DETERMINANTS OF ADOPTING ENVIRONMENTALLY FRIENDLY TECHNOLOGY: A CASE OF SOYBEAN FARMING IN EAST JAVA

DETERMINAN MENGADOPSI TEKNOLOGI RAMAH LINGKUNGAN: SEBUAH KASUS USAHATANI KEDELAI DI JAWA TIMUR

By:

Joko Mariyono[1)] and Heru Setyoko[2)]

[1)]PhD Candidate in International and Development Economics, The Australian National University, Canberra. E-mail: joko-mariyono@anu.edu.au

and [2)]International Relief and Development, Jakarta

(Diterima: 2 Pebruari 2005; Disetujui: 9 Pebruari 2006)

ABSTRAK

Teknologi ramah lingkungan merupakan pilihan yang tepat untuk menciptakan pertanian yang berkelanjutan. Namun, petani tidak selalu menerima teknologi tersebut karena petani bersifat lembam. Oleh karena itu, sangatlah penting untuk mengetahui faktor yang memengaruhi adopsi teknologi tersebut. Kajian ini bertujuan untuk menganalisis faktor yang berpengaruh terhadap adopsi teknologi ramah lingkungan pada usahatani kedelai. Kajian ini menggunakan metode estimasi logit, Tobit dan probit bertingkat untuk mengukur kemungkinan petani mengadopsi komponen teknologi ramah lingkungan. Data dikumpulkan dari tiga kabupaten di Jawa Timur tempat kedelai dibudidayakan secara intensif. Hasil kajian ini menunjukkan faktor sosial ekonomi mempunyai pengaruh yang beragam terhadap adopsi komponen teknologi. Secara keseluruhan, kelompok tani, luas usahatani, kepemilikan lahan, dan pelatihan memungkinkan petani untuk mengadopsi teknologi secara keseluruhan. Akan tetapi, yang taat–azas dengan penggunaan pestisida adalah pelatihan, karena petani yang mengikuti pelatihan menggunakan pestisida lebih sedikit.

INTRODUCTION

The challenge for developing agrarian countries in the next 25 years is not only to satisfy the growing effective demand for food and fibre, but also to help increasing calorie intake, and to do it in an environmentally sustainable fashion (Janvry et al., 2002). This is indicated by the fact that 'consumer awareness of the environment and preferences for more environmentally benign products appears to be growing steadily around the developed world and in selected developing countries' (Erickson and Kramer–LeBlanc, 1997). Reinhard and Thijssen (1998) claim that environmentally sustainable development of a competitive agriculture becomes the major goal of an agricultural production system. The series of International Organization for Standardizations (ISO) 14000 strongly recommend producers to improve policies and measures in producing goods that are toxic–residue free and maintain a sound environment (Sombatsiri, 1999).

For those reasons, Indonesian agricultural policy has revolutionized its policy by introducing an environmentally friendly strategy of plant protection. This is carried out through a programme that introduces Integrated Pest Management (IPM) technology, which is initiated in 1986 when Presidential Decree No. 3, 1986 was issued (World Bank, 1993). The programme is motivated by the fact that agriculture is no longer ecologically operated. Such condition has led

1996) and in the 1980s (Barbier, 1989). In addition, there exist other adverse impacts of unwise use of pesticide, that is environmental and health problems (Bond, 1996; Kishi et al., 1995).

The programme was then realized in 1989 (R lling and van de Fliert, 1994), with 'the objectives of guarded pest population (i.e. to keep pests below economic threshold levels), limited use of chemical pesticides, and an improved environment and better public health' (Untung, 1996). The training, namely Farmers' Field School (FFS), is basically a human resource development (HRD) programme (R lling and van de Fliert, 1994). In the field, the training does not only involve a pest control strategy, but also other aspects of farming such as balanced and efficient fertilizing, efficient use of water, crop rotation and soil conservation. The following IPM principles: grow healthy crops; conserve and utilise natural enemies; carry out regular field observations, and develop farmers as IPM experts in their own field are central to the FFS (Untung, 1996).

Related to advantage of IPM technology, there exists a strong claim that adopting the technology is able to reduce the use of pesticides significantly. This is because in the field trials, the training is able to cut down pesticide use by 50% without sacrificing the level of production (Bond, 1996). Useem et al. (1992) states that by adopting IPM principles farmers reduce pesticide application without significant effect on production. However, it is still debatable, whether most farmers are willing to accept and adopt the technology. The possible cause is that farmers are reluctant to change their behaviour related to agricultural practices because, in general, 'most individuals are risk averter' (Salvatore, 1996). The behaviour towards risk is dependent on their socio-economic backgrounds such as education, experience, and wealth (Rola and Pingali, 1993). Therefore, the objective of this paper was to analyse socio-economic backgrounds of farmers that possibly influence the adoption of some components of IPM technology.

MATERIAL AND METHODS

Data Collection and Location

Three districts of East Java: Mojoker-to, Pasuruan, and Banyuwangi were selected as study site since soybean agribusiness was intensively conducted in those districts. This study employed the before and after approach as suggested by Gittinger (1982) with the particular objective of identifying the impact of the training programme on the probability of adopting components of IPM technology and pesticide use. Data was collected during soybean-planting season of 1997 and 1998/1999. The procedures of data collection were done as follow.

In the soybean-planting season of 1997, there were twenty randomly selected farmers in each region. The selected farmers then were observed during one planting season before attending training. The activities related to soybean cultivation starting from land preparation to harvesting were recorded in the structured forms. After harvesting, the selected farmers participated in a training programme for one planting season. In 1998, after completing the training programme, the

Components of Ecological Technology

This study extended four principles of IPM, namely to grow healthy crops; to conserve and utilise natural enemies; to carry out regular field observations; and farmers as IPM experts in their own field. Referring to an ecological research of Luther (1993) who applied IPM technology on soybean farming in eastern Java, the components of IPM technology were divided into three sections: preparation, maintenance, and pest control. The preparation consisted of land tillage, selecting variety, and row-planting. The maintenance comprised mulching, weeding, and irrigating. The pest control included field observation and pesticide application. If farmer applied those components of technology in soybean farming, this meant that farmer operated farm in environmentally sustainable fashion. The summary statistics for components of ecological technology could be seen in Table 1.

Econometric Modelling

This study employed logit, Tobit and ordered probit models to predict the probability of adopting components of ecological technology, which was introduced through IPM training. Mathematical derivations of those models is referred to explanations of Johnston and Di Nardo (1997). Let define

$$X_i\beta = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \varepsilon_i \qquad (1)$$

where X is a vector of socio-economic factors with X_k for k=1,2, ...,8 with 1=age, 2=education, 3=joining farmers' group, 4=size of occupation, 5=land-ownership, 6=being trained; 7= dummy location of Mojokerto, 8=dummy location of Pasuruan, d is error terms; β_j for j=0,1,...,8 are coefficients to be estimated, and subscript i represents individual sample observation. The equation (1) will be used in establishing econometric models of logit, Tobit, and ordered probit.

In mathematical terms, the logit model that describes the probability of adopting each component of ecological technology given socio-economic factors of farmer, can be expressed as:

$$P\{Y_i = 1\} = \frac{\exp\{X_i\beta\}}{1+\exp\{X_i\beta\}} \qquad (2)$$

where Y_i is components of ecological technology that consists of land tillage, variety, row-planting, mulching, weeding, irrigating, and field observation. It is not difficult to see that the value of $P\{Y_i=1\}$ is bounded between zero and

Table 1. Summary Statistics for Components of Ecological Technology

Variable	Obs.	Mean	Std. Deviation	Min	Max
Land-tillage (1=yes, 0=otherwise)	120	0.65	0.48	0	1
Varieties (1=yes, 0=otherwise)	120	0.92	0.28	0	1
Row-planting (1=yes, 0=otherwise)	120	0.87	0.34	0	1
Mulching (1=yes, 0=otherwise)	120	0.80	0.40	0	1
Weeding (1=yes, 0=otherwise)	120	0.96	0.20	0	1
Watering (1=yes, 0=otherwise)	120	0.84	0.37	0	1
Pesticide use (times)	120	1.62	0.81	0	3
Eco-technology (number of components)	120	5.91	1.05	3	7

Source: Authors' calculation.

equal to one, which follows a cumulative logistic distribution, is dependent on some socio-economic factors X. When Y_i is equal to one, it means that farmer adopts each component of ecological technology. If $ß_j$ is positive, it means that one point increase in $X_{k=j}$ will result in more likely for farmer to adopt ecological technology, and vice versa.

Related to the pesticide application, this study employs Tobit model (Johnston and Di' Nardo, 1997). This is because pesticide use leads to a negative externality, such that some farmers may avoid from using pesticides if they understand that pesticides are not necessarily used in their farm. Thus, when farmers do not use, this means that the number of pesticide application is not immediately zero, but may be less than zero. However, it is unobservable, and bounded at zero. In mathematical terms, the Tobit model of pesticide application can be expressed as:

$$Y^*_i = X_i ß + \varepsilon_i \qquad (3)$$

where Y^* is pesticide use which is unobserv-able, and X_i is a vector of socio-economic factors as mentioned above including dummy location; ε is error terms which follows $N(0, \sigma^2)$, and ß is coefficients to be estimated. In this case, the observable variable is:

$$Y_i = \begin{cases} Y^*_i & \text{if } Y^*_i > 0 \\ 0 & \text{if } Y^*_i \leq 0 \end{cases} \qquad (4)$$

This model is called a censored regression model since it is possible to view the problem as one in which observations of Y^* at or below zero are censored. If $ß_j$ is positive, this represents an increase in the expected value of Y as a result of an increase in $X_{k=j}$.

In addition, it is important to analyse the probability of adopting seven components of technology altogether. This is because adopting those makes it possible for farmer to manage soybean farming in environmentally sustainable fashion. For this purpose, an ordered probit is employed. Since there are seven components of technology, the dependent variable of interest is the sum of components of technology that is adopted by a farmer. But, there is no farmer who adopts less than three components of technology, and therefore there exists five levels of ecological technology acquisition. In mathematical terms, the ordered probit in this case can be expressed as:

$$P\{Y^n_i = 1\} = \Phi\left(\frac{C_n - \mathbf{X}_i\beta}{\sigma}\right) - \left(\sum_{n=3}^{7} \Phi\left(\frac{C_{n-1} - \mathbf{X}_i\beta}{\sigma}\right)\right) \qquad (5)$$

where n=3,4,...,7 is number of components of technology adopted by a farmer, Φ is cumulative standard normal density function, and C is the thresholds that the unobservable variable must cross to change the value of Y. When n is equal to three, it means that farmer only adopts three components of technology, but when n is equal to seven, it means that farmer completely adopts the technology. In this case, $C_{n-1} < C_n$ means that the greater n is the better. For instance, $Y^4_i = 1$ means that an i^{th} farmer adopts four of seven components of technology, and $Y^5_i = 1$ means that an i^{th} farmer adopts five of seven components of technology. If it is the case, $Y^5_i = 1$ is better that $Y^4_i = 1$. For the case of n=7, the probability of completely adopting technology can be expressed as:

$$P\{Y^7_i = 1\} = 1 - \Phi\left(\frac{C_6 - \mathbf{X}_i\beta}{\sigma}\right) \qquad (6)$$

For the sake of convenient analysis, let normalize σ to equal one. When $ß_j$ is positive, an increase in $X_{k=j}$ unambigadopting the technology. The probability of partially adopting the technology however, will be dependent on the magnitudes of the threshold C_n.

Instead of using ordinary least square (OLS), logit, Tobit and ordered probit models are used in this study to avoid from being biased because of bounded dependent variable (Greene, 1993), and inefficient because of heteroskedasticty (Verbeek, 2000). All models are non-linear, and will be estimated using maximum likelihood estimation (MLE). STATA ver.8 is used for estimating the logit, Tobit, and ordered probit models.

Testing for Hypothesis

To identify whether the socio-economic factors matters in the probability of adopting components of technology, a hypothesis is built. The hypothesis is that the probability of adopting components of technology is affected by socio-economic factors embedded in farmers. It can be formulated as:

Ho: $ß_0 = ß_1 = ß_2 = ß_3 = ß_4 = ß_5 = ß_6 = ß_7 = ß_8 = 0$, and H_1: one of them $\neq 0$

The hypothesis will be rejected if likelihood ratio (LR) is greater that χ^2 critical at 1%, 5%, and 10%. For individual impact of each socio-economic factor, the hypothesis is formulated as:

Ho: $ß_j = 0$ and H_1: $ß_j \neq 0$, for $j=1,2,...,8$

The hypothesis will be rejected if z-ratio is greater than z critical at 1%, 5%, and 10% levels. If those hypotheses are rejected, these mean that the corresponding factors have significant impact on the probability of adopting components of technology. The summary statistics for socio-economic factors embedded on farmers can be seen in Table 2.

RESULT AND DISCUSSION

In all logit models, dummy variables for location were excluded from the model because the locations provide perfect prediction of success on probability of adopting the component of ecological technology. However, in the Tobit and ordered probit models that not involves prediction of pesticide application; the dummy for location still existed. All in all, the models demonstrated that socio-economic factors influenced significantly the probability of adopting technology. Related to partial impact of socio-economic factors on the probability of adopting technology, each socio-economic factor had various significant effects. The socio-economic factors that had no significant impact meant that farmers with those factors could be more or less

Table 2. Summary Statistics for Socio-economic Factors

Variable	Obs.	Mean	Std. Deviation	Min	Max
Age (year)	120	45.33	9.08	23	67
Education (1=ES, 2=JHS, 3=SHS)	120	1.73	0.86	1	3
Joining group (1=joined, 0=otherwise)	120	1.32	1.00	0	3
Land size (hectare)	120	0.51	0.24	0.15	1
Land owner (1=owner, 0=otherwise)	120	0.50	0.24	0	1
Training (1=trained, 0=otherwise)	120	0.50	0.50	0	1

Note: ES: elementary school, JHS: junior high school, SHS: senior high school.
Source: Authors' calculation.

Table 3. Logit Model of Soybean Preparation

Explanatory Variables	Dependent Variables					
	Land-tillage		Variety		Row-planting	
	Coefficient	z-ratio	Coefficient	z-ratio	Coefficient	z-ratio
Constant	−9.6997	−3.66[a]	5.8953	1.84[b]	−3.6693	−1.34[d]
Age	0.0508	1.01[d]	−0.0216	−0.40[d]	0.0781	1.33[d]
Education	0.9561	2.02[b]	−1.8148	−2.61[a]	−0.1980	−0.33[d]
Group	0.5645	1.52[d]	−1.3141	−1.98[b]	1.4448	2.03[b]
Size	17.2245	5.35[a]	2.9749	1.56[d]	−0.5478	−0.29[d]
Ownership	−2.4340	−2.66[a]	4.0008	2.41[b]	3.0171	2.30[b]
Training	−0.2824	−0.42[d]	1.0883	1.10[d]	2.6514	2.32[b]
Log likelihood	−31.25939		−21.162018		−25.171498	
LR	χ^2 (6)=92.87[a]		χ^2 (6)=26.52[b]		χ^2 (6)=43.90[a]	

Note: a) significant at a=1%; b) significant at a=5%; c) significant at a=10%; d) insignificant.
Source: Authors' estimation.

Table 3 showed the logit models of adopting ecological technology related to stages of preparation in soybean farming. The models suggested that, in the case of land-tillage, more educated farmers and the farmers who operated larger farm were more likely to adopt land-tillage. In contrast, farmers were less likely to adopt land-tillage when they operated their own land. In the case of selecting varieties, farmers who operated farm on their own land were more likely to select good variety of soybean. However, more educated farmers and being joined farmers in farmers' group were less likely to cultivate good variety of soybean. In the case of row-planting, farmers who joined farmers' group, operated farm on their own land, and participated training were more likely to adopt row-planting in soybean farming.

Table 4 showed the logit models

Table 4. Logit Model of Soybean Maintenance

Explanatory Variables	Dependent Variables					
	Mulching		Weeding		Irrigation	
	Coefficient	z-ratio	Coefficient	z-ratio	Coefficient	z-ratio
Constant	3.4414	1.31[d]	11.2820	2.37[a]	2.9384	1.17[d]
Age	−0.1054	−1.81[c]	−0.1536	−1.75[c]	0.0254	0.53[d]
Education	0.0754	0.13[d]	−2.2954	−2.35[b]	−1.2732	−2.29[b]
Group	1.8039	2.67[a]	−0.3413	−0.42[d]	−1.4878	−2.67[a]
Size	−2.8622	−1.58[d]	3.3631	1.43[d]	1.2526	0.77[d]
Ownership	6.0961	3.49[a]	5.1166	2.15[b]	4.5981	3.30[a]
Training	1.9004	2.39[a]	1.9355	1.39[d]	0.9569	1.18[d]
Log likelihood	−27.420687		−14.513486		−28.216678	
LR	χ^2 (6)=65.26[a]		χ^2 (6)=12.54[c]		χ^2 (6)=48.42[a]	

Note: a) significant at a=1%; b) significant at a=5%; c) significant at a=10%; d) insignificant.
Source: Authors' estimation.

models suggested that, in the case of mulching, farmers who joined farmers' group, operated farm on his/her land, and participated training were more likely to apply a mulching. On the contrary, farmers were less likely to adopt mulching when they were getting older. In the case of weeding, farmers who operated farm on their own land were more likely to control weeds. However, older farmers and more educated farmers were less likely to control weed. In the case of irrigation, farmers who operated farm on their own land were more likely to provide water for soybean farming. Conversely, more educated farmers and farmers who joined farmers' group were less likely to provide irrigation for soybean farming.

Table 5 showed the logit model for field observation, Tobit model for pesticide use and ordered probit model for adopting all components of technology. The model suggested that, in the case of field observation, farmers who joined farmers' group and participated training were more likely to do regular field observations. But, more educated farmers were less likely to do regular field observation. Related to the number of pesticide spraying, farmers would use fewer pesticides when they were getting older, more educated and trained. But, farmers who operated larger farm and farmers who operated farm in their own land used more pesticides. One interesting feature was that farmers in region of Pasuruan used more pesticides than those in Banyuwangi and Mojokerto.

If analysis was emphasised on single adoption of components of technology, it seemed that the each socio-economic factor was not consistent in

Table 5. Logit, Tobit, and Ordered Probit Models

Explanatory Variables	Dependent Variables					
	Field observation (logit)		Pestiside use (tobit)		No. of components (ordered probit)	
	Coefficient	z-ratio	Coefficient	z-ratio	Coefficient	z-ratio
Constant (1)					0.0145	0.02[d]
Constant (2)					1.0035	1.31[d]
Constant (3)					1.6883	2.16[b]
Constant (4)					3.8346	4.54[a]
Constant	4.6994	2.21[b]	2.8568	7.87[a]	~~−0.0096~~	~~−0.61[d]~~
Age	−0.0357	−0.81[d]	−0.0227	−3.16[a]	−0.4064	−2.51[b]
Education	−0.7382	−1.74[c]	−0.1465	−2.01[b]	0.5933	3.75[a]
Group	1.1227	2.32[b]	0.0088	0.12[d]	1.7694	3.25[a]
Size	−2.5219	−1.64[d]	0.6475	2.69[a]	3.5323	6.06[a]
Ownership	−0.2198	−0.26[d]	1.1105	4.52[a]	0.9370	3.78[a]
Training	3.1167	2.69[a]	−0.9937	−9.06[a]	1.5435	3.89[a]
Mojokerto			−0.0799	−0.43[d]	−1.0038	−2.28[b]
Pasuruan			2.8568	7.87[a]		
Log likelihood	−29.237776		−104.34148		−106.52061	
LR	χ^2 (6)=31.95[a]		χ^2 (8)=93.15[a]		χ^2 (8)=97.58[a]	

Note: a) significant at a=1%; b) significant at a=5%; c) significant at a=10%; d) insignificant.
Source: Authors' estimation.

could have a positive effect on the probability of adopting one component of technology, and had a negative effect on other components. For example, more educated farmers were more likely to adopt land-tillage, but were less likely to select good variety. Since there were seven components of technology, which were importantly the same and incomparable, these implied that one component could not be sacrificed for the sake of certain technology. As a consequent, it was ambiguous for the policy maker to make a decision. If it was the case, ordered probit was used to deal with such ambiguity. As could be seen, the ordered probit model had four constants because there were five level of technological acquisition as dependent variable. Those constants represented thresholds that the unobservable variable must cross to change the level of technological acquisition. The model suggested that farmers joining farmers' group, operating farm on their own land, having larger size of land and participating training were unambiguously more likely to adopt the environmentally friendly technology on soybean farming they operated. However, it was surprising that more educated farmers were less likely to adopt such technology. Related to regional factor, farmers in Mojokerto were more likely, and farmers in Pasuruan were less likely to adopt such technology than farmers in Banyuwangi.

Recall the objective of introducing IPM technology was to reduce the use of pesticides, which in turn could reduce non-point source pollution. It was expected that adopting all components of technology was capable of diminishing pesticide use. It was, therefore, participating training was the only factor that was capable of enabling farmers to adopt the environmentally friendly technology and to reduce the use of pesticide.

CONCLUSION AND POLICY IMPLICATION

To sum up, some socio-economic factors embedded on farmers operating soybean farming in East Java had influenced adoption of environmentally friendly technology, which was expected to be able to reduce pesticide use. However, the impact was inconsistent when the socio-economic factors were specifically addressed on single component of technology. This was because one factor had opposite impacts on adoption of each component of technology. Thus, it was not easy to make a decision since all components of technology were equally essential in protecting the environment from adverse impacts of pesticide use. Nevertheless, the inconsistency was no longer the case when further analysis is built with joint adoption of all components of technology. By assuming that adopting more components was better, the socio-economic factors leading to adoption of environmentally friendly technology were being joined in farmer's group, larger size of farm, operating farm in owned land and participating training. Surprisingly, more educated farmers tended to not completely adopt such technology, although those farmers reduced pesticide use. This phenomenon also happened with others factors. The only consistent factor for which farmers tended to completely adopt ecological technology and to reduce pesticide use was the training participation. In other words, farmers that had been participated in training would to this phenomenon was to send farmers in training as much as the government was capable of.

ACKNOWLEDGMENT

The authors thank Field Leaders of IPM who worked for Agricultural District Services (Diperta) of Mojokerto, Pasuruan and Banyuwangi for providing substantially worthwhile helps during the field observation and data collection.

REFERENCES

Barbier, E.B. 1989. Cash Crops, Food Crops, and Sustainability: The case of Indonesia. World Development 17(6):879-895.

Bond, J.W. 1996. How EC and World Bank Policies are Destroying Agriculture and the Environment. AgB Publishing, Singapore.

Erickson, A. and C.S. Kramer-LeBlanc. 1997. Ecolabels: The link between environmental preferences and green practices? Pp. 196-206. In: J.A. Caswell and R.W. Cotterill (eds.), Strategy and Policy in the Food System: Emerging issues. Proceedings of NE-165 Conference, June 21-27, 1996. Washington DC, Univ. of Connecticut and Univ. of Massachusetts, Amhers.

Gittinger, J.P. 1982. Economic Analysis of Agricultural Projects. The Johns Hopkins Univ. Press., Baltimore.

Greene, W.H. 1993. The econometric approach to efficiency analysis. Pp. 68-119. In: H.O. Fried, C.A.K. Lovell, and S.S. Schmidt (Eds.), The Measurement of Productive Efficiency: Techniques and Applications. Oxford University Press, Oxford.

Janvry, A., G. Graff, E. Sadoulet, and D. Zilberman, 2002. Technological Change in Agriculture and Poverty Reduction, Concept paper for the WDR on Poverty and Development 2000/01. (On-line). http://www.wtowatch.org/library/admin/uploadedfiles/Technological_Change_in_Agriculture_and_Povert.htm. Download-ed at 6 Nov 2002.

Johnston, J. and J. Di' Nardo. 1997. Econometric Methods. McGraw-Hill Co. Inc., New York.

Kishi, M., H. Norbert, M. Djayadisastra, N.L. Satterlee, S. Strowman, and R. Dilts. 1995. Relationship of Pesticides Spraying to Signs and Symptoms in Indonesian Farmers. Scandinavian Journal of Work Environmental Health 21:124-133.

Luther, G.C. 1993. An Agro-ecological Approach for Developing an Integrated Pest Management System for Soybeans in Eastern Java. Unpublished PhD. Dissertation, University of California, Berkeley.

Reinhard, S. and G. Thijssen. 1998. Resource Use Efficiency of Dutch Dairy Farms: A parametric distance approach. Paper presented at 1998 American Agricultural Economics Association Annual Meeting in Salt Lake City.

Rola, A.C. and P.L. Pingali. 1993. Pesticide, Rice Productivity, and Farmers' Health: An Economic Assessment. World Resources Institute, IRRI.

R lling, N. and E. van de Fliert. 1994. Transforming Extension for Sustainable Agriculture: The case of integrated pest management in rice in Indonesia. Agricultural and Human Value 11(2/3): 96-108.

Salvatore, D. 1996. Managerial Economics in a Global Economy. McGraw-Hill, New York.

Settle, W.H., H. Ariawan, E.T. Astuti, W. Cahyana, A.L. Hakim, D. Hindayana, A. Lestari, Pajarningsih, and Sartanto, 1996. Managing Tropical Rice Pests Through Conservation of Generalist Natural Enemies and Alternative Prey. Ecology 77(7):1975-1988.

Sombatsiri, K. 1999. Policies and Strategic Measure for an Improvement of Laws and Regulations of the Import and Utilization of Toxic Substance in Agriculture. Pesticide Policy Project Publication Series 7.

Untung, K. 1996. Institutional Constraints on IPM Implementation in Indonesia. Publication of the Pesticide Policy Project, Publication Series 3A:37−47.

Useem, M., L. Setti, and J. Pincus. 1992. The Science of Javanese Management: Organizational alignment in an Indonesian development programme. Public Administration and Development 12:447−471.

Verbeek, M. 2000. A Guide to Modern Econometrics. John Wiley & Sons, Ltd., Chichester.

World Bank, 1993. Staff Appraisal Report. Indonesia Integrated Pest Management Training Project. The World Bank, Washington.