FAKTOR-FAKTOR YANG MEMPENGARUHI ADOPSI PETANI PADI PADA TEKNOLOGI PENGENDALIAN HAMA TERPADU

(Kasus Di Kecamatan Chedi Hak, Provinsi Ratchaburi)

SKRIPSI

Oleh:

Dian Galuh Pratita
NIM. 111510601067

PROGRAM STUDI AGRIBISNIS
FAKULTAS PERTANIAN
UNIVERSITAS JEMBER
2015

FAKTOR-FAKTOR YANG MEMPENGARUHI ADOPSI PETANI PADI PADA TEKNOLOGI PENGENDALIAN HAMA TERPADU

(Kasus Di Kecamatan Chedi Hak, Provinsi Ratchaburi)

SKRIPSI

Diajukan Guna Memenuhi Salah Satu Persyaratan untuk Menyelesaikan Program Sarjana pada Program Studi Agribisnis Fakultas Pertanian Universitas Jember

Oleh:

Dian Galuh Pratita
NIM. 111510601067

PROGRAM STUDI AGRIBISNIS
FAKULTAS PERTANIAN
UNIVERSITAS JEMBER
2015

FACTORS AFFECTING RICE FARMER'S ADOPTION IN INTEGRATED PEST MANAGEMENT TECHNOLOGY:

(A Study Of Chedi Hak Subdistrict, Ratchaburi Province)

By:

DIAN GALUH PRATITA 5620000044

Submitted to:

Assoc. Prof. Dr. Am On Aungsuratana

DEPARTMENT OF AGRICULTURAL EXTENSIONAND COMMUNICATION

FACULTY OF AGRICULTURE AT KAMPHAENG SAEN

KASETSART UNIVERSITY

2014

VALIDATION

The present undergraduated thesis entitled "***Factors Affecting Rice Farmer's Adoption In Integrated Pest Management Technology: A Study Of Chedi Hak Subdistrict, Ratchaburi Province***" has been done as the result of Join Degree Program between Jember University and Kasetsart University. It has been examined by Research Supervisor Associate Professor Dr. Am-On Aungsuratana and Research Co-Advisor Dr. Rapee Dokmaithes and published in Faculty Of Agriculture Kasetsart University and further validate by examination committee in Faculty of Agriculture Jember University by Ir. Anik Suwandari, M.P., Dr. Ir.Joni Murti Multyo Aji, M.Rur.M., Ebban Bagus Kuntadi, S.P, M.Sc., and Dr.Ir.Triana Dewi Hapsari, M.P.

DEDICATION

In the name of Allah SWT, this research has been dedicate for;

1. Beloved parents; Alm. Irfan Boedi Setiawan and Dr. Asrumi, M.Hum. for their support, kindness, and best wishes.
2. Teachers since kindergarten up to University for the best knowledge .
3. Agribusiness Study Program, Faculty of Agriculture, Jember University.

MOTTO

"*Indeed, Allah will not change the condition of a people until they change what is in themselves.*"

(QS Ar-Ra'd : 11)

"Success in life is not about luck, it is about managed thoughts, focused attention and deliberate action"

(Trudy Vesotsky)

"Dream in light years, challenge miles, walk step by step"

(William Shakespeare)

DECLARATION OF UNDERGRADUATED CANDIDATE

This declaration is made by:

Name : Dian Galuh Pratita

SID : 111510601067

I declare that this undergraduate thesis entitled “Factors Affecting Rice Farmer’s Adoption In Integrated Pest Management Technology: A Study Of Chedi Hak Subdistrict, Ratchaburi Province” is a true copy of my thesis, including any final revisions as approved by my thesis committee and that this thesis has not been submitted for a higher degree to any other University or Institution.

Jember, June 2015
Author,

Dian Galuh Pratita
SID 111510601067

UNDERGRADUATED THESIS

FACTORS AFFECTING RICE FARMER'S ADOPTION IN INTEGRATED PEST MANAGEMENT TECHNOLOGY: A CASE STUDY OF CHEDI HAK SUBDISTRICT, RATCHABURI PROVINCE

By:

Dian Galuh Pratita

SID. 111510601067

Advisors from Thailand

(Kasetsart University Kamphaeng Saen Campus)

Research Supervisor	:	Assoc. Prof. Dr. Am-On Aungsuratana
Research Co-Advisor	:	Dr. Rapee Dokmaithes

Research Co-Advisor from Indonesia

(Jember University)

Research Co-Advisor 1	:	Ir. Anik Suwandari, MP.
		NIP 196404281990022001
Research Co-Advisor 2	:	Dr. Ir. Joni Murti Mulyo Aji, M.Rur.M.
		NIP 197006261994031002

PENGESAHAN

Skripsi berjudul "***Factors Affecting Rice Farmer's Adoption In Integrated Pest Management Technology (A Case Study Of Chedi Hak Subdistrict, Ratchaburi Province)***" telah diuji dan disahkan pada:

Hari : Senin

Tanggal : 25 Mei 2015

Tempat : Fakultas Pertanian Universitas Jember

Dosen Penguji 1,

Ir. Anik Suwandari, MP.
NIP 196404281990022001

Dosen Penguji 2,

Dr. Ir. Joni Murti Mulyo Aji,M.Rur.M
NIP 197006261994031002

Dosen Penguji 3,

Ebban Bagus Kuntadi, SP., M.Sc.
NIP 198002202006041002

Dosen Penguji 4,

Dr. Triana Dewi Hapsari, SP., MP.
NIP 197104151997022001

Mengetahui,
Dekan,

Dr. Ir. Jani Januar, MT.
NIP 195901021988031002

SUMMARY

Factors Affecting Rice Farmer's Adoption in Integrated Pest Management Technology: Study of Chedi Hak Subdistrict, Ratchaburi Province, Dian Galuh Pratita, 111510601067, Agribusiness Study Program, Department Of Agriculture Social Economics,Faculty of Agriculture University of Jember.

Food security and sustainable agriculture is one important point in Thailand agricultural development. Thailand has great amount on pesticide consumption as agricultural input. To achieve the good sustainable agriculture, Thailand adopt the IPM technology as the advanced technology. The study focused on analyzing and identifying factors affecting adoption of technology dissemination (IPM). The main focus in this investigation is to determine factors affecting rice farmers in IPM technology adoption. The main idea of research is to deliver a number of possible policy implications and recommendation for productivity improvement, income generation and higher standard of living of rice cultivators towards self sufficiency and sustainability of rice in Thailand.

The benchmark survey in this investigation was obtained from one rice progressive farmer in Chedi Hak Sub district, Mueang Ratchaburi District, Ratchaburi Province. The sample was selected using a purposive sampling technique including the progressive farmer, extension officer, and stakeholders. Survey items of this study was used interviewing schedule in terms of SWOT analysis and Matrix analysis. Descriptive quantitative analysis was used to determine ecological condition, personal background, factors affecting adoption of IPM, and KAP of IPM. The findings shows that the progressive farmer has high capability, acceptability, and practicality towards IPM technology model (prevention, monitoring, identification, pest action, and evaluation). There are some factor affecting adoption of IPM technology including personal background, input used, physical factors, biological factors, social factors, economic factors, institutional factors, and psychological factors. While the main constraint in the IPM adoption including complexity of IPM technology, weak perception of IPM technology, labor intensive, easy access of pesticide, and lack awareness of pollution.

The findings generated recommendations for rice production policy measures that focused in four dimension including policy orientation by research and development on redesign IPM technology, implementation oriented by promotion IPM in the mass media, academic orientation by providing , and public orientation by concerning in quality and safety of product.

________________	________________________	__/__/_____
Student Signature	Thesis Advisor's Signature	

RINGKASAN

Factors Affecting Rice Farmer's Adoption In Integrated Pest Management Technology: A Study Of Chedi Hak Subdistrict, Ratchaburi Province, Dian Galuh Pratita, 111510601067, Program Studi Agribisnis, Jurusan Sosial Ekonomi Pertanian Fakultas Pertanian Universitas Jember.

Ketahanan pangan dan pertanian berkelanjutan meruapakan hal penting dalam perkembangan sektor pertanian di Thailand. Thailand dalam perkembangan sektor pertaniannya, telah mengkonsumsi pestisida dalam jumlah besar. Untuk mencapai kondisi pertanian berkelanjutan yang lebih baik, Thailand mencoba mengadopsi teknologi Pengendalian Hama Terpadu atau IPM (*Integrated Pest Management*). Penelitian ini berfokus pada analisa dan identifikasi faktor-faktor yang mempengaruhi adopsi Pengendalian Hama Terpadu. Fokus utama dalam karya ilmiah ini adalah untuk memberikan sejumlah implikasi kebijakan dan saran untuk peningkatan produktivitas, penghasilan, peningkatan kualitas hidup petani padi dalam rangka pencapaian swasembada beras di Thailand.

Data dalam penelitian ini berasal dari satu petani sukses di Kecamatan Chedi Hak, Kabupaten Mueang Ratchaburi, Provinsi Ratchaburi. Sample dipilih menggunakan metode *purposive sampling* (*jugmental sampling*) mencakup petani, penyuluh pertanian, dan stakeholder. Survey item yang digunakan dalam penelitian ini adalah wawancara mendalam dalam bentuk SWOT dan matriks. Analisis deskriptif kuantitatif digunakan untuk menjelaskan kondisi ekologi, latar belakang petani, faktor-faktor yang mempengaruhi adopsi PHT, dan KAP dari PHT.

Hasil dari penelitian ini ditemukan bahwa petani tersebut memliki tingkat penerimaan yang tinggi dari model PHT (*prevention, monitoring, identification, pest action, and evaluation*). Terdapat beberapa faktor yang mempengaruhi adopsi PHT meliputi, latar belakang, penggunaan faktor input, faktor fisik, faktor biologi, faktor sosial, faktor ekonomi, faktor institusi atau kelembagaan, dan psychological faktor. Sedangkan masalah utama dalam adopsi PHT adalah kerumitan PHT, rendahnya harapan petani dalam PHT, tingginya penggunaan tenaga kerja,

mudahnya akses terhadap pestisida, dan kurangnya kepedulian terhadap polusi. Berdasarkan hasil yang diperoleh terdapat beberapa rekomendasi yang meliputi empat dimensi meliputi dimensi kebijakan, dimensi implementasi, dimensi pendidikan, dan dimensi kemasyarakatan.

ACKNOWLEDGEMENT

All praises to Allah for the strengths and blessing in completing this undergraduate entitled “Factors Affecting Rice Farmer’s Adoption in Integrated Pest Management Technology: A Case Study of Ratchaburi Province, Ratchaburi Province”. This research has been done as one of completing study in Undergraduate Program in Agribusiness Study Program, Faculty of Agriculture, Jember University. I would like to thanks and express my appreciation to;

1. Dr. Ir. Jani Januar, MT., as the Dean on Faculty of Agriculture, Jember University.
2. Dr. Ir. Joni Murti Mulyo Aji, M. Rur. M., as the Head of Agribusiness Study Program, Faculty of Agriculture, Jember University.
3. Ir. Anik Suwandari, MP., and Dr. Ir. Joni Murti Mulyo Aji, M.Rur. M., as The Research Co-Advisor, Ebban Baus Kuntadi, SP., MP., and Dr. Triana Dewi Hapsari, SP., MP., as examine committee for their kindness and suggestion on this undergraduate thesis.
4. Ir. Anik Suwandari, MP., as academic advisor for her kindness and motivation during my study.
5. Beloved parent, for my dad: Alm. Irfan Boedi Setiawan and my mom: Dr. Asrumi, and my younger brother: Firnanda Pulung Wibowo for all of their motivation, support, and encourage with their best wishes.
6. Associate Prof. Am-On Aungsuratana as The Research Supervisor and Dr. Rapee Dokmaithes as The Research Co-Advisor in Agricultural Extension and Communication Department, Faculty of Agriculture, Kasetsart University, for their excellent guidance, caring, patience, and providing me with an excellent atmosphere for doing research in Thailand.
7. All member of Agricultural Economic Laboratory in Faculty of Agriculture University of Jember including Loriza Gevi Anggasasi, Nila Wahyu Permana, Yuanita Ayu Wulandari, Resi Ayudya, Desinta Eka Pramesti, Nadia Oktalindyah Johan, Elvan Chandra Widiayanto, and Rizki Yanuarti for their kindness and best suggestions.

8. My best friends ; Dinda Dewanti, Maya Dewi Maharani, Loriza Gevi Anggasasi, Akhmad Wasis Brillianto, Andika Lussy Ayu Wulandari, Puji Agustin, Sheilla Anandyta Ramadhanti, Rahmat Budiarto, Amirudin Akhmad Fauzi, Argya Narendra, and Dimas Handi Putranto for supporting me in this research.
9. The extension officer (Pi Mew) and the progressive farmer (Ajharn Walit) as the respondent for their fully support and cooperating during data collections.
10. All students of Agribusiness Study Program’” 11 (Agb”11) for their support and encouragement

The author realizes that this research is far from perfect. Therefore, it needs some suggestions and recommendation. Hopefully this research can be useful for readers.

Jember, June 2015 Author

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1.
INTRODUCTION

1.1 Statement of the Problems

Food and Agricultural Organization [FAO] (2013c, 2013f) reported that rice is the biggest commodity in terms of production in the world. In 2009, world rice production recorded 456,8 million tons of milled rice and in 2011 increase to 481,2 million tons. These rice production based on 163 million ha area harvest in the world. The average of world yield is currently 4.8 tons per ha. It has increase from 2009 respectively. Asia is the biggest region in rice production, accounting for 435 million tons of milled rice production in 2011. It based on 145.2 million hectares rice harvest area. Rice is an important commodity in the world, because of rice is a major food staple and a mainstay for the rural population and for household food security. Asia have an important roles in world rice condition, because of 90% of world rice production comes from Asia. Rice is considered as a “strategic “ commodity in many countries both developed and developing and has consequently remained subject to a wide range of government controls and interventions.

Global rice consumption in 2011 is around of 449,7 million tons of milled rice. Asia is not only as the biggest producer in rice commodity in the world but also as the biggest consumer in rice. In 2009, total consumption of milled rice in Asia around of 397 million tons with 77 kg per capita. Based on International Grain Council (2013), shows that there was increasing on trend both of rice production and rice consumption in the world. It is predicted start from 2016, world rice consumption is more higher than world rice production. It is mean that demand of rice is higher than supply. It can affected in sustainable condition. Sustainable of food become the major focus in agricultural development because of the main function of rice as a major staple food in the world.

Thailand is agricultural country, with total population growth up to 0,3 % until 2012. The increasing of total population not related with total employment in agricultural sector. In 2008 total employment in agriculture about 43% of total population, in 2009 it decreased became 39% respectively. Rice is the most important staple crop for Thailand because 65 % of farmer belonging in rice farming. Rice is the important commodity in Thailand, not only as a staple food but also as export commodity (FAO, 2013d).

International Rice Research Institution [IRRI] (2013) reported that there was increasing in Thailand milled rice production from 2000 until 2011. In 2000 Thailand rice milled production was around of 17.229,27 tons and increased 24.2 % in 2009 (21.410,73 tons). In addition, consumption of milled rice has increased to approximately 24.3 % in 2009 from 10.436 tons in 2000 to 12.969 tons. It can be seen that percentage of increasing in production and consumption is equal.

Increasing in rice consumption and rice production become the factor of increasing in pesticides use in Thailand. Mostly pesticides in Thailand is imported product, and increased every year. Paneat (2012) pointed that total imported pesticides in Thailand increased every year. In 2000, quantity of pesticides import less of 40.000 tons, in 2010 quantity of pesticides import was 120.000 ton. It can be seen that Thailand's pesticides imports was extremely increase.

According to Tapintha (1998), pesticides (including insecticides, herbicides, and fungicides) are used widely in modern agriculture. These chemical compounds are used by farmers worldwide to protect crops from insects and mites, weeds and aquatic plants that clog irrigation systems, plant diseases (caused by fungi, bacteria, and viruses), nematodes, snails and slugs, rodents, and birds that consume enormous quantities of seed and grain. Pesticides have been used globally to minimize financial losses and maintain food supplies. Increasing in agricultural production become the main factor of increasing pesticide use.

Indiscriminate and excessive uses of pesticides are causing inexorable damage to health and environment. The dissemination of the input intensive technology package during the green revolution period failed to recognize the gravity of mishandling and intricate technology (APO, 2000). Increasing in pesticides use can be indicator of environmental pollution. Regarding the more awareness of food safety among environment and consumer, IPM become one of the advance technology that can provide this point. Kumari (2012) pointed that integrated pest management (IPM) is a systematic approach to pest management that focuses in minimize pest population below economic threshold level (ETL) or keep pest population at an acceptable level in some tactics. Tactics may include cultural, mechanical, biological, and chemical methods of pest management.

Ratchaburi is located 80 kilometers west of Bangkok. Ratchaburi is one province in central of Thailand. Agriculture become the main important of income source in Ratchaburi, which 41,4% of household incomes from agriculture sector. Total land holding in Ratchaburi is currently 21.592.365 rai or 3.454.778,4 ha, of which 39,6% (8.541.412 rai) is rice area. In 2003 rice production recorded 249.000 tons. Considering the use of pesticides, 75% reported using pesticides, of which 71,1 % used chemical pesticides, 5.3% using organic, and 1,3% using natural enemies (National Statistic Organization [NSO], 2003).

Adoption in IPM technologies cannot do in clearly, there are many factors that can affect the decision making of farmers to adopt or not. Therefore, this study focus on determinate factors that affecting rice farmers to adopt IPM technology in study area (Chedi Hak Sub District, Ratchaburi Province, Thailand). In order to form an appropriate strategy and recommendation for designing a model of IPM technology and to enhance adoption among farmers.

1.2 Research Questions

Based on the objective and problem statement, the research question for the study was developed as follow:

1. What kind of factors affecting farmer's adoption in IPM technology?
2. What are the appropriate measure to enhance farmer's capability on IPM technology?

1.3 Objectives of Study and Expected Results

1.3.1 Objectives of Study

1. To identify factors affecting farmer's adoption in IPM Technology namely;
   a. to obtain and describe the study areas and its vicinity.
   b. to obtain and describe basic personal and socio economic background of rice cultivator.
   c. to determine rate of farmers knowledge, attitudes, and practices in IPM technology.
   d. to investigate and determine factors affecting rice farmer's adoption in IPM technology.
2. To assess constraints and recommendation in adoption in IPM technology in study area.

1.3.2 Expected Results

This research has been performed, mainly focuses on analyzing and identifying factors affecting adoption of technology dissemination (IPM). The main focus in this investigation is to determine factors affecting rice farmers in IPM technology adoption. The main idea of research is to deliver a number of possible policy implications and recommendation for productivity improvement, income generation and higher standard of living of rice cultivators towards self sufficiency and sustainability of rice in Thailand.

CHAPTER 2.
LITERATURE REVIEW

2.1 Sustainable Agriculture

2.1.1 The Concept of Food Security

World Health Organization [WHO] (2010a) defined food security as condition when all people at all times, have access to sufficient, safe, nutritious food to maintain a healthy and active life. Commonly, the concept of food security is defined as including both physical and economic access to food that meets people's dietary needs as well as their food preferences. Food security is built on three pillars; food availability (sufficient quantities of food available on a consistent basis), food access (having sufficient resources to obtain appropriate foods for a nutritious diet), and food use (appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation).

In addition, United Nations Development Program (UNDP) (2009), explained dimensions of food security that can be split into four components: availability, access, utilization and stability.

1. Food availability: the availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid).

2. Food access: access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet. Entitlements are defined as the set of all commodity bundles over which a person can establish command given the legal, political, economic and social arrangements of the community in which they live (including traditional rights such as access to common resources).

3. Utilization: utilization of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well being where all physiological needs are met. This brings out the importance of non-food inputs in food security.

4. Stability: to be food secure, a population, household or individual must have access for adequate food at all times. They should not risk losing access to food as a consequence of sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food insecurity). The concept of stability can therefore refer to both the availability and access dimensions of food security.

Nellman (2009) explained that there are seven option for improving food security. One of these is support farmers in developing diversified and resilient ecoagriculture systems that provide critical ecosystem services (water supply and regulation, habitat for wild plants and animals, genetic diversity, pollination, pest control, climate regulation), as well as adequate food to meet local and consumer needs. This includes managing extreme rainfall and using inter-cropping to minimize dependency on external inputs like artificial fertilizers, pesticides and blue irrigation water and the development, implementation and support of green technology also for small-scale farmers.

2.1.2 The Concept of Sustainable Agriculture

According to FFTC (1992), sustainable agriculture is ecologically stable, conserving the natural resources base to provide for the needs of future generations. Instead of depending on purchased inputs such as chemical fertilizers and pesticides, the sustainable farm makes maximum use of renewable resources that produced on the farm itself. However sustainable agriculture does not mean a return to traditional farming.

United State Department of Agriculture USDA (1999) defined sustainable agriculture means an integrated system of plant and animal production practices having a sit-specific application that over the long terms will; satisfy human food and fiber needs, enhance environmental quality and the natural resource base upon which the agricultural economy depends, make the most efficient use of non renewable resources and on farm resources and integrate where appropriate, sustain the economic viability of farm operations, and enhance the quality of life for farmers and society as a whole.

In addition, Kumar (2006) defined that a sustainable farming system is a system in which natural resources are managed so that potential yield and the stock of natural resources do not decline over time.

SAI (2010) state that sustainable agriculture is the efficient production of safe, high quality agricultural products, in a way that protects and improves the natural environment, the social and economic conditions of farmers, their employees and local communities, and safeguards the health and welfare of all farmed species. Therefore there are three principle of sustainable agriculture: economic, social, and environment.

Kentucky University (2012) mentioned that sustainable agriculture can be broken into three components: economic, environmental, and social. (1) Economic profitability can be define that a farm must be economically viable. Fertilizer and pesticide cost are generally reduced on a sustainably managed farm. (2) Environmental sustainability concerns is the central of sustainable agriculture. Sustainable agriculture is frequently described as: ecologically sound practices that have little to negative effect on natural ecosystem. Sustainable agriculture also seeks to have a positive impact on natural resources and wildlife. Renewable natural resources are protected, recycled, and even replaced in sustainable systems. A key to successful sustainable production is healthy soil. Insect, disease, and weeds are managed, rather than controlled, in sustainable systems. The goal is not necessarily the complete elimination of pest but rather to manage pests and diseases to keep crop damage within acceptable economic levels. Sustainable pest management practices emphasizes prevention through good production and cultural methods. (3) Social sustainability relates to the quality of life for those who work and live on the farm, as well as those in the local community. Fair treatment of workers, positive farm family relationships, personal interactions with consumers and choosing to purchase supplies locally.

Based on Buddhaboon (2013), sustainable rice cultivation means rice cultivation system can be maintained to produce grain yield for world population consumption indefinitely. Sustainable rice cultivation also refers to sustainable of social (farmer to consumer), sustainable of environment (climate, soil, water), sustainable of economic (equitability of among beneficially).

2.2 Environmental Degradation

2.2.1 The Concept of Environmental Degradation

According to Panayotou (1993), the terms " environment" refers to both the quantity and quality of natural resources, renewable and nonrenewable. It is also includes the around of environment ,which consists of the landscape, water, air, and the atmosphere and constitutes and essential element of the quality of life. The environment is a critical determsinant of the quantity, quality, and sustainability of human activities and life in general. In addition, environmental degradation is the reduction of the environment in quantity and its deterioration in quality. Environmental pollution is classic case of a public externalities. It originates from variety of source including wastes from agricultural activities such as runoff of excess pesticides and fertilizer.

FAO (2007) indicate that agriculture is often responsible for environmental degradation, such as non-sustainable food production, poor fuel use, natural resource depletion and habitat exploitation. At the same time farmers should be considered as key players in stopping degradation of vital ecosystems. It needs the political will to reverse the degradation of ecosystems through the change of agricultural policies, institutions and practices. Agriculture has to be at the centre stage if we want to preserve an ecological balance on which current and future generations.

Nelleman (2009) state that environmental degradation due to unsustainable human practices and activities endanger the entire production platform of the planet. Land degradation and conversion of crop land for non food production including bio-fuels, cotton and others are major threats that could reduce the available cropland by 8-20% by 2050. Species infestations of pathogens, weeds and insects, combined with water scarcity from overuse and te melting of the Himalayas glaciers.

2.2.2 Environmental Impact of Pesticides Use

Tapintha (1998) pointed out that resulting from heavy application, pesticides residues have been found in soil, water, and agricultural product in Thailand. Residues in water such as lakes, streams, and rivers are polluted by many kinds of pesticides. Pesticides also directly travel to soil during spraying, normally in the upper layer, pesticides concentration levels in soil are more higher than in water. Pesticides residues also on agricultural product. It can be transferred directly to human.

In addition, Ping (2004), reported that The Kingdom of Thailand, has faced one of increasingly serious environmental degradation. The problem is intensive farming (pesticide, herbicide, fertilizer, and irrigation). Intensive farming in Northern Thailand is a reality, and this system has been seen as a problem to the environment mainly because of its amount of chemicals used. Farmers use more and more pesticide, herbicide, and fertilizer which through irrigation system into soil, rivers and even groundwater. Intensive rice farming make a heavy pollution with nitrates. Dangerous pesticides applied in farms find their way into rivers and groundwater, and into foods sold in Thai markets.

Greenpeace (2008) reported that around 91% freshwater in Thailand is used for irrigation for the almost 5 million hectares of irrigated agriculture. Due to the high use of agrochemicals in Thailand in the last years, there is a high potential for pollution of water sources through irrigation runoff, return flows, and infiltration. From 1999 to 2001 a survey of three major rivers along paddy fields area includes : Thachin river in Supanburi and Nakhonpathom, the Chao Phraya river in Pathumtani and Nontaburi, and the Bangpakong river in Chachengsao.

WHO (2010b) defined pesticide in any substance or mixture of substance or microorganism including viruses, intended for repelling destroying or controlling any pest, including vectors of human or animal disease, nuisance pests, unwanted species of plants or animal causing harm during production, processing, storage, transport or marketing of food, agricultural commodities.

FAO (2013b) mentioned that insecticides, herbicides and fungicides are also applied heavily in many developed and developing countries, polluting fresh water with carcinogens and other poisons that affect humans and many forms of wildlife. Pesticides also reduce biodiversity by destroying weeds and insects and hence the food species of birds and other animals. In developed countries, pesticide use is increasingly restrained by regulations and taxes. In addition, pesticide use will be curbed by the growing demand for organic crops, produced without chemical inputs. The future is likely to see increasing use of appropriate and proper pesticides, resistant crop varieties and ecological methods of pest control (IPM).

2.3 Integrated Pest Management (IPM)

2.3.1 Definition of Integrated Pest Management (IPM)

According to Dagupsta (2004), IPM is intended to reduce ecological and health damage from chemical pesticides by using natural parasites and predators to control pest populations. Since chemical pesticides are expensive for poor farmers, IPM offers the prospect of lower production costs and higher profitability. However, adoption of IPM may reduce profitability if it also lowers than productivity, or induces more intensive use of other production factors. On the other hand, IPM may actually promote more productive farming by encouraging more skillful use of available resources.

Palis (2006) state that IPM aims to reduce pesticide use while at the same time sustaining food production, protecting the environment, and ensuring the good health of farmers, their families, and consumers. IPM is an agricultural technology that has been promoted since the 1970s but did not gain widespread adoption until 1990s, when it was disseminated through the farmer field school (FFS).

According to Borkhani (2010) and Rahman (2012), IPM is an effective and environmentally friendly approach in pest management system. It combines of practices including biological, chemical, cultural, and other practices. IPM can manage pest population to avoid economic damage and minimize adverse side effect. IPM enables farmers to reduce their reliance on pesticides while maintain or increasing yields, crop quality and profitability.

FAO (2013a) defined IPM as the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified (ETL) and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.

2.3.2 The Concept of IPM Technology

Environmental Protection Agency [EPA] (2012) point out that IPM is not a single pest control method but, rather, a series of pest management evaluations, decisions, and controls. In practicing IPM, growers who are aware of the potential for pest infestation follow a four-tiered approach. The four approaches include:

1. Action Thresholds: before taking any pest control action, IPM first sets an action threshold, a point at which pest populations or environmental conditions indicate that pest control action must be taken. Sighting a single pest does not always mean control is needed. The level at which pests will become an economic threat is critical to guide future pest control decisions.

2. Monitoring and Identifying Pests: Not all insects, weeds, and other living organisms require control. Many organisms are innocuous, and some are even beneficial. IPM programs work to monitor for pests and identify them accurately, so that appropriate control decisions can be made in conjunction with action thresholds. This monitoring and identification removes the possibility that pesticides will be used when they are not really needed or that the wrong kind of pesticide will be used.

3. Prevention: As a first line of pest control, IPM programs work to manage the crop, lawn, or indoor space to prevent pests from becoming a threat. In an agricultural crop, this may mean using cultural methods, such as rotating between different crops, selecting pest resistant varieties, and planting pest free rootstock. These control methods can be very effective and cost efficient and present little or no risk to people or the environment.

4. Control: Once monitoring, identification, and action thresholds indicate that pest control is required, and preventive methods are no longer effective or available, IPM programs then evaluate the proper control method both for effectiveness and risk. Effective, less risky pest controls are chosen first, including highly targeted chemicals, such as pheromones to disrupt pest mating, or mechanical control, such as trapping or weeding. If further monitoring, identifications, and action thresholds indicate that less risky controls are not working, then additional pest control methods would be employed, such as targeted spraying of pesticides. Broadcast spraying of non-specific pesticides is a last resort.

In addition, Nevada University (2013) point out that there are some principles of integrated pest management;

1. Identify pest: the cause of the problem and associated plant or animal species must be correctly identified.

2. Establish monitoring guidelines for each species: routine monitoring of both pests and natural enemies also known as beneficial organism, is an important part of IPM.

3. Establish an action threshold for the pest: Fundamental principle of IPM is that a certain number of individual pests can and should be tolerated. Farmers start by determining whether the pest will cause unacceptable damage to the value of their crop. The economic threshold is defined as the pest population level that produces damage equal to the cost of preventing damage by controlling the pest. The threshold is the pest density or population level, at which management should occur.

4. Evaluate and implement control tactics: Select tactics that will be most effective, economical and have least impact on non target species and the environment. Select methods that will impact beneficial organisms as little as possible while suppressing the pest. If a pesticide is one of the selected management tools, beneficial enemies (usually insects) will likely also be killed.

2.3.3 Principles of IPM Technology

According to Word Bank (2005), there are some principles of IPM technology process;

1. Grow a healthy crop: focus in this principle is on cultural practices aimed at keeping the crop healthy. These includes: selection varieties that are resistant or tolerant to pest, attention to soil, nutrient, and water management.

2. Manage the agro-ecosystem: it is such a way that pests remain below economic damaging levels, rather than attempt to eradicate the pest. Prevention of pest build up and encouragement of natural mortality of the pest is the first line of defense to protect the crop. Non-chemical practices are used to make the field and the crop inhospitable to the insect pest species and hospitable to their natural enemies, and to prevent conditions favorable to the build up of weeds and diseases.

3. Decisions to apply external inputs as supplementary controls are made locally, are based on monitoring of pest incidence and are site-specific: external inputs may include predators or parasites (bio-control), labor to remove the pest manually, pest attracting lures, pest traps, or pesticides. Pesticides are generally used if economically viable non-chemical pest control inputs are not available or failed to control the pest. They are applied only when field monitoring shows that a pest population has reached a level that is likely to cause significant economic damage and the use of pesticides is cost-effective in terms of having a positive effect on net farm profits. Selection of products and application techniques should aim to minimize adverse effects on non-target species, people and the environment.

2.3.4 The Economic Injury Level (EIL)

According to Buhler (1997), Economic Injury Level or called damage threshold is the lowest population density that will cause economic damage, economic damage being the amount of injury which will justify the cost of artificial control measures. Figure 2.1 shows the concept of economic injury level. A certain level of crop loss is economically acceptable if the value of what is lost is less than the cost of control.

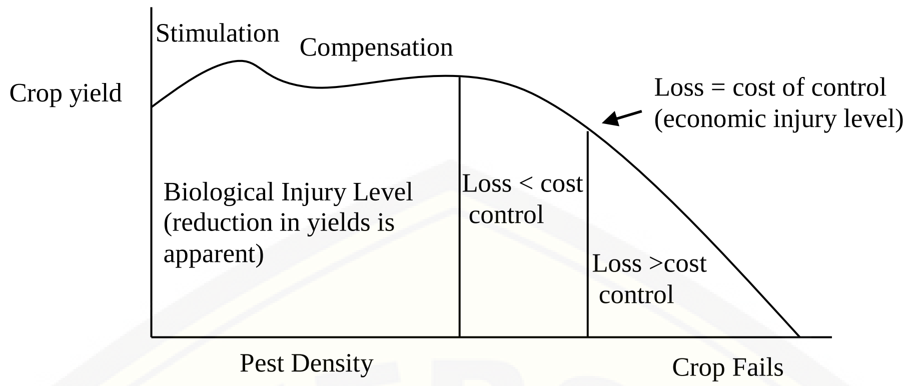

Figure 1.1 The economic injury concept

Source: Buhler (1997)

2.3.5 The Economic Threshold (ET)

According to Norton (1993), where the state of nature, in this case the level of pest attack, can be monitored in some way before a decision has to made, the decision maker can choose that action most appropriate to the monitored level of attack. This is the basis for the economic threshold approach, and we can express the decision rule in economic terms, as follows: "when the level of attach is such that the benefit resulting from treatment is greater than the cost of treatment, then treatment should be applied". This can be expressed in more formal terms, as follows:

$$\text{The benefit of control} = \theta\ PDK$$

Where θ = the level of pest attack (such as the number of insects per plant, the number of weeds per m2, or the % infected plants); P=the price of the crop or livestock product, expressed in $ per ton; D= the damage coefficient, expressed as the amount of loss per hectare or the reduction in price caused per unit of pest attack associated with a particular control action. It becomes profitable to apply the nematicide when

$$PD\theta K \geq C$$

At the economic threshold level of attack, the benefit of a particular control action (as defined above) just equals the cost of this control action I, expressed in $ per hectare. That is, where:

$$\theta^*PDK=C$$

Solving for θ*, the economic threshold level of attack:

$$\theta^*=C/(PDK)$$

While this break even, economic threshold, as defined above, can be determined for many pest problems having a linear damage relationship (Figure 2.2a), for situations where a threshold relationship occurs, the economic threshold has to be redefined as :

$$\theta^* = T + [C/(PDK)]$$

where T is the damage threshold, that is, the maximum level of pest attack below which losses do not occur (Figure 2.2 b)

These economic threshold formulae can be useful in obtaining a rough idea of the influence of the different variables on the break-even of attack for particular control actions. However, for practical decision making, an action threshold needs to be determined. The economic threshold will provide some useful baseline information but to determine an appropriate action threshold, as a practical decision rule, a number of additional factors will also need to be taken into account, including:

1. Empirical, trial and error experience
2. The dynamics of the pest population, particularly for endogenous pests, that can build up over time. This raises questions concerning the optimal level and timing of control rather than the much simpler break-even criterion of the economic threshold
3. The risk attitude of the farmer, which will influence the margin for error that will need to be included to make the action threshold acceptable.

As stated above, the economic or action threshold may be an appropriate decision rule where there is available information on the level of pest attack. However, in many if not most situations, knowledge of the state of nature (pest attack) is not available at the time a decision has to be made. For such situations, the pay off matrix is more appropriate means of representing the decision problem.

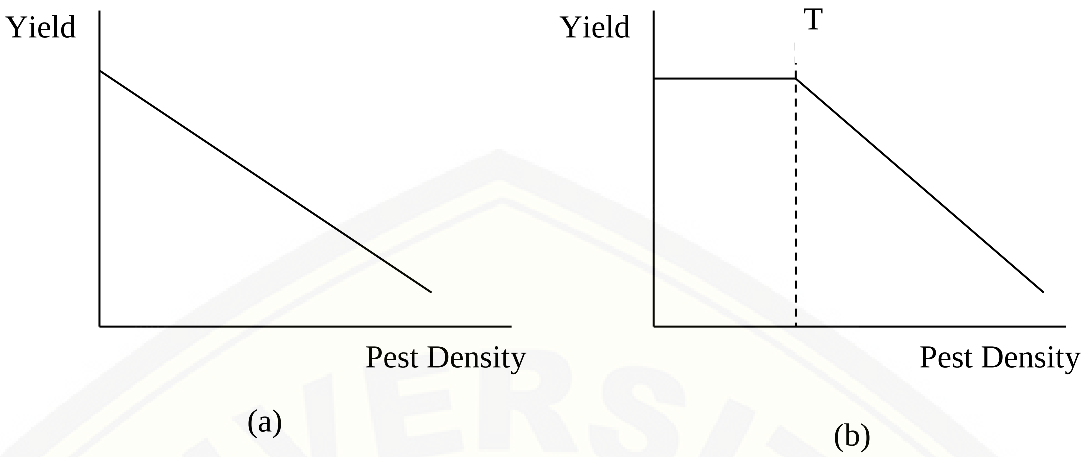

Figure 2.2 Linear and threshold damage relationship

Source: Norton (1993)

The damage relationship describes the level of loss associated with different levels of pest attack. Although this relationship is often non linear, for decision making purposes it is only necessary to distinguish two forms of damage relationship. A linear damage relationship (Figure 2.2a) is associated with pest that are vectors of disease, where the crop is unable to compensate, or where the major concern is the presence of during a pest causing quarantine or cosmetic damage. In this case, the slope of the damage relationship is the critical factor determining the degree of control required.

The second relationship, threshold damage, has the form shown in Figure 2.2b. there is a level of tolerance associated with low levels of pest attack, or compensation to damage occurs, particularly where this damage is to part as of the plant which are not part of the marketable yield, such as leaves and roots of fruit crop.

2.3.6 Technique of Integrated Pest Management (IPM)

In terms of IPM methods, IRRI (2009), point out that components of IPM practices include:

1. **Pest-resistant crop varieties**: this is the easiest, effective, compatible, economical and practical method among all the pest management practices. Such crop varieties are extensively used in pest prone areas as a principal method of IPM or as a supplement to other pest management strategies.

2. **Cultural methods**: these refer to good agronomic practices that enhance the crop productivity and also suppress the pest population. The cultural practices which are commonly used for rice system are;
    a. Proper sanitation: timely removal of weed to reduce the pest survival and reduce the chance or any carryover of the pest
    b. Proper water management timely irrigation and good drainage system is required to control plant hoppers.
    c. Proper spacing: provision of alley ways of 30 cm. Width after 2-3 m bed planting particularly in the white backed plat hopper and brown plant hopper prone area, proves helpful
    d. Time planting: timely and synchronous planting can reduce the occurrence of insect pests like yellow stem borer.
    e. Balanced fertilizer: judicious and optimum dose of nitrogen and other fertilizer based on soil testing is essential. Split dosage of nitrogen can also reduce the risk of gall midge, leaf hopper, brown plant hopper, etc.
3. **Biological control**: biological control is the mainstay of the IPM strategy. Out of 100 phytophagus insects having potential of becoming pests, only a few attain the pest status while the rest are kept under check by their natural enemies. Even those which attain the pest status have biological agents like predators, parasites ,and pathogens which decrease their population in the rice ecosystem, it is very important to conserve the natural enemies of pest in the field. Avoid the use of broad spectrum pesticides when natural enemies are abundant.
4. **Chemical control**: application of pesticides is no doubt one of the quickest and sometimes the only solution for the sudden outbreak of pests, specially insect pests. Their application draws the farmer to quick and visible action.

In addition, NPIC (2000) defined there are some methods in IPM technology; cultural methods, physical methods, biological methods;

1. Cultural methods: tolerant varieties, putting the right plant in the right place (place plants in an environment where they will grow well), starting with healthy transplants, keeping plants healthy, keeping your area clean (proper sanitation can prevent many pest problems), rotating annual plants, and companion planting and intercropping (companion planting involves growing two or more specific types of plant together in the hope that the combination will discourage disease and insect pests).

2. Physical methods: hand picking, spraying in water, pruning, and using barriers (row covers, plant cages, plant collars, sticky barriers, metal barriers).

3. Biological methods: beneficial insects, protecting beneficial insects, and creating habitat for beneficial insects.

4. Chemical methods: choose the chemical that meets the following criteria; least harmful to the environment, least toxic to the applicator, most specific to the pest, and least harmful to beneficial organisms.

2.3.7 IPM in Thailand

According to The Thai Government has been training farmers in IPM. This training helps farmers to grow their crops with less pesticide. The first step in IPM is to learn how to grow a healthy crop. Strong plants are less likely to suffer from pests. Farmers can grow a healthy crop by selecting a suitable variety, providing the right fertilizer, making sure the plants get water when it is needed. If a healthy crop is attacked by a few pests, it will recover without any difference to the yield. The next step in IPM is to recognise the types of insects that are living in the field. Some insects are harmful to the crop but many of them are useful. One of the things that useful insects do is to kill pests. If farmers can see plenty of useful insects in their field, they don’t need to spray with pesticides. If they did spray, they would kill both types of insect, and in most cases the pests would come back to the field quicker than the useful insects. Integrated Pest Management is different from organic production. IPM farmers sometimes use pesticides, but they have been trained to carefully decide if chemicals are really needed and to select chemicals that are less harmful to human health and the environment (for example botanical pesticides or bio-pesticides).Thousands of farmers have completed IPM training in Thailand. The training has been organised by both the Ministry of Agriculture and Cooperatives and the Ministry of Education. Support has been provided by foreign agencies such as the Danish

Government (DANIDA), the German Government (GTZ) and the Food and Agriculture Organisation of the United Nations.

According to APO (2000), the IPM strategy has been recommended in the policy guideline of the DOA since 1985. The programs are more focused on progressive agricultural zones. The Ministry of Agriculture and Cooperatives through DOA and DOAE has established IPM demonstration plots in selected crops, namely: rice, cotton, sugarcane and vegetables (crucifer and onion) and extended to 18 economical crops since 1995. From, 1995 to present, under the policy guideline of Ministry of Agriculture and Cooperatives, there has been research and development in minimizing the pesticide usage in agriculture food crops production in order to reduce environmental pollution, better health, better life and sustainable agriculture. IPM is one of the strategies to solve core problems and reach the target.

FAO (2005) reported that IPM in Thailand has been put in the nation social and economic development plan since the seventh plan until present . IPM as well as good agricultural practice (GAP) is the main activity in the Food Safety Programme set by Ministry of Agriculture and Co-operatives starting from 2004. IPM is a collaborative project of the Department of Agriculture, Department of Agricultural Extension (DOAE), the Royal Project and DANIDA.

Fuchs (2007) explained IPM by definition is a challenging subject due to its complexity and its application to commercial agriculture, which requires active management. Proper implementation of IPM requires that those who wish to implement it have an understanding of ecological principles and interactions involved in crop management. Successful implementation generally occurs only when technology is developed through research demonstrated in the location in which it will be used and an educational process has been conducted to make end users aware of the technology, its benefit and how it fits into a production system.

Praneetvatakul (2013) pointed that the introduction of Farmer Field Schools (FFS) in Thailand in 1999 marked a turning point in terms of the government’s attitude towards pesticides. After the concept was endorsed by the King of Thailand, FFS were rapidly implemented in rice growing communities across the country and the USD 7 million outbreak budget was cancelled with 15% of it reallocated to FFS training. However, the promotion of FFS and integrated pest management (IPM) was not sustained, and although the concept still appears in government policies, support for it is currently very low.

In the agricultural sector, adoption of advanced technique or technology may take various forms such as using a new variety, changing the farming process, altering resource inputs, combining different farming practices and so on (Ellis in Huy, 1993). Chi (2008) said that the advantages of IPM included input cost reduction (saving from less seed and pesticide use), benefit increase, and environmental protection. Rice IPM strategy gives high profit to farmer and minimize the bad effects of chemicals (FAO, 1997 in Bandara 1999).

2.3.8 Factor adoption in Integrated Pest Management (IPM) Technology

A variety of studies are aimed at establishing factors underlying adoption of technology. Some studies classify factor of adoption into some categories; farm characteristic, farmer characteristic, institutional characteristic, exogenous factors, and characteristic of innovation. In terms of technology dissemination, Palis (2006) defined that technology adoption in agriculture has often been problematic. Although various agricultural technologies have been developed over the past half century, many can be found only in scientific journals and are not being practiced by their target users. Integrated pest management is an agricultural technology that has been promoted since the 1970s, but did not gain widespread adoption until the 1990s when it was disseminated through the farmer field school (FFS). IPM aims to reduce pesticide use while at the same time sustaining food production, protecting the environment and ensuring the good health of farmers, their families, and consumers. Bad perception become the most factor why farmer did not want to adopt new technology (general believe among farmer that insects is harmful). Attending in FFS can decrease the bad perception in participate (farmers) and decrease application of chemical insecticides. FFS needs to consider the cultural understandings, the shared norms and values, and the cultural history of the target population in order to achieve success and ultimately the widespread adoption of IPM.

According to Bonabana (2002), factor affecting of adoption IPM technology includes; economic factors (include farm size, cost of technology, level of expected benefit, and off farm hours), social factor (age of adopter, education, and gender concern), and institutional factors (information and extension contact).

Singh (2008) indicated that farmer's characteristics such as age, education, knowledge regarding negative externalities of pesticide use; perception regarding expected yield losses due to pests if pesticides not used; institutional factors such as membership in farmers club; farm size and frequency of meeting with extension personnel have significant effect in adoption behavior in IPM technology. Formal training of farmers on IPM technology was positive and significant in paddy farmers. Farmer who participated in self help groups and owned smallholdings were more likely to adopt IPM practices.

Veisi (2012) found that there are some factor of adoption behavior of IPM technology; exogenous factors (external factor, access of information, access of input, attitude of reference group), farm characteristic (farm size, soil quality, mechanization, number of plots, and labor use), farmer characteristics (age, education, experience, knowledge, attitude, spiritual and religion), and characteristics of innovation (feasibility of IPM practices).

Borkhani (2013), point out that there was positive and significant correlation between IPM technologies adoption and variables including participation in FFS programs, opinion of the leader, participation in extension-education activities, and participation in local association. It shows the important role of agricultural extension agents which can affect paddy farmer's perception and behavior to adopt and apply IPM technologies.

2.3.9 Constraints in Adoption IPM Technology

According to Govind (2004), there are some constraint in adoption IPM technology in India among IPM farmer and Non IPM farmer ; (a) bio physical constraints (lack of assured irrigation, inadequate of inputs, labor scarcity , pest and disease), (b) communication constraints (difficult in remembering method, lack of persuasion by extension agent, inability to understand details given by change agents), (c) personal constraints (lack of knowledge to identify pests and disease, difficult in calculate dosage, poor education in standard of IPM), (d) socio economic constraints (high of cost input, lack of economical support), and (e) technological constraints (difficult to apply biological method).

Chi (2008), point out that the main reasons of non adoption of IPM included weak perceptions of IPM and low education of farmers, weak teaching capacity and limited knowledge of extension staff, not well organization, and management of extension programs, limitation of concrete conditions of local area and fund.

Ofuoku (2009), pointed out that low adoption in technology can caused by low contact with extension agent. In addition, Hoang (2006) explained that the reason of this problem are; the extension workers lack of knowledge and skills; extension worker cannot communicate effectively with targeted groups not only because they do not have much in common with them but also because they are not equipped with the necessary social skills, organizational know how, and knowledge of the communities they are dealing with.

Borkhani (2010), found that there are five barriers in adoption IPM; infrastructure barrier, management barriers, economic and social barriers, institutional barriers, and training – skill barriers. The researcher gave some solution to solve this problem; educate farmer about benefit of IPM, FFS is the best approaches which facilities awareness enhancement and participation of farmer, increasing plant protection clinic, and increasing center for presenting input for IPM.

Kumari (2012) and Rahman (2012) mentioned that some constraints in adoption of IPM are: cultural practices (lack of knowledge about balanced use fertilizers), adoption mechanical practices (labor intensive), adoption of biological and chemical practices (non availability of bio control agents and bio fertilizer) and social and economical constraints (small farm size). The most important problem that faced with farmer is because IPM very labor intensive. Knowledge and perception about the benefits of using IPM practices were largely lacking at the field level. As a result the farmers could not acquire enough confidence on IPM technologies.

2.3.10 The IPM Strategy

According to APO (2000), the extension of IPM in Thailand is progressing gradually but steadily. However the future view for IPM strategy in Thailand should focus on:

1. Pesticide management through safe, efficient, applicable, and economic use of pesticides.
2. Utilization of promising natural enemies such as egg parasitoids, larva parasitoids, predators and other parasitioids.
3. Maximum use of microbial insecticides.
4. Minimize use of chemical insecticides especially those with long residue effect development of practical treatment threshold.
5. Development of other alternative control methods.
6. Development and focus on application technique on different crops/areas.
7. All promising IPM packages will be tested in growing area and evaluated for its cost effectiveness, cost benefit, and impact to environment.
8. Crop yield by IPM farms will be checked, analyzed regularly for toxic residues by Agricultural Toxic Substance Division, DOA.

2.4 Rice Production in Thailand

Rice is an important commodity in Thailand. Over 80% of Thailand population eats rice as their meal, with annual per capita consumption around 133 kg per capita. The importance of rice in Thailand also can be seen on the Table below that Thailand is the Fourth biggest rice producer country in the world. In 2012 total production of rice in Thailand around 37.8 million tons based on 12,600,000 hectares. While China recorded as the first biggest country accounting for 204.2 tons which based on 30,557,000 hectare area. Thailand total area of rice was higher than Myanmar but lower than Indonesia. It can be seen that total area of rice farming was related with total production.

Table 2.1 The fifth biggest rice producer countries in 2012

Country	Area (Ha)	Production (Ton)
China	30,557,000	205,985,229
India	45,500,000	152,600,000
Indonesia	13,443,443	69,045,141
Thailand	12,600,000	37,800,000
Myanmar	8,150,000	33,000,000

Source: FAO (2013e)

Thailand export quantity of rice during 2007-2011 as shown in the Table below, it has dynamic performance, tends to increase. in the 2007, total export quantity of rice around 9.2 million tons which has increased around 16.5% to 10.7 million tons in 2011. Rice not only important for Thailand domestic consume, but also as export commodity.

Table 2.2 Thailand export quantity in 2007-2011

Unit: ton

Year	Quantity
2007	9,165,197
2008	10,186,678
2009	8,594,921
2010	8,905,751
2011	10,675,194

Source: FAO (2013)

Based on the Table 2.3 , total rice area in Thailand tends to increase during 2008 to 2012. During those time, total area was increased 18%, followed by increasing in the production and yield dramatically around 19% and 1.2% respectively. Increasing on the total area related with the increasing on the production, and makes the yield increase either.

Table 2.3 Thailand total area, production, and yield of rice in 2008-2012

Year	Area (Ha)	Production (ton)	Yield(Kg/ha)
2008	10,683,549	31,650,632	2,963
2009	11,141,447	32,116,063	2,883
2010	12,119,524	35,583,635	2,936
2011	11,944,320	34,588,355	2,896
2012	12,600,000	37,800,000	3,000

Source: OAE (2013, 2012, 2011)

According to the Table below, shows that Central plain region can produce major rice and second rice. In the last five years reported that major rice production has dynamic performance, tends to decrease. While second rice production tends to increase. In 2008, major rice production accounting for 5,585,555 tons, it decreased become 4,876,834 tons in 2011. While second rice production has increase from 4,481,873 tons in 2008 to 4,848,098 tons or increase around 8%.

Table 2.4 Central plain total rice production in 2008-2012

Unit: ton

Year	Production	
	Major	Second
2008	5,585,558	4,481,873
2009	5,631,360	3,807,506
2010	5,014,112	4,553,506
2011	4,876,834	5,164,356
2012	5,462,249	4,848,098

Source: OAE (2013, 2012, 2011)

Ratchaburi is one province in Central plain region which has potential in rice cultivation. Ratchaburi Province can produce major rice and second rice. during 2008 to 2912, both major rice production and second rice production has increased performance every period. Major rice production has increased 9%, while the second rice production has increased 17.7%. the increasing performance shows that Ratchaburi Province has developed on rice production sector.

Table 2.5 Ratchaburi total rice production in 2008-2012

Unit: ton

Year	Production	
	Major	Second
2008	206,559	193,882
2009	209,844	167,030
2010	219,682	189,623
2011	223,782	202,329
2012	225,357	228,182

Source: OAE (2013, 2012, 2011)

According to Sangbuapuan (2012), about 17 million out of 5.6 farm families in the country are engaged in rice farming. Thailand have two strategies plan in rice farming. The first rice strategic plan, 2007-2011, consisted of four components concerning production management and development of farmers, marketing management and product development, a drive for exports, and speedy and cost-effective product distribution. The second rice strategic plan to be implemented form 2011 to 2015, the Ministry of Agriculture and Cooperatives and the Ministry of Commerce will work more closely in order to link production and marketing for greater efficiency. Thailand has set a target to retain its rice planting area at 62 million rai or about 21 million acres, during the period of the country's second rice strategic. The second rice strategic plan has three components. First, research and development will be emphasized in order to produce rice varieties of good quality, which are able to resist rice crop insect and be adjustable to the changing climatic conditions. The second component is developing in rice production and products, with a target to increase productivity from 405 kilogram to 679 kilogram per rai, an increase about 10%. It seeks to lower production costs for farmers by 15% in 2015. Moreover this components also involves rearrangement in the rice farming system, efficient use of water, and development of the production system

Panuwet (2012) explained that as an agricultural country and one of the world major food exporters, Thailand relies heavily on the use of pesticides to protect crops and increase yield. The Office of Agricultural Economics (OAE, 2011) and The office of Agricultural Regulation (OAR, 2010) showed that pesticide use increase in the last decade with more than 100.000 tons of active ingredients being imported to Thailand.

According to Tapintha (1998), some approach in pesticides controls are legislation, regulation and education. There are four acts in law in regulation that have ever been done by Thailand Government ; the national environmental quality act, the factories act, the public health act, and the hazardous substance act, the regulate pesticides in Thailand. The national environmental quality act attempts to control pesticides residues by defined concentration standards. The factories act controls pesticide manufacturing and repackaging in factories. The hazardous substances act established in 1967 and amendment in 1973 and 1992 was enacted to control the import, export, manufacture, sales, storage, transport, and use of hazardous substance including pesticides.

In terms of pesticide use condition in Thailand, Praneetvatakul (2013) reported that Thailand has been progressively banning the most hazardous pesticides over recent years, and by 2011 had banned 98 active ingredients from being used in agriculture. Activists have also called for bans on pesticides such as carbofuran, methomyl and dicrotophos to be introduced, yet opponents of such bans have argued that these chemicals are essential for Thai agriculture and food security. In 2004, the Thai government tried to improve food quality and food safety by introducing a public standard for good agricultural practice, called Q-GAP. The standard has expanded rapidly with certificates issued to 212 thousands farms in 2010 alone. However, recent case studies suggests that the expansion of this scheme has been too rapid, as there is a general lack of compliance among farmers and an insignificant impact on both the average quantity and toxicity of pesticides used. On the supply side, the government has tried to rein in pesticide use through regulation. In 1992 the hazardous substance act harmonized the registration, licensing and monitoring of pesticides following the FAP Guidelines on the Registration and Control of Pesticides, however these stricter regulations have proved difficult to enforce because there are a large number of companies involved in the pesticide trade, there are millions of farmers using pesticides.

2.5 Adoption Innovation

2.5.1 Main Elements in the Diffusion of Innovations

Roger (2003), defined there are four main elements in diffusion of innovations. Firstly, innovation: An innovation is an idea, practice, or project that is perceived as new by an individual or other unit of adoption. An innovation may have been invented a long time ago, but if individuals perceive it as new, then it may still be an innovation for them. Secondly, communication channel: communication is a process in which participants create and share information with one another in order to reach a mutual understanding. This communication occurs through channel between source. A source is an individual or an institution that originates a message. A channel is the means by which a message gets from the source to the receiver. Diffusion is a specific kind of communication and includes these communication elements: an innovation, two individuals or other units of adoption, and communication channel. Thirdly, time: the time aspect is ignored in most behavioral research. The innovation diffusion process, adopter categorizes and rate of adoption all include a time dimension. The last one, social system: the social system defined as a set of interrelated units engaged in joint problem solving to accomplish a common goal.

2.5.2 The innovation-Decision Process

Rogers (2003) described the innovation-decision process as an information-seeking and information-processing activity. Figure 4 shows the five steps of innovation decision process: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation.

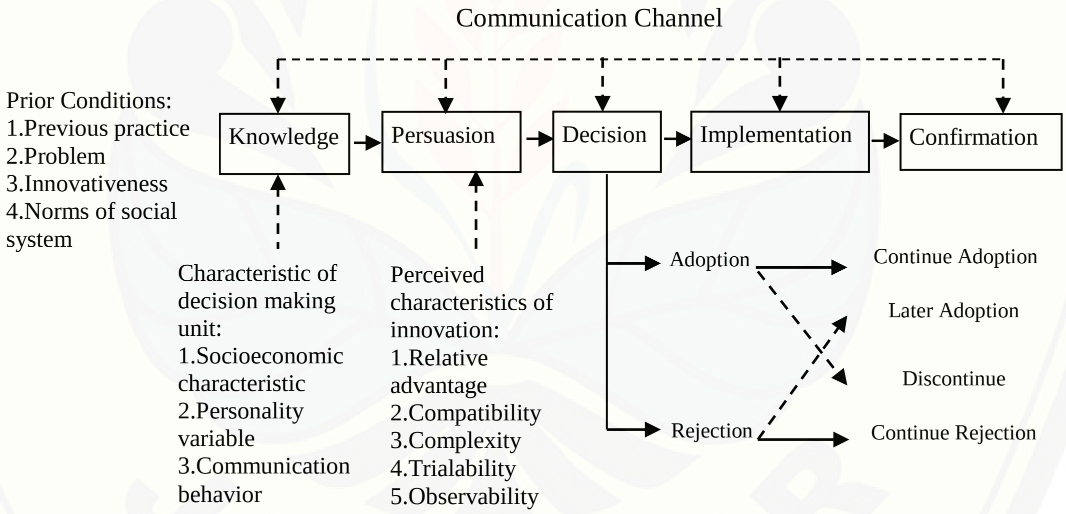

Figure 2.3 Model of five stages in the innovation decision process

Source: Roger (2003)

Firstly knowledge: in this step, an individual learns about the existence of innovation and seeks information about the innovation. “What?,” “how?,” and “why?” are the critical questions in the knowledge phase. Secondly, persuasion: the persuasion step occurs when the individual has a negative or positive attitude toward the innovation. Thirdly, decision: at the decision stage in the innovation-decision process, the individual chooses to adopt or reject the innovation. Adoption refers to full use of an innovation as the best course of action available and rejection means not to adopt an innovation. Fourthly, implementation: at the implementation stage, an innovation is put into practice. The last one, confirmation: decision must be reaffirmed or rejected.

According to Sanders (1966), there are some step in effecting change in adoption technology;

1. Initiation
2. Limitation
3. Diffusion
4. Organization and planning for action
5. Conducting the program
6. Evaluation

Initiation as the first step emphasized that someone comes up with a new idea or recognized a problem. The decision that this problem is important and that something need to be done about it is made by one or more persons. Involving "key" persons among the relevant social system at this point is necessary. The second step legitimation, refers to the process of getting approval of the idea from the power structure of the relevant social systems. It is important to identify who these influential people are and to make plans to get their support. Organizational and planning for action as the fourth stage implies that at some point, a group of "key" people and organization must be brought together to explore alternatives. They should look at relevant situational data and define groups and organizations whose support is needed. Conducting the program and evaluation, indicate that the plans should be carried through to completion and evaluation conducted to determine the degree of which objective are achieved.

2.5.3 Attributes and Rate Adoption Theory

Rogers (2003), defined diffusion as the process by which innovation is communicated through channels over time among members of a social system. There are five attributes which most affect the adoption on a new idea of new technology. These include; relative advantage (how the innovation is better than the current way of doing things), compatibility (how the innovation fits in with other management practices), complexity (the level of difficulty to understand and use the innovation), trialability (the degree to which an innovation can be used on a trial or experimental basis), and observability (how visible the results of the innovation are to others). Rate of adoption as the relative speed with which an innovation is adopted by members of a social system. The number of individuals who adopted the innovation for a period of time can be measured as the rate of adoption of the innovation.

2.5.4 Adopter Categorize Theory

Adopter categories as the classifications of members of a social system on the basis of innovativeness. Innovativeness is the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system. Figure 2.4 shows the classification of adopter, it includes innovators, early adopters, early majority, late majority, and laggards.

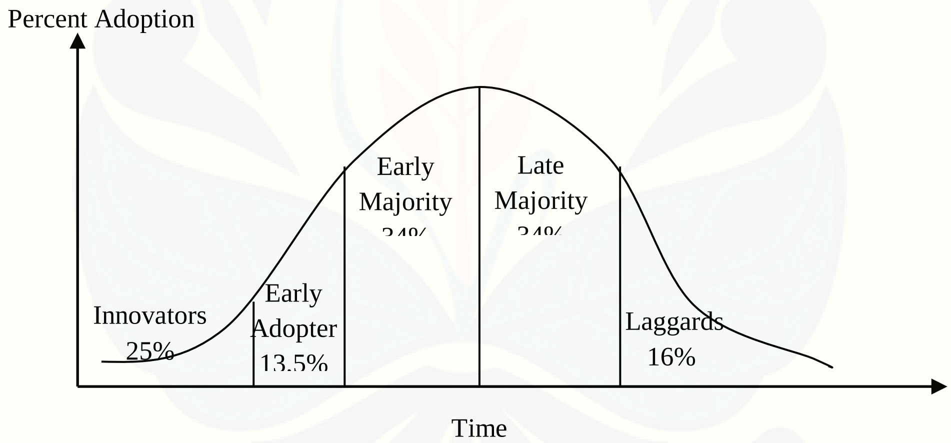

Figure 2.4 Five categories adopter in adoption technology
Source: Rogers (2003)

Innovators were willing to experience new ideas as the risk takers and pioneers. Early adopters are more likely to hold leadership roles in the social system, other members come to them to get advice or information about the innovation. The early majority adopts the innovation just before the other half of their peers adopts it. The late majority includes one-third of all members of the social system who wait until most of their peers adopt the innovation. Laggards have the traditional view and they are more skeptical about innovations and change agents than the late majority.

2.5.5 Farmer's Socio Economic Characteristics

According to Choirotunnisa (2008), adoption of advance technology by farmer can be effected by the social factors and economic factors of farmers. Harold (1971) stated that adoption of the approved farm practices reveal the individual's characteristic relation to his rate of adoption of such practice including age, farm income, social participation, education, land holding, experienced, and communication source as follow:

Age

According to Sutarto (2008), age will effect on the physic capability and respond to the new thing in the rice cultivation. The old farmer was difficult to understand the new technology and change the way of thinking and practice. Fardiaz, M (2008) also pointed out that the younger farmers has higher motivation to know the new thing in the rice cultivating, therefore they were has high level of adoption than the old farmer. However the younger farmer has limitation of experienced, they still has higher motivation on adoption of advanced technology. According to Nurdin (1981) in Choirotuinissa (2008), the unproductive age was under 15 and more than 65 years old. While the productive age was 15 years old to 64 years old.

Farm income

Higher gross farm income related with the adoption rate by farmers. Farmer that has higher income will has higher adoption rate than farmer that has lower income (Harold, 1971). Farm income will increase the motivation of farmer to take the decision on adoption of technology.

Social participation

Individuals who belong to and are active in numerous organizations tend to adopt innovations earlier than those that are less active socially. A possible and acceptable avenue of explanation for this participation-adoption relationship is to examine the type of relationships persons have with other people (Harold, 1971)

Education

Rate of adoption is directly related to number of years of formal schooling. However it is not one of the most reliable indicators because it also effect by age, income, and experienced (Harold, 1971). Choirotunnisa (2008) also stated that there are two types of education including formal education and informal education. In the informal education, extension service will increase the farmer's knowledge towards rice cultivation system. Extension service aimed to help farmer on identification farmer's problem. While the formal education was the years of formal education. Farmer who has higher education will has higher level of adoption than farmer that has lower education.

Land holding

According to Rahardjo (1999) in Sutarto (2008) stated that land holding will effect on the level of farm income which can be factor on the level of adoption the advanced technology. Lionberger in Choirotunissa stated that larger area makes the owner has higher adoption of technology because of high capability in financial. Adopter that more innovative has larger area because their farm was oriented on commercial farm. The adopter will increase their productivity (adopt the advance technology) to increase their profit.

Experienced

The rate of adoption of any innovation would be influenced by the number of previous adoption of other farm practices defined as satisfactory by the adopters (Harold, 1971). Sutarto (2008) stated that that there are two kinds of experienced including the good and the bad experience of an object. People will develop a positive attitude towards the object when it can makes a good experienced and vice versa if it related with the bad experienced he will develop negative attitudes.

Communication source

Different stages in the adoption process are influenced by different communication sources. These source are usually listed as mass media, neighbors, agricultural agencies, and dealers and salesmen. In the trial and adoption stages agricultural agencies including cooperative extension is the second important agencies in individuals adoption an innovation. While the primary influencing is neighbors (Harold, 1971).

2.6 Conceptual Framework

In order to address all research objectives, this research was conducted within the framework as present in Figure 2.5 as follow:

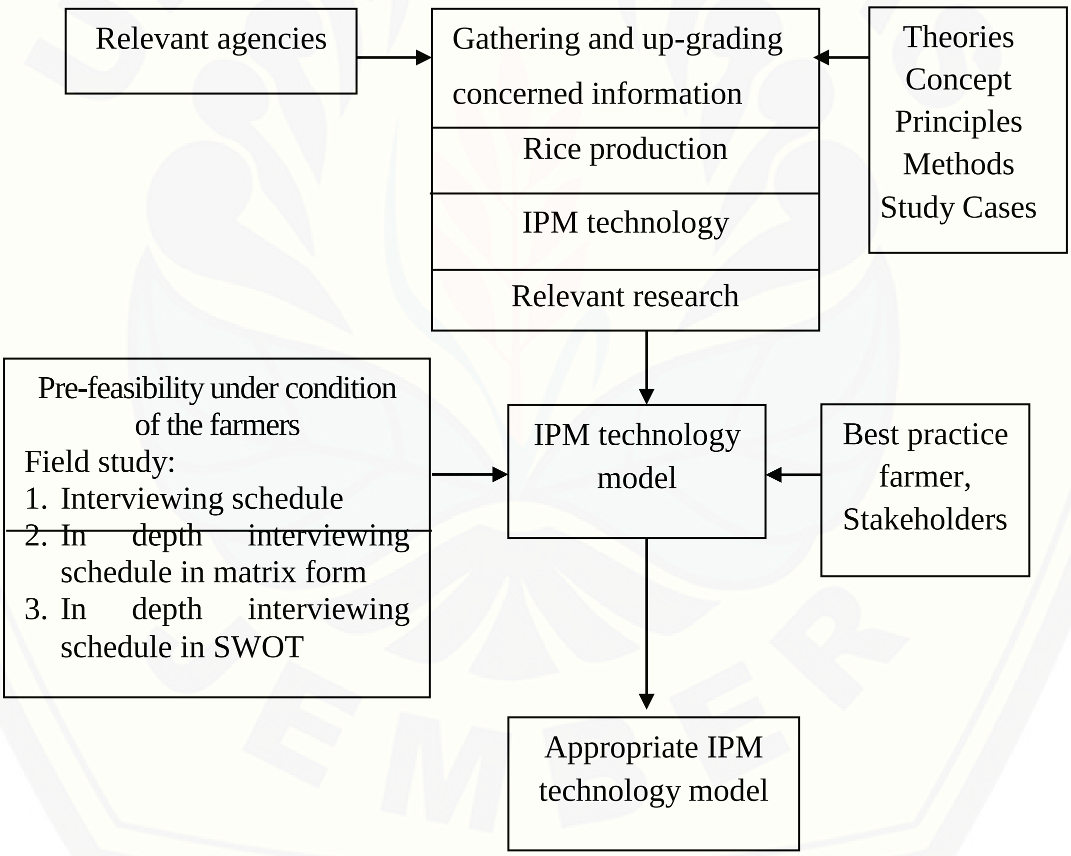

Figure 2.5 Conceptual Framework

2.7 Research Hypothesis

The testing hypothesis of this study involves the factors affecting adoption of IPM technology among rice farmers in the study area. From the relevant research papers, many independent variables had statistically significant relationship with dependent variables. Then in this investigation, the research hypothesis are as follows:

1. There are relationship between farmer's personal background factors, including age, gender, education level, household member, marital status, year of experience with adoption of IPM technology, and media perception with adoption of IPM technology.

2. There are relationship between input used factors, including cost of seeds, cost of fertilizer, cost of pesticide, cost of labor input, cost of machinery input, cost of land use, and cost of opportunity capital with adoption of IPM technology.

3. There is relationship between physical factor including location from paddy field to water resources.

4. There are relationship between biological factors including, infestation by brown plant hopper, rat, golden snail, and weed with adoption of IPM technology.

5. There are relationship between social factors including IPM training and number of group belonging with adoption of IPM technology.

6. There are relationship between economic factors including land tenure and utilization, accessibility of credit, farm income, and non farm income with adoption of IPM technology.

7. There are relationship between institutional factor including number of extension contact and number of service provider contact with adoption IPM technology.

8. There are relation between psychological factors including level of farmer's knowledge, attitude, and practice towards IPM technology with adoption of IPM technology.

2.8 Structure of Hypothesis

Based on the hypotheses the structures of testing hypotheses is presented in Figure

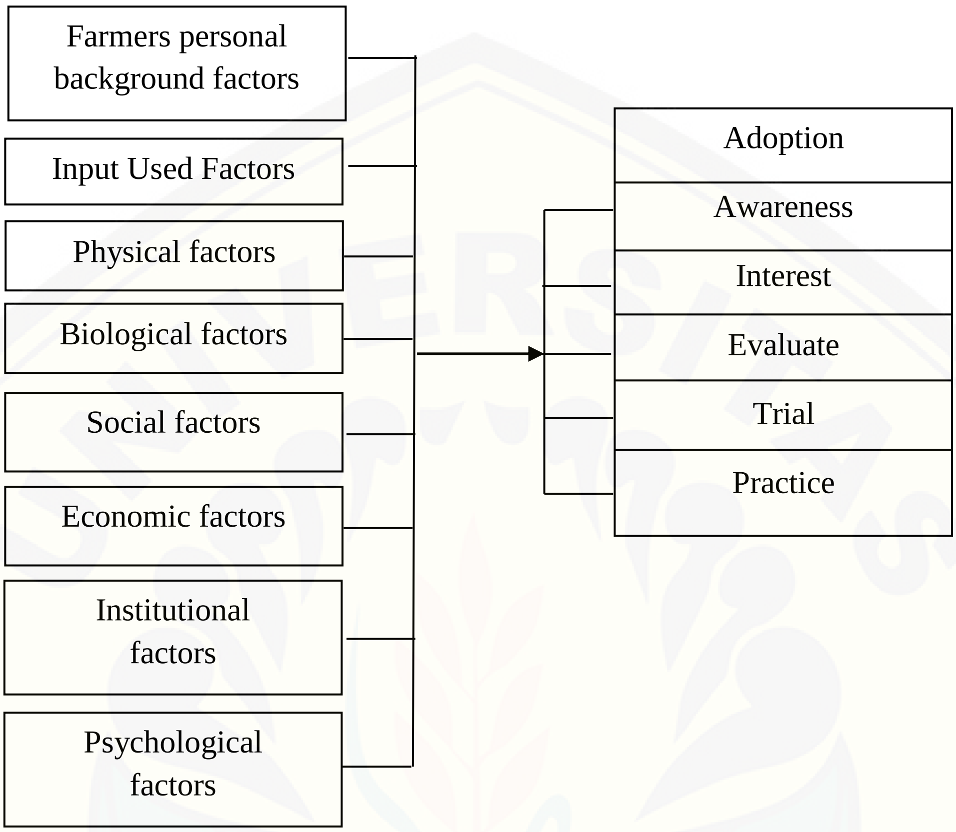

Figure 2.6 Structure of testing hypotheses

CHAPTER 3.
RESEARCH METHODOLOGY

This chapter presents the methods of data collection and data analysis in this study based on primary and secondary data. This chapter is organized to detail out the population and sampling technique, data collection, and analytical method. The whole research methodology will be wrapped up in research framework at the end of the chapter.

3.1 Population and Sampling Technique

The determination of sample was selected by purposive sampling technique (Judgemental sampling). Rianse and Abdi (2009) purposive sampling technique is an acceptable kind of sampling for special situation, it based on the researcher judgment as to who can provide the best information to achieve the objectives of the investigation. According to Malhotra (2007), judgemental sampling is a form of convenience sampling in which the population elements are selected based on the judgement of the researcher. The population of this investigation are one progressive rice farmer and extension officer in the study area. It was because the extreme condition of the area and respondent has high potential on giving the appropriate information of this research.

3.2 Data Collection Methods

Data for the research study were obtained in crop year 2013/2014 from representative best practice farmers and stakeholders in IPM technology in rice cultivation. This research conduct in some survey items includes interviewing schedule, in depth interviewing schedule in terms of matrix form, and in depth interviewing schedule in terms of SWOT analysis as follows:

1. **Interview Schedule** : Interviewing is commonly method of collecting information from respondent which an interviewer tries to elicit information more flexible. In addition, interview schedule is a kind of research tool which written list of questions, open ended or closed, prepared for use by

interviewer in person to person interaction (Kumar, 2011). In this investigation, interview schedule with several key informant persons including progressive rice cultivator will be performed. The interview was conducted in the middle of March 2014, at the farmer's hall room in two days one night for 10 hours.

2. **In Depth Interview Schedule in Terms of Matrix Form** : In depth interviewing as repeat face to face encounters between the researcher and respondent direct towards understanding information perspectives on their lives, experience, or situation (Kumar, 2011). In this investigation matrix form use to identify and analyze some factors that related with adoption of IPM technology in terms of causal, impact, among rice cultivators. The information will be obtained from middleman and farmer's group leader.
3. **In Depth Interview Schedule in Terms of SWOT Analysis** : In this investigation, in depth interview schedule in terms of SWOT analysis is use to know the four aspect in adoption of IPM technology, such as strength, weakness, opportunity, and threat. He aim of any SWOT analysis is to identify the key internal and external factors that are important to achieving the objective. The information will be obtained from progressive rice cultivator, farmer's group leader, and extension office.

The primary data was collected from respondent by using designed survey items and in depth case study. In order to fulfill the requirement of data analysis, an appropriate survey item was designed into nine divisions according to the need and objectives of study as follows:

i. Respondent's personal background: the firs part of survey item concentrated on respondent's personal background. The details of question to gather it personal background includes age, gender, religion, marital status, education level, year of schooling, household member, rice experience, and media perception.

ii. **Respondent's input used factor**: in the second part, the detail of respondent's agricultural factors is focused. It includes question to investigate cost of input use includes cost of seeds, cost of fertilizer, cost of pesticide, cost of labor input, cost of machinery input, cost of depreciation, cost of land use, and opportunity cost of capital.

iii. **Rice biological factor**: in the third part, the detail of pest damage in respondent's rice cultivation is focused. It includes question to investigate infestation of brown plant hopper, rat, snail, and weed in rice cultivation

iv. **Respondent's social background**: in the fourth part, the detail of respondent's social background is focused. It includes question to investigate frequency of IPM training and number of group belonging.

v. **Respondent's economic background**: in the fifth part, the detail of respondent's economic background is focused. It includes question to investigate the land tenure and utilization, accessibility of credit, farm income, and farm non income.

vi. **Institutional and support system**: In this category, the question to examine the relationship between respondent and extension agent is created. It also include quality and number of service provider.

vii. **Respondent's knowledge and attitude of IPM technology in rice cultivation** in the seventh part, the detail of respondent's psychological background is focused. It includes questions to investigate knowledge, attitude among respondent's towards IPM technology.

viii. **Respondent's adoption of IPM technology** in the eight part including existing practices of IPM technology among rice farmers.

ix. **Constraints and recommendation**: The last part of the survey item provided space for respondents to give an opinion on what kind of constraint that they had faced and the recommendation.

3.3 Analytical Method

Descriptive quantitative analysis will be used in this research. This method will describe about ecological condition of the area, factors affecting of adoption in IPM technology, and also rate of knowledge attitude and practice as follows;

i. Ecological analysis of research site

In terms of ecological analysis, both descriptive and quantitative analytical methods were applied. The data related to study area such as history, location and accessibility, slope and topography, land suitability, soil profile, climate (average rainfall, temperature, and relative humidity), natural resources, irrigation system, land utilization and agricultural farming system have been gathered from key informant.

ii. Descriptive analysis

Data collected will be analysis by descriptive analysis based mainly on a progressive farmer experience in adopting IPM since 2009. This is aimed to analysis the personal background of farmers, factors affecting adoption of IPM technology, and the constraint that faced by farmers in the crop year 2013/2014.

3.4 Operation Definition

1. **Respondent** refers to progressive rice farmer at Chedi Hak Sub District, extension officer at Chedi Hak Sub district. In addition stakeholders as the verification committee of quisioner and result.
2. **1 Rai** equal to 0.16 hectares while 1 hectare equal to 6.25 rai.
3. **1 acres** equal to 0.404685 hectares.
4. **Rice farmer** refers to progressive farmers in rice cultivation at Chedi Hak Sub district in main crop year 2013/2014.
5. **IPM technology** refers to the innovation that gathered and upgraded from intensive studies by literature review, key informant interview with rice expertise, The model includes five items including 1) prevention, 2) identification, 3) monitoring, 4)pest control action, and 5) evaluation and 15 sub items. Regarding IPM technology application, in this investigation measures for 3 level including have been done anytime =3, rarely = 2, and never = 1.
6. **Prevention** refers to cultural practices of farmers in rice cultivation in main crop year 2013/2014. It refers to seven steps including clearing before cultivation, using tolerant varieties, using appropriate spacing, balancing in

fertilizer application, appropriate water management, harvesting method, and rotating annual crop.

7. **Identification** refers to three main step including identifying pest, identifying beneficial organisms, and identifying pest damage.
8. **Monitoring** refers to six steps including monitoring of pest, monitoring beneficial organisms, recognizing early symptom, action threshold, tracking damage that caused by pest, and written record.
9. **Pest control action** refers to proper strategy on pest management. It refers to three main practices including physical practices, biological practices, and chemical practices.
10. **Evaluation** refers to evaluate the strategy and written record
11. **Cultural practices** can be preventive method of pest damage. It refers to proper sanitation, using tolerant varieties, proper spacing of plant, balancing in fertilizer application, proper water management, harvest close to ground, and rotating annual crops in main crop year 2013/2014.
12. **Physical** refers to hand picking, mowing, using barriers, trapping in rice cultivation in main crop year 2013/2014.
13. **Biological practices** refers to creating habitat for beneficial organism release natural enemies, protecting beneficial organism, and use bio pesticide in rice cultivation main crop 2013/2014.
14. **Chemical practices** refers to using pesticide based on monitoring and ETL, using selective pesticide based on following criteria including least toxic for environmental, beneficial organism, and specific to target, and applying in right time and right dosage in main crop 2013/2014.
15. **Factors affecting rice farmer adoption** refers to farmer general background, input used factors, physical factors, biological factors, social factors, economic factors, institutional factors, and psychological factors.
16. **Farmer's personal background** factors refers to age, educational status, household member, rice experience, and number media perception.
17. **Educational level** refers to level of attained in school include who never attended in school among rice farmer in Chedi Hak Subdistrict.

18. **Household member** refers to number of actual household member who stays together in the same roof more than six months per year.
19. **Rice experience** refers to number of year of farmer's experience in rice cultivation.
20. **Number of media perception** refers to type and frequency of media perception that respondents have been used in perceiving IPM technology information. It includes personal media, mass media, and interactive media.
21. **Input used factors** refers to farm input used for rice cultivation during main crop year 2013/2014 including cost of seeds, cost of fertilizer, cost of pesticide, cost of labor input, cost of machinery input, cost of land use, and opportunity cost of capital.
22. **Seed input** refers to rice seed for cultivation in main crop year 2013/2014 including multiplication seeds and farm saved seed.
23. **Fertilizer input** refers to chemical and organic fertilizer applied in rice cultivation in main crop year 2013/2014.
24. **Pesticide input** refers to insecticide, herbicide, pesticide, fungicides and others that used in rice cultivation in main crop year 2013/2014.
25. **Labor input** refers to number of man days permanent or temporary paid and family labor used in rice cultivation in main crop year 2013/2014.
26. **Machinery input** refers to respondent owned, borrowed, or rented machine from service provider used for rice cultivation in main crop year 2013/2014.
27. **Land input** refers to total actual land that respondent used for rice cultivation in main crop year 2013/2014 including farmer's own and rented land.
28. **Return** refers to yield, net income, net earning, and net profit from rice cultivation in main crop year 2013/2014.
29. **Net earnings** refer to the total gross income generated from rice cultivation subtracting by the total variables cash cost (NE = GI – TV cash cost) in main crop year 2013/2014.
30. **Net profit** refers is determined by deducting gross income of rice cultivation by total production cost in main crop year 2013/204 (NP = GI – TC).

31. **Physical factors** refers to location from their paddy field to water resources and soil suitability for rice.
32. **Biological factors** refers to percentage of pest , rat, golden snail, and weed in rice cultivation in main crop 2013/2014.
33. **Social factors** refers to IPM training and number of group belonging.
34. **IPM training** refers to type of organization and frequency of respondent in attending IPM training.
35. **Number of group belonging** refers to number of agricultural group that the farmer become the member.
36. **Economic factors** refers to land tenure and utilization, accessibility of credit, farm income, and non farm income.
37. **Land tenure and utilization** refers to respondent's land status ownership, includes owned, rented, and least for main crop year 2013/2014.
38. **Accessibility to credit** refers to respondent's financial condition of credit source, amount and interest rate of credit in main crop year 2013/2014.
39. **Farm income** refers to total income of respondents based on agricultural sector in main crop year 2013/2014.
40. **Non farm income** refers to total income of respondents based on non agricultural sources in main crop year 2013/2014.
41. **Institutional factor** refers to number of extension contact and availability and quality of service provider.
42. **Number of extension contact** refers to number of agriculture extension agents from government agencies, university, and private company that have visited the respondents during main crop year 2013/2014.
43. **Availability and quality of service provider** refers to number of service provider that offer their service to respondents, such as extension agent, financial service, input supplier, land preparation contractor, transport contractor, marketing agent, and others in main crop year 2013/2014. Quality of service provider measured by ranked from 1= very poor, 2= poor, 3= moderate, 4= good, and 5= very good..

44. **Psychological factors** refers to level of farmer's knowledge, attitudes, and practices towards IPM technology.
45. **Farmer's knowledge** refers to farmer's current understanding on IPM technology. The level of right knowledge in rice cultivation towards IPM technology model including of identifying, monitoring, action threshold, implementation, and evaluation. It measured by three multiple choice which only one answer is correct. The score of correct is 1 and the wrong answer is 0.
46. **Adoption of IPM technology** refers to the existing application to rice cultivation in IPM technology that measured by 3 level including anytime=3, sometimes=2, and never=1.

CHAPTER 4.
RESULT AND DISCUSION

4.1 The Study Area and Its Vicinity

4.1.1 Location and Boundaries

Based on etymology, word “Ratj” or “Raja” means King and word “buri” or “puri” means city, it can be said that Ratchaburi means the city of King. Ratchaburi Province located in the central of Thailand 100 kilometers from Bangkok, with latitude $13^0$31’44’’ N and longitude $99^0$48’52”E. This province covering land area around 5,196 square kilometer and bounded on the north by Kanchanaburi Province and Nakhon Pathom Province; on the south by Petchaburi Province; on the east by Samut Sakhon Province and Samut Songkram Province; on the west by Burma. Ratchaburi Province divided into 10 district including Mueang Ratchaburi, Chom Bueng, Suan Phueng, Damnoen Saduak, Ban Pong, Ban Phae, Photharam, Pak Tho, Wat Phleng, and Ban Kha as shown in Figure below.

Mueang Ratchaburi is the capital district in Ratchaburi Province. This area located in latitude $13^0$31’42’’ N and longitude $99^0$48’42”E and covering by some district including in the north by Photharam District and Ban Poeng District; in the south by Pak Tho District and Ban Kha district; in the east by ban Phae and Damnoen Saduak; and in the west by Suan Phueg District and Chom Bung district. Mueang Racthaburi divided into 22 sub district including Na Mueang, Chedi Hak, Don Tako, Nong Klang Na, Huai Phat, Khung Nam Won, Khun Krathin, Ang Thong, Khuk Mo, Sam Rueang, Phikun Thong, Nam Phu, Don Rae, Hin Kong, Khao Raeng, Ko Phlapphla, Lum Din, bang Pa, Phong Suwai, Khu Bua, Tha Rap, and Ban Rai.

Figure 4.1 Map of Thailand highlighting Ratchaburi Province
Source: Applied from World Map (2011)

4.1.2 Geography

Ratchaburi Province covering by mountains and forest. More than 30% of the area is forest that has some important mineral. The mountains has height around 200-30 meters above sea level. The west side of Ratchaburi bounded by Burma. The Central of the area is wet lands because flowed by Mae Klong river.

Figure 4.2 Topographic map of Ratchaburi Province and its vicinity
Source : applied from Google maps (2013)

4.1.3 Climate

Generally climate of Central Thailand is tropical moonson. As shown in Figure below, the pattern of temperature, rainfall, and relative humidity during the year 2009 – 2013 estimate with the data of Ratchaburi Agrometeorological Station (Meteorological Department, 2014).

The rainy season from April through November, in the other side, the dry season start from December until March. The minimum temperature is varied from 17.1 ^{0}C to 23.6 ^{0}C with average was 21.4^{0}C. While the maximum temperature between 33.0 ^{0}C to 39.2 ^{0}C with average around 36.1 ^{0}C. Based on the figure and table below, the temperature will increase in February and the highest temperature occurred between June, after that the temperature will decrease respectively. The average temperature in that area was 20.7 ^{0}C. The precipitation varied from 1.4 mm to 207.1 mm. The high precipitation occurred in September and October, while the low month of precipitation is in January and February. The average of precipitation and relative humidity during 2009 to 2013 was 84.3 mm and 71.3 % respectively.

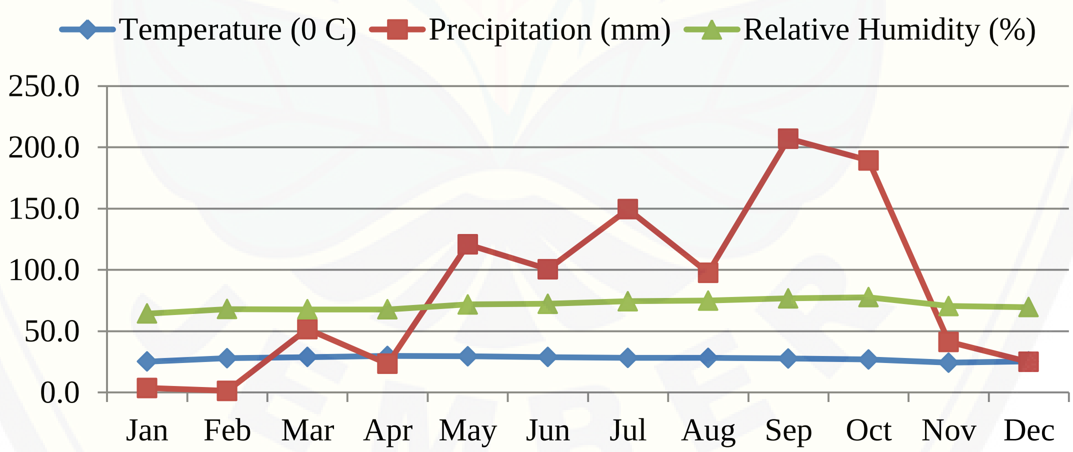

Figure 4.3 Temperature, Rainfall, and Relative Humidity in Ratchaburi Province, Central Thailand during 2009-2013

Source: Estimate with the data of Meteorological Department (Ratchaburi Agrometerological Station, 2014)

Table 4.1 Average Maximum, Minimum, Precipitation, and Relative Humidity in Ratchaburi Province, during 2009-2013

Month	Temperature(0C) Minimum	Temperature(0C) Maximum	Precipitation (mm)	Relative Humidity (%)
January	17.1	34.4	3.6	64.4
February	20.5	36.8	1.4	68.0
March	20.8	38.1	51.7	67.8
April	22.9	39.2	23.4	67.8
May	23.6	38.5	120.8	71.8
June	23.7	36.3	100.6	72.4
July	23.4	36.0	149.4	74.4
August	23.6	35.9	97.7	75.0
September	23.2	35.6	207.1	76.8
October	21.6	34.6	189.3	77.8
November	19.1	33.0	41.3	70.5
December	17.4	34.3	25.0	69.6
Average	21.4	36.1	84.3	71.3

Source: Estimate with the data of Meteorological Department (Ratchaburi Agrometerological Station, 2014)

Table below showed the current condition of climate in Ratchaburi Province in 2013. The minimum temperature between 15^0C to 23.7^0C, while the maximum temperature between 35.5^0C to 40.5^0C. Precipitation of the area varied from 0.4 mm to 258.8 mm, which the highest precipitation month is in September.

Table 4.2 Temperature, Precipitation, and relative humidity in Ratchaburi Province, central Thailand in 2013

Month	Temperature (^{0}C) Minimum	Temperature (^{0}C) Maximum	Precipitation (mm)	Relative Humidity (%)
January	17.6	37.6	1.6	66
February	22.2	37.1	4.2	65
March	21.7	38.8	60	68
April	22.1	40.5	24.8	67
May	23.3	38.4	108.6	69
June	23.3	36.2	223.6	77
July	23	35.5	179.6	75
August	23.7	35.7	103.8	74
September	23.2	36.4	258.8	79
October	21.7	33.8	79.4	76
November	15	33.9	0.4	66
December	15	33.9	79.8	69

Source: Estimate with the data of Ratchaburi Agrometerological Station, 2014

4.1.4 Surface Hydrology

As shown in Figure below, there are some surface water in Ratchaburi Province. Only one main stream that support agricultural sector in Ratchaburii Province called Mae Klong River. This area can provide the appropriate irrigation system for rice farming.

Figure 4.4 Ratchaburi City Map

4.1.5 Soil Suitability for Rice

Based on the Figure 4.5, showed that there are four classification of soil suitability for rice farming in Thailand including yellow means very appropriate, green means moderate appropriate, blue means less appropriate, and red means inappropriate. Figure 4.5 below showed that Ratchaburi Province has 364,374 acres of agricultural area which 45.8% or approximately 166,781 acres is very appropriate; 36.5% or 132,933 acres is moderate appropriate; and 17.6% or 64.042 acres is inappropriate for rice farming.

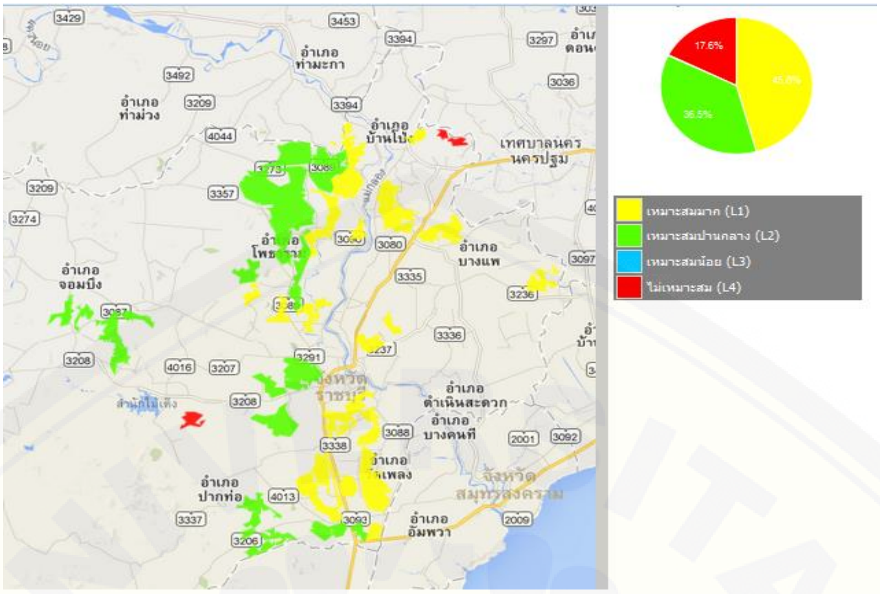

Figure 4.5 Soil Suitability of Rice in Ratchaburi Province, 2014

Source: Rice Center (2014)

Based on the Ratchaburi Province soil suitability, specific in Mueang Ratchaburi of the capital of district in this province has 68,679 acres of agricultural area which is 55.1% is very appropriate for rice farming or around 37,865 acres; 32.2% or 22,079 acres is moderate appropriate; and 12.7% or 8,728 acres is inappropriate for rice farming

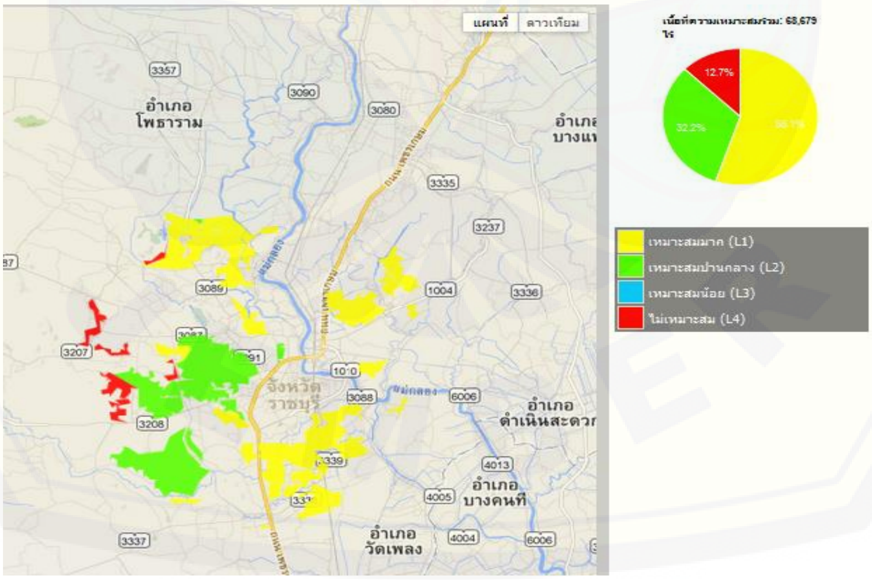

Figure 4.6 Soil suitability of rice in Mueang Ratchaburi Province or Amphoe Mueang

Source: Rice Department of Thailand (2014)

According to two figure before, showed that the area is very suitable for rice farming. In the figure below, Chedihak Subdistrict has 7,093 acres of agricultural area which 13.1% or 929 acres is very appropriate for rice farming; 86.4% or 6,129 acres is moderate appropriate; and 0.5% or 64.042 acres is inappropriate in rice farming.

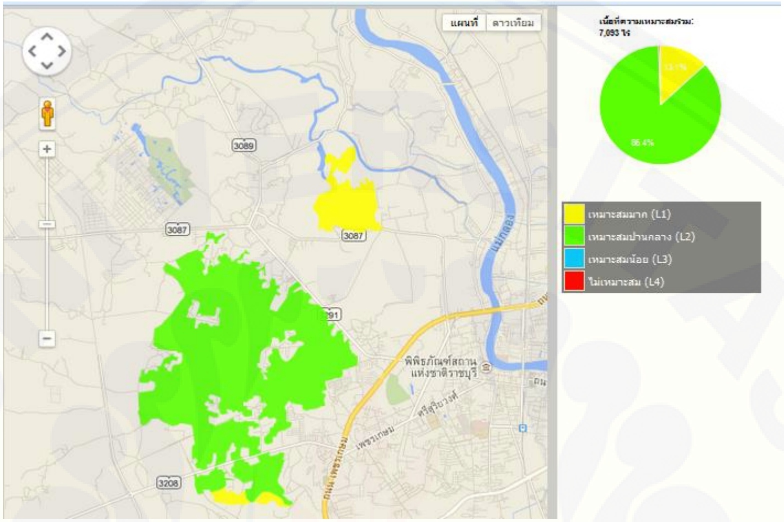

Figure 4.7 Soil suitability of rice in Chedi Hak Subdistrict
Source: Rice Department of Thailand (2014)

4.2 Personal Background and Socio Characteristic

Respondent in this study was progressive rice farmer. He is 56 years old. He work as full time farmer. He has experienced in rice cultivation more than 20years. His rice farm around 23 rais which is rented area. He has 5 household member which all of them was farm labor in the rice cultivation. IPM is one kind of advanced technology which was adopted by the farmers. There are two source of media perception in terms of IPM technology that received by farmer including personal media and interactive media. Personal media was provided by the government officer while interactive media was training program in IPM technology.

In terms of input used, farmer in the study area can produce the good quality of seeds. There are two kinds of seeds which used by farmer including Chainat and Suphan cultivar. Those seeds will be sold around 20 THB per kilogram seeds and needs 20 kilograms of seed per rai. Suphan variety is appropriate in Chedi Hak than another variety, this variety also tolerant with BPH. In terms of fertilizer, farmer used chemicals and organic fertilizer. There are three kinds of chemical fertilizers that has been used by farmer including 46-0-0, 16-20-0, and 0-0-60. For urea application, farmer will apply 5 kilograms per rai. Totally in one rai they needs 50 kilograms of fertilizer.

In addition, respondent did not used chemicals in pest control. He only used biological control to manage their farm. Trichoderma is the best way to prevent pest in the rice cultivation. Kasetsart University and some private company provide the Trichoderma but farmer still prefer to use Trichoderma from Kasetsart University because more effective that from private company. Farmer use machinery in rice management in three steps including preparation (tillage), plant stage (fertilizer application), and harvesting which is the price is 550 THB, 650 THB, and 550 THB, respectively. Machine used can decrease labor used in rice management, in 23 rais of area he only needs 5 family labor in management, and 2 until 3 hired labor for harvesting process, the wage of hired labor is 300 THB per person per day. In terms of land rent, he have to pay 1,000 THB per rai area for 23 rai. For another input used, he only has to spent for petroleum around 200 THB per rai. According to those investigation, it can be seen that input used factors not become factors affecting in adoption of IPM technology. Farmers has their own knowledge in managing input used factors in their farm (detail cost and return provided in appendix A). While he did not used pesticide to control his farm. He already adopt IPM technology in pest management. He cultivated two periods in one year, there was no crop rotation. To prevent pest infest, farmers also planted some herbs in some side around the area.

The respondent was belonging in some group including cooperatives, BAAC, and Farmer’s group. As progressive farmer he also get the credit from BAAC with the interest around 7%. This loan will be used for rend the land. In terms of institutional support, there are some institutional that support the farmer including Department of Agriculture Staff, Department of Agricultural Extension, and University staff. All of those institution was give advanced technology in rice cultivation in order to enhance capability of farmers.

4.3 Rate of Knowledge, Attitude, and Practice

In this part will describe rate of knowledge, attitude, and practice of respondent as progressive farmer according to the question that has five main items which has 28 sub items as follow;

4.3.1 Knowledge on IPM Technology

According to Aungsuratana (2007) in Hasim (2013), pointed out that to analyze the level's of farmer capability based on their scores on question given. Based on the Table below, respondent knowledge in prevention is 60% correct while 40% was not correct. The respondent know well in cultural practices on prevention including tillage the soil and using the herbs to prevent the pest surrounding the rice area. The appropriate spacing in the rice farm is 20x25 cm. While the respondent used different time on the fertilizer application including when in the 3 days after transplant and 20 days after transplant, and respondent did not used rotation system. He cultivated rice two crops in one year and the harvest method was not close to ground. On the identification items, respondent know well of the three sub items including identification pest, identify beneficial organism, and identify pest damage.

Respondent also well known in the monitoring items which include five sub item; monitoring of pest, monitoring of beneficial organism, recognizing early symptom, action threshold, and written record. In the pest control action items, respondent was correct in the 7 sub items including hand picking technique, barriers technique, trapping, release natural enemies, create habitat of natural enemies, pesticide use based on monitoring and ETL, and criteria of appropriate pesticide. In the evaluation items, respondent know well of both two sub items including evaluation strategy and record.

Table 4.3 Distribution of knowledge towards IPM technology procedures

No	Items	Correct		Wrong		Total	
		No	%	No	%	No	%
1	Prevention	6	60	4	40	10	100
2	Identification	3	100	-	-	3	100
3	Monitoring	5	100	-	-	5	100
4	Pest control action	7	87.5	1	12.5	8	100
5	Evaluation	2	100	-	-	2	100

Source: Survey

4.3.2 Attitude on IPM Technology

In the prevention items, respondent was agree for 50% of total sub items including proper sanitation (tillage the soil), proper varieties (tolerant on pest), proper water management, balancing in fertilizer application, and using herbs to protect the area. The respondent was not decided about appropriate spacing and harvest to the ground technique. While respondent disagree with the appropriate time for fertilizer application. In the identification items, monitoring items, and evaluation items, respondent was agree on all of the sub items. While in the pest control action, respondent agree for 6 sub items including hand picking, barriers, trapping, release natural enemies, pesticide use based on monitoring and ETL, and the criteria of appropriate pesticide.

Table 4.4 Distribution of respondent attitude on the IPM technology

No	Items	Agree		Undecided		Disagree		Total	
		No	%	No	%	No	%	No	%
1	Prevention	5	50	2	20	3	30	10	100
2	Identification	3	100	-	-	-	-	3	100
3	Monitoring	5	100	-	-	-	-	5	100
4	Pest control action	6	75	2	25	-	-	8	100
5	Evaluation	2	100	-	-	-	-	2	100

Source: Survey

4.3.3 Practices on IPM Technology

According to the interview, respondent was adopt the 6 sub items of prevention, 3 items in identification, 5 sub items in monitoring, 5 sub items in pest control action, and 2 sub items in evaluation. According to the Table below, the respondent as progressive farmer was adopt 19 sub items from 28 sub items in the IPM technology or 67% adopt the technology.

Table 4.5 Distribution of practices on IPM technology

No	Items	Anytime		Sometimes		Never		Total	
		No	%	No	%	No	%	No	%
1	Prevention	6	60	-	-	4	40	10	100
2	Identification	2	66.7	1	33.3	-	-	3	100
3	Monitoring	5	100	-	-	-	-	5	100
4	Pest control action	5	62.5	1	12.5	2	25	8	100
5	Evaluation	2	100	-	-	-	-	2	100

Source: Survey

Table 4.6 Adoption of IPM technology

Technique	Variable
Prevention	Tillage the soil in land preparation Use appropriate spacing (25 cm x 25 cm) Use tolerable varieties of BPH Apply 5-10 kg per rai of urea in top dressing Using herbs to protect the area
Identification	Identification of pest (BPH) Identification of beneficial organism Identify the problem, causal, and associate plant or animal species correctly before do the treatment
Monitoring	Regularly monitoring to know the early symptom Tolerable level of BPH is if less than 10 larvae per hill Distinguished between pest and beneficial organism Write the record for monitoring procedure
Pest control action	Use traps to prevent rat damage Use light traps to prevent BPH Use hand picking to remove weed Using trichoderma as natural enemies
Evaluation	Continue monitoring during evaluation process Write a record for future guidelines

Source: Survey

4.3.4 Comparison between Knowledge and Practices

As presented in the Table, the result of comparison between farmer's knowledge and practice on IPM technology can be conclude that farmer know the IPM principle and this knowledge related to the practices that farmer has been done. There are two sub items that was not related including using pesticide based on the monitoring and ETL and using selective pesticide. In both sub items, farmer stated agree and know it well, but in the practices he did not used the chemicals as pest control. From this finding, the progressive farmer had knowledge and practice on IPM technology. Therefore the farmer get the good market and good price. Because of the quality of rice, he become contract farmer from hospital as the buyer. This investigation is parallel with study of Gunaratne (1999) that the trained farmers that understood the principles of IPM package will adopted the IPM based on the availability of input.

Table 4.7 Comparison between knowledge and practice in IPM technology

Item	Sub item	Knowledge	Practice
Prevention	Proper sanitation	√	√
	Using tolerant varieties	√	√
	Proper spacing	√	√
	Balancing fertilizer application	√	√
	Proper water management	√	√
	Appropriate time on fertilizer application	x	x
	Harvest close to ground	x	x
	Rotation annual crop	x	x
	Using herbs to protect the area	√	√
Identification	Identification pest	√	√
	Identification beneficial organism	√	√
	Identification pest damage	√	√
Monitoring	Monitoring of pest	√	√
	Monitoring of beneficial organism	√	√
	Recognizing early symptom	√	√
	Action threshold	√	√
	Written record	√	√
Pest control action	Physical practices		
	Hand picking	√	√
	Using barriers	√	√
	Trapping	√	√
	Biological practices		
	Create habitat for beneficial organism	√	√
	Release natural enemies	√	√
	Protecting the beneficial organism	√	√
	Chemical practices		
	Using pesticide based on monitoring and ETL	√	x
	Using selective pesticide	√	x
Evaluation	Evaluate the strategy	√	√
	Write record	√	√

Note:√ refers to either correct knowledge or practice
x Refers to either not correct knowledge or not practice
Source: Survey

4.4 Factors Affecting Adoption of IPM Technology in Chedi Hak Sub District

Factors affecting adoption of IPM technology in the study area including personal background, input used factors, physical factors, biological factors, social factors, economic factors, institutional factors, and psychological factors as follows;

4.4.1 Personal Background

There are some sub factors in personal background that effect in adoption of IPM technology in rice farmer including age, education, experienced, and number of media perception. The older farmer has low interested in the advanced technology and low interest to adopt the technology. According to Sutarto (2008), farmer's age will effect on physical capability on the rice farming activities. Tiamiyu (2009) also stated that younger farmers are more likely to be interested in adopting new technology. The finding shows that the age of respondent was 56 years old. According to Nurdin (1999) in Choirotunissa (2009) the productive age was between 16-64 years old.

Education of the respondent was senior high school. It can be conclude that the respondent still in the productive age and has high education to increase the rice farm capability in order to enhance the rice farming. In addition, Soekartawi (2005) in Choiritunisa et all (2008) stated that farmer that has high education will adopt the innovation faster than the low education farmer. While education level both formal and informal will effect on the way of thinking and decision making on rice farming..

Ofuoku (2009) also stated that age and education has effect on the IPM adoption of rice farmer in Nigeria. The education of farmers influences their ability for a balanced assessment of innovations disseminated to them.

The other important factors in adoption of IPM technology was experienced in the rice farming. The progressive farmer has experienced more than 20 years in rice farming and adopt some technology in the seed production and rice cultivation technique. Sutarto (2008) Pointed out that adoption of farm innovation would be influenced by the number of previous adoption of other farm practices defined as satisfactory by the adopters.

Farmers only get the information from extension officer (government officer) as personal media and training course that held by Department of Agriculture. There is no mass media on promotion IPM technology among farmers. From those media, farmers get all of the information in IPM technique including identification, monitoring, controlling, and evaluating. Farmers can meet with extension officer once a week, and get the training course every year for 20 weeks.

4.4.2 Input Used Factors

Input used factors that has effect in adoption of IPM technology by farmer was the availability of Trichoderma as biological control and chemicals substance availability. Kasetsart University has developed Trichoderma as commercial use among farmers. That innovation makes farmer easy to get the biological control. In the other side, chemicals substance availability is easier to get because of available in every sub district.

4.4.3 Physical Factors

Chedi Hak Subdistrict has good water resources access. It effect on the irrigation system of rice farming in the study area. Progressive farmer easy to control the water level in the rice farming. Easy in water access increase the interested of the progressive farmer to used IPM technology. IPM technology needs water to control the weeds. Galawat, F (2012) pointed out that farmers who have access to irrigation perform significantly better in the rice activities. In terms of soil suitability, Chedi Hak subdistrict has 7,058 acre area or 99.5 % of the total area was appropriate for rice cultivation. This amount consist of 13.1% very appropriate for rice cultivation, while 86.4 % was moderate appropriate for rice cultivation (Rice Departent of Thailand, 2014).

4.4.4 Biological Factors

Biological factors including pest infest, rat, disease, and weeds. Pest infest in the study area was less than 5%. Disease infest in the study area was spot leaves that not more than 5%. Rat problems in the study area was around 20%. The most important problem in the study area was weed problem. farmer faced weed problem for more than 70%. Less of pest and disease infest makes the progressive farmer want to adopt IPM technology.

4.4.5 Social Factors

Social factors including IPM training and number of group belonging. Both of two categories has relation with the decision making of farmer to adopt IPM technology or to decrease chemicals used in the rice farming. Every years, Department of Agriculture has FFS program to increase farmer knowledge in terms of IPM technology. This program start from 2010 until now. The program held for 8 until 20 weeks. Hoang et all (2006) said training courses are the most common method of extension service to disseminate agricultural innovation. There is a correlation between training course and information source.

In the study area, there has training centre as place on transferring technology from the government to the farmer in Chedi Hak Subdistrict.. Farmers has joined with some organization including cooperatives, farmer's group, BAAC, and training centre. While farmer get IPM training from rice center department and Department of Agriculture. Tiamiyu (2009) stated that membership of association is expected to assist farmers to get easy access to credit and other production inputs. It can also enhance access to technological information. Farmer can get some information in rice management from the training course including cost efficiency, input efficiency, and bio control management as IPM control in the rice farm. According to Hasim(2013), active in social activities will increase the adoption of technology because the adopter think that the community or organization is important for them.

4.4.6 Economic factors

Farm income become the main factor for farmer to adopt IPM technology. it related with the market of rice product. Sutarto (2008) pointed out that farm income is one kind factors that effect on adoption of technology. Farmer has contract with the hospital in the study area, they will buy higher from the market price if the quality is good. Those quality include safety and healthy. IPM technology is appropriate to achieve those quality. According to the interview with the respondent, he only has 23 rais of rice farm that only rented with 1,000 THB per rais. Farmer also get the credit from BAAC. With 7%interest. BAAC has important role in helping farmer to increase their capability in rice management. Based on the area, farmer can produce 20 tons of grain per crop. in one year, farmer can produce 40 tons of grain. In terms of marketing of rice, farmer has contract with the hospital in the study area. it is because farmer used biological control in their farm that makes their farm and product is less chemical substance. Hospital will pay 20 THB – 25 THB per kilogram grain. In terms of non farm income, farmer also get 100,000 THB per year from the training.

4.4.7 Institutional Factors

Institutional factors that has effect on rice farmer’s decision making in adoption of IPM technology including number of extension contact and quality of service provider. Farmer has high frequency contact with the extension officer. It increase farmer motivation to adopt the technology based on the suggestion of extension officer. Extension officer under Department of Agricultural Extension always provide extension service once a week, while University staff also provide the information once a month. It makes good relationship between farmer and extension officer . Tiamiyu (2009) pointed out that extension contact is very important determinant of technology adoption because any newly developed technology is introduced to farmers through the activities of extension agents. A farmer whose contact with extension agents is very high is expected to be more familiar and more knowledgeable about the use of improved agricultural innovation. In addition, Ofuoku (2009) also stated that the level of adoption of technologies in IPM adoption among farmers in Nigeria was consistently and significantly affected by level of extension service.

4.4.8 Psychological Factors

Psychological factors including knowledge, attitude, and practice of IPM procedures. The progressive rice farmer has know well and adopt 22 items from 29 items of IPM procedures, including :

Prevention

In terms of prevention, farmer always tillage the soil to get proper sanitation before planting. They used machine on tillage soil. Farmer also used appropriate variety in their farm including Chainat and Suphan. Farmer used Suphan toprevent BPH. Farmer also used appropriate spacing around 20 x 25 cm in their farm. To prevent weeds in the farm, farmers always keep the water 5 -10 cm from the soil surface, but this method still can not control the weed in the farm. Farmer always used balanced fertilizer on cultivation management, for urea the suitable amount is 5 to 10 kg per rai. Farmers apply fertilizer in 3 days after transplanting and 20 days after transplanting.

In harvesting, farmer used machine that has 30 cm from the soil surface. Because of there is low of pest infestation, farm from ground method is not problem. farmer also not rotate the annual crop to prevent the pest infestation. They have native knowledge to protect their farm from pest infestation. Farmer produce rice in two times per year, they used some herbs in some area surrounding the rice farm to prevent pest infestation. This method effective to protect the farm from pest.

Identification

Farmers well known the beneficial organism, and BPH as the main pest in Thailand. In terms of identifying pest damage, farmer will identify the cause of problem and associated plant or animal species, take a look in small sign of damage, and also mixed their experience with their knowledge. Those steps will be the guide on identification of problem in their farm.

Monitoring

Farmers know the tolerable level of BPH, if only 1 BPH per plant, they will take it out and leave it, but if they found more than 10 BPH per hill, it needs to take more action. Farmer also used Trichoderma as natural enemies in their field. Farmer also well known that regularly monitoring is important in rice management process. Farmer always make a record in terms of monitoring process and also give announcement to the another farmers in the group.

Pest Control Action

As progressive farmer, he prefer used biological control and physical control in pest management. Chemicals control is the last option and when it needed urgently. Farmer used traps in rice protection from rats, and used hand picking on weed problem. while in BPH control he used light traps but it is rarely because the study area is not faced big problem of BPH infestation. Using biological control can create habitat for beneficial organisms (Trichoderma). Farmer always used Trichoderma as biological control in the rice field. Although they not used chemical substance in pest control, farmer know that indicator of used pesticide is based on monitoring and ET. The pesticide should less harmful to the environment .

Evaluation

In terms of evaluation, farmer always monitor the area regularly to know the problem in the farm. Farmer also always make a record and give the announcement to the another farmers about the cultivation report. Evaluation is important steps in IPM technology because monitoring became the main guide to making decision.

Table 4.8 Factors affecting rice farmers adoption of IPM technology

Factor	Variables
Personal Background	Age Education Experienced Number of group belonging
Input used	Biological control availability Chemicals substance availability
Physical	Water resources Rice soil suitability
Biological	Pest Disease Weed
Social	IPM training Number of group belonging
Economic	Farm income
Institutional	Number of extension contact Quality of service
Psychological	Knowledge, Attitude, Practice

Source: Survey

Strength Point	Weakness Point
Soil suitability Biological control access Experienced in farm Water resources Awareness in the chemicals substance	Chemical substance availability Complexity of IPM procedures Less reliable information Labor intensive Age Education Awareness on pollution
Opportunity	**Threat**
Thailand Agricultural Standards Good Agricultural Practices Extension service FFS training	Pest Disease Disaster Price

4.5 Constraint and Recommendation of Adoption in IPM Technology

In this part will describe about the major constraints and recommendation on adoption of IPM technology. According to the extension officer and the progressive farmer, majority of farmers in the study area joined in the IPM training that held every year for 16-20 weeks. But although they know the principle of IPM technology, the adoption among rice farmer still low than expected.

4.5.1 Personal constraint

There are three categories in personal constraints including farm size, lack of awareness of pollution, and weak perception of IPM technology. According to extension officer, farm size become the constraint in IPM adoption, majority of farmer that has big farm did not want to adopt IPM technology because it difficult on manage and control, they prefer to used chemicals substances when see the symptom, but for the small farm, they can adopt because IPM is low cost and small farm size is easier to manage and control. Farm size is not the only factors, but it is also depend on the personal background of the farmer including age, education, and experienced. The others constraint including lack of awareness and weak perception of IPM technology among rice farmer. Lack of awareness of pollution become constraints in adoption of IPM technology. Majority of farmers know that chemical is dangerous for environment and human life, but they did not care if they use large amount of chemicals substance in their farms especially for pest control.

Weak perception of IPM technology is the main constraints in adoption of IPM technology. Majority of farmer did not believe that IPM is effective, they prefer used chemicals in pest control because chemicals has direct effect to the target than biological control. Using chemicals in easier than IPM technology. Chi,T.T.N (2008) pointed that farmers did their old practices and hesitated to adopt the innovation because they worried the yield loss when applied new technology that they had not known well. The weak perception of IPM technology makes some impact including

4.5.2 Biological constraint

The main problem in the study area was weed problem that faced more than 70% in the rice farm. IPM technology can not solve this problem, it makes the farmer still used chemical substance to cleaned the weed and not adopt the IPM technology. according to the extension officer, majority of farmer will prefer used chemicals than adopt IPM technology because using chemicals is more effective than used IPM methods.

4.5.3 Input used constraint

There are some constraint in input used that makes farmer did not want to adopt IPM technology including labor intensive of IPM procedures, easy access of chemicals substance, and complexity of IPM methods.

1. Labor intensive

   IPM technique needs more labor intensive in controlling and monitoring the rice farm. It become barriers for farmer to adopt the IPM technology. farmer prefer to used chemicals to decrease labor used. Kumary, G. (2012) stated that labour intensive is the first problem which faced by the rice growing farmers on IPM technology in terms of mechanical practices.

2. Easy access of chemicals

Farmer can get the chemicals very easy, they can get from the shop in the village or call to the distributor and they will sent it directly. Although the chemicals price is expensive, farmers still use it because of the direct effect on their farm.

3. Complexity of IPM procedures

IPM consist of some procedures start from identification, monitoring, action, and evaluation. For farmer that has awareness in the chemicals used will adopt IPM technology, but farmer with the low education and lack awareness on chemicals used will reject the IPM technology. Chi, T.T.N (2012) said that the extent of IPM application was low do to the complexity leading to difficulty to be applied by farmers. IPM comprises of many measures, which are not well acquired by farmer's educational level.

Table 4.9 Constraint on adoption IPM technology

Constraints	Rank
Complexity of IPM technology	1
Weak perception of IPM technology	2
Labor intensive	3
Easy access of pesticide	4
Lack awareness of pollution	5
Weed problem	6

Source: Survey

Table 4.10 Recommendation on IPM technology dissemination

Dimension	Recommendation
Policy oriented	Enhance the FFS training Provide periodical training for farmers Provide training for extension agent Increasing promotion of IPM practices in mass media
Implementation oriented	Increase the extension officer Increase the frequency of meeting Increase the coordination between farmers and extension officer Increasing young farmer participation Stakeholders should stimulate adoption of IPM technology

Source: Survey

Table 4.11 Matrix Analysis on main problem and recommendation of adoption IPM technology

Problem	Causal	Impact	Solution	
			Policy	Implementation
Weak perception of IPM	1. IPM is effective only for long term 2. Using chemicals is easier than IPM control procedures and the effect can be directly to the problem	1. Low adoption of IPM technology 2. Increase in chemicals consumption 3. Insect will more tolerant to the chemicals substance	1. Research and development in terms of IPM model 2. Promote the effect of chemicals used intensively 3. Provide training of FFS step by step	1. Farmers should aware with effect of chemicals used
Complexity of IPM program	1. IPM consist of some steps that it was too much for farmer	1. Farmer can not understand fully of IPM procedures	1. Research and Development in IPM models 2. Educate farmer	1. Extension officer should educate the farmer continuously
Labor intensive	1. Controlling and monitoring steps	1. Farmers prefer used chemicals	1. Research and development on efficiency labor used 2. Provide training for the farmers in controlling and monitoring	1. Farmers increase their capability in monitoring to decrease the labor used
Easy access of chemicals substance (pesticide)	1. Provided in every village 2. Easy to get the pesticide	1. High consumption of chemicals 2. High pollution	1. Government should makes limitation of chemicals access 2. Educate the farmers of using biological control	1. Extension officer should persuade the farmer to decrease the chemicals used
Lack awareness of pollution	1. Did not care about the chemical effects 2. Orientation in high yield only	1. Increasing of chemicals used 2. In efficient of FFS	1. Promote the IPM technique in the mass media 2. Promote the important of decreasing chemicals used	1. Farmer should increase frequency with extension officer
Weed problem	1. Condition of the area 2. IPM can not solve this problem	1. Decrease the yield 2. Farmer used chemicals 3. Low adoption of IPM	1. Research and development on weed control 2. Educate the farmer on weed control	1. Farmer can used hand picking

Source: Survey

CHAPTER 5.
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

1. Ratchaburi province covered by mountain and forest that has height 200-300 meters above sea level. The average of maximum temperature was 36.10 C while the average of minimum temperature was 21.40C. The precipitation and relative humidity was 84.3 mm and 71.3 % respectively. The main river for irrigation in Ratchaburi is Mae Klong River. Ratchaburi agriculture total area around 364,374 acres which 45.5% was very appropriate for rice cultivation, 36.5% was moderate appropriate for rice cultivation. Based on that amount, Chedi Hak Sub district has 7,093 acres of agricultural area which 13.1% is very appropriate for rice cultivation, while 86.4% was moderately appropriate.
2. This study was describe mainly based on a progressive farmer experience in adopting IPM in this study. The farmer was 56 years old and has been work as rice farmer more than 20 years. He manage 23 rais of rice farm which was rented land. There are two kinds of media perception including personal media and interactive media on IPM information provider. In his farm, he used Suphan cultivar which was produced in the local area. There are three kind of fertilizer that has been used including 46-0-0, 16-20-0, and 0-0-60. He did not used chemical substance on pest control but he used Trichoderma as biological control. Machinery was used in the land preparation, planting stage, and harvesting. He was belonging on cooperatives, BAAC, and farmer’s group. His farm income was 60,000 THB while his non farm income around 100,000 THB.
3. The farmer has known 23 sub items from 28 sub items or 82% of the IPM technology including prevention, identification, monitoring, pest control action, and evaluation. Farmer has positive attitude on IPM model. The progressive farmer has been agree with 21 sub items or 75% of total sub items. The farmer has been practices 22 sub items of IPM technology. while

in the comparison of knowledge and practices, farmer has been know mostly of the IPM technique but not all of the stage has been practices.

4. There are some factors affecting in adoption of IPM technology including personal background (age, education, experienced, and number of group belonging), input used factor (biological control availability, and chemicals substance availability), physical factors (water resources and soil suitability for rice), biological factors (pest, disease, and weed), social factor (IPM training and number of group belonging), economic factor (farm income), institutional factor(number of extension service and quality of service), and psychological factor (knowledges, attitudes, and practices).
5. There are some main constraint in adoption of IPM technology including complexity of IPM technology, weak perception of IPM technology, labor intensive, easy access of pesticide, lack awareness of pollution, and weed problem. although farmer already joined in the IPM training in terms of farmer field school (FFS) but majority of farmers still used large amount of pesticide. The main problem is the complexity of IPM technique that difficult to adopt by farmers.

5.2 Recommendation

Based on the findings, some recommendation can be made to the stakeholders in the appropriate strategy on policy, implementation, academic, and public to increase the adoption of IPM technology, specifically in Ratchaburi Province, Chedi Hak Sub district as follows;

1. Based on the findings, there are three aspect on the policy orientation measures including research and development, human resources development, and infrastructure support.
   a. Research and development in redesign and modify the IPM technology based on farmers capability.
   b. Research and development of weed control should be performed to increase the motivation of farmer decreasing chemicals used

c. Human resources development by providing training for farmers and extension officer to increase the capability.

d. Promote the IPM technique and adverse effect of chemicals used in the mass media such as television and radio to increase the awareness of farmer and increase the knowledge of farmer.

2. Extension officer should educate the farmer to increase their awareness on chemicals used by training and visiting approach. The extension service should maintain regularly. Farmer should increase their frequency on extension service to increase their knowledge.
3. In term of academic orientation, the knowledge about the adverse effect of excessive chemicals used and substitution of chemicals used to the biological control should be promote as technical know how to the farmers.
4. Consumer should more concern on the quality and safety of product in the reasonable price. It will increase the farmers awareness to their product and increase the motivation of farmer to get adopt the IPM technology.

LITERATURE CITED

Asia Productivity Organization (APO). 2000. *Farmer-Led Integrated Pest Management*. Tokyo: Asian Productivity Organization.

Bandara, R.M.G. and C. Sivayoganathan. 1999. Impact Assessment of Farmer Training in Integrated Pest Management in Irrigated Rice Cultivation. *Tropical Agriculutral Research Extension Journal* 2 (1): 51-54.

Bartlett, A. and H. Bijlmakers. 2003. *Did You Take Your Poison Today?* (Online). Available: http://thailand.ipm-info.org/documents/Your_poison_today_%28English%29.pdf

Bonobana, J. and Wabbi. 2002. *Assessing Factors Affecting Adoption of Agricultural Technologies: The Case of Integrated Pest Management (IPM) in Kumi District, Eastern Uganda.* M.S. Thesis, Virginia Polytechnic Institute.

Borkhani, F.R. , A. Rezvanfar, H.S. Fami and M. Pouratashi. 2010. Investigating the Major Bariers to Adoption of IPM Technologies by Paddy Farmers. *American-Eurasian Journal of Toxicological Science* 2 (3): 146-152, (Online). Available: http://www.idosi.org/aejts/2%283%2910/5.pdf

Borkhani, F.R. , A. Rezvanfar, H.S. Fami and M. Pouratashi. 2013. Social Factors Influencing Adoption of Integrated Pest Management (IPM) Technologies by Paddy Farmers. *International J. of Agricultural Management and Development* 3(3): 211-218, (Online). Available: http://www.ijamad.com /ijamad/3(3)/IJAMADSeptember2013P211.pdf

Buddhaboon, C. 2013. *Sustainable Rice Cultivation: A path Toward Climate Change Mitigation and Adaption***.** Bangkok: Rice Department (MOAC), Thailand.

Buhler, W. 1997. *Integrated Pest Management: Ideals and Realities in Developing Countries*. London: Lynne Rienner Publisher.

Chi, T. T. N. 2008. Factors Affecting Technology Adoption Among Rice Farmers In The Mekong Delta Through The Lens Of The Local Authorial Managers: An Analysis Of Qualitative Data. *Omonrice* 16: 107-112, (Online).Available: http://clrri.org/ver2/uploads/noidung/16-14.pdf

Choirotunissa. 2008. Hubungan Karakteristik Sosial Ekonomi Petani dengan Tingkat Penerapan Model Pengelolaan Tanaman Terpadu Padi Sawah di Desa Joho Kecamatan Mojolaban Kabupaten Sukoharjo. Skripsi. Surakarta: Universitas Sebelas Maret.

Dagupsta, S. 2004. *Is Environmentally-Friendly Agriculture is Profitable for Farmer Evidence on Integrated Pest Management in Bangladesh*

(Online). Available: http://www.eldis.org/vfile/upload/1/document/0708/DOC16950.pdf

Environment Protection Agency (EPA). 2012. *Integrated Pest Management* (Online). Available: http://www.epa.gov/oecaagct/tipm.html.

Fardiaz, M. Pengaruh Karakteristik Petani Terhadap Tingkat Pengambilan Keputusan Inovasi dalam Usaha Sayuran ORganik. *Thesis*. Bogor: Bogor Institute.

Food and Agriculture Organization (FAO). 2005. *Thailand* (Online).

Available: http://www.fao.org/docrep/008/af340e/af340e0l.htm.

Food and Agriculture Organization (FAO).2007. *Agriculture Key Player to Stop Degradation of Vital Ecosystems***.** Available Source: http://www.fao.org/NEWSROOM/en/news/2007/1000542/index.html.

Food and Agriculture Organization (FAO). 2013. *FAO Statistical Book 2013.*

Food and Agriculture Organization (FAO). 2013a. *Integrated Pest Management* (Online). Available: http://www.fao.org/agriculture/crops/core-themes/theme/pests/ipm/en/.

Food and Agriculture Organization (FAO). 2013b. *Prospects For the Environment Agriculture and The Environment* (Online).

Available: http://www.fao.org/docrep/004/y3557e/y3557e11.htm.

Food and Agriculture Organization (FAO). 2013c. *Rice Production in Thailand (1992-2012)* (Online). Available: http://faostat3.fao.org/wds/rest/table/excel.

Food and Agriculture Organization (FAO). 2013d. *Thailand Land Resources 2011* (Online). Available: http://faostat3.fao.org/faostat-gateway/go/to/browse/area/216/E.

Food and Agriculture Organization (FAO). 2013e. *Top 10 World Comodity Production in 2012* (Online**).** **a**vailable: http://faostat3.fao.org/wds/rest/table/excel.

Food and Agriculture Organization (FAO). 2013f. *World Annual Growth(2000-2012)* (Online**).** Available: http://faostat3.fao.org/wds/rest/table/excel.

Food and Fertilizer Technology Center (FFTC). 1992. *Sustainable Agriculture for The Asian and Pacific Region* (Online).

Available: www.**fftc**.agnet.org/files/volume/53/53_1.pdf

Fuchs, T. W. 2007. **Ecological Based Integrated Pest Management**. UK: Biddles Ltd.

Google Maps. Ratchaburi (satelit) (online). Available: https://www.google.co.id/maps/place/Provinsi+Ratchaburi,+Thailand/@13.5466922,99.6181599,151127m/data=!3m2!1e3!4b1!4m2!3m1!1s0x30e31dd8cf77f347:0xeb3e1ac0a7db5582?hl=id

Govind, S. And G. Perumal. 2004. Constraints Encountered in The Adoption of IPM Technologies. *Journal of Agricultural Science* 17(4): 741-746, (Online). Available: http://14.139.155.167/test5/index.php/kjas/article/viewFile

Greanpeace. 2008. *Agrochemicals Unmasked: Fertilizer And Pesticide Use In Thailand And Its Consequences To The Environment* (Online).

Available: www.greenpeace.org/seasia/th/.../2/agrochemicals-in-thailand-eng.pdf.

Green, W. H. 2002. *Econometric Analysis*. 5th Edition. New York: New York University.

Gujarati, D. N. 2004. ***Basic Econometrics***. 4th ed. New York: McGraw-Hill.

Hansen, B. 2013. *Econometrics* (Online). University of Wicanson.

Available: www.ssc.wisc.edu/~bhansen.

Harold. 1971. *Selectec Socioeconomic Characteristics of Farmers Associated with the Use of Soil Testing*. University of Park

Hasim, Mohd Bin Haji. 2013. Socio Economic Analysis on Rice Based Farming System Towards Efficiency Input Use: A Case Study in Mukim Bagan Serai, Kerian District, State of Perak, Northern Penisular Malaysia. *Thesis*: Kasetsart University.

Hoang, L. A., J.C. Castella, and P. Novosad. 2006. Social Networks and Information Access; Implications for agricultural Extension in a Rice Farming Community in Northen Vietnam. *Agricultural and Human Values* 23: 513-527, (Online).

Available: http://link.springer.com/article/10.1007%2Fs10460-006-9013-5#page-1

Huy, H.T. 2006. Technical Efficiency of Rice Producing Households in the Mekong Delta Vietnam. *Asian Journal of Agr. And Dev*.6(2): 35-50.

International Grains Council (IGC). 2013. *Five Year Global Supply and Demand Project* (Online). Available: www.igc.int/en/downloads/grainsupdate/igc_5yrprojections.pdf.

International Rice Research Institute (IRRI). 2009. *Integrated Pest Management of Rice in Rice-Wheat Cropping System* (Online). Available: http://www.knowledgebank.irri.org/ckb/PDFs/croppingsystem/agronomical/integrated%20pest%20management%20of%20rice%20in%20rice-wheat%20cropping%20systems.pdf.

Katz, D. A. 1982. *Econometric Theory and Applications*. New Jersey: Prentice Hall, Inc, Englewood Cliffs.

Kumar, P. and S. Mital. 2006. Agricultural Productivity Trend in India: Sustainability Issues. *Agricultural Economics Research Review* 19: 71-88, (Online).

Available: http://ageconsearch.umn.edu/bitstream/57779/2/DrP-Kumar.pdf

Kumari, G. 2012. Constraints in Adoption of Integrated Pest Management Practices by Rice Growing Farmers of Jammu Division. *Indian Research Journal of Extension Education* 2: 15-17, (Online).

Available: http://www.seea.org.in/special_issue/vol2/04.pdf

Malhotra, et all.2007. *Marketing Research*. Third Edition : Pearson Education.

National Statistic Organization (NSO). 2003. *Central Plain Agricultural Census* (Online). Available: http://www.nso.go.th

National Pesticide Information Centre (NPIC). Integrated Pest Management. The Oregon University (Online). Available: http://www.uaf.edu/files/ces/districts/tanana/mg/manual/23-Integrated-Pest-Management.pdf.

Nelleman, C. et al. 2009. *The environmental Food Crisis; The environment's Role in Future Food Crisis*. Northway: Bikkerland Tlykkert.

Nevada University. 2013. *Principles in Integrated Pest Management* (Online). Available: http://www.unce.unr.edu/programs/sites/ipm/principles/.

Norton, G.A, and J.D. Mumford. 1993. *Decision Tools for Pest Management*. Cambridge: UK Press.

Office of Agricultural Economic. 2011. *Agricultural Statistic of Thailand 2011*. Ministry for Agricultural and Cooperatives Bangkok: Thailand.

Office of Agricultural Economic. 2012. *Agricultural Statistic of Thailand 2012*. Ministry for Agricultural and Cooperatives Bangkok: Thailand.

Office of Agricultural Economic. 2013. *Agricultural Statistic of Thailand 2013*. Ministry for Agricultural and Cooperatives Bangkok: Thailand.

Ofuoku, A.U., E.O. Egho and E.C. Enujeke. 2009. Integrated Pest Management (IPM) Adoption among Farmers in Central Agro-Ecological Zone of Delta State, Nigeria. *Advances in Biological Research* 3 (1-2): 29-33, (Online). Available: http://www.idosi.org/abr/3%281-2%29/6.pdf

Palis, F. G. 2006. The Role Of Culture In Farmer Learning And Technology Adoption : Case Study Of Farmer Field Schools Among Rice Farmers In Central Luzon Philippines. *Agriculture and Human Values* 23: 491–500, (Online). Available: http://link.springer.com/article/10.1007%2Fs10460-006-9012-6#page-1

Panayotou, T. 1993. *Green Markets; The Economics of Sustainable Development*. California: Institute for Contemporary Studies.

Panuwet, P. 2012. Agricultural Pesticide Management in Thailand: Situation and Population Health Risk. *Environmental Science Policy* 17: 72–81, (Online). Available: http://www.ncbi.nlm.nih.gov/pubmed/22308095

Ping, X. 2004. Environmental Problems and Green Lifestyle in Thailand. Thailand: Asumption University.

Praneetvatakul, S., P. Schreinemachers, P. Pananurak, and P. Tipraqsa. 2013. Pesticides, External Costs and Policy Options For Thai Agriculture. *Environmental Science and Policy* 27: 103-113, (Online). Available: http://www.sciencedirect.com/science/article/pii/S1462901112001906

Rahman, M. M.. 2012. Problems and Suggestions for Farmers Adoption of IPM Practices in Rice Cultivation. *Bangladesh J. Agr. Res*. 37(1): 121-128, (Online). Available: www.banglajol.info/index.php/BJAR/article/download/11183/8169

Ms. Rattana. Extension Officer of Department of Agricultural Extension. June, 23, 2014.

Rianse, Usman and Abdi. 2009. *Metodologi Pneelitian Sosial dan Ekonomi (Teori dan Aplikasi)*. Bandung: Alfabeta.

Rice Department of Thailand. 2014. *Soil Suitability for Rice in Ratchaburi, Chedi Hak* (Online). Available: http://www.ricethailand.go.th/home/index.php?option=com_wrapper&view=wrapper&Itemid=44.

Rogers, E.M. 2003. *Diffusion of Innovations*. 5th ed.. New York: Free Press.

SAI. 2010. *Sustainable Agriculture* (Online).

Available: http://www.saiplatform.org/sustainable-agriculture/definition.

Sanders, H.C. 1966. *The Cooperatives Extension Service***.** United State: Prentice Hall-Inc.

Sangbuapuan, N. 2012. ICT Policies Influencing Development of Rice Farming in Thailand: A Case Study of the Community Rice Center of The Rice Department. *International Journal of Innovation, Management and Technology* 3(6):763-768, (Online).

Available: http://www.ijimt.org/papers/334-CM327.pdf

Singh, A., A.K. Vasiht, R. Kumar, and D.K. Das . 2008. Adoption of Integrated pest Management Practices in Paddy and Cotton: A case Study in Haryana and Punjab. *Agr. Econ. Research Review* 21: 221-226, (Online).

Available: http://ageconsearch.umn.edu/bitstream/47675/2/7-Alka-Singh.pdf

Sutarto. 2008. Hubungan Sosial Ekonomi Petani dengan Tingkat Adopsi Inovasi Teknology Komoditas Jagung di Sidoharjo Wonogiri. Agritech No. 24.

Tapintha, A. 1998. *Pesticide Use and Residual Occurrence In Thailand*.

Available: http://link.springer.com/content/pdf/10.1023/A:1006156313253

Thailand Meteorological Department (TMD). *Yearly Statistic Data Classified by Month (Ratchaburi Meteorological Station)* (Online). Available: http://www.aws-observation.tmd.go.th/web/reports/weather_year.asp

Tiamiyu, et all. 2009. Technology Adoption and Productivity Difference among Growers of New Rice for Africa in Savana Zone of Nigeria. Tropicultura (27): 193-197 (Online). Available: http://www.tropicultura.org/text/v27n4/193.pdf.

University of Kentucky. 2012. *Sustainable Agriculture* **(**Online).

Available : http://sustainableag.ca.uky.edu/

Upadhyay, R. K. 1998. *Integrated Pest and Disease Management***.** New Delhi: APH Publishing Corporation.

United State Department of Agriculture (USDA). 1999. *Sustainable Agriculture; Definition and Terms* (Online).

Available: http://www.nal.usda.gov/afsic/pubs/terms/srb9902.shtml

Veisi, H. 2012. Exploring the Determsinants of Adoption Behaviour of Clean Technologies in Agriculture a Case of Integrated Pest Management. *Asian J. of Technology Innovation* 20(1): 67–80, (Online). Available: http://www.tandfonline.com/doi/pdf/10.1080/19761597.2012.681435

Walit. Rice Progressive Farmer. June, 23, 2014.

World Bank. 2005. *Pest Management Guide Book* (Online)**.** Available : http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTARD/EXTPESTMGMT/0,,contentMDK:20631451~menuPK:1605318~pagePK:64168445~piPK:64168309~theSitePK:584320,00.html

World Health Organization (WHO). 2010a. *Food Security* (Online).

Available: http://www.who.int/trade/glossary/story028/en/.

World Health Organization (WHO). 2010b. **Guidelines on Public Health Pesticide Management Policy** (Online). Available: www.who.int/whopes/resources/SEA_CD_.

World Map. 2011. Ratchaburi Maps (Online). Available: http://www.mapsofworld.com/thailand/provinces/ratchaburi-map.html

APPENDICES

APPENDIX A. Appendix Cost and Return

i. Total Variable Cost

Total variable cost (TVC) consists of total variable input cost. It includes cost for seeds, fertilizer use, pesticides use, farm equipment input, machine input and others input cost such as gasoline for farm, electricity, etc.

ii. Total Fixed Cost

Total fixed cost (TFC) consists of land utilization cost, land tax, and depreciation cost of farm machine.

iii. Total Cost

Total cost (TC) is determined by total variable cost (TVC) + total fixed cost(TFC) by both cash and non cash expenses:

TC= TVC+TFC

Cost of seeds : the cost of seed that farmers produce and buy from the government agency or private company at quantity and current price.

Cost of fertilizer : the cost of fertilizers input that farmers receive from subsidy and buy from the input supplier at quantity and current price.

Cost of pesticide : cost of pesticides input that farmers receive from subsidy and buy from the input supplier at quantity and current price

Cost of labor input : cost of labor inputs consists of both cash and non cash expenses that farmers pay for labor forces including family and paid labor. The measures and calculation are by hour and land size in ha for each activity. Labor cost is determined by number of working hour per rai multiplied by minimum wage rate per day and divided by 8 hours per day. In addition, man day is determined by number man per day multiplied by number of working hour per day and multiplied by number of days, divided by 8 hours per day.

$$\text{Man labor cost} = \frac{(\text{Number of working hour/rai x Wage rate/day})}{\text{8 hours/day}}$$

$$\text{Man day} = \frac{\text{Number of working man/day x Number of working hour/day/one person x Number of days}}{\text{8 hours/day}}$$

Cost of machinery input: Cost machinery input consists of farmers owned machine and hired machine from service provider.

Depreciation Cost: Cost of farmers own asset that is used for rice cultivation. The straight line method is applied to calculate their depreciation cost according to Aungsuratana (2000) cited in Hasim (2003), under the condition of:

i. Four wheel tractor with 15-60 H.P, the working life span is 10 years;
ii. Two wheel tractor with 7-15 H.P., the working life span is 8 years;
iii. Plough machine, the working life span is 10 years;
iv. Diesel engine, the working life span is 7 years;
v. Petrol engine the working life span is 5 years;
vi. Irrigation pump, the working life span is 6 years;
vii. Sprayer engine, the working life span is 6 years;
viii. Transplanting machine, the working life span is 10 years;
ix. Combine machine, the working life span is 10 years;
x. Thresher, the working life span is 10 years.

Depreciation of each farm machine cost per year is determined by value of the first bought price subtracting by value of the last operated price divided by number of operated year and multiplied by percentage of operated period.

$$\text{Depreciation cost} = \frac{\text{First buying value-Current value}}{\text{Number of operated}} \times \text{\% of Operated period}$$

Cost of land use: cost of land use is non cash expense calculated from total cultivated area which farmers use for cultivate rice in main crop year 2013/2014 under rented land rate. Theoretically, the suitable method to determine cost of land use consists of two categories, includes calculate from cost of rented land (which comes form number of planted land multiplied by rented land rate, then divided by twelve month then multiplied by production month) and calculate from land tax cost.

Cost of land use = (Total cultivated area x Rented land rate) + (Cost of land tax)

Opportunity cost of capital: According to Aungsuratana (2000) cited in Hasim (2012), opportunity cost of capital consisted of the opportunity cost of non cash and cash expense. For non cash expenses, it is determined by total variable non cash cost multiplied by savings interest rate and divided by production month of rice crop per year. For cash expenses, will be determined by total variable cash cost multiply by loan interest rate.

Opportunity cost of non cash expenses = Total variable non cash cost x Saving interest rate

Opportunity cost of cash expenses = Total variable non cash cost x Loan interest rate

iii. Return analysis

To analyze the return of rice cultivation, the following measures will be calculated, includes: yield, net earning, and .net profit

iv. Gross Revenue: The gross income of re cultivation is defined as the value of the total output of rice cultivation over main crop year 2013/2014, whether output is sold or not. The gross enterprise income was determined by total yield harvested (TP) multiplied by selling price (P) to government, private miller or middle man. Therefore, the gross income was measured as total revenue (GR) of rice cultivation.

$$GR = TP \times P$$

ii. Net Earnings: Net farm earnings is total to all owned available resources use in farm production. Net farm earnings are determined by gross enterprise income subtracting by variable cash cost.

$$NE = GR - TVC \text{ (cash cost)}$$

iii. Net Profit : Net profit of rice cultivation is defined as the return of rice enterprise production in main crop year 2013/2014. The net profit is determined by gross enterprise income subtracting by total cost.

$$NP = GR - TC$$

Appendix B. Appendices of Figures

Figure 1Together with rice progressive farmer and extension officer

Figure 2 Farmer learning centre, CHedi Hak Sub district

Figure 3 In depth interviewing with extension officer

Figure 4 In depth interviewing schedule with rice progressive farmer

Figure 5 Rice condition in the study area

APPENDIX C. Survey Item

FACTORS AFFECTING RICE FARMER'S ADOPTION IN INTEGRATED PEST MANAGEMENT TECHNOLOGY: A CASE STUDY OF CHEDI HAK SUBDISTRICT RATCHABURI PROVINCE,

KASETSART UNIVERSITY

General information of respondent

1. Name :
2. Address, village : ……………………………….Moo……………………………No…………. ……...
   Street …………………………………………….Alley……………………………….
   Sub district……………………………….District…………………………. ………..
3. Occupation :a. Progressive farmer
   b. Extension Officer
   c. Farmers group leader
   d. Middleman

Date :

Signature of Respondent,………………………..2014,

( )

PART I. PERSONAL BACKGROUND OF RESPONDENT

1.1	Age	:			
1.2	Gender	:	( ) Male	( )Female	
1.3	Working status		( ) full time	( ) part time	
	Experienced	:			
	Education level		( ) less than primary ( )informal school		( ) junior high school ( ) senior high school ( ) university

1.4 Household Information

No	Relationship	Gender (M/F)	Age (Year)	Education	Occupation		
					Farm Labor	Non Farm	Others
1							
2							
3							
4							

1.5 Media perception of IPM

Type of Media	Times			Information*
	Week	Month	Year	
1 Personal Media				
1.1 Neighbor				
1.2 Group Leader				
1.3 Government Officer				
1.4 Private Officer				
2 Mass Media				
2.1 Newspaper				
2.2 Television				
2.3 Radio				
2.4 Internet				
3 Interactive Media				
3.1 Training course				

Note : *

1	:	Rice varieties	3	:	Pesticide use	5	:	Economic Threshold Level
2	:	Fertilizer use	4	:	Water use	8	:	IPM control

PART II. Input Used Factors

Component	Category	Name	Amount	Price	Total Cost	Total
Seed	Multiplication					
	Farm save					
Fertilizer	Chemical					
	Organic					
Pesticide	Herbicide					

	Fungicide					
	Insecticide					
Machinery	Preparation					
	Plant stage					
	Harvest					
Labor	Family					
	Hired					
Land use	Owner					
	Rent					
	Tax					
Other	Water					
	Petroleum					
	Electricity					

PART III. BIOLOGICAL FACTOR

No	Infestation of pest and disease	Percentage of damage (%)
1	Pest (specify)	1 2 3 4
2	Rats(specify)	1 2 3 4
3	Weed (specify)	1 2 3 4
4	Disease (specify)	1 2 3 4
5	Others (specify)	1 2 3 4

Note:

1= Less than 20% 2=25-50% 3=51-75% 4= more than 76%

PART IV. SOCIAL BACKGROUND

4.1 Number of Group Belonging

No	Organization	Position		What kind activity	What is the benefit?
		General	Committee		
1	Cooperatives				
2	BAAC				
3	Farmer’s group				
4	House wife group				
5	Youth group				
6	Rice cultivator group				
7	Others				

4.2 IPM Training

No	Organized by:	Information (Content)
1		
2		
3		

PART V. ECONOMIC FACTOR

5.1 Land Tenure and Utilization

Please specify the related information to the land that you have been occupied in main crop year 2013/2014.

No	Land Size	Location	Ownership			Land Utilization
			Owned	Rented	Least	
1						
2						
3						
Total						

5.2 Accessibility to credit

5.2.1 Do you access any credit facilities in crop year 2013 ?YES (   )NO (   )

5.2.2 If YES please provided information below:

If yes, where you get the credit?

( ) BAAC ( ) Commercial bank

( ) Agricultural Cooperatives ( ) Others

How much the amount of credit and the interest (% per year)?

If NO why you did not access the credit?

( ) Not available ( ) Enough capital

( ) High interest ( ) Others

5.3 Rice yield and income

Please specify the yield that you has been harvested and sold in main crop year 2013/2014.

category	Land size/ name	Yield(Unit/year)	Price (Bath)	Quantity	Total Income (Bath/year)
Farm					
Non farm					
Total					

PART VI. INSTITUTIONAL FACTORS

6.1.1 Concerning of rice production improvement, please specify who are the extension agents, the frequency of them visiting you in main crop year 2013/2014 as follows:

No	Type of Extension Agent	Frequency	Quality	Information
1	DOA staff		1 2 3 4 5	
3	University Staff		1 2 3 4 5	
4	Company		1 2 3 4 5	
6.	Others		1 2 3 4 5	

Note :

1=Very Poor 2=Poor 3=Moderate 4=Good 5=Very Good

Part VII. Farmer's Knowledge and Practices towards IPM technology

7.1 Prevention

1. What is the suitable way to get proper sanitation before planting?

   a. Tillage soil b. Herbicide application c. No idea

   Do you tillage the soil in land preparation?

   a. Anytime b. Rarely c. Never

2. What is the suitable varieties of rice to prevent brown plant hopper damage?

   a. RD 31 b. RD 47, RD 49 c. Depend on the price

   Do you use rice varieties RD 47,RD49 to prevent brown plant hopper damage?

   a. Anytime b. Rarely c. Never

3. What is the appropriate spacing for paddy field?

   a. 20x30 cm or 30x30cm b. 5x5 cm or 10 x10 cm c. No idea

   Do you use 20x30 or 30x30 cm for spacing?

   a. Anytime b. Rarely c. Never

4. How is the right water system management to control weeds?

   a. 5-10 cm from soil surface b. No irrigation c. No idea

   Do you maintenance water level 5-10 cm from soil surface to control weeds?

   a. Anytime b. Rarely c. Never

5. What is the suitable amount for Urea application in top dressing?

   a. 5-10 kg/rai b. 10-20 kg/rai c. No idea

   Do you apply urea 5-10 kg/rai in top dressing?

   a. Anytime b. Rarely c. Never

6. When is the appropriate time for fertilizer application in the first time?

   a. 14-15 days after transplanting b. Directly after transplanting c. No idea

Do you apply the fertilizer in the first time 14-15 days after planting?

a. Anytime b. Rarely c. Never

7. When is the appropriate time for fertilizer application in the second time?

a. 45 days after transplanting b. 60 days after transplanting c. No idea

Do you apply the fertilizer in the second time in 45 days after transplanting?

a. Anytime b. Rarely c. Never

8. What is the suitable method of rice harvesting to prevent pest damage?

a. Close to ground b. Far from ground c. No idea

Do you use method close to ground in harvesting?

a. Anytime b. Rarely c. Never

9. What is the suitable way in prevent pest infestation?

a. Rotation annual crop b. Rice plant in every year c. No idea

Do you rotate your planting in one year?

a. Anytime b. Rarely c. Never

10. What is the suitable way in prevent infestation based on your experienced?

a. Used herbs b. Used pesticide c. No idea

Do you use herbs as prevention on your field?

a. Anytime b. Rarely c. Never

7.2 Identification

1. Which one is bneneficial organism?

a. Spider b. catenpilar c. Snail

Do you think that spider is beneficial organism?

a. Anytime b. Rarely c. Never

2. What do you estimate if there is insect with brown wings (5 mm long)?

d. Brown plant hopper e. Ants f. Spider

Do you estimate that if there is an insect with brown wings is BPH?

a. Anytime b. Rarely c. Never

3. How do you identify pest damage in your field?

a. The cause of problem and associated plant or animal species must be correctly identified
b. Take a look in small sign of damage
c. Use experience

Do you identify the problem, causal and associated plant or animal species correctly before do the appropriate treatment?

a. Anytime b. Rarely c. Never

7.3 Monitoring

1. What should you do if found 1 BPH /plant during monitoring?

   a. Kill the plant b. Leave it c. Insecticide application

   Do you apply insecticide if found 1 BPH/plant?

   a. Anytime b. Rarely c. Never

2. What is the natural enemies that common use to release in the paddy field?

   a. Trichoderma b. Ants c. Plant hopper

   Do you use Trichoderma as natural enemies in your field?

   a. Anytime b. Rarely c. Never

3. What is appropriate time to monitoring?

   a. Regularly b. In the early of planting c. No idea

   Do you do regularly monitoring to know early symptoms?

   a. Anytime b. Rarely c. Never

4. How much injury of plant hopper damage can tolerable?

   a. <10 larva/hill b. >10 larva/hill c. No idea

   Do you tolerate if there is less 10 larvae/hill rice plant ?

   a. Anytime b. Rarely c. Never

   a. Anytime b. Rarely c. Never

5. How to maximize the monitoring procedure?

   a. Save in mind b. Give announcement c. Write a record

   Do you write a record for monitoring procedure as your guidelines?

   a. Anytime b. Rarely c. Never

7.4 Pest control action

1. What should you do to protect rice area from rats damage?

   a. Canopy of rice plant b. Traps c. Barriers

   Do you use canopy in rice plant to protect the area from rats damage?

   a. Anytime b. Rarely c. Never

2. What should you do to protect area from plant hopper damage?

   a. Hand picking b. Light traps c. Barriers

   Do you use light traps to protect your area from plant hopper damage?

   a. Anytime b. Rarely c. Never

3. What should you do to protect the field from weed?

   a. Hand picking b. Light traps c. Barriers

   Do you use hand picking method to remove the weed?

   a. Anytime b. Rarely c. Never

4. What is the appropriate method to create habitat for beneficial organism?

   a. Food and water availability b. Predator availability c. No idea

   Do you create the habitat for beneficial organism?

   a. Anytime b. Rarely c. Never

5. What is the appropriate natural enemies for rice pest?

   a. Silk b. Trichoderma c. Ants

   Do you use Trichoderma in your rice field?

   a. Anytime b. Rarely c. Never

6. What is the indicator to use pesticide?

   a. Monitoring result, ETL b. Neighbor field condition c. No idea

   Do you based on monitoring result before use pesticide?

   a. Anytime b. Rarely c. Never

7. What is the right time to apply pesticide?

   a. Planting stage b. Early of planting c. Every week

   Do you apply pesticide in planting stage?

   a. Anytime b. Rarely c. Never

8. What is the right criteria of pesticide?

   a. Less harmful to environment b. Low price c. High price

   Do you choose pesticide based on least harmful in environment?

   a. Anytime b. Rarely c. Never

7.5 Evaluation

1. What should you do during evaluation?

   a. Continue monitoring b. Leave the field c. No idea

   Do you still continue of monitoring during evaluation process?

   a. Anytime b. Rarely c. Never

2. What is the suitable way to end the IPM process?

   a. Save in mind b. Give announcement c. Write a record

   Do you write a record to keep the appropriate strategy of pest management?

   a. Anytime b. Rarely c. Never

PART VIII. ATTITUDE OF IPM TECHNOLOGY

	Items	Agree	Not sure	Disagree
1	**Prevention**			
	i. Tillage the soil in land preparation			
	ii. Use 20x25 or 30x30 cm for spacing			
	iii. Use tolerable varieties in BPH			
	iv. Maintenance water level 5-10 cm from soil surface			
	v. Apply 5-10 kg of Urea in top dressing			
	vi. Apply fertilizer 14-15 days after planting			
	vii. Apply fertilizer 45 days after transplant			
	viii. Harvest close to ground can decrease pest damage			
	ix. Rotating annual crop to decrease pest infestant			
2	**Identification**			
	i. Estimate that if there is an insect with brown wings with length 5 mm of body is brown plant hopper			
	ii. Spider is beneficial organism			
	iii. Identify the problem, causal, and associate plant or animal species correctly before do the treatment			
3	**Monitoring**			
	i. Apply insecticide when find 1 BPH/plant			
	ii. Trichoderma common use as natural enemies			
	iii. Regularly monitoring to know early symptoms			
	iv. Tolerable level is if less than 10 larvae/hill rice plant			
	v. Distinguished between pest and beneficial organism correctly			
	vi. Write a record for monitoring procedure as your guidelines			
4	**Pest control action**			
	i. Use traps to prevent rat damage			
	ii. Use light traps to prevent plant hopper damage			
	iii. Use hand picking to remove weed			
	iv. Create habitat for beneficial organism is important step in IPM			
	v. Using Trichoderma as natural enemies			
	vi. Spray early in the day when insect are less active can protect beneficial organism			
	vii. Using guidelines for pesticide use (appropriate dosage)			
	iii. Applying pesticide in planting stage			
	ix. Chose pesticide based on least harmful environment			
5	**Evaluation**			
	i. Still monitoring during evaluation process			
	ii. Write a record for future guidelines is important			

PART IX. CONSTRAINT AND RECOMMENDATION

8.1 Constraint in adoption IPM technology

Items	Have		Solution	
	No	Yes	Never	Have
Personal constraints				
Farm size				
Lack of awareness of pollution				
Weak perception of IPM technology				
Physical constraints				
Lack of adequate drainage facilities				
Biological constraints				
Weed problem				
Pest and disease problem				
Input used constraints				
Labor intensive				
Non availability of input				
High cost input				
Lack of equipment facilities				
Easy access to chemical				
Complexity of IPM technology				
Social constraints				
Lack of farmer active organization				
Lack of coordination between farmer and extension agent				
Economic constraints				
Lack of credit facilities				
High rate of interest				
Lack of capital				
Lack knowledge about balanced fertilizer				
Lack knowledge about control				
Lack knowledge about ETL				
Institutional constraints				
Lack of proper training facilities				
Lack of extension service				
Lack or training for extension worker				
Difficult to contact extension worker				

8.2 Recommendation of IPM technology

No	Recommendation	Agree	Not agree
1	**Implementation**		
	Enhance extension service		
	Increasing frequency of meeting		
	Increasing coordination between farmer and extension worker		
	Increasing young farmer and woman participation of training program		
	Stakeholders (traders, administrators, and scientist stimulate adoption of technology		
2	**Policy**		
	Enhance the FFS training		
	Provide periodical training for farmers		
	Provide training for extension agent		
	Increasing promotion of IPM practices through national media		
	Provide credit facilities		
	Prohibit insecticide selling without prescription		

MATRIX ANALYSIS OF
SWOT AND FACTORS AFFECTING RICE FARMER'S ADOPTION
IN INTEGRATED PEST MANAGEMENT TECHNOLOGY:
A CASE STUDY OF CHEDI HAK SUBDISTRICT
RATCHABURI PROVINCE,

Component	Agree	Disagree	Not sure	Description and Recommendation
		Strength		
Soil suitability				
Biological control availability				
Experienced in rice farm				
Water resources				
Farm size				
Education level of farmer				
Availability of native knowledge				
Personal background (age, education, gender)				
		Weakness		
Lack awareness of environmental pollution				
In ability to take risk without using insecticide				
Chemical substance availability				
Low price of product				
High production cost				
High cost of pest control				
Complexity of IPM				
Less reliable information				
Labor intensive				

Lack knowledge of farmer				
Personal background (age, education, gender)				
Opportunity				
Thailand Agricultural Standards				
GAP Standardization				
Government Policy				
Extension service				
Financial support				
IPM training (Farmer Field School)				
Threat				
Brown Plant Hopper				
Disease				
Weather				
Disaster				
Price				

Problem	**Causal**	**Impact**	**Solution**	
			Policy	**Implementation**
Non Availability of bio control				
High cost in pest control				
Complexity of IPM program				
Lack of funding				
Others….				