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Assessment of agrochemical use among rice field farmers in municipalities surrounding Lake Mainit, Philippines

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Abstract

This study was conducted to determine agrochemicals that are commonly used by farmers from selected areas surrounding Lake Mainit. A survey using structured interview schedule and secondary data from municipal agriculture office were used in data collection. A total of 199 respondents were surveyed. Most of the farmers (87.94%) were using pesticides and inorganic fertilizers. Farmers indiscriminately used pesticides, with an average 2.3 tank/hectare of insecticides, 1 tank/hectare for herbicide, and 1-2 tanks per hectare for fungicide and molluscicide were applied to one cropping season of rice. Very few of the farmers are biologically controlling crop pests and diseases. Increasing farmers' awareness and training aimed at sustainable agriculture and agrochemical use on an integrated pest management approach is suggested.

Keywords: Pesticides; Fertilizers; Farmers; Wetlands; Agriculture

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1. Introduction

Modern agriculture would not have reached such high productivity without the development and usage of agrochemicals. Agrochemicals refers to the broad range of pesticides including insecticides, fertilizers, hormones, herbicides, fungicides, and other growth chemicals (Jamala et al., 2006). This chemical is used to improve crop productivity, control pests, and treat or control diseases (Omari, 2014). The use of agrochemicals contributes not only to the healthy growth of crops and animals but also to improve farm work efficiency and stable supply of agricultural produce (Kughur, 2012).

Use of crop protection chemicals, farmers are able to produce bigger and more crops on less land with efficient production of the food process contributing to high agricultural productivity thereby maximizing profit. The benefits of the use of agrochemicals are not only confined to its farmers but to the majority of the people across the world. Because of this, agrochemicals will still be used for many decades to ensure food supply (Wang and Liu, 2007). It will improve food safety and quality, increase in profit, and even improve human health by eliminating pest and diseases.

However, despite the advantages of agrochemicals, the risks and drawbacks of its use are far outweighs more than its benefits. The effect of the chemicals applied could result in the reduction of biodiversity and ecological balance of an area. Moreover, continued use of the same pesticide can trigger the pest to become resistant. Several problems in relation to pesticide use have been contemplated but the future trend in use of most of these compounds in agriculture to treat plant disease will obviously not decrease (Epstein and Bassein, 2003).

Use of different agrochemicals like pesticides and conventional fertilizers exists in wetlands that are mostly converted into rice paddies. Wetlands, which are considered useful ecosystems have been exploited for the water source, land encroachment, pollution inputs, and reclamation or land conversion. The run-off of agricultural chemicals into the surface water bodies of wetlands can cause an increase of productivity of those aquatic ecosystems leading to eutrophication or the excessive richness of nutrients in an aquatic ecosystem due to runoff from nearby land. This can cause a dense growth of plant life and death of animal life from lack of oxygen. This is a scenario that people in living close to Lake Mainit do not want to happen in the near future. Lake Mainit is surrounded by rice field farms in its littoral zones and farmers usually utilize agrochemicals to increase rice production. Different municipal agriculture surrounding Lake Mainit have farmers that are practicing or using agrochemicals that may possibly affect the condition of the lake because it serves as the catchment basin. It is highly possible that the washed-away chemicals from pesticides and fertilizers may flow into the lake.

Because Lake Mainit has many iconic freshwater species, people from the surrounding area see the use of agrochemicals as a threat to aquatic biodiversity. The need to determine the kind of agrochemicals that are used by farmers would fill in the information gap because it can provide baseline data on the agricultural situations in Lake Mainit. Thru this information, possible types of agrochemical pollutions that could be released to the environment could be determined. Thus, this study aims to determine the common agrochemicals used by rice farmers from selected areas and common practices of pest management practices with regards to usage of the agrochemicals. This study is also useful to local government units since it can provide information for sustainable agriculture strategies and identify specific constraints and opportunities for appropriate agriculture. They could also utilize information from this study for local policy changes emphasizing on proper usage of agricultural chemicals for an ecologically based pest management sector.

2. Methodology

2.1. Study Area

The study was conducted in Lake Mainit which is considered the fourth largest lake in the country (Figure 1). The lake belongs to both provinces of Surigao del Norte and Agusan del Norte. It falls within the jurisdiction of four municipalities namely Mainit, Alegria, Kitcharao, and Jabonga. The livelihood of the people in the study area depends mostly on agriculture, fishing, and petty trades.

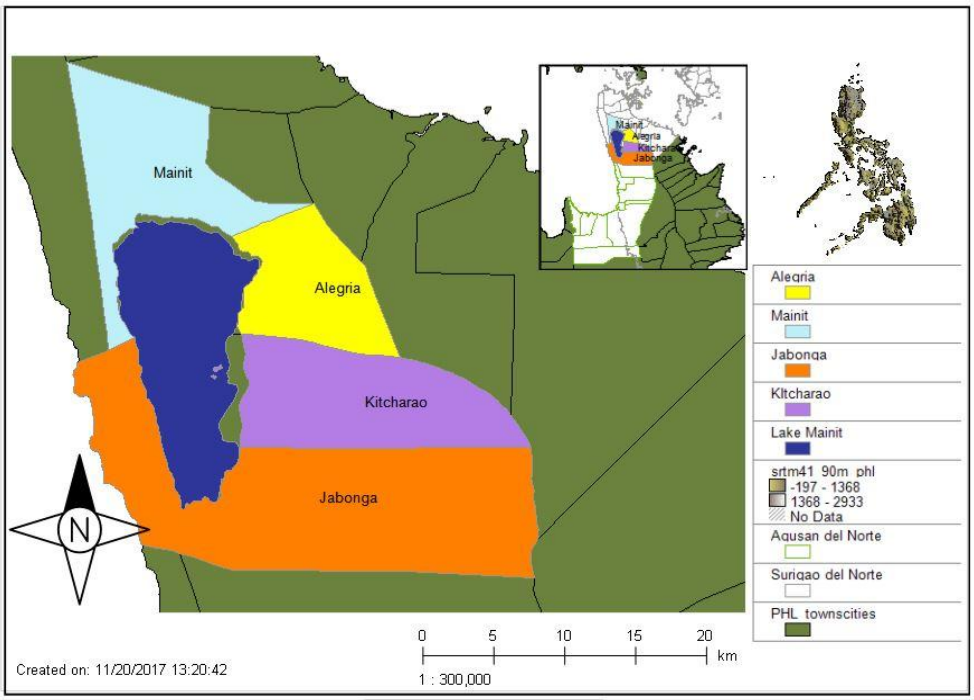

Figure 1. Map showing the four municipalities around Lake Mainit

2.2. Data Collection

The study interviewed 199 rice field farmers from four municipalities surrounding Lake Mainit. The Cochran`s Formula was used to determine the sample size using equation one.

Equation 1 $n_0 = \frac{Z^2pq}{e^2}$

Where n_0 = the partial sample size when N (total population) is large

Z = the value from z-table

e = the desired level of precision

p = the (estimated) proportion of the population, and

q = 1-p

To solve n_0, the following values for Z^2 = 1.96, p = 0.5, q = 1-p = 0.5, and e = 0.05 were used generating n_0 = 389. Since the total population is known, the exact sample size was calculated using equation two.

Equation 2

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

With the total population of 389 respondents, the sampling size that was used in the survey was 199 (Table 1).

Table 1. Distribution of sample population by municipalities

Municipality	Sample size
Jabonga	92
Kitcharao	47
Alegria	15
Mainit	45
Total	**199**

A structured interview schedule was administered to selected farmers from different municipalities. Simple random sampling technique was used in selecting respondents. Prior to the selection of the respondents, information from municipal leaders, Local Government Unit (LGU), and Department of Environment and Natural Resources (DENR) were used to generate a list. The study included criteria about rice farming, use of agrochemicals, and willingness to participate during the interview. The number of selected farmers varied between municipalities because of differences in populations and number of people involved in farming activities also varied.

3. Results and discussion

3.1. Demographic characteristics and profile of farmers

Most of the farmers that were interviewed in this study were males (72.4%) indicating less female farmers (27.6%) involved in rice production. Most respondents were male because rice farming is viewed as a male-dominated farming activity though female farmers also play significant roles in the agriculture industry. The average age of farmers surveyed was 47.9 years with 59.3 % between 36 and 55 years of age. It was also noted that a few numbers of farmers (14) are still working in the rice farm despite of old age (> 65 years). A considerable number of respondents (37.7%) had finished primary education, 47.7% finished secondary school, and 14.6% were educated and finished up to the tertiary level. Majority of the respondents had 1-3 dependents (67.3%) while the highest had 7-9 dependents (4%). A few farmer respondents were single and had no children (5.5%). Most farmers (86.4%) are assisted by their family members to augment their income though there is one case in which the respondent is the sole breadwinner in their household. Most of the respondents (38.2%) had 11-20 years of farming experience though there are a few that had been working in their farm for more than 61 years. The average number of years the respondents had lived in their village was 36.4 and some indicated that they were also born in their respective area. Most respondents had been a resident of their community for 31-40 years (23.6%) and a significant number of the farmer had been in their community for more than 40 years. Majority of the farmers (87.9%) are dependent on the use of pesticides to manage pest problems in their farms and inorganic fertilizers (87.9%) to supplement soil nutrients.

3.2. Pesticides used

A total of 24 brands of pesticides with 21 different active ingredients were found to be in use during the survey period (Table 2). Insecticides (58.3%) were the most commonly used pesticides followed by herbicides (29.16%). About 50% of the pesticides used belong to the World Health Organization toxicity class II (moderately hazardous) with 20.8% under toxicity class III (slightly hazardous) and 16% under toxicity class U that is unlikely to pose an acute hazard in normal use. However, a notable 12.5% is under toxicity class Ib which is highly hazardous were used by the farmers. These findings are not particularly surprising, because farmers who overuse pesticides apparently view them as a guaranty for high yields (Damalas et al., 2006; Al-Zadjali et al., 2014), and the more important concern is that crop damage by pests leads to economic loss (Matthews, 2008). The estimated total amount of active ingredients of pesticides applied by farmers were 2.2 liters per hectare every cropping season, and pesticides for moderately hazardous class contributed by 50% of the total active ingredients. A considerable number of the farmers (87.94%) were found to have overused pesticides. There was a substantial variation in inter-farm pesticide overuse, which ranged from 1.37 to 2.2 liters per hectare every cropping season. Pesticide application frequency occurs once a week to twice a month depending on the pest infestation. Farmers who relied solely on pesticides for crop protection used more chemicals than other farmers. The majority of farmers who overused pesticides (87.94%) realized that they were overdoing application of pesticides, and believed that it is indispensable for high yields. These findings demonstrate a strong perceived dependence on pesticides exists among farmers. The same result was also found from the study of Schreinemachers et al. (2017) who showed that vegetable farmers in Laos, Cambodia, and Vietnam heavily depend on pesticides for managing pests and disease in leaf mustard and yard-long bean.

Table 2. Pesticides used by rice farmers surrounding Lake Mainit and their toxicological class

Brand Name	Active Ingredient	Formulation	WHO Toxicity class	Target Pest
Insecticide				
Karate 2.5 EC	Lambda-cyhalothrin	SL	II	Caterpillars,aphids, whiteflies, and thrips

Arrow 100 EC	Bifenthrin	SL	II	StemBorer, Gall Midge, Leaf Folder, Brown Plant, Hopper (BPH), White Backed Plant Hopper, Green Leaf Hopper & Thrips
Furadan 5G	Carbofuran	WP	Ib	StemBorer, Gall Midge, Leaf Folder, Brown Plant, Hopper (BPH), White Backed Plant Hopper, Green Leaf Hopper & Thrips
Chix 2.5 EC	Beta-Cypermethrin	SL	II	StemBorer, Gall Midge, Leaf Folder, Brown Plant, Hopper (BPH), White Backed Plant Hopper, Green Leaf Hopper & Thrips
Descarte 2.5 EC	Lambda-Cyhalothrin	SL	II	StemBorer, Gall Midge, Leaf Folder, Brown Plant, Hopper (BPH), White Backed Plant Hopper, Green Leaf Hopper & Thrips
Solomon 300 OD	Imidacloprid+Beta-Cyfluthrin	SL	II	StemBorer, Gall Midge, Leaf Folder, Brown Plant, Hopper (BPH), White Backed Plant Hopper, Green Leaf Hopper & Thrips
Siga 300EC	Pyrimethanil	WP	III	StemBorer, Gall Midge, Leaf Folder, Brown Plant, Hopper (BPH), White Backed Plant Hopper, Green Leaf Hopper & Thrips
Brodan 31.5 EC	Chlorpyrifos + BPMC	SL	II	StemBorer, Gall Midge, Leaf Folder, Brown Plant, Hopper (BPH), White Backed Plant Hopper, Green Leaf Hopper & Thrips
Winner®	Formetanate	SL	Ib	StemBorer, Gall Midge, Leaf Folder, Brown Plant, Hopper (BPH), White Backed Plant Hopper, Green Leaf Hopper & Thrips
Cymbush 5 EC	Cypermethrin	SL	II	StemBorer, Gall Midge, Leaf Folder, Brown Plant, Hopper (BPH), White Backed Plant Hopper, Green Leaf Hopper & Thrips
Lannate 40 SP	Methomyl	WP	Ib	StemBorer, Gall Midge, Leaf Folder, Brown Plant, Hopper (BPH), White Backed Plant Hopper, Green Leaf Hopper & Thrips
Bulls-eye®	Difenoconazole	SL	II	StemBorer, Gall Midge, Leaf Folder, Brown Plant, Hopper (BPH), White Backed Plant Hopper, Green Leaf Hopper & Thrips
Nurelle	Cypermethrin + Chlorpyrifos	SL	II	StemBorer, Gall Midge, Leaf Folder, Brown Plant, Hopper (BPH), White Backed Plant Hopper, Green Leaf Hopper & Thrips
Magnum 5 EC	Cypermethrin	SL	II	StemBorer, Gall Midge, Leaf Folder, Brown Plant, Hopper (BPH), White Backed Plant Hopper, Green Leaf Hopper & Thrips
Herbicide				
2,4-D Amine 40 EC	2,4-D Amine	SL	II	Barnyard grass; Blackgrass; Knotweed
Inferno® Duo	Glyphosate	SL	III	
Rogue ® EC	Dichloropropene	SL	U	Barnyard grass; Blackgrass; Knotweed
Pyanchor Ultra 8.5 EC	Pyribenzoxim	SL	II	Barnyard grass; Blackgrass; Knotweed
Machete EC	Butachlor	SL	III	Barnyard grass; Blackgrass; Knotweed
Ricestar Xtra	Fenoxaprop-P-Ethyl+Ethoxysulturon	SL	U	Barnyard grass; Blackgrass; Knotweed

Roundup ProBiactive®450	Glyphosate	SL	III	Barnyard grass; Blackgrass; Knotweed
Fungicide		SL		
Vanguard 75wg	Cyprodinil	WP	III	Venturia sp., Monilinia sp., Botrytiscinerea sp.
Molluscicide				
Maskada 70 WP	Niclosamide Ethanolamine Salt	WP	U	Snail
Surekill 70 WP	Niclosamide	WP	U	Snail

a. Ib: highly hazardous; II: moderately hazardous; III: slightly hazardous; U: unlikely to pose an acute hazard in normal use; NC: not classified.
b. SL: Soluble, WP: Wettable powder

3.2.1. Insecticides

Insecticides are being used to eradicate several pest species to rice. Most developing nations use greater quantities of insecticidal chemicals, given that insects create the greatest problems (Ecobichon, 2001). Most of the respondents (88%) said that the common target pest includes rice stem borer and black bug (88%). The stem borers are generally considered the most serious pest of rice worldwide and it occurs and infests plant from seedling stage to maturity. The black bug has also been occurring periodically in large numbers and causing extensive damage to rice crops in many parts of rice growing countries (Pathak and Khan, 1994). For insecticide, an average 2.3 tank/hectare were applied to one rice cropping season. Most farmer respondents said that they applied only 1 tank of insecticide per hectare but others (28.6%) indicated that they utilize more than 2 tanks per hectare while some even had 10 to 15 tanks per hectare. The insecticide has the mean price of 521.00 PhP (≃ US $10). The data for the prices of insecticide were dispersed which means that there are some brands that are too expensive and too cheap. The perceived toxicity of all insecticides was effective which means that all the dosages of the application the pesticide were effective to kill all the targeted pests. The range of pesticides presently in use, particularly insecticides, could be viewed as evidence of serious pest problems and the difficulty in their control, most probably due to their resistance (Urech et al., 1997)

3.2.2. Herbicide, fungicide, and molluscicide

Both small and large-scale farms are reported to indiscriminately use large quantities of different pesticides (Ngowi et al., 2007). To aid the eradication of other pests and diseases in the rice field, farmers within the lakeshore of Lake Mainit utilize other pesticides such as herbicides (86.4%), molluscicides (4.5 %) and fungicides (2.5%). Herbicides are mostly used by the respondents to eradicate weeds. Most farmers apply one tank of herbicide per hectare (57.8%) and are sprayed before and after sowing. Ecobichon (2001) mentioned that farmers prepare and spray in sequence, pre- and post-emergent herbicides during the growing season of some crops. Mean price for herbicide mostly bought by the respondents is 602 PhP (≃ US $11.5). Very few farmers are using fungicide and molluscicide. Fungicide is used infrequently because of fewer presence of fungi in the area. On the other hand, molluscicide is used to eliminate the golden snail but limited only to areas closer to the lakeshores directly influenced by the water from the lake. The two pesticides are mostly applied after sowing with 1-2 tanks per hectare. Mean price of fungicide and molluscicide is PhP 427 (≃ US $8.2) and its perceived toxicity is effective according to the users.

3.3. Fertilizers

Most of the respondents also used inorganic fertilizers such as urea (86.4%), sulfate (45.2%), potash (57.3%), and complete (82.4%) (Table 3). Respondents said that they usually can utilize approximately 2-3 sacks of the different fertilizers per hectare in one cropping season. They mostly apply the fertilizers after they plant the seed for plants to take the nutrients directly from the fertilizers. Prices of the mentioned fertilizers usually ranged from 900 to 1200 PhP (≃ US $17 to 23). They rely on inorganic farming because the yield is high compared to using organic fertilizers. Mohd et al. (2002) said that the effect of inorganic fertilizer on growth and yield of the plant were noticed to have high production weight, number per plant and the highest yield per plant and per hectare were recorded because of the use of inorganic fertilizers.

Table 3. Fertilizers used by rice farmers in Lake Mainit.

Brand Name	Type	Recommended Rate	Mean Application rate (sack/ha)
Atlas Fertilizer and Planters	Urea	46-0-0	1.9
Atlas Fertilizer	Sulfate	21-0-0	2.4
Atlas Fertilizer and Planters	Potash	0-0-50	1.5
Atlas Fertilizer and Planters	Complete	14-14-14	2.0

3.4. Pest management practices of farmers on Lake Mainit

Most of the farmers (87.4%) said that they use the same pesticide over and over but one (1) is noted to sometimes change the pesticides he is using. They did not change the brands that they are currently using since they have perceived it to be effective. In the study of Schreinemachers et al. (2017), farmers were generally satisfied with the effectiveness of pesticides and felt that they were necessary. Accordingly, most of the farmers in neighboring areas also use the same brands. Friends, neighbors and lead farmers were more important sources of information to solve problems of pest and diseases (Schreinemachers et al., 2017). The majority also observed that their product is good. Some farmers mentioned that it might also be a burden to them if a newly used pesticide will not be effective in eradicating the pest. However, change in the use of pesticides could be brought about by increased resistance of pest to the chemical hence, farmers must find new pesticides (Berg, 2001). They do not change the dosage of the chemical/s as specified in the manual.

They do this because most of them are anxious if the crop will be affected and others refer to the recommendation of their friends, relatives, and neighbors.

Table 4 shows that the hired applicator is usually the one who decides the chemicals to be bought for farm use. The decision on buying the pesticide and fertilizers is highly dependent on the person who received professional training on the applications of the said agrochemicals. Most receive training (61.3%) from the municipal agriculturist about the use of the pesticide. Trained farmers have better knowledge about insect pests and the proper use of pesticides, adopted more integrated pest management practices, and reduced the frequency of spraying and mixing different pesticides (Gautam, 2017). Technical knowledge, training, and education on pesticides, and trusted sources of pesticide information all impact how users follow a label (Webster and LePrevost, 2018). There is a high probability that a greater percentage of farmers with professional training background knows how to understand the labels on the agrochemicals before purchase and use. These farmers are conscious of the expiry date and the implications of their activities on the environment. Islam and Kashem (2000) noted that there is a correlation between environmental pollution awareness and those farmers who have been trained. According to Gaber and Abdel-Latif (2012), farmers who received training on the usage of pesticide had more knowledge about the negative effects of pesticides on health and routes of contamination with pesticides because it was discussed on training that they had attended.

Table 4. Cross-tabulation on who decides the chemicals to be bought

		Training on pesticide and fertilizer application		Total	Percentage
		Yes	No		
Decision-maker as to what pesticides and fertilizer are to be bought	Land Owner	45	35	80	45.71%
	Hired Applicator	77	18	95	54.29%
Total		122	53	175	100%
Percentage		69.71%	30.29%	100%	100%

In applying the pesticides, all of the farmers utilize a lever operated knapsack sprayer. The sprayers used are usually made of stainless steel with a longer lifespan. Majority of the respondents mentioned that it is most convenient for them because they can easily walk in the field while having the sprayer on their back. Heong et al. (1992) found that 80% of the 915 rice farmers in the Muda, Malaysia owned and use a lever operated knapsack sprayer. This type of sprayer will likely remain as the main spray equipment.

They do not use the pesticide to other crops recommended only for rice (86.9%) because they do not want to damage the other crops they have. Farmers also respect the recommendations of the municipal agriculturist and technicians as to the type of pesticides to be used on different crops.

Most have no alternative pest control method (68.3%) but only a few use organic ways to control the pest. This includes the use of *Tinospora rumphii* (panyawan) extract that is buried in the soil. *Glossogobius* sp.

(locally known as pyjanga) fish fermented in the soil until extracted for use, and using the gallbladder of goats. The said practices create a strong, pungent, and stinky odor in which farmers observed most of the insect pests deter areas applied with the said repellant. This finding indicates that alternative use of biopesticides is not widely done in the area.

4. Conclusions

Farmers having rice fields in the lake shores of Lake Mainit are utilizing different kinds of agrochemicals to intensify production of rice and protect it from pests and diseases. Insecticides, herbicides, fungicide, and molluscicide were commonly used as pesticides while urea, sulfate, potash, and complete were the convenient fertilizers used. Farmers perceived toxicity of pesticides as effective indicating that all the dosages of the application of the chemicals were effective to kill the targeted pest. Friends, neighbors and lead farmers are often instrumental source of information to address pest problems in the farm though they would also listen to technicians and extension workers who would visit their area on an occasional basis. The one who decides on buying the agrochemicals is highly dependent on the person who had received professional training on the applications of the chemicals because of they had better and technical knowledge than the common rice farmers. However, most of the farmers put too many chemicals on the crop with an average 2.3 tank/hectare of insecticides, 1 tank/hectare for herbicide, and 1-2 tanks per hectare for fungicide and molluscicide per cropping season of rice. They believed that pesticides are indispensable for high yields implying that pest management is solely relying on pesticides. This indicate a need for intervention to reduce the dependence of farmers on agrochemicals. Farmers should also be trained to have a wider knowledge on the efficient and safe use of agrochemicals to minimize the likely undesirable effects of chemicals that they are currently and constantly using. This study paves way to promote awareness to community and government agency on the use, overuse, and misuse of agrochemicals hence a massive information campaign should be done among farmers in the area. Intensive programs on integrated pest management can also contribute to a large impact on alternative use of pesticide and may reduce the detrimental effects associated with agrochemical use. A review on the national and local policy of the organic agriculture law in the Philippines can also be done to determine the gaps and pretext as to why farmers could not fully embrace and practice organic farming in spite of the benefits and subsidies given by the government. In this manner, environmental pollution caused by farming can be reduced and will safeguard the ecological component of the lake and its neighboring environment.

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