Integrated Pest Management Training and Sustainable Farming Practices of Vegetable Growers in Indonesia

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ABSTRACT. The National Integrated Pest Management Training Program in Indonesia has provided opportunities for vegetable farmers to learn about farming practices that reduce reliance on chemical pesticides while maintaining high yield potential. This study compares samples of trained and untrained cabbage and potato farmers with the objective of comparing adoption levels of sustainable practices. A Farmer Sustainability Index was computed for each farmer surveyed to judge the relative sustainability of farm operations. Results indicate that farmers with IPM training follow more sustainable practices than their untrained counterparts. A regression model was constructed to explain the index values. The model revealed that IPM training and farmer knowledge of the ecology of his farm are positive factors that significantly affect the index value. *[Article copies available for a fee from The Haworth Document Delivery Service: 1-800-342-9678. E-mail address: getinfo@haworthpressinc.com]*

KEYWORDS. Integrated Pest Management, IPM training, Indonesia, vegetables

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INTRODUCTION

In 1986 the Government of Indonesia proclaimed by Presidential decree that integrated pest management would be the national pest management strategy. Fifty-seven broad-spectrum insecticides were banned from use on rice, and subsidies to reduce the price of pesticides to farmers were eliminated. These steps were followed by the initiation of the National IPM Training Program aimed at providing farmers with the information necessary to make informed pest management decisions.

The purpose of this paper is to provide an analysis of IPM training of cabbage and potato growers in major growing areas of four provinces. The analysis focuses on the sustainability of farm practices that are integral components of the IPM training program. Trained farmers are compared to untrained farmers from the same regions.

The need for IPM training in Indonesia became apparent after devastating outbreaks of brown planthopper, *Nilaparvata lugens* (Stal), on rice in the 1970s and 1980s. These outbreaks were caused by excessive use of chemical insecticides to control the pest (Oka, 1979; Kenmore et al., 1987). The Government took an aggressive stand on the issue and initiated farmer training in IPM in 1987. That program has grown rapidly and continues to expand to include more farmers and crops other than rice.

Though the training is mainly targeted to rice farmers, because rice is the staple food commodity in Indonesia, producers of other crops have also taken advantage of the training system that has been instituted. Vegetable farmers have a particular interest in IPM because pest problems are much more complex in vegetables than in rice, and pesticide use is much more intense on vegetables (Lim, 1990; Shepard et al., 1997). Therefore, the issue of sustainability of farming practices among vegetable growers is a concern in Indonesia and other areas where similar production techniques are employed. The system that is commonly observed throughout Indonesia in areas where these crops are grown is clearly unsustainable in the long-term. Excessive pesticide use pollutes rural water supplies and causes health hazards for farm workers and rural residents (Kishi et al., 1995). Environmental harm to biodiversity and down-stream habitats has not been measured, but is undoubtedly severe in many localities. The question addressed in this paper is whether trained farmers practice significantly more sustainable techniques, in terms of their overall production systems, than untrained farmers.

Vegetable production is a rapidly increasing component of the agricultural sector in Indonesia (Central Bureau of Statistics, various years). Domestic consumption is rising as incomes increase, and exports, mainly to Singapore and Malaysia, are important for some crops (Ferrari, 1994). Because vegetables are perishable and most vegetable markets are localized, prices are volatile. When prices are strong, vegetable production is very profitable compared to staple crops such as rice. Input costs are high and yields can vary dramatically because of pest problems, so vegetable production is quite risky (Hammig and Rauf, forthcoming). Common production methods for all the major vegetables use high levels of chemical pesticides as one means of mitigating risk. Integrated pest management approaches that have been developed for certain vegetable crops promise to maintain production potential while dramatically reducing, or entirely eliminating, the need for chemical pesticides. These approaches potentially offer vegetable producers increased profits and reduced environmental and health costs (Hammig et al., 1997; Shepard et al., 1997).

METHODS

Data were collected by personal interview during the dry season of 1996. Cabbage growers in the provinces of Central Java, East Java, and North Sumatra, and potato growers from these three and West Java, were surveyed. Two villages were selected from each province to take part in the survey. The villages selected were located in major vegetable growing areas and had access to an IPM training school in the past.[1] Approximately half the farmers surveyed had participated in a school. The sample size was 240 cabbage farmers and 320 potato farmers. Information was obtained related to landholding size and ownership status, variety planted, number and type of pesticides used, cost of pesticides and other farm inputs, reasons for selecting a given type of pest control, and farmer's knowledge of the interaction between pesticides and the agro-ecosystem. Background information on each grower including age, education, family size, and off-farm employment was also gathered. Crop specific information related to the crop harvested immediately preceding the interview.[2]

The Government of Indonesia has recognized the danger of continuing farming practices based on intense chemical pest control (Wardhani, 1991). IPM training programs are designed to help farmers make the decisions necessary to manage their crops most efficiently. This includes reduced dependence on chemical pesticides by increasing reliance on beneficial organisms that naturally occur in crop fields. Furthermore, cultural practices that lead to growing a healthy crop are also studied in the Farmer Field Schools (Oka, 1991; Wardhani, 1991). Thus, farmers who have completed IPM training should be better equipped to select more sustainable farm practices than farmers who have not been similarly trained.

To evaluate the sustainability of farmers surveyed a Farmer Sustainability Index (FSI) was constructed, and each farmer's FSI score was calculated. The method utilized is an extension of the technique developed by Taylor et al. (1993) and applied by Mohammed et al. (1994) in their study of cabbage farmers from the highlands of Malaysia. The FSI index is constructed through the accumulation of a series of score values assigned to specific responses to questions from the survey.

Sustainability involves many different dimensions. In general, it includes some substitution of on-farm resources for purchased synthetic fertilizers and agricultural chemicals and the utilization of certain cultural and conservation techniques. The ultimate goal is to achieve effective and efficient short and long-term use of natural resources while providing income for production expenses and family needs. Examples of sustainable practices include crop rotations and inter-cropping to control weeds and optimize land utilization; modified planting dates and cultural practices; soil erosion control; techniques that release minerals from soil reserves and recycled; selection of disease resistant or tolerant cultivars; use of livestock wastes, crop residues, and green manure to enhance soil fertility; planting of nitrogen-fixing legumes; and application of IPM, which incorporates many of these elements. The FSI used in this study focused on IPM practices, since IPM training was the principal discriminator between the groups of farmers surveyed.

Practices that contribute to profitability, productivity, and environmental and human health are believed to enhance sustainability and were assigned positive values. Different weights were assigned to different practices on the basis of how strongly each practice contributes to sustainability. Negative values were assigned to practices that are not sustainable. Values of zero were assigned to practices that were considered neutral.

For chemical pest control on cabbage, scoring criteria are similar to the criteria used by Taylor et al. (1993) based on their work in the highlands of Malaysia. They followed official IPM recommendations that a maximum of three sprays were necessary to control the diamondback moth, *Plutella xylostella* (L.), and the clubroot plant disease, *Plasmodiophora brassicae*. Thus, a maximum score of four was given to farmers who sprayed only one to four times per season. Eight to 11 sprays was considered neutral, and based on Sastrosiswojo's (1994) estimate that on average cabbage and potato farmers in West Java spray 16 times per season, any number of sprays greater than 19 received a score of negative six.

The scoring for pesticide applications by potato farmers was the same except for two differences. The potato survey included information on fungicide use to control blight (*Phytophthora infestans*) and the number of insecticide treatments to control thrips (*Thrips tabaci*). The maximum score for fungicide was based on Sastrosiswojo's recommendation of approximately four sprays for effective integrated control. The scores for potato insecticide were the same as cabbage except for an upward adjustment to account for an increase in pesticide treatments during the rainy season.

Other adjustments were made for rainfall as well. The survey data in this study were taken from a large geographical area where variation in pest control could be attributed to climatic differences. To account for this variation the mean number of sprays and the average rainfall were calculated for each region. Both sets of values were tested for significant differences in means using ANOVA. The results of these tests are given in Table 1. If a region had a significantly higher number of sprays and a significantly greater amount of rainfall, the FSI score was adjusted accordingly.

Other measures to control pests within the IPM framework include cultural and sanitary practices, the use of control thresholds, sampling techniques, and the use of resistant varieties. Cultural and sanitary practices involve deliberate manipulation of the environment to make it less favorable for insect pests and diseases and more favorable for insect predators and parasitoids (Sastrosiswojo, 1994). For cabbage several of these measures are applied in the IPM approach. The destruction of crop residues after harvest serves as a precaution against

TABLE 1. Average number of pesticide applications and average rainfall, 1989-1994, by crop and province.

Crop/Province	Average number of insecticide applications	Average number of fungicide applications	Rainfall (cm)
Cabbage			
Central Java	8.0[a]	n/a	7.7[a]
East Java	6.0[a]	n/a	4.6[a]
North Sumatra	16.0[b]	n/a	8.7[a]
Potato (dry season)			
West Java	7.9[a]	11.1[a]	5.1[a]
Central Java	12.8[b]	11.0[a]	1.5[b]
East Java	7.4[a]	10.9[a]	2.3[b]
North Sumatra	14.0[c]	9.9[a]	7.9[c]
Potato (wet season)			
West Java	5.9[a]	15.9[a]	11.6[a]
Central Java	8.6[b]	19.7[b]	6.1[a]
East Java	12.3[c]	23.1[c]	7.9[a]
North Sumatra	9.2[b]	17.7[a]	10.2[a]

Note: The Tukey Test was used to compare means. Averages that are not statistically different at a significance level of five percent have the same letter.

future contamination by clubroot and black rot (*Xanthomonas campestris*). Cabbage seedbeds should be planted in areas that have not been planted previously to cabbage. Sterilization of seedbeds and treatment of seeds to control downy mildew (*Peronospora parasitica*) are also important. Treatment of the soil with lime enables the farmer to adjust soil pH for healthier plants. Farmers who use these measures earn positive values in their FSI scores.

Sanitary and cultural practices for potato primarily involve selection of healthy and disease resistant seeds and tubers. There are a number of disease resistant varieties currently on the market in Indonesia. These provide some degree of protection against late blight, and farmers who use them earn positive FSI values. Because blight and viral diseases can be transmitted through the seed tuber, mother plants should be uninfected. The risk of contamination increases if the seed tubers are gathered from the farmer's seedling beds or if they are purchased from other growers. To minimize the risk, tubers should be purchased from a seed producer.

Potato farmers' response to wilted plants within three weeks after planting is important for sanitary reasons. Positive FSI values are assigned if wilted plants are removed and destroyed. Ignoring wilted plants early in the season receives a negative score because of the likely spread of disease organisms requiring future applications of fungicide.

The use of control thresholds is an essential element of IPM methods. Thresholds are based on routine observation of pest populations and some objective measure of the dynamics of population changes. Farmers who sample their fields and use prescribed action thresholds earn positive FSI values. Farmers who follow routine calendar spray schedules are given negative values.

In Indonesia, the use of pesticide "cocktails" is common. Farmers often mix combinations of insecticides, fungicides, foliar fertilizers, and perhaps a surfactant without regard to the condition of the crop requiring application.[3] Van der Noll et al. (1994) reported that vegetable farmers in east central Java routinely mix pesticides under the misperception that one pesticide alone is not powerful enough to remedy the target pest problem. The use of cocktails and the general ignorance surrounding pesticides are detrimental for a variety of reasons. First, the lack of safety precautions during applications results in serious injury to the pesticide applicators (Kishi et al., 1995). Second, inaccurate doses significantly contribute to pest resistance and depletion of predator and parasitoid populations. Third, financial costs of needless pesticides are high. Finally, mixing of chemicals results in combinations of toxic material for which the environmental and health consequences are not well understood, but they are certainly detrimental. Thus, farmers using pesticide cocktails were assigned negative values in their FSI scores.

SUSTAINABILITY RANKING

The results of the FSI scoring for the complete sample of cabbage and potato farmers are given in Table 2. The purpose of the FSI is to measure the degree to which a farmer's activities reflect a norm of sustainable agriculture in the context of IPM practices. The scoring system rated practices that are counterproductive, by the standard of IPM methods, as negative. Thus, farmers receiving a low negative FSI score are considered unsustainable. Similarly, high positive scores indicate that farmers employ sustainable practices. Intermediate scores

TABLE 2. Farmer Sustainability Index (FSI) scores for cabbage and potato farmers.

Crop/Statistic	Raw Score	Indexed Score
Cabbage		
Mean	6.5	53.2
Maximum	19.0	100.0
Minimum	−12.5	0.0
Standard Deviation	4.3	20.6
Potato		
Mean	2.3	53.8
Maximum	23.5	100.0
Minimum	−22.5	0.0
Standard Deviation	8.5	18.5

indicate some mix of sustainable and unsustainable practices. To facilitate ease of interpreting the scores, they were indexed to a scale of zero to 100, where 100 is the most sustainable observation in the sample.

The degree of sustainability characterizing the practices of a particular farmer is subjective, except for those with exceptionally high or low FSI scores. However, a ranking of sustainability based on FSI scores is a useful means for comparing the various groups surveyed. To this end, a five-tier classification scheme was developed. Based on FSI scores, farmers were classified as sustainable, marginally sustainable, neutral, marginally unsustainable, or unsustainable. FSI score ranges and percentage of farmers falling into these categories are presented in Table 3.

The summary statistics for the FSI scores indicate that cabbage and potato farmers in Indonesia show a consistent pattern across crops. About half of the growers of each crop fall in the sustainable categories. The remainder are either neutral or unsustainable.

The same classifications across locations and discriminating between those with IPM training or not are shown for cabbage and potato farmers in Tables 4 and 5, respectively. The majority of cabbage growers in Central Java and East Java are at least marginally sustainable by this measure, while North Sumatra growers are clearly less sustainable. IPM training for cabbage growers in Central Java and North Sumatra appears to provide significant benefit. Trained farmers in these provinces tend to utilize more sustainable practices than their

TABLE 3. Sustainability ranking of cabbage and potato farmers.

Crop	Classification	FSI Score Range	Percentage of Farmers
Cabbage	Sustainable	> 25	23.3
	Marginally Sustainable	10-25	37.1
	Neutral	− 10-10	24.6
	Marginally Unsustainable	− 10- − 25	12.1
	Unsustainable	< − 25	3.0
Potato	Sustainable	> 25	20.1
	Marginally Sustainable	10-25	27.9
	Neutral	− 10-10	27.0
	Marginally Unsustainable	− 10- − 25	15.3
	Unsustainable	< − 25	9.4

TABLE 4. Percentage of cabbage farmers in each sustainability classification based on IPM training.

Location	Classification	All Cabbage Farmers	IPM Trained	Not Trained
Central Java	Sustainable	31.3	60.0	3.0
	Marginally Sustainable	28.8	25.0	33.0
	Neutral	33.8	13.0	55.0
	Marginally Unsustainable	6.3	3.0	10.0
	Unsustainable	0.0	0.0	0.0
East Java	Sustainable	22.5	17.5	27.5
	Marginally Sustainable	62.5	70.0	55.0
	Neutral	13.8	12.5	15.0
	Marginally Unsustainable	1.3	0.0	2.5
	Unsustainable	0.0	0.0	0.0
North Sumatra	Sustainable	21.3	43.0	0.0
	Marginally Sustainable	15.0	25.0	5.0
	Neutral	26.3	18.0	35.0
	Marginally Unsustainable	28.8	10.0	48.0
	Unsustainable	8.5	5.0	13.0

untrained counterparts. Cabbage IPM training in East Java has not resulted in improvements commensurate with the other provinces. This is an indication that training programs are not of uniform quality. IPM methods for all vegetable crops are in early stages of development (Shepard et al., 1997), and pest problems for a particular crop

TABLE 5. Percentage of potato farmers in each sustainability classification based on IPM training.

Location	Classification	All Potato Farmers	IPM Trained	Not Trained
West Java	Sustainable	37.5	70.0	5.0
	Marginally Sustainable	47.5	30.0	62.5
	Neutral	16.2	0.0	32.5
	Marginally Unsustainable	0.0	0.0	0.0
	Unsustainable	0.0	0.0	0.0
Central Java	Sustainable	17.7	31.6	4.9
	Marginally Sustainable	20.2	31.6	9.7
	Neutral	21.5	18.4	26.8
	Marginally Unsustainable	21.5	15.8	26.8
	Unsustainable	18.0	2.6	31.7
East Java	Sustainable	7.5	9.8	5.1
	Marginally Sustainable	28.6	26.8	30.8
	Neutral	27.5	26.8	28.2
	Marginally Unsustainable	21.5	14.6	25.6
	Unsustainable	15.0	21.9	10.3
North Sumatra	Sustainable	17.5	25.0	10.0
	Marginally Sustainable	26.3	27.5	25.0
	Neutral	40.0	37.5	42.5
	Marginally Unsustainable	12.5	10.0	15.0
	Unsustainable	3.8	0.0	7.5

may be different in different places. Therefore, Farmer Field Schools can be expected to display varying degrees of quality.

A similar pattern emerges for potato farmers. As a whole, most potato growers in West Java are in the sustainable or marginally sustainable categories. Growers in the other provinces are much more evenly distributed across the sustainability spectrum. IPM training improves the sustainability of potato growers in all provinces, though the impact in East Java is only slight.

The preponderance of the evidence shows that IPM training is a major factor enhancing sustainability of vegetable production in Indonesia. The theme of the training–to grow a healthy crop–requires that the farmer pay attention to cultural practices in addition to pest control that enhance his production potential within a sustainable system. The data on FSI scores by the farmers represented in this survey indicate that training does, in fact, enhance sustainability and that the lessons learned from the Farmer Field Schools persist over time.

EMPIRICAL MODEL

An empirical model was constructed to evaluate the impact of selected variables on individual FSI scores. By estimating the parameters of this model, one should gain insight into the importance of some farm and farmer characteristics that may enhance sustainability. Also, the model results may serve as a guide for public programs aimed at raising the level of sustainability among Indonesian vegetable growers. The model is specified to explain the FSI as a function of variables related to the farm enterprise and farmer characteristics. In the form of a linear regression the model is:

$$FSI = \alpha + \beta_1 KPI + \beta_2 IPM + \beta_3 ED + \beta_4 JOB + \beta_5 EXP + \beta_6 TSIZE + \beta_7 RENT + \beta_8 LOCATION + \varepsilon$$

where:

FSI = farmer sustainability index, 0-100;
KPI = farmer knowledge and perception index, 0-100;
IPM = 1 if completed IPM training, 0 otherwise;
ED = 1 if completed junior high school or more, 0 otherwise;
JOB = 1 if reported off-farm employment, 0 otherwise;
EXP = 1 if 10 years as farmer, 0 otherwise;
TSIZE = total farm size, 1000 m^2;
RENT = proportion of land rented;
LOCATION = dummy variables for each study site, East Java omitted; and
ε = random error term.

The parameters α and β_i were estimated for each sample of farmers from each location for both crops. Results of the estimations are given in Table 6.

The results show that the knowledge and perception index (KPI), and IPM training are the two major factors leading to sustainability of farming practices by both cabbage and potato growers. The knowledge and perception index was developed in the same manner as the FSI, but different questions and responses were used to construct the KPI.[4] The FSI is restricted to actual production practices employed by the grower while the KPI is derived from grower responses to questions about his knowledge of the ecology of his farm. The model

TABLE 6. Regression results to explain Farmer Sustainability Index for Indonesian cabbage and potato growers.

	Parameter Estimates	
Explanatory Variables	Cabbage	Potato
Intercept	33.79*** (9.52)[a]	35.36*** (9.51)
KPI	0.35*** (7.32)	0.21*** (4.55)
IPM	2.46*** (11.77)	10.92*** (5.27)
ED	1.18 (0.39)	0.65 (0.27)
JOB	4.00 (1.50)	−0.32 (0.16)
EXP	−0.73 (0.32)	−5.72 (2.09)**
TSIZE	0.21 (2.09)**	−0.09 (1.67)*
RENT	[b]	−1.39 (0.40)
CENTRAL JAVA	0.001 (1.35)	−2.48 (0.84)
SUMATRA	−16.71*** (6.35)	−0.71 (0.25)
WEST JAVA	[c]	11.96*** (4.50)
R^2	0.58	0.33

Note: *** = significant at 99%, ** = significant at 95%, * = significant at 90%.
[a]Absolute t-values are given in parentheses.
[b]Rented land for cabbage production was negligible in this sample.
[c]Cabbage data were not collected in West Java.

clearly indicates that sustainability is enhanced through farmer education to understand the biological processes of producing his crop. This model shows that IPM training geared to growing a healthy crop through fundamental understanding of crop ecology is a major contributor to the adoption of sustainable farming practices.

Most of the other variables that were expected to affect sustainability failed to display consistent impacts. The size of farming operation is significant for both cabbage and potato growers, but the direction of the impact is not consistent. Larger size of cabbage growers leads to greater sustainability, but the larger the potato farm the less sustainable it becomes. Experience in farming is consistently negative. Farmers with more than 10 years' experience tend to follow less sustainable practices than their less experienced counterparts, but the effect is not significant among cabbage growers.

Location dummy variables show that compared to East Java, Sumatra cabbage growers are significantly less sustainable. However, potato growers in Sumatra are not significantly different from East Java, while West Java potato growers are more sustainable than those in East Java. These results show that there is no consistent pattern of sustainability uniquely attributable to location. This implies that farmers across the country do not differ substantially in terms of the sustainability of their approach to producing crops unless some intervention occurs that targets the sustainability issue. The IPM training program is one such intervention that provides statistically significant improvements to the sustainability of farm operations.

CONCLUSIONS

This study demonstrates that IPM training is an important factor affecting farm sustainability among Indonesian vegetable growers. And, the impact of IPM training persists over time.

Indonesian vegetable farmers typically apply large amounts of chemical pesticides on vegetable crops. Chemicals are applied to vegetables much more intensively than they are to other crops. Reduction in chemical use can be achieved without loss of yield by employing IPM techniques conveyed to farmers through government sponsored Farmer Field Schools.

Most vegetables in Indonesia are grown in highland regions where temperatures are relatively cool and water is plentiful. These are also delicate ecological zones and farming practices may have noticeable impacts on downstream ecosystems. Thus, the long-term sustainability of vegetable farming systems is a key economic and social issue.

The results of this study demonstrate that farmer training is the crucial element of a strategy to enhance widespread adoption of sustainable practices. Once farmers understand the options available to them, and appreciate the role that naturally occurring beneficial organisms can play in crop protection, they will readily embrace sustainable alternatives. Government policy to support training is therefore clearly in the public interest as well as in the interest of the farmers who receive training.

NOTES

1. The farmers who had IPM training represented in these surveys received training in 1993.
2. Vegetable producers generally plant year around. Rotations vary depending on location and farmer choice based on market conditions and personal preferences. Climate affects the rotation in that the annual pattern varies between the wet season, September to April, and the dry season, May to August.
3. The use of pesticide cocktails, per se, is not necessarily bad; however, the authors' personal observations and discussions with farmers reveal that in the large majority of cases among Indonesian vegetable farmers, pesticides used are not selected because of their particular efficacy against a target pest. Instead, the cocktail is applied in hopes that something in the mix will control the pest.
4. The information used to calculate KPI scores is given in Appendix 1.

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APPENDIX 1. Knowledge and Perception Indexes.

Table A-1. Knowledge and Perception Index for cabbage growers.

Questionnaire Statement	Response	Score
1. Spraying crops within one week of harvest is dangerous to consumers	Agree Disagree	+2 −2
2. Frequent spraying leads to pest resistance	Agree Disagree	+2 −2
3. Recognize predators as enemies of pests	Yes No	+ 1 0
4. Spraying will destroy natural enemies	Yes No	0 −1
5. Elimination of predators will cause pest populations and crop damage to increase	Agree Disagree	+1 0
6. Club root disease is caused by:	a. a "germ" b. "infertile soil" c. "poor quality of dung"	+1 0 0
7. Lime application can reduce club root infestation	Agree Disagree	+1 0

Table A-2. Knowledge and Perception Index for potato growers.

Statement	Response	Score
1. Causal agent of wilt:	"germ" "poor tuber used as seed"	+1 +.5
2. Wilt can be transmitted to healthy crops	Agree Disagree	+2 −2
3. Blight can become resistant	Agree Disagree	+1 0
4. Knows about resistant seed varieties	Yes No	+1 0
5. Recognizes insect predators	Yes No	+1 0
6. Spraying will kill insect predators	Agree Disagree	+1 −1