduction in overall production material and operational costs. In IPM, pesticide application is based on the action thresholds and not on scheduled sprays. The population and plant damaged due to pathogen are assessed through scouting to determine when a pesticide application is necessary (action threshold) (Eliza et al., 2013). This allowed farmers to control the pests and diseases with lower frequency of pesticide applications, thus, the amount of pesticide use (Table 5) and the application cost were lower (Table 4) than the scheduled pesticide applications.

The amounts of inorganic fertilizer used were also different between low and high IPM adopters (Table 4). Low IPM adopters used fertilizer with rates based on their own experiences, other farmers' experiences, or regional recommended rate for wide areas that focuses on urea fertilizer use. In contrast, the high IPM adopters determined fertilizer requirements based on area-specific soil analysis; thus, they used less urea but more ZA and NPK fertilizers and SP36 compared to the low IPM adopters.

Table 4: Average amounts of pesticide and fertilizer used by farmers

Type of pesticide and fertilizer	Soppeng Regency		Maros Regency	
	Low IPM Adopter	High IPM Adopter	Low IPM Adopter	High IPM Adopter
Pesticide (l/ha)				
Insecticide	3.2	2.0	2.9	1.6
Fungicide	1.9	1.2	1.8	0.72
Herbicide	1.4	1.2	1,2	1.14
Fertilizer (kg/ha)				
Urea	185.0	103.2	153	53.5
ZA	48.0	114.0	43.5	112
NPK	58.3	128.2	49.0	63
SP36	105.3	97.5	108.2	105

Source: Field survey, 2018

Table 5 also shows that low IPM adopters used limited insecticide modes of action because they choose insecticide based on his own or fellow farmers' experiences. On the other hand, the high IPM adopters used various recommended active ingredient for certain pest and disease. This enables them to rotate the active ingredients from time to time in order to prevent the development of resistant pest and disease against certain active ingredient. Rotation of insecticides with different modes of action prevent the pest from adapting to insecticide used as a prerequisite for insect to develop a resistance against the insecticide (University of California-IPM, 2019).

Table 5: Major pests and diseases and pesticides used in rice field with different levels of IPM adoption

Pest and Disease	Low IPM adopter		High IPM adopter	
	Pesticide (Active ingredient)	Application frequency	Pesticide (Active ingredient)	Application frequency
Stem borer	Dimehipo	4-5	Dimehipo, imidacloprid, fipronil, abamectin, buprofezin	1-2
Rice stink bug	Methomyl	1-2	Neem, imidacloprid	0-1
Slug	Fentin acetate	1-2	Water management and trap, fentin acetate	0-1
Rice blast	Tricyclazole	2-3	PGPR agents, Tricyclazole	1-2
Rice leaf blight	Mancozeb	2-3	PGPR agents, Mancozeb	1-2

PGPR = Plant growth promoting rhizobacteria

Source = Field survey, 2018

Conclusion and Recommendation

The medium and high IPM adopters gained more economic profits than the low IPM adopters. In addition, IPM technological transfer occurred from older farmers who participated in IPM-FFS to younger farmer generation. In order to improve IPM implementation by the younger farmers, they need to be provided with continuous extension support which includes education, facilitation, consultation, supervision and guidance, monitoring and evaluation in farmer adoption of IPM innovations.

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