

**An Interactive Science and Social
Project 2010-2011**

Troubleshooting a School Hydroponics Garden



Sponsor: Wat Pathum Wanaram School

Advisors: Dr. Luxsana Dubas and Associate Professor
Karen Lemone

Chananya	Sangkhaphong	5033859723
Ploy	Kanoktanaporn	5033896923
Pornkanok	Munikorn	5033893023
Silaphot	Wong	5033914523
Thanaphon	Sinlapakarnon	5033879223
Visutha	Chairuengjitjaras	5033912223
Waroot	Saengnark	5033904223

ABSTRACT

Wat Pathum Wanaram School has asked us, the SSP 4 group to troubleshoot their hydroponics garden. The plants in the garden overshoot and do not blossom. Our goal is to increase the fertility of the hydroponics garden. Our methodology consists of four objectives, identifying the cause of the fertility problem, identify pests, determine an extermination method, and educate the students. The garden is unhygienic, thus we recommend a routine schedule and have created a set of guidelines for a sustainable and doable approach based on tender, love, and care.

ACKNOWLEDGEMENT

We would like to thank Wat Pathum Wanaram School, our sponsor, for giving us the opportunity to work at the school. We highly appreciate Mrs. Pataraporn Jirojwong, Mr Sompop Intarajun, Mr. Virat Khunpun, Ms. Lalita Prasat and Mr. Sa-aad the janitor for giving us the working place, equipments, and the support in doing this project.

We highly appreciate the following hydroponics experts for giving us the useful advices and tips regarding the hydroponics farm: Mrs. Suntaree from Hawaii, Miss Patcharin Phudtharit from Chaipattana Hydroponics Farm in Prajeenburi province, Village Chief Mr. Tun.

We highly appreciate our project advisors, Dr. Karen Lemone and Dr. Luxsana Dubas, for assisting us with our project plan and helping with our project writing.

Chananya	Sangkhaphong
Ploy	Kanoktanaporn
Pornkanok	Munikorn
Silaphot	Wong
Thanaphon	Sinlapakarnon
Visutha	Chairuengjitjaras
Waroot	Saengnark

EXECUTIVE SUMMARY

Introduction

Hydroponics is the art of growing plants without the use of soil or dirt. Wat Pathum Wanaram has asked us to assist in troubleshooting their hydroponics garden situated on the rooftop of the school. The school is unsatisfied with the general character and the fertility of the plants where they shoot up instead of blossom. Our goal is to increase the fertility of the hydroponics garden.

Literature Review

The main enemy of hydroponics is pests and disease. Prevention is the best method in solving pests and disease problem. This can be done by keeping the garden and its equipments clean, vary the plants based on its resistance, ventilate the garden and greenhouse to maintain suitable temperatures, and observing the garden regularly for infections. Nine parameters in hydroponics include light, turbidity in tap water, water temperature, quality of water, climate and weather, mineral deficiency symptoms, growing of algae, electrical conductivity of the fertilizer formula, and the pH of the fertilizer formula. These parameters determine the growth efficiency and fertility of the plants in a hydroponics garden.

Methodology

The problem is the fertility of the plants in the hydroponics garden were not meeting the school's expectations. Our goal is to help in Wat Patumwanaram School increase the fertility of the hydroponics garden. We created four objectives in tackling the problem for a sustainable approach that can be maintained in the future which includes identifying the cause of the fertility problem, identifying the pests, determination of an extermination method, and educating the students in these techniques.

Results

From direct observation of Wat Pathum Wanaram School, we were able to determine that the garden was very dirty which indirectly resulted in lowered fertility of the plants. The garden is also infected with three types of pests which are located on the back of the plants' leaves and large amounts of ants. One of these pests is known as millie bugs which coexist symbiotically with ants. An analysis by hydroponics experts allows us to determine that there

is insufficient sunlight and ventilation in the garden. Furthermore, the temperature within the garden is too high due to insufficient ventilation. The humidity levels in the garden are not suitable during daytime. From more direct observation, the students in the hydroponics curriculum are eating snacks in the hydroponics garden which causes ants which are pests carriers to come to the garden. The pH and electrical conductivity of the hydroponics system is not at a suitable range which affects the growth rate and ultimately, the fertility of the plants.

Conclusion

Tender, love, and care is needed in order to ensure a doable and sustainable approach for maintaining garden hygiene and fertility. This is divided into three categories which are the hygiene of the garden, the environment, and the fertilizer formula. The garden at Wat Pathum Wanaram school has accumulated dusts and particles over time. This creates a hospitable environment for pests and fungus which directly affects the fertility of the plants. Dusts and particles will also affect the flow of the fertilizer formula in the hydroponics system by clogging the pipes. Furthermore dusts and particles will decrease the amount of sunlight from entering the greenhouse, resulting in over shooting plants that do not blossom. The environment of the nursery is unsuitable with insufficient sunlight and ventilation due to its location. Environmental factors such as temperature and ventilation of the garden on the rooftop must be adjusted as mentioned in the recommendation section to ensure plants' fertility in the garden. The last cause which is the fertilizer formula must be maintained to standards by routine checks and adjustments. The education of the students at Wat Pathum Wanaram school will ensure a doable and sustainable approach in the maintenance of the garden, instilling and increasing tender, love, and care. A guideline will ensure that future students taking the hydroponics course learn and understand proper methods in hydroponics garden maintenance. This is a form of feed forward management that minimizes the causes of the fertility problem, ensuring a sustainable and doable approach in the future.

Recommendation

We recommend Wat Pathum Wanaram in solving seven problems. The school must clean its equipments every harvest cycle including disinfecting the garden and its equipment with dilute bleach to ensure garden hygiene. The fertilizer formula height in the platform must be reduced to half the height of the sponge in the black pots to allow the plants to breathe properly. Gray shading nets can be utilized to decrease the temperature in the garden

to a suitable level, where at the same time will allow sufficient sunlight into the garden. We recommend removing the net surrounding the garden to allow more air, increasing the ventilation and decreasing the temperature of the garden. Alternatively, replacing the current net with a larger grid sized net will also be effective. We recommend a routine check of the electrical conductivity and pH levels in the hydroponics system to allow determination of adjustments of these values by adding fertilizer for electrical conductivity and adding acid or base for adjusting pH. Furthermore we strongly recommend a new sprinkler schedule to decrease the humidity level and maintain the same humidity throughout the day. The change is from a full one hour sprinkler session to a one minute session every hour from 10.00 am to 02.00 pm.

AUTHORSHIP

There are seven members in our group SSP4. We brainstormed the ideas, problems, and solutions together. The following are each of the member's main contribution to the project:

- Chananya Sangkhaphong is responsible for the Thai-English translation during the project work and the report's introduction part.
- Silaphot Wong is responsible for most of the report content such as abstract and executive summary, data collection, and the final report's grammar correction.
- Ploy Kanoktanaporn is responsible for the weekly agenda and data collection.
- Pornkanok Munikorn is responsible for the data collection, report's contents, and the powerpoint slides.
- Thanaphon Sinlapakarnon is responsible for the data collection, finding equipments, and the methodology part.
- Visutha Chairuengjitjaras is responsible for the powerpoint slides and the results part.
- Waroot Saengnark is responsible for the data collection, finding equipments, and the overall report contents.

TABLE OF CONTENTS

	PAGE
ABSTRACT	2
ACKNOWLEDGEMENT	3
EXECUTIVE SUMMARY	4
AUTHORSHIP	7
TABLE OF CONTENTS	8
LIST OF FIGURES	10
LIST OF TABLES	11
CHAPTER	
I. INTRODUCTION	12
II. LITERETURE REVIEW	14
2.1 Pests and Diseases	15
2.1.1 Common pests of hydroponics plants	16
2.1.2 Common diseases of hydroponics plants	16
2.2 Light	16
2.2.1 Sunlight	16
2.2.2 Artificial Light	17
2.3 Turbidity in Tap Water	17
2.4 The effect of water's temperature	18
2.5 The quality of water	18
2.6 Problems during the summer	18
2.7 Mineral deficiency symptoms	19
2.8 Growing of algae	19
2.9 Conductivity	20
III. METHODOLOGY	21
3.1 Objective 1: Identify the cause of the fertility	21
3.2 Objective 2: Identify pests	21
3.3 Objective 3: Determine an extermination method	22
3.4 Objective 4: Educate the students in these technique	22
IV. RESULTS	23
V. CONCLUSION	26

5.1	Love	27
5.2	Care	27
5.3	Recommendations	28
5.3.1	Cleanliness of the garden	28
5.3.2	Fertilizer formula level	29
5.3.3	Temperature in the garden	29
5.3.4	Temperature of the fertilizer formula	30
5.3.5	Electrical conductivity level	31
5.3.6	Sprinkler schedule	31
5.3.7	Pests	32
REFERENCES		33

LIST OF FIGURES

Figure		PAGE
Figure 1	Hydroponics farm with well TLC	25
Figure 2	Equipment in hydroponics garden at Wat Pathumwanaram are not arranged properly	28
Figure 3	Sprinkle in hydroponics garden	31

LIST OF TABLES

Table		PAGE
Table 1	Comparison of 3 hydroponics farm	24
Table 2	Air temperature at WatPathumwanaram's hydroponics garden is over standard	29
Table 3	Water temperature at Wat Patumwanaram's hydroponics garden is over standard (3 days average)	29
Table 4	EC level at Wat Pathum Wanaram's hydroponics garden (3 days average)	30

CHAPTER I

INTRODUCTION

Hydroponics is a technique of growing plants without using soil. It is becoming a popular way of growing plants because it eliminates most pests and disease that are caused by the soil. Nowadays, plants grown hydroponically are in market demand due to bigger and better products and thus have become another alternative for health-concerned consumers.

Wat Pathum Wanaram School created a hydroponics garden for two main purposes: to raise food for the school's lunch program and to educate the students in a hydroponics curriculum. The school is currently unsatisfied with the general character and fertility of the vegetable plants from a hydroponics garden. The plants are not as tall and thick as the school would like. Another problem is that plants appear "to shoot up" instead of blossoming. Furthermore, pests are infecting the garden.

The school had addressed the fertility issues and is using a common fertilizer formula. The hydroponics garden has so far been successful in using separate fertilizer solution pumps for each platform to decrease the possibilities of water borne disease and the spreading of pests. Additionally, the school has tried flooding the hydroponics garden with water to prevent carrier insect from getting into the garden. They have also used herbal extracts in an attempt to kill the pests.

However, these techniques have not been successful of getting rid of the pests' problem. Using the same fertilizer formula for different plants may affect the fertility. Each plant may require specific fertilizer formula. Moreover, the pests in the garden have not been totally eradicated which might also contribute to the fertility problem. Although flooding has helped decrease the number of insects in the garden, aphids still remains in large numbers. In addition, the hydroponics garden was not clean enough because the school didn't clean it regularly.

The goal of this project was to increase the fertility of the hydroponics garden. This goal was realized by fulfilling the following objectives:

1. Identify the causes of the fertility problem
2. Address the problem of the plants' fertility problem

3. Identify the pests and their effects
4. Determine a better extermination method for pests
5. Educate the students in these techniques

CHAPTER II

LITERATURE REVIEW

Hydroponics is an agricultural technique used for growing vegetables without the use of soil or dirt. There are different types of hydroponics, all of which rely on water-based nutrient formulas. The system operates via water pumps, where the water-based nutrient formulas circulate through the system, enabling the roots of plants or vegetables to retrieve necessary nutrients from the system. Macronutrients such as nitrogen, phosphorus, and potassium must be suitably calculated to ensure effective growth for different plants. [1]

There are six elements needed to set up a hydroponics garden, consisting of the system itself, the fertilizer formula, an inert media, a UV source, time, and plant seeds. The system utilizes a pump that keeps the fertilizer formula flowing in an inert media. The UV source whether natural or artificial enables plants to perform photosynthesis which progresses the life cycle of the plants.

Hydroponics in Thailand is mostly used for household cooking. Most hydroponics products are kailaan and Chinese cabbage, which was previously imported. An increase in health awareness and health cuisines has sparked Thais to take an interest in hydroponics. In the past few years the demand for hydroponic vegetables, especially organic hydroponic vegetables have increased. With rich flavors and better tastes when compared to soil grown vegetables, importers of these products were able to increase the price on the basis of supply and demand. More recently, the techniques and utilities for operating hydroponic gardens have been introduced by many Thai companies, thus resulting in local hydroponic products with more affordable prices.

Hydroponic equipments and utilities are considerably expensive. Due to Thailand being in the tropical climate zone, conventional hydroponics is unsuitable. Most hydroponic gardens in Thailand require greenhouses to protect the system from extreme heat. The construction of green houses adds to the cost of the hydroponics garden. Any type of plants or vegetables can be grown via hydroponics system, some more efficient than others. These

include tomatoes, sweet peppers, hot chilies, lettuce, spinach, chard, squash, cucumbers, broccoli, beans, snow peas, herbs, flowers of all types and house plants.¹

In theory, hydroponics garden decreases the amount of pests, especially those that live in soil, resulting in decreased usage of pesticides. The fact remains that pests still infect hydroponic gardens, but there are alternatives such as insecticidal soaps, natural pyrethrums, and beneficial insects for the eradication of these pests. Feed forward management strategy of hydroponic gardens should be used to prevent pests instead of waiting for them to grow and then trying to eliminate them. To accomplish this, the hygiene of the garden must be taken into account, cleaning the garden at every harvest cycle. Suitable water based fertilizer formulas should be used to maintain the health of plants in the garden to prevent pests and diseases that target weak plants.

2.1 Pests and Diseases

Even without the use of soil, pests and diseases are still able to infect hydroponic gardens. There are many types of bacteria that cause diseases and even more insects and pests that destroy crops.

Methods of preventing pests and diseases

- Keep the garden and equipments hygienic and clean
- Vary the plants based on disease and pest resistance
- Ventilate the garden or greenhouse and maintain suitable temperatures
- Regular observation of plants to detect problems as soon as possible to prevent further infestations and infections

Many insects or pests can be eliminated by simple means. Most pests can be picked or wiped off from the leaves or stems of the plants. Weak concentrations of soapy water are used to eliminate smaller pests because they cannot be handpicked. These are preliminary measures that are used as an attempt to contain or eliminate the infection in early stages. If the hydroponics garden is heavily contaminated, organic insecticides and pesticides may be used to eliminate infections. Organic insecticides and pesticides eventually breakdown into harmless substances. Depending on the grade of the product, the time for the chemicals to

¹ <http://www.thefarm.org/charities/i4at/surv/hydro.htm>

breakdown can range from one to thirty days. Plant extracts from various herbs or spices can be used to limit or even eliminate certain types of pests or diseases.²

2.1.1 Common pests of hydroponics plants:

- Aphids: small insects with a variety of species that draws nutrients from the plants leaves.
- Caterpillars: larvae of butterflies that feeds on leaves.
- Ants: carriers of other pests that help each other increase its population.

2.1.2 Common diseases of hydroponics plants:

- Rust: red pus on beneath the leaves that causes leaf burning.
- Club Root: roots of the plant become a club-like shape which prevents growth and development.
- Crown and Stem Rot: fungus that causes stems become soft and eventually rots.
- Root Rot: fungus that causes roots to rot.
- Powdery Mildew: fungus that causes white spots beneath the leaves.
- Early Blight: causes brown spots on leaves that diminish development and growth of a plant due to lessen ability of photosynthesis.
- Black mold: fungus that causes leaves to turn black or gray.³

Problem in hydroponics

2.2 Light

2.2.1 Sunlight

Sunlight is a significant factor in plant growth which directly affects the productivity of a garden because sunlight is the source of energy for the photosynthesis process in plants. Photosynthesis uses sunlight or UV radiation along with carbon dioxide gas to draw nutrients from the ground which produces oxygen as a byproduct. Different species of plants require different amount of sunlight. A garden should plant species that require similar amount of

² <http://www.gthydro.com/hydroponicsgrowingtips.html>

³ <http://www.onlinegardenertips.com/Hydroponics/What-Are-The-Pest-And-Diseases-Of-Hydroponics.html>

sunlight. Furthermore sunlight also affects the temperature of the fertilizer formula. The higher the temperature, the lower the amount of oxygen remains within the system. ⁴

Plants and vegetables will begin to grow tall and not full, when there is insufficient sunlight. The plants want more sunlight, and therefore will try to grow in height instead of in width. Plants grown in a hydroponics garden should have similar growing environment needs to minimize complications. This will ensure that all the plants grown in a hydroponics garden has full productivity. There should not be artificial light during the night, because like all living things plants also need their rest. ⁵

2.2.2 Artificial Light

Plants require sunlight to grow. During the rainy season in Thailand, the amount of sunlight plants receive is decreased, therefore decreasing the amount of growth time provided to the plants. Artificial lighting can be used to increase the growth time of plants in a hydroponics garden. The sun emits every wavelength or lambda that every species of plants require. Different species of plants utilize different wavelengths or lambdas in the spectrum, and therefore will react to artificial lighting differently. Different types of artificial light are therefore used for different types of plants to ensure maximum growth efficiency. The productivity of plants increases or decreases according to the amount of light it receives.

Greenhouses are used to control the environment of a hydroponics garden. Glass is the main choice for most greenhouses although it may be more costly because it does not change with time and is convenient for maintenance. The ability of glass to fully transmit light is great for ensuring sufficient sunlight in a greenhouse. Inadequate light will result in low productivity. Light is a major factor which must be considered when growing plants. ⁶

2.3 Turbidity in Tap Water

During the rainy season, floods can occur and cause turbidity in tap water. This will cause major problems in hydroponic gardens. Turbid tap water or unclean water causes diseases and decreases the productivity of a hydroponics garden. A water filtration system can be installed to filter out particles and increase the cleanness of the water.

⁴ <http://www.gthydro.com/hydroponicsgrowingtips.html>

⁵ <http://www.gthydro.com/hydroponicsgrowingtips.html>

⁶ <http://www.gthydro.com/hydroponicsgrowingtips.html>

2.4 The effect of water's temperature

The temperature of the fertilizer formula must be maintained in order to prevent over heating of the system. High temperature in the hydroponic system will cause the dissolution of oxygen diatoms which directly affects the plants absorption rate of nutrients. It is suggested that 28°C is the most suitable temperature for fertilizer formulas. Pumps are not only used to circulate the fertilizer formula but also to maintain the temperature to a lower state.

2.5 The quality of water

Water is the main source of life for plants and therefore must maintain its quality. Plants must be able to draw water freely in order to ensure its growth. Water that is used in the hydroponics garden must go through filtration systems. If water is not filtered, there may be elements that are already present in the water. Elements are added in the stock solution for fertilizer formula, therefore if there are already elements present in the water, the water would be filled with excess elements which will decrease the effectiveness of the solution.

Furthermore there are salts that are dissolved in water sources, containing sodium chlorides, magnesium sulfates, etc. The amount of salt in the water can be measured through the value of electrical conductivity. The electrical conductivity or EC must be maintained at approximately 250-750 micromhos which are considered as moderate or useable water. If the EC of a water source is more than 6000 micromhos, the water is considered to contain too much salt and is dangerous for plants.

The pH of water is another factor that must be checked and maintained in a hydroponics system. As plants absorb nutrients from the fertilizer formula, the water will become more basic. If the water becomes too basic, the plants ability in absorbing nutrients will be decreased, and therefore will cause the plants to eventually wither and die.

2.6 Problems During the Summer

Summer causes many problems for vegetables and plants in Thailand. This is because Thailand being a tropical climate country causes vegetables to ripen faster. The different rates of vegetable ripening depends on the species of the vegetable, whether it is native or foreign.⁷

Most Thai vegetables do not have problems with temperatures because they are native and are grown in tropical climates. Most Thai vegetables have problems with insect pests, especially worms and aphids. Diseases that infect Thai vegetables mostly occur in the summer when there is extreme scorching heat which causes root rotting. Foreign salad vegetables have more problems with temperature. This is because they are foreign species that are mostly grown in different climates and colder temperatures. Temperatures for growing foreign salad vegetables should not exceed 30°C or else problems concerning pythium will occur.

2.7 Mineral Deficiency Symptoms

There are three types of mineral deficiencies which are nitrogen, phosphorous, and iron deficiency. Nitrogen deficiency causes the leaves to become yellow and prevents the development of roots. Phosphorous deficiency causes dark green foliage and decreases the growth rate of the plant. Plants affected with phosphorous deficiency may appear to have a purple-greenish color. Iron deficiency causes the veins in the leaves to have a yellow color. The yellow veins will affect new leaves and if the symptoms persist, the leaves will become white.

2.8 Growing of algae

Another problem in hydroponic gardens is the growing of algae. Algae should be prevented from growing in the first place to avoid this problem. Algae grow when the fertilizer formula is constantly exposed to air and sunlight. The most efficient method in preventing algae is keeping the lids of the system closed and sealing the edges that are exposed to air and sunlight. Algae can be removed by scrubbing with a brush or using hydrogen peroxide with concentrations of 3ml of 3% H₂O₂ per one gallon of water. Algae grow even more easily when there are particles in the fertilizer formula. This problem can be solved by using a particle filtration system that can be attached to the pump itself. Algae will consume the nutrients in the fertilizer formula and can also block the pipes, preventing the flow of the system.

2.9 Conductivity

The fertilizer formula of a hydroponics system must be checked and measured frequently for maintenance of the electronic conductivity value. This can be done easily but requires sophisticated electronic devices with high technology. Electronic conductivity is the measure of the amount of salts that are dissolved in a batch of water. This value represents how well electricity can travel or be transferred in a batch of water. The electronic conductivity represents the strength of the fertilizer formula which is used to determine the amount of chemicals that needs to be added. Young plants in the nursery should not be allowed to have strong fertilizer formulas with high conductivity. Different species of plants require different amounts of nutrients and fertilizer formulas including the electronic conductivity. As the plants grow, the electronic conductivity in the fertilizer formula should be increased for the needs of the plants. A low conductivity in the fertilizer formula means that there are small amounts of nutrients left in the formula.

CHAPTER III

METHODOLOGY

The problem that occurred in Wat Patumwanaram School's hydroponics garden was that the fertility of the plants in the hydroponics garden were not meeting the school's expectations. Our goal was to help in Wat Patumwanaram School increase the fertility of the hydroponics garden. In order to realize our goal, each objective was carried out by using the following methods.

3.1 Objective 1: Identify the cause of the fertility

The direct observation would be sponsors' hydroponic garden observation at Wat Pratumwanaram School. Observations allow us to obtain additional data about the hydroponic garden position and its condition and helped us understand what the underlying causes of the problems were. Because there was a possibility that the problems came from many causes, the entire information gathered from the direct observation at the garden would provide us with information about how serious each cause was so we could identify the major cause that contributed to the hydroponic garden's fertility problem and solve accordingly.

After we did direct observation at Wat Pratumwanaram hydroponics garden, next we would interview the hydroponics garden experts to ask them about what we observed from the garden. We would ask them which were the causes of fertility problems that have to be solved and how.

3.2 Objective 2: Identify pests

In order to effectively eliminate the pest in the hydroponic garden, we have to identify the species of each pest. This step was necessary because different species of pest contribute to different problems as well as the solution to kill one kind of pest may make other kind of pest stronger. A good solution that affects all pests infected the garden with no side effect was needed. We would collect the sample of each pest we found at the hydroponic garden to give it to the expert for the identification. Sample collection was the most effective way to identify the species of the pest because written down the details and verbal description leaves many margin of error that would ultimately hinder our progress.

Because of the lack of knowledge about fungus, help from the expert in this field was needed to identify the pest and the possible ways for elimination. Because she graduated and

specializes in the biotechnology field, therefore she could easily identify the pest and suggest a way to approach to the elimination.

3.3 Objective 3: Determine an extermination method

The pests would be collected and partitioned depending on its type and will be tested in the lab at the faculty for organic ways to kill those pests gather from the expert. By performing lab tests before field tests, the experiments would not affect the hydroponics garden if something went wrong. After that we would prioritize our steps in executing the solution based on the results of the experiment performed in the lab, from the easiest pest to eliminate to the hardest.

3.4 Objective 4: Educate the students in these techniques

After the solution yield successful results, we would let students of Wat Patumwanaram School participate more in our activities in the garden as well as educate them about the method we used to eliminate pests in case they came back to the garden again. In the future, when the hydroponic garden faces other problems, these methods could also act as the guideline for the students to adapt a suitable counter measure to tackle that problem.

CHAPTER IV

RESULTS

From direct observation of the hydroponics garden at Wat Pathum Wanaram, we were able to determine that the garden was unhygienic. The person responsible for school's garden claims that the garden is cleaned every two to three months. They said that it is standard procedure but from an interview and direct observation with hydroponic experts, the prudent practice in keeping garden hygiene is to clean and disinfect the garden every harvest cycle with bleach and water solution.

Furthermore, direct observation provided us the opportunity to determine the severity of pest infection. We found that there were three types of pest two of which are aphids, the other being ants. Hydroponics experts informed us that prevention or feed forward management is the best and most practical solution in getting rid of pests. Ants exist symbiotically with millie bugs, carrying them from one plant to another. The millie bugs extract nutrients from the plants and in exchange excrete nutritional fluids for ants passing by. Hydroponics expert Mrs. Suntaree advised us to use diluted soapy water to decrease the amount of aphids. Furthermore disinfecting the garden will assist in decreasing the amount of ants, thus reducing the amount of aphids. Alternatively, we obtained another professional opinion from Ms. Patcharin at the Chaipattana Foundation for hydroponics support. She agreed with Mrs. Suntaree on using soapy water solution to spray the plants, but informed us of the limitations and the method being a temporary solution. This was because the soapy water cannot totally eradicate the aphids, but will only reduce its amount. Ms. Patcharin suggested using organic pesticides that eventually breakdown into harmless substances. We found out that there were many grades of organic pesticides that can be used, ranging from spraying one day before harvest to spraying thirty days before harvest, all depending on the quality of the pesticide.

The expert also informed us that the light in the garden was insufficient so the general characteristic of the plants were overshooting and not blossoming. For example Chinese morning glories are supposed to blossom but due to the insufficient sunlight, they were overshooting instead. This problem is caused by the dusts and particles that are covering the roof of the garden. In order to increase the sunlight, the removal of the accumulated dusts and particles on the roof that obstruct and allow minimal amount of sunlight to pass through the

garden is necessary. Both Mrs. Suntaree and Ms. Patcharin agreed that the nursery must be relocated to the roof top. The nursery garden is currently on the ground level behind the building where there is limited sunlight due to the surrounding facilities and structures. We also noticed that the cabbage grown at Wat Pathum Wanaram's school would not take a bush like appearance as it should but instead it blossomed, which was not what the school expected. The experts told that the cause of the cabbages blossoming is due to high temperatures within the greenhouse.

The last problem that we found was the student's actions and their behaviors when they work in the garden. What we observed when they were at the garden was that they usually fool around, eating snacks and throwing equipments around in the greenhouse. The expert comments that these actions caused by the students can possibly result in negative effects to the garden. In addition, the pests are able to spread all over the garden and the plant could be infected by the food they brought in. However, we will be educating them on how to take proper care of the greenhouse and its equipments, including rules and regulations to follow when working in the hydroponics garden.

Regarding the pH and EC factors, an interview from Village Chef Mr. Tun concluded that monitoring of pH level is not necessary at Wat Pathum Wanaram School's hydroponics garden. This is because the school uses a fertilizer which is added with Fe EDTA. Fe EDTA reduces the precipitation of the fertilizer, both at the too high and too low pH level. Normally, pH should be monitored and adjusted because the fertilizer precipitates when the pH is unsuitable. Due to the adding of Fe EDTA, the monitoring of pH at the school's hydroponics garden is not necessary. In addition, method of adjusting pH by using acid is too dangerous to be used at the school where there are lots of young children.

	Wat Pathum Wanaram School Farm	Prajeenburi Farm (Miss Patcharin)	Petchburi Farm (Mr. Tun)
<i>Water Store Duration</i>	2 Day	2 Day	1-2 Day
<i>Pumping System</i>	Entire day	Alternate between 15 min operation and 30 min rest	Entire day
<i>Cleaning Platform</i>	Once every 2-3 cycles	Every harvest cycle	Every harvest cycle
<i>EC Checking</i>	Wednesday Randomly	Once every 2-3 days	Everyday
<i>EC Adding</i>	Wednesday Randomly	Once every 2-3 days	After every checking if necessary
<i>Water Temp</i>	26-31°C	<30°C	<30°C
<i>Environmental Temp</i>	28-35°C	< 32°C	35°C
<i>Nursery Duration</i>	7-15 Day	7-15 Day	15 Day for only lettuce

Table 1: Comparison of 3 hydroponics farm

CHAPTER V

CONCLUSION

Tender, love, and care otherwise known as TLC is the fundamental factor in managing a hydroponics garden. TLC can also be referred to as a feed forward style of management where problems are prevented instead of solving them once they occur. Our results show that the objectives are subsets of the fundamental factor TLC. Wat Pathum Wanaram School has initially addressed the problem on fertility of the vegetable plants from hydroponics garden. As we have found through scientific investigation and interviews with experts, TLC is the main factor that can be divided into three main categories, the cleanliness of the garden, the environment, and the fertilizer formula. These three categories include ten parameters which are the causes of the fertility problem.



Figure 1: Hydroponics farm with well TLC

The cleanliness of the hydroponics garden is a main category under TLC that is most vital to the survival of the plants in a hydroponics garden. Cleanliness or garden hygiene can be closely associated with tender. The cleanliness of the garden includes three parameters which are dust and particles, pests, and the net surrounding the greenhouse. First, the dust and particles that accumulate through time is a major cause in low hygiene of the garden. Once a

garden has accumulated dust and particles, the hydroponics water system may be clogged which will prevent the flow of fertilizer formula. A garden is also more prone to be infected with pests and disease when dust and particles accumulate. Second, pests are the results of low hygiene in a garden. Pests attack plants in various different ways depending on its species, in this case attacking the leaves of the plants. By attacking the leaves, they tend to cause negative effects to the plants' nutrient absorption system. Lastly, the net which surrounds the greenhouse appears to be darkened through dust. The accumulation of dust and particles on the net allows limited sunlight to penetrate through the garden's greenhouse. Without sufficient sunlight, the plants over shoot which causes them to grow upright and not blossom.

5.1 Love

The environment of the hydroponics garden is the second category under TLC. The environment determines the surroundings of the plants grown within the garden, and without love for the environment of the plants, they will overshoot and not blossom. This includes four parameters which are sunlight, temperature, and moisture. The first parameter is sunlight as referred to previously which causes plants to over shoot. The nursery at Wat Pathum Wanaram receives insufficient sunlight due to its location and therefore is compensated by additional resources with time and money. The second parameter is the temperature within the garden. The net surrounding the greenhouse not only reduces sunlight but also reduces the ventilation within the garden. Without ventilation the temperature suitable for the plants growth will be too high. Lastly, the garden is moist. Excess moisture in the air within the garden creates an environment that is suitable for microorganism growth, causing diseases and enabling pests to flourish within the garden.

5.2 Care

The last category under TLC is the fertilizer formula. Care for the hydroponic system concerns the fertilizer formula, the little things that are overlooked. This includes three parameters and one problem which are the water pump cycle, the electro-conductivity, the pH values, and pests. Firstly the water pump cycle in the hydroponics garden is the factor that determines the growth of plants. The water pump cycle decreases the temperature of the fertilizer formula that runs through the system, at the same time creates oxygen molecules that prevent root rotting. The water pump cycle can be reduced from a 24/7 full operation cycle to fifteen minutes of operation cycle for every 45 minutes. The next parameter is the

EC and pH values of the fertilizer formula. These values determine the fertilizer formula's efficiency which with the suitable values will allow the plants to absorb nutrients properly. The EC and pH values must be measured and adjusted constantly to prevent insufficient nutrients within the fertilizer formula. Pests are present in the garden due to lack of care. Pests can be easily removed through thorough observation and care, picking them or rubbing them off with water as soon as they are found, to reduce the possibility of widespread infection.

The education of the students at Wat Pathum Wanaram on hydroponics garden is to ensure a sustainable and doable approach in the maintenance of the garden. This is also to instill and increase the tender, love, and care that the school will be able to provide, due to new students taking the course every year. This is a form of feed forward management that minimizes the causes of the fertility problem, ensuring a sustainable and doable approach in the future.

5.3 Recommendations

5.3.1 Cleanliness of the Garden

Wat Pathum Wanaram School currently cleans its equipment's concerning hydroponics every two to three harvest cycles but the floor and the greenhouse itself is cleaned once a year. We recommend that schedules and guidelines should be set up for students. Furthermore, training the students to clean the entire hydroponic garden thoroughly, scrubbing all the equipments such as the foam platform and the black pot for putting in plants every harvest cycle will enable the school to maintain a sustainable approach for garden hygiene. We recommend the combinatorial use of bleach and water, using one table spoon to five liters of water ratio for disinfecting the garden by spraying the whole system including the greenhouse. Bleach will evaporate after twenty four hours but to be on the safe side, we recommend two to three days before starting the next planting cycle.



Figure 2: Equipment in hydroponics garden at Wat Pathumwanaram are not arranged properly

5.3.2 Fertilizer Formula Level

Regarding the fertilizer formula level within the platform, we recommend adjusting the water system cycle. The water level should be maintained at the appropriate height which is half the height of the sponge in the black pot. This is easily achieved by adjusting the water regulator within the platform.

5.3.3 Temperature in the Garden

The temperature within the hydroponics garden at the roof is above the ideal temperature for a hydroponics garden. Wat Pathumwanaram School does not utilize the use of shading nets, claiming to cause insufficient sunlight, thus resulting in plants overshooting. We recommend the use of gray shading nets instead of black shading nets that absorb every color in the visible spectrum. The use of gray shading nets will decrease the heat but at the same time will allow sufficient sunlight to pass through for fertile growth.

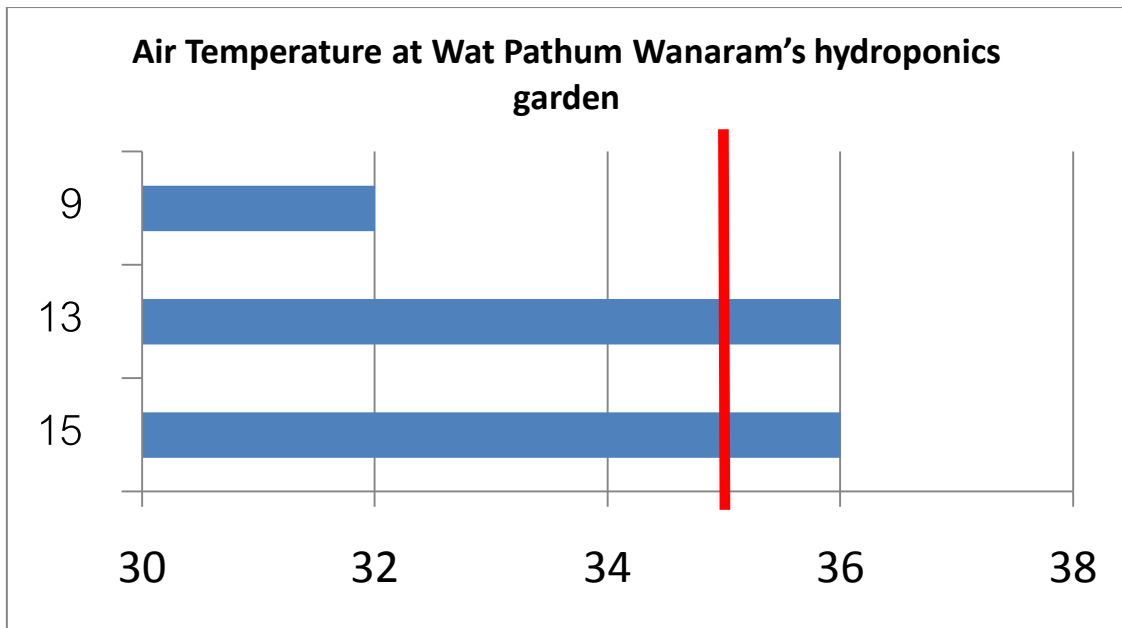


Table 2: Air temperature at Wat Pathumwanaram's hydroponics garden is over standard

5.3.4 Temperature of the Fertilizer Formula

The temperature of the fertilizer formula in the hydroponics system at Wat Pathum Wanaram School is higher than the ideal standards. We recommend allowing more air into the garden by removing or increasing the grid size of the net surrounding the greenhouse. This design will be most effective if combined with the shading net mentioned previously in decreasing heat during the daytime.

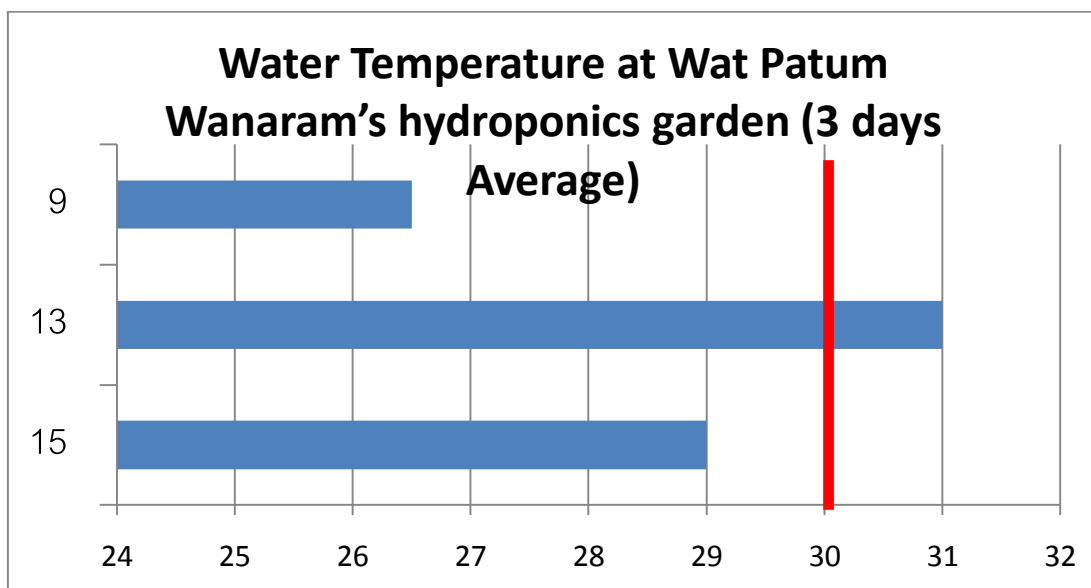


Table 3: Water temperature at Wat Patumwanaram's hydroponics garden is over standard (3 days average)

5.3.5 Electrical Conductivity Level

Wat Pathumwanaram School does not adjust the EC levels for each platform system. Each type of plant requires different EC levels for efficient growth due to their rate of nutrient consumption. Wat Pathum Wanarm School grows four main types of vegetables which is morning glory, kale, lettuce, and cabbage, their ideal EC levels for each species being 1.8, 3.5, 1.2, and 3.5 respectively. We recommend the adjustment and maintenance of EC levels which decreases over time. A routine measurement of EC levels is recommended to be performed ever three days

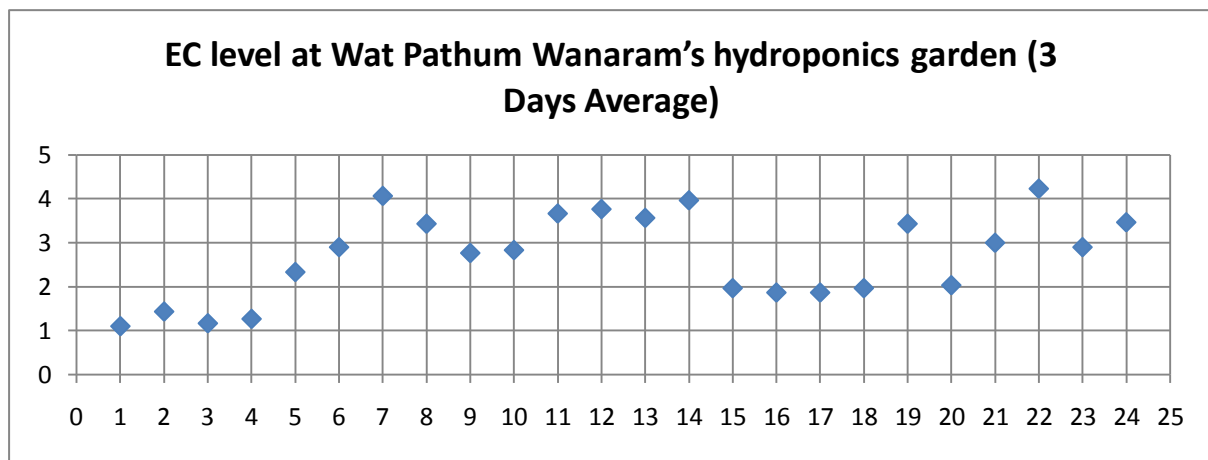


Table 4: EC level at Wat Pathum Wanaram's hydroponics garden (3 days average)

5.3.6 Sprinkler Schedule

We strongly recommend Wat Patum Wanaram School to change the sprinkler schedule from one hour per day to one minute every hour from 10:00 pm to 2:00 pm to avoid unsuitable moisture level within the greenhouse. This will reduce the operation cost of sprinkler water and at the same time, keep the humidity in the garden at a suitable level, preventing a fungus friendly environment from occurring. Furthermore we strongly recommend an increase in sprinkler time from one minute per hour to two minutes per hour during summer to compensate for scorching heat.



Figure 3: Sprinkle in hydroponics garden

5.3.7 Pests

Pests are infecting the garden in large amounts. We recommend the use of organic pesticides that are harmless to the plants. Organic pesticides have many grades, which depends on the school's budget. The cheaper the pesticide, the longer amount of time it must be sprayed before it can be harvested. Alternatively, pests can be prevented by thorough daily observation. Soapy water can be used to cover the plants' leaves which help in pest prevention. Furthermore, rubbing or picking off the pests as soon as they are found is recommended to prevent a widespread infection of pests.

REFERENCES

- 2.10 <http://www.thefarm.org/charities/i4at/surv/hydro.htm>
- 2.11 <http://www.gthydro.com/hydroponicsgrowingtips.html>
- 2.12 <http://www.onlinegardenertips.com/Hydroponics/What-Are-The-Pest-And-Diseases-Of-Hydroponics.html>
- 2.13 <http://www.gthydro.com/hydroponicsgrowingtips.html>
- 2.14 <http://www.gthydro.com/hydroponicsgrowingtips.html>
- 2.15 <http://www.gthydro.com/hydroponicsgrowingtips.html>
- 2.16 <http://www.gthydro.com/hydrogardeningandhydroponicfaq.html>