Situation and adoption of soilless culture technology for vegetable production in Thailand

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ABSTRACT: In Thailand there is a high demand for safe vegetable especially to serve local consumption and over 22 million of tourists per year. Growing number of tourists and health conscious Thai people are the important market for hydroponic vegetable production. Hydroponic farmers can grow temperate lettuce all year round and all over Thailand because the environment especially temperature and nutrient solution in crop production can be controlled. Farmers can grow about 16 crops per year of consistently superior quality vegetables. The research procedure consisted of two main steps: 1) documentary reviews, study visits abroad and seminar sessions in Thailand to select the best vegetable growing system suitable to Thailand condition especially for cash crops, like temperate lettuce and herbs as well as popular local crops. The focus group discussions involving SWOT analysis were conducted on this issue. 2) interviews of 58 farmers to collect information and follow up on soilless culture technology transfer. From the research findings it can be concluded that 1) Nutrient Film Techniques (NFT), Dynamic Root Floating Techniques (DRFT) and Deep Flow Techniques (DFT) worked well for soilless growing of leafy vegetables while the Substrate Culture Technique is more suitable for fruit vegetables. 2) Most farmers learnt and adopted the soilless culture technology, but they screened and modified the equipment using local material to cut the cost. 3) Most farmers in this group were well-educated and adopted the appropriate soilless culture technologies and grew temperate leafy vegetables by using NFT. 4) Those farmers were interested in improving the growing techniques to meet the standard for each individual vegetable variety as well as trying to reduce the cost and adapting the equipment by using local materials.

Keywords: soilless culture, hydroponic systems

Introduction

Vegetable growing in soil is still predominant in Thailand. Thai farmers have to face many serious problems such as drought, flood, pests, plant diseases, low quality products and misuse of insecticides causing risks for their income earning. Other disadvantages include soil-borne diseases and high temperature. Continual growing plant on an open field without break or crop rotation can lead to excessive build-up of soil pathogens, while high temperature can cause low yield and low quality. Moreover, heavy rain can pave way for secondary infection from fungi and bacteria. Therefore, new agricultural technologies have been researched and developed by government agencies, research institutes, universities and importantly, the Royal Development Projects.

Thailand, like any other countries in the tropics, is under the influence of monsoon. During the rainy season, various crops can be damaged due to the heavy rainfall (334 mm in September) followed by diseases. Chemicals used in controlling pests and diseases are very expensive and possibly leave residues in plant products, while there is growing demand for high quality vegetables with minimal or no pesticide residues,

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both for local consumption and for export. Therefore, it becomes necessary to study alternative methods of plant growing (Wattanapreechanon and Wattanapreechanon, 1997).

In Thailand, hydroponic technology has been developed rapidly since two decades before. HRH Princess Mahachakri is the first who introduced the idea of possible soilless culture for crop production in the country. During her visit to Israel in 1977 and to Japan in 1983, where agricultural development, including hydroponic systems at a commercial scale, attracted her attention. Upon her return, she graciously suggested that soilless culture techniques should be seriously studied and developed in Thailand. In 1987, the Food and Agriculture Organization (FAO), in order to mark the celebration of H.M. the King's 60th birthday, granted financial support for research and development of soilless culture for crop production in Thailand to be jointly conducted by Kasetsart University and the Royal Development projects, Bureau of the Royal Household. The purpose of this project was to study the possible use of soilless substrates for crop production in Thailand. It also concentrated on finding alternative means of crop production for small farmers in the areas with soil problems (e.g. sandy, saline or acid-sulfate soils) which covered about 30 percent of the arable land. Another aspect of the project was to identify which of the demanding techniques of hydroponics could be easily adopted by farmers.

The number of soilless culture growers has increased every year. In 2010,there were 188 growers compared to 250 registered hydroponics growers in 2014 for commercial vegetable production in Thailand (Department of Agriculture, 2014). In addition, several small hydroponic units were used in vegetables production for home consumption. Those commercial hydroponic vegetable farms are located in Bangkok and its surrounding areas as well as in tourist attraction provinces such as Phuket, Chiang Mai, Prachuap Khiri Khan and Surat Thani. All equipment are locally manufactured, reducing the initial investment and capital cost required by the growers.

There are numbers of commercial hydroponic vegetable planting systems in Thailand. Each system required different amount of capital investment. In the study of the characteristics of hydroponic vegetable production systems by using DRFT method and PC method (PVC gullies), it was found that the average product price was 42.99 baht and 40.00 baht per kg respectively. The financial analysis of these hydroponic vegetable planting farms showed that both methods were financially feasible (Jongjairuk, 2005).

The feasibility study on vegetable growing by using hydroponic system was conducted in Chiang Mai, on the 3 rais, using NFT system, which was a popular system suitable for Thailand. The result of the financial analysis showed that the total project investment life covered 10 years. With the payback period of 2 years 11 months and 18 days. The project was feasible for the investment (Srinuanjan, 2008).

Objective of the study

1) To obtain the best soilless culture system suitable to Thailand condition for cash crops, like temperate lettuce and herbs as well as popular local crops with optional investment and operation cost.

2) To study the situation and adoption of soilless culture technology in Thailand.

Methodology

This research started with the literature review to collect primary and secondary data from research references, results from trial works, data analysis and identification of the best systems that can be extended to farmers. The situation of soilless culture vegetable production was studied so that growers would be able to choose and adopt the soilless culture technology for vegetable production. In addition, growers would accept the new hydroponic technology in order to improve the productivity and increase their income. The research was carried out during 2010-2013. Sampling in this research by purposive technique consists of 2 groups.

1) 22 members of expert from the Thai Soilless Culture Forum Committee, Kasetsart University, and soilless culture farmers are used for Focus Group discussion.

2) 58 soilless culture or hydroponic farmers for in depth interview are chosen as representatives of those in each part of Thailand.

Results and Discussion

By using hydroponic culture, farmers all over the country could grow temperate lettuce all year round. They were Frillice Iceberg, Cos, Oak leaf, Coral or Lollo Rossa, Butter Heads and western herbs e.g. : rocket, sweet basil. With the development of Thai tourism, economic, situation and enhancement of people living quality, there was a tendency for more consumers to seek and purchase healthy, safe and high quality vegetable. Thai growers had to put more effort in producing high quality vegetable to serve such needs and help reduce the import.

1. Advantages of soilless culture/hydroponic

Although soil growing method was the standard practice for vegetable growing throughout Thailand, there were many serious problems such as soil borne disease, high temperature, pest, weed, highly mechanized, excessive labor, large amount of water supply, seasonal cultivation, bad working condition, environmental limitations (drought, floods) and unstable production. In some places like urban area or tourist attraction locations, soil was not available for crop growing.

Soilless culture was identified as a technique that could prevent many problems that might incur in unsuitable environments (**Table 1**). Since growers could control both the aerial and root environments of plants, plants could grow better while the growing season could be extended, and finally there was an increase in crop yields and income.

Since 1997 after the country's economic crisis, soilless culture or hydroponics has expanded throughout Thailand. Currently five soilless culture systems were practiced, namely, NFT, DRFT, DFT, aeroponics, and substrate culture. However, the existing information, data, and recommendations were still minimal and inadequate for the interested persons to study and help them make decision before implementing this new technology.

Of the five soilless culture systems in use in Thailand, growers chose a system based on their conditions taking the following factors into account: crop size, crop price, varieties, climate, tropical environment, and cost of investment.

Research results proved that soilless culture had more advantages over soil culture as shown in **Table 1**, which indicated that yield, income, and the number of crops per year of soilless culture were much higher than that of soil culture.

Table 1 Comparison between soil and soilless production of temperate lettuce varieties, herb in NFT with PVC gullies in evaporative cooling house conducted at Luk Phra Dabos Agricultural Training and Development Center, Samut Prakan Province during 2013.

Vegetables / Data concern	Lettuce[1] (Soil culture)	Green oak	Red oak	Red Coral	Butter Head	Cos	Frillice Iceberg	Rocket Young vegetable
1. Plot size (m)	1.00x5.00	1.60x12.00	1.60x12.00	1.60x12.00	1.60x12.00	1.60x12.00	1.60x12.00	1.60x12.00
2. No.of plants (plants/ m^2)	9	25	25	25	25	25	25	250
3. Yield (kg/plot)	7.90	60	56	48	64	68	55	38
4. Average yield (kg/ m^2)	1.58	3.13	2.92	2.5	3.33	3.54	2.86	1.98
5. Wholesale price (Baht/kg)	20	65	65	65	65	65	65	100
6. Income (Baht/m^2)	31.60	203.45	189.80	162.50	216.45	230.10	185.90	198
7. Annual Crops	4	14	14	14	14	14	14	14

[1] Collected form The Royal Northern Project because most temperate lettuces and herbs cannot grow in Bangkok.

In a hydroponic system, replanting could be done immediately after harvest, as farmers did not have to sterilize the soil, making it possible to have continuous production. Hydroponic vegetables had no toxic substances, no pesticides and no harmful microorganisms, which meet the most stringent catering specifications (Wilson, 2000).

Growers who decided to grow vegetable by hydroponic techniques, had to familiarize themselves with the principles of hydroponic culture and the basic requirements of planting and caring, so that the system could successfully be established and operated generating high productivity and income. They had to select the techniques that were suitable for their condition. **Figure 1** below is the result of this action research showing the situation and how to start hydroponic farm.

2. Marketing survey

Growers need to do marketing survey before starting their hydroponic farm. They should take into account the efficacy of the current marketing system and situation of the marketing. Contract market is workable for hydroponic product due to stable yield, continuous cultivation and stable price. Furthermore, consumers were quite happy with high quality products and stable price. In fact, most hydroponic products were sold in modern trade such as supermarkets and high class restaurants. Deciding on the marketing program, the marketing surveys should concentrate on products, price, place, and promotion (Kotler, 2009).

2.1 Product

Hydroponic crops should start with vegetable to serve a high demand of hygienic vegetable for the incoming tourists and health conscious Thai people. These crops were temperate lettuces like Frillice Iceberg, Cos, Oak leaf, Coral, Butter Head, sweet peppers, table tomatoes western herbs e.g.; rocket, sweet basil, water cress and some popular local crops with food safety at a reasonable price. These vegetables grew well in the hydroponic system all year round throughout the country and no competition with field grown vegetable, which could not grow well in summer and rainy seasons. Hydroponic vegetable had much better quality and was still in high demand. However, the volume of hydroponic vegetable supply was still lower than the demand.

2.2 Price

The high quality and quantity of hydroponic vegetable could be produced all year round, so the price was quite high and stable. The price of products was not the key factor but the quality and stable supply were more important. Well designed package of hydroponic vegetable was more attractive and could attract consumers to buy the products. In addition, most hydroponic products got Good Agricultural Practice (GAP) certificates as a guarantee that the product was safe, hygienic and grown with standard technique.

2.3 Place (distribution channels)

Most hydroponic products were sold in modern trade such as supermarket and high class restaurants. However, it was possible for farmers and wholesalers to enter the contract, because hydroponic growers could provide stable supply of quality products convenient for wholesalers to distribute to retailers to sell at high price. Therefore, growers should also pay attention to local market with some popular local crops for health conscious Thai people, which is a bigger market than exotic vegetables market. It was recommended that growers should identify the market and make contract before starting the cultivation.

2.4 Promotion

Most modern trade such as supermarket need some promotion especially in cold season, when there was a competition with field grown vegetable, which could double the vegetable supply at a lower price; but this happens only for a few months. Other products like mixed salad pack, sometimes with a sacket of salad dressing included, was a new way in promoting hydroponic products, which could absorb the surplus supply and simultaneously expanding the hydroponic industry.

3. Field survey for key success factors of soilless culture or hydroponics in Thailand.

Commercial soilless culture or hydroponics production of fresh vegetables in Thailand has been growing steadily. In order to succeed, growers had to take many key factors into account as shown in **Figure 1**. This include good varieties, suitable production site, contract market and good management (Wattanapreechanon and Sukprasert 2012).

4. Crop selection for suitable system

At present, there are 5 soilless culture/ hydroponic systems for commercial vegetable production in Thailand. After finishing field survey, growers need to select crops for suitable system. The focus group discussion, was held in November 2010. From the brainstorming sessions

involving SWOT analysis on the inputs, outputs, and processes of soilless culture, it was evident that DRFT, NFT, and DFT systems worked well for leafy vegetable production, but substrate culture was suitable for fruit vegetables (sweet peppers, tomatoes, etc.). These results were similar to a previous study by Montri and Wattanapreechanon (2006). However, the high initial capital cost and mechanical complexity could be reduced by using newly simplified local materials and simple equipment as recommended by Ratanakosol (1997). The hydroponic systems suitable to cash crops like temperate lettuce and herbs in NFT, DRFT, DFT, Aeroponic system and some popular local crops (Chinese cabbage, Chinese celeries Chinese kales, water convolvulus etc.) were recommended to grow in DRFT, NFT, DFT systems. For fruit vegetable (tomatoes, sweet pepper) it was recommended to grow them in substrate culture (Wattanapreechanon and Sukprasert, 2012).

Although, growers have already selected crops, and chose the best system for crops they wanted to grow. Simultaneously, growers need to study the situation of hydroponic production in the country.

5. Situation of hydroponic production in Thailand.

There were many factors related to hydroponic production that should be considered by growers, who would like to succeed (**Figure 1**).

5.1 System manufacturers and companies

At present, most system manufacturers and companies could produce new equipment by themselves e.g. plastic gullies, plastic pots, polystyrene as planting bed, urethanes foam as growing media, many hydroponic equipment, and different hydroponic sets with many systems suitable for Thailand condition. Those were sold to home gardens as well as to commercial growers and exporters. Some companies got new ideas and techniques from local research and academic works, Thai Soilless Culture Forum and did their own R & D. They also did an extension work by introducing new techniques and findings to the growers. Some companies did not only sell hydroponic equipment but also grew vegetable at a commercial scale to advocate products to new growers.

5.2 Growers

Most hydroponic growers intended to get stable supply of quality products with stable price and high income (56.9% could earn approximately 100,000-500,000 Baht/year). These growers gained knowledge from system manufacturers and companies, from which they bought the hydroponic system, Thai soilless culture forum and research findings. Most growers chose to grow high value vegetable varieties (65.5% grow temperate lettuce and herbs), which were suitable for their growing system and marketable. Growers organized into groups or small clusters (84.5%) in order to ensure that they could provide stable supply for wholesale and retail markets. Most hydroponic growers (74.1%) got Good Agricultural Practice (GAP) certificates.

5.3 Distributors and exporters

Hydroponic vegetable was usually harvested with the root system intact in order to prolong shelf life and prevent premature wilting. Most growers often had the small plastic pot or urethane foam on the root system. Cold storage facilities were essential in removing field heat. Transport in covered vehicles to reach market as quickly as possible were also important. Refrigeration at the

optimum temperature, combined with high humidity, was the best method in extending storage or shelf life. Most distributors have run packing house with good package to protect and prolong its life. The plastic wrappers, attractive decorated bags were used for gourmet vegetable.

5.4 Marketing

Most growers had to organize good transport to the wholesalers and make sure that there was consistent supply of produce to the markets. Contract market was workable for hydroponic products due to stable yield, continuous cultivation and stable price. Most growers (84.5%) had their own contract market. In fact, most hydroponic products were sold in modern trade such as supermarket and high end restaurants. The price of products was the key factor but the quality and stable supply were more important.

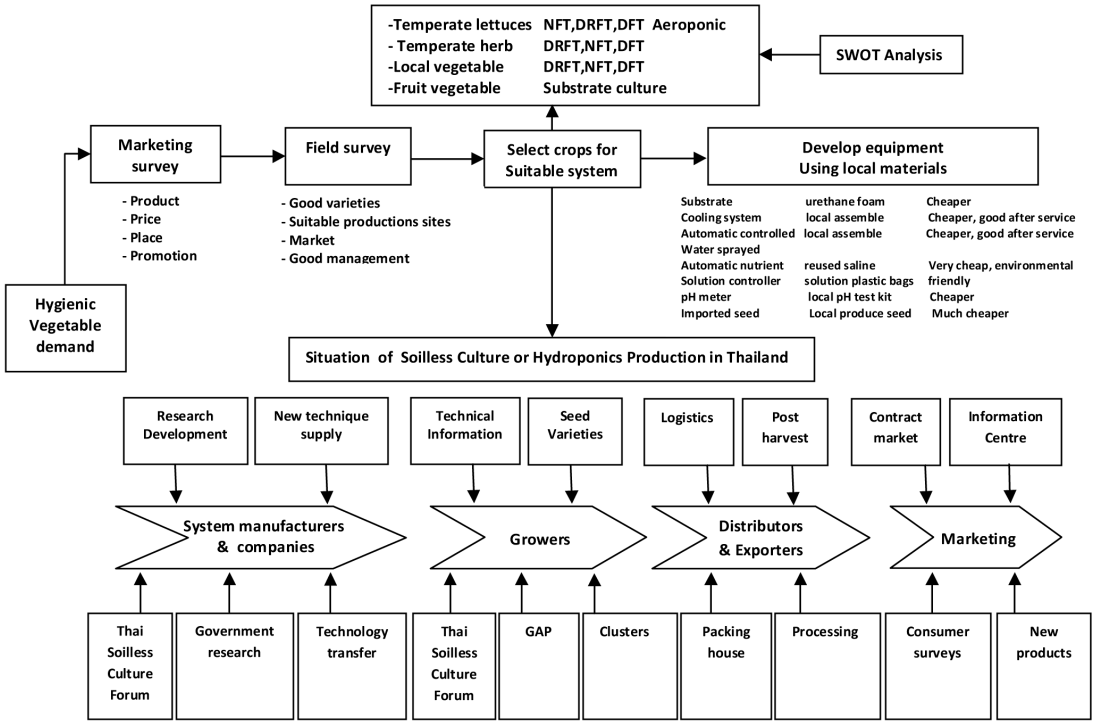

Figure 1 Situation and How to Start Hydroponic Farm

6. Development of equipment using local materials

In Thailand hydroponic had taken a rapid progress during the last two decades, but the production was still lower than that in the developed countries. Many problems still remained to be solved. Much attention should be paid to developing cultivation methods and standardization for each crop. This included production cost reduction and product quality improvement. It was also necessary to develop equipment using local material for hydroponic farm. The ongoing research should identify the hydroponic systems suitable for growing cash crops like temperate lettuce, herbs and some popular local crops with local hydroponic equipment (Figure 1).

7. Adoption of soilless culture technology

Technology including idea, knowledge, method, practice or technique are one of the means to achieve the improvement of productivity and income. They will be accepted as valuable under the following conditions (Sukprasert, 2008).

1. It is practicable as supported by evidence of scientific proof and credibility.

2. It is flexible or can be applied or modified for further development.

3. It can lead to multiplied effects, with various target groups continuing to transfer the technology to others.

Interview schedule to collect primary data and in-depth interviews with 58 soilless culture growers, the research revealed that

1) Most of soilless culture growers were educated persons. They preferred using NFT, DRFT and DFT for leafy vegetable, but substrate culture for fruit vegetable. They choose NFT (48.3%) in growing temperate lettuce using the imported seed (53.4%) germinated on urethane foam cubes as substrate.

2) Most growers held bachelor's degrees (69%), the rest held other education level. They preferred growing only temperate lettuce (51.7%) because it was a new cash crops, with stable high price, cheaper than the import and without competition from soil grown (**Table 2**).

Table 2 Different crops grown by hydroponics and background of growers

Education		Crops								Total
		Temperate lettuce, herb, local vegetable	Temperate lettuce, herb	Temperate lettuce, local vegetable	Temperate lettuce, fruit vegetable	Temper-ate lettuce	Temperate herb	Local vegetable	Fruit vegetable	
Below under graduate	Count	0	3	0	0	4	0	0	4	
	Expected Count	.2	1.5	.9	.2	5.7	.2	.2	2.1	
	% of Total	0.0%	5.2%	0.0%	0.0%	6.9%	0.0%	0.0%	6.9%	
Under graduate (Bachelor)	Count	0	5	3	1	22	1	1	7	
	Expected Count	.7	5.5	3.4	.7	20.7	.7	.7	7.6	
	% of Total	0.0%	8.6%	5.2%	1.7%	37.9%	1.7%	1.7%	12.1%	
Graduate	Count	1	0	2	0	4	0	0	0	
	Expected Count	.1	1.0	.6	.1	3.6	.1	.1	1.3	
	% of Total	1.7%	0.0%	3.4%	0.0%	6.9%	0.0%	0.0%	0.0%	
Total	Count	1	8	5	1	30	1	1	11	
	Expected Count	1.0	8.0	5.0	1.0	30.0	1.0	1.0	11.0	
	% of Total	1.7%	13.8%	8.6%	1.7%	51.7%	1.7%	1.7%	19.0%	

3) Most hydroponic growers intended to get stable supply of quality products with stable price and high income (56.9%). Most growers (51.7%) chose to grow high value vegetable varieties which were suitable for their growing system and marketable. Most growers (55.2%) had working experience (1-5 years) and organized into groups or small clusters in order to ensure that they could provide stable supply for the wholesale and retail markets. Some growers (15.5%) invested in evaporative cooling systems for better quality and higher yield of product (Senadee, 2012). Many growers (63.8%) preferred net house with plastic roof in order to prevent damages from rain and improve pest control measures at low capital investment.

4) Most of them (96.28%) heard, received and tried appropriate technologies. All growers (100%) gained more information from training courses, books and internet etc. However, 76.3% imitated, modified and continued to use but 2.8% failed (resulted lower than standard) and 20.9% of growers did not apply (only temporary change of behavior) as shown in **Figure 2**. Much attention was paid to developing and standardization of the cultivation methods proper for hydroponic condition for each crop. This included production cost reduction, product improvement and also developed equipment using local material for their farm.

5) Most growers learnt soilless culture techniques form short training courses organized by government universities and private companies, textbooks and internet then accepted / received and adopted as in **Figure 2**.

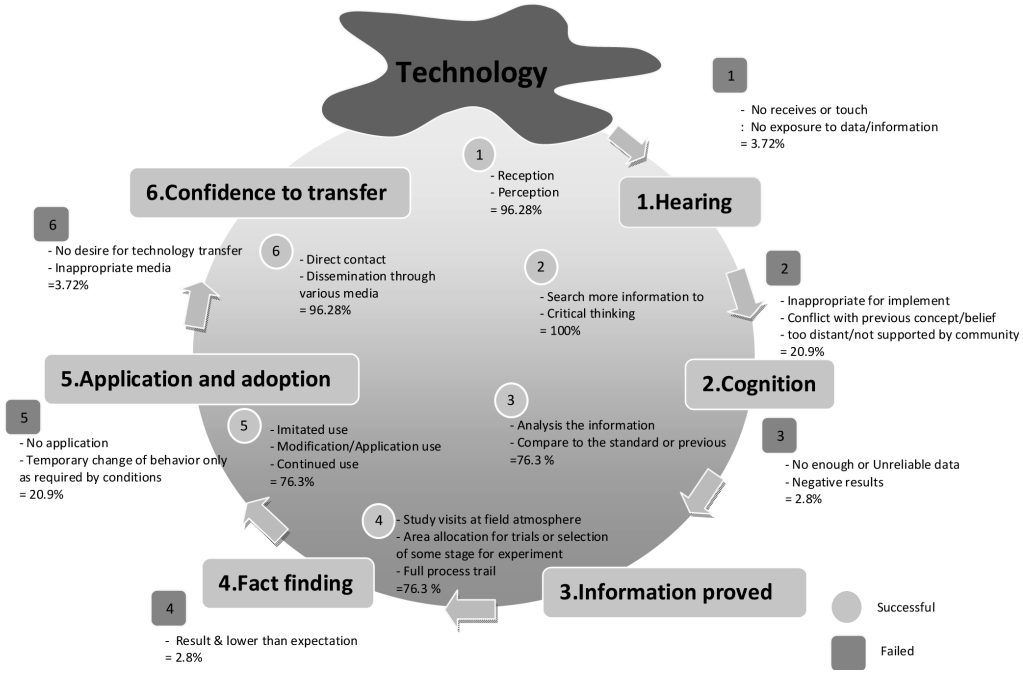

Figure 2 Reception and adoption of soilless culture technology

Source: Modified from Sukprasert (2008)

Conclusion

There was a high demand for hygienic vegetable especially to serve the incoming tourists and health conscious Thai people, which was the important market for hydroponic vegetable production. Most hydroponic farms were in Bangkok and its vicinity and in tourist attraction provinces. Although hydroponic farm became more popular and was expanded throughout the country as the consumption volume was increasing everyday, temperate and some local varieties of vegetables were produced to serve the market demand both with the similar phenomenon as described by Rest (1993) and Paul (2000). Growers who decided to grow vegetable using hydroponic method need to do local market survey and field survey to select

crops and suitable system. It was also necessary to study situation of hydroponic production in Thailand and how to reduce the production cost especially by using local hydroponic equipment before starting their hydroponic farm. There were some hydroponic systems suitable for leafy vegetable such as NFT, DRFT, DFT. For temperate lettuce and herbs they could be grown about 10-16 crops per year. DRFT, DFT, and NFT were suitable for some popular local crops, which was produced 10.5-12 crops annually. The substrate culture was suitable for fruit vegetable.

Furthermore, growers need to familiarize themselves with the hydroponic culture principles and basic requirements in planting and caring, which could contribute towards successful establishment and operation of highly productive and rewarding hydroponic unit. Hydroponic development was the ongoing process. Growers had to think of the techniques that were suitable for their condition. In addition, management skill and contract market were needed.

From the in-depth interviews and the research, it was revealed that most of soilless culture growers were educated persons, growing temperate lettuce in NFT, learnt and accepted all appropriate technology through the phenomenon as explained by Sukprasert (2008). Much attention was paid to developing and standardization of cultivation methods for hydroponic condition for each crop. This included production cost reduction, product improvement and also equipment development using local material for their farm.

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