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Application of Liquid Fertilizer as Supplementary Foliar Spraying for Green Mustard NFT Hydroponics Farming

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DECLARATION

I hereby declare that the work embodied in here is the result of my own research except for the excerpt as cited in the references.

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Application of Liquid Fertilizer as Supplementary Foliar Spraying for Green Mustard NFT Hydroponic Farming

ABSTRACT

Green mustard is in very high demand in Malaysia. They are the second most cultivated crop in Malaysia. The increase in food demand due to a growing population, declining fertile land and COVID-19 pandemic poses one of the biggest challenges faced. NFT hydroponics is a new practice in producing vegetables in stacked layers. This system is a method that has long been used in developed countries to produce clean, quality vegetables and a lucrative income, especially for some types of high value vegetables. Therefore, an experiment was conducted to study the benefits of liquid fertilizer and additional foliar spraying for outdoor green mustard NFT hydroponics farming. A total of 60 green mustard seedlings has been planted for planted in NFT hydroponic for field experimental. The study had implemented design in NFT hydroponic system using 3 types of treatment with 3 replication which is organic fertilizer, inorganic fertilizer and AB that have been used for this experiment. Data on plant height and leaf width has been taken 3 times a week while data for SPAD meter, EC meter, pH has been taken once a week. Fresh weight of green mustard was recorded after harvested. The data collected has been subjected to one-way ANOVA. Results of the experiment showed that treatment organic foliar spraying had produced the highest leaf width, weight and SPAD chlorophyll values compared to treatment inorganic and control treatment. In conclusion, organic foliar spraying is recommended for use in hydroponic NFT to obtain high quality of the vegetables.

Keywords: *Liquid fertilizer, Green Mustard, NFT hydroponics farming*

Penggunaan Baja Cecair sebagai Semburan Daun Tambahan untuk Pertanian Hidroponik NFT Mustard Hijau

ABSTRAK

Sawi hijau mendapat permintaan yang sangat tinggi di Malaysia. Ia adalah tanaman kedua paling banyak ditanam di Malaysia. Peningkatan permintaan makanan berikutan pertambahan penduduk, kemerosotan tanah subur dan wabak COVID-19 menimbulkan salah satu cabaran terbesar yang dihadapi. Hidroponik NFT adalah amalan baru dalam menghasilkan sayur-sayuran dalam lapisan bertindan. Sistem ini merupakan satu kaedah yang telah lama digunakan di negara maju untuk menghasilkan sayur-sayuran yang bersih, berkualiti dan pendapatan yang lumayan terutama bagi beberapa jenis sayuran yang bernilai tinggi. Oleh itu, satu eksperimen telah dijalankan untuk mengkaji kebaikan baja cecair dan semburan daun tambahan untuk penanaman hidroponik NFT sawi hijau luar. Sebanyak 60 anak pokok sawi hijau telah ditanam untuk ditanam secara hidroponik NFT untuk ujikaji lapangan. Kajian ini telah melaksanakan reka bentuk dalam sistem hidroponik NFT menggunakan 3 jenis rawatan dengan 3 replikasi iaitu baja organik, baja bukan organik dan AB yang telah digunakan untuk eksperimen ini. Data ketinggian tumbuhan dan lebar daun telah diambil 3 kali seminggu manakala data untuk meter SPAD, meter EC, pH diambil seminggu sekali. Berat segar sawi hijau direkodkan selepas dituai. Data yang dikumpul telah tertakluk kepada ANOVA sehala. Keputusan eksperimen menunjukkan bahawa semburan daun organik rawatan telah menghasilkan lebar daun, berat dan nilai klorofil SPAD yang paling tinggi berbanding rawatan bukan organik dan kawalan. Kesimpulannya, penyemburan daun organik disyorkan untuk digunakan dalam NFT hidroponik untuk mendapatkan kualiti sayuran yang tinggi.

Kata kunci: *Baja cecair, Sawi Hijau, penanaman hidroponik NFT*

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LIST OF SYMBOLS

% Percentage

°C Degree Celsius

LIST OF ABBREVIATION

Cm	Centimetre
Kg	Kilogram
PPFD	Photosynthetic Photon Flux Density
UMK	University Malaysia Kelantan
ANOVA	Analysis of Variance
SPSS	Statistical Package for the Social Science

CHAPTER 1

INTRODUCTION

1.1 Research Background

Brassica juncea, which is commonly called as green mustard, and known as 'sawi pahit' by the local in Malaysia. It belongs to the Brassicaceae family and is believed to be originated from Central Asia, but are now grown worldwide. Green mustard the vegetable is a plant of horticultural has a role as a source of vitamins and minerals. The demand on greens is increasing. This plant is grown alongside five other leafy vegetables in Malaysia, including bitter mustard, japanese mustard, flower mustard, white mustard, and even kailan (Harress 2017). In Malaysia, a total of 9443 hectares of mustard were planted in 2018. According to the study Anem, (2011) Johor is the state with the highest green mustard production in Malaysia, with 2280 hectares. Green mustard is a short-lived crop that is now grown commercially as a monocrop by farmers.

There are two types of mustard: seed oil and vegetable mustard. Mustard leaves are widely grown in Southeast Asia. In our local market, leaf mustard is a popular leafy vegetable (Arifin, Rochdiani et al. 2018). These vegetables are consumed in a variety of ways, including fresh greens in stir-fry, pickles, and brine. It has a distinct flavour and a strong odour. The title type is exported from Thailand as a canned pickled vegetable. Sarawak imports large quantities of salted mustard from Thailand and China in both plastic and earthen jars. Leaf mustard is an erect, unbranched annual herb with varying leaf shape and size, headed or headless inflorescences, and terminal raceme inflorescences. It thrives in fertile maternity loamy soil.

Based on Zamriyetti, et al. (2019) stated that vegetables are popular among the community because they are high in vitamins, minerals, protein, and fibre. The large area used for cultivation cannot help the community's ever-increasing need for vegetables. Horticulture crops are leafy vegetables that are important because they contain more vitamins than other vegetables. With a tropical climate that provides sufficient rainfall and heat, farmers are becoming more diligent in their farming activities. With the right temperature, these climatic conditions have caused the crops they grow to thrive.

Green mustard has evolved into a vegetable crop with a significant role to play in today's society. The demand for green mustard has increased significantly from year to year. This is why the community has progressed in cultivating mustard plants in all areas of their home yard. As stated by Yuliantika and Dewi (2017) one method of increasing mustard crop productivity is to use modern crops such as NFT hydroponics, which is a simple, efficient cropping system that produces lucrative and high-quality yields. The technology of such crop systems is very important in today's era and should be adopted by society because it is in line with modern times.

1.2 Problem Statement

By 2050, the world's population is expected to be nearly 10 billion and feeding a large population will be a major challenge (Ranganathan, 2019). The increase in food demand due to a growing population and declining fertile land poses one of the biggest challenges faces. The need for vegetables such green mustard is needed from year to year because the population in Malaysia is increasing. NFT hydroponics is a new practice and this new method that produces food in stacked layers. This planting system is ideal for growing vegetables because it is simple, inexpensive, and effective on a wide range of crops. It is a method that has long been used in developed countries to produce clean, quality vegetables and a lucrative income, especially for some types of high value vegetables. Until such time as this method is expanded in our country to ensure food that is safe to eat and adequate.

Liquid fertilizer is formulated to include what plants need. It will provide nutrients for plants through the flower, through foliar feed, or through the soil and root system of a plant. It will provide nutrients. Over-fertilization can limit the use of nutrients and cause a number of environmental and economic problems. The balanced input of fertilizers has nonetheless played a major role in increasing agricultural output. In a NFT hydroponics system, the addition of liquid fertilizer can be done in the stacked layer irrigation so that the plants constantly have a fresh supply of nutrients. There are many types of fertilizers that are best suitable for use in NFT hydroponics, among them are organic fertilizer, inorganic fertilizer and AB fertilizer only without additional foliar spraying.

1.3 Hypothesis

H0: There is no effect on growth and yield performance of green mustard when spraying the liquid fertilizer in the NFT hydroponics.

H1: There is an effect on growth and yield performance of green mustard when spraying the liquid fertilizer in the NFT hydroponics.

1.4 Objectives

The main objective of the study is to apply different liquid fertilizer as supplementary foliar spraying to the green mustard vegetable that has been planting in the NFT hydroponics farming. Below are the sub-objectives for the study:

1. To analyse the different effects of liquid fertilizer as foliar spraying to green mustards growth and yield in NFT hydroponics
2. To investigate the most preferable and suitable rate of liquid fertilizer as foliar spraying to green mustard in NFT hydroponics
3. To analyse the nutrient content amount in green mustard leaves after sprayed liquid fertilizer application

1.5 Scope of Study

The focus of the study is to determine the effect of liquid fertilizer to the green mustard vegetable that have been planted in the NFT hydroponics farming and the its impact on the yield performance. This research also very important to identify the suitable rate of growth performance of green mustard to observe height of plant, width of leaf, SPAD meter to check the chlorophyll on the leaf and time taken to the plant can be harvested. The best plant that takes the shortest time to grow would be determined at the end of the experiment.

1.6 Significance of Study

The significance of study is to determine the ability of organic liquid fertilizer, inorganic liquid fertilizer and AB fertilizer on green mustard in NFT hydroponics. Inorganic fertilizer is favoured by farmers in the agricultural industry because it is simple to use and obtain. Farmers' understanding of the use of inorganic liquid fertilizers is also limited. This is due to farmers' failure to understand the inorganic liquid fertilizer's impact on human health and the environment. In this study would be the useful and benefits of using organic liquid fertilizer instead of using inorganic liquid fertilizer. Nowadays, the organic fertilizer is very friendly to human health and environment. At the same time the organic fertilizer can supply nutrients to in a form of foliar spraying.

1.7 Limitation of Study

However in this study have a few limitation of study when using NFT hydroponic system as implemented design which is using the crop protection chemical for pest and disease control as can effect in experimental data. Then the temperature, humidity and light source are unable to be controlled when doing experiment outside from the greenhouse.

CHAPTER 2

LITERATURE REVIEW

2.1 NFT Hydroponics System

The term hydroponics is derived from the Latin words *hydro* and *ponic*, which mean working with water. Hydroponics became popular in Malaysia around the year 2000, when the price of goods skyrocketed. However, this is only a temporary situation, possibly due to a lack of knowledge and understanding of how hydroponics works. According to Al-Tawaha, et al. (2018), claimed that the NFT hydroponics system necessitated a significant degree of knowledge, expertise, technical skills, and financial commitment for the greenhouse system. However, in early 2016, more and more people wanted to learn the basics of hydroponics that can be done at home. Studies of soilless plant cultivation can be traced back to the 1600s. There are many scientists who have contributed a lot of information towards producing a good hydroponic system

Among the various hydroponic systems used, the NFT hydroponic system is a very effective and productive system (Anem 2012). The reservoir hydroponic system was first introduced in Malaysia in the early 1980s by the Department of Agriculture, who used reservoir technology with a polystyrene tray with 8-12 planting holes and a simple hydroponic fertilisation package. Most reservoir hydroponics are done as a hobby, but there have been some entrepreneurs who have commercialised reservoir hydroponics systems in Melaka in the past. For those who are new to hydroponic farming, NFT hydroponic technology is a bit more complicated.

According to Yuliani, et al. (2021) stated that NFT hydroponics is a different cropping system than regular crops because it is soilless farming and uses different media as well as more effective irrigation systems than regular crops. The benefits of planting with an NFT hydroponics system are simple to maintain, particularly when attempting to control the value of the nutrient content, which can be controlled by itself. Vegetables grow quickly and maximally because the plants receive adequate water, oxygen, and nutrients (Yuliani, Rusli et al. 2021). Significant reduction in water costs/consumption as a result of hydroponic farming, which uses only 10% of the total crop use on land. Hydroponics can also reuse water used for planting after harvesting, requiring only the addition of water if needed, and thus lowering crop production costs. The savings in fertiliser use are significant because there is no waste and it also does not pollute the environment. In the same production rate, the use of hydroponic fertilisers consumes only 1/4 of the amount of soil fertiliser. Significant space savings because hydroponic techniques require only one-fifth of the land area required by above-ground crops to produce the same yields

2.2 System Structure of NFT Hydroponics in Malaysia

People are becoming interested in growing vegetables in their backyards or small gardens. According to Phibunwatthanawong and Riddech (2019) the NFT agricultural system is an innovative solution to the problem of increasingly narrow open space that is being dominated by buildings. The plants in this design are stacked and grow in either closed or open greenhouse areas. This NFT farming system is widely used by them today because it is a very efficient cropping system. In other words, because it is a simple cropping system that does not require soil media for planting, this NFT farming system is ideal for residents living in urban or rural areas.

2.3 Type of NFT Hydroponics System

There are various types of hydroponic structural systems that are frequently employed in vegetable crops nowadays. The Drip System is the most widely utilised hydroponics system. Vital nutrients are given to a tank of water to establish a nutrient reservoir that is maintained apart from the plants. The water is then pushed up a network of tubes and distributed to the plants individually. An Ebb and Flow System, on the other hand, makes use of a nutrient reservoir, keeping the water in a separate tank from the plants, which are placed on a grow tray above. A timer is set to trigger a pump that is stored in the nutrient reservoir on a regular basis. The third technique is Nutrient Film

Technique (NFT), which is commonly employed in commercial hydroponics, particularly for short-harvest crops.

In a continuous cycle, the nutrient solution is injected from the reservoir into the grow tray. The growth chamber has a little downward slope, which allows the solution to flow from the top end of the tray to the bottom, where it is recycled back into the nutrient reservoir (Sesanti and User 2016). Fourth, the most technologically sophisticated hydroponic system is the Aeroponics System. As in the NFT system, the plants are hung in the air, with their roots dangling down below. The nutritional solution is then forced up a tube, where it is misted over the hanging roots by a second, higher-pressure pump. Fifth is Deep Water Culture (DWC), by far the simplest method of hydroponics. According to Sesanti and User (2016) stated based on their study, DWC are often used in classrooms to provide a working example of a hydroponics system and the nutrient solution in this type of system is not circulated, it is essential to include an air stone to keep the water oxygenated. Finally, an Aquaponics System is used, in which the fish live in a nutrient reservoir. Their waste, like any uneaten food, emits ammonia into the water. Ammonia is harmful to fish, and if they remain in ammonia-contaminated water, they will die; thus, it must be removed to keep them healthy.

2.4 Type of Vegetables used in NFT Hydroponics System

According to Aulia Ulzanna (2021) stated that broccoli raab, certain herbs, spinach, salad or leafy greens, and cruciferous vegetables are examples of these plants. For certain herbs, are ideal for the NFT system and are the most commonly grown options in the NFT channel. Basil is an excellent type of herb because it is the simplest and most widely grown. Their root system is not extensive, and they grow quickly. Other herbs that can be grown in NFT include cilantro, parsley, Thai, lemon, Genovese, and others. Next for salad or leafy greens, these include spinach, lettuce, and arugula (Aulia Ulzanna 2021). Brassicaceae Family is Brassicaceae vegetables, also known as cruciferous vegetables, include mustard greens and kale. However, due to space constraints, the NFT is not suitable for types that form heads, such as broccoli and cabbage. They grow large and have massive roots, and their maturity period is lengthened as a result, making them unsuitable for the NFT system. Certain fruits and flowers, the NFT system includes certain flowers and fruits. Strawberries are an example of a fruit that can be grown in the NFT channel. Strawberries are small growing fruits that can be grown in a shallow system. As a result, they are ideal for NFT. Orchids, pansies, and nasturtiums are examples of flowers that can be grown in NFT channels.

Lastly, the NFT system is primarily used to grow leafy greens with a short growth period. Nutrient film techniques, on the other hand, are not appropriate for larger or taller plants such as cabbage, trees or shrubs, or root crops. They are also incompatible with plants with larger root systems or those that take longer to grow.

2.5 Liquid Fertilizer

The application of liquid fertilizer as a supplemental foliar spraying for vegetable NFT hydroponics is the subject of this study. Fertilizers are known to be important in helping to increase soil fertility and crop yield. Based on their study, Ahmed, et al. (2021) shows it also contain plant nutrients that are directly supplied for plant growth and it is critical to assist in increasing soil fertility to meet the crop's growth needs from the early stages until harvest. For farmers who are successfully growing food crops, liquid fertilizer is becoming an alternative method for supplementing extra nutrients. While liquid fertilizer is often discussed, small and large farmers continue to use it. According to Phibunwatthanawong and Riddech (2019), a farmers must understand the advantages and disadvantages of liquid fertilizer and they need to learn with the correct method to apply the fertilizer to crops.

Liquid fertilizer provides many advantages, includes it sprayed on the leaves and will penetrate the leaves, plant cell walls through the epidermal and stomata cells and increase photosynthetic activity (Hong, 2021). Liquid fertilizers is more effective because it can penetrate plant cells completely, then it acts more like vitamin and provides other micro elements such as boron, calcium, plant growth regulator (PGR) and so on to increase high quality and yields (Pooja & Ameena, 2021). In this study, there were 3 types of fertilizer used which is organic fertilizer, inorganic fertilizer and AB fertilizer. The use of these 3 types of fertilizers is to evaluate the growth of green mustard, to analyse the different effects of liquid fertilizer, to investigate the most preferable and suitable rate of liquid fertilizer and to analyse the nutrient content amount in mustard green leaves after put the liquid fertilizer application. There are many different and advantages of these 3 types of fertilizer.

2.5.1 Organic Liquid Fertilizer

Organic liquid fertilizer contain essential plant nutrients as well as beneficial microorganisms that recycle organic matter (Phibunwatthanawong and Riddech 2019). For organic fertilizer, it produced from natural materials without a mixture of chemicals such as decomposition of agricultural waste that is easily decomposed, for example crop waste and animal waste. Based on Churilova and Midmore (2019), stated that organic fertilizer release nutrients only when the soil is warm and moist, which corresponds to when plants are most in need. However, because they rely on soil organisms to decompose organic matter, nutrients are released more slowly than with inorganic fertilisers. Although this method reduces the risk of nutrient leaching, it takes time to provide nutrients to plants (Susanti, Astri et al. 2020). Nowadays, the used of organic fertilizer is becoming more widespread and it has become the choice of farmers and gardeners to increase soil fertility to produce healthier and safer agricultural products.

2.5.2 Inorganic Liquid Fertilizer

While for inorganic fertilizer, it produced from the factory through a chemical process, premix or compound to the crop to meet the needs of the crop. Inorganic fertilisers provide this nutrition in plant-ready form right away. However, the concentration of nutrients increases the risk of burning the plant, and the rapid release of nutrients may leach them deeply into the soil and water table, where plants cannot access them. The use of inorganic fertilizers in accordance with the specifications, rules or procedures that have been set will bring commensurate results. But the indiscriminate use of chemical fertilizers only worsens the environmental and economic conditions of gardeners.

2.5.3 AB Liquid Fertilizer

Hydroponics nutrient A&B is a water soluble granular (set A) and water soluble powder (set B) plant food contains N, Ca & Fe (Sesanti and User 2016). It is an all-in-one balanced fertiliser for hydroponics, indoor/outdoor potted plants, and herbs. Hydroponic nutrients A&B has consistently produced outstanding results for a large community of urban growers. It is a two-part solution that is simple to use and consistently produces powerful results. Ideal for use with soil, rockwool, coco, or aero applications. The hydroponic nutrients A&B formula was created as a two-part nutrient to maximise growth potential. To promote healthy, lush vegetative growth, the formula contains all primary nutrients. Lastly AB fertilizer is a mixture of fertilizer A and fertilizer B. Fertilizer A is high in potassium, while fertilizer B is high in sulphate and phosphate. The results demonstrated that varying the AB MIX nutrition and the liquid organic fertiliser based on LMO (Local Microorganisms) significantly increased the growth of green mustard.

CHAPTER 3

MATERIALS & METHODS

3.1 Plant Material

This study was used *Brassica juncea* that were propagated by seeds in a seedling tray at Universiti Malaysia Kelantan, Jeli Campus. Seedlings were sown for a week then transferred into NFT Hydroponics pots and 60 of green mustard seedling was used for this study.

Figure 3.1: Examples of NFT hydroponics

3.2 Materials and Equipment

The material used were measuring tape, organic and inorganic liquid fertilizer, AB fertilizer, sponge, pots, pressure hand pump sprayer bottle and replica of NFT hydroponics. All the NFT hydroponic system will be used AB fertilizer as the main source nutrients to the crop for all the treatment during experiment. The replica of NFT hydroponics has been provided at the Institute of Food Security and Sustainable Agriculture (IFSSA) site in Universiti Malaysia Kelantan, Jeli Campus

Table 3.2 Number of replications

Treatment	Number of replications
Control (AB fertilizer only)	20
Treatment 1 (AB fertilizer) (Inorganic foliar spraying)	20
Treatment 2 (AB fertilizer) (Organic foliar spraying)	20

3.3 Methods

Table 3.3: Type of treatments and number of replications

Treatment	Fertilizer	Number of replications
Control (AB fertilizer only)	No foliar spraying	20
Treatment 1	Inorganic foliar spraying	20
Treatment 2	Organic foliar spraying	20

3.3.1 Preparation of Organic Liquid Fertilizer

Prepare 7.5ml of organic fertilizer, 2ml of adhesive and 1.5 litres of water to make a mixture of organic fertilizer as recommend by the supplier. In a container filled with water, mix the fertilizer and adhesive, then stir until smooth and well blended. Fill a hand pump sprayer with ready-mixed fertilizer and spray it on green mustard at NFT hydroponics, application of foliar spraying needs to be performed one time a week.

3.3.2 Preparation of Inorganic Liquid Fertilizer

Prepare 3.75ml of inorganic fertilizer, 2ml of adhesive and 1.5 litres of water to make a mixture of inorganic fertilizer as recommend by the supplier. In a container filled with water, mix the fertilizer and adhesive, then stir until smooth and well blended. Fill a hand pump sprayer with ready-mixed fertilizer and spray it on green mustard at NFT hydroponics, application of foliar spraying needs to be performed one time a week

3.3.3 Preparation of AB Liquid Fertilizer

Prepare 1 litres of water, then 5 litres of set A fertilizer and 5 litres of set B fertilizer. In a container filled with water, mix the fertilizer of set A and set B, then stir until smooth and well blended. At least 13 types of nutrients need to be supplied to the crop for complete growth. Nutrients are supplied to crops using water -soluble fertilizers or commonly known as AB fertilizers that contain complete nutrient content. It is mixed with water at a certain rate to produce a nutrient solution that is filled into the nutrient solution reservoir container. This nutrient solution must be sufficient because it will be reduced throughout the growth of the plant.

3.3.4 Adhesive

Adhesive is a type of liquid that is mixed into foliar fertiliser using the spray method so that the sprayed fertiliser sticks to the leaves because green leaves have transcuticular holes, which are holes located between the cell structure and the stomatal pores through which the sprayed nutrients can enter. Reduce water stress by swiftly absorbing and dispersing fertilisers and pesticides. Fertilizer and pesticide sprays can swiftly and effectively penetrate to the bottom of the leaves. The glue is silicone-based; thus, it is safe for the plants. Can reduce the amount of fertiliser and insecticides used by preventing spray leaking. Enhances the efficacy of maintain fertilizer fertilisers used in spraying. 2ml of adhesive is dissolved in 10 litres of water for foliar fertiliser.

3.4 Harvesting

Green mustard plant can be harvested within 28 days or 30 days of the transplant. To harvest it, can pull the green mustard plant immediately from sponge slowly. Most leafy vegetables can be harvested within a month from the planting pot. For leafy vegetables it is recommended to change the nutrient solution to water a few days before harvest to reduce the nitrate content in the leaves. Before planting new crops, it is best to wash the pots of hydroponic plants from any dirt and moss. Mosses easily grow in hydroponic systems because nutrient solutions are also a source of food and drink for them. The principles governing when a fruit or vegetable should be harvested are critical to its subsequent storage, marketable life, and quality. Fruit and vegetable physiologists divide the life cycle of fruits and vegetables into three stages: maturation, ripening, and senescence. Maturation indicates that the fruit is ready for harvest. The edible part of the fruit or vegetable is fully developed at this point, but it may not be ready for immediate consumption. Ripening occurs after or during maturation, making the produce edible as indicated by taste. Senescence is the final stage, which is characterised by natural degradation of the fruit or vegetable, such as loss of texture, flavour, and so on (senescence ends at the death of the tissue of the fruit).

3.5 Data Collection and Statistical Analysis

The effect on growth performance of green mustard has been assessed by observing the plant height, leaf width for 3 times a week and for SPAD meter observing for once a week. The data were collected and analysed using SPSS version 26.0 and software - one-way ANOVA. The Tukey test were analysed to compare the mean between treatments at p= 0.05 or 5% significantly.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Growth performance analysis of green mustard with the different fertilizers

According to the study, all of the plants for each treatment continue to grow from day to day by using the NFT hydroponic system with various liquid foliar fertilizer, including organic and inorganic fertilizers. From the continuous observations, on the other hand, revealed significant differences in the growth performance of green mustard plants for each treatment. All growth performance data were collected during the growth stage, beginning the day after transplanting (DAT) until of harvest period. Each treatment received the same AB fertiliser ratio, the same amount of water, and the same pH rate (6.2–6.5) as measured by a pH metre. Each treatment's fertiliser use had a different value, which was measured using a SPAD chlorophyll metre to determine the chlorophyll content in green mustard leaves.

4.1.1 Plant Height

Figure 4.1.1 shows that there is no significant difference in plant height when compared to the treatment applied to green mustard even though there is a difference in height measurements between treatment 1, treatment 2 and treatment 3. From the Figure 4.1.1 shows that treatment 1 (organic foliar fertilizer) greatly affects the growth of green mustard compared to treatment 2 (inorganic foliar fertilizer) and treatment 3 (AB fertilizer only). Based on the Figure 4.1.1, it shows that among the 3 types of fertilizer used, organic foliar fertilizer shows good results in the growth performance of green mustard compared to other liquid fertilizer. Thus, selection of fertilizer is crucial as it could affects the growth of green mustard plants. According to Zamriyetti, et al. (2019) stated that the application of supplementary fertilizers to green mustard produces highest crop height and the best response to crop growth. The height of green mustard in organic treatment shows the highest pattern compared to the others treatment.

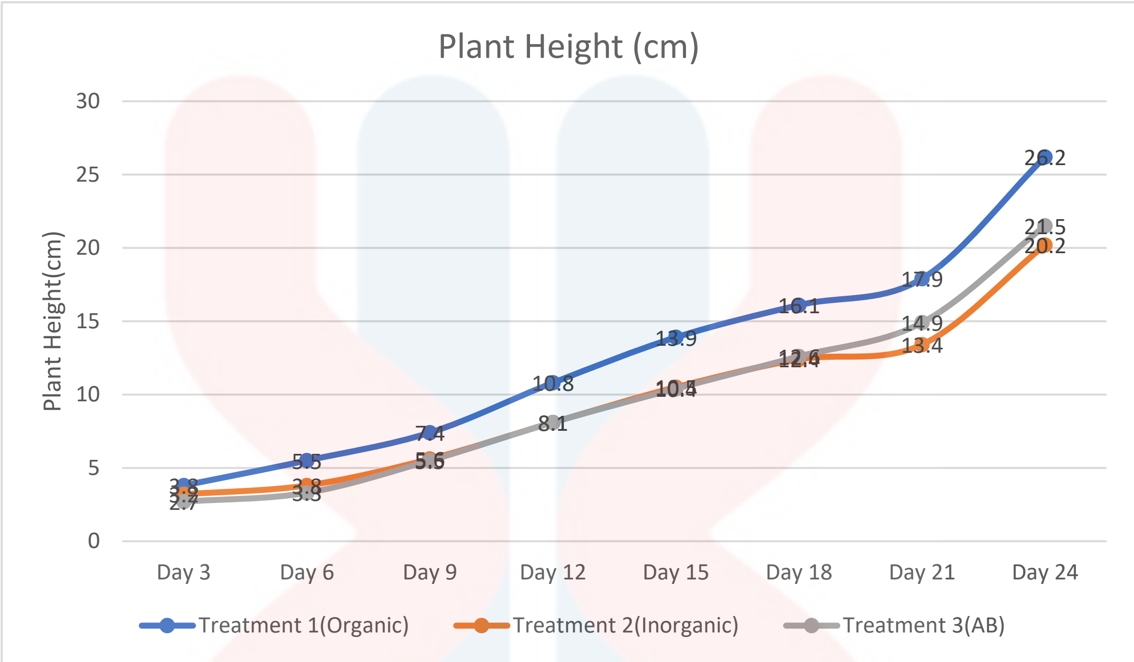

Figure 4.1.1: The growth performance of plant height of green mustard using different type of fertilizer

4.1.2 Leaf Width

The data in Figure 4.1.2 show the growth parameters of green mustard’s leaf width. Green mustard was found to be influenced by organic treatment from day 1 to day 8 and to have a significant difference in measurement for leaf width. Treatment 1 produced good results and was suitable for green mustard based on changes and differences in leaf width. Based on the comparison of the three types of treatments, it was discovered that organic fertiliser produced highest leaf width when compared to other fertilisers in term of growth performance for green mustard. When compared to other treatments, the width of green mustard’s leaves in the organic treatment showed the highest pattern of leaf width. As stated by Zamriyetti, et al. (2019) Treatment 1 (organic fertiliser) was proven to be effective in increasing the number of leaves and leaf breadth significantly.

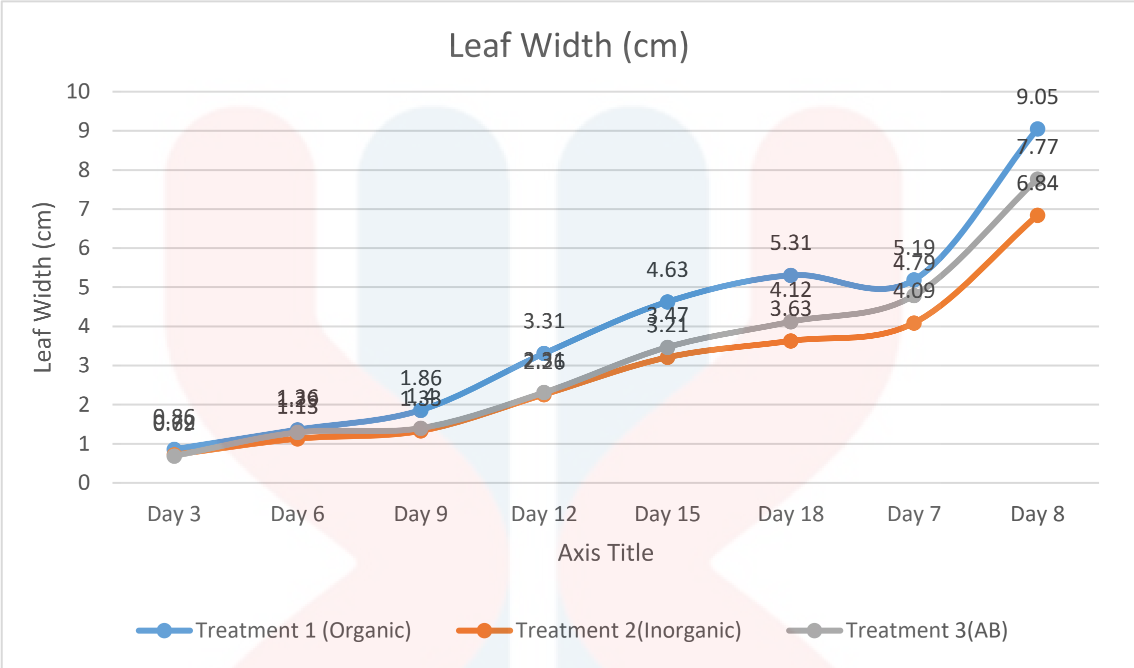

Figure 4.1.2 show the growth parameters of green mustard's leaf width using different type of fertilizers

4.1.3 SPAD Meter

Observation of leaf chlorophyll content was carried out when harvesting green mustard plants four weeks after planting. Based on Figure 4.1.3, shows that the treatment with a combination of organic fertilizer, inorganic fertilizers and control treatment. Chlorophyll is abundant in leaf and other plant parts with green characteristic and plays a role in the process of plant photosynthesis (Setiawati, Aini et al. 2019). Chlorophyll is in chloroplasts, where photosynthesis process was occurs. Figure 4.1.3 shows that the chlorophyll content in the green mustard leaves against the treatment applied. It was found that the chlorophyll content of green mustard treated from week 1 until week 4 shows that the Treatment 1 (week 1: 24, week 2: 33, week 3: 36, week 4: 38) had significant increase compared to Treatment 2 (week 1: 23, week 2: 31, week 3: 31, week 4: 34) and Treatment 3 (week 1: 24, week 2: 33, week 3: 33, week 4: 36). Organic fertilizers used on green mustard produce good result on plant height, leaf width, and a high chlorophyll content. The more chlorophyll content in leaf will result in higher photosynthesis process.

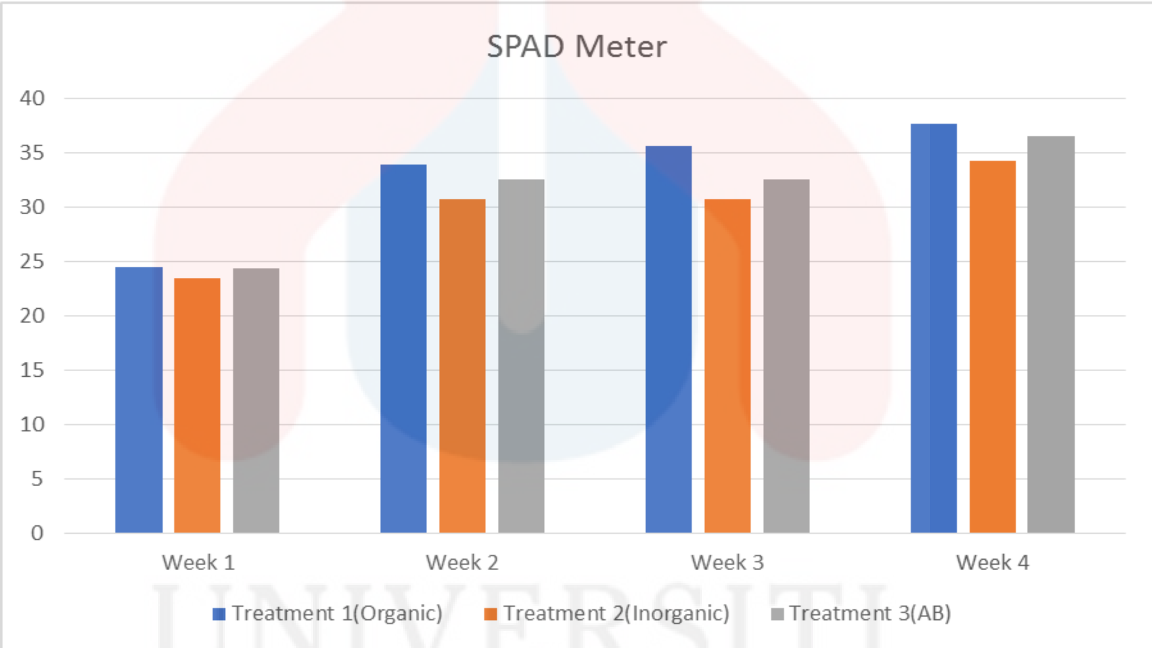

Figure 4.1.3: The growth performance of SPAD values of green mustard using different type of fertilizer

4.1.4 Plant Weight

Plant weight of green mustard as affected by liquid fertilizer are shown in Figure 4.1.4. The result showed that the treatment 1 (organic fertilizer) have significant increase in plant weight as compared to treatment 2 (inorganic fertilizer) and treatment 3 (AB fertilizer). When the tested plants were subjected to three different types of treatments, significant changes were observed. Green mustard sprayed with treatment 1 (organic fertiliser) had the highest weight of 26.5 grams, followed by treatment 3 (AB fertiliser) with 17.1 grams and treatment 3 (inorganic fertiliser) with 9.1 grams. Based on the result, Zamriyetti, et al. (2019) stated that the rise in crop fresh weight is related to an increase in crop height and the number of leaves as the vegetative component of the crop consumes extra nutrients, such as organic fertilisers. The availability of nutrients, particularly N nutrients for green mustard plants, has a significant impact on plant growth and development.

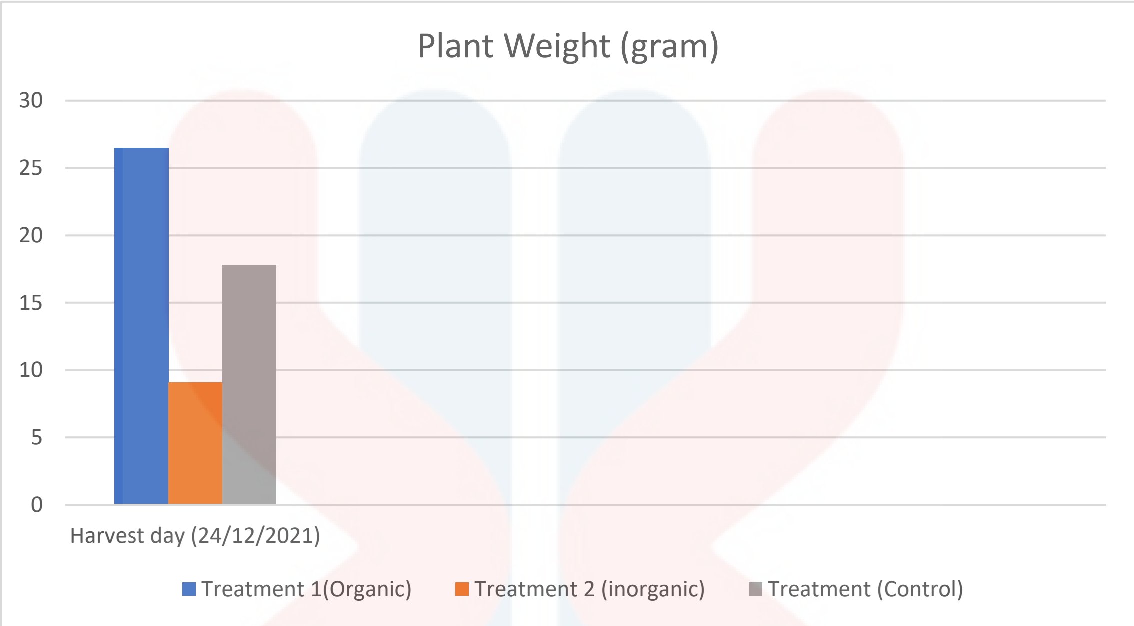

Figure 4.1.4: The growth performance of plant weight of green mustard using different type of fertilizer

4.1.5 pH level for Green Mustard

The pH level of green mustard plants in each treatment varies somewhat depending on the amount of water provided. To see the reading change, the pH of the nutrition solution must be measured. The availability of nutrients in solution is indicated by changes in pH. The pH level is maintained in accordance with the needs of the plant growth stage, with mustard preferring a pH range of 6.0 to 6.5. (Resh, 2013). The projected optimal pH of roughly 6.42 is shown in Figure 4.1.5.

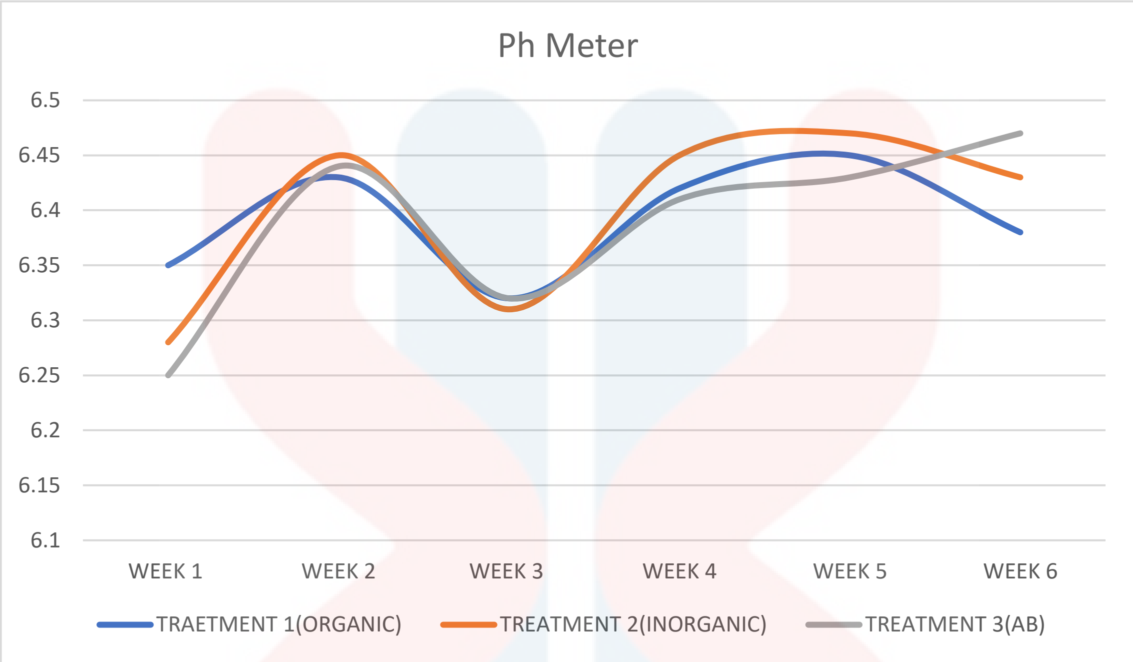

Figure 4.1.5: Graph of pH level per week

4.1.6 EC Readings for Green Mustard Plants

The EC levels will differ depending on the type of plant and the type of extra fertiliser used. To obtain an accurate measurement, the EC metre used must be stable at 27 °C ambient temperature. The EC values for mustard should be in the range of 2.0-2.1 mS/m (Resh, 2013a) The EC values were kept within the daily mustard suitability range. The estimated optimal EC value is around 1.9 mS/m, as shown in Figure 4.1.6.

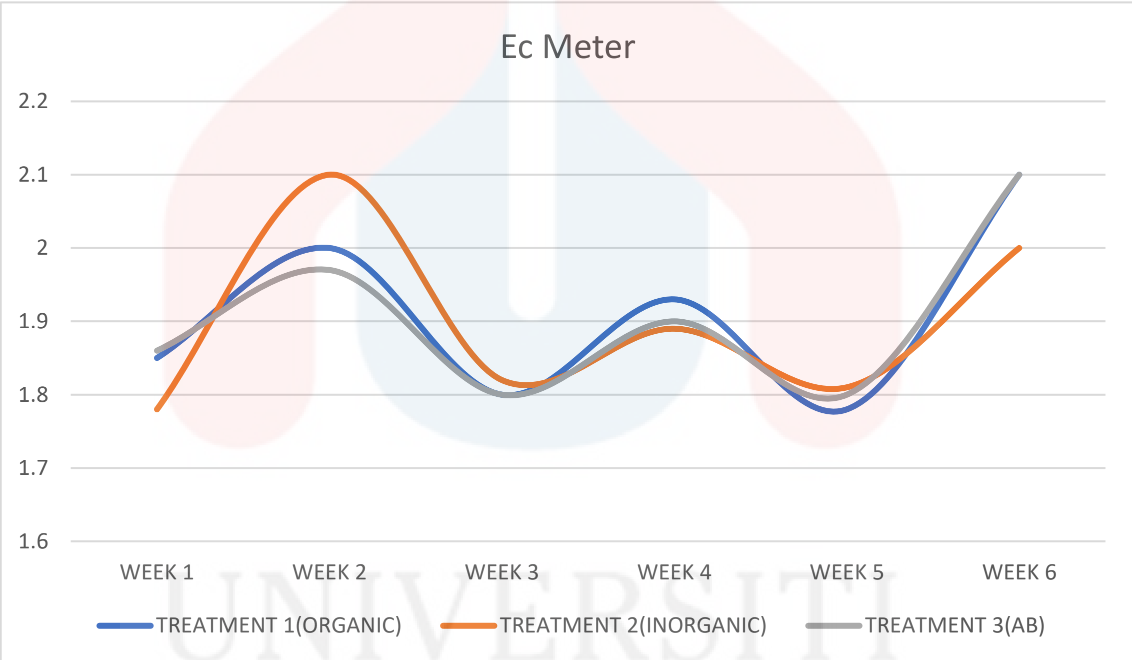

Figure 4.1.5: Graph of pH level per week

4.2 Yield performance analysis of green mustard with the different fertilizer

Various studies have compared the yields of organic fertilizer plants with inorganic fertilized plants. The vegetables that have been treated with inorganic fertilizers such as cucumber, tomato and cabbage are obtaining higher yields than organic fertilizer. However, study done by Phibunwatthanawong and Riddech (2019), show that the organic fertilized leafy vegetables like lettuce and amaranthus have more dry mass than the inorganically fertilized. The slow release of nutrients from organic fertilizer into the soil can reduce loss of nutrients due to run off, leaching and volatilization. According to the study, by using the NFT hydroponics system with various liquid fertilizer, including organic and inorganic fertilizer, all of the plants for each treatment continue to grow from day to day. From continuous observations, this study revealed significant differences in green mustard plant yield performance for all the treatment. All the data of yield performance were gathered during growth stage but only the final data were recorded.

Table 4.1: Yield performance of green mustard with the different foliar fertilizer

Group	Plan Height	Leaf Width	Plant Fresh Weight
Control	21.51^{b}	7.77^{b}	17.75^{b}
Treatment 1	26.19^{a}	9.05^{a}	26.06^{a}
Treatment 2	20.21^{b}	6.84^{b}	9.33^{c}
Significant	0.05	0.05	0.05

*Means separation in each column followed by the same letter are not significantly different at= 0.05

4.2.1 Plant Height

Table 4.1 shows the analysis of the results for plant height to the effect of additional fertilizer application for Treatment 1, Treatment 2 and control on green mustard yield. From the results, it shows that the final plant height of each treatment has a significant change and improvement. As a stated by Susanti, et al. (2020), different fertilizer treatment used for green mustard may affected their yield and growth performance. Therefore, in this study, all the treatment that used for this study has a shown different significant change to the growth of the green mustard which explain back the result where Treatment 1 (26.19) had the highest plant height compared to other treatment, followed by Control (21.51) and Treatment 2 (20.21) was the lowest.

4.2.2 Leaf Width

Based on the Table 4.1, there were changes and different in the leaf width for each of treatment. The results of the leaf width analysis for green mustard with additional fertilizer application for Treatment 1, Treatment 2 and Control were significant ($p<0.05$) among each other. From the Table 4.1, Treatment 1 (9.05) had the widest leaf width compared to other treatment, followed by Control (7.77) and Treatment 2 (6.84) has the lowest. Compared to the chemical fertiliser and control treatment, green mustard that sprayed with organic fertiliser plant produced more leaves and have much wider leaves. As stated by Thakulla, et al. (2021), their study found that leaf width showed a significant effect when using different treatment of fertilizer compared to the control treatment which shown similarly to the current study where organic liquid fertilizer showed much superior in term of leaf width increment compared to other treatment.

4.2.3 Plant Fresh Weight

Table 4.1 showed that there was significant different result ($p<0.05$) in term of plant fresh weight comparison between all the treatments. The results showed that the plant fresh weight of all treatments increased and changed significantly. Treatment 1 (26.06) had the highest fresh weight compared to other treatment, followed by Control (17.75) and Treatment 2 (9.33) was the lowest. This indicated that organic based fertilizer capable to increase vegetable fresh weight compared to inorganic based fertilizer whilst planting the vegetable in the NFT hydroponic with additional liquid fertilizer spraying. This help to increase the selling point of the vegetable through increment of the mass and quality of vegetable in the market.

4.2.4 SPAD Meter

Table 4.2 shows the comparison of the SPAD values analysis of green mustard with different liquid fertilizer according to various planting weeks. From the Table 4.3, all the treatment showed no significant differences at $P< 0.05$ during all the planting weeks. As a stated by Zhu, et al. (2012), the value of SPAD chlorophyll value will increase gradually with a large amount of N and affect the total chlorophyll content in the leaves. Therefore, from the study, it showed that Treatment 1 exhibit higher SPAD values from Week 1 until Week 4 compared to other treatment which followed by Control and Treatment 2.

Table 4.2: Yield performance of green mustard with SPAD meter

Group	Week 1	Week 2	Week 3	Week 4
Control	24.30[a]	32.65[a]	32.50[a]	36.55[a]
Treatment 1	24.50[a]	33.85[a]	35.65[b]	37.65[a]
Treatment 2	23.47[a]	30.75[a]	30.65[a]	34.25[a]
Significantly	0.05	0.05	0.05	0.05

*means separation in each column followed by the same letter are not significantly different at= 0.05

4.2.5 Nitrogen content

According to Table 4.3, Treatment 1 (0.462231) had the highest nitrogen content, followed by Control (0.42021) and Treatment 2 (0.266133) was the lowest. Nitrates are a very abundant source of nitrogen in both natural and agricultural systems. By adding organic fertilizers, it is possible to increase the activity and expression of nitrate assimilation. The main reason why green mustard showed better in term of growth & yield performance when sprayed with organic liquid fertilizer was due to high nitrogen content availability and improve further nutrient absorption with organic-based nutrient composition.

Table 4.3: Nitrogen content for green mustard

Type of Treatment	Nitrogen Content (%)
Treatment 1	0.462231
Treatment 2	0.266133
Control	0.42021

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The results of this study indicate a stimulus effect from the treatment of foliar organic and inorganic spraying to green mustard plants. Parameters of plant height, plant weight and leaf width for all mustard plant treatments increased significantly ($P \leq 0.05$) while chlorophyll content showed no significant differences at $P \leq 0.05$ throughout all the planting weeks. Thus, this study proves that the maximum growth of green mustard is successfully achieved when the plants have been supplemented with organic and inorganic foliar spraying method on leaves. Although treatment control showed a similar effect to organic foliar spraying liquid fertilizer, organic foliar spraying liquid fertilizer exhibited higher value in term of plant heights, leaf width and final fresh weight. To conclude, the overall results of studies show that based foliar spraying as supplementary fertilizer can be applied to the green mustard in the NFT hydroponic system to ensure healthier and vigorous growth of green mustard.

5.2 Recommendations

Leaf -based spray as an additional fertilizer can be used on green mustard in the NFT hydroponic system and it can also be applied to other crop systems such as indoor farming, vertical farming and aquaponic. To ensure inorganic fertilizers, on the other hand, need to be improved in terms of sources of materials for production of the organic fertilizers so that the fertilizer is much environment friendly, good smell friendly and suitable for hydroponic crops. Because it uses waste materials, the organic leaf fertilizer used in this study is particularly beneficial for hydroponic crops. As a result, more studies on organic supplementary fertilizers for green mustard NFT hydroponic planting can be done by replacing AB fertilizer with organic fertilizer as the main fertilizer in the tank for irrigation circulation instead of spraying it onto the leaves of green mustard.

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APPENDIX A

Figure A1: Hydroponic NFT rack used for 3 treatments

Figure A2: EC Meter and pH Meter Readings for Green Mustard Plants

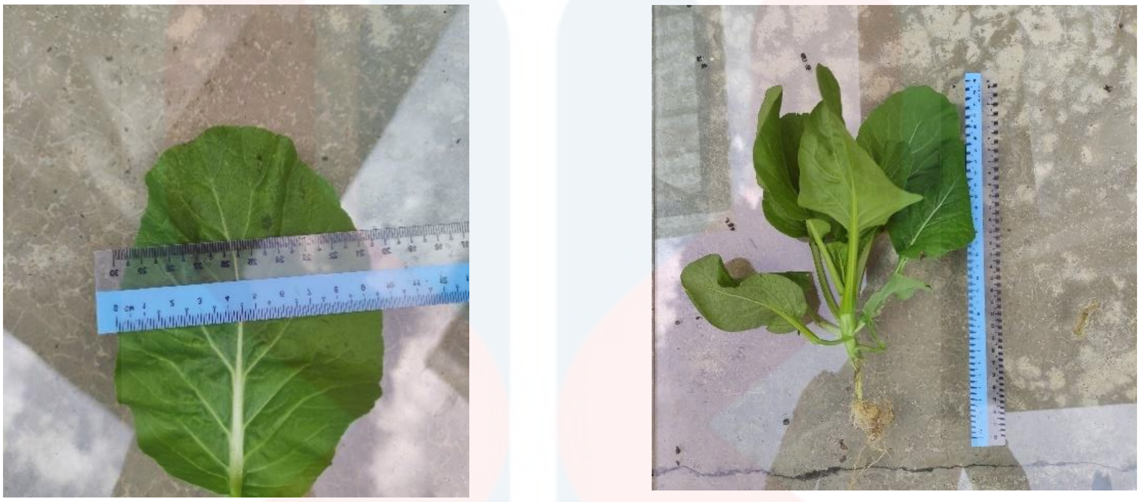

Figure A3: Measuring plant height after harvest using ruler

Figure A4 : Measuring Green Mustard Chlorophyll using a SPAD Meter.

Figure A5: The Type of Fertilizer Used for Green Mustard

APPENDIX B

Table B1: ANOVA table for plant height, leaf width and plant fresh weight

ANOVA

SPAD week 1

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.193	2	.597	.021	.979
Within Groups	85.380	3	28.460		
Total	86.573	5			

Table B2: ANOVA table for SPAD Meter (week 1)

ANOVA

SPAD week 2

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.773	2	4.887	4.195	.135
Within Groups	3.495	3	1.165		
Total	13.268	5			

Table B3: ANOVA table for SPAD Meter (week 2)

ANOVA

SPAD week 3

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	25.563	2	12.782	24.116	.014
Within Groups	1.590	3	.530		
Total	27.153	5			

Table B4: ANOVA table for SPAD Meter (week 3)

ANOVA

SPAD week 4

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12.040	2	6.020	3.064	.188
Within Groups	5.895	3	1.965		
Total	17.935	5			

Table B5: ANOVA table for SPAD Meter (week 4)

PLANT_WEIGHT

Tukey HSD[a]

TRAETMENTN	N	Subset for alpha = 0.05		
		1	2	3
TREATMENT 2	20	9.3300		
CONTROL	20		17.7500	
TREATMENT 1	20			26.0550
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 20.000.

Table B6: Tukey HSD test for plant weight

PLANT_HEIGHT

Tukey HSD[a]

TRAETMENTN	N	Subset for alpha = 0.05	
		1	2
TREATMENT 2	20	20.2100	
CONTROL	20	21.5050	
TREATMENT 1	20		26.1900
Sig.		.618	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 20.000.

Table B7: Tukey HSD test for plant height

LEAF_WIDTH

Tukey HSD[a]

TRAETMENT	N	Subset for alpha = 0.05 1	 2
TREATMENT 2	20	6.8350	
CONTROL	20	7.7650	
TREATMENT 1	20		9.0500
Sig.		.157	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 20.000.

Table B8: Tukey HSD test for leaf width

SPAD week 1

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05 1
TRAETMENT 2	2	23.4700
CONTROL	2	24.3000
TRATMENT 1	2	24.5000
Sig.		.980

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

Table B9: Tukey HSD test for SPAD meter (week 1)

SPAD week 2

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05
		1
TRAETMENT 2	2	30.7500
CONTROL	2	32.6500
TRATMENT 1	2	33.8500
Sig.		.124

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

Table B10: Tukey HSD test for SPAD meter (week 2)

SPAD week 3

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05	
		1	2
TRAETMENT 2	2	30.6500	
CONTROL	2	32.5000	
TRATMENT 1	2		35.6500
Sig.		.162	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

Table B11: Tukey HSD test for SPAD meter (week 3)

SPAD week 4

Tukey HSD[a]

TREATMENT	N	Subset for alpha = 0.05 1
TRAETMENT 2	2	34.2500
CONTROL	2	36.5500
TRATMENT 1	2	37.6500
Sig.		.179

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

Table B12: Tukey HSD test for SPAD meter (week 4)