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DETERMINANTS OF PESTICIDE MISUSE IN PHILIPPINE ONION PRODUCTION

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ABSTRACT

Pesticide misuse can be a serious problem in developing countries where environmental laws tend to be lax. Vegetable crops are especially susceptible because of the large amounts of pesticides applied per hectare and relative lack of information on appropriate pest management practices. Farm households were surveyed in six villages in the Philippines to gather information on their pest problems and perceptions, pest management practices, and socioeconomic characteristics. The data were analyzed in a logit analysis to assess socio-economic factors influencing pesticide misuse on onions. Reduced misuse is associated with age, education, pest management training, and credit from a cooperative. Increased misuse is associated most strongly with visits by chemical company representatives or by Department of Agriculture technicians or with belonging to a cooperative or village association. The need for training for both farmers and agricultural technicians is evident from this study.

INTRODUCTION

Pesticides have contributed to sizeable productivity gains in agriculture worldwide. However many pesticides, particularly if misused, are hazardous to the environment and human health. Dangers to the environment and health are particularly strong in developing countries where environmental laws tend to be lax and producers often have little or poor information about the products they apply. Scientists at the International Rice Research Institute (IRRI) have found that injudicious use of insecticides in the Philippines, for example, particularly early in the growing season, are disrupting the natural ability of the rice ecosystem to cope with pest infestations (Heong *et al.* 1995). And, they have found that unsafe application practices are damaging farmer health (Rola and Pingali, 1993). A participatory appraisal activity with rice-vegetable farmers in Nueva Ecija province in the Philippines found heavy pesticide use on onions, eggplant, and yard-long beans with apparent pesticide misuse (Litsinger *et al.,* 1995).

Pesticide misuse can have several dimensions. Farmers may apply the wrong pesticide or the wrong amount of a pesticide or apply a pesticide at the wrong time. The pesticide then fails to control the pest in an economically optimal manner or causes health problems for the farmer or farm family. From society's standpoint,

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optimal pesticide use considers off-farm environmental and health costs associated with pesticide use as well. Pesticide misuse can have both short- and long-run impacts. Short-term impacts include acute human health problems, potential productivity losses, and decreased water quality on or near the farm. Long-term impacts can include surface and groundwater pollution, increased pesticide resistance and pest resurgence, reduction in natural enemy populations, danger to animal species, and long-run harm to human health.

Despite these potential problems, pesticide misuse persists, particularly on vegetable crops that are vulnerable to a wide range of pests. However, few studies have assessed the relative importance of factors influencing pesticide misuse. Several studies have examined factors affecting adoption of particular farming practices, including integrated pest management (IPM) technologies (Burrows, 1983; McNamara *et al.* 1991; Rook and Carlson, 1985; Napit *et al.*, 1988; Harper et al., 1990; Thomas, *et al.* 1990; and Fernandez-Cornejo *et al.* 1992). Most of these studies have used logit analysis and found that the types of crops and technologies as well as specific socio-economic characteristics such as farm size, farmer age, and education, influence technology adoption. In order to assess social, economic, and other factors influencing pesticide misuse on vegetables in the Philippines, farm-household-level survey results were analyzed using logit analysis focused on a major vegetable, onions *(Allium cepa* L.). This paper reviews the results of that analysis and suggests actions that might reduce pesticide misuse. While the results are specific to the Philippines, the approach should prove useful for analyzing causes of pesticide misuse in other settings.

Before turning to the logit analysis, the results of the surveys are briefly summarized to provide background on the study area and prevailing pest management practices. The logit model is then discussed, including the key variables and hypotheses. Finally, the results are presented and policy implications considered.

Description of Study Area and Pest Management Practices. Six villages in the area around San Jose City in Nueva Ecija were targeted for the analysis. The San Jose area has a total of 18,725 hectares, 92,000 people, 4800 farm families, and the six villages comprise approximately 44 percent of the total agricultural land in San Jose. Nueva Ecija is in the Central Luzon, the rice bowl of the Philippines, but San Jose also produces substantial amounts of vegetables during the dry season and is considered the heart of the onion growing area in the country. An interview survey of 300 farmers, 50 from each of the six villages, found that 77 percent produce both rice *(Oryza sativa* L.) and vegetables, 18 percent produce only rice, and 5 percent produce only vegetables (Lazaro *et al.*, 1995). Over 90 percent identified onions as their primary vegetable crop.

Farmers planted an average of 0.6 hectares of dry season vegetables and 1.4 hectares of wet season rice, and earned roughly four times as much from their vegetables as their rice. All farmers were able to describe the pest damage in their fields, but had difficulty identifying specific pests that caused the damage. Most pests named by farmers were general categories and included worms, thrips *[Thrips tabaci* (Lindeman)], hoppers, whiteheads, moths and butterflies. Damping-off and bulb rot were mentioned as fungal diseases. Forty-five percent of vegetable producers were aware of natural enemies, but the "natural enemies" mentioned most were spiders and dragonflies.

Pest control was considered important by vegetable farmers with over 98 percent applying pesticides on their most recent vegetable crop. The most common pesticides applied were Monocrotophos, Cypermethrin, Endosulfan, Methyl Parathion, and Methomyl. Half of the farmers believed that pesticides must be sprayed before the crop is four weeks old. Another 20 percent sprayed pesticides when pests were identified in the field or at the first sign of damage. Twelve percent sprayed at least once per week. Many farmers sprayed by the second week after planting. The average number of applications was four, with a few farmers spraying up to 24 times per season. Several farmers had no particular pests they were targeting with pesticides and used whichever pesticide was available. A follow-up survey of 228 of the original 300 respondents was conducted to obtain information on their social and economic characteristics.[2] Seventy-eight percent of the respondents were between the ages of 31 and 60. Fifty-three percent owned the property they farmed, 29 percent were tenants or lessees, and the remainder were either hired laborers or holders of a pre-ownership "certificate of land transfer." Only one respondent had no schooling while 43 percent had only primary schooling. Forty-five percent had some high school training and more than 11 percent had attended college. Seventy-two percent of farmers received credit, with major sources being: cooperatives/land banks, 28 percent; relatives/neighbors, 34 percent; money lenders, 52 percent; and traders, 4 percent. Thirty-four percent received credit "in kind" as pesticides.

Advice on pest management came from a variety of sources. Fifty-five percent had attended or a family member had attended a "Farmer Field School," a 16 week IPM training program on rice. Fifty-eight percent had been visited by an agricultural technician (extension agent) to discuss IPM. When reporting the most important factors and/or sources of information in deciding which pesticides to use on vegetables, 58 percent listed pesticide price as extremely important. Smaller percentages listed the advice of the agricultural technician (20%), chemical company representative (14%), retail pesticide dealer (12%), or neighbor (5%) as extremely important. Seventy-eight percent believed pesticides can harm water quality and 73 percent believed that water quality on their own farms has been affected by pesticides.

In addition to the farmer surveys, a participatory appraisal (PA) was held in the villages during which a multi-disciplinary team of scientists were able to probe in more depth pest management practices and beliefs, institutional factors affecting pesticide use, and other factors.[3] The PA revealed the potential importance of credit policies and cooperatives in influencing pesticide use or misuse.

MATERIALS AND METHODS

Logit analysis is used with the data from the farmer surveys to assess the importance of socioeconomic characteristics and other factors affecting pesticide use on onions. Several studies have used this type of limited-dependent-variable approach to determine factors affecting adoption of IPM technologies but none have

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[2] The original survey of 300 farmers was conducted to obtain baseline information at the beginning of a major rice-vegetable IPM project. Three months. later, the follow-up survey was conducted to facilitate policy and other socioeconomic analysis.

[3] The primary purpose of the PA was to supplement information from the farmer surveys and from one year of crop monitoring to prioritize research activities on a major rice-vegetable IPM project in the region.

used the approach to assess factors influencing misuse of pest control.

Pesticide misuse in vegetables is a multi-faceted phenomenon. The Philippines pesticide misuse analysis focused on the timing of pesticide applications on onions, specifically whether pesticides were sprayed during the seedling stage for thrips [*Thrips tabaci* (Lindeman)], worms (primarily *Spodoptera litura* (armyworm), Lepidoptera: Noctuidae), and ants. Onions were the primary vegetable crop for more than 90 percent of the farmers and thrips are not a threat to onions until after the seedling stage as the plant is too small to protect the thrips from other mortality factors. Using pesticides for worms during the seedling stage of onions is misuse because the leaves of the onion plant are too small and narrow for the moths to lay eggs on. Spraying for ants is misuse as many species of ants are natural enemies to pests. The reason for focusing on the seedling stage is that other aspects of misuse are still being identified more specifically through the field work of entomologists, plant pathologists, and weed scientists in San Jose. Basic characteristics of farmers who grow onions and of those who spray during the seedling stage are presented in Table 1.

Several factors were hypothesized to affect pesticide misuse during the seedling stage, including producer characteristics, farm structure and institutional arrangements, sources of pesticide information, and pesticide and pest management perceptions (Table 2). Most of these hypothesized factors were included in previous adoption studies referenced above. However, being a member of a cooperative or other association, credit sources, and specific pesticide information sources were identified as potentially important factors by the surveys and PA. Among producer characteristics, the specific variables included in the model are: age (AGE), education (EDUCN), access to IPM training (FFS), exposure to pest management information from an agricultural technician (VISAGT), tenure status (TENSTAT), and membership in an organization (MEMBER). It is anticipated that the likelihood of misuse increases with age as older farmers may be slower to change practices and be less concerned about health effects of pesticides, which may not occur for several years. Increased education is expected to reduce pesticide misuse because farmers are more likely to read pesticide labels and seek out other sources of information.

Table 1. Characteristics of farmers in sample.

Characteristic	Number who grow onions	Number who spray onions during seedling stage
Total number	211	127
Member of crop	72	50
With IPM training	104	63
Visited by Ag technician	124	82
Owner and operator	110	60
Average age	47 years old	46 years old
Years of schooling	8 years	8 years

Table 2. Factors affecting misuse of pesticides.

Variable Name	Definition
Producer Characteristics	
AGE	farmers' age
EDUCN	farmer's educational attainment: 1 for no schooling (0 yrs), 2 for some primary school (1-6), 3 for some high school (7-10), and 4 for some college (11 or more)
FFS	1 if farmer or family member attended FFS training; 0 otherwise
VISAGT	1 if visited by an agricultural technician to discuss IPM; 0 otherwise
TENSTAT	1 if owner/operator; 0 otherwise
MEMBER	1 if member of a cooperative, village association, or farmers' association; 0 otherwise
Farm Structure and Management	
LABOR	number of non-wage labor persons in family besides the farmer
IRRIG	1 if the vegetable acreage is irrigated; 0 otherwise
ONAREA	total onion area on farm
BORROW	1 if farmer received credit for vegetable production; 0 otherwise
COOP	1 if source of vegetable credit is cooperative/ landbank; 0 otherwise
FRN	1 if source of vegetable credit is a friend, relative, or neighbor; 0 otherwise
ML	1 if source of vegetable credit is a money lender; 0 otherwise
KINDPES	1 if farmer receives a portion of credit in-kind as pesticides; 0 otherwise
Pesticide Information Sources	
COST AGTECH PESTDEAL CHEMCO NBOR SAFETY	relative importance of information source when deciding which pesticide to use: 1 if extremely important, 2 if very important, 3 if somewhat important, and 4 if not important
Pesticide and Pest Management Perceptions	
NENEMY	1 if farmer believes that killing the natural enemies in the field by applying pesticides can hasten pest infestation; 0 otherwise
WAQUAL	1 if farmer believes pesticides can be harmful to water quality; 0 otherwise
IMPACT	1 if farmer believes pesticides have harmed the water on his/her farm or attributes the health problems of a family member to pesticides; 0 otherwise

If the farmer or a member of his family has attended a Farmer Field School, the farmer is considered to have access to IPM training, which is expected to reduce pesticide misuse. The same is expected if the farmer has been visited by an agricultural technician, or has more secure tenure. Membership in a cooperative, farmer's association, or village association is expected to decrease pesticide misuse as these organizations provide a forum for discussion on production practices including IPM. However, cooperatives often purchase pesticides in bulk which may encourage excessive pesticide use and these organizations might be providing incorrect or biased information on pesticides. Also, some credit sources used by cooperatives require farm plans that encourage excessive pesticide use.

Pesticide misuse is expected to decrease as the number of working family members (LABOR) besides the farmer increases. As the number of farm laborers increases, the use of alternative pest management practices becomes more probable as the alternatives are often more labor intensive than pesticides. The effect of receiving credit (BORROW) should increase pesticide misuse as farmers may be pressured by creditors to use pesticides. If the source of the credit is a cooperative/ Landbank (COOP), the probability that a farmer will misuse pesticides may increase due to the requirement of a farm plan, but if the source of credit is a friend, relative, neighbor (FRN), or money lender (ML), the likelihood of pesticide misuse may be relatively less. Receiving pesticides in-kind as part of a loan (KINDPES) should also increase the chances that a farmer will misuse pesticides.

Farmers were asked to rank on a scale from one (extremely important) to four (not important), the influence of price (cost) and of five sources of information in deciding which pesticide to use. These information sources include: agricultural technician (AGTECH), pesticide dealer (PESTDEAL), chemical company representative (CHEMCO), neighbor (NBOR), and the FPA pesticide safety label (SAFETY). Increased importance of pesticide price and advice from a pesticide dealer or chemical company representative is expected to increase pesticide misuse. Information from an agricultural technician and FPA safety label would reduce it.

The perceptions that killing natural enemies will hasten pest infestation (NENEMY) or harm water quality (WAQUAL) are expected to reduce pesticide misuse. Farmers may be less likely to misuse pesticides if they believe they will reduce water quality on their own farm. Finally, farmers who have been personally harmed by pesticides either by their farm's water quality having been noticeably affected or by someone in their family having become acutely ill from pesticides (IMPACT), will be less likely to misuse pesticides.

Statistical Procedure. The pesticide misuse analysis uses a logit model in which a dependent variable takes a value of 1 if there is pesticide misuse and 0 otherwise. Logit is used when the dependent variable involves an "either or" situation or when the variable falls into groups or categories. In the general bivariate logit model, the probability of pesticide misuse by the *i*th farmer is given by

$$Pi = F(B'X) = 1/[1 + \exp(-B'X)], \quad (1)$$

where F is the cumulative distribution function (Maddala, 1988). The log likelihood function of the general multinomial logit model is

$$\log\ L = \sum_{i=1}^{n} \sum_{i=1}^{m} Yij \log Pij, \quad (2)$$

where Yij is a dummy variable equal to 1 if individual *i* falls into the *j*th category and 0 otherwise. It is assumed that each producer's objective function contains a nonstochastic portion which equals *B'X*, where *B* is a row vector of parameters and *X* is a column vector of the exogenous variables. The model is estimated using maximum likelihood. The parameter estimates provided by the logit model do not provide the change in probability associated with the change in an explanatory variable. Instead, the marginal effects must be computed using the following equation:

$$\partial P_i / \partial x_{ij} = \beta_j P_i (1 - P_i), \quad (3)$$

where ßj is the initial parameter estimate for independent variable j. These probabilities are provided for each variable. The overall significance of the model is measured in two ways. Goodness of fit is evaluated using the McFadden R^2 which is defined as:

$$\text{McFadden } R^2 = 1 - [\text{Log } L(\beta_{ML}) / \text{Log } L_0], \quad (4)$$

where Log L(ßML) and Log L_0 are the log-likelihood values of the restricted model and unrestricted model respectively. The McFadden R^2 equals zero when the likelihood function with all parameters is no greater than the likelihood function with the constraint that all parameters equal zero except the constant. The predictive ability of the model is judged by the number of correct predictions divided by the total number of observations. A variation of this measure is reported for each outcome by dividing the number of correctly predicted misusers or non-misusers by the number observed. Significance levels of variables are reported as well.

Data used in the analysis are from the two IPM-CRSP baseline surveys. The final sample used for the logit analysis included only 164 observations, rather than 228 as only those farmers who listed onions as their main vegetable crop were included in the analysis. AGE, EDUCN, and LABOR were included as continuous variables, information sources were included as a ranking from 1 to 4, and all other independent variables were included as intercept dummies.

RESULTS

Results of the logit analysis are presented in Table 3. The initial model has a log-likelihood value of 72.49 and a McFadden R^2 of 0.214. A McFadden R^2 of between 0.2 and 0.4 is typical for logit models (Sonka, *et al.*, 1989). The model's chi-squared value is 39.45 which is significant at 0.018 level. Of the 164 total observations, 80 percent are predicted correctly, with 92 percent of misusers and 44 percent of non-misusers correctly predicted.

The only variable significant at the 1 percent level is CHEMCO. As farmers reduce the level of importance given information from a chemical company representative when deciding which pesticide to use (e.g. from extremely important to very important, etc.), the probability of misusing pesticides decreases by 16 percent.

Table 3. Socio-economic determinants of pesticide misuse in San Jose City.

Variable	Coefficient	Standard Deviation	Significance Level	Probability Effect
Constant	4.1596		0.0558	0.6409
AGE	-0.0033	12.3700	0.0990	-0.0005
EDUCN	-0.7128	0.6754	0.0566	-0.1098
FFS	-0.9795	0.4919	0.0611	-0.1509
VISAGT	0.8243	0.4864	0.0994	0.1270
TENSTAT	-0.1741	0.4952	0.6940	-0.0027
MEMBER	1.2743	0.5014	0.0198	0.1963
LABOR	0.1672	1.3107	0.3821	0.0026
IRRIG	0.3868	0.4952	0.4155	0.0060
ONAREA	-0.2063	0.5907	0.6186	-0.0032
BORROW	1.3306	0.4270	0.1580	0.2050
COOP	-1.8004	0.4232	0.0636	-0.2774
FRN	-1.2003	0.4270	0.1863	-0.1849
ML	-1.1298	0.4444	0.1869	-0.1741
KINDPES	1.3352	0.3774	0.1009	0.2057
COST	-0.3649	0.6599	0.2953	-0.0562
AGTECH	0.3765	0.6851	0.3249	0.0058
PESTDEAL	0.3373	0.6626	0.4777	0.0052
CHEMCO	-1.0607	0.7361	0.0075	-0.0163
NBOR	0.1300	0.9105	0.6250	0.0020
SAFETY	0.2716	0.4193	0.6276	0.0042
NENEMY	-0.8180	0.2710	0.2614	-0.1260
WAQUAL	-0.1964	0.4308	0.8005	-0.0030
IMPACT	0.8432	0.4152	0.2811	0.1299
McFadden R Squared		0.214		
Log Likelihood		-72.49		
Chi-squared		39.45	p-value	0.0177
Correct prediction (%)	Total: 79.88	Misusers: 91.87	Non-Misusers: 43.90	

MEMBER is significant at the 5 percent level, as membership in a cooperative, village association or farmers' association increases the probability of pesticide misuse by 20 percent.

Significant at the 10 percent level are AGE, EDUCN, FFS, VISAGT, and COOP. Contrary to expectation, as age and education increase, the probability that the farmer misuses pesticides decreases. Access to IPM training (FFS) has the effect of reducing the probability of misuse by 15 percent. While casual observation has led many to conclude that there is little carryover from FFS on rice to IPM on vegetables, it appears that there indeed may be some carryover. Contrary to expectations, a visit by an agricultural technician to discuss pest management increases the probability that a farmer will misuse pesticides by 13 percent, while receiving credit from a cooperative reduces the probability of pesticide misuse by 28 percent. The latter result is surprising because results indicated that membership in a coop or other association increased the probability of misuse, thereby leaving the role of cooperatives in pesticide misuse ambiguous.

Five variables are significant at the 20 percent level. If a farmer receives credit for vegetable production, the model predicts that the farmer is 20 percent more likely to misuse pesticides. However, receiving credit from a friend decreases the likelihood that a farmer will misuse pesticides by 18 percent, while receiving credit from a money lender decreases the likelihood of misuse by 17 percent. If a farmer receives credit in-kind as pesticides, the probability that the farmer misuses pesticides increases by 21 percent. Finally, a farmer that agrees with the perception that pesticides can harm water quality is 3 percent less likely to misuse pesticides.

DISCUSSION

Looking at the results as a whole, the conclusion one comes to is that educational activities and interpersonal contact are what is really important in influencing pesticide misuse. The need for farmer training and awareness is evident in the reduced instances of pesticide misuse by farmers who attended the Farmer Field School and by farmers who viewed pesticides as harmful to water quality and natural enemy populations. Because farmers belonging to cooperatives, farmer organizations, and village organizations are more likely to misuse pesticides, targeting these groups with training in the proper use of pesticides could reduce the problem. Similarly, targeting farmers who receive credit may reduce the amount of pesticide misuse.

IPM training needs to be improved for Department of Agriculture technicians. The high value placed on an agricultural technician's advice increases the probability of pesticide misuse unless technicians are imparting the latest IPM advice. One problem may be the absence of IPM strategies for the technician to impart. In addition, an examination of the relationship between DA technicians and chemical companies may be warranted. Because the influence of chemical company representatives increases the probability of pesticide misuse by farmers, chemical company training may also be inducing agricultural technicians to recommend pesticide use when it is unnecessary. Therefore, the advice of an agricultural technician, which may be necessary to receive crop insurance, could actually promote misuse. A firm commitment to responsible pesticide use and to IPM by the extension system in the Department of Agriculture could help decrease pesticide misuse.

Future research should focus particularly on broadening the definition of misuse to include more aspects such as application of the correct pesticide, amount of pesticide applied, and timing of pesticide applications. While these factors are relatively well known for rice in the Philippines, they are not for vegetables. Future studies should also examine the relationship between pesticide price and incentives to misuse pesticides. The nonsignificance of the price variable in this study was primarily due to the lack of variation in the variable as nearly all farmers said they considered price extremely important in deciding which pesticide to use.

Logit applied to survey data provides a relatively simple approach to assessing factors influencing pesticide misuse. The potential for misuse in its many dimensions exists in virtually all countries, even where relatively detailed pesticide recommendations are available. Pesticide misuse analysis can help focus extension programs and other sources of information to foster productivity enhancing and environmentally sustainable pest management practices.

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