DEVELOPMENT OF GREENHOUSE CROP PRODUCTION IN THAILAND

Thammasak Thongket
Department of Horticulture
Faculty of Agriculture at Kamphaeng Saen
Kasetsart University, Thailand
E-mail: thammasak.t@ku.th

ABSTRACT

The use of greenhouses for commercial-scale crop production in Thailand was not realized until the early 1990s when the “Doi Kham” foundation, the former King Rama IV Royal Project, disseminated the greenhouse technology to their hill-tribe contracted growers in the Northern region in order to make all-year round crop production feasible. In the short following time, the distinctly widespread use of greenhouse took placed as the emerging of soilless culture industry occurred in the mid 1990s and during the last decade, the challenges caused by climate change and the demand for high quality vegetables from the health concerned consumers has pressured the vegetable growers to consider adopting a kind of protected cultivation technology for producing their crops. Lastly, the latest Thailand 4.0 government policy for economic development launched in 2016 has pushed forward the use of the greenhouse technology for crop production with higher efficiency. Therefore, the greenhouse crop production especially for horticultural crops in Thailand is in the promisingly rising trend. In general, the greenhouse types used in Thailand can be classified according to the levels of technology as the follows: 1) the low-technology greenhouse such as insect exclusive net-house made by local technology and the cost ranges between US$ 15-25 per square meter. This type is commonly and widely used for growing the domestic leafy and fruit vegetables such as lettuces, Chinese kale, Pak choi, basil, water spinach, eggplant, hot chili and yard-long bean in the central region; 2) the moderate technology greenhouse which has naturally ventilated-roof structure cladding with UV-protected polyethylene sheet and insect-exclusive-net at the side walls made by either local or imported technology and the costs ranges between US$ 35-60 per square meter. This greenhouse type is the most popular for growing high-value exotic crops such as melon, cherry tomato and exotic cucumber as well as ornamental crops such as chrysanthemum in different regions; and 3) the high technology greenhouse which is the closed or semi-closed system type such as the greenhouse with the fan-pad evaporative cooling system and with or without the automatic climate control and fertigation system mostly made by imported technology and the cost ranges between US$ 80 until >120 per square meter. The use of this high cost greenhouse technology is still limited and mostly used for growing the high-value and exotic cool-season crops such as lettuces, strawberry, sweet pepper and the high-value orchid e.g. Phalaenopsis. The research finding for suitable growing media and fertigation technique has been conducted in some extent but for greenhouse cooling is very limited. Hence, the major problems for greenhouse crop production found in Thailand is the heat accumulation and the greenhouse design that is suited for tropical climate condition with reasonable price is highly desirable.

INTRODUCTION

Thailand is located between 5°37′ and 20°27′ latitude and between 97°22′ and 105°37′ longitude. This gives Thailand the tropical monsoon climate with three distinct seasons namely: the summer season (March to May) with hot and humid condition, the rainy season (June to October) with rain storm and mild temperature and the winter season (November to February) with relative cool, dry and sunny sky conditions. However, the micro climate condition varies with regions and topography.

Despite of the continuous declining of contribution of agriculture to total GDP (from 13.34% in 2011 to 8.33% in 2016), the agricultural sector still continuously plays the vital role for the Thailand economy and well-being of Thai people since it involves more than 40% of country population and 50% of land used. Therefore, the agricultural development has been the major focus in every National Economic and Social Development Plans. Nevertheless, at the present, Thai growers are encountering a number of crop production constraints, e.g. climate change, pest infestation, water and labor shortage and environmental pollutants. These constraints cause yield and quality reduction and the all-year round crop production could not be realized. Moreover, the labor in the agriculture sector is aging and the number is decreasing due to the migration to industry and service sectors which are growing up and look more promising. The crop production method with higher efficiency is urgently required to cope with above mentioned challenges. For horticultural crop production, the protected cultivation
by growing crops under greenhouse condition which is popular in temperate and subtropical climates to protect crops from undesirable weather condition allowing crops to be grown throughout the year may be the solution to Thailand current problems. Since, this technology has been used successfully to grow crops, especially the high-value one, under the adverse conditions in different climate of various places around the world. Therefore, in the late 2011s, Thai government has begun to push forward the development of smart farming technology in which, for the horticultural sector, greenhouse technology is to replace the less effective out-door farming.

GREENHOUSE CROP PRODUCTION

Chronology of Development

Although, the greenhouse technology has been using for crop production worldwide for more than 100 years but the commercial greenhouse crop production in Thailand, by far, is relatively limited as compared with Japan, Korea, Taiwan and China.

The late use of greenhouse for commercial purpose might be because in the past, the lower-cost crop production in the open field was successfully accomplished without environmental hardship. Therefore, the costly greenhouse technology could not yet play much role in commercial crop production but rather, it was used for research purpose in both public and private institutes. It was until 1990 onward that the use of greenhouse technology for commercial purpose in Thailand began to be realized.

The well-known public enterprise that is most likely the pioneer of using greenhouses for commercial crop production in Thailand is the “Doi-Kham” foundation or the Royal Project Foundation as the former name. This organization has been using greenhouses for both research and commercial production purposes since early 1990’s. The different greenhouse technologies from different sources were tested in their research stations. The technology that was mostly suited to their environment was transferred to their contracted growers of 38 royal project development centers. Their contracted growers are the hill-tribe people who live in 10 provinces of the Northern region of Thailand. In the past, they used to grow the opium poppy and cultivated some other field-crops by using slash and burn manner. Both activities were illegal causing them to hide or run-away from law enforcement without the opportunity to settle down their families and had normal life of living. By the long vision and kind heartedness of His Majesty the late King Rama IX, the royal project, therefore, was initiated since 1969. The aim of this project were to provide the opportunity for the hill-tribe people to perform various farming and earn regular income that could support their good living. The integrated agricultural extension projects were introduced to these hill-tribe people living around each of the center. The plant growing techniques and essential input supplies for farming were given to them. The harvested produces were bought back to the centers with the reasonable price according to their quality and the produces were further sold to the consumers both domestic and abroad. The greenhouse technology was introduced to these contract growers since the early 1990’s to facilitate the growers to be able to grow crop all-year round. Since, during the dry season in the hilly area, water is the limiting factor for growing crops in the open field. By using greenhouse, one can grow crop such as tomato, cucumber and sweet pepper all-year long. The success of greenhouse crop production by the growers in the “Doi-Kham” foundation project proved that the greenhouse technology could make crop growing possible under changing weather conditions in Thailand over different seasons of a year.

The extensively widespread greenhouse crop production in Thailand took place when the soilless culture industry in Thailand emerged in the mid 1990s. Beside the substrate culture growing technique for growing crops in the greenhouse used by growers of “Doi Kham” Foundation, the various hydroponics technique were brought to Thailand for producing high-value vegetables such as lettuces, herbs, melon, sweet pepper, tomato and exotic cucumber. Prior to the introduction of this commercial hydroponic technology, Thailand had to import the high quality exotic variety lettuces that are used by high-class restaurants and hotels and airlines and they were relatively expensive. Therefore, the well-known hydroponic technique called Nutrient Film Technique (NFT) was brought to Thailand by a private company named the Accent Hydroponics 1997 (Thailand) in 1997. This technique was widely accepted by many growers around the country who were interested to grow these exotic-variety lettuces and supply them to the high-demanding local markets. However, this exotic variety lettuce was vulnerable to tropical climate condition in Thailand especially during hot and rainy seasons when air temperature and humidity are too high causing the growth reduction, tip burn symptom and early bitter taste developing. The greenhouses technology, then, were used in order to protect the crop from excessive heat and moisture. As the result, the all-year round production of these lettuces become feasible under the tropical climate condition in Thailand. Another classic example of the extensive use of greenhouse for the successful all-year round crop production in Thailand was for melon growing. Melon is the exotic plant to Thailand originating from hot and arid zone of the Africa and Southwest Asia. It is vulnerable to humid climate. The excessive moisture during the rainy season can promotes the infection of downy mildew disease, the harmful leafy disease for cucurbits. The growth, yield and quality of infected melon plants are decreased dramatically. Lately, the demand for high quality melon in Thailand is increasing and the price per kilogram
ranges between US$2-4. This can give a fortune for the growers who can produce the high quality melon especially in the wet and cool seasons. Polyethylene roof greenhouse then is used to protect melon from rain-fall in the rainy season and from chilling temperature during the night time in the winter season.

Later, the pressure from the health-concern consumers during the last decade forced the vegetable retailers to exclusively buy only chemical-free and high quality vegetables from their suppliers. As the consequence, vegetable suppliers, therefore, passed the pressure to their contracted vegetables growers to seriously change their cultural practice toward the Good Agricultural Practice system. Many growers, especially leafy vegetable growers, then turned to use greenhouse technology for producing their crops. This made the greenhouse use gradually became more widely spread across the country.

**Application of Greenhouses**

The use of greenhouses for research and germplasm conservation works in both public and private institutes in Thailand have a long history before they were used for commercial production of high value vegetables and flowers. These crops mostly are exotic and vulnerable to adverse conditions and pests in Thailand. By growing them under greenhouse condition, the high yield and quality throughout the year can be realized. Later, the greenhouses are used by the seed companies for commercial seed production and for the last decades, they have played a great role in the commercial seedling production which is the rising agro-business in Thailand. Furthermore, nowadays, greenhouses are also used in the tourism business. The exotic vegetables and flowers such as lettuces, melons, strawberry, tulip, lily and orchids, etc., are cultivated inside the greenhouses as the display to attract tourists in many agro-tourism farms and resorts around country.

**Greenhouse Technology**

*Technology sources*

At the beginning, the greenhouse technology for commercial crop production used in Thailand came from oversea. It was imported by the leading agro-business companies in Thailand from the world’s leading greenhouse technology countries such as, Israel, France, the Netherlands, Taiwan, and recently from India and China. The Quonset roof poly-house (Figure 1) from Taiwan was the first greenhouse technology brought to Thailand by the greenhouse pioneer, “Doi-Kham” Foundation. The modern greenhouse design from Israel was used to be popular among private companies in Thailand before the lower cost greenhouse technology from India and China become more competitiveness in the present. The local greenhouse design was eventually developed in the later stage (Figure 2). Some of them are modified from oversea technology. It is relatively cheaper and become more popular among growers who are small-land holders.

![Figure 1: Quonset or arch roof greenhouse design used by hill-tribe growers of “Doi-Kham” Foundation in the Northern region, Thailand.](image-url)
Greenhouse technology types
The greenhouses technology in Thailand can be classified by the level of technology and investment cost as follows:

1) Low technology greenhouse. This type includes the insect proof net-house and simple poly-house without roof ventilator and irrigation and fertigation system. The cost ranged between 15-25US$ per square meter. The cultivation method is mostly done in soil and irrigation and fertilization is done manually. Most of them are used to grow domestic leafy vegetables.

2) Medium technology greenhouse. They are the poly-house with different roof ventilation design and equipped with a single or combination of cooling system such light screen, fan and fogging system. Most of them have the fertigation system with either auto or manual control. The cost per square meter of this type of greenhouse ranges between US$35-60. It is most widely greenhouse type used in Thailand nowadays.

3) High technology greenhouse. The closed or semi-closed system greenhouse such as the polyethylene greenhouse or polycarbonate greenhouse with fan-pad evaporative cooling system and with or without computerized climate control and fertigation system is the highest technology greenhouse used in Thailand. They are the most expensive one and the cost per square meter ranges is between US$ 80 to more than 120. The use of this such an expensive type of greenhouse is still limited in Thailand.

Frame-structure material
The galvanized frame is the most common structure of the greenhouse in Thailand. The wooden framed structure such as bamboo stem was popular in the past and still be used by some growers in the hilly area of the North where it is still locally available. The high-cost truss frame structure types of greenhouse could only be found in a few wealthy agricultural farms and in the research institutes.

Cladding materials
The polyethylene (PE) film is the most common greenhouse roof-cladding material nowadays for growing high-value crops. Most of them are imported. The thickness of PE film varies from 100 to 200 microns. The added UV absorber usually ranged between 3-7%. This gives the life span of 3-4 years under Thailand climate condition. However, due to the high cost of these imported PE film, the growers sometimes delay the replacement of greenhouse roof plastics to 4-5 years. The research for the domestic production of high quality PE film is ongoing at the Metal and Material Technology Center under the National Science and Technology Development Agency (NSTDA), Ministry of Science and Technology (MST), Thailand. The prototype of PE plastic film with UV and IR exclusion property is already accomplished and is under the field testing process before commercial production begins. The insect-exclusive net has been used as the major side-wall cladding material of greenhouses. The common pore size use ranges between 20-40 mesh and this technology can be produced domestically. The use of other greenhouse cladding materials such as glass, polycarbonate film and acrylic film in the commercial greenhouse are very limited and could only be found in research institutes and public botanical gardens.
Greenhouse cooling system
The passive cooling system using roof ventilator is the most common cooling system for greenhouse cooling in Thailand. The greenhouse structure with different roof ventilation styles from oversea has been brought and tested under hot and humid condition of Thailand since 1990s. The double-roof greenhouse providing two-side ventilators along the length of roof was the most popular passive cooling greenhouse for many years before the newly imported tropical greenhouse design is gaining more popularity at the present (Figure 3).

Figure 3: The double-roof greenhouse design (Left) and the tropical greenhouse design (Right) from oversea technology

The light shading is also common greenhouse cooling method in Thailand. The shading net is the essential and common greenhouse accessory found in almost every greenhouse in Thailand regardless of the greenhouse cooling method used. In orchid farms, the shading screen also serves as the roof-top cladding material. The most popular light shading screen is the black color with the light blocking capacity ranging between 50-70%. All of this light shading nets is locally produced. However, the imported aluminate shading net is also found.

The evaporative cooling method is the second most popular cooling method for greenhouse in Thailand, by which the fog/mist system is more popular than fan-pad system which its cost is higher. The use of fan-pad system for cooling greenhouse is limited and mostly used for growing high value cool-season crops. However, the performance efficiency of the type of evaporative cooling greenhouse varies with micro climate. The study of effect of fan-pad evaporative cooling methods on climate inside the greenhouses located at the Asian Institute of Technology, Thailand in 2005/06 revealed that the average day and night time temperature inside the greenhouse with fan-pad cooling system decreased only 2.6 and 3.2°C, respectively as compared to outside air when the average ambient temperature and RH% were 32°C and 63%, respectively. This indicated the relatively low efficiency of fan-pad cooling system under humid condition in Thailand.

Growing technique
Soil is the most popular medium for growing domestic leafy vegetables in insect proof net-house e.g. Chinese kale, Pak Choi, Chinese cabbage, sweet basil, holy basil and water convolvulus while high value vegetables such as exotic variety lettuces, water cress, rockets and herbs are grown by using hydroponic growing technique. For growing fruit vegetables e.g. melon, tomato, sweet pepper, egg plant and cucumber, the substrate culture technique by using the coco-coir dust as medium is the most popular. Kasetsart University, Nakhon Pathom province, Thailand in 2015 revealed that the coco-coir dust used as the media for lettuce growing can be reused for four consecutive times before growth and yield was significantly decreased due to physical properties changing. This confirms that the coco-coir dust should be the promising greenhouse growing media for Thailand.

THE GOVERNMENT SUPPORTS AND POLICY
Even though, the development of commercial crop production in Thailand has taken place by trial and error of the private sector, nevertheless, later, the public sector has shown their best efforts to support and push forward the development of greenhouse crop production industry in the country.

In 2011, Kasetsart University with the technical assistance from the Israel government established the greenhouse technology complex at the Kamphaeng Saen Campus, Nakhon Pathom province. The greenhouse technologies suited to tropical climate condition were brought by the leading Israel’s greenhouse technology companies to be displayed and operated at this greenhouse complex (Figure 4). The aim of this complex is to serve as the greenhouse technology demonstration and training center for Thailand as well as for the South East Asia and others in the tropical region. The center is now open for all visitors from domestics and aboard. To proof that the greenhouse crop production under the tropical climate condition is feasible, the center has conducted the commercial greenhouse vegetable production throughout the year and occasionally, conducts the national and international training and workshop on greenhouse crop production and management. In 2015, the Thailand International Development and Cooperation Agency, Ministry of Foreign Affair and the Israel's Agency for International Development Cooperation in the Ministry of Foreign Affairs (MASHAV) and Kasetsart University had co-organized the international workshop on the greenhouse crop production and management to disseminate the greenhouse technology to the growers in the South East Asia region.

![Figure 4: The Israel’s supporting greenhouse technology complex at Kasetsart University, Nakhon Pathom and its training activities in 2013.](image)

The Thailand 4.0 Policy, the latest economic development model launched in 2016, aims to elevate the country to be high-income nation by using innovation and technologies. The agricultural sector is needed to transform from conventional farming to modern style such as smart farming. Vegetable and flower growers, therefore, is promoted and assisted to use greenhouse technology to produce high quality vegetables and flowers all-year round. In 2017, the greenhouse crop production supporting project had already started in some provinces in the central region. The a number of pilot greenhouses of 6 x 24 m² are loaned to growers participating in the project along with the academic training so as to boost up the production of safe and high quality vegetables and to increase income of the growers.

Furthermore, MST has also participated in developing of greenhouse technology for the country. The temperature, relative humidity, solar radiation and soil moisture sensors together with their application software for on-line monitoring and controlling the greenhouse micro-climate had been developed by the National Electronics and Computer Center (NECTEC), NASTDA, MST. It is commercially available now and being used by some modern greenhouse farms.

Lastly, the Ministry of Agriculture and Cooperatives by the Horticultural Research Institute, Department of Agriculture (DOA) decided to enhance their greenhouse technology capability starting from seeking the technical assistance from the oversea. An agricultural expert team headed by Dr. Ray R.J. Chang of Taiwan
Agricultural Research Institute was invited to explore the greenhouse technology and crop production situation in Thailand during the mid of June 2017. Later, the project proposal of the greenhouse technical supporting to Thailand will be drafted and proceeded. Under the same efforts, DOA with the support from major modern trade food retailers in Thailand will establish the modern-style greenhouse complex at the DOA’s research centers in the provinces that are located in the heart of the horticultural crop production area of the country e.g. Nakhon Pathom, Chiang Mai and Khon-Kaen provinces. The facilities will be used for demonstrating and transferring the greenhouse technologies to the researchers, extension agents as well as growers through various training courses.

PROBLEMS AND CONSTRAINTS

The average maximum temperature in Thailand is always greater than 32°C throughout the year and the use of fan-pad greenhouse cooling method is still limited due to the high investment and operation cost. Therefore, the rising of temperature exceeding the optimum temperature for plant growth inside the greenhouse as the effect of heat accumulation is a common phenomenon especially during the hot and sunny days which is prevailing climate condition for Thailand. The exotic and cool-season crops grown inside the greenhouses using a passive cooling method are always subjected to growth and quality reduction as the result of excessive heat. The cost-effective greenhouse designs that suited to the local environment of each particular region are still greatly desirable. Secondly, the knowledgeable personnel regarding greenhouse crop production is limited in Thailand. Most of greenhouse farms still lacked the experienced personnel as well as skilled labors and the easy-access greenhouse technology transferring system from the public sector is not yet in place. The appropriate greenhouse cooling and fertigation methods are the two major greenhouse technologies that most of Thai greenhouse growers still lack of. As the result, the yield and quality of greenhouse produces are poor during the summer season and the efficiency of fertilizer use of many greenhouse farms especially the small-farms, is rather low.

PROSPECT FOR GREENHOUSE CROP PRODUCTION INDUSTRY

According to the current pressure and driving forces e.g. climate change, labor shortage and consumer demand and the supporting from the public and private sectors described above, it is anticipated that the greenhouse crop production industry in Thailand in the near future will be in the rising trend and becoming more widespread than the past decades. The cost-effective greenhouse design suitable for particular region will be developed and made available by the local private sector. As the result, there will be more conventional-farming growers who will change to smart farming by using greenhouse technologies. Next, the existing greenhouse farms especially the big farms will improve their production efficiency by using more automation in the greenhouses. ICT will be used widely for remote controlling the devices in the greenhouses. Lastly, it is promisingly anticipated that, with the attractiveness of modern greenhouse technology, there will be more young generation coming from various sectors to join the greenhouse crop production industry and make it becoming more sustainable in the future to come.

REFERENCES