KNOWLEDGE, ATTITUDE AND PRACTICES ON POTATO PEST MANAGEMENT OF ETHNIC FARMERS IN SOUTHERN SHAN STATE, MYANMAR

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A Thesis Submitted in Partial Fulfillment of the Requirements
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ความรู้ทัศนคติและแนวทางปฏิบัติในการจัดการศัตรูพืชของเกษตรกรกลุ่มชาติพันธุ์ผู้ปลูกมันฝรั่งในรัฐฉานใต้ประเทศเมียนมาร์

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Field of Study	Environment, Development and Sustainability
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เปย์ ปา ปา ออง :

ความรู้ทัศนคติและแนวทางปฏิบัติในการจัดการศัตรูพืชของเกษตรกรกลุ่มชาติพันธุ์ผู้ปลูกมันฝรั่งในรัฐฉานใต้ประเทศเมียนมาร์. (KNOWLEDGE, ATTITUDE AND PRACTICES ON POTATO PEST MANAGEMENT OF ETHNIC FARMERS IN SOUTHERN SHAN STATE, MYANMAR) อ.ที่ปรึกษาหลัก : ศุภวรรณ วิเศษน้อย

การเพาะปลูกมันฝรั่งเป็นแหล่งที่มาของรายได้ครัวเรือนที่สำคัญของเกษตรกรชนกลุ่มน้อยในรัฐฉานใต้ประเทศเมียนมาร์เกษตรกรส่วนใหญ่ใช่สารเคมีกำจัดศัตรูพืชอย่างกว้างขวางเพื่อเพิ่มผลผลิตและควบคุมศัตรูพืชในที่เพาะปลูกการใช้สารเคมีกำจัดศัตรูพืชอาจนำไปสู่ผลกระทบทางด้านสุขภาพของเกษตรกรและประเด็นปัญหาด้านสิ่งแวดล้อมหลายอย่างจุดประสงค์หลักของงานวิจัยนี้คือเพื่อสำรวจความรู้/ความเข้าใจทัศนคติและแนวทางปฏิบัติทางการเกษตรในปัจจุบันของเกษตรกรในการจัดการศัตรูพืชในการผลิตมันฝรั่งเกษตรกรผู้เข้าร่วมในงานวิจัยนี้จำนวน100คนได้รับการคัดเลือกในแต่ละหมู่บ้านโดยการใช้เทคนิควิธีการสุ่มตัวอย่างแบบแบ่งกลุ่มและแบบเจาะจงโดยใช้แบบสอบถามที่มีโครงสร้างเพื่อเก็บข้อมูลจากหมู่บ้านในเมืองกะลอสิ่งที่ค้นพบคือ72%ของเกษตรกรใช้แต่สารเคมีกำจัดศัตรูพืชเนื่องจากเป็นวิธีที่มีประสิทธิภาพมากกว่าและแค่28%ของเกษตรกรเท่านั้นที่ใช้สารเคมีและวิธีทางเลือกผลการวิจัยพบว่า15%ของเกษตรกรชาวตองโย5%ของชาวปะโอและ8%ของชาวดะนุใช้วิธีควบคุมศัตรูพืชแบบทางเลือก(ชีววิธีวิธีกายภาพวิธีเขตกรรม)เกษตรกรกลุ่มชาติพันธุ์ที่ปลูกมันฝรั่งใช้วิธีกายภาพและวิธีกลมากที่สุดเกษตรกรส่วนใหญ่ได้รับการฝึกอบรมโดยเจ้าหน้าที่มาจากบริษัทยาปราบศัตรูพืชในขณะที่แค่3%ของเกษตรกรเท่านั้นที่ได้รับความรู้จากเจ้าหน้าที่รัฐจำนวนครึ่งนึงของเกษตรกรมีความรู้ระดับปานกลางเกี่ยวกับการจัดการศัตรูพืชเกษตรกรส่วนมากมีทัศนคติในระดับต่ำเกี่ยวกับชีววิธีและวิธีกายภาพในการควบคุมศัตรูพืชในบริเวณพื้นที่ศึกษาสถานภาพสมรสประเภทของที่ดินเพาะปลูกประสบการณ์การทำเกษตรกรรมและการเพาะปลูกพืชอื่นๆได้มีความเกี่ยวข้องที่สำคัญกับวิธีการควบคุมศัตรูพืชในการผลิตมันฝรั่งงานวิจัยนี้จะช่วยให้นักส่งเสริมการเกษตรสามารถให้การฝึกอบรมที่เหมาะสมแก่เกษตรกรเพื่อให้เกษตรกรได้พัฒนาความรู้เกี่ยวกับการจัดการศัตรูพืชสำหรับพืชบนพื้นที่ราบสูง.

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Potato is cultivated as the main tuber crop which is essential for ethnic farmers' household income in Southern Shan State, Myanmar. Most ethnic farmers use chemical pesticides widely to enhance crop yield and to control pests in the farm. The use of chemical pesticides could lead to a series of health impacts of the farmers and environmental issues. The main aim of the study is to explore farmers' knowledge, attitude and current farm practices on pest management in potato production. The participants of 100 farmers were chosen from each village with a cluster and purposive sampling technique using structured questionnaires to collect the data from a village in Kalaw Township. The finding showed that 72% of farmers use only chemical pesticides due to more effective and only 28% of the farmers used chemical and alternative methods. In the result, 15% of the Taung Yo ethnic farmers, 5% of the Pa-O, and 8% of the Danu are used alternative pest control methods (biological, physical and cultural pest control method). Physical and mechanical method is one of the most applied methods for the ethnic farmers in potato production. Most farmers received training from pesticide companies' staff and whereas only 3% received information from governmental officials. Half of the farmers have moderate knowledge level on pest management. Most farmers have low attitude on biological and physical pest control methods in the study area. Marital status, type of farmland, farm experience and other crops plantation were significantly related to pest control methods in potato crop production. This study will help extension workers to provide appropriate training and improve farmers' knowledge, attitude and practices of pest control management for the highland crop.

Field of Study:	Environment, Development and Sustainability	Student's Signature .....
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Pyae Pa Pa Aung

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List of the Abbreviations

AED	Agricultural Extension Division
CARTC	Central Agricultural Research and Training Centre
DAR	Department of Agricultural Research
DAE	Department of Agricultural Extension
DOA	Department of Agriculture
DOP	Department of Planning
GAP	Good Agricultural Practice
GDP	Gross Domestic Product
FAO	Food and Agricultural Organization
MOALI	Ministry of Agriculture, Livestock and Irrigation
NARI	National Agricultural Research Institutes
NGO	Non- government Organization
PP	Plant Protection Division
ILO	International Labor Organization
INGO	International Non-governmental Organization
IPM	Integrated Pest Management
SME	Small and Medium Organization
SPSS	Statistical Package for Social Science
YAU	Yezin Agricultural University

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CHAPTER 1
Introduction

1.1 Rationale

Agriculture is the majority of the backbone of Myanmar's economy for the population in Myanmar. About 67% of the population are farmers who live in rural areas and their livelihoods drive the agricultural sector (David A. Raitzer, December 2015). The agricultural sector can contribute about 21.4 % of the country's Gross Domestic Product (GDP) in 2018 (Dr Laurie Bonney & Dr Theingi Myint, 2019) . The main crops of the country are rice, maize, corn, vegetables, and other high-value crops. Agricultural products are also included as the country's largest export commodity and can support the Myanmar people's economy. The Government of Myanmar tries to export good agricultural products to foreign countries. Therefore, farmers are trying to get good quality agricultural products and more yield for export.

In developing countries, most farmers use high amounts of agrochemicals such as pesticides, insecticides, herbicides and fungicides to improve agricultural crop production and to control pests and diseases in their farming. In Myanmar, most farmers use high amounts of chemical pesticides to get more yield on their farms. In agricultural production, pest and disease infestations are common occurrences and constraints for the farmers. The use of pesticides on the farm seems to be increasing year after year. Thailand and China are the main pesticide import countries to Myanmar and some of the agro-chemical traded in over the land border with China and Thailand. Therefore, this is one of the main challenges for the Department of Agriculture, trade unions, international agencies, chemical pesticides retailers, and farmers.

The use of chemical pesticides in crop cultivation has not only advantages but also disadvantages. It is seen that pesticides could prevent crop damage and bring high yields. On the other hand, the pesticide residue can endanger farmers and the environment. The amount of pesticides use in agricultural production depends on different crops and the weather conditions but these practices are unsustainable in the farming system for long-term. Unsustainable farming practices could be found in

many regions of Myanmar and they also threaten future food security and livelihoods of people in rural areas.

The use of pesticides in crop production causes problems relating to the health condition of the farmers and farm workers and beings negative impacts to the environment, such as fish kill and insect damages, air and water pollution etc. Unsystematic use of pesticides and their residues can devastate soil; harm other natural enemies; and damage soil biomass and microorganisms. Therefore, pest management in agricultural production is very important. It is widely seen that some farmers in the developing countries are testing integrated pest management (IPM) such as cultural, biological, physical and chemical methods to manage pests because it is an effective and friendly method for environment for declining chemical usage.

Potato (*Solanum tuberosum)* is the third most important single food crop in human consumption around the world (Devaux et al., 2021) . According to FAO, over one billion people consume potatoes in a variety of ways including India and China (Devaux et al., 2020). Myanmar is the third-highest potato production in the Great Mekong Sub-region (Lwin, 2012). Currently, there are many kinds of potato varieties still cultivated in Myanmar and they also play the main role of household food in the diet plan. In Myanmar, potato is cultivated not only for food security but also cash crop for ethnic farmers, especially in Southern Shan State.

Shan State, a hilly region, is dwelt by many ethnics people and the livelihoods of many households rely on agriculture and local products as the situation of climate is favorable for the various crops. Shan State has become a major area of the potato cultivation because it is one of the traditional businesses and an important cash crop for ethnic people. Favorable fertilization and suitable weather for potato cultivation makes high yield of potato cultivation in Shan State. In hilly regions, the potato is one of the most potential and important tuber crops not only for consumption but also for cash crops that contribute to the country's economic and food safety. Potato production also uses a high amount of pesticides than other crops (Lwin, 2012). Potato is cultivated as summer, pre-monsoon, post-monsoon, and winter crops in Shan State.

In Southern Shan State, potato is one of the most important cash - crops for ethnic farmers compared to other crops as potato is cultivated, produced and sold as

raw materials or processed products. Although the average Myanmar potato yields rose marginally, it has decreased in recent times. Furthermore, the cost of production still increases (Annette Pronk & Nang, 2016). In the local market, potatoes are bought by consumers extensively and are used in different kinds of meals in the kitchen. Potato is used in making the traditional meals and it is a must for some famous foods in Shan State. Moreover, there are a number of small and medium enterprises (SMEs) that make value-added, processed food from potatoes such as crisps, fries, curry, street food, and other processed product which will enhance the income generations of households in Shan State.

Potato production is input-intensive and it utilizes more chemical fertilizers, herbicides, pesticides, insecticides, and fungicides than other crops (Lwin, 2012). In recent times, the use pesticide has risen dramatically. It is found that pesticides consist of many toxic substances which can cause health risks to humans and the environment. Ethnic farmers in Southern Shan State use various and tremendous amounts of pesticides on their farms. Furthermore, some farmers overuse or misuse the agrochemicals and it degrades and pollutes the soil, water, and air quality, especially in developing countries. Moreover, the pesticide residues are left in the potato, soil and cooked and processed food.

Currently, most of the potato farmers rely on the chemical pesticides for pest management and to get high yield but some of the ethnic people may control pests and diseases with their traditional methods but a number of farmers do not like these methods. Pesticide use in the farm could impact farm income, the health of the farmers and farm workers, the environment, and the ecosystem directly and indirectly. Some pesticide sellers and pesticides company staff may persuade the famers by indicating how their pesticides are effective and it saves time. As a result, farmers tend to use their chemical pesticides for having high yields.

(Tun, 2019) studied on farmers' Knowledge, Attitude, and Practice of pesticide Usage (Case Study: Vegetable Growers), it is observed that most farmers used the chemical pesticide in traditional ways during their farming years. According to this result, the vegetable growers find it difficult to get information on negative impact of pesticides from the Department of Agriculture. The respondents do not have sufficient knowledge of food safety and other pest management knowledge

abilities. Therefore, agricultural training and appropriate knowledge are needed to improve appropriate precautions for the health of the farmers when they are growing crops.

(Aung., November, 2019) studied the Awareness of farmers in Application of Pesticides (Case Study: Kalaw Township) and reported that most of the farmers have knowledge gaps in the field and they used large amounts of pesticides in this area. Most of the respondents thought pest problems are more important than disease issues. Most of the farmers asked neighboring farmers how to solve the pest problems and what pesticides should be used. Although they know pesticides have negative effects, they have no knowledge of pesticides affecting the human body and they are even less aware of health impacts and environmental side effects.

(Oo et al., 2012) had studied on Farmers' Perception, Knowledge, and Pesticide Usage Practices (Case Study: Tomato Production in Inlay Lake, Myanmar) and reported that almost all farmers read the labels of pesticide bottles and packages before using pesticides, while majority of farmers have no knowledge related to Integrated Pest Management (IPM) and pest problem.(Aung et al., 2020) has found that the respondents who have more farm experience were more accepting of the IPM method and some did not accept organic pesticides and traditional method because it needs more time and it is low effective. Most farmers have experienced pest infestations in the past but old farmers and farmland ownership are not adopted.

In Myanmar, only a small number of farmers who have knowledge on the impact of pesticides and along with small-scale farmers try to encourage good agricultural practices, environmental problem, good agricultural practices and sustainable agriculture. According to (Aung., November, 2019), most farmers have less knowledge of plant pest and disease problems, and some farmers cannot decide to buy the appropriate pesticides for their farm problems. At present, Myanmar has no effective and acceptable system for pesticide management and best practices in sustainable pest management and pesticide use (Tun, 2019).

However, most ethnic people are farmers and their livelihood rely on agricultural products and most studies were focused on non-ethnic farmers' knowledge, attitudes, and practices towards pesticide use on farms of the farmers. Ethnic farmers received none of the attention of for their knowledge, attitudes, and

practices towards pesticide use in their farm production. There are very few studies and reports that have been documented and studied the ethnic farmers, especially on the assessment of their knowledge on pest management and attitudes toward the alternative method.

There was also a limited study on encouraging local or ethnic farmers for more sustainable methods and farming practices. There are big challenges for reducing pesticide use in agricultural sectors and to better understanding their attitudes toward sustainable practices. Therefore, the research was designed to study the farmers' knowledge, attitude, and practices of pesticide use and pest management of ethnic farmers.

1.2 Potatoes Production in Myanmar

The potato is one of the essential foods and cash crops for farmers and consumers, especially in Shan State which is made up of the largest volume of cultivated areas compared to other regions. Potato is the third most important single food crop all over the world and it is also included in one of the vital edible tuber crops in Myanmar. More, it plays a crucial factor in food security and income. The most potato cultivated townships in Southern Shan State (hill and mountains) are Kalaw, Pinlaung, and Pindaya. In addition, Sinphyukyune is the main potato cultivated township in the Magway region (central dry zone) in Myanmar (Table 1).

At present, the potato is one of the most popular tuber crops in the main curry and healthy diet in the households of Myanmar, and it is consumed as a dish or snack because it contains high nutrition. In addition, potatoes are cultivated and value-added (fries and crisp) and sold and distributed around the country, particularly in Southern Shan State. In 2019-2020, the potato sown area is 31000 ha (Department of Planning, 2020).

In Myanmar, currently, the potato market has stable market prices. In the international market, fresh potatoes in Myanmar are mostly restrained to across-country border trading among other neighboring countries in recent years. In the wholesale market, there is no fluctuation in potato prices. Consumers buy potatoes to cook as curry for their food safety. Currently, potatoes are grown and mainly sold in

the markets of Shan State. In potato production, the organic farming system is not influenced by the markets. Although potatoes are used in alternative methods to control pests in potato production, the prices of potatoes that used chemical pesticides in the market are not different. On the other hand, the production of potato chips, snacks, and potato fries is commercial in the markets at the household level (Lwin, 2012). Almost all farmers cultivate potato production using chemical pesticides to get high yields. Mostly price differences of potatoes depending on the potato varieties. The price of Chinese potatoes is higher than in Shan State and Chinese potatoes are mostly utilized in curry but Shan potatoes are commonly used in potato chip businesses.

In Southern Shan State, potato is one of the most promising cash crops for ethnic farmers and traders compared to other crops as raw materials or processed potato products (Lwin, 2012). Over the earlier period, although the average Myanmar potato yields rose marginally, it decreased in recent times. Furthermore, the cost of potato production still increases year by year. In the local market, potatoes are bought by consumers extensively and are used in different kinds of meals in the kitchen. Moreover, potato is included in the traditional meals and some famous foods in Shan State.

Southern Shan State has the fertile lands and there have been a favorable climate for potato cultivation as well as improved potato storage facilities. Nowadays, potato production is already a cash crop for ethnic farmers and has the potential to develop the income of ethnic farmers in the future, especially in Southern Shan State. There are a number of small and medium enterprises (SMEs) of local people in Shan State that make value-added, processed food from potatoes such as crisps, fries, curry, street food, and other processed product which will enhance extraordinary in the next years.

Table 1 Potatoes production areas in Myanmar

Root and Tuber Crop	State & Region	Agro-ecology	Township	Village	Remark
Potato	Shan State-South	Hill and mountains	Kalaw	Heho	One season; winter crop, after paddy
				Letpanpin	Two seasons; summer, pre & post monsoon
			Pinlaung	Naungtayar	Three seasons: summer, pre & post monsoon
			Pindaya	Kyone	Three seasons: summer, pre & post monsoon
	Magway Region	Central dry zone	Sinphyukyune	Sinphyukyune	Winter crop, alluvial soil

Source: Root and Tuber Crops: Untapped Potential for Food and Nutrition Security and Rural Livelihood Development in Myanmar (Department of Agriculture, MOALI, 2016-2017)

1.3 Problems and Issues of Potato Production

Myanmar's agricultural system has many challenges and problems with the farm, storage, marketing, and packaging system. Potato cultivated areas are progressively rising year after year in Myanmar, especially in Southern Shan State and concomitantly, pests and diseases would be one of the issues in potato production. The potato harvesting process is very important. Most farmers use the traditional methods as well as the modern technology because potatoes are one of the most easily agricultural tuber crops to damage. In India, the production of the potato

may reduce because of late blight from 5 to 90 % depend on the condition of climatic change in India (Mehi et al., 2018). Mostly, late blight can be seen in post-monsoon crop potatoes than in monsoon Moreover, the production of the potato can loss due to harmful organisms (pest, diseases, bacteria and viruses). Therefore, pest management is an essential tool to reduce crop production loss without causing injurious impacts on the environment.

In Southern Shan State, there are many kinds of diseases in potato production, among them, bacterial wilt, late blight, early blight, and root-knot are the major pests and diseases. According to the potato ethnic farmers' experience, the drought of water and heavy rain reduces the yield of potatoes. There are seed and soil-borne diseases that bring a high-level effect on the potato production process. In Japan, late blight is damaged by tubers of potato through the production stages and rapidly spreads throughout the process because of the high volume of airborne. In general, farmers use the application of fungicides to control it (Asano & Tamiya, 2016).

The pesticide use of summer potato cultivators is higher than monsoon potato cultivators (Lwin, 2012). Most farmers started spraying fungicides when they see the symptoms of late blight in the upland crops. The use of pesticides is changed because of different crops and weather conditions. The use of chemical pesticides in potato cultivation has advantages and disadvantages, and pesticides support farmers to prohibit crop damage and bring high yields but the pesticide residue can endanger farmers and animals, especially in developing countries.

In Myanmar, some of the potato farmers still face late blight of potato especially in the Southern Shan State. Thailand has the same view on late blight of potato that it is the main issue of losing economic and it needs management with different kinds of chemical fungicides for a year. The cultivators require good quality seed varieties for high yields, and disease resistance to late blight for potato cultivations around the world. In Thailand, northern agricultural regions are the best probably place for seed potato in Southeast Asia and the level of rainwater and occurrence of disease level is lower than in other regions (Kittipadakul et al., 2016).

1.4 Ethnic Farmers' Potato Production

In Myanmar, Shan State is one of the largest agricultural regions, covering 155,800 km^2 and a hilly region mainly consists of agro-ecological zones of agricultural products and tourism sectors in Myanmar (Thaung Naing Oo, 2019). Shan state has many kinds of ethnic people and most are farmers who cultivate various upland crops, fruits, and vegetables including cash crops such as rice, maize, wheat, groundnut, soybean, potato, cabbages, cauliflower, etc. Ethnic people in Shan State have the most fascinating history in Myanmar and they have lived together in Myanmar for over a thousand years. The name of the ethnic people in Shan State are Pao, Wa, Danu, Taungyo, Kayan, Innthar, Lahu, Palaung, and Li Sue and they rely especially on cultivation of rural agricultural farming crops even in urban areas such as rice, tropical, and sub-tropical fruits and vegetables.

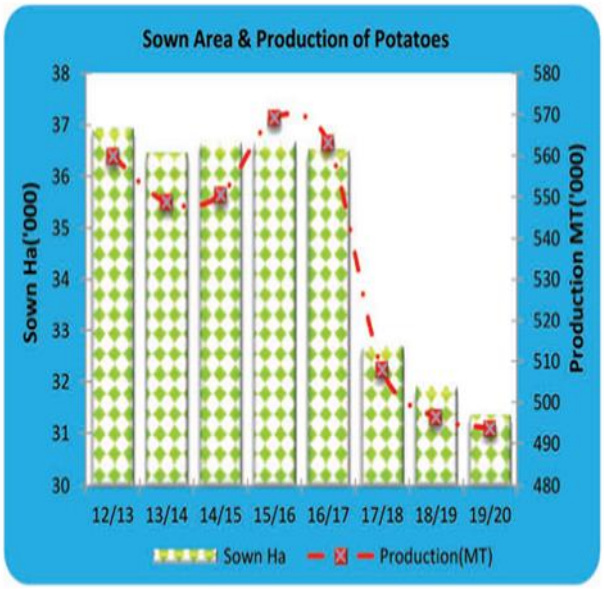
In Shan State, Taungyi and Pintaya are the main potato production area because the weather in the upland areas is suitable and fertile soil can enhance yield. The main potato-planted areas of Myanmar are Kalaw, Heho, Aungban, Pintaya, Pinlaung, Nyaung Shwe, and Naung Cho Townships in Shan state (Lwin, 2012). At present, potato is one of the main culinary crops for ethnic people in Southern Shan State and the main income of most ethnic people from agricultural crops.

The main potato varieties are Marki, Carolus, and China varieties in Southern Shan State. Ethnic farmers grow potatoes not only for food safety but also for export. In the domestic market, potato is a commercial crop by consumers and traders. In Myanmar, about 70 % of the potato growing area is in the hilly region and most growers are ethnic people (Lwin, 2012). The potato production areas in Shan State are 31,000 hectares where potato varieties can be planted more than two times in a year. Table 2 shows the cultivated area and production amounts of potatoes in Myanmar from 2012 to 2020 (Department of Planning, 2020).

Department of Agriculture (DOA) and Yezin Agricultural University (YAU) have always introduced diverse potato varieties to farmers in Myanmar. Most of the ethnic farmers planting potatoes use only chemical pesticides to control pest and diseases but some ethnic farmers have never known about the organic farming systems. They always spray chemical pesticides as soon as they see pests and diseases

in their potatoes farms and some farmers even spray chemical pesticides once a week in their farms. Some of the ethnic farmers spray chemical pesticides more than 10 times in a season to protect pests and diseases and mostly they use insecticides and fungicides in their farm according to their experiences.

Table 2 Sown Area and Production of Potatoes



POTATOES

YEAR	SOWN ('000Ha)	HARVESTED ('000Ha)	YIELD (MT/Ha)	PRODUCTION ('000MT)
2012/13	37	37	15.16	560
2013/14	36	36	15.05	549
2014/15	37	36	15.11	551
2015/16	37	37	15.51	569
2016/17	37	37	15.42	563
2017/18	33	33	15.53	508
2018/19	32	32	15.54	496
2019/20	31	31	15.74	494

Source : Department of Agricultural Land Management and Statistics, Department of Planning, Ministry of Agriculture, Livestock and Irrigation

Source: (Department of Planning, 2020)

1.5 Pest Management in Potato Production

In agricultural system, pest management is an integral part to get good quality products and high yields. Pest means organisms and unwanted things which can damage plants including crops such as insects, bacteria, fungi, weeds, viruses, and animals. In the crop production process, pests decline the crop productivity and quality on the field from the seedling stage to after harvesting.

The modern potato varieties are very important for potato production and good trial fields are essential things to get healthy tuber crops. The improvement of potato production could safeguard farmers' food security and income generation in the near future. Pests are one of the major constraints to developing potato commercial

production on the farm. The potatoes have been persecuted by a number of serious insect pests because of various reasons such as climate change, the activities of the people, crop tolerance level, trade and transportation, and neighboring farm activities.

All over the world, the potato tuber moth is one of the main pests negatively affecting potatoes. Climate change could increase the possibility of insect's living patterns and ecological patterns. Therefore, potato farmers need to know clearly pests and natural enemies because natural enemies are sensitive and they provide the farm's ecosystem and biology. The main insect pest species in potato production are Acrididae, Aphididae, Chrysomelidae, Gelechiidae Cicadellidaeae, Reduviidae, Coreidae, Coccinellidaeae, Curculionidae and Agromyzidae respectively in figure 1 (Myaing et al.).

The prevention of pest and diseases attack is very important to get a great high yield and good quality. Most farmers use chemical pesticides to prevent pest management in potato production. During the growing seasons, most commercial farmers use more pesticides than the traditional methods to extend their plantations and to get a good price. The application of pesticides frequently could improve their crop yield at the moment and later cause highly hazards farmers' health, damage of soil fertility, and the environment pollution. Therefore, crop rotation, integrated pest management methods, use of resistant varieties and certified seed tubers are also good pest management practices.

In Southern Shan State, most ethnic farmers face pest problems seriously and potato production is lost due to pest and disease attacks which are threatening small-scale farmers' income and commercial potato production. The condition of climate change can affect the impacts of the pest and diseases, most commercial potato ethnic farmers use pesticides broadly to get good quality tuber crops and small-scale ethnic farmers are not used pesticides deeply because of the cost of the pesticides is increasing at present.

Integrated pest management (IPM) is an essential method to prevent insect pests which could save the environment and biodiversity. Some farmers use physical and mechanical pest control method and traditional method to reduce the cost of chemical pesticide and to control pest. According to (Myaing et al.), the biological

control method is the best method to manage pests because there was the lowest cost to prevent pests and it is effective.

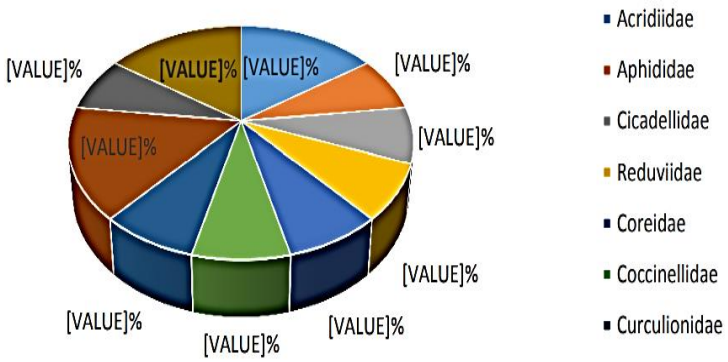


Figure 1 The percentage of the insect pest species in potato, Myanmar
Source: (Myaing et al.)

1.6 Problems and Issues of Pest Management

Plant pests are the main sectors influencing the food production process and social development for thousands of years (Palmgren et al., 2015). Although farmers use many kinds of pest management methods, crop production is still reduced unruly because of pests and diseases in some regions. Sustainable pest insect management and good agricultural practices are essential because the population growth is increasing and food security and food safety are necessary for a stable society. Once a disease outbreak occurred food shortages lead to an increase in disastrous effects on human society, for example, potato late blight in the 1840s (Austin Bourke, 1964).

According to agricultural history, most farmers have their own traditional pest management method based on the crops and regions. Nowadays, most farmers use a chemical that is popular to control pests and diseases due to low labor requirements, ease to use, and effective and rapid removal of unwanted pests (Aung et al., 2020). Chemical use of pest management also has problems, pesticides are expensive year after year. Some farmers have problem using pesticides on their farms because they

cannot afford to buy them. If farmers do not use pesticides on their farms, crop yields are stable.

In Myanmar, most farmers did not practice the traditional method which indicates that farmers in Myanmar this method cannot implement pest infestation effectively and need more farm workers and farmers cannot decide to change to a new farming system (Aung et al., 2020). In potato production, disease attacks are more serious than pest attacks but cutworm, tuber moth, and spotted beetle devastate by severe ways potato plant and yield (Lwin, 2012).

1.7 Agricultural Extension System in Myanmar

In Myanmar, Department of Agriculture (DOA) became the main center of the country's agricultural extension service. Yezin Agricultural University, the Department of Agriculture (DOA) and the Department of Agricultural Research (DAR) are under the Ministry of Agriculture, Livestock, and Irrigation (MOALI), they are the main responsible sectors for agricultural extension services in Myanmar.

According to the Ministry of Agriculture, Livestock and Irrigation (MOALI), vital agricultural research, projects and extension are severely underfunded. In the Department of Agriculture, each township has a sub- agricultural office that responds to develop agriculture sections such as knowledge sharing activities, data collection, advanced and appropriate technology, and farm-needed equipment.

The Central Agricultural Research and Training Centre (CARTC) is the majority of the service training center for extension workers to upgrade their quality knowledge and capacity-building skills which is essential for the development of the agricultural extension systems and knowledge in Myanmar. From 1995 to 2000, some of the extension workers get the agricultural training from National Agricultural Research Institutes (NARI) such as 33 % for crop production, 31% for advanced administrative training, 14 % for soil and water management, 7 % for plant protection, 5 % of agricultural extension, 4 % of other, 3 % of agricultural economics and school technology (Figure 2) (Cho & Boland, 2004).

The agricultural extension division (AED) is the main division to extend the agricultural knowledge that has been organized at the district and township levels.

The role of the village-level agricultural extension workers is the most crucial in transferring the advanced technology as well as they are always in contact with farmers in villages directly, and they cultivated the demonstration trials and farms with modern technology with farmers in the village, managed the growing period, found out the problems in the village, and reported to the officer. The agricultural extension manager meets and evaluates the ongoing extension programs, makes the discussion, and plans for the next extension programs. There are many advantages for farmers not only in township but also in villages because it is a way to be a sustainable agricultural system, save environment, and food safety.

The village-level extension workers come and meet with farmers at home or on farms individually or in groups to discuss or train for the transfer of current modern agricultural technologies and arrange field visits and field demonstrations. Currently, NGOs, social media, and private community groups are sharing regarding good agricultural practices. In Agricultural Extension division, stage, and region level have many government staff nearly 7,516 members (Paing Oo, 2016). In the Department of Agriculture (DOA) in states and regions, Myanmar and Bago, Sagaing, Magwe, Mandalay, and Shan State are the most numbers of agricultural government staff.

Myanmar's government extends agricultural knowledge on social media and introduced agricultural platform applications. Moreover, INGO, NGOs and private companies introduced their social media platforms such as applications, face-book pages, and websites. Farmers who live in villages near the urban area are interested in learning and reading knowledge but farmers who live in rural areas cannot understand and access to use for these platforms because of internet connection and poor interest in it. This is one of the extension problems as well as extension workers also have many limitations.

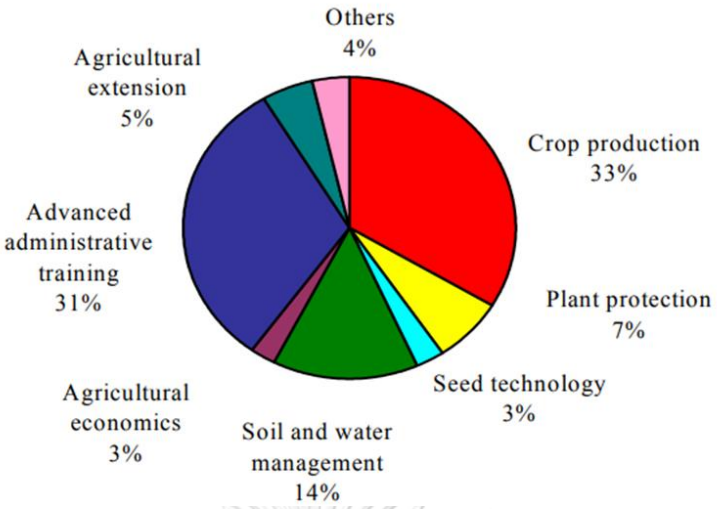


Figure 2 In-country training experience of the respondents (1995-2000)
Source: (Cho & Boland, 2004)

1.8 Research Questions

1. What are the ethnic potato farmers' existing knowledge levels on pest management and how much do they understand about pest management techniques, both, conventional (pesticide) and non-chemical methods?
2. What are the ethnic potato farmers' attitudes toward pest management methods?
3. What are the factors that affect pest management practices in the potatoes production?
4. What types of knowledge and methods do the agricultural extension workers provide as an alternative to conventional method for farmers?

1.9 Research Objectives

- To identify knowledge level of ethnic farmers on pest management in Southern Shan State
- To study the ethnic farmers' attitudes values toward different pest management methods

- To identify factors affecting farmers' practices of pest management methods in their farms
- To investigate the role, knowledge and methods of agricultural extension workers in the promotion of alternative methods of pest management for ethnic farmers in Southern Shan State.

CHAPTER 2
Literature Review

2.1 Pesticides Use and Effect in Potato Farming

In potato production, farmers use more inputs such as fertilizer, pesticides, fungicides, irrigation systems, and other necessary things in accord with good agricultural practices. Subsequently, a high volume of pesticide residues is found in the crop because farmers use different types of pesticides unsystematic and overused. In 2018-2019, the amounts of pesticides used in potato production are 1,899,281 pounds for powder and 286,550 gallons for liquid, and 3,548,816 pounds for powder and 788,011 gallons for liquid are utilized from 2019 to 2020 (MOALI, 2020). Unrestrained utilization of chemical pesticides can degrade the more large-scale environment, drain to ground water and on the soil (Butler, 1969). In case, cited that chemical pesticides can receive into our food crop with many ways (Abelson, 1993) and (Fan & Jackson, 1989) also reported that the amount of chemical residue can find into the daily food that human eat.

Agro-chemical is a chemical compound (pesticides, insecticides, fungicides, and herbicides) to protect against pests and diseases, and maintain and enhance the agricultural product. The negative impact of chemical pesticides consisting of the human health aliments of farm workers and environmental perversion has been found both developed and developing countries (Popp et al., 2013). Pesticides consist of toxic substances which lead to health risks for humans and animals (Hellweg & Geisler, 2003). The chemical pesticides residue in soil and water can aggregate to natural enemies and food chain with many types of ways (Muzafar et al., 2021).

The annual global pesticides marketing are approximately 3 million tonnes affiliated with investment about USD 4o billion (Popp et al., 2013). The types of pesticides and different amounts are imported to Myanmar from other foreign countries, especially Thailand and China such as insecticides, fungicides, herbicides, household insecticides, plant growth regulators, rodenticides, fumigants, and others (Table 3). Although the cost of pesticides has increased, the utilization of pesticides is rising year after year to get a high yield in Myanmar.

The use of chemical pesticides is one of the problems not only for Myanmar but also global impact. Most of the chemical pesticides that have been applied in the US, Europe, and Asia countries cause not only effects the scene but also have negative effects in the field area that are spread away from the origin (Cone 2006). The problem of chemical pesticide usage in developed countries is fewer countries human resources, environmental health risks, social impact, and economic cost (Frey, 1995). Moreover, approximately 14 million people also suicide by using chemical pesticides in the 1960s (Karunarathne et al., 2020).

Approximately 385 million cases of accidental acute chemical pesticide poisoning occur each year, as well as 44% of the farmers, are affected by pesticide effects (Cha et al., 2014). In Myanmar, Plant Protection Division (PPD) of the Department of Agriculture is responsible for the implementation of the Pesticide Law as well as cooperating with Wageningen University & Research group to assess pesticides ahead of granting registration (Knipe et al., 2017). Most of the banned pesticides (carbendazim and carbofuran) according to Myanmar pesticides law are input and used by retailers and farmers in Shan State and registered chemical pesticides (aluminum phosphide and paraquat) have inconsistently high case mortality and inadvertent poisoning ((ILO), 2021).

In conclusion, farmers must use chemical pesticides to control pests in crop production and other activities. On the other hand, the chemical pesticides impact are becoming worse all around the world. The impact of chemical pesticides damages the soil, water, environment, biodiversity, and food poisoning. Pesticides are used when people suicide because they get poisoned easily and they are strongly effective. In the tuber crop, pesticides can get on the soil and leaves on the tuber leaves.

2.1.1 Environmental Effect

According to the farmers' practices, pesticides are frequently found not only on farms but also in the home garden. Some farmers have enough knowledge related to agriculture and use the agrochemicals systematically on their farms and some are misunderstandings related to pesticides used in agricultural production. Some people knew how to use pesticides but they did not follow the label because they want to

protect against pests and diseases immediately. Most farmers have environmental problem because of chemical pesticides in Myanmar, especially since farmers who did not discard the use of chemical package and bottles (May Lin Aung, 2021).

The chemical pesticides can change according to their nature from liquid to a vapor by a process called Volatilization (Muzafar et al., 2021). Moreover, Pesticides can spread in many ways as air borne particles in the air. Nearly half of the environmental impact pesticides are related to soil life, 36 % impact aquatic life and 17 % also impact groundwater in ware potatoes (GUZMAN, 2018). In starch potato farms, 50 % of the total environmental impact pesticides affect soil life, groundwater 31 %, and 19 % affect aquatic life. In seed potatoes, a total of 66 % are represented in the soil life, aquatic life 16%, and 18% are represented in the groundwater (GUZMAN, 2018).

In potato production, water irrigation is one of the essential factors for agricultural practices. Therefore, the government provided sufficient and systematic irrigation for crop high production every season. Groundwater is one of the very important supplies for the agricultural sector and the level of groundwater are permanently declined in previous decades. The potato yields are actuality sensitive tuber crops to soil water deficits (Bakhtawer & Afsheen, 2021). Drought may significantly impact crop production even though the drought level is middle (Darwish et al., 2006). The usage of chemical pesticides vitiates the groundwater in the region (Manamsa et al., 2016). Some of the research shown that irrigation support tuber crop yields and water needs depending on the differences in potato varieties.

Chemical pesticide residue in the environment can potentially moving into the groundwater or well (Muzafar et al., 2021). Some chemical are naturally volatile and may evaporate according to the situation vapor pressure of the atmosphere and temperature(Mandy Bish 2020). Similarly result reported that low humidity and high temperatures can enhance the potential for drift by processing to evaluate chemical faster (Woodrow et al., 2019).

The environmental impact of pesticides can lower the quality of the soil, and harm the groundwater level and aquatic ecosystems, and air and the impact is not easy to measure. According to the Geological Survey, agrochemicals pollute every stream and more than 90 % of wells (Gilliom et al., 2006). In the United State, the

amount of pesticides used in potatoes cultivation is very high when compared with the volume of pesticides used in other crops. In 1995, 11 major potato-producing states used 71 million pounds of pesticides (Murphy, 1997).

The total Myanmar agricultural area was degraded and land degradation is still increasing in Myanmar., reported that one of the reasons for land degradation is incorrect agricultural practices such as incorrect amounts of chemical fertilizers, pesticide overuse and misuse, and organic carbon inputs (Bhattacharyya et al., 2015). Chemical pesticides can be reduced sun power, air temperature, moisture, and soil condition and can slowly degrade aquatic animals (Helfrich, 2009).

Chemical pesticides can impact the environment severely not only on agricultural farms but also on global warming. Most farmers know the impact of chemical pesticides, but they cannot change their pesticides habit on the farm. After applied chemical pesticides are on the field, pesticides can infiltrate into the soil, evaporate in the air and flow into the well near the farm. This process can diffuse all around the world and it causes adverse effects on humans, animals, and the environment. The impact of chemical pesticides may encourage global warming, climate change, and high temperature.

2.1.2 Health Effect in Farmers

In developing countries, most farmers used chemical pesticides to improve crop yield and to protect against various kinds of pests and diseases. Some farmers did not dispose the waste of pesticide containers and bottles which cause to human health problems. Almost all farmers faced health poisoning due to chemical pesticides in their farm lifetimes within 1 to 7 times (Lekei et al., 2014). Most of the respondent suffered health problem such as headaches, fever, respiration problem, eye irritation and vomiting during farming season (May Lin Aung, 2021).

Most farmers in Myanmar build a farmhouse near their farms, to see their farms and control the pests and diseases which affected farmers, health of the family members, and villagers near the farm directly and indirectly. In Shan State, chemical pesticides are easily sold and used not only on-farm but also in home gardens broadly

buy because pesticides can easily import from China and Thailand. Some farmers do not know what amount is suitable for the crop.

In Southern Shan State, local people use pesticides on farms widely which is threatening their health. In Myanmar, about 41.67 % of respondents have experienced physical poison particularly, dizziness, nausea, eye, blurry vision, skin rashes, excessive sweating, etc (Win et al., 2020). About 50 % of the farmers used traditional pest control methods to reduce the cost of chemical pesticides in crop production (Aung et al., 2020).

Table 3 Imported Pesticides to Myanmar between 2019-2020

No	Type of Pesticides	Amount (MT)
1	Insecticide	19,383.16
2	Fungicide	5,663.69
3	Herbicide	20,568.51
4	Household Insecticide	605.79
5	Plant Growth Regulator	60.00
6	Rodenticide	20.00
7	Fumigant	20.00
8	Other	4,836.18
	Total	51,157.33

Source: Department of Planning, Ministry of Agriculture, Livestock and Irrigation, 2020

2.2 Assessment of Knowledge in Pesticides use

Pesticide is an integral part of the agricultural production and farming system at present. The use of pesticides is an unsafe condition and pesticide bottles, and containers are disposed of carelessly not only give harm to the health of the farm

workers but also cause extreme damage, especially in developing countries. Therefore, the knowledge of the risk of pesticides used in the farming systems has gotten the attention all around the countries including Myanmar. Half of the respondents had low knowledge related to spraying chemical pesticides in a systematic ways and negative impact of insecticides usage in their farm (Aung et al., 2020).

The level of the farmers' knowledge and awareness use of pesticides among farmers needs to be secured because it is one of the reasons to handle and control the effect of negative impact. Some researcher reported that 98 % of the farmers of a study showed most farmers did not get any agricultural training in Egypt (Ibitayo, 2006). Some studies showed that although farmers have good knowledge and favorable attitudes toward pesticide use, these were not influenced by common farming practices, causing the overuse of pesticides (Fan L et al., 2015). More than 70 % of farmers did not read the labels of the pesticides since they cannot read and understand the languages of the labels (56 %), the foreign languages were written (35 %) and 45 %of their information and instructions were very long and disarranged in Kuwait (Jallow et al., 2017).

The knowledge of the farmers' pesticides used by using 11 self-assessment statements (Bagheri, 2019). It shows that majority of the knowledge of the farmers towards pesticide use in apple farms of northern Iran, 85 % of farmers do not wash their clothes when they used spraying separately from ordinary clothes and 75 % of the farmers showed that they do not read the labels of pesticides.

2.3 Behavior toward Pesticides Use in farmers

Agriculture is one of the most vulnerable livelihood sectors and most the farmers and farm workers suffer work accidents while preparing to cultivate the agricultural crops. In the agricultural production process, many kinds of pests and diseases damage crop yields. Therefore, pesticides are becoming one of the major inputs in modern agricultural production and because of their highly effective capacity for crop production. Farmers and farm workers faced a high risk of the

negative effects of pesticide, and they have too little knowledge regarding to the behaviors of pesticides used in agricultural production.

The effect of the pesticides and chemical residue characteristics on the farm depends on the behavior of the pesticides. Farmers' age, gender, education, and level of farm experience can be influenced by farmers' behavior in pesticide use. Famers' unsuitable behavior toward pesticide use more trouble to the situation of the farm. In Bangladesh, more than 47 % of farmers overuse pesticides (Dasgupta., 2005).

Farmers' protective behavior in pesticide use among different crops types and regions which shows never discard used pesticides containers in the field, on the other hand, after spraying, changing clothes, and showering and storing pesticides carefully and safely are the lowest frequencies, never applying pesticides more than prescribed by Department of Agricultural Extension (DAE), selecting new kinds of pesticides recommended by DAE and buying low toxicity pesticides were the most accepted practices of protective behavior (Ali et al., 2020). The respondents in the South-East were adopted wearing protective equipment while spraying.

2.4 Practices on Pesticides Use

Agriculture is one of the most threatening livelihoods sectors because the agricultural area is a large region as a source of the workforce around the world. There are a large number of farmers and farm workers who experience work risks and hazards. In Bangladesh, the perception of the farmers and their decision are related to the environmental effects of advanced agricultural technology (Rahman, 2003). The practices of pesticides are also very important role in the Agricultural sector. Almost every farmer used pesticides to mitigate pests and diseases, to get more yield and good quality products.

When spraying pesticides in the field, farmers must wear protective equipment such as long boots, gloves, face masks, and goggles (Okoffo et al., 2016) &(Yarpuz-Bozdogan, 2018). Moreover, farmers should read the label of the pesticides and should use a systematic and methodical approach. High amounts of pesticides and the wrong methods lead to health hazards. It is not only short-term but also long-term

effects on the nervous system (Hashmi et al., 2011). Farmers need to understand well the times of the pesticide spraying, directions, and weather conditions.

Pesticides should be stored separately and keep out away from children and food. Some children are taken to the farms and they may be accidentally poisoned to children. Higher education laborers have experienced a high level of awareness on pesticide practices (Baruah et al., 2011). The age, education, and farm experience of farmers can consider the impact of the pesticides and young farmers, low educated and less farm experience in sown fruits can harmful (Isin & Yildirim, 2007).

All respondents in the studied areas used the agrochemicals on their farm, 80 % of the farmers read the labels of the pesticide, only 14 % of farmers used pesticides in their farming near the harvest time and 3 % of farmers using the mouth to remove the obstruction from pesticide tank's nozzle, 97% of respondents took bath after pesticides spraying and 15 % of respondents eating food while spraying (Table 4) (Aung., November, 2019).

Safe use practices for chemical pesticides practices are essential for farmers in the agricultural farming system. The use of chemical pesticides is not temporary, it is used for long-term usage in crop production. Therefore, farmers need to use the appropriate products and be prepared for pesticide spills. Moreover, reading and following the pesticide instructions on the bottles are very important because some farmers never read the label and did not follow the label directions. While spraying pesticides, using protective equipment may protect their impact.

Table 4 Farmers' practices in pesticides application

Item	Frequency	Percentage
Using mouth to suck pesticide tank's Nozzle	4	3
Taking bath after spraying the pesticide	126	97
Eating and chewing food while spraying the pesticide	19	15

Source: (Aung., November, 2019) (A Study on the Awareness of Farmers in Application of Pesticides – Case Study in Kalaw Township)

2.5 Ethnic Farmers' Pest Management

In developing countries, most of the ethnic people rely on agricultural productions for their livelihoods and the cultivations might have impacts of traditional cultures. In agricultural production, the majority of the farmers named the pests from their farms in the local languages (Singh et al., 2021). (Bhuyan, 2006) reported that the usage of plant parts and crop products is a beneficial component of the ethnic people to manage pests and diseases.

In India, (Patel et al., 2020) have claimed that pest management practices based on indigenous technology should be a vulnerable tool to sustainable agriculture production for food safety. (Grzywacz et al., 2014) said that only biological control agents can be generated lower cost than using chemical pesticides by most of the poor farmers in Africa. Physical pest control method are very important method for postharvest phytosanitary treatment to control pests when crop storage (Vincent & Hallman, 2009).

In Southern Shan State, (Aung et al., 2020) said that over 70% of the farmers have knowledge of natural pesticides such as tobacco and neem but they have low knowledge of yellow sticky trap usage and traditional method to control pests and unwanted pests. (FAO, 2020) reported that the majority of the agricultural-trained farmers use low chemical and biological control methods to increase their economic situation. reported that ethnic people in the rural area spent their days for household work and traditional farm practices are used in their agricultural livelihood (IWGIA, 2020). Most of the rice farmers are also applied physical control method and field sanitation practices on the farms (Dirk Babendreier et al.).

Alternative pest management practices are vital knowledge resources that are native to the agricultural farming system in rural areas. In rural areas alternative peat management practices (biological and physical methods) are used before knowing modern agricultural technology. In Shan State, physical pest control methods are still using practices because they can reduce pesticides cost. If crop farms are badly affected by pests, the physical methods also cannot control them. The biological control method is not popular because only some organizations are guided

to use it. There are many chemical pesticides company are one of the reasons for using chemical pesticides significantly.

2.6 Problems and limitations of Agricultural Extension System

The agricultural extension was introduced to share the knowledge in rural area and help farmers effectively education learning and to enhance their capacity and productivity and thus becoming increase income, educated and standard of living (Hasan, 2021). Some of the researchers mentioned that the role of the agricultural extension includes the extend and service all part of the farmers as well as to rural development, young people and farmers (Khin Oo, 2012) & (Hameed, 2019).

In Myanmar, (Paing Oo, 2016) said that poor transportation system and low motivation for agricultural extension workers and unskilled staff to share their knowledge as extension workers. Therefore, extension workers cannot regularly visit the farmers' farm. Farmers need relevant extension programs and community involvement of the farmers in extension planning ((Khin Oo, 2012). Agricultural extension work needed to enhance capacity building for developing human resources and (Paing Oo, 2016) reported that nearly over 50% of extension workers got Diploma certificate and only 0.8% are graduated in 2016. Most of the extension worker did not invite indigenous women to attend the agricultural training and they thought only men did spraying pesticides on the farm (IWGIA, 2020).

2.7 Impact of Agricultural Extension

Agricultural extension is essential to improve the knowledge of farm practices and to improve high yield. (Aung et al., 2020) reported that most farmers used chemical pesticides to control pests. Most farmers in Bangladesh are recommended the chemical to use within two to five times.(Islam & Hossain, 2021). Many factors are caused as being related to the misused and overused of chemical pesticides (Wu & Ge, 2019). This reason is a lack of knowledge and the absence of agricultural extension training and misunderstanding of information related to pesticide usage (Hu et al., 2007).

Agricultural extension service share knowledge to farmers on various views of crop production systems and management including suitable pesticides use (Uddin, 2008). The positive impact of agricultural extension have many outcomes for food production and agricultural government used millions of dollars to enhance the agricultural extension program (Muyanga & Jayne, 2006). Transferring knowledge and extension services can innovate the use of pesticides and agricultural inputs and promote rural programs (Karim, 2018).

When extension workers share knowledge to farmers in rural areas have many limitations, especially in developing countries. Most extension workers go to the rural area as well as share knowledge, they used thick paper, pamphlets, and posters because there has no electricity. Peer-to-peer methods are not used widely in Myanmar extension sectors. Now peer to peer learning method is used in some areas and extension workers may train farmers to use it and to gain confidence and discuss and learn with each other. In social media information, some villages have electricity problems and connection problems to share knowledge. Extension workers introduced agricultural applications are to use it well and contact them if farmers have some farm problem or something they want to know.

2.8 Theoretical Framework of the Study

This study followed the works of the KAP framework proposed by (Balegha et al., 2021), (Zamri et al., 2020) and (Wang et al., 2017), and other relationship diagram researchers who have used knowledge, attitude, and practice diagram and an interrelate relationship among farmers' knowledge, attitude and practices on pest management. Agricultural extension services improve farmers' knowledge, attitude and practices to control peat. The aim of this study is to understand knowledge and attitudes and practices toward pest management among ethnic farmers in Southern Shan State, the socio-economic of the ethnic farmers, and the agricultural extension system, and relationships directly and indirectly in Myanmar. This study focused on pest management and their knowledge, attitude, and practice on agricultural farms and the issues of the extension system in potato farmers.

In this study, the KAP-O framework shows that farmers' knowledge (of chemical pesticide usage and alternative pest control method), and attitude (perceived risk, attention, and threat of chemical pesticide and alternative pest control method). Farmers' socio-demographic characteristics toward farmers' farm practice (pest control method and prevention) in crop production. Guided by existing literature (Allahyari et al., 2017; Aubin Ndjadi Wembonyama Kasongo et al., 2020; Aung et al., 2020), the socio-economic is considered in this study (age, gender, ethnic group, education Status, farm size, farmland Ownership, farm experiences, farm income, etc.) Agricultural extension services may improve farmers' knowledge, attitude, and practices on pest management systems. Although not covered in this study, the conceptual framework perceives that farmers' knowledge of potato pest management can influence cultivators' attitudes toward potato pest control methods.

There are many factors to understand clearly and widely related to pest management on the farm because there are many kinds of farmers' knowledge, attitude, and practices on pest management. Farmers' knowledge, attitudes, practices, and socio-economic are interrelated each other. Farmers' socio-economic certain link farmers' knowledge, attitude, and practices on pest management. Agricultural extension services increased farmers' knowledge levels which can enhance attitudes and practices. The agricultural extension is also an essential sector that shares modern and appropriate technology and good agricultural practices, farmers get significant and positive knowledge from the agricultural extension system which improves farmers' knowledge, attitude and practice. The theoretical framework is shown below in figure 3.

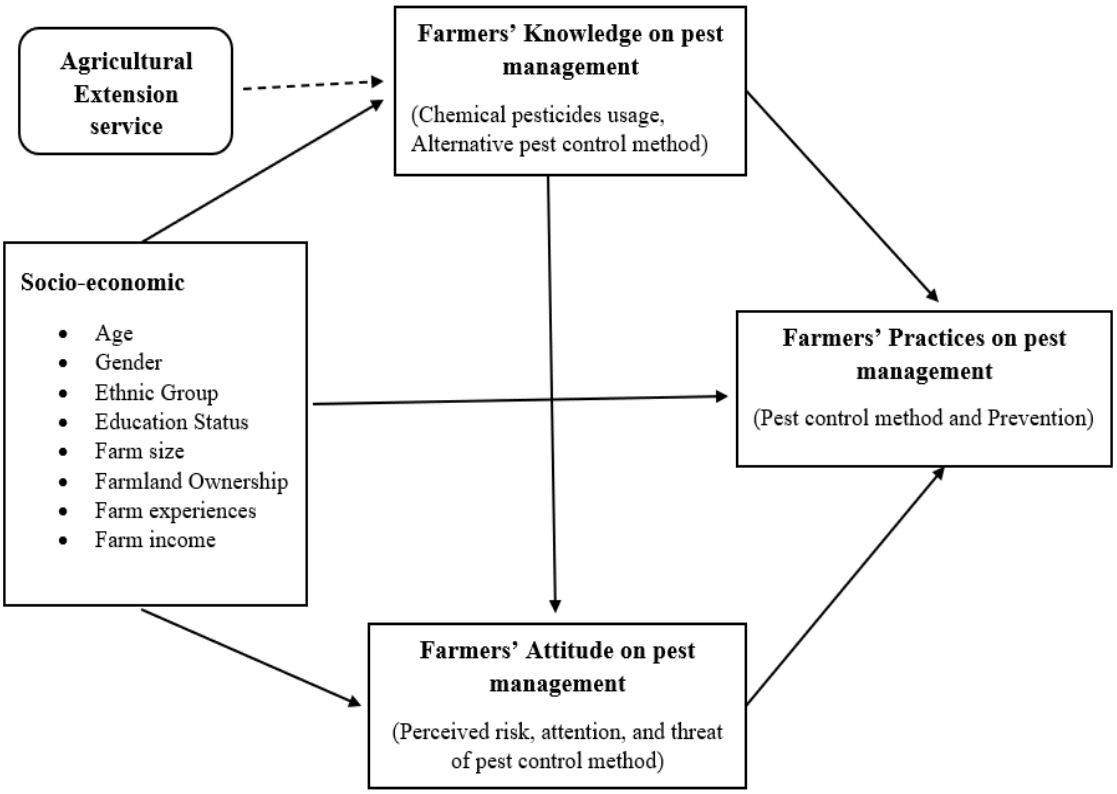


Figure 3 Farmers' Knowledge, Attitude and Practices on Pest Management in Southern Shan State, Myanmar

CHAPTER 3
Research Methodology

3.1 Study Area

Shan State is situated in eastern Myanmar and shares international borders with Thailand to the south, China to the north, and Laos to the east of Shan State and it is located at an elevation of about 1280 m above sea level. In 2019-2020, the total potato production areas are 31 thousand hectares, and 494 thousand metric tons are produced in Myanmar (Department of Planning, 2020). Most of the potato production areas of Shan State are located in the Taunggyi district and Kalaw Township (Figure 4). There are 27 village tracts in Kalaw Township and most of the ethnic people (Taung Yo, Danu, Pa-O and Palaung) are potato farmers and they use different sorts of chemical pesticides for many kinds of the upland crop in these villages.

In this research, the multistage sampling method is utilized and 2 villages from Kalaw township were chosen purposively because the ethnic farmers from the study areas mainly grow potatoes and predominance in potato production. Farmers who cultivate potatoes are chosen as a target population of respondents in 2 villages, in Southern Shan State by purposive sampling. Again, one of the major reasons for choosing 2 villages from Kalaw township as the study area is the most potatoes cultivated areas, promising crops, and the main cash crops for ethnic people and farmers in Southern Shan State.

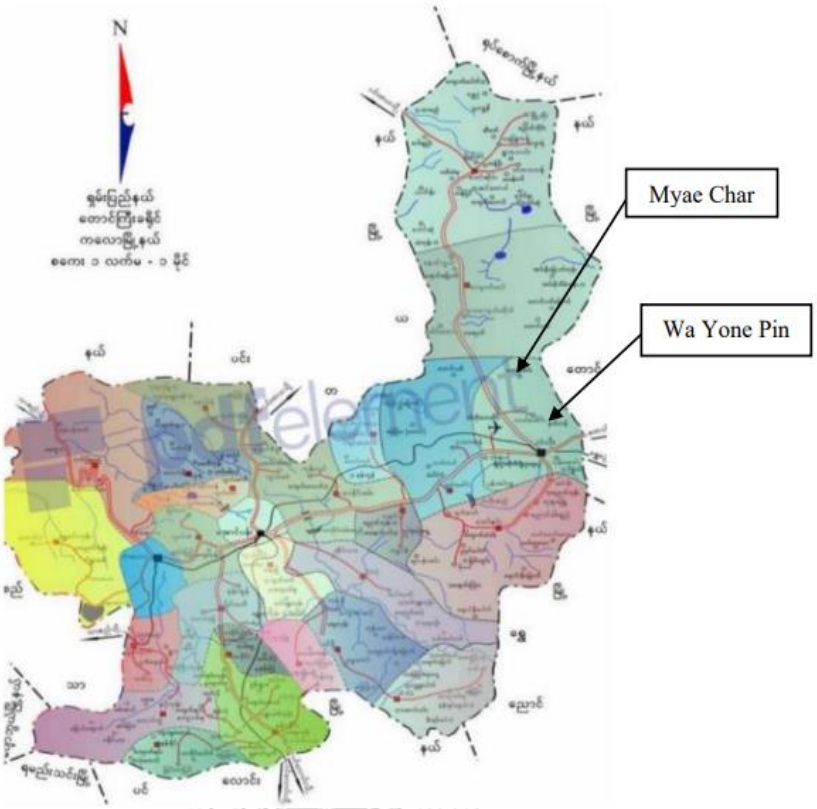


Figure 4 Map of Kalaw Township, Southern Shan State
Source: Department of Agriculture, Kalaw Township

3.2 Research Procedure

The purpose of this research is to gain a deep understanding of ethnic farmers' knowledge, attitude and practices on pest management and the role of the agricultural extension system (key informant interview) in Southern Shan State. It is also undertaking to find out the level of farmers' pest management and their knowledge and attitudes in potato farms, in Southern Shan State.

Both qualitative and quantitative methods were used to collect the necessary data in this study. The qualitative methodology was utilized to collect the data for holistic understanding, knowledge, behavior, and practices of pesticides used by the potato farmers.

The quantitative methodology was also used to quantify the data and measure the variables and circumstances and describe frequencies in order to access

information to determine and analyze the significant number of results. The most significant values and amounts were defined to recognize as effective representation data in this study.

3.3 Data Collection

3.3.1 Primary data collection

In this study, data collection was performed as both field surveys and secondary data with regard to compiling necessary information and document for results. The household-level survey interview was investigated by using questionnaires and checklists with structured and semi-structured questionnaires. The information collected from ethnic farmers were conducted on farmers' socioeconomic and characteristics (age, gender, family members, education status, farm experience, etc.) farmers' knowledge, attitudes, and practices of pest management on the ethnic potato farmers in Southern Shan State. The collected data was taken from the farmer's participation and gathered to discuss with potato cultivators and to understand their difficulties in potato crop production.

A pilot survey data was collected before actual data collection by phone call or internet for obtaining accomplished questionaries that would be in operation directly for the interview which could support the real survey to get completed answers from farmers for the study.

In the survey, a total of 87 farmers that cultivated potatoes was randomly selected from 2 villages for this study and was interviewed with a set of questionnaires during September 2022. Ethnic farmers who cultivate potatoes in the selected area were selected for a face-to-face interview.

In this study, the first section of the questionnaire includes general information, ethnic farmers’ socioeconomic characteristics. This is intended to know the socio-economic data, their knowledge, attitude, and practices on pest management etc. The features of this study highlighted the characteristics of farmers and farms, their knowledge, and attitude toward pest management, and their problems, and challenges. Moreover, the information included in the questionnaire survey consisted of the name of the pests and pest management methods.

3.3.2 Data Collection in farmers

For the survey and data collection, due to the political crisis and Covid-19 restrictions, I requested the authorized person for permission to visit and interview ethnic farmers who cultivated potatoes in the study area. The potato growers were asked to gather and fill in the structured and semi-structured questionnaires in the monastery or some farm areas. The questionnaire was then translated into the Myanmar language and a translator was able to assist in any way where their ethnic languages were needed.

The respondents were asked the question to rate the farmers' knowledge of each statement on a scale from 1=yes, and 0=no which were categorized. Similarly, the farmers' attitude scale was assessed on five points Likert-type scale with 1= strongly disagree, 2=disagree,3= not certain,4=agree and 5 = strongly disagree. These scores are represented by the good/ bad attitudes of the farmers (Chepchirchir et al., 2021).

Before operating the real interview, the survey questionnaires were pretested by interviewing 30 sample farmers who cultivate potatoes in this area to check their gentleness and evaluate how easy to explain to the farmers and to understand the questionnaires. After getting farmers' feedback, further necessary documents were revised to impeccable questionnaires. Cronbach's alpha test was used for the reliability test of the questionnaires and the coefficient value obtained was 0.76.

3.3.3 Data Collection in government extension staff

Key informant interviewees were elected for in-depth interviews such as 6 government office staff that facilitate extension workers with unstructured questionnaires in supporting the potato production system. The interview aims to understand the extension system, to know what kinds of training they share with farmers, their issues in potato production, and other information regards to farmers' extension services. In the study area, I contacted the Department of Agriculture to get further assistance with data collection. They informed that extension staffs were not significantly assigned for providing particular knowledge to famers for potato

production in the study area. Nevertheless, agricultural extension workers were not seen because of the political crisis. The extension workers were interviewed in their office according to their availability.

3.3.4 Secondary data collection

The secondary data was gathered throughout the government organizations and the different companies for previous agricultural statistics and other data. The secondary data was covered the production of the potato, sown area, pest management, pesticide usage, extension system, different agricultural statistics, and other data was obtained from the Department of Agriculture, journals, published books, research papers, dissertations, and thesis, etc.

3.4 Sampling Technique

The research applied the probability and non-probability sampling methods to get the survey data and data collection. For probability sampling, the method chosen was the multi-stage sampling method for the study area. This method was selected because of the naturally occurring groups in which it was being studied. In this non-probability sampling, Wa Yone Pin village and Myaechar village were chosen as the purposively sampling method. The farmers who grow potatoes were selected by a random sampling method. The research implemented the condition of the potato farmers' knowledge, attitude, and practices on pest management to collect the data in Kalaw township. In the study areas, most of them are ethnic people who cultivate potato crops. Most farmers cultivate potatoes and other seasonal crops for their livelihoods.

In the sampling frame of 2 villages, the two villages have 670 farmers who mainly cultivate potato. Therefore, 87 farmers of the sample size of potato farmers were increased to 100 farmers to reduce the potential rejection of the respondents and enhance the validity of the study by using Yamane (1967:886) formula (Israel, 2012).

$$n = \frac{N}{1 + N(e^2)}$$

n = Sample Size

N = Total Number of Population (670)

e = Allowance Error percent (0.1) (e = 0.1 means 90 % level of significant)

Therefore, the required total sample at the survey area is 87 and however, 100 farmers were selected for this study to cover the potential incomplete and missing answers.

3.5 Data Analytical Methods

Both quantitative and qualitative data were involved in this study. Excel and Statistic Package for Social Sciences (SPSS for windows) software was used to input the information and to calculate means and standard deviations.

3.5.1 Descriptive statistics

In this study, data was analyzed with the Statistical Package for Social Sciences (SPSS). The descriptive analysis using means, frequencies, standard deviation, and percentages were used to describe the socio-economic and to find out the knowledge, attitude, and practices of the farmers regarding pest management, explain the potato farmers' characteristics, the factors keeping using pesticides, methods of pest management. The farmers' knowledge levels were obtained from mean score of the data analysis. The mean score of the farmers was applied for determining the knowledge level of the potato farmers. The class interval of Harshbarger (1977) as the following formula;

$$\text{Class} = \frac{\text{The highest score} - \text{the lowest score}}{\textit{The number of levels}}$$

Descriptive analysis was done by the characteristics of potato farmers, their knowledge, attitude, practices on pest management and the role of the extension staffs and alternative methods of pest management for ethnic farmers in Southern Shan State. The data results will be described by texts, tables, and figures.

3.5.2 Analytical statistics

The potato farmers' practice of pest control management was estimated by using binary logistic regression. The collected data (qualitative and quantitative) were first entered into Microsoft excel. Then, the data were re-entered into the Statistical Packages for Social Science (SPSS) 26 software. Actual farming data were analyzed by binary logistic regression model using Statistical Package for Social Sciences (SPSS) 26 software. Binary logistic regression was used to understand the socio-economic demographic factors affecting of pest management. The independent variables are socio-economic factors such as gender, age, Education level, family member, Farm size, farmland ownership and farm experience, etc. The dichotomous dependent variable Y have two values of pest control management, 0 = decision to practice chemical pesticides and 1= decision to practice chemical and alternative method.

3.6 Benefit of the Study

In agricultural production, pest management is playing a very important role and various pests could damage crop production and reduce the quality of the product. A clear understanding of ethnic farmers' knowledge, attitude, and practices on pest management and effective ways need to know about ethnic farmers' potato production because potato is the main cash crop for ethnic farmers, especially in Southern Shan State. This data can support to improve the potato cultivation and may decline the negative effect of pesticides. If the level of farmers' knowledge of pest management is discovered, the extension workers will be able to consider what sort of training and agricultural knowledge sharing section are needed to implement in the study area. The farmers are able to know their knowledge gaps and will be able to find out the importance of their traditional pest management method and their effectiveness.

CHAPTER 4

Results and Discussion

4.1 Socio-economic of potato farmers

According to the Table 5 , the majority of the respondents are males and only 23% of respondents are female in this study sample households.(Negatu et al., 2016) It is seen that only a small number of farmers women have advantages from cultivation because women cannot handle chemical pesticides to control pests. Over half of the farmers are Taung Yoe ethnic people, 27% of respondents are Danu, 15% of ethnic people are Pa-O and only 1% of the farmers are Palaung. Most farmers are males because they lead and decide their farmland method and types of crop production. In addition, farmland areas are too far to access, and most are upland areas on the other hand. Most of the women live in their homes to cook and care for their children only.

In Table 5, fifteen respondents are between 18-24 years and 22% of farmers are between 25-34 years, 35-44 years, and 45-54 years, 13% of respondents are between 55-64 years and over 65 years of farmers are 6% in this study area. Regarding to education level of participants, most of the respondents finished primary school and 29% of respondents received monastic education, and 16% of participants completed basic middle school education. Only 3% completed basic high school education. Only 3% of the respondents received degrees from university and 2 % of the respondents are undergraduates respectively. Researchers from other countries found that more than 80% of farmers have elementary and middle school education levels and while a low level of participants graduated from high school. (Munif & Rachmawati, 2020). According to the result, most of the farmers have low-level of education and they control pests according to their farm experiences.

In this study, half of the respondents had only 1-3 acres of farm size, about 28% of respondents had 4-6 acres of land holding size, the rest of the four owned 7-9 acres,10-12 acres, 13-15acres and over 16 acres which are 4%, 8%,2%, and 3% respectively. (Enzo Emanuel Raimondo & Susana Edith Cabrera, 2022) cited that most of the farm areas are near the rural area and sides of the main road connected with two towns and around the hilly areas. Therefore, using chemical pesticides is a

very important concept to be considered in a sustainable way. Most types of farmlands of respondents have upland and lowland + upland farms, most of the farmland is upland farms and, only 5% are lowland and upland types in this area. It is seen that most respondents own farms and they operated them by themselves but 19% of respondents do not own farms and they have to rent others' farms for their profits.

Regarding farm experience, it was grouped into four categories as presented in Table (5). Most farmers had over 10 years of farming experience because they have been having experience in potato cultivation since they helped their parents from their childhoods. Therefore, it can be assumed that most farmers have somewhat experiences in potato production. In addition, 15 % of the respondents had less than 3 years and 3-6 years of farm experience and the lowest farm experience are seen from 7-10 years respectively.

According to their farmland and weather conditions, most farmers planted upland rice for their food safety. It is discovered that corn is the second largest crop planted for food security and livelihood, and other vegetables (cabbage, cauliflower, soybean, coffee, and chrysanthemums) and onion and ginger are planted as commercial crops and it constitutes 3% in this area. Almost all farmers in this survey planted other crops on their farm for their food security and commercial purposes in every season because their main livelihood is agriculture, and their income comes from agricultural sector.

Most farmers grew not only potatoes but also other crops on their farmland at the same time for food security. 32% of the respondents planted vegetables (cabbage, cauliflower, soybean, coffee, and chrysanthemum), 26% and 24% of farmers grew corn and rice as the main crop and only some farmers planted onion and ginger respectively.(Atreya et al., 2012) from other countries cited that potato is the main cash crop for households in the study area and they cultivated other crops tomato, chili, and cauliflower for consumption.

The main income source of most farmers in the study area is potato production and other planted vegetables such as corn, cabbage, and chrysanthemum. The annual household income of participants can be categorized into four groups, over half of the respondents (54%) had got 3,000,000 - 5,000,000 kyats, about 38% of farmers had got

5,000,0001 - 7,000,000 kyats and the rest of respondents included income group less than 3,000,000 kyats and 7,000,001 - 9,000,000 kyats with 4% respectively.

Table 5 Socio-economic status of potato farmers

Variables	Frequency(N=100)	Percentage (%)
Gender		
Male	77	77
Female	23	23
Ethnic Group		
Taung Yo	57	57
Pa-O	15	15
Danu	27	27
Palaung	1	1
Age		
18- 24 years	15	15
25-34 years	21	21
35- 44 years	23	23
45- 54 years	22	22
55- 64 years	13	13
Over 65 years	6	6
Education level		
Monastery	29	29
Primary School	47	47
Middle School	16	16
High School	3	3
Undergraduate	2	2
Graduate	3	3
Farm size		
Between 1-3 acres	55	55
Between 4-6 acres	28	28
Between 7-9 acres	4	4
Between 10-12 acres	8	8
Between 13-15 acres	2	2
Over 16 acres	3	3
Type of farmland		
Upland farm	95	95
Lowland + Upland	5	5
Farmland ownership		
Owner-self operated	81	81
Lease-self operated	19	19

Farm experience		
Less than 3 years	15	15
Between 3- 6 years	15	15
Between 7– 10 years	10	10
Over 10 years	60	60
Names of previous crop		
Rice	60	60
Corn	25	25
Onion	3	3
Ginger	3	3
Vegetables	9	9
Name of the other crops		
Rice	25	25
Corn	26	26
Onion	11	11
Ginger	6	6
Vegetables	32	32
Main source of income		
Potatoes	83	83
Others	17	17
What is your annual household income?		
Less than 3,000,000 kyats	4	4
3,000,000 - 5,000,000 kyats	54	54
5,000,0001 - 7,000,000 kyats	38	38
7,000,001 - 9,000,000 kyats	4	4
More than 9,000,000 kyats	0	0

(1 USD = 2094 Kyats)

Source: Survey Data (2022)

4.2 Current Farm Practices of Ethnic Potato farmers

4.2.1 Ethnic Potato farmers' current pesticides farm practices

In Table 6, it is shown that most of the participants of potato farmers used only chemical pesticides to control pests and diseases in their farming years. On their farms, the majority of the respondents used only chemical pesticides and only 28% of farmers used chemical and alternative methods (physical and mechanical, and

organic) to protect against pests in crop production. Most of the respondents answered that they use only pesticides because it is more effective than others, 31% of farmers applied chemical pesticides easily and 3% of respondents used chemical pesticide on their farm to save time. Most of the farmers purchased chemical pesticides in the pesticide shops in the markets and only 12% of respondents bought it from private chemical pesticides company's staff directly. Farmers with good social communication have more awareness of pest management in crop production (Allahyari et al., 2017).

In this study area, the majority of the farmers applied chemical pesticides in their potato fields by themselves to save money and about 19% of farm owners hired the farm workers to spray the chemical pesticides in crop production. There are many kinds of chemical pesticides to control pests and improve crop yield. Most farmers used insecticides in their potato farms and about 40% of respondents used fungicides on the potato farm. In the result of the some researcher, most farmers used large amounts of insecticides and fungicides to control pests in potato production, especially fungal disease, and 3% of respondents use herbicides (Okonya & Kroschel, 2015).

The majority of the farmers assumed pest and insect problems are more important than disease and fungi issues. Most farmers precisely about 63% always read the chemical pesticide instructions and some farmers sometimes read the pesticide labels. Nevertheless,19 % of farmers never read the labels and instructions but 18% of farmers read them before spraying pesticides. Some farmers could read the pesticides instruction on the pesticide packages and bottles, and a few respondents could read the labels but they ignored the pesticide labels (Okonya & Kroschel, 2015). It should be noted that pesticide buyers and sellers need more training and formal training. On the other hand, most of the chemical pesticides are very expensive for potato farmers, they enter easily across the border of the country, and some are written in foreign languages. This is one of the reasons for the farmers to read the pesticide labels.

Regarding protective equipment, most farmers never wear protective equipment when spraying pesticides which caused excess chemicals to their bodies and damages their health of the farmers. About 34% of respondents always wear

protective equipment and, 29% of respondents wear covered clothes when applying pesticides. While spraying chemical pesticides, most farmers wear long boots and face masks 38% and 34%, 24% of respondents also wear gloves, jackets, and goggles are used 1% of respondents and 2% of farmers used other accessories respectively. Less than half of the respondents did not use face masks when applying pesticides, especially in summer season (Wang et al., 2017). The previous study (Abbassy, 2017) found that most of the respondents have knowledge for safety implementation of pesticide usage for applying protective equipment.

In the comparison of farmers' knowledge level of pest management among different farmers, the result of (Muleme., J. 2017) concluded that the participants who wore personal protective equipment had a lot knowledge metric than those who did not cover while applying pesticides. Therefore, pest management training influences the knowledge level among potato farmers

About 35% and 32% of respondents get agricultural information concerning the proper use of chemical pesticides from company staff and neighboring farmers and friends because they believe that a lot of pesticide information sources are from chemical company staff and neighboring farmers. 19% of respondents got information from other sources, 9% of farmers decided what chemical pesticides should use in their farm by self-learning 3% and 2% of respondents received information from government staff and social media respectively. The majority of the farmers got the information related to pesticides from friends, family, and on social media which can influence cultivators' knowledge of safe chemical pesticide handling (Malhotra & Kaur, 2014).

In this study area, more than half of the farmers face some kind of health issues related to chemical pesticides and 41% of respondents thought they have no health problems or symptoms related to pesticides while spraying pesticides on their farm. About 16% of respondents have itching, 10% of respondents have dizziness, headache, and tiredness, and others 9%, 6%, and 1% respectively. According to (Lekei et al., 2014) approximately 80% of the respondents reported that farmers did not adjust their sprayers when applying chemical pesticides. Moreover, there are significant relationships between huge poisoning and uncertain pesticide removal practices in Table 6.

Table 6 Ethnic Potato farmers' current pesticides farm practices

Characteristics	Variables	Percentage (%)
Which methods do you use to control pest in your farm?	Chemical pesticide method	72
	Alternative method	0
	Chemical + Alternative method	28
Reasons to use chemical pesticides	Easy to use	31
	More effective	66
	Save time	3
	Reduce farm workers	0
	Others	0
Where do you buy chemical pesticides from?	Markets/ Shops	88
	Company Staffs	12
	Government (Officially)	0
	Others	0
Who apply the chemical pesticides in the field?	Farmers	81
	Farm workers	19
	Others	0
Which chemical pesticides is mostly used in your farm?	Insecticides	60
	Fungicides	40
	Herbicides	0
	Others	0
Do you read the pesticide label before applying?	Never	18
	Sometimes	19
	Everytime	63
Do you wear the protective equipment while applying?	Everytime	34
	Sometimes	29
	Never	39
What kinds of protective equipment do you wear?	Face mask	34
	Long boots	38
	Jacket	1

	Glove	24
	Goggles	1
	Others	0
Where did you get information concerning the proper use of chemicals pesticides from?	Government Staff	3
	Company Staff	35
	Neighboring Farmers and friends	32
	Social Media	2
	Manual (Self-learning)	9
	Others	19
What kinds of health problem from using pesticides?	Tired	6
	Headache	9
	Dizziness	10
	Itching	16
	Eye Irritation	0
	Others	1

4.2.2 Ethnic Potato farmers' current alternative pest control farm practices

In Table 7, the majority of the potato farmers used only chemical pesticides and only 28% of farmers used chemical and alternative methods (physical and mechanical, and organic) to protect against pests in crop production. Most farmers prefer to use chemical pesticides in their potato production. In the alternative method (physical and mechanical) on their farm was about 16%, 7%, and 5% of respondents applied other methods (organic pesticides) and biological methods to reduce pest on their farm. (Karamidehkordi & Hashemi, 2010) concluded that all farmers had no experience related to biological methods to manage pests on the farm.

In previous studies, some of the researchers (Barzman et al., 2015) showed that using the alternative and combining pest control methods can cause more effective and sustainable results in pest management. (Göldel et al., 2020) cited that alternative pest control methods are supported to control the Colorado potato beetle which is the most widespread potato pest.

There were about 18% of farmers using the alternative method to reduce the cost of the chemical pesticide, 9% of respondents used it to decline pests and diseases depending on their experience, and only 2 % of respondents used alternative methods to decrease pesticides use and chemical residue in their study area.(Aung et al., 2020) cited that farmland owners are more passionate than hired farm farmers in alternative methods of pest control.

Some farmers used the alternative methods according to their experience, about 8% of respondents used the alternative method under one year, about 7% of farmers have over 6 years of experience, 6% of farmers have experienced 1-2 years, and 3-4 years and only 2% growers have 5-6 years for using the alternative method in crop production are shown in the following Table 7.

In this study area, neighboring farmers and friends, and private pesticide company staff mainly gave the information of alternative methods in 13% and 12% of farmers and 3% of growers got the information from government staff and only 1% of participants learned the alternative method from others sector. There were 21% of farmers bought farm equipment for the alternative method from the market, 4% of growers did the necessary equipment manual and about 2% of respondents bought the necessary supplies and equipment for the alternative method are shown in Table 7.

According to Table 7, most farmers (63%) did not receive any training and other necessary support related to agriculture from the Department of Agriculture (DOA) in this study area and about 37% got the training and other supplies from the government staff. Sometimes, farmers did not attend the training when the government staffs give the training because farmers told them they have no time to attend the training. About 16% of farmers got good agricultural practices training, 11% of people received pest management training from DOA, pesticide usage training and mechanical using training are trained in 7% and 1% and others kinds of agricultural training are trained about 3% of farmers respectively.

Comparing of the percentage of farmers who get training, the result of (Bagheri, 2019) concluded that some of the cultivators (27.0%) received an agricultural extension training program concerning pest control methods, therefore most farmers have less knowledge related to pest management. (Vitunskiene & Makšeckas, 2018) reported that the governmental negotiation in farmers' knowledge

training cause a positive effect on their crop production. The result of (Samiee et al., 2009) study revealed that most percentage of the respondents never participated in farmers' training on sustainable pest management practices. Generally, they have more experience in insecticide practices rather than other kinds of pest control methods.

Among them, above 90% of farmers did not receive any materials or financial support from DOA in this study area. About 4% and 2% of respondents get fertilizers and financial aid support from DOA and only 1% got new potato seed varieties to support from the government. (Karamidehkordi & Hashemi, 2010) found that 25% of cultivators went to the agricultural extension center but only 10 % received their suggestion and recommendations related to chemical pesticides. However, 73% of potato growers got training from private chemical pesticides company because they give more supports knowledge, and training, about 20% of people received training from private potato organization in Kalaw and only 1% got training from Non-government Organization respectively in Table 7.

Table 7 Ethnic Potato farmers' current alternative pest control farm practices

Characteristics	**Variables**	**Percentage**
Which methods do you use to control pest in your farm?	Chemical pesticide method	72
	Alternative method	0
	Chemical + Alternative method	28
Reasons to use alternative method	Lower cost	17
	Protect health	0
	Protect the environment Decrease the pesticides use	0
		2
	Others	9
What kinds of the alternative method do you use in your farm?	Biological	5
	Physical & mechanical	15
	Traditional or Cultural	1
	Others	7

How long have you been using the alternative method according to your answer in question 2.13?	Less than 1 year	8
	Between 1- 2 years	6
	Between 3-4 years	6
	Between 5-6 years	2
	Over 6 years	6
Where did you learn about alternative method?	Government Staff	4
	Company Staff	11
	Neighboring Farmers and Friends	12
	Social Media	0
	Others	1
Where did you buy supplies and equipment for alternative method?	Markets	20
	Company Staff	2
	Farmers	0
	Government	0
	Manual (Self-learning)	4
	Others	2
If yes, what kinds of trainings you get from Department of Agriculture?	Good Agricultural Practices	16
	Pest Management	11
	Pesticide Usage Management	7
	Mechanical Using Training	1
	Others	3
What kind of support have you received from the Department of Agriculture (DOA)?	Financial Aids	2
	Fertilizer	4
	Pesticides	0
	Machine	0
	Others	1
Where did you get your training related to the potato farming?	Pesticides Company	73
	Non-government Organization	1
	Private Organization	20
	Others	0

Source: Survey Data (2022)

4.2.3 Ethnic farmers' Pest Management Practices of potato cultivation

Table 8 reveals that 42% of the ethnic farmers are Taung Yo and some farmers used chemical and alternative method to control pest in the field. Among them, 9% of the farmers applied physical and mechanical methods, and 3% of Taung Yo farmers used biological control methods and other organic and natural pesticide pest control methods from plant materials such as neem and tobacco. The ethnic farmers in India applied biological pest control method such as butterflies, catastrophe and other natural enemies (Surya Rathore et al., 2021). It is found out that 10% of Pa-O ethnic farmers used chemical pesticides for their farms. On the other hand, 2% of Pa-O people used physical and mechanical methods and other organic pest control methods to manage pests in potato production. Biological methods may support as pest management practices of indigenous people in Philippines (Mulanay, 2019). Nineteen Danu people implemented different chemical pesticides in the field and 4% of Danu people applied physical pest management methods, 1% of the farmers used biological and traditional pest control methods, and 2% of potato cultivators used their local traditional pest control method. Indigenous farmers in India used cultural practices pest management in some food products such as citrus crop (Singh et al., 2021). Many kinds of physical pest control methods may be benefitted in a pest management system incorporating other integrated pest management methods (Vincent & Hallman, 2009). One of the Palaung people who participated in the interview had chemical pesticide practices on the farm.

In this result, most of the ethnic farmers are Taung Yo . There are a variety of chemical pesticides used by farmer and they also applied not only chemical pesticides but also manual ways (by hand to remove pests and weeds and using mattock to take off the soil and discard farm waste) to control pest issue in the field and no one used the traditional method. Danu ethnic farmers are the second largest farmers who commonly used physical and mechanical methods and a Danu farmer used traditional methods because Bamboo, candles, and fuel are used as their traditional method' materials. On the other hand, Pa-O ethnic cultivators also used physical and mechanical methods. Finally, a Palaung farmer who cultivated potatoes never used alternative methods in crop production. In conclusion, most of the respondents used

physical and mechanical methods to decrease pests because it is low cost and other family members also can help leisurely.

Table 8 Distribution of ethnic farmers' pest management practices of potato cultivation

Total Ethnic Group	**Pest Management Practices**	**Number of farmers**
Taung Yo (57)	Chemical Pesticide	42
	Chemical + Biological control method	3
	Chemical + Physical and mechanical method	9
	Chemical + Traditional method	0
	Chemical + Others	3
Pa-O (15)	Chemical Pesticide	10
	Chemical + Biological control method	
	Chemical + Physical and mechanical method	1
	Chemical + Traditional method	2
	Chemical + Others	0
		2
Danu (27)	Chemical Pesticides	19
	Chemical + Biological control method	1
	Chemical + Physical and mechanical method	4
	Chemical + Traditional method	1
	Chemical + Others	2
Palaung (10)	Chemical Pesticides	1
	Biological control method	0
	Physical and mechanical method	0
	Traditional method	0
	Others	0

Source: Survey Data (2022)

4.3 Factors affects farmers' pest control method

Table 9 Binary Logistic Regression Estimates the factors influencing the potato farmers' pest control method (N = 100)

Variables	B	S.E.	Sig.	Odd ratios	P value
Gender	-0.776	0.612	0.205	0.46	0.20^{ns}
Age	-0.004	0.222	0.986	0.996	0.98^{ns}
Ethnic	-0.036	0.318	0.910	0.965	0.91^{ns}
Marital	-3.168	1.748	0.070	0.042	0.07*
Education level	-0.253	0.278	0.363	0.777	0.36^{ns}
Type of farmland	-2.259	1.228	0.066	0.105	0.06*
Farmland ownership	-0.667	0.706	0.345	0.513	0.34^{ns}
Farm experience	0.502	0.302	0.096	1.653	0.09*
Other crops plantation	2.13	0.735	0.004	8.415	0.00***
Annual household income	-0.516	0.428	0.228	0.597	0.22^{ns}
Constant	4.647	2.937	0.114	104.265	

In binary linear regression, *, **, *** and ns show 10%, 5%,1% level of significance and non-significance respectively.

$$\text{Ln}\,(Pi / (1- Pi)) = ß_0 + ß_1X_1 + ß_2X_2 + \ldots\ldots + ß_n X_n + e$$

$$\text{Ln}\,(Pi/(1- Pi)) = 4.647-0.776X_1-0.004X_2-0.036X_3-3.168X_4-0.253X_5-259X_6-0.667X_7+ 0.502X_8 +2.13X_9-0.516\ X_{10}$$

Where, X_1= Gender, X_2= Age, X_3= Ethnic, X_4= Marital, X_5= Education level, X_6= Type of farmland, X_7 = Farmland ownership, X_8= Farm experience, X_9= Other crops plantation,

X_{10} = Annual household income

The binary logistic regression was used to determine factors affecting adoption on pest management. Table 9 shows the result of the data analysis of the binary logistic regression model to assess the factors influencing the decision of pest management by potato farmers' pest management practices (chemical pesticides and alternative methods).

In this study, coefficient of marital status and type of farmland were significant at 0.1 level. Farmers' marital status and type of farmland were negatively related with the adoption as expected in hypothesis. The odds ratios associated with marital status and type of farmland were 0.042 and 0.105. The coefficient of farm experience was positively significant at 0.1 level and other crop plantation was positively significant at 0.01 level.

It is observed that the estimated odds ratio of 0.042 indicates that farmers who calculate the potato's marital status are 0.042 more likely to perform better pest management. Similarly, the estimated odd ratio of 0.105 indicates that ethnic farmers' type of farmland areas is 0.105 more perform to control pests in potato crop production. Regarding to ethnic farmers' farm experience level estimated odds ratio of 1.653 indicated that those farmers' farm experience level and above level are 1.653 more likely to perform better pest control strategy. In the same fashion, the estimated odds ratio of 8.415 indicates that respondents from other crop plantations are 8.415 more likely to form better pest management systems.

In the result of the regression analysis, it can be concluded that the odd ratios of martial of the farmers, type of farmland, farm experience, and other crop plantation are significant ethnic farmers' pest management methods in potato production in Southern Shan State.

4.4 Farmers' Knowledge on Pest Management

According to Table 10, almost all farmers have knowledge related to pest control well that pests can damage crops and only 4% did not know pests can break crop production, over half of the farmers accept pests can extend to other neighboring

farms and 33% of people told pests cannot spread to other farms. Almost all farmers knew pest management is very important to get more yield. The majority of the farmers know the effect of pest control according to the method of the pest management system and about 60% of farmers did not know the way of pest controlling method correctly and only 40 % know the pest management method and how to control it. most respondents did not know the way pests and enemies how to different completely. (Atreya et al., 2012) shown that two-thirds in Nepal respondents knew that pesticides affected natural enemies on the farm.

In the usage of chemical pesticides, about 86% of respondents accepted pesticides significantly affect for controlling pests and only 14% of people thought chemical pesticides cannot affect and damage pests later because most pests are resistant to the chemical pesticides in the agricultural systems. (Endalew et al., 2022) cited that 33.3% of growers had enough knowledge related to chemical pesticide and knowledge towards pesticide is essential to follow safe farm workers.

More than 80% of people well understood that the impact of chemical pesticides entering into the body and that occur acute toxic symptoms but 16% of farmers did not know health issues and toxic systems due to the chemical pesticides. Eighty percent growers knew chemical pesticides could damage on the environment and biodiversity dangerously but 20% did not know the disadvantages of chemicals on the environment. This study is found that farmers' knowledge on the negative impact of the pesticides on the environment is very important to prohibit pesticide risk (Endalew et al., 2022). More than 70% of farmers agreed pesticides could cause residue on soil, air, water, and crop and only 28% could not agree on the impact of pesticide residue.

In Table 10, it is showed that over 83% of farmers did not know how to choose chemical pesticides and 17% of farmers knew how to choose the pesticides in the markets correctly, most of the respondents need more knowledge of pest management. However, almost all farmers knew some pesticides are restricted in the country by the government. More than 50% of farmers experienced the reasons for excluding pesticides from use in their fields and about 41% of people did not experience why they removed chemical pesticides from the market. Only 18% of farmers understand to read the constructions on the pesticide bottles and containers

but 82% of potato growers could not understand chemical pesticides containers labels because they are written in English languages, Thai languages, and other foreign languages. Only16% of people followed the construction of chemical pesticides but more than 84% of farmers did not follow the constriction of the chemical pesticides in the study areas. Therefore, most farmers have misunderstandings related to the amount of pesticide while spraying pesticides.

In alternative methods, more than 60% of respondents did not think that alternative methods could control pests and 37% of farmers thought alternative methods are useful to control pests but effectively. Above 60% of people thought the implementation of an alternative method could decrease the negative effect on the environment and 37% of growers did not think the alternative method could decline the chemical residue on the environment. Over 60% of farmers believed alternative methods might be safe for the health of the farmers and farm workers and 36% of people did not believe alternative methods for decreasing the health of the farmers and farm workers. About 21% and 46 % of respondents knew the biological control method and physical control method but 79% and 54% of growers did not know the biological and physical control methods in the agricultural farming system (Bakhtawer & Afsheen, 2021). Forty-six percent of farmers knew the physical control method and 54% of farmers did not know the physical and mechanical control method respectively. (Aung et al., 2020) cited that half of the farmers had knowledge of traditional methods to reduce the cost of pesticides but they did not practice the traditional method.

Table 10 shows that farmers who cultivate potato in Southern Shan State have knowledge of pest management method but most farmers cannot segregate natural enemies and pest in the field. Similarly, over half of the farmers did not know exactly and indeterminately what pests are effective with pesticides because many kinds of new chemical pesticide products are imported into the markets. Chemical pesticides seller always introduced all new products to use for managing pests. Therefore, farmers may confuse effective pesticides with pests in crop production. According to the data, most farmers understand pesticide usage and their impact. However, most farmers did not understand the pesticide label when applying pesticides in the field because some pesticide instructions are described in English languages, Thailand

languages, and Chinese languages. Alternative methods are less aware of farmers than chemical pesticides as well as most farmers did not know biological methods to control pests as alternative methods. Nearly half of the farmers knew the physical and mechanical methods.

Table 10 Farmers' Knowledge on Pest Management

Types of Knowledge	Items	Yes (%)	No (%)
Knowledge on Pest Control Method	Pest damage crop	96	4
	Pest can spread to other farms	67	33
	Pest management method is an essential in crop production	95	5
	The effectiveness of pest control depends on the method of pest management	94	6
	You know the controlling method	40	60
	You can differentiate pest and natural enemies in fields	33	67
Knowledge on using chemical pesticides	Chemical pesticides affect when controlling pest	86	14
	You know the adverse health effects of chemical pesticide exposure on human health	84	16
	The implementation of chemical pesticide damage the environment	80	20
	Chemical pesticides can leave residue in crop	72	28
	You know how to choose the correct pesticide	17	83
	You know some pesticides are banned from using in the field	90	10
	You know the reasons prohibiting pesticides from using in the field	59	41
	You understand the chemical pesticide container label	18	82
	You follow the chemical pesticide container label	16	84
	Alternative methods can control pest effectively	37	63

Knowledge on alternative method	The implementation of an alternative method could reduce the negative impact on the environment	63	37
	Alternative methods may be safe the health of the farmers	64	36
	You know biological control	21	79
	You know physical control	46	54

Source: Survey Data (2022)

4.4.1 Farmers' Knowledge Level on Pest Management

Table 11 Distribution of the farmers' knowledge level on pest management

(n=100)

Knowledge level	Frequency	Percentage
Lower level (less than 40%)	23	23
Moderate level (41-70%)	50	50
High level (>71 %)	27	27

The class interval was calculated by the interval of Harshbarger (1977) formula. In Table 11, the distribution of the knowledge level of the ethnic farmers on pest management showed that 23 % of respondents had a lower level of knowledge and 50% of the farmers had moderate level while 27% of farmers who had a high level of the farmers' knowledge.

According to Table 11, the knowledge level of farmer is very important for pest management in the farm. A high level of farmers' knowledge is vital for controlling the standard of pest management and crop quality. Some farmers had high level knowledge, but they use chemical pesticides in their farm purposefully and significantly.

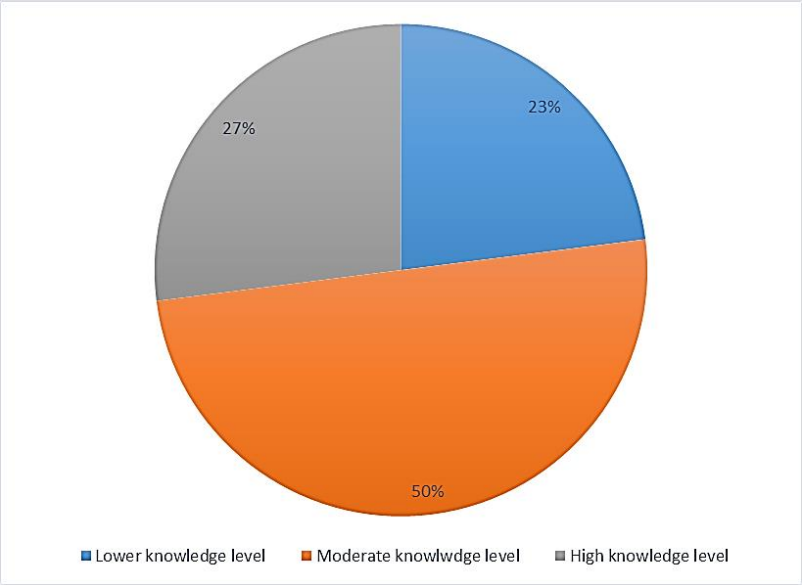


Figure 5 Farmers' knowledge level on pest management

According to this study, nearly half of the farmers have a middle knowledge level of pest management. Therefore, they understand the impact of chemical pesticides generally, but they used the chemical pesticides intentionally and they believed only chemical pesticides can kill pests in the field and there are many chemical pesticides company staffs. Farmers less alternative pest control methods and some farmers did not know the organic method and biological methods. Hence, farmers need help from agricultural officers and other private community organizations related to alternative methods and their pros and cons.

4.5 Farmers' Attitudes on Pest Management

Table 12 shows that farmers agreed that pest management is very important (Mean =4.16). The potato cultivators had mildly agreed the methods of pest management are very useful depending on the kinds of pests and crops (Mean=3.88). The growers nearly agreed pest management records should keep in the growing season (Mean=3.7). Most of the farmers had well knowledge and suitable resources in pest management(Singh et al., 2021).

In chemical pesticide usage, farmers had agreed chemical pesticides can control pests effectively (Mean=3.77). More than 86% of the farmers also agreed chemicals can enhance crop production on farms (Cevik et al., 2020). Nearly half of the farmers have positive attitudes related to the chemical pesticides handling process on their farms (Endalew et al., 2022). Most of the farmers agreed the purpose of using chemical pesticides is to overcome pest attacks purposively. The respondents in this study area had well knowledge the purpose of chemical usage is to reduce pest attacks (Mean=3.95). Some of the respondents had a soft attitude the harmful effect because of chemical pesticides (Mean=3.63). Only 22% of the farmers had attituded health risks related to chemical pesticides (Cevik et al., 2020).

Farmers had an attitude that chemical pesticide can cause air pollution and environmental impact (Mean=3.68). Each of the farmers had a low attitude towards the danger of the pesticides for farmers' health risk and environmental impact (Atreya et al., 2012). In the comparison of farmers' attitudes toward pest management, the result of (Kusumawardani et al., 2019) concluded that the respondents have the attitude that chemical pesticides have negative effects and lead to air and water pollution. Farmers believed that natural enemies may reduce when applying pesticides on the farm (Mean=3.78).

In the alternative method result, the majority of the farmers had not thought that alternative method can control pests. On contrary this result, (Allahyari et al., 2017) showed that nearly 50 % of the farmers had pretty attitude levels of technical knowledge of alternative pest management. Similarly, a researcher found that the alternative method user enjoys life on the farm and participates in the community(Sullivan et al., 1996). Farmers had positive attitudes alternative methods can safe for the health of the farmers and reduce the negative impact on soil and land (Mean=3.62) and (Mean=3.64). Some of the cultivators believed that alternative methods are not easy to manage pests in the field.

In the biological control method, some growers had negative attitudes towards biological can manage pest (Mean= 3.11) and most of the farmers had negative attitudes about biological method easy to use (Mean=2.75). (Maolin Hou, 2020) found that biological control method can manage stemborer species in rice production. The result found that farmers had to attitude biological method can reduce

health risks, the impact on land and soil and air pollution (Mean=3.64), (Mean=3.7) and (Mean= 3.68). The majority of the treatment respondents used a biological control method in rice and maize production (Babendreier et al., 2019).

Table 12 shows that farmers had negative attitudes towards physical and mechanical method that can manage pest in the field (Mean=2.97). Most farmers disagreed that physical methods are not difficult to use in crop production (Mean=2.82). The majority of the physical control methods are appropriate in the postharvest period (Vincent & Hallman, 2009). However, potato cultivators had attitude physical control methods can decrease health impact for farmers and farmworkers (Mean=3.7). Most respondents also had attitude physical control method can sustainably land and soil (Mean=3.7) and farmers agreed that it can decline air pollution (Mean=3.71) shown in Table (12). The physical control methods promote farm behavioral changes and lead to damage pests in crop protection (Vincent & Hallman, 2009).

In conclusion, most of the farmers had a general attitude toward pest management related to chemical pesticides but only some farmers strongly agreed, and some are not sure about pest management methods. In alternative methods, one-third of the farmers had no attitude to control pests, as well as nearly half of the farmers, had no attitude to biological and physical methods because they just knew and heard of the physical and biological methods. They had not applied them systematically in the agricultural farm system.

Table 12 Farmers' Attitudes on Pest Management

Types of Attitudes	Items	Strongly Disagree	Disagree	Not Certain	Agree	Strongly Agree	Mean	SD
Pest Management	Pest management is very important	1	0	0	80	19	4.16	0.50
	Pest management methods are used according to the types of pests and crops	1	2	8	86	3	3.88	0.52
	Pest management record should keep	1	10	13	70	6	3.7	0.77
Chemical Pesticides Method	Chemicals pesticide can control pests completely	0	6	19	67	8	3.77	0.67
	The purpose of using chemical pesticides is to overcome pest attacks	0	0	9	87	4	3.95	0.35
	Chemical pesticides can be a harmful health problem	0	13	12	74	1	3.63	0.72
	Chemical pesticides cause air pollution	0	12	11	76	1	3.66	0.7
	Chemical pesticides have negative environmental effect	0	10	13	75	2	3.69	0.68

	Chemical pesticides used can reduce natural enemies	0	5	12	83	0	3.78	0.52
Alternative Method	Alternative method also can control pest	0	11	54	34	1	3.25	0.65
	Alternative methods be safe for the health of the farmers	0	2	35	62	1	3.62	0.54
	Alternative method can save for land and soil	1	0	33	66	0	3.64	3.56
	Difficult to use alternative method	1	2	41	52	4	3.56	0.65
Biological Control Method	Biological control can control pest	1	18	50	31	0	3.11	0.72
	Biological control easy to use	3	32	52	13	0	2.75	0.71
	Biological control can reduce health problems for farmers	0	1	35	63	1	3.64	0.52
	Biological control can reduce the impact on land and soil	0	1	29	69	1	3.7	0.50
	Biological control can reduce air pollution	0	2	29	68	1	3.68	0.53
	Physical and mechanical control method can control pest	4	25	42	28	1	2.97	0..85
	Physical and mechanical control method easy to	7	28	42	22	1	2.82	0.89

Physical and Mechanical Control Method	use							
	Physical control can reduce health problems for farmers	0	0	30	70	0	3.7	0.46
	Physical control can reduce the impact on land and soil	0	0	30	70	0	3.7	0.45
	Physical control can reduce air pollution	0	0	29	71	0	3.71	0.45

Source: Survey Data (2022)

Figure 6 shows that the majority of the farmers have a good attitude toward pest management regarding chemical pesticides, as well as the advantages and disadvantages of pesticides in the study area. Farmers did not agree that alternative methods can control pests in the field because they did not know deeply about alternative methods and some farmers believed that they could use difficult to use and they hope that it can get more effective chemical pesticides even if it is expensive. Farmers' attitude, farmers had low attitudes toward biological control methods easy to use to manage pests because most farmers did not know the definition of biological methods. Some farmers used the biological pest control method because private agricultural organizations introduce it and demonstrate how to use it in the field. Physical and mechanical methods also did not agree physical control methods easy to use but most farmers did it in crop production because physical methods are also their daily activities and family members also can cooperate unproblematically.

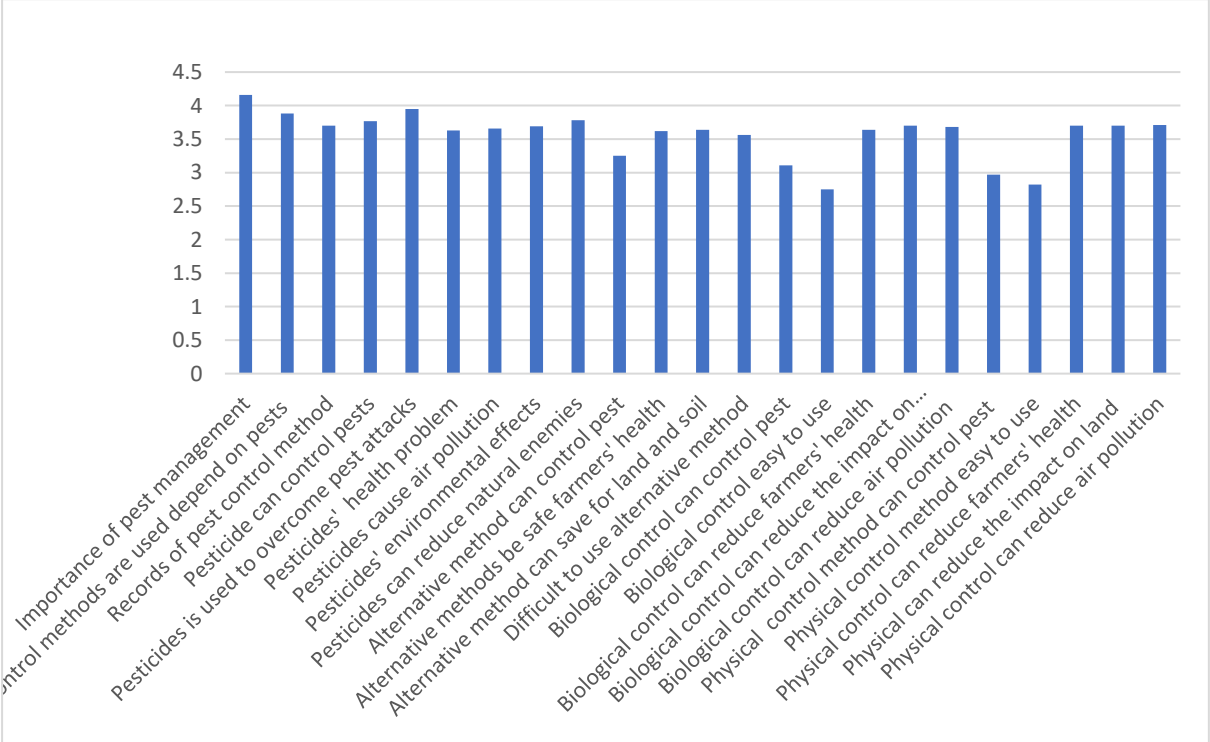


Figure 6 Bar chart showing Ethnic Farmers' Attitude level on Pest Management in Southern Shan State, Myanmar

4.6 Key Informant Interview with Government Staff Officers

Table 13 List of the Key Informant Interview with Government Staff Officers

Position	Department
Staff Officer	Department of Agriculture, Kalaw Township
Deputy Staff Officer	Department of Agriculture, Kalaw Township
Assistant Deputy Staff Officer	Department of Agriculture, Kalaw Township
Assistant Deputy Staff Officer	Assistant-Deputy Staff Officer
Research Officer	Agricultural Research Farm, Aung Ban, Heho, Kalaw Township
Leader	Heho Potato Farmers Organization

Source: Survey Data, Oct 2022

In this survey, staff officers, research officers, deputy staff officers, and assistant deputy staff officers from MOALI in Kalaw Township and the leader of Heho Potato Farmers Organization were interviewed for qualitative interviews, their responsibility and knowledge sharing system for their extension and farmers' knowledge and attitude pest management methods in this area in Table 13. They were interviewed with an open-ended interview with aid of a voice recorder and later re-wrote into themes, their answers would provide.

4.6.1 Types of Knowledge and Training

According to the types of knowledge, the agricultural extension workers shared agricultural knowledge with the farmers during the relevant training programs. The agricultural extension staff from DOA in Kalaw township answered that they implemented the agricultural training related to upland crops (rice, corn, potato, avocado, ginger, cauliflower, cabbage, etc.) in this area and met the farmers from villages directly and discussed them with matter related to their crop production problems and pest and diseases issues, etc. They also shared knowledge related to crop production process, pest management system, pesticides usage, good agricultural

practices, organic farming practices and farm marketing skills. The agricultural extension workers performed training programs at least twice a year and created demonstration fields for the farmers. Extension workers commonly used motorcycles to go to the field and checked the farmers' farm and the situation of the pest and diseases and tell the methods to control pests and diseases. Extension workers did the meeting in the office or monastery and discussed farmers' issues, crop production methods, and pest management methods to develop their crop production.

The extension workers encouraged the farmers to emphasize on the sustainable and safe use of pesticides, the best ways to choose these pesticides for pest management strategies because some chemical pesticides are written in foreign languages and are very expensive for farmers. Therefore, it is very essential for the farmers to have the correct choice of chemical pesticides, and sometimes they had some damage because of climate change. Extension officers always suggested that farmers should reduce the usage of chemical pesticides and apply the organic and other physical methods in their farm, and officers demonstrated the organic agricultural practices and manure compost in the training. Nevertheless, farmers focused only on the use of chemical pesticides in their farm because they thought that pesticides have more effect quickly than organic.

4.6.2 Methods of the Agricultural Trainings

The extension workers responded that they supported the suitable technology, fertilizers, and good potato varieties to the farmers twice a year and shared them the advantages and disadvantages of using pesticides in crop production. Farmers visited the other villages to join training where they could be able to discuss each other and share their farm issues and knowledge. Moreover, DoA launched an online application for the farmers to understand pests and diseases naturally. Sometimes, extension workers did workshops and field demonstrations to cooperate with other private agricultural organizations. Myanmar's government tries to promote peer to peer learning approach in agricultural extension systems, but this method has not yet had an effect in the agricultural sector. So, extension workers also need to understand the peer-to-peer method strategy impressively. Sometimes, the extension workers

shared agricultural knowledge individually at the farm or at home. They also gave pamphlets to farmers and announced them in the notice boards in the public area to let farmers know and understand agricultural knowledge. However, most farmers prefer to kill pests immediately when they spray pesticides. Farmers more believe in pesticide companies' staff than government staff because they always sell with discounts and promotion of their pesticide products in farm meetings.

Most farmers wish to buy chemical pesticides with cheap prices than quality products for their farm problems. Therefore, farmers need chemical pesticides more and more to decline pests. Although some farmers did not have enough knowledge, they are not willing to participate in the training programs. Two years ago, officers distributed face masks, pheromone traps, and yellow sticky traps to farmers so as to trap through colorful sticky cards but they did not use them systematically and usefully on their farm.

4.6.3 The role of the agricultural extension workers in the promotion of alternative methods of pest management

The role of the agricultural extension workers is very important in the promotion of alternative methods of pest management for ethnic farmers in Southern Shan State. Sometimes, extension workers gave training cooperatively with INGO, NGO, and other private organizations about alternative methods such as green manure, organic manure, and neem. Extension officers said that large-range farmers prefer using alternative methods in crop production in Shan State. Sometimes, farmers came to the agricultural training only if the extension workers reinforced them to join the training programs. Extension workers always check around the farm to know the condition of the crop production. Moreover, they said that they knew the condition of the local farm area in the agricultural production system.

4.6.4 The problem and limitations of extension workers

The problem and limitation of extension workers in the Southern Shan State is quite revealed. It is reported that some farmers did not want to join the meeting for

many reasons - they did not want to spend their time to participate in such agricultural training. Whenever the extension workers have the training, they always see the same farmers and they do the demonstration field in some villages because most farmers did not believe the extension workers. The problem is that farmers thought the training and practices that extension workers gave are not useful and they do not need to follow. They tried to solve the pest issues on their farm with their neighboring friends. Mostly, the majority of the farmers have never contacted the Department of Agricultural. When the extension workers go to the villages, they also have transportation issues, especially in the rainy season. Most farmers who joined their training did not follow their method related to suitable and good agricultural practice methods. Extension staff said that they have limitation related to the budget for the training and field demonstration but if they are granted with a more concrete budget, they might share knowledge and technologies with farmers. In Myanmar, agricultural extension volunteers are not rare because most farmers have no time and are interested to be volunteer trainers. They always spend on the farm and always settle for their livelihoods in the study area. This is one of the problems and limitations of the extension workers.

4.6.5 Plan to reduce the pesticide use

Currently, they would be no plan to reduce the chemical pesticide used in the study area completely because most farmers desired to use chemicals in the field as well as they thought only chemical pesticides can control pests and enhance crop production. Agriculture officers are introducing organic farming and Good Agricultural Practices (GAP) practice to educate farmers and share the advantages and disadvantages of alternative methods. The agricultural extension officers advised the chemical pesticides companies' staffs to sell and share alternative methods for agricultural production and for protecting pests, getting high yields and covering health problems, and saving the environment. Now, social media is very important to introduce the agricultural management strategy and suitable technology.

In the future, extension workers are planning to reduce chemical pesticide usage in Southern Shan State, but it is very difficult to reduce chemical pesticides in

crop production. Extension workers more deeply introduce alternative methods in the agricultural production system to control pests and reduce the cost of pesticides and environmental impact in the study area. Moreover, they also check the chemical pesticides unexpectedly to know their pesticide storage structure and knowledge. They also use social media platform widely to make awareness of usage of pesticide in cultivation among farmers.

As the result, agricultural extension workers gave training and shared knowledge of different kinds of agricultural crop methods and practices but the frequency of the training they could implement is very not actually reliable. Farmers in Shan State should have received more training and knowledge because they are many kinds of upland crops that are cultivated using chemical pesticides. Vegetables and crops in Shan State are distributed to all areas of the country. Therefore, it can be assumed that food security and food safety depend on the farmers. Mostly, extension workers gave training on how to use chemical pesticides systematically and good agricultural practices. Moreover, extension workers should give training more emphasizing on alternative pest control methods to the farmers. If every village has a field demonstration farm, it is a valuable practice to guide farmers.

CHAPTER 5

Conclusion, Recommendation and Limitation

5.1 Conclusion

The research paper has found that the potential problems for human and environmental exposure to pesticides in a selected study area. This research brings useful information for a better understanding of knowledge, and practices on pest management of the ethnic farmers in potato production in Southern Shan State.

This study found that the socio-economic conditions of the potato farmers in two villages are ethnic people such as Taung Yo, Pa-O, Danu, and Palaung. The education level of the respondents was a primary school, but they have a lot of farm experience in potato production. Most farmers cultivated not only potatoes but also other upland crops for their commercial and food security but their household income mainly depends on potato production. In farmers' practice, the majority of the farmers use only "Chemical Pesticides" to control pest issues and to improve yield, only a few people use "Chemical Pesticides and Alternative Methods", and no one uses only alternative methods to manage pests in their farm because they assume that chemical pesticides are more effective and are easy to use. They may cause negative environmental effects, land degradation, crop residues, and loss of biodiversity.

According to the results of the farmers' knowledge of pest problems and management, the majority of the farmers have knowledge related to pest management, but some respondents believed that pests cannot spread to the neighboring farm. Moreover, some farmers cannot decide on pests and natural enemies in the field and they are intractable to choose suitable chemical pesticides for their pest problems. Some farmers did not know the impact of chemical pesticides on the environment, human health, and chemical residue in crops. Over half of the farmers did not know alternative methods can control pests and reduce the negative effect on the environment and health issues.

According to the study, all respondents are ethnic people, they are Taung Yo, Pa-O, Danu, and Palaung. Among them, 42% of the Taung Yo used chemical pesticides and 15% applied alternative methods, 8% of the Danu respondents used alternative methods, 5% of the Pa-O farmers applied alternative methods and Palaung

respondents did not use alternative methods. However, physical and mechanical pest control methods are most used by ethnic farmers to control pests in potato production. Mostly farmers removed pests by hand and shovels to manage pests because this method is low cost and family members also can help.

The statistical test showed that half of the farmers have “Moderate Knowledge Levels”, 27 % of the farmers have a “High knowledge Level” and only 23 % of the respondents have a “Lower knowledge Level”. Generally, most farmers have a middle knowledge level and awareness regarding pest management in crop production. Farmers used chemical pesticides although the impact of chemical pesticides. Moreover, some farmers can not give enough time for alternative methods, some farmers did not know what is organic and they need only effective chemical pesticides to control pests on the farm.

The statistical tests showed that farmers’ marital status, type of farmland, farm experience, and other crop plantation are significant farmers’ pest management methods. In the result, the type of farmlands and marital status are negatively significant to the pest management and farm experience and other crop plantation is positively significant to pest management in the study area. Male ethnic farmers are more interested in alternative methods than female farmers. Ethnic farmers who had many years of experience are more interested in alternative methods in the field.

Most farmers who purchased chemical pesticides from the market, always read the pesticide label before spraying and some people never read the instructions on the labels of pesticides. Most farmers never wore protective equipment when spraying chemical pesticides such as long boots, masks, and jackets. The majority of the farmers got information related to pest management from pesticide companies’ staff. Most farmers have experienced some pesticide-related health issues such as itching, dizziness, tiredness, headache, and respiration problem after using pesticides.

Chemical pesticides company staffs are the main information center concerning pesticides and some farmers used “Alternative Methods” to reduce the cost of pesticides. Among them, the “Physical and Mechanical Method” is used as the main alternative method on their farm. Some farmers received different kinds of agricultural training from the Department of Agriculture (DOA).

According to the survey finding on farmers' attitudes toward pest management among potato cultivators, some potato farmers have no attitude chemical pesticides can be a harmful health problem, cause air pollution, and have a negative environmental effect. The majority of the farmers agreed that chemical pesticides can control pests effectively and 83% of potato growers agreed that spraying chemical pesticides can decline natural enemies on the farm,

Most farmers did not know "Alternative Methods" to manage pests and believed that alternative methods are very difficult to use in the field. The majority of the respondents had no attitude and they believed that it is very difficult to use but some agreed that "Biological and Physical Methods" can save the health problems of the farmers and farm workers and decrease air pollution and the negative impact of soil. Ethnic farmers had no attitude related to physical and mechanical, but they did know it can save environmental impact.

According to the results, extension workers currently gave training related to pest management in various kinds of upland crop production and shared knowledge with the farmers but most farmers did not attend the training and are not interested in it. Extension workers introduced alternative pest control methods, organic methods, good agricultural practices, and how to choose pesticides correctly. Sometimes extension staff gave the potato farmers face masks, protective equipment, and sticky traps but they never use it, and alternative methods are not familiar to farmers and not esteemed. The extension worker tries to reduce the use of chemical pesticides but most farmers thought only chemical pesticides to control pests. They demonstrated field trials and test other potato varieties and introduced good quality and suitable potato varieties. Sometimes, extension workers visited and cared for the plantation of potatoes and inspected the condition of the potatoes.

In the future, the extension workers will support more training from farmers and promote new concepts such as pest management, environment-friendly crop protection method, and reducing the impact of chemical residues. Extension workers' capacity building also will support and promote to be strong. The government extension workers will deeply introduce alternative methods and organic farm practices. Moreover, field demonstration and good agricultural practices are described in the village.

5.2 Recommendation

- Ethnic farmers should receive more alternative pest control methods (physical and biological methods) from extension workers and private organizations to enhance farm practices and yield because alternative methods also can suppress pests in the field and may lower the cost of chemical pesticides farmers.
- Farmers should be provided more training and farm practices to improve farmers' attitudes toward pest management methods from agricultural organizations in crop production. Farmers should consider the impact of chemical effects on the soil, air, and environment in this area.
- Cultivators should reduce using chemical pesticides with the alternative method in crop production because farmers also used chemical pesticides in other upland crops which addresses the vulnerability of food security of household meals in Southern Shan State
- Ethnic farmers need more emphasis on use of chemical pesticides and participate in the training programs arranged by relevant government institutions and should cooperate in field demonstrations and discussions because most farmers did not interest in the agricultural training.
- Extension workers commonly need more support and funds for training, sharing information, and field demonstrations in all villages in Southern Shan State. Moreover, they should re-evaluate and monitor farmers' farm activities and results after getting training.
- The Myanmar government should provide funding, capacity-building training, and necessary facilities for extension workers to be convenient when they go to the village and share agricultural knowledge.
- Government should provide suitable varieties, and necessary farm materials to farmers at a low price to be ever farmers can buy them because farmers who purchased farm machines and seed varieties from the market are very expensive.

- The Department of Agriculture should always train and check the shopkeeper's chemical pesticide storage structure and banned chemical pesticides. They need to share alternative methods of supplements. Moreover, the government should restrict regulations of pesticides and control the manufacture of pesticides effectively.

5. 3 Limitation

- Farmers in the study area were not asked what types of chemical pesticides they are using in crop production. So, future study may collect whether farmers use banned pesticides or not in Shan State.
- This study analyzed farmers' knowledge, attitudes, and practices on pest management. Future study may require to understand the marketing of potato production.
- The fact that chemical pesticides' impact on soil and water is not included in this study. Thus, future study may collect the impact of soil and water due to chemical pesticides.
- In this study, the attitudes or mindsets of farmers relating to extension sector of agriculture is not well revealed. Therefore, it is recommended that further study may be sought in future.
- Deep research for the extension services in Southern Shan State could not be included in this study. Therefore, future study may include more in-depth research and gaps between extension workers and farmers.
- The implication of the research is not explored for different potato varieties and their yield. Thus, future study may collect the potato varieties in Southern Shan State and their yield in crop production.

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Appendix (1)

INTERVIEW QUESTIONS

Knowledge, Attitude and Practices on Pest Management of Ethnic Potato Farmers in Southern Shan State, Myanmar

INTRODUCTION: You are invited to participate in a survey that is a part of my master's thesis research at Chulalongkorn University in the Environment, Development, and Sustainability Program. This research aims to examine the ethnic farmers' knowledge and attitudes towards different pest management methods, factors affecting farmers' selection, and the role of the agricultural extension workers in promoting alternative methods. For each question, please answer to the best of your ability.

The questionnaires form consists of 4 parts:

Part I. Socio-economic information of ethnic potato farmers

Part II. Current of Farm Practices of ethnic potato farmers

Part III. Farmers' Knowledge on Pest Management of ethnic potato farmers

Part IV. Farmers' Attitudes toward on Pest Management of ethnic potato farmers

Date - / / 2022 Name of the collector:

Farm Location

Village Track –

Village –

Township _

District _

1. Socio-economic of potato ethnic farmers

1.1 Gender

☐ Male ☐ Female

1.2 Age (years)

☐ Between 18- 24 years ☐ Between 25-34 years ☐ Between 35-44 years

☐ Between 45- 54 years ☐ Between 55- 64 years ☐ Over 65 years

1.3 Marital Status

☐ Single ☐ Married ☐ Divorced

1.4 Education Level

☐ Monastery ☐ Primary School ☐ Middle School

☐ High School ☐ Undergraduate ☐ Graduate

1.5 Family members

☐ Less than 3 ☐ Between 3- 6 ☐ Between 7- 10

☐ Over 10

1.6 Number of children

☐ None ☐ 1-2 ☐ 3-4

☐ Over 5

1.7 Average size of farmland (acres)

☐ Between 1-3 acres ☐ Between 4-6 acres ☐ Between 7-9 acres

☐ Between 10-12 acres ☐ Between 13-15 acres ☐ Over 16 acres

18 Type of farmland

☐ Lowland Farm ☐ Upland farm ☐ Lowland + Upland

☐ Garden Farm

1.9 Farm land ownership status

☐ Owner-self operated ☐ Lease-self operated ☐ Unregistered farm land

1.110 Farm experience in potato farming

☐ Less than 3 years ☐ Between 3- 6 years ☐ Between 7– 10 years

☐ Over 10 years

1.11 Names your previous crop if any (otherwise go to 1.12).

☐ Rice ☐ Corn ☐ Onion ☐ Ginger
☐ Vegetables ☐ Others (Please specify.....)

1.12 Do you have any other crops in your farm?

☐ Yes, (answer 1.13) ☐ No, (skip to 1.14)

1.13 Names of the other crops in the farm

☐ Rice ☐ Corn ☐ Onion ☐ Ginger
☐ Vegetables ☐ Others (Please specify.....)

1.14 Main source of incomes

☐ Potato farm ☐ Others (Please specify.....)

1.15 What is your annual household income from potato production

☐ Less than 3,000,000 kyats ☐ 3,000,000 - 5,000,000 kyats ☐ 5,000,0001 - 7,000,000 kyats ☐ 7,000,001 - 9,000,000 kyats ☐ More than 9,000,000 kyats

2. Current Farm Practices of Ethnic Potato farmers

2.1 Which methods you use to control pest in your farm?

☐ Chemical pesticide method (Answer 2.2-2.11) ☐ Alternative method (Answer 2.12- 2.16) ☐ Both methods (Answer 2.2-2.16)

2.2 Reasons to use chemical pesticides

☐ Easy to use ☐ More effective ☐ Save time
☐ Reduce farm workers ☐ Others (Please Specify.....)

2.3 Where do you buy chemical pesticides from? (You can choose more than 1 answer)

☐ Markets/ Shops ☐ Company Staffs ☐ Government (Officially)
☐ Others (Please Specify.....)

2.4 Who apply the chemical pesticides in the field? (*You can choose more than 1 answer*)

☐ Farmers ☐ Farm workers ☐ Others (Please Specify.....)

2.5 Which chemical pesticides is the most used in your farm?

☐ Insecticides ☐ Fungicides ☐ Herbicides

☐ Others (Please Specify.....)

2.6 Do you read the pesticide label before applying?

☐ Never ☐ Sometimes ☐ Everytime

2.7 Do you wear the protective equipment while applying?

☐ Everytime ☐ Sometimes ☐ Never

2.8 What kinds of protective equipment do you wear? (You can choose more than 1 answer)

☐ Face mask ☐ Long boots ☐ Jacket

☐ Glove ☐ Goggles ☐ Others (Please Specify.....)

2.9 Where did you get information concerning the proper use of chemicals pesticides from?

☐ Government Staff ☐ Company Staff ☐ Neighboring Farmers and Friends

☐ Social Media ☐ Manual (Self-learning) ☐ Others (Please Specify.....)

2.10 Do you have any pesticide-related health issues?

☐ Yes ☐ No (Skip 2.11-2.16)

2.11What kinds of health problem from using pesticides? (You can choose more than 1 answer)

☐ Tired ☐ Headache ☐ Dizziness

☐ Itching ☐ Eye Irritation ☐ Others (Please Specify.....)

2.12 Reasons to use alternative method

☐ Lower cost ☐ Protect health ☐ Protect the environment

☐ Decrease the pesticides use ☐ Others (Please Specify.....)

2.13 What kinds of the alternative methods (systems do not use conventional methods) do you use in your farm? (You can select more than 1 answer)

☐ Biological methods ☐ Physical & mechanical method ☐ Traditional or Cultural method ☐ Others (Please Specify.....)

2.14 How long have you been using the alternative method according to your answer in question 2.13?

☐ Less than 1 year ☐ Between 1- 2 years ☐ Between 3-4 years
☐ Between 5-6 years ☐ Over 6 years

2.15 Where did you learn about alternative method?

☐ Government Staff ☐ Company Staff ☐ Neighboring Farmers and Friends ☐ Social dia ☐ Others (Please Specify.....)

2.16 Where did you buy supplies and equipment for alternative method?

☐ Markets ☐ Company Staff ☐ Farmers ☐ Government
☐ Manual (Self-learning) ☐ Others (Please Specify.....)

2.17 Have you been receiving any trainings and support by Department of Agriculture?

☐ Yes ☐ No (skip to 2.20)

2.18 If Yes, what kinds of trainings you get from Department of Agriculture? (You can choose more than 1 answer)

☐ Good Agricultural Practic ☐ Pest Manag nt ☐ Pesticide Usage Management ☐ Mechanical Using Trainig
Others (Please Specify.....)

2.19 What kind of support have you received from the Department of Agriculture (DOA)? (You can choose more than 1 answer)

☐ Finalcial Aids ☐ Fertilizer ☐ Pesticides

☐ ☐

Machine Others (Please Specify.....)

2.20 Where did you get your training related to the potato farming?

☐ Pesticides Company ☐ Non-government Organization ☐ Private ☐ Organization ☐ Others (Please Specify.....)

3. Farmers' Knowledge on Pest Management

Please read each statement carefully and mark ✓ or × in the each of the following statements that you feel most strongly about.

	Statements	**Yes**	**No**
1.	Pest damage crop		
2.	Pest can spread to other farms		
3.	Pest management method is an essential in crop production		
4.	The effectiveness of pest control depends on the method of pest management		
5.	You know the controlling methods		
6.	You can differentiate pest and natural enemies in fields		
7.	*Chemical pesticides completely affect when controlling pest*		
8.	You know the adverse health effects of chemical pesticide exposure on human health		
9.	The implementation of chemical pesticides damage the environment		
10.	Chemical pesticides can leave residue in crop		
11.	You know how to choose the correct pesticide		
12.	You know some pesticides are banned from using in the field		
13.	You know the reasons prohibiting pesticides from using in the field		
14.	You understand the chemical pesticide container label		
15.	You follow the chemical pesticide container label		
16.	Alternative methods can control pest effectively		

17.	The implementation of an alternative method could reduce the negative impact on the environment		
18.	Alternative methods may be safe the health of the farmers		
19.	You know biological control (reduction of pest populations by natural enemies)		
20.	You know physical control (mechanical and hand control where the pest)		

4. Farmers' Attitudes on Pest Management

Please read each statement carefully and mark ✓ or × in the each of the following statements that you feel most strongly about.

	Statements	**Strongly Disagree**	**Disagree**	**Not Certain**	**Agree**	**Strongly Agree**
1.	Pest management is very important					
2.	Pest management methods are used according to the types of pests and crops					
3.	Pest management methods should records					
4.	Chemicals pesticide can control pests completely					
5.	The purpose of using chemical pesticides is to overcome pest attacks					
6.	Chemical pesticides can be a harmful health problem					
7.	Chemical pesticides cause air pollution					
8.	Chemical pesticides have negative environmental effects					

9.	Chemical pesticides used can reduce natural enemies					
10.	Alternative method also can control pest					
11.	Alternative methods be safe for the health of the farmers					
12.	Alternative method can save for land and soil					
13.	Difficult to use alternative method					
14.	Biological control can control pest					
15.	Biological control easy to use					
16.	Biological control can reduce health problems for farmers					
17.	Biological control can reduce the impact on land and soil					
18.	Biological control can reduce air pollution					
19.	Physical and mechanical control method can control pest					
20.	Physical and mechanical control method easy to use					
21.	Physical control can reduce health problems for farmers					
22.	Physical control can reduce the impact on land and soil					
23.	Physical control can reduce air pollution					

Questions for Key Informant Interview

Knowledge and Attitude on Pest Management of Ethnic Potato Farmers in Southern Shan State, Myanmar

General Information

Interviewer	(1) Male (2) Female
Date of Interview	
Time of interview	
Location	
Name of key informant	
Position	
Organization	
Category of informant	(a) Government (b) Private (c) Other agricultural org
Level of key informant	(a) National (b) Regional (c) Township

Interview Questions

1. What types of knowledge and trainings did the agricultural extension workers give to the potato ethnic farmers?
2. What methods did you use while training to the farmers and how many times a month do you give training?
3. What is the role of the agricultural extension workers in the promotion of alternative methods of pest management for ethnic farmers in Southern Shan State?
4. What is the problem and limitation of extension workers in this area?
5. Do you have plan to reduce the pesticide used in this area?

Appendix (2)

Information of the data collection

Potato Fields in Kalaw Area

Interview of farmers from Wa Yone Pin Village, Kalaw Township

Interview of farmers from Myae Char Village, Kalaw Township

Interview with Extension Officer of DOA, Kalaw Township

VITA

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PLACE OF BIRTH	Kyaikhto Township, Mon State, Myanmar
INSTITUTIONS ATTENDED	Yezin Agricultural University, Myanmar
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