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Pesticide use Pattern and the Environmental Knowledge, Attitude and Behavior of Farmers: A Case Study in Tomohon City, North Sulawesi

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Abstract- Pesticide residues have long become global environmental and food safety issues. The use of pesticide continued to increase, and so was the reports of environmental and health problems related to residue and exposure of pesticide. Integrated pest management (IPM) was introduced in Indonesia as one of pest control approach to reduce pesticide use and exposure. The objectives of this research were to study pesticide use pattern of cabbage farmers in Tomohon (those who graduated from IPM farmer field school and those who did not), and relationship between environmental knowledge, attitude and behavior the farmers in related to pesticide residues. This research was conducted using survey technique for data collection. The questionnaires used were list of multiple and open question to collect demographic characters of farmers and consumers, pesticide usage manner. Data of environmental knowledge, attitude and behavior were collected using questionnaires with structured statements with 5 point Likert Scale. Structural equation modeling and path analysis was used to analyze relationship between knowledge, attitude and behavior while the rest by descriptive statistic. The results showed that pesticide residues in cabbage sold in Manado and Tomohon was below MRL. Farmer fields school IPM improved farmer behavior in pesticide usage, however, the transfer of IPM knowledge and experience to other farmers did not materialized as expected. It should be expanded to other farmers but with improved curriculum. Farmers had reasonably high environmental knowledge, but the respective attitude and behavior was only average. This knowledge did not manifest in pro environmental behavior such as pesticide use manner. Farmers behavior in pesticide uses did not determined by their respective knowledge and attitude, but by other factor, especially economy (successful crop) for safe family income.

Keywords- *pesticide residue, cabbage, Farmer Field School IPM, environmental knowledge, attitude, behavior*

I. INTRODUCTION

The effects of pesticide residues on the environment and food safety have long been national and international issues. Fresh fruits and vegetables are among the most debated agricultural products in Indonesia, one of which is cabbage, due to their pesticide residues. Farmers' behavior in pesticide application on their cabbage plantations is believed to the main source of this problem. Many researchers have investigated this issue to determine the level of residues on agriculture and food commodities as well as in the environment including soil, water and the organism (Zhang *et al*., 2011; Kennedy, 1998; Williams and Hammitt, 2001; Gold *et al*., 2001) including the efforts of detoxification.

Since the invention of synthetic pesticides, their production and use have been steadily increased, and seemed to be an inevitable part of modern agriculture. In 1975 active substances of pesticides in the market were only 543, increased to 812 in the year 2000 and to 890 in the year of 2004 (Stenersen, 2004). In China pesticide production in last 2 decades was increased more than 12 times (Zhang *et al*., 2011). Data of pesticide use in Indonesia is difficult to access, but according to Indonesia National Commission on Pesticide the registered brands of pesticides in 1998 was only 500. In 2003, however, the number doubled to 1040, and to 1600 brands in the year 2006 (Nugroho, 2007).

To reduce the usage of synthetic pesticides, which are known for their persistence in the environment, various efforts were introduced including organic pesticides, reduction of pesticide subsidy, maximum residues limit, introduction of good agricultural practices, development of pest resistant variety, and introduction of integrated pest management (IPM). Among those efforts, IPM was considered best way of reducing farmers' pesticide use, because farmers are directly involved in planning and decision making in their farms. IPM is a participatory approach to pest management based on ecology and economic considerations in order to achieve ecological and sustainable agro-ecosystem management (Abadi, 2007). By full and correct implementation of IPM, the negative impacts of pesticide use on the environment, people and agricultural products can be alleviated or reduced, while keeping the farming activity profitable.

In Indonesia, the implementation of IPM was legally adopted since 1992 as a national policy in pest management, although the idea had been introduced years before. The IPM knowledge and philosophy were transferred to farmers in a setting called farmer field school of Integrated Pest Management (FFS-IPM). Since then, thousands of Indonesian farmers were trained in FFS-IPM approach. The FFS-IPM program in Indonesia was considered a success, although many experts had different opinions. The fact is, farmers' pesticide uses are still high, and in incorrect way in term of doses, frequency, interval and manner (Supriatna, 2004, Supriatna and Sadikin, 2006; Saptana *et al*., 2006; Indrianingsih *et al*., 2005; Abadi, 2007; Feder *et al.,* 2004). The same situation had been reported elsewhere in the world (Ziziba and Mekuria, 2007; Mahantesh and Singh, 2009; Shetty *et al*., 2010; Passiany *et al*., 2012 and Zhang *et al*., 2011). Experts called this situation as paradox phenomenon in which the farmers are trapped in situation where pesticide has become inevitable in their farming life. By joint the FFS-IPM, the farmers were expected to learn and adopt environmentally friendly knowledge and technology to manage their crops. This bottom-up approach was expected to produce confident, wise and critical thinking farmers to make their own decision in farming activities. In addition, the FFS-IPM graduates were expected to transform the knowledge and experience they had during training to other farmers in their groups or neighborhood. The intense publication and reports of pesticide use and residue in agricultural produce has raised questions on farmers' behavior in pesticide use, and the attitude and knowledge that driven that behavior. This research was aimed to study the relationship of environmental knowledge, attitude and behavior of cabbage farmers in Tomohon City in relation to pesticide use and their application manner and to study the difference between FFS-IPM graduates and non FFS-IPM in this regard. Findings of this research could provide useful information for curriculum improvement of FFS-IPM which is still considered a better approach of educating farmer on pro-environment and sustainable agriculture.

II. LITERATURE REVIEW

Environmental behavior of people has been investigated for many years, especially in developed world. Kollmuss and Agyeman (2002) mentioned that many environmental problems and issues have their roots on irresponsible environmental behavior. They also found a significant correlation between environmental knowledge, attitude and behavior. One the concepts depicted the relationship of knowledge, attitude and behavior was a Knowledge-Attitude-Behavior Model by Kollmuss and Agyeman. This model was developed based on several previous behavior theories such as Theory of Reasoned Action (Ajzen and Fishbein, 1980) and Theory of Planned Behavior (Ajzen, 1991). According to these theories, the more people know the relationship of their attitude and behavior and the effect of their behavior, the more likely they will adjust their behavior. It is suggested that people have to logically consider the information they learned and apply to their behavior. Many researcher found linear relationship between knowledge and attitude that subsequently affect behavior (Wilson and Tisdell, 2000; Titlidil *et al.* 2009; Kaisser *et al.,* 1999a and b; Hini *et al.,* 1995; Meinhold *et al.,* 2009; Barr, 2007), although most the relationship were only moderate in strength. According to Ajzen (1991) knowledge was believed to background factor that affected one's attitude to a behavior.

Attitude is one's evaluation on various aspects of social world around, and how the evaluation cause a like or dislike feeling toward an issue, ideas, people or object (Baron and Byrne, 2004). Attitude is ambivalent in nature, that is our evaluation of issue, ideas, people or object are not always positive or negative but more often mix of the two reactions. Once an attitude has been formed, it is difficult to change for long time, especially if it is a fully negative or positive. Chai and Chen (2010) defined attitude as a condition of mental and nerves readiness that direct somebody to objects or situations related to him/her. Environmental attitude is rooted on one's concept of oneself and how far one considers he or she is an integral part of the environment. Kaisser *et al.* (1999) found that although only small part of environmental behavior can be explained by environmental knowledge, but the relation was positive. Using structural modeling equation they showed that knowledge and attitude accounted for 40% of pro-environmental variance and predicted 75% variance of environmental attitude. Meinhold and Mallkus (2005) supported this finding.

Base on the above theories and findings, a relationship model between environmental knowledge, attitude and behavior of Tohohon's cabbage farmers in regard to pesticide use was proposed as follow:

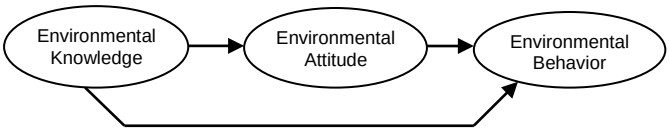

Figure 1. Model diagram of relationship between knowledge, attitude and behavior

From the above model diagram, the following hypothesis was proposed:

H1: There were positive relationships between environmental knowledge and attitude, knowledge and behavior and attitude and behavior of Tomohon cabbage farmers.

H2: There were differences in level of relationship between graduates of FFS-IPM and non-graduate FFS-IPM

H3: There were difference in pesticide application manner between SSF-IPM graduated farmer and non SSF-IPM graduated farmer

III. METHODOLOGY

1) Research Location

This research was commenced from December 2010 to June 2012 in Tomohon city and Manado of North Sulawesi.

Cabbage farmer respondents were taken from Tomohon area, which is a horticulture centre of North Sulawesi. Cabbage sample for analysis was taken from cabbage farm in Tomohon, traditional market and supermarket in Manado and Tomohon.

B. Farmer respondent

Research population was cabbage farmers in Tomohon. Sample was selected by stratified random sampling. The two strata were FFS-IPM graduates and non FFS-IPM graduates (will be addressed as IMP farmer and non-IMP farmer the rest the paper). Total 125 questionnaires distributed, 113 were returned or eligible for analysis.

The questionnaire for data collection consisted of 2 parts, first part was for data collection of demographic information and pesticide uses; second part was for collection of farmer environmental knowledge, attitude and behavior. The second part questionnaire was a structured statement, with the response of 5 point Likert Scale. The response for knowledge and attitude were scored as 5 = strongly agree; 4=agree; 3=neutral; 2=disagree; 1=strongly disagree; whereas those for behavior were 5=always; 4=almost always; 3 = neutral 2 = some times; 1 = never. The statements were modified and adjusted from (Kaisser *et al.* 1999; Barber *et al.* (2009) dan Van Liere, 1978)

C. Data analysis

Demographic and pesticide use data were analyzed with descriptive statistics whereas the knowledge, attitude and behavior relationship were analyzed with Structural Equation Modeling (SEM) and path analysis using LISREL 8.80 program. Pesticide residue of cabbage sample taken from farmers' field, and retailer (traditional market and supermarket) was analyzed by chromatography method (in PT Angler BioChem, Surabaya, a food and environmental lab analysis with national accreditation).

IV. RESULTS AND DISCUSSION

A. Description of sample farmers

Tabulated data showed that in general both farmer groups (IMP and non-IMP farmers) were similar in level of education. More than 60% graduated from high school, and only 6.2% had preliminary school education. Around 68%-75% of both farmer groups grow cabbage and other vegetable crop with farm size between 0.25 – 1,0 Ha, in which more than 70% farmers own their farm. The average family income of IPM farmer was higher than non IPM farmers. More than 52% of graduated farmer has had monthly income between Rp 2.5 million to Rp. 5 million, whereas only 18% of non-graduated farmers had income in that category. More than 19% of IPM farmers had income up to Rp. 7.5 million, whereas more than 67% on non-graduated farmer only has Rp.1 million to Rp. 2.5 million. It seemed that the main different between the two farmer group was in income. The other categories including ages were similar.

B. Pesticide Residue and Pesticide Use pattern

Analysis of pesticide residue from all samples (from farmer fields and from traditional and supermarket in Tomohon and Manado showed that no sample was detected pesticide residue above maximum residue limit (< 0.05 ppm) for 6 of mostly pesticides. The part that contained high residual pesticide was at the outer part of cabbage crop that left in the field by farmer when harvest. It means that pesticide applied did not penetrate into the inner part of cabbage crop. The morphology of cabbage protects the inner part from pesticide. This is a somewhat advantageous properties of cabbage compared to other leafy vegetables or fruits in which the edible part is the whole part that is harvested. Despite of high intensity of pesticide application, the edible part of cabbage contained low level of pesticide residue. This fact, however, did not mean that pesticide residue in cabbage was below limit, because all the residues was concentrated on the non-edible, outer part of the crop which contained high level of pesticide.

Tabulated data on pesticide use pattern showed that before make decision to apply pesticide most of IPM farmer made field observation, whereas only 50% of non IPM do the same. More than 90% of IPM farmer consider direction of the wind during application as compared to less than 70% in non IPM farmer. Only 57.35% of non IPM farmer did personal body cleaning (shower and change cloth) immediately after application as compared to 71.68% on IPM farmer. About 38.8% on non IPM farmers washed their pesticide equipment in the well, whereas none of IPM farmer did the same. It was obvious that farmers, especially those of non-IMP did very poor preventive measures during pesticide application. It was certainly that they would have high pesticide exposure. This findings were supported by other research done elsewhere in Indonesia (Supriatna, 2004, Supriatna and Sadikin, 2006; Saptana *et al.*, 2006; Indrianingsih *et al.*, 2005; Abadi, 2007; Feder *et al.*, 2004). According to Zhang *et al.* (2011) most of the illnesses related to pesticide were not related to residue in staple food people are eaten, but mostly to direct exposure during unprotected pesticide application and careless behavior.

TABLE I. THE METHODS USED IN PREVENTION AND CONTROL OF PEST INFESTATION DURING CABBAGE CROP SEASON (PERCENTAGE OF TOTAL FARMERS IN EACH FARMER CATEGORY)

Prevention methods (%)			Controlling methods (%)		
Methods	IPM farmer	Non IPM farmer	Methods	IPM farmer	Non IPM farmer
Pesticide application	43,28	63,01	Pesticide application	62,32	81,94
Crop rotation	31,35	19,18	Trapping	2,90	4,17
Use pest resistant species	13,43	6,85	Use of sex pheromone	0,00	0,00
Fence guard	5,97	1,37	Use of natural predator	34,78	13,89
Other (sanitation)	5,97	9,59			
Total	100	100		100	100

Indrianingsih *et al*. (2005) mentioned that farmer considered pesticide as "medicine" to protect from pest, not a "poisonous" material that deserved to be handled carefully. According to Khan (2009) factors that affect whether or not farmers adopt safe behavior of pesticide use are not well understood. Some experts believe that this behavior were due to lack of knowledge and information. Some reports, however, showed that, despite high knowledge of health and environmental impact of pesticide, farmers and pesticide workers showed poor safety measure during pesticide handling (Damalas, 2006; and Khan, 2009). In his study Khan (2009) reported that practically all sample farmer in his research using pesticide intensively with minimum body protection although 88% of farmer perceived pesticide as high health risk and more than 77% has had experienced health effect during pesticide handling.

There was markedly different in the IPM and non IPM farmers' approaches in preventing and controlling pest infestation. More than 63% of non IPM farmers use pesticide for prevention whereas that of IPM farmer was 43.23%. Similar pattern was seen in method of controlling pest infestation where more than 81% of non IPM farmer used pesticide as compared to only 62.32% of IPM farmer. The use of more environmentally friendly methods such as crop rotation and pest resistant varieties were also higher for IPM farmer. Similarly seen in controlling method by natural predator was markedly higher in IPM farmer (34.78%) as compared with non-IMP farmer (13.89). In spite of more favorable number showed by IPM farmers, preventing and controlling pest in cabbage crop by Tomohon farmer still highly depended on pesticide. It seemed that IPM philosophy and approach has not been fully adopted and practiced by cabbage farmer. Similar trend was also reported by others (Supriatna, 2004, Supriatna and Sadikin, 2006; Saptana *et al.*, 2006; Indrianingsih *et al.*, 2005; Abadi, 2007; Feder *et al.*, 2004). Some better pictures were report in Africa (Ziziba and Mekuria, 2007) and Brasili (Passiany *et al.*, 2012).

TABLE II. FREQUENCY OF PESTICIDE APPLICATION DURING CABBAGE CROP SEASON (PERCENTAGE OF TOTAL FARMERS IN EACH CATEGORY)

Frequency of application	percentage	
	IPM farmer	Non IPM farmer
Every three days	0,00	13,64
Every week	14,29	43,94
Every two weeks	63,27	15,15
If there was pest infestation	22,44	27,27
Total	100	100

TABLE III. THE TIME INTERVAL OF LAST PESTICIDE APPLICATION BEFORE HARVEST (PERCENTAGE OF TOTAL FARMER IN EACH FARMER CATEGORY)

Interval	Percentage	
	IPM farmer	Non IPM farmer
One day before harvest	0,00	17,19
Three days before harvest	2,13	18,75
One week before harvest	8,51	9,36
10 days before harvest	4,26	10,94
Two week before harvest	74,47	35,94
One month before harvest (depend on situation)	10,64	7,81
Total	100	100

Somewhat different patterns were seen in intensity (Table 2) and interval (Table 3) of applications. More than 13 % of non IPM farmer applied pesticide every 3 days and almost 44 % did every week, whereas more than 63% of IPM farmer applied every 2 weeks and non-did every 3 days. This pictured a high intensity of pesticide use especially for non-IMP farmer. This situation was made even worst by the fact that almost 36% of non IPM farmer applied pesticide 1-3 days before harvest. Much more better picture was seen for IPM farmer that more than 74% applied 2 week before harvest (as compared to almost 36% for non-IMP farmer), and non-did within 1 day and only 2.3% did within 3 days. In term of intensity, the IPM farmer showed much lower picture. From these two tables, however, it can be seen there was still 2.3% IPM farmer did apply pesticide 3 days before harvest, and 8.51% in 1 week before harvest which is considered not a not enough time interval for the pesticide to naturally degrade to a save level of residue. These two tables also showed that, although in much different degree, the two farmer categories still applied pesticide in calendar-wise pattern. A pattern that is not opposed by IPM approach. Feder *et al.* (2004) implied that the adoption of IPM technology and philosophy which was considered some complicated and time consuming needed to be reformulated and adjusted according to the finding of IPM evaluative research. Reksosudarmo (2008), on the other hand, suggested that the government of Indonesia should continue support with more funding the FFS-IPM because it had showed positive to GDP increase, and also reduced pesticide use according to this research finding.

C. The relationship of farmers' environmental knowledge, attitude and behavior

The SEM analysis showed that the proposed model of the relationship of farmer knowledge, attitude and behavior for IMP farmer was confirmed (p-value 0,556 significant level of 5%; MRSEA=0,000) by the data observed. The relationship between variable, however, only the relationships of knowledge-attitude and attitude-behavior were meaningful (path coefficient value of 0.54 and 1.01). Subsequent significant test, showed only attitude and behavior was significant ($t>1.95$). Considering the r^2 value for behavior was 0.78 means that 78% of variance behavior contributed by knowledge and attitude. For non IPM farmer, using path analysis, it was found that only knowledge has positive and

significant relationship with attitude, the other relations were insignificant. With r^2 of 0.36 mean that 36% of attitude variance was contributed by knowledge for non IPM farmers.

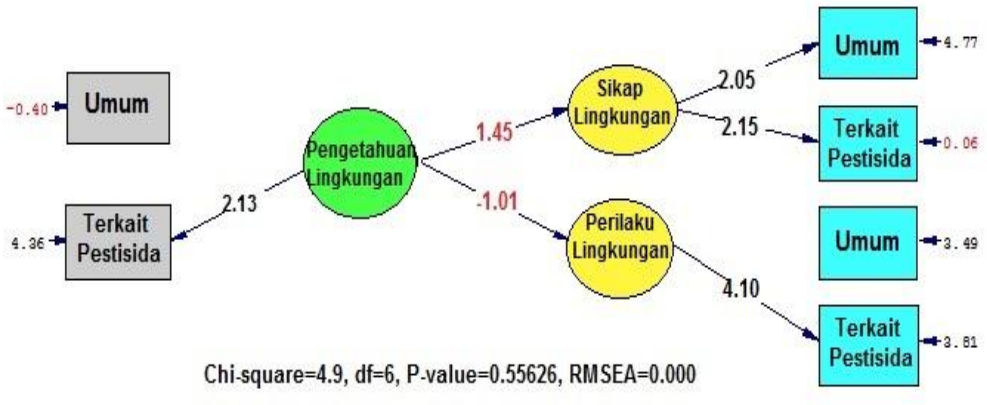

Figure 2. Significant test of path coefficient between environmental knowledge, attitude and behavior of IPM farmer (standardized solution)

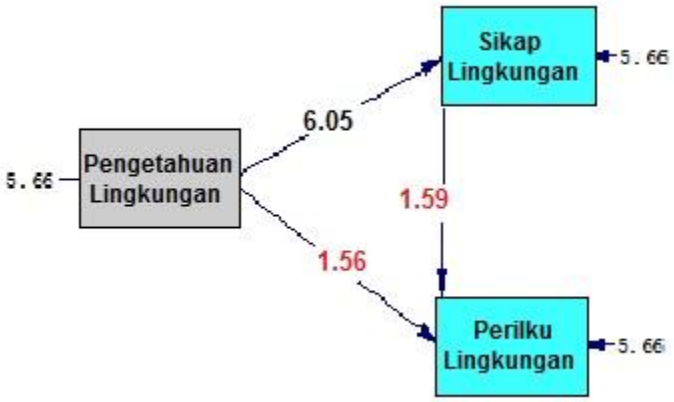

Figure 3. Significant of path coefficient on Non IPM Farmer environmental data

Considered the average score of environmental knowledge, attitude and behavior both IPM and non IPM farmer (Table 4), it seemed that IPM farmers had higher level of environmental knowledge, attitude and behavior as compared to non IPM farmers. For both farmer groups, however, the score tend to decrease from knowledge to behavior. This data showed that the level of farmers' knowledge did not correspond with their attitude and subsequent behavior. The higher score for IPM knowledge are likely attribute to knowledge and experience they had during farmer field school. However, as seen in their respective pesticide use patterns it was obviously the transfer of knowledge between IMP farmers to other farmers did not did not take place as expected according to the idea oh FFS of IPM. In addition to that, this data showed that the higher knowledge score IPM farmer did not induce better environment attitude and behavior, as also shown by structural analysis. The non IPM farmers, on the other hand, although there was a positive relationship between knowledge and attitude as shown by path analysis, the mean score of knowledge was only about average in strength. Hence, it effect on attitude score was also small. Many studies showed similar results that the relationship of knowledge, attitude and behavior are inconsistent and somewhat weak (Barr, 2007; Ahnstrom et al, 208; Barber, 2009; Hinn et al., 1995; Kaisser, 1999a; Kollmus and Agyeman, 2002; Mahanthes and Singh; 2009; Sulistyono et al, 2009). The most obvious cases were reported among farmer. Many farmers in various study, especially in developing countries, showed that farmers actually showed higher level of environmental knowledge regarding the effect of pesticide residue on environment as well as on human. Their actual behavior, especially in pesticide use, was very poor in term of dose and use pattern. Most of them did not handle the pesticide with high care. Many of the farmers in this research actually did not eat the cabbage they planted for sell because fear of the pesticide residue. It showed that they had some degree of knowledge about the effect of pesticide residue on their health, but they did use pesticide in bad manner.

TABLE IV. AVERAGE SCORE OF ENVIRONMENTAL KNOWLEDGE, ATTITUDE AND BEHAVIOR OF IMP- AND NON IPM FARMERS*

	IPM Farmers		Non IMP Farmers	
	Mean	SD	Mean	SD
knowledge	4,41	0.42	3,72	0.61
Attitude	3,32	0.44	3,18	0.50
Behavior	3,27	0.64	3.03	0.51

Score between 1 to 5 (Likert Scale), the higher the score the stronger the level*

Thapa (1999) cited some experts conclusion on this matter that people may have knowledge of environmental problems, but they do not act accordingly because their political and economic value are not consistent with such behavior. According to Van der Linden (2012), perception is a significant predictor of environmental behavior and can potentially change behavior but only if accompany by strong message and the risk is perceived as direst and personal. Sulistyono et al., 2009 and Indrianingsih et al. (200%) reported that farmers usually considered pesticide as "drug for bugs" not a poisonous material that deserved to handle with high care. So the risk may not be perceived as direct. In addition, the effect of pesticide residue on environment and human may be considered as not personal matter for the farmer. The main risk perception for the farmers in their farming activity is that pest may attack any time, and if it happen they may lost their crop. Pesticide is considered a safety measure to ensure good harvest, and good family income. Van der Linder (2012) mentioned that although knowledge is a necessary condition for behavioral change, but it is not a sufficient condition.

The main different between the IPM farmer and the non IPM farmer is in their pesticide use intensity and their level of knowledge, attitude and behavior, which was somewhat higher than that of non IPM farmer.

V. CONCLUSION

Cabbage farmers in Tomohon are still heavily dependent on pesticide in controlling pest and disease in their cabbage plantation, and they used it with high intensity, especially for non PHT farmers. Nevertheless, the implementation of IPM has reduced and improved the level and patter of pesticide of farmers to become more environmental friendly, hence it is still better approach to be used to achieve sustainable and pro-environment agriculture. The method, however, need to be improved in order for the transfer and adoption of knowledge to take place. Improvement of environmental knowledge and of the effect of pesticide on human health is not the main driving force to change farmer behavior in pesticide uses. The main focus of farmer perception in pesticide use was to ensure good harvest for better profit. These findings should be taken into consideration in improving curriculum and implementation of IPM.

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