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Adoption of integrated pest management (IPM) technologies in Southern Philippines: constraints and motivations

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Abstract Determining the factors that influence farmers' adoption of IPM is critical to a successful sustainable pest management program. This study was conducted to determine the constraints and motivations in IPM adoption, involving 112 farmer participants of a Two-year IPM Training program (Years 2018 to 2019) in Southern Philippines. Of the 40 adopted technologies, ten were affected by training attendance. Most of the adopted technologies belonged to the bottom tier of the IPM Pyramid, which are the abiotic actions such as crop rotation, adopted by 42 to 85% of the participants. Training completers had higher level of adoption, from moderate to very high, than absentees whose adoption were mostly from low to moderate. Learners of IPM-based pesticide use also adopted IPM technology at a higher level than non-learners. Motivations, such as increases farm productivity and income, highly influenced training attendance. Constraints influenced the level of adoption. Lack of time and capital were common constraints among the various adopters, from low to very high adopter types. Low to high adopters also indicated laziness as a constraint in IPM adoption. Thus, these constraints and motivations are important factors to consider in designing IPM training programs to encourage attendance to training and, eventually, adoption of IPM technologies.

Keywords: Adoption constraint, Adoption motivation, Integrated pest management, Technology adoption

Introduction

Integrated Pest Management (IPM) is a crop protection strategy with promising benefits of profitability and sustainability to its adopters (Parsa *et al.*, 2014). Its practice aims to promote minimized applications of chemical pesticides with emphasis on the safe and proper pesticide management (Stenberg, 2017). It comprises of multiple compatible technologies for pest suppression that are safe, cost-effective and environmentally friendly. Throughout the years, the IPM concept evolved, although the management of pest population, rather than controlling it, remained as the core of the concept (Peterson *et al.*, 2018).

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IPM is a holistic approach to pest management using available resources (Stenberg, 2017). It incorporates various pest management strategies into a system and optimizes them to understand the compatibility of these strategies (Stenberg, 2017). Optimization is relevant because the different strategies can have synergistic or antagonistic effects when applied at the same time (Stenberg, 2017). Ecological and evolutionary concepts are key concepts in IPM, thus, discussions of ecological relationships in IPM are inevitable (Peterson *et al.*, 2018). In particular, managing pest population, below a certain level that causes substantial host stress, is an acceptable approach, rather than killing the pests in totality (Peterson *et al.*, 2018). Thus, taking advantage of host resistance is a priority in pest management which is relevant in the practice of IPM (Stenberg, 2017). Generally, interaction within the IPM system involves the host's resistance affecting other components of the system, while, all the other elements affecting the biological control agents (Stenberg, 2017).

The IPM Pyramid is an important element of the IPM concept. This shows the organization of different crop protection strategies into pyramidal tiers: the bottom, the middle and the top tier (Stenberg, 2017). Briefly, the bottom tier consists of abiotic actions applied anytime including mechanical, physical, cultural, optic, and audative control practices. Above the bottom, the middle tier consists of practices that are classified as 'ecological' such as the biological control. Finally, the top tier of the pyramid includes application of chemical pesticides that is based on the economic threshold level (ETL) or action threshold. The ETL justifies applying pesticide only when necessary, that is, if the technologies at the bottom and middle tier failed to keep pest populations under ETL.

In the Philippines, various programs were developed to promote IPM. These programs are implemented by various government agencies for adoption by the local farmers (Oliver and Dizon, 2016). Among the factors influencing IPM adoption, technical assistance, training, financial assistance, farmers' knowledge and monthly income mainly influenced the adoption of IPM. Providing technical assistance and training remain as top priority activities in various extension programs in the country (Oliver and Dizon, 2016), thus, extension programs often commence with these activities.

Despite the apparently substantial promotion, IPM adoption remained low (Alwang *et al.*, 2019). From farmers' perspective, awareness and knowledge, perceptions of low profitability of IPM technologies, and risk and uncertainty were identified as main contributory factors to low IPM adoption (Larochelle *et al.*, 2019). Substantial reports on IPM adoption involving key informant farmers and agronomists were also able to reflect complex issues (Jørs *et al.*, 2017). The reasons for low IPM adoption also differed in developing countries than in developed countries which emphasizes the presence of differential prioritization when it comes to IPM adoption (Parsa *et al.*, 2014). IPM adoption obstacles in developing countries are continuously overlooked by the literature (Parsa *et al.*, 2014). Adoption studies have been done for years but few efforts have applied a behavioral economic perspective (Alwang *et al.*, 2019). Understanding behaviors of farmers may help in making informed decisions in crafting strategies to overcome these behavior-related hindrances in IPM adoption (DellaVigna, 2009). A more vigorous analysis of these factors need to be done (Parsa *et al.*, 2014), particularly, looking at the constraints and motivations that influence farmers' behavior towards IPM adoption.

IPM adoption requires farmers' participation in IPM training programs. To improve adoption, technical assistance and training must continuously be provided by implementers (Oliver and Dizon, 2016). Intensive training of farmers is necessary to gain a positive outcome despite the complexity of the IPM Concept (Alwang *et al.*, 2019). Dividing a training into various sessions allows better recall and absorption of knowledge (Cepeda *et al.*, 2006). Hands-on sessions to familiarized farmers in IPM practices also increase technical efficiency of the farmers (Rahman and Norton, 2019). Guided by these information, this study was conducted and sought to determine the constraints and motivations in IPM adoption and the relationship of adoption to training attendance and learning acquisition. This was conducted from the year 2018 to 2019 and involved 112 farmer participants from five towns in Southern Philippines, who were registered in the Two-year IPM Program funded by the Commission on Higher Education - National Agriculture and Fisheries Education System. The study was done with the assistance from the Department of Agriculture and the Local Government Units of the five towns. The results of this study could be used by concerned government agencies and proponents of extension programs in designing appropriate IPM training programs to enhance IPM adoption in the country.

Materials and methods

Description of the research area

The study was conducted in thirteen villages within five towns in the Region of SOCCSKSARGEN (Region XII) located in the Southern part of the Philippines. The region has a total land area of 2,243,651 hectares of which 775,309 hectares are used for agricultural production. More than 4 million people live in the region and about 837,000 people are employed in the

Agricultural Sector which represents 50.2% of the entire regional population (NEDA XII, 2011).

The five towns namely General Santos City, Maitum in Sarangani Province, Surallah in South Cotabato Province, Bagumbayan in Sultan Kudarat Province and Midsayap in Cotabato Province were selected as recipients of a Two-year IPM Program funded by the Commission on Higher Education - National Agriculture and Fisheries Education System. The selection was done with the assistance from the Department of Agriculture (DA) in Region XII and the five towns under the Local Government Units based on the profile of the farmers and the need for IPM trainings in the area.

Selection of farmer participants and conduct of the trainings

There were 112 farmer participants in the Program. The main crop of these farmers were rice or corn or both. These farmers own a minimum of half hectare of land. They were selected by the DA because they have not received any IPM training for the past ten years.

Various training sessions were conducted in a span of two-years from the year 2018 to 2019 which included lectures, hands-on, field trips, farm visits, demo farm activities and one-on-one teaching-assistance approach. Two training modules were developed and translated into four Philippine vernacular namely Bisaya, Hiligaynon, Maguindanaon and Filipino. These modules were used during the training sessions wherein 40 IPM technologies within the IPM Pyramid Tiers were emphasized (Table 1). A total of 34 technologies in the bottom tier of the IPM Pyramid composed the training. These are all abiotic actions to control pests and diseases. Six were in the middle tier of the IPM Pyramid which are ecology-based control measures. The training also incorporated the IPM-based pesticide use which focused on pest identification, the concept of the Economic Threshold Level (ETL) for the pests and diseases, and proper use, handling and storage of pesticides.

Data collection and statistical analyses

A one-on-one interview of each of the 112 respondents was done at the end of the program. The interview was guided by a questionnaire comprising of open and closed-ended questions. The questions were related to the participants' attendance to trainings, technology adoption, and the constraints and motivations in attending trainings and adopting technologies. Answers that require clarifications were verified based on the monitoring reports made during farm visits, by communicating with the DA or contacting the farmer. Short quizzes were also administered post-training.

Data were collated and subjected to appropriate statistical analysis. Basic statistics such as frequencies, averages and percentages were obtained. A binary logistic regression was done to examine whether training attendance had a significant effect on the odds of adopting specific IPM technologies among the 40 IPM technologies. A Pearson Chi-square Test of Independence was also done to examine whether training attendance or adoption and constraints were independent. This test was also used to examine whether learning acquisition or constraints and level of adoption were independent. The Fisher's Exact Test was used to examine relationships between motivation or constraints and training attendance when Chi-square test was not appropriate.

Table 1. Forty technologies in the IPM Pyramid emphasized during the two-year IPM training of small landholder farmers of Region XII, Southern Philippines

IPM Pyramid Tier	Technologies
Bottom (Abiotic actions)	1) Planting Resistant Variety, 2) Proper Crop Maintenance, 3) Rouging, 4) Shredding, 5) Pasturing, 6) Flooding, 7) Burning, 8) Solarization, 9) Proper Animal Waste Management, 10) Proper Crop Harvest and Storage Management, 11) Tillage, 12) Planting, 13) Date Manipulation, 14) Trenching, 15) Girdling, 16) Reflective Mulches, 17) Indigenous Mulching, 18) Use of Trap, 19) Use of Sound, 20) Border Cropping, 21) Crop Rotation, 22) Multicropping, 23) Agroforestry Conservation, 24) Organic Farming, 25) Use of Organic Pesticide, 26) Use of Indigenous Microorganism (IMO), 27) Use of Oriental Herbal Nutrients (OHN), 28) Use of Fermented Plant Juice (FPJ), 29) Use of Fermented Fruit Juice (FFJ), 30) Use of Fermented Fish Amino Acid (FFAA), 31) Weed Control Action Indicator, 32) Pest Damage Percentage, 33) Average Pest Count, and 34) Trap Barrier System
Middle (Ecology-based)	35) Use of Predator, 36) Use of Parasitoid, 37) Use of Pathogen, 38) Use of Antagonist, 39) Use of *Metarhizium anisopliae* and 40) Use of *Trichoderma harzianum*
Top	IPM-based Pesticide Use with knowledge on Pest Identity, Economic Threshold Level and Proper Pesticide Use, Handling and Storage

Results

Effect of training attendance to IPM technology adoption

Majority of the respondents completed all the trainings without absenteeism (Table 2). A number of technologies out of the 40 technologies introduced and emphasized during the Two-year long training series were adopted by the farmer participants. A wide range of adoption from low to very high was exhibited by the completers with percentages ranging from 4.46 to 45.54%, while, by the absentees with percentages of 0.89 to 5.36% and no high adoption. There was an association between attendance to training and level of adoption. Completers had high and very high adoption levels, while only one absentee exhibited very high adoption but no high adoption.

Table 2. Relationship of training attendance to the level of adoption of IPM by farmers of Region XII, Southern Philippines (n, 112)

Level of adoption/1,4	**Frequency (n) and percentage (%) by attendee type**2			
	Completers/2		Absentees/3	
	n	%	n	%
Low	9	8.04	6	5.36
Moderate	51	45.54	6	5.36
High	34	30.36	0	0.00
Very High	5	4.46	1	0.89
Total	99	88.39	13	11.61

1/ Pearson Chi-square Test showed significant relationship of training attendance to the level of adoption based on an alpha value of 0.001; p-value, 0.0009.
2/ Completers had perfect attendance to all trainings.
3/ Absentees had recorded absence to at least one training.
4/ Level of adoption was based on the percentage of adopted technologies, out of the 40 technologies, as follows: Low (<25%); Moderate (25 to 50%); High (51 to 75%); and Very High (76% or higher).

Impact of training attendance to adoption of specific IPM Technologies

Only 45% or 18 out of 40 technologies were adopted by the farmers but adoption percentage varied with the technology being examined involving at least 41.96% of the adopters. Adoption of only ten out of the 40 technologies was affected by training attendance (Table 3). The overall model for adoption of each of these ten technologies was of excellent fit, indicating that training attendance affected the odds of adopting these technologies with percentage decrease ranging from 75 to 92% for a unit increase in absenteeism.

Effect of learning acquisition on ETL concept and IPM-based pesticide use to IPM technology adoption

Majority of the respondents (91.96%) considered chemical control as one of the options for controlling pests and diseases which is in the top tier of the IPM Pyramid while the remaining percentage of 8.04% indicated that they did not use any chemical pesticide and depended on control measures in the bottom and middle tier of the IPM Pyramid.

Learning acquisition on IPM-based pesticide use and the level of adoption were dependent of each other (Table 4). However, the level of adoption was independent of the learning acquisition on ETL concept. A wide range of adoption was shown, with high to very high adoption generally attributed to learners.

Table 3. Technologies with adoption affected by training attendance of farmers of Region XII, Southern Philippines (n, 112)

Specific Technology/1	% adoption/2	Model/3, $\chi^2(1)$=	McFR2/4	Decrease in odds of adoption (%)
Shredding	59.82	5.08	0.03	75
Planting Dates Manipulation	84.82	4.93	0.05	78
Crop Rotation	42.86	5.06	0.03	79
Organic Farming	60.71	8.67	0.06	84
Use of Indigenous Microorganisms	59.82	12.38	0.08	90
Use of Oriental Herbal Nutrient	44.64	9.69	0.06	91
Use of Fermented Plant Juice	47.32	10.90	0.07	92
Use of Fermented Fruit Juice	41.96	8.56	0.06	90
Parasitoid Use	44.64	5.66	0.04	81
Antagonist Use	66.07	11.51	0.08	88

1/ Binary logistic regression showed that training attendance had a significant effect on the odds of adopting specific IPM technologies at alpha of 0.05.
2/ Percentage of respondents who adopted the specific technology.
3/ Significant model at alpha of 0.05.
4/ McFadden's R^2 values of > 0.2 are indicative of models with excellent fit.

Table 4. Relationship of learning acquisition, on ETL Concept and IPM-based pesticide use, to IPM technology adoption by farmers of Region XII, Southern Philippines (n, 112)

Concept[/1]	Learning acquisition[/2]	% respondents by level of adoption[/3]			
		Low	Moderate	High	Very high
ETL[ns]	No	0.00	3.50	14.71	16.67
	Yes	100.00	96.49	85.29	83.33
Pest Identification*	No	20.00	7.02	0.00	0.00
	Yes	80.00	92.98	100.00	100.00
Pesticide Handling*	No	20.00	21.05	0.00	0.00
	Yes	80.00	78.95	100.00	100.00
Pesticide Formulations*	No	33.33	1.75	20.59	0.00
	Yes	66.67	98.25	79.41	100.00
Pesticide Toxicity*	No	40.00	5.26	41.18	33.33
	Yes	60.00	94.74	58.82	66.67
Pesticide Pictograms*	No	20.00	1.75	20.59	0.00
	Yes	80.00	98.25	79.41	100.00
Safe-use of Pesticides*	No	33.33	3.51	41.18	0.00
	Yes	66.67	96.49	58.82	100.00

[1]/ *Significant using Pearson Chi-square Test based on an alpha value of 0.05; ns, Not significant.
[2]/ Yes indicates that respondents correctly answered an average of at least 60% of the questions in quizzes.
[3]/ Level of adoption (based on the % of adopted technologies): Low (<25%); Moderate (25 to 50%); High (51 to 75%); and Very high (76% or higher). Percentages presented are within the level of adoption for each concept.

Motivations and constraints to adoption of IPM technologies

Motivations and training attendance were dependent of each other (Table 5). Constraints and level of adoption were also dependent of each other. Motivations, such as increases farm productivity and income, highly influenced training attendance for both completers and absentees. Motivations did not influence the level of adoption of IPM technologies. Constraints influenced the level of adoption. Lack of time and capital were common constraints among the various adopters, from low to very high adopter types. Low to high adopters also indicated laziness as a constraint in IPM adoption but not very high adopters.

Table 5. Motivation and constraints to adoption of IPM technologies based on training attendance and level of adoption by farmers of Region XII, Southern Philippines (n, 112)

Motivation[1]	**% respondents by attendee type**[2]		**% respondents by level of adoption**[4]			
	Completers	Absentees	Low	Moderate	High	Very high
Increases productivity	40.40	30.77	40.00	36.84	47.06	16.67
Increases income	34.34	30.77	33.33	28.07	38.24	66.67
Becomes more efficient	7.07	30.77	20.00	12.28	0.00	16.67
Increases knowledge	5.05	7.69	0.00	10.53	0.00	0.00
Others	13.13	0.00	6.67	12.28	14.71	0.00
Constraints[3]						
Lacks time	24.24	7.69	0.00	26.32	26.47	16.67
Too tedious	11.11	7.69	0.00	10.53	17.65	0.00
Prioritizes personal affairs	10.10	7.69	0.00	14.04	8.83	0.00
Lacks capital	8.08	7.69	26.67	3.51	2.94	33.33
Laziness	7.07	23.08	33.33	5.26	5.88	0.00
Lacks resources	5.05	7.69	6.67	7.018	2.94	0.00
Others	34.34	38.46	33.33	33.33	35.29	50.00

[1]/ Significant relationship between motivation and attendee type determined using Fisher's exact test based on an alpha value of 0.05.

[2]/ Completers had perfect attendance to all trainings. Absentees had recorded absence to at least one training. Percentages presented are within each attendee type.

[3]/ Significant relationship between constraints and level of adoption determined using Pearson Chi-square Test based on an alpha value of 0.05.

[4]/ Level of adoption was based on the percentage of adopted technologies, out of the 40 technologies, as follows: Low (<25%); Moderate (25 to 50%); High (51 to 75%); and Very High (76% or higher). Percentages presented are within each level of adoption.

Discussion

Training is an avenue for learning new knowledge. In extension services for farmers, trainings are vital activities which aim at enhancing farmers' knowledge and skills in various agricultural systems such as the IPM (Lukuyu *et al.*, 2012). They bring new knowledge or awareness which directly affects the level of IPM adoption (Jayasooriya and Aheeyar, 2016). Increasing IPM adoption requires increasing awareness about IPM through trainings (Kirinya *et al.*, 2013). IPM adoption also requires farmers' participation in

IPM training programs (Oliver and Dizon, 2016). Farmers' trainings are often conducted not shorter than a day, thus, the learning process is intensive (Mazur, 2014). This intensive training is necessary to gain a positive outcome despite the complex IPM concepts discussed during trainings (Alwang *et al.*, 2019). Even though the trainings were divided into various sessions which allows better recall and absorption of knowledge (Cepeda *et al.*, 2006), missing even a single day of training could mean missing a substantial amount of new knowledge. Missing a single session can also make a participant out of track of the topics which may result to confusion and the eventual discouragement to adopt the technology. This reiterates that attendance to training highly influenced the level of adoption of IPM. Completers are more likely to adopt at higher levels than those who were absentees. The reason could be because completers were able to gain more knowledge about the technologies through the trainings. Concepts such as that of the IPM are novel for those who had not attended IPM trainings for at least ten years. Concepts that are novel but frequently discussed are better understood by farmers which potentially lead to adoption (Jayasooriya and Aheeyar, 2016). Hands-on sessions also familiarized farmers in IPM practices which can also increase their technical efficiency (Rahman and Norton, 2019), however, the farmer should be present during these sessions in order to practice IPM. Absenteeism reduced the amount of information accessed by farmers which is a clear obstacle to IPM adoption (Alwang *et al.*, 2019). Therefore, the challenge boils down to designing trainings that are encouraging, interactive and favorable to farmer participants in order for farmers to have the urge to attend and complete training sessions.

When breaking down IPM technology package into its various components (Stenberg, 2017), it is still evident that training attendance affects the odds of adopting specific technology. Mostly, technologies adopted belong to the bottom tier of the IPM Pyramid which are the abiotic actions such as cultural control (Stenberg, 2017). A number of ecology-based controls in the middle tier of the IPM Pyramid were also adopted. Despite the discrepancies in adoption, it does not mean that one tier is far more superior than the other, given that IPM emphasizes compatilibity among the strategies used. The possible reason for such discrepancy is that the amount of technologies in the bottom tier is substantial, thus more options are available for farmers to select than those in the middle tier. Furthermore, ecology-based control requires the use of living organisms which means that the possibility of mortality of the biological control agent and discontinuity of applying the control is also inevitable (Stenberg, 2017). Often times, complex IPM practices increases the burden on potential adopters, which tends to discourage adoption (Alwang *et* *al.*, 2019). Nevertheless, it is undeniably true that a unit increase in absenteeism resulted to decreased technology adoption by 75 to 92%. This denotes that it is essential to design trainings that participants would not want to miss in order to promote increased IPM adoption. It is also important to design technology packages that are easily implemented because farmers adopt IPM in a piecewise fashion (Alwang *et al.*, 2019).

Almost 92% of the respondents recognized the use of chemical pesticides as a component of IPM. IPM-based pesticide use is located in the topmost tier of the IPM Pyramid (Stenberg, 2017). Learners tended to adopt IPM technology at a higher level than non-learners. Specifically, important concepts learned included Pest Identification, Pesticide Handling, Pesticide Formulations, Pesticide Toxicity, Pesticide Pictograms and Safe-use of Pesticides. These concepts appeared to be easily learnt by farmers and were obviously useful in the field (Togbé *et al.*, 2015). Learning the ETL Concept was independent of the level of adoption. Both learners and non-learners can adopt IPM at various levels. Even learners of ETL Concept can have low adoption while non-learners can have high adoption. ETL Concept is more complicated than the other concepts in IPM-based pesticide use, which requires a rigorous process of teaching and learning (Alwang *et al.*, 2019). Practices that are simple are more likely to be adopted (Heong and Escalada, 1998). Since ETL is pest specific, it is not possible to provide generalizations or develop a one-size-fits-all IPM package (Alwang *et al.*, 2019). This provides a greater challenge to agricultural scientists because establishing an ETL, even for one pest alone, requires extensive research works and exchanges of scientific information which are not only resource-requiring but also temporally sensitive.

Motivations influenced training attendance while constraints affected IPM Technology adoption. Among the motivations, productivity and economic motivations were major influencing factors in training attendance. Economic and time constraints were major factors influencing the level of adoption as indicated by very high level adopters. Since IPM requires collective action (Parsa *et al.*, 2014), productivity such as increased yield and income was a sound reason to complete trainings. Although this motivation was not dependent on the level of adoption as presented in this study, this still qualifies as a main contributory factor to IPM adoption as reported by others (Alwang *et al.*, 2019). Economic and time constraints were prominent obstacles for adopting IPM (Oliver and Dizon, 2016) but overcoming these constraints led to very high adoption. Many low level adopters also indicated laziness as a major obstacle to IPM adoption. This seems odd but had compelling psychological explanations (DellaVigna, 2009). In behavioral perspective, this constraint belongs to the non-standard preferences which is similar to procrastination (Alwang *et al.*, 2019). Because IPM adoption tend to require more effort, low adopters may be overwhelmed with the amount of work required and eventually decide to just continue with their usual practice (Heong and Escalada, 1998).

This study revealed that completing IPM trainings resulted to higher adoption level. Completers were more inclined to adopt specific types of technologies than absentees. Learners had higher adoption level than non-learners. Increased farm productivity and income were major motivations of farmers in attending trainings, while lack of time and capital were major constraints in technology adoptions for all levels of adopters and laziness for low adopters. Motivations did not differ among completers and absentee but constraints did. Finally, motivations did not differ with the level of adoption but constraints did. Thus, these constraints and motivations are important factors to consider in designing IPM training programs to encourage attendance to training and, eventually, adoption of IPM technologies.

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