HEALTH AND ENVIRONMENTAL INCENTIVES OF ADOPTED ECOLOGICAL TECHNOLOGY IN RICE FARMING

INSENTIF KESEHATAN DAN LINGKUNGAN DARI TEKNOLOGI EKOLOGI YANG DISERAP PADA USAHATANI PADI

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ABSTRAK

Selama kurun waktu 1970–80an, pertanian Indonesia terlihat tidak berkelanjutan karena penerapan teknologi berbasis teknologi kimiawi, yang merusak kesehatan dan lingkungan. Teknologi ekologi yang merupakan tindakan tepat, diserap untuk dapat berkelanjutan, dan hal ini telah dilakukan oleh pemerintah Indonesia. Teknologi tersebut diharapkan dapat memberikan insentif ekonomi dan juga manfaat kesehatan dan lingkungan. Kajian ini bertujuan untuk menganalisis secara ekonomi penerapan teknologi ekologi dan mengidentifikasi manfaat ekonomi, kesehatan, dan lingkungan. Kajian dilakukan di Jawa, tempat teknologi tersebut telah dimasyarakatkan secara luas. Secara khusus, kajian ini menekankan pada penggunaan pestisida. Data kerat–lintang dan runtut waktu selama 1989–90 dikumpulkan dari instansi pertanian tingkat propinsi, dan analisis dilakukan dengan panel ekonometri. Hasil analisis menunjukkan bahwa penyebaran teknologi ekologi memberi manfaat pada masyarakat setempat. Apabila dalam nilai uang, manfaat yang diperoleh dari penerapan teknologi ekologi sangat tinggi. Oleh karena itu, sangatlah masuk akal bagi pemerintah untuk melembagakan teknologi tersebut karena dapat meminimumkan masalah lingkungan dan meningkatkan taraf hidup masyarakat.

INTRODUCTION

In Indonesia, agricultural sector plays important role in economy because of the fact that agriculture still absorbs approximately 50% of employment and provides share around 20% of Gross Domestic Product (GDP) (Hill, 2000). In a certain region where agriculture dominates regional economy, agriculture is able to bring human being better of since 'regional income measures provide indications of personal and community welfare and economic growth, … a change in real income is usually taken to imply a change in welfare in the same direction' (Bendavid, 1974). Unfortunately, the sector is frequently less preferred than other sectors. This brings about the local governments do not focus seriously on the sector.

However, in the era of decentralization in which the central government no longer get intervene the local governments; it is crucial for some local regions to exploit their own local resources, including agricultural resource. However, exploitation of the local resource needs to be conducted in wise manner. Some regions, where agriculture is one of the potential contributors in economy, have implemented ecological technology in order to improve the performance of its sustainability. The technology is well known as integrated pest management (IPM). Despite the fact that the technology is based on plant protection, it does not merely perform agronomical practices. It is expected to be capable of increasing productivity and reducing pesticide use in which during the green revolution the pesticides are not used wisely. One important thing to note is that during the green revolution, pesticides no longer diminished pest attack, but created other problems such as pest resistance, pest resurgence, human health and environmental pollution (Barbier, 1989; Bond, 1996; Kishi et al., 1995). The technology is ecologically sound, because it definitely utilises natural capabilities of controlling pest attack in agricultural production. The following ecological principles that have been implemented are to grow healthy crops; to conserve and make use of natural enemies; to carry out regular field observations; and to develop farmers as IPM experts in their own field (Untung, 1996).

The technology is currently being implemented in some regions where rice, which is politically and economically strategic, dominates agricultural productions. However, the social benefit that is exclusively possessed by the technology has not been explored economically. This study, therefore, aimed to analyse the economics of implementation of ecological technology, and try to identify the economic, health and environmental incentives that can be gained by local community of the region. By showing the monetary value of social benefit, it expected to be able to give incentive and stimulated other regions to adopt the technology.

MATERIAL AND METHODS

Data Collection and Location

This study used the case of Yogyakar-ta, Indonesia where information on technology and data on production are well documented and available. The data were compiled from a number of sources including the Annual Report of the Provincial Agricultural Office and statistical data published by the Provincial and District Statistical Offices. This study that consisted of data collection, data database management, data transformation and econometrical analysis was carried out in 2002-2003. There was no need to apply a certain method of sampling since this study used secondary time series data. Locations were selected based on the availability of data. The selected locations were expected to be representative since the data was aggregation of all farmers in each location during one year. Rice was chosen as the object of this study since it was the major commodity. The agrochemical input analysed was pesticide use, because pesticides had more damaging envi-ronmental effects than other agrochemicals.

The data used in this study comprised four districts in nine-year period (1990-98), in which there was dissemination of IPM technology. Types of data analysed were: annual production of rice, annual use of pesticides, numbers of training on technology (unit), annual average price of rice (Indonesian Rupiah = IDR per kg), annual average price of fertilizers and pesticides (IDR per l/kg), and the amount of land. Summary statistics for variables used in this study could be seen in Table 1.

Underlying Theory

The theory of economics of production is utilized as fundamental framework of this study related to technological progress. Mathematically, with respect to introducing ecological

Table 1. Summary Statistics for Variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
Pesticide use	40	863.29	725.31	50.3	2484
Rice Production	40	146310.50	94106.09	21896	303153
Price of rice	40	439.47	213.44	263.25	1147
Price of pesticide	40	6665.61	1798.68	4273.64	11229.48
Price of fertilizers	40	735.14	281.84	364.96	1305.24
Unit of training	40	159.10	129.67	4	391
Area	40	24599.67	15697.02	5409	50589

Note: Author's calculation.

fixed factor land L, technology T, and the other factors (ε), can be specified that the profit function faced by farmers is:

$\Pi = \pi(\mathbf{P}_{Xi}, P_Y, L, T, \varepsilon)$ ....(1)

where: $\mathbf{P}_{Xi}$ is vector of variable input prices; P_Y is output price. A statement of Pindyck and Rubinfeld (1998) that corresponds to the Hotelling's lemma in Jehle and Reny (2001), postulates that supply for output and demand for input equations corresponding to maximized profit derived from Π can be expressed as follow:

$Q = q(\mathbf{P}_{Xi}, P_Y, L, T, \varepsilon)$ ....(2)

$X_i = x_i(\mathbf{P}_{Xi}, P_Y, L, T, \varepsilon)$ ....(3)

In an economic view of plant protection, pesticides are not considered as productive input, but as protective input instead. This means that pesticides will provide a significant contribution if there exists serious pest attack. If the pesticides works effectively to control the pest attack, this will save yield loss associated with the pests. Thus pesticides are not capable of increasing yield (Lichtenberg and Zilberman, 1986). The ecological technology pays particular attention on the pesticide use, despite the fact that technology also considers agronomical advantages. The static comparatives of supply for output and demand for pesticides with respect to ecological technology therefore are expected to be $\partial Q/\partial T > 0$, and $\partial X/\partial T < 0$. These phenomena happen since the ecological technology does not only influence total factor productivity (TFP), but also affect production elasticity of inputs. In this case, impact of technology is unlike the common use of technological progress analysis that only pays attention on TFP. Graphically, the impact of ecological technology on production can be expressed as Figure 1.

Figure 1 illustrates production of Q using input X, which is protective input. $Q=F^{\circ}(X)$ is the initial production function. This function results in supply for output and demand for input $S^{\circ}q$ and $D^{\circ}x$, respectively. If the product and input markets are competitive, the producer aims to maximize profit, and the prices of Q and X respectively is $P^{\circ}q$ and $P^{\circ}x$, the level of production will be Q°, and the level of input use will be X°, where marginal product of X [slope of $F^{\circ}(X)$] is equal to ratio of $P^{\circ}x/P^{\circ}q$. Furthermore, along with implementation of ecological technology, the production function will move to $F^1(X)$. By holding assumption that $P^{\circ}x$ and $P^{\circ}q$ remain constant,

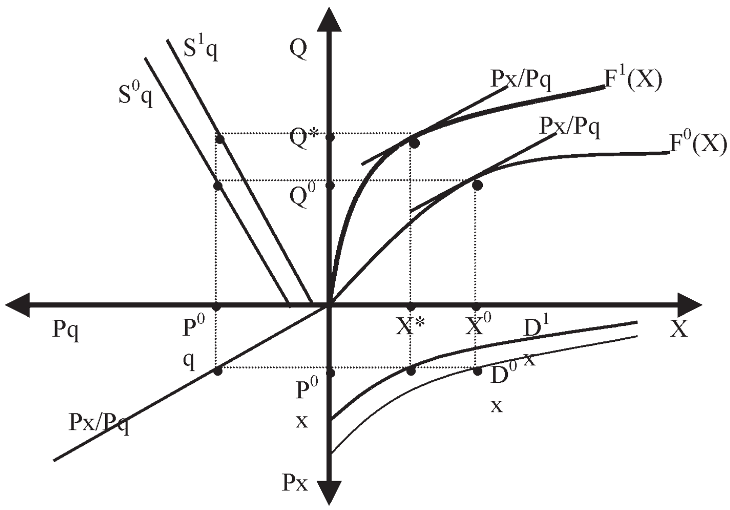

Figure 1. Effect of ecological technology on economic production

output moves from S° q to S^1 q and demand for input moves from D° x to D^1 x. Thus, the increase in implementation of ecological technology in rice production lead to increase in production and decrease in input use. The decrease in input use does not reduce the level of production since the input, pesticides, is not a productive input, but a protective input instead (Lichtenberg and Zilberman, 1986).

It should be pointed out that pesticides are detrimental to human health and the environment, despite the fact that they are protective to yield loss associated with pest attack. It is therefore pesticide use also leads to what called externality, which can be defined as a negative effect of the actions of one individual, firm or nation on another without compensation (Seitz et al., 1994). With respect to pesticides, negative externalities are unintentional side effects of pesticide use like pesticide residues and health effects. The negative external effects can be subdivided into two categories. The first harming the user directly and the second concerning both the user and the society in total (Jungbluth, 1996). Thus a decrease in pesticide use will have external benefits.

Model Estimation

Functions of demand for pesticides used in rice farming and supply for rice are respectively expressed as:

$X = ß_0 + ß_1P_Y + ß_2P_F + ß_3P_X + ß_4\ln T + ß_5L$ ....(4)

and

$Y = \phi_0 + \phi_1P_Y + \phi_2P_F + \phi_3P_X + \phi_4\ln T + \phi_5L$ ....(5)

where X is pesticides, Y is rice, P_Y is price of rice, P_F is price of fertilizers, P_X is price of pesticides, T is dissemination of ecological technology, and L is land. The technology is taken in log form because it represents the percentage change in the number of farmers who have participated in training with such technology.

Test hypotheses that can be formulated from both functions are:

H_0 : $\partial X/\partial \ln T=0$; and $\partial Y/\partial \ln T=0$

use were the responses of producers to any changes in market prices. If the quantities of rice and pesticides came from the quantities sold in the market, both supply for rice and demand for pesticide functions would be simultaneous with demand for rice and supply for pesticide functions, respectively. The estimations consequently should be done using a simultaneous model (Greene, 2003). A computer programme called STATA ver.8 was used to run the estimation. A Hausman test would apply to determine whether a fixed effect or random effect was suitable in this case. If the test indicated that there was no statistical difference between fixed and random effects, the estimates reported in this paper would be the random effect models, because these models were more efficient (Greene, 2003; Wooldridge, 2000). Furthermore, joint tests for prices would be conducted if the individual test for those prices did not show statistical insignificancy, resulting from multicolinearity problem.

RESULTS AND DISCUSSION

The supply function for rice, and the demand function for pesticides in rice farming, which were estimated using random effect, was respectively shown in Table 2 and Table 3.

It was indicated that the joint test for coefficients on prices were significant in both supply for rice and demand for pesticides. Testing individually for those coefficients showed us that prices were not significant. This was due to usual phenomena, called multicolinearity problems, resulting from high correlation among prices over time. This paper payed closer attention to the ecological techno-logy, and did not highlight the price factor much. Thus, it was sufficient to test jointly the significance of coefficients on prices.

Table 2 showed that implementing ecological technology significantly lead to increase in supply for rice. One percentage increase in implementing ecological technology caused an increase in supply for rice by around 9,517 tons. It implied that implementing IPM technology was able to lift up rice production. This was in line with the finding of Irham (2001) and Kusmayadi (1999) indicating that farmers who had participated in IPM training were able to produce higher rice than farmers who had not participated.

Table 2. Supply Function for Rice

Independent variable	Coefficient	z-ratio
Constant	10,961.00	0.47
Price of rice	31.73	0.42
Price of fertilizer	−18.17	0.62
Price of pesticide	−7.69	0.14
Ecological technology	9,517.10	2.13*
Rice planted area	5.81	43.13**
χ^2 joint test for restriction of price coefficients=0	12.46**	
R^2	98.71	

Note: Dependent variable: produced rice (tons), **) significant at α=0.01; *) significant at α=0.05.
Source: Author's estimation.

Table 3. Demand Function for Pesticides in Rice Farming

Independent variable	Coefficient	z-ratio
Constant	2,560.00	3.41
Price of rice	2.97	1.56
Price of fertilizer	0.99	0.56
Price of pesticide	−0.32	−1.25
Ecological technology	−470.42	−2.16*
Rice planted area	0.02	3.24*
χ^2 joint test for restriction of price coefficients=0	8.53*	
R^2	48.63	

Note: Dependent variable: pesticide use (kg), **) significant at α=0.01; *) significant at α=0.05.
Source: Author's estimation.

ecological technology brought about a decrease in demand for pesticide use in rice farming by approximately 470 kg. It meant that the use of pesticides fell as a result of implementing IPM technology. This result was supported by Braun et al. (2000) stating that implementing IPM technology reduced cost associated with pesticide use. Similarly, Useem et al. (1992) concluded that IPM training in rice was able to reduce pesticide use with out sacrificing rice production, even rice production rises. This was because after participating IPM training, pesticide application was no longer on fixed schedule, but it was dependent on ecological situation; and consequently farmers delayed applying pesticides (Irham and Mariyono, 2001).

With respect to changes in prices, joint test indicated that prices had significant impact on supply for rice and demand for pesticides in rice farming. Based on estimated regional supplies for rice and demand for pesticides, it was explainable that implementing ecological technology had brought about the process of rice production more environmentally friendly. This was called "clean" production process, which discharged lower pesticide waste. As mentioned by Cacho (1999) chemical inputs used were not perfectly captured by the production system, and were discharged into the environment. The decrease in pesticide use, consequently contributed any benefits both in private and social terms. The benefits of implementing ecological technology could be broken down as follow.

Increase in yield, which was showed by the increase in supply for rice. The increase in supply for would enhance consumer surplus and, certainly producer surplus if the demand of product was elastic. A decrease in pesticide use created an additional profit because of less input use. The decrease in pesticide use, in turn will leads to health and environmental benefits since the decrease in pesticide use would reduce pesticide externality (Jungbluth, 1996). Related to health impact of pesticide use, Pawukir and Mariyono (2002) proved that farmers would be more suffering from illness when they used more pesticides. A study using farm survey in the Philippines by Cuyno et al. (2001) showed that implementing IPM technology provided health and environmental benefits, transfer concepts that 'referred to the process by which a demand function or value, estimated for one environmental attribute or group of attribute at a site, was applied to assess the benefits attribute to similar attribute or site' (Garrod and Willis, 1999). If it was the case, health cost of certain amount of pesticide use that impose on the producers was obtained from a study conducted in the Philippines by Rola and Pingali (1993), that was 1,623,137.34 • $470^{0.62}$ = 73,630,193 IDR. Producers would gain the amount of monetary value of health benefit, which resulted from implementing ecological technology. Furthermore, Mourato et al. (2000) had well estimated external costs of pesticide application using a contingent valuation method to estimate consumers' willingness to pay (WTP) of a kilogram decrease in pesticide use. The consumers' WTP represented the value of health resulting from consuming low-residue-pesticide products and the value of increase in environmental quality. The estimated environmental cost associated with pesticide application of one-kilogram pesticides was equivalent to 60% of average price of pesticides. During the period of 1989-90, the prevailing price of pesticides was, on average, 11,200 IDR. Thus the environmental benefit of one percentage increased in implementing the ecological technology was equivalent to 0.6 • 11,200 • 470 = 3,158,400 IDR. If the estimated external cost could be assumed as shadow price of pesticides pollution, one percentage increase in implementing ecological technology would reduce external cost about 73,630,193 + 3,158,400 = 76,788,593 IDR. The amount of external cost reflected additional increase in utility, which would be gained by both farmers and other people in the region.

All in all, because of implementing the ecological technology, rice production in Java become sustainable, as Barbier (1989) stated that sustainable agriculture was occurred when both the real cost and the real environmental cost of production was expected to remain constant or fall as production expands. The same statements of Acton and Gregorich (1995) and Norman et al. (1997) indicated that the technology had brought agriculture into sustainable fashion because of the following reasons. (1) Satisfying human food and fibre needs. It was demonstrated by the increase in rice production. (2) Enhancing environmental quality and the natural resource base on which the agricultural economy depends. It was demonstrated by the decrease in pesticide application that pollutes the environment. (3) Making the most efficient use of non-renewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls. It was demonstrated by lower level of pesticide application with higher level of rice production. (4) Sustaining the economic viability of farm operations that demonstrated by higher profit of rice farming practice derived from lower pesticides use and higher production of rice. (5) Enhancing the quality of life of farmers and society as a whole that demonstrated by lower externality resulting in safe food for farmer and other societies.

CONCLUSION AND RECOMMEND-ATION

Some regions where agriculture still played a key role in regional other community. Increase in yield, which was showed by the increase in supply for rice. The private benefit for farmers was represented by the increase in production and decrease in pesticide use, and both lead to generating additional profit. For the community, the increase in supply for rice would enhance consumer surplus. It was means that rice was more available for consumers and it much easier for community to access rice in the market. The social benefit came from the decrease in pesticide use, because it would leads to increases in health and environmental benefits since the pesticide externality would decrease as pesticide use was reduced.

The beneficiaries of social benefit were farmers and other community. In terms of monetary value, such benefit of implementing ecological technology was considerably high. Because of such benefits, the rice farming practices in regions adopting the technology went into the direction of sustainable fashion. It was therefore sensible for the local government to widely institute the ecological technology, since this was able to minimise environmental problem, and lead to an increase in standard living of the people.

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