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An economic evaluation of IPM practices in cabbage production in Cameron Highlands, Pahang

(Penilaian ekonomi terhadap pengalaman IPM dalam pengeluaran kubis
di Cameron Highlands, Pahang)

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Key words: IPM, adoption, economic evaluation

Abstract

Concerns on the negative effects of pesticide use in developing countries have motivated the development of Integrated Pest Management (IPM) programmes in these countries. In Malaysia, the IPM collaborative research support programme (CRSP-IPM) was established to specifically address the widespread misuse of pesticides in cabbage cultivation in Cameron Highlands, one of the major vegetable producing regions in the country.

IPM adoption in cabbage production includes research on the optimal use of pesticides, complementary weed control strategies, and alternative cultural and biological controls. Results of this study showed that the programme would generate economic benefits which include improvements in water quality, food safety, pesticide application safety, and long term sustainability of pest management systems. The calculated economic benefits in terms of aggregate cost savings per season for 102 farmers were RM57,433 for insecticides, RM1,840 for herbicides, and RM311 for fungicides.

Introduction

Pesticides are often applied in inappropriate amounts to cabbage, as there is a premium attached to unblemished and "fresh" looking produce. The most widely used pesticides among cabbage growers in Cameron Highlands are Category II and III. The pesticides are known to have high toxicities. A study on pesticide residues in Malaysia reported that 34.5% of samples contained pesticide residues exceeding maximum residual limit (MRL) (Jusoh et al. 1992). Long-drawn-out exposure to pesticides has been associated with several chronic and acute health effects like non-Hodgkin's lymphoma, leukemia, as well as cardiopulmonary disorders, neurological and hematological symptoms, and skin diseases (Blair and White 1985; Hoag et al. 1986; Antle and Prabhu 1994).

According to the Malaysian Crop Care and Public Health Association (MCPA), RM326 million and RM307 million worth of agricultural chemicals were used in Malaysia during the financial year 2001 and 2002, respectively *(Table 1)*. This represents an average growth rate of 1.76% increase over the past 10 years in the nominal value of agricultural chemicals used in the country. Among the agricultural chemicals, a large percentage of expenditure in recent years (73%) has been for herbicides *(Figure 1)*.

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Table 1. Consumption of agricultural chemicals in Malaysia, 1993–2002 (RM million)

Agricultural chemical	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	AGR (%) 1993–2002
Herbicide	200.0	210.0	220.0	227.0	245.0	235.0	290.0	273.0	220.0	209.0	0.489
Insecticide	39.0	41.0	43.0	47.0	52.0	58.0	65.0	68.0	52.0	62.0	5.151
Fungicide	13.0	14.0	15.0	16.0	17.5	19.0	22.0	23.0	17.5	23.0	6.339
Rodenticide	10.0	11.0	11.0	11.0	11.5	13.0	15.0	14.0	11.5	13.0	2.915
Total	262.0	276.0	289.0	301.0	326.0	325.0	392.0	378.0	326.0	307.0	1.761

Source: Anon. (2003)
AGR = Average Growth Rate

This was followed by 17% for insecticides, 6% for fungicides, and 4% for rodenticide. The use of agrochemicals to improve crop yield and manage pests and diseases continues to be an important input (Anon. 2003). Pests and diseases represent a major constraint hindering the production of vegetable crops in Malaysia. At least 85% of the vegetable farmers reported that pests and diseases were their major problems. About 65% of these farmers needed extensive use of pesticides to control the problems (Ghazali et al. 1994).

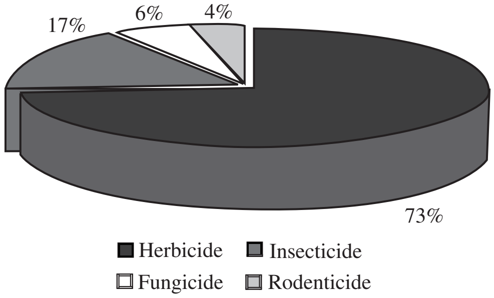

Figure 1. Percentage distribution of agricultural chemicals in Malaysia, 1993–2002

The empirical level of adoption of IPM programme by growers ranges between 30% and 100%, and without significant presence of the extension component, the IPM adoption levels stand at around 30% (Sivapragasam 2001). Adoption of IPM in vegetable production includes research on the optimal use of pesticides, complementary weed control strategies, and alternative cultural and biological controls. If successful, the programme should generate benefits that can be measured in economic terms. These benefits include improvements in water quality, food safety, pesticide application safety, and long run sustainability of pest management systems.

The aim of this study was to carry out economic assessment on the benefits, impacts and factors associated with the adoption of IPM practices in cabbage production within Cameron Highlands..

Methodology

Primary data collection from 102 cabbage farmers in three zones, via, Northern, Central and Southern zones were undertaken to identify farm and farmer characteristics, pesticide usage, pest management practices, perceptions about pesticide hazards, awareness of IPM strategies and willingness to adopt specific IPM technologies. McFadden's Random Utility Model was used as the theoretical framework for analysis of the type of discrete, binary choice problem embodied in selection of pest management technology in this study (Antle and Capalbo 1995).

The decision maker's unobserved net gain in utility of adopting practice *j*, denoted by U^*j is the difference between an individual utility from deciding to adopt the technology and utility from not adopting the technology.

This net gain can be interpreted as being explained by the variables X_j that would have explained utility levels with adoption or without adoption, plus the disturbance term, such that:

$$U^*_j = U_{adoption} - U_{non\text{-}adoption} = X_j\beta_j + \varepsilon_j$$

Since only the decision on whether or not to adopt is observed, it can be inferred that:

$$Y_j = \begin{cases} 1 \text{ if } U^*_j - \varepsilon_j \geq X_j\beta_j \\ 0 \text{ if } U^*_j - \varepsilon_j < X_j\beta_j \end{cases}$$

Where Y_j is a binary variable representing adoption of practice j and X_j is a vector of regressors relevant in explaining adoption.

The likelihood function is formed as: $L=\pi_i\ (e^{Xi\beta}/(1 + e^{Xi\beta}))\ \pi_j\ (1/(1+ e^{Xi\beta}))$; the subscript i denotes adopters and j denotes non-adopters. This likelihood function is maximized with respect to β (using an iterative procedure, usually Raphson-Newton) to get the maximum likelihood estimates of β (β^{MLE}).

The explanatory variables (regressor) used in the logit analysis are classified according to the following general categories:

1) farmer characteristics
2) managerial factors
3) farm structure
4) physical/location factor
5) information/institutional factors
6) awareness/perceptions regarding pesticide impacts.

The variable names used and definitions are provided in *Table 2*.

Results and discussion

A synthesis of results from the estimation and evaluation procedures described in the methodology section is presented here. It begins with a discussion of the results from descriptive statistics analysis of the survey data, and is followed with a discussion of the results from the step-by-step evaluation of the IPM programme in Cameron Highlands, Malaysia.

Table 2. The explanatory variables (regressor) used in the logit analysis

Definition variable	Unit
Farmer characteristics	
Age (AGE)	No. of years
Educational attainment (EDUC)	No. of years
Experience of farming (EXPER)	No. of years in cabbage farming
Tenure status (OWNER)	1 = owner-operator or 0 = otherwise
Managerial factors	
Farm hours (FHOURS)	Time spent on farm per week; number of hours
Off-farm work (OFFWORK)	1 = farmer has off-farm employment or 0 = otherwise
Pesticide costs (PESCOST)	Ratio of pesticide expenses to total operating costs; per cent
Farm structure	
Farm size (FARMSIZE)	No. of hectares
Cabbage profit share (PSHARE)	Ratio of profits from cabbage to total farm income; per cent
Physical/location factor	
Site dummies	1 = farm is located in that site or 0 = otherwise
North zone (NORTH)	
Central zone (CENTRAL)	
South zone[a] (SOUTH)	
Information/institutional factors	
IPM awareness (ADVICE)	1= if farmer had heard of IPM before 1 = farmer obtained pest control from the specified source; 0 = otherwise;
IPM training (ATTEND)	1= farmer attended an IPM training; 0 = otherwise
Awareness/perceptions regarding pesticide impacts	
Preventive against pesticide exposure (PREVENT)	Use of preventive measures against pesticide exposure Health impact (SICK) 1 = farmer got sick after spraying pesticide; 0 = otherwise

[a] Variable dropped from the model to avoid a singular matrix

Socio-economic profile

The respondents, viz farmers were asked about their farm area, which was classified into North, Central and South zones. The number of respondents from North, Central and South zones were 32 (31.4%), 36 (35.3%) and 34 (33.3%) respectively. Among the respondents, 73.5% were Chinese, 21.6% were Indian and 4.9% were Malay. As shown in *Table 3*, majority (91.1%) of the respondents interviewed were above 31 years old. Only 2.9% of the respondents were females. Because of the very limited number of females in the sample, further analysis considering gender differences could not be explored.

Table 3. The socio-economic profile of farmers in North, Central and South zones, 2003–2005

Socio-economic profile		Location -Zone			Total n = 102 (100%)
		NORTH n = 32	CENTRAL n = 36	SOUTH n = 34	
Village	Tanah Rata	NA	9	NA	9(8.8)
	Brinchang	NA	14	NA	14(13.7)
	Kea Farm	NA	13	NA	13(12.7)
	Kuala Terla	11	NA	NA	11(10.8)
	Kampong Raja	15	NA	NA	15(14.7)
	Blue Valley	6	NA	NA	6(5.9)
	Ringlet	NA	NA	17	17(16.7)
	Boh Road	NA	NA	15	15(14.7)
	Bertam Valley	NA	NA	2	2(2.0)
Race	Malay	1	2	2	5(4.9)
	Chinese	23	29	23	75(73.5)
	Indian	8	5	9	22(21.6)
Gender	Male	29	36	34	99(97.1)
	Female	3	NA	NA	3(2.9)
Farmer's age	Below 30 years	4	2	3	9(8.8)
	31–40 years	5	9	11	25(24.5)
	41–50 years	14	18	13	45(44.1)
	Above 51 years	9	7	7	23(22.5)
Academic level	Never been to school	1	NA	NA	1(1.0)
	Primary school	16	8	13	37(36.3)
	Secondary school	13	28	20	61(59.8)
	Higher degree	2	NA	1	3(2.9)
Farmer's experience	Below 10 years	5	4	8	17(16.7)
	11–20 years	16	20	18	54(52.9)
	21–30 years	5	8	7	20(19.6)
	Above 31 years	6	4	1	11(10.8)
Type of farming	Part time	3	3	6	12(11.8)
	Full time	29	33	28	90(88.2)
Time spent on-farm a week	Below 10 hours	2	1	3	6(5.9)
	11–20 hours	6	1	3	10(9.8)
	21–30 hours	6	11	10	27(26.5)
	Above 31 hours	18	23	18	59(57.8)
Income (RM/season)	Below 10,000	1	NA	2	3(2.9)
	10,001–20,000	15	9	18	42(41.2)
	20,001–30,000	8	17	8	33(32.4)
	Above 30,001	8	10	6	24(23.5)

Values in brackets indicate percentage of 'n'
NA = Not available
n = No. of respondents

Most of the respondents (59.8%) had gone through secondary school education and 36.3% had only primary school education, 1.0% received higher education at Bachelor's degree level, 2.0% at diploma level and among the remaining respondents 1.0% did not go to school at all. Ghazali et al. (1994) reported that 16.5% of vegetable growers had no formal education.

The majority of the respondents (88.2%) treated agriculture as their full-time job. About 38% spent 31–40 hours per week on the farm which was equivalent to 5–8 hours per day working on the farms. About 19% were working for more than 50 hours per week, which was more than 8 hours per day working on their farm.

Farm characteristics and operations

Farmers selected across the three zones showed no significant differences in terms of farm characteristics. In terms of land tenure status, 22 farmers or 61.1% of farmers in the Central zone had Temporary Occupational License (TOL) *(Table 4)*. Under TOL, farmers leased lands from the government on a year-by-year basis. In the North and South zones, 46.9% and 41.9% respectively, of the respondents were operating TOL farmlands and the total percentage under TOL was 50.0% of the total 102 respondents surveyed.

Cabbage was usually transplanted two seasons a year, the first round in October, November and harvested before the rains started in December and the second season was from around April to June. Land preparation started 45 days before planting, with harvesting activities between 70 and 120 days after planting. The average farm net income per month for each acre of the cabbage planted in the Central zone was RM10,518 which was substantially higher as compared to those planted in the North and South zones which were RM8,132 and RM8,913 respectively.

Indicators of pesticide exposure

Several questions about farm environment and the precautionary measures the respondents took against pesticide exposures were incorporated in the survey to assess the degree of environmental risks in the areas. Surface water in the regions was at risk from pesticide runoff. The distance of the cabbage farms to surface water ranged from as close as 5 metres to about 300 metres and the average distance was 27.52 metres *(Table 5)*.

In general, the respondents knew about protection against pesticide exposure. More than 80% of the respondents wore face masks (or any substitute), and more than 90% wore long pants or long-sleeved shirts and shoes when applying pesticides.

About 83% of the farmers used government water supply as their main source of drinking water, and only 17% from other sources (river, mountain water and pond). As an indication of how important it was to farmers to avoid being sick from contaminated water, they were asked whether they boiled the water before drinking. About 93% boiled their water before use.

Goodness-of-fit measures of IPM technology adoption

The likelihood ratio tests indicate that the amount of variations explained in each of the model (REPRUN, MULC, TRIWKLY, ONEHERB, MICROBIO, TRAP, and ETL) was significantly different from zero. Two criteria for goodness-of-fit are reported in the table, the –2 Log L statistics. Two values for both measures were highly significant (99.0% confidence level), providing evidence that the regression coefficients were significantly different from zero *(Table 6)*. Count R^2 which is a ratio of correct predictions to the total number of observations was 0.71 for the REPRUN model, 0.75 for the TRAP model, and 0.75 for the MICROBIO model. This suggested that the selected regressors were good predictors of adoption and non-adoption of IPM technologies.

The proportion of correct prediction compares the correct predictions of both adoption and non-adoption with the observed outcomes based on explanatory variable information. Results showed that

Table 4. Summary of farm characteristics

Farm characteristic		Location – zone			Average n = 102 (%)
		NORTH n = 32 (%)	CENTRAL n = 36 (%)	SOUTH n = 34 (%)	
Tenure land status	Self ownership	4 (12.50)	6 (16.67)	2 (5.88)	12 (11.77)
	Rental	12 (37.50)	6 (16.67)	15 (44.12)	33 (32.35)
	TOL	15 (46.88)	22 (61.11)	14 (41.18)	51 (50.00)
	Others	1 (3.12)	2 (5.55)	3 (8.82)	6 (5.88)
Farm size (total)	Below 1.0 acre	4 (12.50)	7 (19.44)	9 (26.47)	20 (19.61)
	1.1–2.0 acres	17 (53.13)	20 (55.56)	15 (44.12)	52 (50.98)
	2.1–3.0 acres	6 (18.75)	8 (22.22)	8 (23.53)	22 (21.57)
	Above 3.0 acres	5 (15.62)	1 (2.78)	2 (5.88)	8 (7.84)
Farm size (cabbage)	Below 0.5 acre	4 (12.50)	9 (25.00)	8 (23.53)	21 (20.59)
	0.6–1.0 acre	9 (28.13)	13 (36.11)	13 (38.23)	35 (34.31)
	1.1–1.5 acres	6 (18.75)	6 (16.67)	5 (14.71)	17 (16.67)
	1.6–2.0 acres	9 (28.12)	5 (13.89)	6 (17.65)	20 (19.61)
	2.1–2.5 acres	2 (6.25)	2 (5.55)	1 (2.94)	5 (4.90)
	Above 2.5 acres	2 (6.25)	1 (2.78)	1 (2.94)	4 (3.92)
Cabbage planted	1.0 season	0 (0.00)	0 (0.00)	3 (8.82)	3 (2.94)
	2.0 seasons	16 (50.00)	22 (61.11)	25 (73.53)	63 (61.77)
	3.0 seasons	16 (50.00)	14 (38.89)	6 (17.65)	36 (35.29)
Cabbage yield/season	Below 5,000 kg	7 (21.88)	7 (19.44)	10 (29.41)	24 (23.53)
	5,001–10,000 kg	13 (40.62)	17 (47.22)	17 (50.00)	47 (46.08)
	10,001–15,000 kg	7 (21.88)	6 (16.67)	5 (14.71)	18 (17.65)
	Above 15,000 kg	5 (15.62)	6 (16.67)	2 (5.88)	13 (12.75)
Cabbage price per kg	Below RM1.00	20 (62.50)	19 (52.78)	19 (55.88)	58 (56.86)
	RM1.01–RM1.50	11 (34.38)	12 (33.33)	11 (32.35)	34 (33.33)
	Above RM1.50	1 (3.12)	5 (13.89)	4 (11.77)	10 (9.81)
Total cost per season	Below RM3,000	10 (31.25)	17 (47.22)	10 (29.41)	37 (36.27)
	RM3,001–RM4,000	12 (37.50)	11 (30.56)	13 (38.24)	36 (35.29)
	RM4,001–RM5,000	4 (12.50)	5 (13.89)	7 (20.59)	16 (15.69)
	Above RM5,000	6 (18.75)	3 (8.33)	4 (11.76)	13 (12.75)
	Total	32 (100.00)	36 (100.00)	34 (100.00)	102 (100.00)

Values in brackets indicate percentage of ‘n’
n = No. of respondents

Table 5. Indicators of pesticide exposure

Pesticide exposure	Percentages of “yes” responses			Total n = 102 (%)
	NORTH n = 32 (%)	CENTRAL n = 36 (%)	SOUTH n = 34 (%)	
Do you boil your drinking water?	29(90.63)	34(94.44)	32(94.12)	95(93.14)
Drinking water source (pond, mountains)	7(21.87)	4(11.11)	6(17.64)	17(16.67)
Do you wear the following?				
Face mask	21(65.62)	34(94.44)	28(82.35)	83(81.37)
Long pants	31(96.88)	36(100.00)	31(91.18)	98(96.08)
Long-sleeved shirts	27(84.38)	34(94.44)	32(94.12)	93(91.18)
Shoes	27(84.38)	35(97.22)	32(94.12)	94(92.16)
Average distance between surface water and cabbage fields (metres)	52.76	15.61	14.20	27.52

Values in brackets indicate percentage of ‘n’
n = No. of respondents

Table 6. Goodness-of-fit measures/Predictive ability of the logit models

Measure of Goodness- of-fit	Logit models						
	REPRUN	MULC	TRIWKLY	ONEHERB	MICROBIO	TRAP	ETL
Adoption (Percentage of correct prediction)	97.5	91.4	91.7	93.9	93.7	87.0	68.8
Non-adoption (Percentage of correct prediction)	77.3	50.0	83.3	88.9	91.7	87.5	97.7
Count R^2	71.57	28.59	65.19	72.84	75.24	75.24	56.77
-2 Log L λ^2 value	65.491	36.277	90.091	96.475	99.647	99.647	50.307
p-value	0.2661	0.6354	0.7471	0.7284	0.5568	0.7591	0.5216

Table 7. Predicted adoption rates by site (region)

	Region (%)			
Variable	SOUTH	NORTH	CENTRAL	Average (%)
REPRUN	64.71	84.38	91.67	80.39
MULC	64.71	68.75	91.67	75.49
MICROBIO	50.00	53.13	94.44	66.67
ONEHERB	44.12	53.13	91.67	63.73
TRIWKLY	50.00	53.13	77.78	60.78
TRAP	38.24	25.00	61.11	42.16
ETL	14.71	9.38	13.89	12.75

the REPRUN model correctly predicts 97% of adoption cases and 77% of non-adoption cases. For the other two models, 87% (TRAP) and 93% (MICROBIO) adoption cases were correctly predicted, while non-adoption was correctly predicted for 87% (TRAP) and 91% (MICROBIO) of the observations. The strong predictive ability of each of the models in estimating the probabilities of adoption provides justification for using these probabilities to project adoption rates in the area.

Estimated adoption rates based on logistic regression

The estimated adoption rates for each technology in each of the sites were based on the logistic regressions. The logit models estimated the predicted probabilities of adoption which are shown in *Table 7*. A farmer is classified as an adopter if the predicted probability of adopting a particular technology for an individual farmer given his or her specific set of attributes, is greater than his or her probability of non-adoption i.e. greater than 50% of the predicted probability of adoption practices REPRUN, MULC, MICROBIO, ONEHERB, and TRIWKLY. While the TRAP adoption was 42.2%, the ETL had only 12.8% of the respondents from the survey.

Factors affecting the adoption of IPM technologies

Influence of the explanatory variables on the adoption of IPM technologies is shown in *Table 8*. Logit regression results for the REPRUN model revealed that farm experiences negatively affect willingness to adopt cabbage pruning and leaf burning as an alternative control for pest larvae and nematodes. The coefficients for AGE and EDUC turned out to be positive while PSHARE and PESCOST variables turned out to be negative. One possible explanation for these results could be that farmers who are younger, highly educated, have smaller farms, have more secure land tenure, and have less experience in vegetable farming carried out more IPM practices. Only the Central zone showed a significant relationship at alpha 5%, while variables FHOURS, PESCOST and NORTH were significant at alpha 10%, and FARMSIZE with PREVENT at 15% level of significance. It shows that the significant variables increased the probability of REPRUN adoption.

The probability of adoption of the MULC model using plastic mulching increased when farmers are young and can spend more hours in their farms. This was proven by the coefficient OFFWORK which was positively correlated with the increase of MULC adoption. Positive correlation was also due to FARMSIZE. It showed that bigger farm size farmers tended to increase MULC adoption. Adoption of more MULC meant that controlling weed was more efficient and at the same time it reduced the amount of weedicides used. On top of savings in environmental costs, the reduction in pesticide use also reduced operating expenses *(Table 9)*. Calculated reduction in economic costs showed the aggregate cost saving per season (of 102 cabbage farmers) were RM57,433 for insecticides, RM1,840 for herbicides, and RM311 for fungicides.

Conclusion

In this study, 102 respondents were interviewed to identify farm and farmer characteristics, pesticide usage, pest management practices, perception about pesticides' hazards, awareness of IPM strategies and willingness to adopt specific IPM technologies. The probabilities of adoption of the IPM technologies were predicted using a maximum likelihood logit model. The adoption model incorporated information on farmer attributes, farm structures, environmental awareness, managerial factors, and perceptions to predict willingness to adopt the technologies. The predicted adoption rates for each technology were: 80.39% for the REPRUN, 75.49% for the MULC, 66.67% for the MICROBIO (BT.), 63.73% for the ONEHERB, 60.78% for the TRIWKLY, 42.16% for the TRAP, and 12.75% for ETL technology. Calculated reduction in economic costs showed the aggregate cost saving per seasons (of 102 cabbage farmers) of insecticides, herbicides and fungicides was RM59,585.

The estimated adoption model provided insights into the factors that influence adoption of different technologies. For example, information factors such as the source of pest control advice were highly significant in the different models. Results indicated that if pest control advice was obtained through farmer cooperatives, the probability of adoption also increased.

The educational efforts designed to increase awareness may be worthwhile. The adoption model estimated allows for adoption rates to be further projected to a larger community and bigger population given information on average values of general socio-economic attributes of cabbage producers is available.

This study provides justification for public investment of resources in training and educational programmes to increase awareness about IPM and promote IPM adoption particularly in areas like North zone. The South group even has an advantage over the North group in that they have been exposed to IPM concepts in cabbage and some of the practices and beliefs learned from cabbage IPM are carried over in their cabbage farming.

The Central groups on the other hand are proactive and very receptive to try out new technologies. Since the cooperative is already investing in training programmes and seminars about IPM, price incentives or market-based policies such as accreditation scheme might be the best approach to promote adoption of IPM technologies. These groups of farmers are more likely to react to pricing regulations such as lower price of bioinsecticides (like those containing *Bacillus thuringiensis*) since a substantial portion of their operating costs (26%) are spent on pesticides.

The economic success of a highly organised group of farmers makes a good case for espousing establishment of farmers' cooperatives to help hasten IPM technology

Table 8. IPM willingness to adopt models: Logistic regression results

IPM Model	REPRUN		MULCH		TRIWKLY		ONEHERB		MICROBIO		TRAP	
Variable [a]	Parameter estimate	Odd-ratio	Parameter estimate	Odd-ratio	Parameter estimate	Odd-ratio	Parameter estimate	Odd-ratio	Parameter estimate	Odd-ratio	Parameter estimate	Odd-ratio
INTERCEPT	-7.8593	0.0004	-4.5726	0.0103	-12.5572**	0.0000	-20.8104**	0.0000	-21.2184**	0.0000	-12.3294	0.0000
AGE	0.0310	1.0315	-0.0169	0.9832	-0.0523	0.9490	-0.2136	0.8076	-0.2689*	0.7642	0.0747	1.0775
EDUC	0.1782	1.1951	0.1584	1.1717	0.1227	1.1305	0.4775	1.6121	0.4953	1.6411	0.1394	1.1496
EXPER	-0.0264	0.9740	0.0478	1.0490	-0.0120	0.9881	0.0227	1.0230	0.0894	1.0936	-0.1279*	0.8799
OWNER	0.7031	2.0201	-1.6630**	0.1896	1.8121	6.1230	-0.6002	0.5487	-1.3003	0.2725	-0.2091	0.8113
FHOURS	0.0997*	1.1048	-0.0003	0.9997	0.0169	1.0171	0.1005	1.1057	0.1124	1.1189	-0.0596	0.9422
OFFWORK	2.6897	14.726	0.2625	0.7691	0.1133	1.1199	2.9030	18.227	3.4012	30.0013	-1.5361	0.2152
PESCOST	-0.0022*	0.9978	-0.0017**	0.9983	-0.0050***	0.9950	-0.0036***	0.9964	-0.0050**	0.9950	-0.0051***	0.9949
FARMSIZE	1.0761	2.9332	1.0096**	2.7445	2.6672***	14.399	2.2142**	9.1544	3.2112**	24.8086	2.4057***	11.086
PSHARE	-0.0165	0.9836	0.0240	1.0243	0.0325	1.0331	0.0356	1.0363	0.0423	1.0432	-0.0093	0.9908
NORTH	2.2714*	9.6934	-0.0301	0.9703	0.6896	1.9929	3.5750**	35.692	3.1484*	23.2983	1.4429	4.2330
CENTRAL	3.0691**	21.522	0.7495	2.1159	0.1391	0.8701	4.8216***	124.15	5.3073***	201.8006	1.3020	3.6765
ADVISE	0.4820	1.6193	-0.3140	0.7305	1.8937*	6.6438	2.5212	12.443	3.5404*	34.4821	3.7872**	44.130
PREVENT	0.3627	1.4372	0.1600	1.1735	2.2079**	9.0966	3.8734**	48.105	3.7575**	42.8395	1.1781	3.2483

[a] Variables that significantly affect the dependent variable are noted with asterisks; ***indicates the variable is significant at $\alpha = 1\%$, **for 5 % level of significance, and *represents 10% level of significance

Table 9. Cost savings from adoption of IPM technologies

IPM Technology	Cost savings (RM) on expenditures for pesticides per season		
	Insecticides	Herbicides	Fungicides
MICROBIO	14,694.36	NA	NA
TRIWKLY	12,831.46		
TRAP	11,201.77		
ETL	3,710.20		
REPRUN	14,995.81		311.00
ONEHERB	NA	853.13	
MULC	NA	987.53	
TOTAL	57,433.60	1,840.66	311.00

NA = Not available

transfer. The IPM – CRSP technologies can reduce pesticide use in cabbages without loss of efficacy. For example, results of the IPM – CRSP field trials showed that herbicide use could be reduced by as much as 50% with adoption of the alternative weed control strategies, and a no-insecticide option is viable to control cabbage pest if biological controls are used.

Finally, as soon as farmers begin to adopt these technologies, impacts on pesticide use can be more accurately estimated. Because different farmers face different constraints or production functions, the reduction in pesticide use from adoption of the technologies may differ from one farmer to another.

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Abstrak

Atas keprihatinan terhadap kesan penggunaan racun perosak oleh negara-negara membangun telah mendorong pembangunan program pengurusan serangga perosak bersepadu (IPM). Di Malaysia, program IPM melalui gabungan penyelidikan dan sokongan (CRSP-IPM) telah diwujudkan khusus bertujuan menyelesaikan masalah penggunaan lebihan racun perosak pada tanaman sayuran kubis di Cameron Highlands, yang merupakan antara kawasan pengeluaran utama sayuran di negara ini.

Pengamalan IPM dalam pengeluaran kubis meliputi penyelidikan tentang pengawalan penggunaan racun serangga perosak secara optimum, teknik pelengkap dalam pengawalan rumpai, dan amalan pengawalan perosak secara biologi. Hasil kajian telah menunjukkan bahawa program ini memberi faedah ekonomi yang meliputi penambahbaikan kualiti air, keselamatan makanan, keselamatan penggunaan racun perosak, dan meningkatkan pengurusan perosak yang mampan dalam masa jangka panjang. Hasil pengiraan mendapati faedah ekonomi diperoleh impak daripada agregat pengurangan kos semusim bagi 102 peladang bagi racun serangga perosak adalah sebanyak RM57,433 racun rumpai sebanyak RM1,840 dan racun kulat sebanyak RM311.