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Environmental Issues in Straw Mushroom Farming In Dong Thap Province, Vietnam

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Abstract

This study investigates the technical process and identify environmental and public health issues related to the use of pesticides and waste treatment in straw mushroom farming in Dong Thap province using field survey and direct interview with 30 farmers in the study area. The results showed that the farmers often use pesticides in the transplanting spawn and covering the straw beds stages. They often applied various types of pesticides belonging to toxicity categories II, III and IV according to World Health Organization (WHO) classification, with 10 active ingredients, in which the Trichlorfon and Fipronil were banned from using. It was found that the pesticides including Sumithion 50 EC, COMCAT 150WP, Tiginon 5gr were used in the straw mushroom cultivation and the time interval between the spraying and the harvest of the mature mushroom was not safe for human consumption according to the safety duration labeled on the pesticide bottles' instruction. This leads to risks to consumers' health. Moreover, the treatment of bottles and packages of the pesticides after use by burning, selling to venders and disposing were improper. The findings of the present study revealed that straw mushroom farming potentially pose risk to surrounding environments and health. Therefore, it is necessary to organize training on advanced farming techniques as well as awareness raising for farmers to minimize these risks.

1. Introduction

The Mekong Delta is one of the major economic regions of Vietnam, which produces most of Vietnam's rice, contributing significantly to the food security of the nation. Although accounting for only 12.1% of the country's area, the region contributes more than 50% of rice production of the nation and more than 90% of annual rice export [1]. However, corresponding to this cultivated area and rice production is the large amount of straw after harvest, which is not very well treated improper. The treatment methods are mainly to bury straw in the soil, burn in the field, etc. Burning straw in the field contributes to the greenhouse effect, pollutes the air environment and can promote leaching of nutrients from the soil [2]. In addition, organic compounds released from direct burial of the straw into the soil could result in harmful effect for ecosystem [3-4]. In recent years, straw has been used to grow mushroom or to mix with other wastes for biogas production thus improving farmers' income or reducing environmental problem, respectively [5-6]. In particular, the straw mushroom farming (*Volvariella volvacea*) has been implemented by many farmers in the Mekong Delta.

Dong Thap Province has abundant raw materials for the straw mushroom farming due to its large rice cultivation area of 541,803 ha which produce more than 3.3 million tons of rice [7]. The species

of straw mushrooms (*Volvariella volvacea*) is commonly used because of it grows easily and has a short growth duration. Additionally, this farming has the low investment costs with the main inputs including rice straw, spawn, labor and water. The mushroom production has brought many practical benefits, it not only solves the growing problem of straw but also upgrades the value chain of rice straw-byproducts, brings higher economic efficiency for farmers. However, to improve productivity, farmers have used more fertilizers and pesticides in the mushroom growing process. In addition, this process also generates a large amount of waste, which will cause many negative effects if not disposed properly. All of these indicate that straw mushroom farming potentially pose risk to environments and public health. Therefore, this study was conducted to identify the environmental and health problems related to the use of pesticides and waste treatment from the straw mushroom farming in Dong Thap province.

2. Methodology

Data were collected by using field survey and direct interview of 30 farmers in Dong Thap province. This data includes the current status of straw mushroom cultivation, use of fertilizers and pesticides and waste treatment generated during mushroom growing process. The questionnaire was designed in a semi-structured form to collect information about pesticides types, dosage, frequency, and understanding of the harmful effects of pesticide uses, and methods of handling the pesticide packages after use. Potential effects of pesticides on the environment and health are assessed through the type of pesticides used, the dosage, frequency, and method of treatment of the pesticide wastes after use. The effects of pesticides were also assessed using the toxicological information of the active substance found in the organism. On the basis of analysis of the current situation, a number of recommendations is proposed to minimize the harmful effects of pesticides use on the environment and humans.

3. Results and Discussion

3.1 Current practices for growing mushroom

3.1.1 General information of the interviewees

The interview results showed that farmers with the ages of 18-45, 46-60 and over 60 years old accounted for 60%, 23% and 17%, respectively. Straw mushroom farmers are mainly men with 87%, who are directly involved in the process of growing and taking care of mushrooms. The educational level of farmers is relatively low, with the rates of 23%, 20% and 40% of primary, secondary and high school, respectively. The remaining are illiterate (accounting for 17%). This affects access to information on advanced farming techniques. Most of people in the study area have income mainly from rice cultivation, mushroom cultivation, and fruit cultivation. In addition, there are other sources of income such as employees, workers, etc., this is consistent with the local socio-economic characteristics. The area for growing mushrooms is from 500-1000 m^2, accounting for 84%, followed by more than 1000 m^2 at the rate of 13% and the remaining 3% are farmers with cultivated area less than 500 m^2. Most of the mushroom growers in the study area follow the family's experience with 76% of the farmers having 5-10 years of experience. In addition, 17% of farmers have experience of less than 5 years and 7% of farmers have more than 10 years of experience.

3.1.2 The process of growing straw mushrooms

The process diagram of growing the mushroom is shown in Figure 1 with steps including preparing the growing area, preparing the materials, composting the rice straw, preparing growing beds and transplanting spawn, covering the straw beds, caring and harvesting.

The stages in the mushroom cultivation process are carried out as follows:

a. Preparation of the growing location

The interview results showed that mushrooms are often grown on soil and brick ground. There are 45% of farmers treat the soil by lime before planting mushrooms for the purpose of preventing

insects and fungi latent in the soil. Meanwhile, 55% of farmers do not treat their land because they plant on brick grounds or on new land.

b. Preparation of the materials

The study area has a relatively large rice growing area, so raw straw used for growing mushrooms is quite abundant. The amount of straw growing mushrooms is mainly bought by straw collectors with prices ranging from 19-28 thousand VND/bales or used their straw. To minimize contamination and for best quality, the straw should be collected right after harvest. Rice straw should be dry, clean, without mold contamination, and should not have been exposed to rain or should not have started rotting in the field.

c. ***Incubation of the rice straw***

The purpose of incubate the rice straw is to promote the mushroom to grow faster. In composting, the rice straw is piled up and wetted for 3-4 days so that the water is evenly absorbed into the straw. The pile is about 1.5-2m wide and 1.5-1.7m high. Straw should be compacted so that the first layer is 0.5m thick, subsequent layers are carried out in the same way until the pile reaches a height of 1.5-1.7m. Proceed to rotate the pile for 7-9 days. Then, the ingredients are examined, if the conditions are met (moisture and odor), then proceed to growing beds and spawning. The incubation time depending on the quality of the straw before being incubated, the incubation time may only need 6 days [8] but it may also take 10-15 days [9].

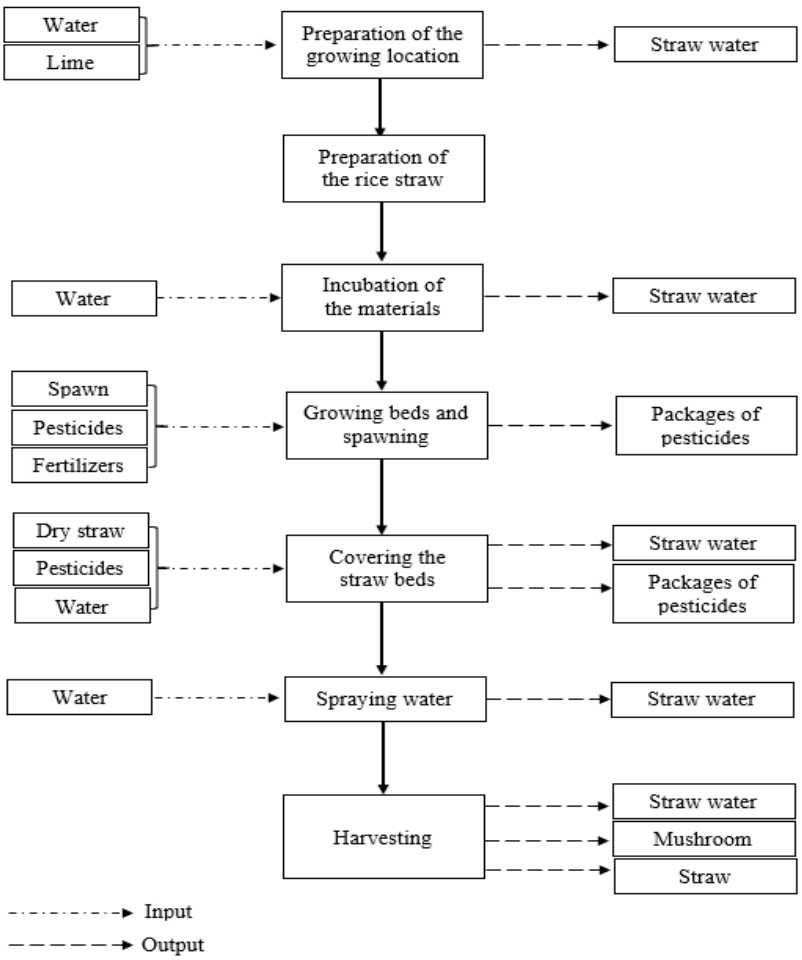

Figure 1. The process of growing mushrooms

d. Growing beds and spawning

The straw after incubation is wrapped tightly into straw pillows, then arranged layer, continue to water and stomp the mushroom bed, and smooth both sides of the bed to create a suitable place for

mushroom to grow. The distance between the two bed is about 4-5 cm to facilitate care and harvest. While the bed straw has often 2-3 layers of straw in the dry season, the rainy season is arranged from 4-5 layers to keep the warm, helping the silk to grow faster. Farmers often spread spawn and fertilize at the same time. The fertilizers used include Than Nong, foliar fertilizer (SUM, Peanut worm, BTV-HUMATE) and nutritional compounds (NT 301.N, HVP 301.N). Besides that, farmers also additional pesticides (Dich Bach Trung 90SP, Emathion 55EC, Sumithion 50 EC, CHIEF 520WP, Karate 2.5EC, Tiginon 5gr, Kajio 5WG), growth stimulants (COMCAT 150WP, Atonik 1.8 SL) and growth regulators (Rice Holder 0.0075SL).

Choosing the quality of the spawn is a direct decision to the mushroom yield. The spawm should have white silk, do not use green mold to ensure productivity. The results of the study showed that 30% of the farmers used the spawn of unknown origin and 70% of the farmers bought the spawn according to traders' recommendation with clear origin. In which, the spawn chosen by 50% farmers is the spawn 9999, followed by the spawn 5 Sai Gon with the rate of 44%, the rest 6% uses Than Nong spawn. With each package of spawn (about 150g) can use for the length bed straw from 2.5-3m.

e. Covering the straw bed

In the first 5-7 days after adding spawn to the straw beds, the beds need to be exposed to the sun to increase the temperature inside, which stimulates mycelial growth. Then, the beds are covered with a dry straw. During this period, farmers added pesticides (Tiginon 5gr, Trichlorfon, Sumithion 50 EC, CHIEF 520WP), growth stimulant (COMCAT 150WP, Atonik 1.8 SL) and growth regulator (Rice Holder 0.0075SL) to increase efficiency.

f. Mushroom Growing Care

The beds can be watered and covered with rice straw to maintain the temperature and humidity as well as to maximize the yield and quality of straw mushroom production. The watering duration of farmers in Dong Thap province similar to duration was mentioned in the study of Thang (2006) [9], watering can be done twice a day when it is cool (in 7-8 am and 4-5 pm). In case of excess water, farmers will stop watering and remove the rice straw cover. When wild mushrooms appear, they must remove all the wild mushrooms to retain nutrients for the mushrooms. During watering, avoid using strong water jets to avoid damaging the filaments and small fruit.

g. Harvesting

The mushroom can be harvested 12 days after transplanting spawn. Mushroom harvest time lasts from 8-22 days, most farmers harvest once time a day in the early morning (3-4 am). In addition, a few farmers harvest one more time in the afternoon at 3 pm. This is also the time that Hau Giang Province Agricultural Extension Center put into the process of growing mushrooms according to the improved method in 2017. Hand picking is the common method of harvesting and sorting the mushrooms. This guarantees less damage and better quality. The mushrooms are picked from the growing beds with a rotating motion. After the first picking, farmers will carefully cover the straw bed and wait for the second harvest. On a mushroom bed, farmers will harvest 2 times, each time lasts for 3-4 days, the second time is usually done after the 1st time from 7- 8 days. The total time of a planting season lasts from 25-30 days. The planting period of farmers in Dong Thap is similar to Can Tho but shorter than that in Hau Giang [6,10].

3.2 Environmental issues in the straw mushroom farming

3.2.1 Environmental problems due to the use of pesticides

The interview results showed that during the process of growing straw mushroom, farmers used many different pesticides, which is shown in Table 1.

Table 1. Active ingredients frequently used in straw mushroom growing

Active ingredients	Trade name	Type	Toxicity categories	Regulations
Extract from Lychnis Viscaria tree	COMCAT 150WP	Growth stimulants	IV	Allowed to use
Trichlorfon (Chlorophos)	Dich Bach Trung 90SP	Pesticides	II	Banned to use
Emamectin benzoate (Avermectin B1a 90% + Avermectin B1b 10%)	Emathion 55EC	Pesticides	III	Allowed to use
Fenitrothion (min 95%)	Sumithion 50 EC	Pesticides	II	Allowed to use
Fipronil	CHIEF 520WP	Pesticides	II	Banned to use
Lambda-cyhalothrin (min 81%)	Karate 2.5EC	Pesticides	II	Allowed to use
Nitrophenolate 0.6%	Atonik 1.8 SL	Growth stimulants	IV	Allowed to use
Thiosultap-sodium (Nereistoxin) (min 95%)	Tiginon 5gr	Pesticides	II	Allowed to use
Brassinolide (min 98%)	Rice Holder 0.0075SL	Growth stimulants	IV	Allowed to use
Emamectin benzoate 50g/kg (5WG)	Kajio 5WG	Pesticides	III	Allowed to use
Kajio 5wg				

In the cultivating farm, the farmers often applied various types of pesticides with 10 active ingredients in 10 trade names surveyed. In which, 80% of active ingredients are on the list of pesticides permitted for use in Vietnam and belonging to toxicity categories II, III and IV according to World Health Organization (WHO) classification. These active ingredients include lychnis viscaria extract, benzoate (Avermectin B1a 90% + Avermectin B1b 10%), Fenitrothion (min 95%), Lambda-cyhalothrin (min 81%), Nitrophenolate 0.6%, Thiosultap-sodium (Nereistoxin) min 95%, Brassinolide (min 98%), Amectin benzoate 50g/kg Kajio 5wg. Among them, there are 03 active ingredients in group II, 02 and 03 active ingredients of toxicity categories III and IV, respectively. The remaining Fipronil and Trichlorfon active ingredients were banned from using with toxicity categories II.

Table 2. The potential effects of pesticides on human and environment

Active ingredients	Toxicity categories	Affected objects
Trichlorfon	II	- Trichlorfon is highly effective against insects - The toxicity of trichlorfon is very high, potentially harmful to human health when absorbed into the body, leading to symptoms of hemorrhage, chest tightness, shortness of breath due to bronchospasm. Severe cases can lead to unconsciousness, nervous disturbances, abnormal heart rhythms and death.
Fipronil	II	- Oral LD50 = 95-97 mg/kg. - Decomposes slowly in plants, moves slowly in water and is nearly immobile in the soil. - Very toxic to bees, fish and natural enemies. - Quick contact and effectively eradicating spiders, stem borers, leaf-rolling worms, and white-chalk hoppers on rice - The US Environmental Protection Agency (US.EPA) has classified Fipronil as a risk group for cancer.

In the process of growing mushrooms, farmers often use pesticides in the transplanting spawn and covering the straw beds stage. According to the use instructions on the package and the bottle of pesticides has 02 types of quarantine for 3 days, 05 types of isolation for 7 days, 02 types of quarantine for 14 days and 01 quarantine for 21 days later when spraying.

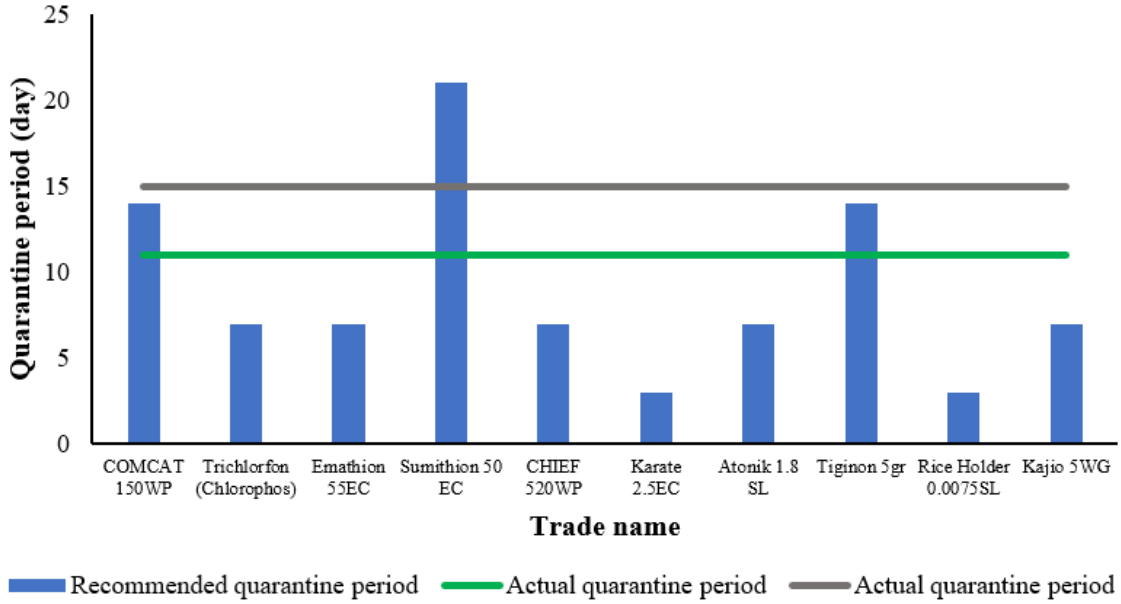

Figure 2. Quarantine time of pesticides in the transplanting spawn stage

At the stage of growing beds and spawning, the farmers used all 10 above pesticides with isolation time from 11-15 days. Accordingly, Sumithion 50 EC has not reached the required isolation time on the package.

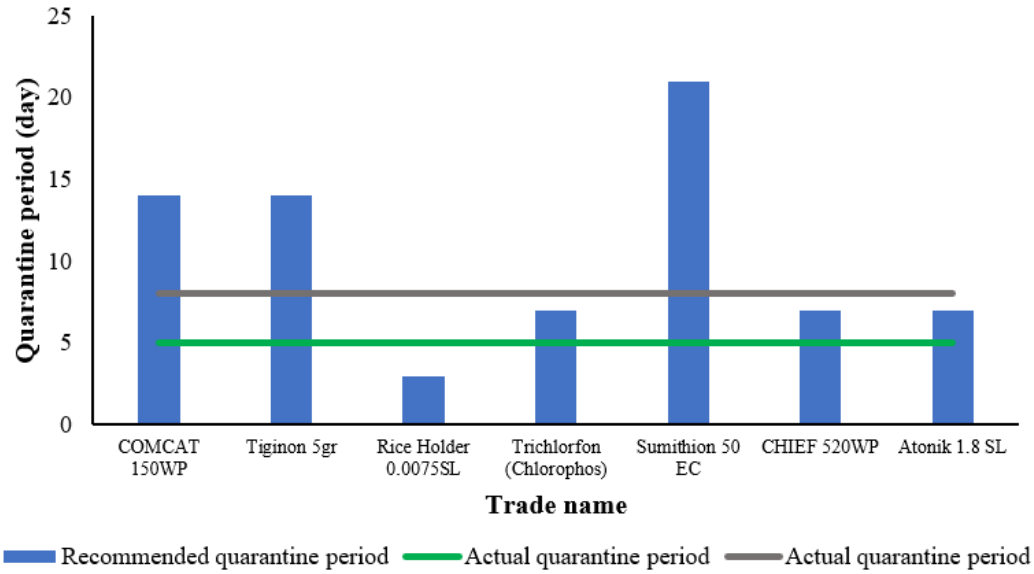

Figure 3. Quarantine time of pesticides in the covering the straw beds stage

Meanwhile, the covering straw beds stage uses only 07 pesticides but it has a relatively short isolation time (from 5-8 days). Therefore, during this period there were 03 pesticides that not have enough isolation time, including COMCAT 150WP, Tiginon 5gr, and Sumithion 50 EC. This leads to the residues of chemicals on straw mushrooms after harvest, causing dangers to consumers such as poisoning, central nervous disorders, headache, vomiting, insomnia, memory loss, etc.

3.2.2 Environmental problems caused by the use of fertilizers

The survey results showed that all farmers used Than Nong fertilizer to fertilize straw mushrooms to increase productivity, reduce disease and help mushrooms become more beautiful. Besides that, to provide nutrition for mushrooms and shorten the care cycle, has 11 and 10 farmers additonally used foliar fertilizers and nutritional compounds, respectively.

Table 3. Fertilizers used in straw mushroom growing

Type	Ingredients
Than Nong	Unidentified
SUM	N: 1,6%. P_2O_5: 1,48%. K_2O: 1,36%. pH: 7.
Sam dat	Acid humic 2.5%, TN (N_{IS}) 4.5%, P_2O_5 3.5%, K_2O 2.5%
NT 301.N	Acid humic 2.5%, total nitrogen 4,5%
BTV-HUMATE	Acid humic 45%
HVP 301.N	Acid humic 10g/L, N 30g/L, P_2O_5 40gr/l, K_2O 40gr/l

Fertilizers such as Sam dat, NT 301.N, BTV-HUMATE, HVP 301.N are biological fertilizers not only increase the yield but also provide minerals and organic matter to help regenerate arable land and prevent soil degradation. Meanwhile, SUM fertilizer is a chemical fertilizer, when applied too much can reduce soil fertility, broken soil structure, hardening soil and causing water eutrophication, indirectly affect people's health. Most of farmers in the study area used fertilizers in the process of growing beds and spawning, while in the study of Hung and Thang (2010) [11], fertilizer was added during the incubation rice straw.

3.2.3 The treatments of bottles and packages of the pesticides

Pesticides are usually contained in nylon bags and plastic bottles. After using, these packages need to be collected and treated separately because this is the hazardous wastes. The packages containing pesticides have ecotoxicity and toxicity, which can cause irritation, acute toxicity, chronic toxicity, reproductive toxicity, genetic mutation, toxic gas, cancer and cause impacts on the environment as well as to biological systems through bioaccumulation. Although there are many potential risks to the environment and public health, the farmers in the study area do not have appropriate treatment solutions, they often burning, selling to vendors or disposing in the field.

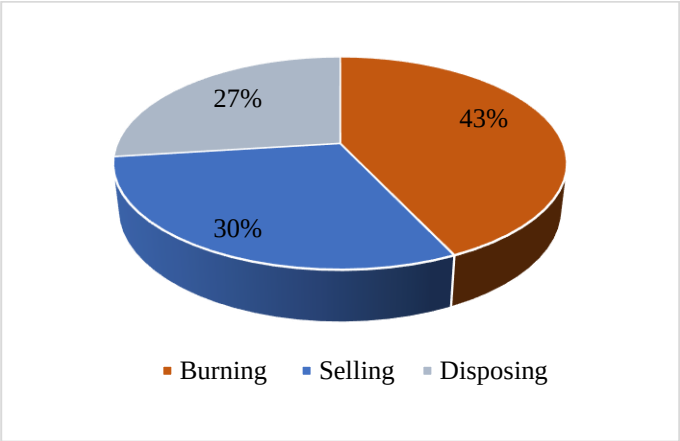

Figure 4. The treatments of bottles and packages of the pesticides

The most commonly treatment method used is burning, followed by storing for sale and finally disposing in the field. All of these methods are not safe for the environment and public health. Part

of the reason for the improper handling of pesticide packages is that the farmers do not really pay attention to the serious impacts of this hazardous waste.

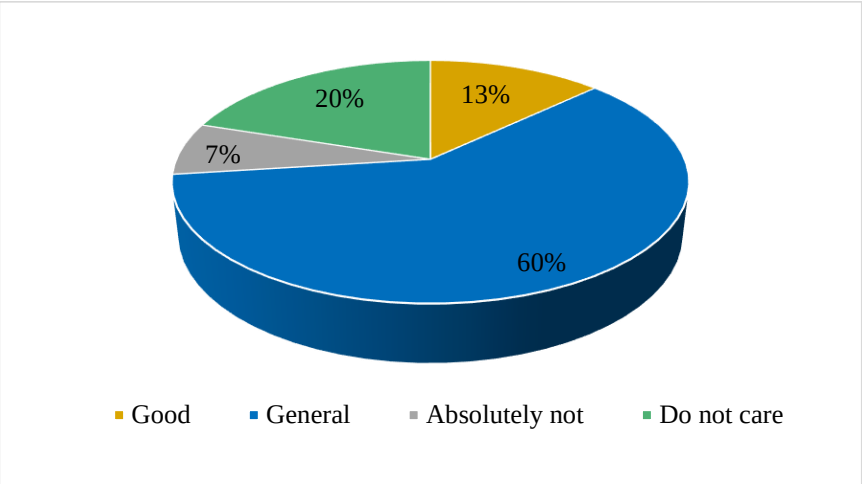

Figure 5. Awareness of farmers of the harmful effects of pesticides

The results showed that farmers have awareness well and generally about the harmful of pesticides are 13% and 60%, respectively. Although the rate of farmers' knowledge about pesticides is quite high, they have not acted properly to limit environmental pollution as well as protect public health. Besides that, 7% of farmers are completely not and even do not care (accounting for 20%) on the harmful effects of these chemicals.

3.2.4 Environmental problems caused by wastes generated in mushroom cultivation

The use of banned pesticides and improper application of treat packages methods can pose health and environmental risks. In which, the use of agricultural products with residues of pesticides can lead to acute poisoning or cause dangerous diseases such as cancer, nervous dysfunction, digestion, circulation of the body and even can cause deformities for the next generations [12]. In addition, the uncontrolled burning method of pesticides at low temperatures will lead to incomplete destruction, producing dust, CO_2, CO, SO_x, NO_x and many other harmful substances. Moreover, disposing of pesticide packages in the field can cause residues of pesticides to spill over rainwater over the soil and surrounding water sources. This residue has serious effects on the quality of the aquatic environment and the growth of aquatic organisms. Furthermore, they will indirectly affect human health through bioaccumulation [13-15].

Besides the pesticide issues, the straw mushroom cultivation also generates a significant amount of straw water. The results showed that all mushroom growing farmers did not carry out any treatment. This waste water is discharged directly into the river (83% of farmers) or discharged into a ditch near their house (accounting for 17%). In addition, the amount of straw after harvest can also cause environmental pollution if not handled properly [16]. In the study area, 53% of farmers selling to traders, the rest of farmers (47%) bringing the straw to compost and selling to gardener or keep them to use for their garden.

3.3 Solution to manage environmental and health risks of the straw mushroom farming

3.3.1 For local authority

Local agencies play an important role in informing and disseminating the benefits and efficiencies of advanced farming techniques and environmentally friendly farming methods. These organizations need to organize technical training courses and information sharing meetings that can introduce farmers to cultivate techniques and illustrate the benefits (ease of practices, environmental protection, biodiversity conservation, etc.). In addition, the management of fertilizers and pesticides

should be strengthened in agricultural cultivation as well as effective packaging treatment. At the same time, policy makers may provide financial or other incentives to facilitate the transition.

3.3.2 For farmers

To protect the environment and limit the impact on public health, farmers need to comply with the 4-correct rule when using fertilizers and pesticides (right medicine, right disease, right dose, right time). In addition, it is necessary to define the information and origin of the pesticides used and comply with the recommended quarantine period. Moreover, it is necessary to apply properly treat measures of bottles and packages of the pesticides after use and by-products. To limit the impact on the environment and avoid the spread of pathogens, farmers need to dig ditches to the straw water to the proper treatment place. At the same time, it is possible to make use of by-products after growing mushrooms to compost organic fertilizers, as food for earthworms or as organic substrates for growing vegetables [16].

4. Conclusion

In the straw mushroom farming in Dong Thap province, the farmers often applied various types of pesticides belonging to toxicity categories II, III and IV according to World Health Organization (WHO) classification, with 10 active ingredients in which the Trichlorfon and Fipronil were banned from using. In addition, farmers also use more fertilizers and nutritional compounds to increase mushroom yield. In the stage of transplanting spawn and covering the straw beds, there were 03 pesticides not have enough quarantine time including Sumithion 50 EC, COMCAT 150WP, Tiginon 5gr. This can pose risks to consumers' health such as poisoning, neurological disorders, vomiting, etc. In particular, treatment of bottles and packages of the pesticides after use improper has negative impacts to the soil, water, air environment, and public health. Additionally, water and straw after harvest are also issues that need to be addressed. All of these indicate that the straw mushroom farming has many potential health and environmental risks. Therefore, the local agencies need to guide cultivation techniques and raising the awareness of environmental protection for the mushroom producers.

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