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RESPONSES OF*BRASSICA RAPA* TO VARYING LIGHT INTENSITIES AND TYPES OF NUTRIENT SOLUTION GROWN UNDER HYDROPONIC SYSTEM

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Abstract

The fact that agricultural activity is dependent on the availability of land makes matters even more complicated when the climate is shifting dramatically. In this perspective, soilless system production is an appealing choice since it offers the possibility of reusing land that has been unproductive as a result of pollution or illness for agricultural uses while simultaneously reducing the amount of water that is consumed. According to the findings presented in the accompanying discussion and conclusions, the light intensities that are received in treatments consisting of one, two, and three layers all have an impact on the growth and development of *Brassica rapa*. The covered group with three layers of the net gave the best results in terms of both growth and development when compared to the control group, which only had one layer of net covering. The levels of light and nutrient solutions had a significant impact, respectively, on the expansion and maturation of the *Brassica rapa* plant. As the number of *Brassica rapa* layers increases, the output of the *Brassica rapa* yield has been shown to have better growth and development responses, most notably in plant yield. The effects of nutritional solutions on plant production, fresh weight, water consumption, and nutrient content in leaf tissue showed that there were no significant differences in the interactions between these variables. According to the findings of the study, gathered nutrients have the potential to be used as fertilizer, which will cut down on the need for mineral fertilizer in hydroponic systems. The temperature of the environment is one of the most important abiotic factors that might impede the process of development, production, and dissemination. It is possible to draw the conclusion from the results that the cultivar has a greater capacity to react to the effects of cold stress.

Keywords: hydroponics, *Brassica rapa*, responses, interaction, climate change

Chapter 1

Introduction

Given that the world's population is expected to increase in the coming years, it appears evident that food security is one of the most important themes of the new millennium and, logically, the most pressing challenge for the agricultural industry. The growing loss of rich soil surface due to environmental contamination and urbanization trends greatly compounds the situation. The intensification of production cycles as well as the monoculture approach, which facilitated the spread of various diseases and the development of related disorders, should be considered. The severe reliance of agricultural operations on land availability in an age of drastic climate change complicates the situation even further. In this regard, the ability to use areas that are no longer productive due to pollution or pathogen concerns for agricultural uses while also lowering water usage makes soilless system production a compelling option. Furthermore, it should be noted that this type of technology represents a positive response toward more ecologically friendly agriculture as well as a viable instrument in the context of the global question of food security.

Hydroponics is an agricultural approach to vegetable production that has been the subject of extensive research. The University of the Philippines at Los Baños has pioneered hydroponics research, and several Filipino scholars are industry leaders. What has not been done, and where this research is critical, is to apply hydroponics to urban, any location, or rooftops and to develop a competitive business model that connects onsite production to onsite consumption, thereby lowering the food supply chain's costs. This model not only provides a viable commercial paradigm for agriculture, but also a sustainable one (Ordonez, 2017).

Brassica rapa as a common commodity sell in the market is a vital component that used employed in the study. Its leaves were edible and are frequently included in stews and soup. Meals made with Pechay (*Brassica rapa*) are frequently accompanied by other vegetables, seafood, or meat commonly served in restaurants and even at home.

It is an important vegetable in Eastern Asia. It is the most widely grown vegetable in China and northern areas of the country, and other major areas of production include Korea. Thus, it is eaten raw or lightly cooked and used in making kimchi as a fermented side-dish eaten.

Statement of the Problem

The goal of this study is to find out the responses of *Brassica rapa* tovarying light intensities and nutrient solutions.

1. What is the effect of the varying light intensity on the growth and yield of *Brassica rapa*?
2. What are the interaction effects of the varying light intensities and different types of nutrients on the growth and yield of *Brassica rapa*?
3. What is the response of *Brassica rapa* in terms of growth and yield?
4. **Significance of the Study**

The following stakeholders will benefit from the study's findings:

<u>Administrators.</u> The result provides insight into how to develop and plan for an Income Generating Program at the institution. It will provide instructions on how to grow

Brassica rapa, including the right intensity of lighting and the right type of nutrient solution to apply.

Community Extension Services Office. The result may be useful for the Community Extension Services (CES) office as they could initiate the seminars and workshops in every barangay to promote Hydroponic System Technology in farming.

Community.The outcome maycontributes to the development of a new style of farming that maximizes the use of a small area at home, particularly during the current epidemic, when people are encouraged to stay at home and are unable to work or earn money. There must be a more effective way to discourage people from purchasing products in the market and keep away from the busy area. As a result, the entire family will survive and will have access to fresh *Brassica rapa.*

Farmers. The study may be beneficial to local farmers to consider a new farming method. It will provide them an opportunity to avoid the use of hazardous chemicals in the production of *Brassica rapa* while still being able to reap the benefits of this sort of farming, as opposed to traditional soil farming.

Investors. The result may encourage businessmen to invest in new ventures and methods of farming in a very practical and useful way.

Local Government Unit. Through this study, the local Government unit may establish a new project for the community and strengthen the collaboration between the private and public sectors.

Scope and Limitation

The approach is limited to the investigation and quantifying of the significant influence played by varying light intensities, utilizing one, two, and three layers of colored black net. There were three different types of nutritional solutions: Yamasaki, NutriHydro, and SNAP nutrient solutions were used to test the growth and development of *Brassica rapa*.

Definition of Terms

To ensure that the terminology used in this study is understood precisely and plainly, the key terms were operationally defined.

Brassica rapa. – refers to the scientific name for pechay, a high-valued vegetable that was used as a subject or independent variable of the study.

Control Group. – Refers to the group of *Brassica rapa* that has no treatment applied in the plants. This group of *Brassica rapa* was grown in a hydroponic system with a typical condition of the environment (no nutrient solution).

Experimental Group. – refers to a group of plants that received varied light intensities and nutrient solutions.

Light Intensity. – refers to the different light received by the experimental group. This was measured using the light meter using a unit of lux.

Hydroponic System. – refers to a new farming technique that employs water as a medium for cultivation and a nutrient solution to maintain the plants' essential nutrients from the time of seedling establishment to the time of harvesting *Brassica rapa*.

Nutrient Solution. – refers to the types of varied types of nutrient solutions (NutriHydro, Yamasaki, and SNAP).

Spectrometer. – refers to the instrument used to determine the amount of light that the *Brassica rapa* received.

Time. – refers to the specific period of analyzing and observing the growth and length of *Brassica rapa*. Technically measured using a meter stick using a unit of an inch.

Related Literature

High productivity, low land and water use, and controlled environments such as hydroponics have emerged as promising solutions for feeding the world's rapidly growing population. Hydroponic systems require a lot of energy, which can be bad for the environment. The hydroponic system is better for the environment (Chen et al., 2020).

Furthermore, the world's population is growing, and traditional farming methods are inefficient at feeding everyone. Hydroponic farming is an efficient and popular farming method in the modern era (Panigrahi et al., 2022).

A hydroponic system is an important and necessary component of a plant factory. Commercial hydroponic crop production currently includes nutrient techniques and water culture systems suitable for small crops such as leafy greens (Niu, 2021).

The study presents the development of hydroponics monitoring systems. Crops have been grown successfully using hydroponics, a system of growing crops without soil. Because of its high efficiency, hydroponics has the potential to fill the gap in flow agricultural production while also serving as an environmentally friendly alternative to soil culture (Vanipriya, Malladi, et al., 2021).

Nowadays, as the potential grows, it becomes more difficult to cultivate plants on land. Because the earth contains various types of soil, it is not possible to cultivate all types of plants everywhere. Farmers are finding it difficult to cultivate plants in the soil due to a lack of water. Farmers must monitor the plants frequently in traditional methods to ensure a good yield. UV rays have an impact on the effects of global warming and the plants. As a result, planting in an uncontrolled environment is more difficult. To overcome all farming problems in order to cultivate plants in water without soil (Vanipriya et al., 2021).

The composition of the nutrient solution determines growth in hydroponics. Because of nutrient absorption, the conductivity and pH are constantly changing. The study describes the various methods of hydroponic in greenhouse controlled with conventional in soil grown. The efficiency of controlling the parameters of conductivity and pH in the hydroponics system provides the producer with an effective and viable alternative in plant production (Domingues et al., 2012).

Consumers worldwide are interested in purchasing organic vegetables, but organic producer councils are strongly opposed to accepting that hydroponic systems can be used while adhering to organic philosophies. In fact, using nutrient solutions derived from acceptable organic sources, biological pathogen control measures, and recirculating hydroponic systems allows for a more sustainable crop production system than traditional soil-based organic systems (Atkin & Nichols, 2004).

Simple changes in the implementation of the hydroponic system, such as high-value material management, carrying cost, and replenishment lead-time components, are more significant (Chouhan et al., 2021).

Drought tolerance can be enhanced by having a large root system. Measuring root characteristics in soil medium is time-consuming, labor-intensive, and tedious. The goal of this study was to determine the relationship between root characteristics of plants grown in hydroponics and in pot experiments. The plant genotype was planted in a four-replication randomized complete block design. When compared to other genotypes, all root characteristics have consistently higher values. Root characteristics in comparison to other genotypes The root characteristics of hydroponic plant genotypes were positively correlated with those of pot-grown plants. The findings suggested that assessing plant root characteristics in hydroponics for potential drought tolerance could replace the assessment in soil medium conditions (Liu et al., 2018).

A popular method for growing plants without soil. The experiments revealed that a commercial hydroponic nutrient solution containing water and essential nutrients performed similarly to those in water flux and reverse salt flux to other inorganic draw solutions. Furthermore, the use of the hydroponic solution is highly advantageous because it contains all of the required macronutrients (N, P, and K) as well as micronutrients (Ca, Mg, S, Mn, B, Zn, and Mo) in a single balance solution and can thus be used directly without the need to add any elements (Checkli et al., 2017).

Environmental Stress in Brassica rapa

Brassica rapa is a temperate-adapted annual biennial herb that is cultivated worldwide. It is widely grown in many countries as an edible vegetable and for the production of vegetable oil to feed the world's growing population. Temperature fluctuations, on the other hand, have a significant impact on plant growth and development, as well as the production of bioactive compounds. The effect of cold stress on seed germination, biomass gain, and biosynthesis content in the medicinally important *Brassica rapa* (IIyas et al., 2022).

Brassica is a major vegetable group that is affected by both biotic and abiotic stresses. The results revealed that responses were expressed after abiotic stress treatments, indicating higher potentials. The findings suggest that chitinase genes could be useful resources in the development of stress-resistant Brassica (Ahmed et al., 2012).

The effects of water stress were studied in experiments under controlled conditions. Water scarcity had the greatest impact on yield and yield components. When water deficit occurred from anthesis to maturity, the results showed a significant reduction (Champolivier & Merrien, 1996).

In a study, the cause of plant diseases could be disease in various parts of a plant such as a leaf, root, and stems; however, the leaf is one of the most important institutes to be observed to identify and detect infection. The study covered various factors that cause abiotic and biotic stress (texture, shape, and size) in plants (Kaur & Gautam, 2021).

A greenhouse experiment with different levels of salinity was conducted to study the effects of salt and drought factors on the growth, physiological, and biochemical responses of Brassica rapa. Individual drought and salt stress conditions were found to have a negative impact on plant growth, including shoot, root fresh, and dry weights when applied separately. However, the combination of drought and salinity exacerbated the negative effects of each stress factor (Sahin et al., 2018).

One of the most significant abiotic stresses affecting Brassica crop production is salinity. Pavlovic et al. (2018) investigated the physiological, biochemical, and hormonal components of short-term salinity treatments in seedlings, with a focus on the biosynthesis and metabolism of auxin. Changes in biochemical stress markers were observed in seedling fresh weight and root growth, as well as a decrease in photosynthesis rate and an increase in reactive oxygen species.

A study that compares results obtained from plants exposed to arsenic present in contaminated soil and with a hydroponic solution to evaluate mine species' strategies for dealing with arsenic toxicity. The findings revealed fundamental differences in plant responses to arsenic depending on growth conditions, including uptake, root-to-shoot translocation, distribution, and detoxification. When grown in soil, it accumulated the most Arsenic in roots and shoots in comparison to other species; however, when exposed to arsenic in hydroponics, it had lower Arsenic concentrations (Zabludowska et al., 2009).

Factors that limit the prospect of long-term production, such as calcium levels in the soil below the plowed zone. This could prevent root elongation and put the crop at risk of drought stress. Experimental data show that low-calcium tolerance varies between and within cultivars (Spehar & Souza, 1995).

The availability and uptake of Ca2+ are reduced in saline soil conditions, resulting in membrane integrity loss and other disorders associated with Ca2+ deficiency in plants. The efficiency of calcium uptake and utilization under saline conditions. According to Arshad et al. (2012), efficient calcium uptake and utilization under saline conditions may be better able to withstand saline conditions in the field. Typically, the response to salinity and low Ca2+ has been measured against salinity alone. Due to salinity and low calcium, physical growth parameters such as shoot length, root length, and shoot and root fresh weights were significantly reduced. As a result, the study demonstrates that certain genotypes can better uptake and utilize calcium than when calcium supply is low, which improves salt under saline conditions.

When the pH of the medium is lower than the Quantitative Trait Locus (QTL) analysis, proton rhizotoxicity inhibits root growth in low ionic strength media. According to the study, different genetic factors regulate resistance mechanisms and aluminum resistance, indicating that there is no simple relationship between the genetic factors controlling each trait (Ikka et al., 2007).

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A hydroponic experiment was carried out to assess the role of potassium and silicon in mitigating the negative effects of NaCl on plant genotypes with varying salt tolerance. The results showed that K and Si improved salt tolerance in plant genotypes due to decreased Na+ concentration and increased K+, resulting in an improvement in K+/n ratio, which is a good indicator to assess plant tolerance to salt stress (Ashraf et al., 2010).

Chromium (Cr) is a well-known carcinogen that is found in half of the Environmental Protection Agency's samples (EPA). The results of this study's X-ray absorption spectroscopy (XAS) revealed that some of the supplied Cr (VI) was taken up by the roots; however, data analysis of the plant tissues revealed that it was fully reduced to Cr (III) in the leaf tissues (Aldrich et al., 2003).

Site Selection

Hydroponics is the growing of plants without soil. The name “hydroponics” implies that the plants grow in water. The plants are grown in growing beds that may be filled with gravel or sand or other material, and the plants get the nutrients from a water solution added to the beds.

Some of the important advantages of successful hydroponics over soil culture are yields can be as much as ten times greater than in soil culture; plants need less space because nutrients are concentrated; the nutrient solution is reused, so the amount of water needed is much smaller, and the nutrients are easier to test and adjust to growing conditions.

***Brassicaceae*in soilless condition**

Nutrient analysis was conducted on pechay grown on two mediums by the Central Analytical Services Laboratory of the National Institute of Molecular Biology and Biotechnology (BIOTECH) of UPLB. Organically grown pechay in conventional plots fertilized with organic matter such as compost was compared with pechay grown on hydroponics solution. The result showed that the pechay grown in hydroponic acquired a higher value in crude protein, crude fiber, and crude fat that helps in the elimination of waste, toxins, protects from diseases, and keeps the body active and resistant. Hence, being low in crude protein and crude fat is nonetheless important in supplementing a poor diet. The study also reported higher calcium and iron content in hydroponically grown pechay (Rotor, 2014).

Iron (Fe) aids in the oxygenation of the body through the lungs and blood. Since oxygen is essential to life, people who lack iron are anemic, docile, and sickly. The most source of iron is leafy vegetables especially the member of the Family Brassicaceae (Rotor, 2014).

Phosphorus (P) is important in the proper functioning of the brain and nerves/ Iodine and phosphorous are very important in brain development. While calcium is important to build and rebuild tissues in the bones and muscles and all the cells of the body (Rotor, 2014).

The book chapter (Aires, 2018), presents a general overview of the role of hydroponics in the enhancement of important types of nonessential nutrients and based on the discussion of the book, hydroponics can be an essential instrument to have vegetables with high nutritional quality. However, both hydroponics and soil-based production systems require proper control and must be implemented correctly with full respect for plant needs, soil, water, environment, growers, and consumer safety.

Hence, a study by (Gashagari et al., 2018) compared and find the best system that will cover the current and future demand with the least cost natural resources consumption. The result showed that the type of seeds doesn't have a significant effect on plant growth. However, the planting system has a significant effect on plant growth, the hydroponic system has a higher growth rate.

In the study of Ezziddine et al. (2021), the performance of nutrient solution on plants yield, fresh weight, water consumption, and nutrient content in leaf tissue showed no significant difference in the yield. The study showed that nutrients recovered can be utilized as fertilizer, thereby reducing the dependency on mineral fertilizer in a hydroponic system.

Environmental Factors Affecting Plant Growth

Media

The growing media used for propagation has several requirements, that is firm and dense to enhance the growth of stems, has the capability to hold water, guarantee plant life, and moderate humidity. The study on the effect of biochar, cocopeat, and sawdust compost in the experiment was carried out to determine the best growth media, vegetative parameters showed good specification in all types of growing media (Marjenah et al., 2016).

Sunlight

Solar radiation is essential for plant growth. Plant leaves absorb sunlight and use it as the energy source for photosynthesis. The ability of a crop to collect sunlight is a function of leaf surface or leaf area index. When a crop is a full canopy, its ability to collect sunlight is maximized (McKenzie, 2017).

The process by which plants make food is called photosynthesis. It happened when a plant absorbs carbon dioxide, nutrients, and water through the holes found in the branches, stems, and leaves of the plant. The light energy triggers a chemical reaction that breaks down the carbon dioxide and water molecules. This process creates a sugar called glucose and also produces oxygen. Glucose produces oxygen and is broken down by organelles called chloroplast contains a green chemical called chlorophyll which gives the leaves a green color. Both the "full sun" and "some sun" plants were able to allow for photosynthesis due to sunlight exposure (*Measuring Plant Growth with Sunlight*, 2019).

If plants get limited sunlight, the photosynthesis process slows down and the plant begins to grow upward and stretch its stems to reach for the sunlight. It is easy to see this process in both the plants that received partial and limited sun. Plants grew to have longer stems and reached out toward the sunlight (*Measuring Plant Growth with Sunlight*, 2019b).

Sunlight concentrated and transmission for daylighting is a booming technology of direct utilization of solar energy. In the study of sunlight concentrating and transmitting system was developed and tested to address the cooling problem under high irradiation. The study showed that comprehensive shade as a cooling measure showed feasible to use to ensure a safe temperature range (Song et al., 2021).

A study explored morphological alterations, photosynthetic responses, and gene expression of plants in the response to strong sunlight. The results showed under strong sunlight promoted the expression of the gibberellin biosynthesis gene and altered the morphological characteristics of plants. The response also to plants under strong sunlight showed promotion of shoots, stem elongation, and branching increase. Hence, a positive effect of the increased expressions of photosynthetic genes and photosynthesis rate. The method that contributed to the improvement of photosynthetic efficiency of the plant leaves, was a way to increase light energy consumption, and thus reduced chloroplast senescence caused by excess light energy (Cao et al., 2021).

Exposure to light and drought will increase the biomass of, and glucosinolates production in *Brassica rapa*. The experiments conducted in long light exposure increased the plant growth. The plants exposed to a combination of drought and long light conditions showed similar growth patterns as control plants. Glucosinolates production increased in plants exposed to long light, while drought exposure had no impact on Glucosinolates production. The findings suggest that long exposure to light was used to increase both the biomass and GL production in *Brassica rapa* (Park et al., 2021).

Shading

Heavy shading is commonly applied during the production of pot plants in order to avoid damage caused by high light intensities; usually the daily light integral photosynthetically active radiation. However, shading carries a production penalty as light is the driving force for photosynthesis. The study showed higher daily light integral led to more leaves and stems. Furthermore, high daily light integral resulted in more compact plants without light damage in leaves or in both cultivars. Hence, less shading stimulates plant growth but also improves plant quality, especially compactness (Li et al., 2014).

Temperature

High temperatures affect plant growth in numerous ways. The most obvious are the effects of heat on photosynthesis, in which plants use carbon dioxide to produce oxygen. Experts at Colorado State University Extension explain that both processes increase when temperatures rise. When temperatures reach uncomfortably high limits, the two processes become unbalanced. The effect of temperature on plants varies widely and is influenced by factors such as exposure to sunlight, elevation, the difference between day and night temperatures, and proximity to surrounding structures (Dyer, n.d.).

In the study of the influence of shading screens by Holcman and Sntelhas (2012) of different colors on different microclimate variables in a greenhouse covered with low-density polyethylene. The experiment conducted showed in treatment with the use of a black screen had the lowest solar radiation transmission.

Temperature is a primary factor affecting the rate of plant development. Warmer temperatures expected with climate change and the potential for more extreme temperature events will impact plant productivity. Few adaptation strategies are available to cope with temperature extremes at this developmental stage other than to select plants. In controlled environment studies, warm temperatures increased the rate of phenological development; there was no effect on leaf area or vegetative biomass compared to normal temperatures. Hence, the major impact of warmer temperatures was during the reproductive stage of development and in all cases, grain yield in maize was significantly reduced from a normal temperature regime. Temperature effects are increased by water deficits and excess soil water demonstrating that understanding the interaction of temperature and water will be needed to develop more effective adaptation strategies to offset the impacts of greater temperature and water will be needed to develop more effective adaptation strategies to offset the impacts of greater temperature extreme events associated with a changing climate Hatfield and Prueger (2015).

Economic impacts are the greatest during drought events that are projected to increase in frequency and intensity as a result of climate change. Therefore management of good yields should be a key consideration when evaluating agricultural drought risk reduction (Foster et al., 2015).

In the study of Yan et al. (2019) the low temperature is one of the most important abiotic factors inhibiting growth, productivity, and distribution. Based on the result it is concluded from this experiment that the cultivar has a higher ability to respond to cold stress (chilling and freezing stresses).

Nutrient Solution

A higher photosynthesis rate contributed to the accumulation of photosynthetic products and supported the material requirements for increasing biomass and improving rhizome functional ingredients (Cao et al., 2021b).

The over-fertilization with $Nh4^+$, Si, or B lead to higher yields, increased color indexes, firmness, sucrose content, and sweetness indexes. Furthermore, the fertilizations led to an improved shelf-life (Valentinuzza et al., 2018).

Brassica contains essential minerals and a range of low molecular weight carbohydrates, but the presence of these nutrients can be affected by moisture stress. The study of Pathirana et al. (2017) determines the response of *Brassica rapto* to moisture stress. The result of the study showed confirmed that biomass production and nutritional quality are greatly affected by moisture stress.

The study of different greenhouse species was grown with different relative humidity. The result was dry weight increased significantly by increasing relative humidity from the lowest to the highest level. Shoot length increased very considerably by increasing the relative humidity in most of the plants. The number of leaves was increased by relative humidity in some of the species while not in others (Mortensen, 2018).

Literature Synthesis

Plants require sunlight to grow. Sunlight is absorbed by plants and used for photosynthesis. The leaf surface index, also known as the leaf area index, measures the ability of a crop to absorb sunlight.

Excessive sunshine causes morphological, photosynthetic, and gene expression changes in plants.

When temperatures rise alarmingly, the two processes become unbalanced. Plants are affected by temperature changes between day and night, as well as how close they are to other structures and how much sunlight they get.

In both cultivars, high daily light levels resulted in more compact plants with no leaf light damage. Less shade promotes plant growth and quality, especially compactness.

The propagation medium must be hard and dense to support stem growth, hold water to assure plant survival, and have the correct humidity level. To find the optimal growing medium.

Sunlight concentration and transmission for daylighting is a modern method of utilizing solar energy. A solar concentrating and transmission system was developed to address the issue of high irradiance cooling.

Theoretical Framework

Hydrotropism

Freshwater is an increasingly scarce resource for agriculture. Plant roots mediate water uptake from the soil and developed a number of adaptive traits such as hydrotropism to aid water foraging. Hydrotropism modifies root growth to respond to a water potential gradient in soil and grow towards areas with higher moisture content (Dietrich, 2018).

The survival of terrestrial plants depends upon the capacity of roots to obtain water and nutrients from the soil. Directed growth of roots in relation to a gradient in moisture is called hydrotropism and begins in the root cap with the sensing of the moisture gradient. Even though the lack of sufficient water is the single most important factor affecting world agriculture, there are surprisingly few studies on hydrotropism (Eapen et al., 2005).

Water shortage remains the single-most-important factor influencing world agriculture, there are very few studies on how plants grow in response to water potential hydrotropism. Terrestrial plant roots dwell in the soil, and their ability to grow and explore underground requires many sensors for stimuli such as gravity, humidity gradients, light, mechanical stimulations, temperature, and oxygen. To date, extremely limited information is available on the components of such sensors; however, all of these stimuli are sensed in the root cap. Directional growth of roots is controlled by gravity, which is fixed in direction and intensity. However, other environmental factors, such as water potential gradients, which fluctuate in time, space, direction, and intensity, can act as a signal for modifying the direction of root growth accordingly. Hydrotropism may help roots to obtain water from the soil and at the same time may participate in the establishment of the root system (Cassab et al., 2012).

Plants are constantly bombarded with sensory inputs and receive numerous biotic and abiotic signals from their environment. Abiotic signals include gravity, light, water, temperature, oxygen, and carbon dioxide as well as other gases. One way in which plants deal with these inputs is by tropism, which is directed growth in response to a stimulus. There are several ways to overcome the challenges of studying root hydrotropism and these methods involve overriding the competing gravitropic response. Some of these techniques include the use of gravitropic mutants, ground-based instruments to mitigate unilateral gravity, and the microgravity environment of space flight. One of the first modern papers on hydrotropism in roots(Kiss, 2003).

Conceptual Framework

Independent Variable

Layers of Net:

- Single,
- Double, and
- Triple

Types of Nutrient Solutions:

- NutriHydro
- Yamasaki
- SNAP

→

Dependent Variable

Brassica rapa

- Height
- Weight
- Length
- Yield

Chapter II

Methods

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Research Design

The study employed an experimental design. As a result, it is deemed to have an equal selection of each *Brassica rapa* in simple Randomized Complete Block Design (RCBD) with three replications. The following will be the treatments:

T_0 = Control group (*Brassica rapa* in SNAP Hydroponic with the normal environmental conditions)

T_1 = SNAP Hydroponic System with different light intensities

T_2 = SNAP Hydroponic System with different levels of nutrient solution

Research Site

The study was undertaken at Midsayap, North Cotabato, Philippines is located in a province between 5 and 8 degrees latitude, which means that Midsayap and all places within its authority were less affected by typhoons. The municipality was classified as having a fourth kind of climate, which was defined by an annual rainfall distribution that is more or less uniform (Midsayap, 2014).

The municipality of Midsayap served as a major commercial and trading center for the region's farmers, who bring their goods to sell or trade (*Investment*, n.d.).

Research Specimen

The study used the *Brassica rapa* or the bok choy as a high valued crop in the market. It is a type of Chinese cabbage, used as a food.

Research Instruments

The study used the following instruments to measure the factors affecting the length, width, height, number of leaves, and yield of *Brassica rapa.*

Ruler. Was used to measure the height, length, and width of the leaves of *Brassica rapa*.

Timer. Was used to regularly monitor the collection of data.

Spectrometer. Was used to measure the temperature and humidity of the controlled environment of the plants.

Power of Hydrogen (pH) Tester. To check the levels of pH of the nutrient solutions.

Research Procedure

Seedling Production of *Brassica rapa*

Brassica rapa seeds were put in a sowing tray that was filled with heat sterilized coco coir before being transplanted. When the seedlings have sprouted, was placed beneath a structure made of plastic covering to protect them from the elements, particularly rain and direct sunshine. When the seedlings reached the true-leaf stage, it was poked by placing the healthy individual in a sowing tray and were placed in a hardening place with a small container. Three days following the germination of the seedlings, a starter solution consisting of a half-strength (12.5 ml) nutrient solution dissolved in 10 liters of waterwill be supplied to the seedlings within 10 days.

Ten days before being transplanted, the seedlings were hardened off. Until it showed evidence of temporary wilting, the seedlings were gradually exposed to sunshine and watered down until they show signs of temporary withering.

SNAP Hydroponics System Set-up (Santos and Ocampo, 2002)

After being grown for 10 days, it was transferred to a growing box with a polyethylene plastic container and was transferred to the treated half-strength solution for 14 days. A total of around 30 liters of water with a nutrient solution was stored in each empty growingbox (30 cm x 40 cm in size). These were lined with polyethylene bags with a thickness of .05 cm. The cover of the growing box was fitted with ventilation holes (2-3 cm in diameter) in order to allow for proper ventilation. There were nine holes, measuring15-20 cm in diameter, and were drilled to accommodate the cups in which the *Brassica rapa* was planted. The cups could hold 8oz to hold the *Brassica rapa* seedlings and were half-filled with coco coir to support the roots of the *Brassica rapa*.

Due to its high cation exchange rate, coco coir storesand releases nutrients as needed, yet it has a tendency to retain calcium, magnesium, and iron. This means that it needs to supplementcrops with specialized coco coir nutrients to increase their calcium, magnesium, and iron levels (Advanced Nutrients, 2018).

Particularly in cases where the roots have not yet developed extensively, the base of the cupis always immersed in the solution. The solution was maintained at 2-4 cm between the bottom of the cup and the top of the solution while the roots grow and develop.

SNAP Nutrient Solution Application(Santos and Ocampo, 2002)

In this study, the nutrient solution was replenished once a week to ensure the water in the growing media decreases the required amount for growing the *Brassica rapa*for a total of 10 liters. Thus, it is required to be checked every Tuesday and Thursday (8:00 am, 10 am, 12 pm, 2 pm, and 4 pm) for possible deficiencies of the *Brassica rapa* and contamination of the nutrient solution in the growing box. The number of *Brassica rapa* per treatmentwas replicated 3 times in a random arrangement with randomly assigned numbers.

Following transplantation, the *Brassica rapa* was available for harvesting 45 days after it was transplanted.

Temperature

The normal condition of the environment per treatment and monitored by the use of a laboratory spectrometer with specific time intervals: 8:00 – 10:00 am, 10:00 – 12:00 pm, 12:00 – 2:00 pm, and 2:00 – 4:00 pm. Observation of the heights and growth records was kept using the daily logbook of the *Brassica rapa*with the given datasheets.

Treatment Method

Light Intensity

Under this treatment, the plot was covered with a 2.2m x 2.0m with different layers of mosquito net that monitored with specific time and temperature in terms of variations of light intensities until the harvest time of the *Brassica rapa*.

The different intensities will be as follows:

T_0 = under normal environmental condition
T_1 = under the cover of two layers of mosquito net
T_2= under the cover of three layersof mosquito net
T_3= under the cover of four layers of mosquito net

The total amount of light that was penetrated through varying layerswas measured using a light meter. The length and width were measured using the foot rule.

Types of Nutrient Solution

The nutrient solution was important in a hydroponic system setup. Therefore, it is important to test the levels of nutrient solution applied to the *Brassica rapa* and its effects on plant growth and development.

Using the different levels of nutrient solution will follows:C_0 = normal

C_1 = Yamasaki Nutrient Solution
C_2 = NutriHydro Nutrient Solution
C_3 = SNAP Nutrient Solution

Data Gathering

The data was gathered in accordance with the methodology used in the study, and in order to be appropriately led in the data collection process:

1. *Brassica rapa.* Height and Width

   The height of the plant was recorded by measuring the plant from the surface of the stalk of the *Brassica rapa* that was seen to the tip of the last leaflet. While the width was measured with the diameter for each *Brassica rapa*. This was one week of growing the *Brassica rapa* seeds out in the growing tray. There were 243 *Brassica rapa* plants that were randomly placed in each block with 9 holes planted with *Brassica rapa*.

2. *Brassica rapa* weight

   The weight of the*Brassica rapa.* were determined in the yield of the production to compare the differences between the treatments. The result was controlled with varied light intensity and different types of nutrient solutions used for a higher yield.

3. Number of the leaves of *Brassica rapa* per plant

   The leaf of *Brassica rapa* was counted per plant in each treatment.

4. Type of Nutrient Solution

The type of nutrient solution was monitored to check the relationship and differences between each treatment.

5. Light Intensities

The amount of light received during the treatment was a greater factor to increase and decrease the yield of *Brassica rapa*. Thus, it was important to measure and check the difference in the result from the replanting to the harvesting period of the *Brassica rapa.*

6. Time Temperature

This measured the differences between the growths of *Brassica rapa.* with the length measured with varied time (8 am, 12 pm, and 5 pm) temperature and determined relationship within the result. Hence, a specimen temperature was monitored by the researcher to investigate and observed.

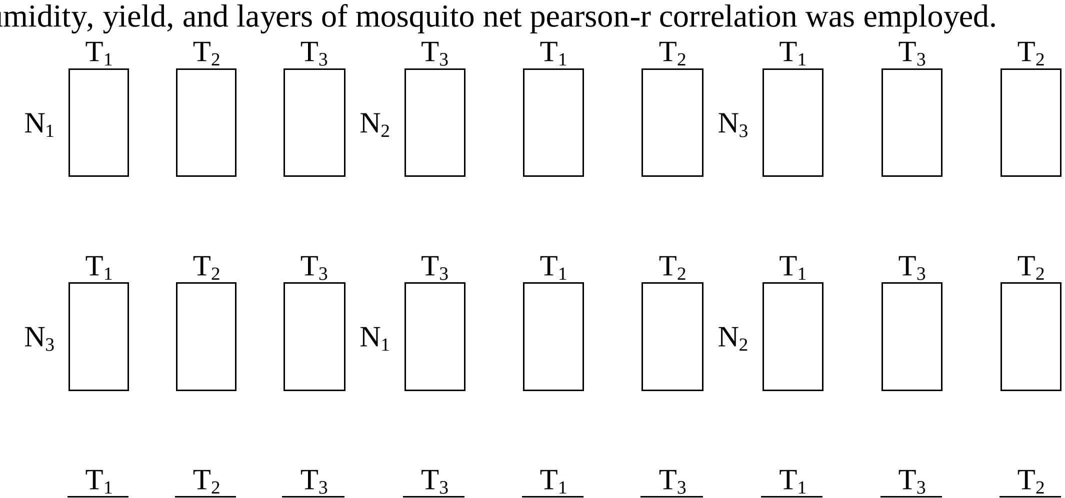
Statistical Tools and Treatment of Data

For the purpose of determining the relationships and mean the difference between data treatments (light intensity and level of nutrient solution) applied to *Brassica rapa*, an analysis of variance (ANOVA) was used in the study. As a result, the tests for normal distribution of each sample the researcher was randomly picked in a growing *Brassica rapa* out from the population of the fully grown seedlings of *Brassica rapa.* was tested in varied lights and treatments. The Analysis of variance and test for correlation was employed to determine the relationships.

Experimental Design and Analysis

The strip plot design was used in this study. The light intensities (T_0 – under normal environmental condition, T_1 – the wooden frame that will scaffold the one layer of mosquito net, T_2 – wooden frame that will scaffold the three layers of mosquito net), was the vertical and the amount of nutrient solution (N_0 – no nutrient solution, N_1 – 30 ml/box of NutriHydro nutrient solution, N_2 –with Yamasaki 30 ml/box nutrient solution, and N_3 with SNAP with 30 ml/box nutrient solution). Each treatment was replicated three times.

The ANOVA was employed inthe strip-plot design that was used to analyze the data for the comparison of each treatment, post hoc test was used for the comparison of the mean difference, while to test the relationship of the intensity of light, humidity, yield, and layers of mosquito net pearson-r correlation was employed.



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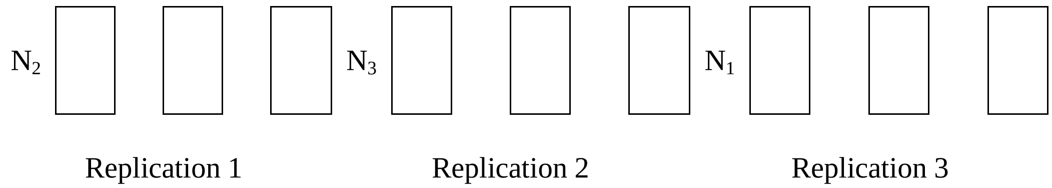

Legend: N_0 = Normal
N_1 = NutriHydro Nutrient Solution
N_2 = Yamasaki Nutrient Solution
NN_3 = UPLB Nutrient Solution

T_0 = Normal
T_1 = Under two layered mosquito net
T_2 = Under three layered mosquito net
T_3 = Under four layered mosquito net

Chapter III
Results

This chapter examines the results of the statistical treatment of the data. The tables are arranged into the following sections: effects of varying light intensity, interactions of varying light and nutrient solutions, and the response of *Brassica rapa* in terms of growth and yield.

Effects of Varying Light Intensities

Table 1 differences in the varying layers of the net in the numbers of leaves in *Brassica rapa*.

Source	*SS*	*Df*	MS	
Between-treatments	107.08	3	35.69	
Within-treatments	2651.80	476	5.57	F =6.40*
Total	2758	479		

The f-ratio value is 6.40. The p-value is 0.00. The result is significant at p<.05

This result showed a significant difference with an$f$-ratio (6.40) and a p-value (0.00) in the layers covered with one, two, and three layers. Therefore, the light intensities received in one, two, and three layers had a difference in the number of leaves in *Brassica rapa*.

Table 2 Pos Hoc Tukey Analysis on varying light intensities.

Pairwise Comparisons		**$HSD_{.05}$ = 1.23** **$HSD_{.01}$ = 1.50**	**$Q_{.05}$ = 3.66**	**$Q_{.01}$ = 4.46**
T_0:T_1	M_1 = 3.54 M_2 = 5.07	1.53		Q = 6.34 (p = .00)*
T_0:T_2	M_0 = 3.54 M_2 = 4.45	0.91		Q = 3.78 (p = 0.03)*

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T_0:T_3	M_1 = 5.07 M_3= 4.16	0.62	Q = 2.57 (p = 0.26)
T_1:T_2	M_1 = 5.07 M_2 = 4.45	0.62	Q = 2.57 (p = 0.26)
T_1:T_3	M_1 = 5.07 M_3 = 4.16	0.91	Q = 3.78 (p = 0.03)*
T_2:T_3	M_2 = 4.45 M_3 = 4.16	0.29	Q = 1.21 (p = 0.82)

The Tukey's HSD (honestly significant difference) facilitates pairwise comparisons within ANOVA data between the mean differences in each treatment. The T_0 had no treatment with normal conditions (M = 3.54) had a significant difference (p = 0.00)in the mean of T_1 with one layer of a net covered (M = 5.07), T_0 had a significant difference (p = 0.03) in the mean with T_2 with 2 layers of net covered (M = 4.45), and T_1 had a significant difference (p = 0.03) between T_3 with 3 layers of net covered (4.16).

Interactions of Varying Light and Nutrient Solutions

Table 3 Relationship between Length, Width, Height, Number of Leaves, and Yield using Pearson *r*, n=48.

Variable	Interactions of varying light of 48 *Brassica rapa*		
	r-value	*p*-value	Decision
Length	0.834**	0.000	S
Width	0.909**	0.000	S
Height	0.896**	0.000	S
Number of Leaves	0.870**	0.000	S
Yield	0.911**	0.000	S

** Correlation is significant at the 0.01 level (2 tailed)

Data revealed that there is a relationship in the length (r = 0.834), width (r = 0.909), height (r = 0.896), number of leaves, yield (r = 0.911) and growth and development of *Brassica rapa*. The p-value of 0.000 < 0.05 level of significance indicates that the null hypothesis had significant relationships between variables is rejected. Therefore, the growth and development of *Brassica rapa* had significant effects in Brassica *rapa* to the varying type of intensities of light used in each group.

Table 4 Relationship between Length, Width, Height, Number of Leaves, and Yield using Pearson *r*, n=48.

Variable	Interactions of varying nutrient solutions of 48 *Brassica rapa*		
	r-value	*p*-value	Decision

Length	1.000-**	0.000	S
Width	0.903**	0.000	S
Height	0.946**	0.000	S
Number of Leaves	0.961**	0.000	S
Yield	0.909**	0.000	S

** Correlation is significant at the 0.01 level (2 tailed)

Data shows a significant relationship in the length (r = 1.000), width (r = 0.903), height (r = 0.946), number of leaves (r = 0.961), yield (r = 0.909) in and growth and development of *Brassica rapa*. The p-value of 0.000 < 0.05 level of significance. Thus, indicates that the null hypothesis which states that there is a significant relationship between variables to the *Brassica rapa* is rejected. Therefore, varying nutrient solutions applied in each group had a relationship to the length, width, height, number of leaves, and yield of *Brassica rapa*.

Responses of *Brassica rapa* in Growth and Yield

Table 5 differences in the varying light to the number of leaves in *Brassica rapa.*

Source	*SS*	*df*	MS	
Between-treatments	263.66	3	87.88	
Within-treatments	2495.21	476	5.57	F =16.76*
Total	2758.88	479		

The f-ratio value is 6.40. The p-value is 0.00. The result is significant at p<.05

The table result showed that there is a significant difference (F = 16.76 <p = 0.00) between and within treatments. It means that replication 1, 2, and 3 with treatments of different light intensities interplaying with the number of leaves in *Brassica rapa*.

Table 6 Pos Hoc Analysis using Tukey to the varying light intensities.

Pairwise Comparisons		**$HSD_{.05}$ = 1.23** **$HSD_{.01}$ = 1.50**	**$Q_{.05}$ = 3.66** **$Q_{.01}$ = 4.46**
T_0:T_1	M_0 = 3.54 M_1= 4.81	1.27	Q = 5.44 (p = .00)*
T_0:T_2	M_0 = 3.54 M_2 = 3.59	0.05	Q = 0.21 (p = .99)
T_0:T_3	M_0 = 3.54 M_3= 5.28	1.74	Q = 7.43 (p = .00)*
T_1:T_2	M_1 = 4.81	1.22	Q = 5.23 (p = .00)*

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	$M_2 = 3.59$		
T_1:T_3	$M_1 = 4.81$ $M_3 = 5.28$	0.46	Q = 1.99 (*p* = .49)
T_2:T_3	$M_2 = 3.59$ $M_3 = 5.28$	1.69	Q = 7.22 (*p* = .00)*

The table shows Tukey's HSD (honestly significant difference) procedure in pairwise comparisons of control groups and treatment groups. The result shows that there is a difference between the sample means of T_0 (3.54) between T_1 (4.81),T_0 (3.54) between T_3 (5.28),T_1 (4.81) between T_2 (3.59), and T_2 (3.59 between T_3 (5.28), while there was no significant difference in the means between T_0 (3.54) and T_2(3.59) and in the means between T_2 (3.59) and T_3 (5.28).

Table 7 showed ANOVA test results with treatment of different replications in the number of leaves of *Brassica rapa*.

Source	*SS*	*df*	MS	
Between-treatments	263.66	3	87.88	
Within-treatments	2495.21	476	5.57	*F* =16.76*
Total	2758.88	479		

The *f*-ratio value is 16.76. The *p*-value is 0.00. The result is significant at *p*<.05

The results demonstrated a significant difference (*p* <.05) in the number of leaves across and within treatments (*F*-statistics = 16.76). As a result, the number of leaves in each treatment varies considerably.

Table 8 Pos Hoc Analysis using Tukey in the varying light.

Pairwise Comparisons		**$HSD_{.05}$ = 1.23 $HSD_{.01}$ = 1.50**	**$Q_{.05}$ = 3.66** **$Q_{.01}$ = 4.46**
T_0:T_1	$M_0 = 3.54$ $M_1 = 4.81$	1.27	Q = 5.44 (*p* = .00)*
T_0:T_2	$M_0 = 3.54$ $M_2 = 3.59$	0.05	Q = 0.21 (*p* = .99)
T_0:T_3	$M_0 = 3.54$ M_3= 5.28	1.74	Q = 7.43 (*p* = .00)*

T_1:T_2	M_1 = 4.81 M_2 = 3.59	1.22	Q = 5.23 (*p* = .00)*
T_1:T_3	M_1 = 4.81 M_3 = 5.28	0.46	Q = 1.99 (*p* = .49)
T_2:T_3	M_2 = 3.59 M_3 = 5.28	1.69	Q = 7.22 (*p* = .00)*

There is a significant difference between the sample means of T_0 (M = 3.54) and T_1 (M = 4.81), T_0 (M = 3.54) and T_3 (M = 5.28), T_1 (M = 4.81) and T_2 (M = 3.59), T_2 (3.59) and T_3 (M = 5.28). Thus, it is demonstrated that altering light has a major impact on the physiological development of plants in both the control and treatment groups. However, there was no significant difference between T_0 (M = 3.54) and T_2 (M = 3.59), nor between T1 (M = 4.81) and T3 (M = 5.28). As a result, the comparison of the treatments within this groups show a similar number of leaves.

Table 9difference of varying types of nutrient solutions.

Source	*SS*	*df*	MS	
Between-treatments	2252.71	3	750.90	
Within-treatments	19618.51	476	41.21	*F* =18.21*
Total	21871.22	479		

The *f*-ratio value is 18.21. The *p*-value is 0.00. The result is significant at $p<.05$

The table shows that there is a significant difference between and within treatments on the height of *Brassica rapa* with the *f*-ratio value is 18.21, and the *p*-value is 0.00. It shows that the Yamasaki, Nutrihydro, and SNAP solution applied in the *Brassica rapa* shows a significant different effects in the growth of *Brassica rapa*.

Table 10 Pos Hoc Analysis using Tukey Test on varying types of nutrient solution.

Pairwise Comparisons		**$HSD_{.05}$ = 1.23** **$HSD_{.01}$ = 1.50**	**$Q_{.05}$ = 3.66**	**$Q_{.01}$ = 4.46**
T_0:T_1	M_0 = 8.13 M_1 = 15.05	6.92	Q = 10.56 (*p* = .00)*	
T_0:T_2	M_0 = 8.13	7.11	Q = 10.85 (*p* = .00)*	

	M_2 = 15.24		
T_0:T_3	M_0 = 9.13 M_3= 15.63	7.51	Q = 11.46 (p = .00)*
T_1:T_2	M_1 = 15.05 M_2 = 15.24	0.19	Q = 0.29 (p = .96)
T_1:T_3	M_1 = 15.05 M_3 = 15.63	0.59	Q = 0.89 (p = .92)
T_2:T_3	M_2 = 15.24 M_3 = 15.63	0.40	Q = 0.60 (p = .97)

The table displayed Tukey's pairwise comparison within the ANOVA results of *Brassica rapa*in the height of treatments. It indicates a significant difference between the sample means of T_0 (M = 8.13) and T_1 (M = 15.05); T_0 (M = 8.13) and T_2 (15.24); and T_0 (M = 9.13) and T_3 (15.63). Therefore, groups within different types of treatments indicate varying growth and development. While there is no significant difference between the means of T_1 (M = 15.05) and T_2 (M = 15.24), T_1 (M = 15.05) and T_2 (M = 15.63), and T_2 (M = 15.24) and T_3 (M = 15.63). Hence, treatments within this group show no differences in the quantitative comparison of growth and development.

CHAPTER IV

DISCUSSIONS

This chapter covers the discussion and implications of the results of the study.

Findings

Effects of Varying Light Intensities

The following discussion and implications deal with the effects of light intensities received in treatments with one layer, two layers, and three layers having significant differences in the growth and development of *Brassica rapa*. The comparison of the control group with one layer of net covered shows better growth and development, while the best result is in three layers covered.

Finding support for the study of Hatfield and Rueger (2015) that temperature is a primary factor affecting the rate of plant development. Warmer temperatures expected with climate change and the potential for more extreme temperature events will impact plant productivity. Few adaptation strategies are available to cope with temperature extremes at this developmental stage other than to select plants. In controlled environment studies, warm temperatures increased the rate of phenological development; there was no effect on leaf area or vegetative biomass compared to normal temperatures.

<u>Interactions of Varying Light and Nutrient Solutions</u>

The growth and development of *Brassica rapa* had a significant relationship with the intensities of light and nutrient solutions.

It supports the studies of IIyas et al., 2022fluctuation in temperature greatly affects plant growth and development and the production of bioactive compounds. An investigation of the effect of cold stress on seed germination, biomass gain, and biosynthesis. Results showed response expression after abiotic stress treatments indicating higher potentials. Ahmed et., 2012 on the development of stress-resistant *Brassica rapa.*In experiments under controlled conditions, it was investigated the effects of water stress. The yield components were mainly affected by water. The results demonstrated a marked reduction when water deficit occurred from anthesis to maturity (Champolivier & Merrien, 1996).

<u>Response of *Brassica rapa* in Growth, Development, and Yield</u>

The yield production of the *Brassica rapa* shows greater responses in growth and development especially the yield of plants with the increase of layers covered in *Brassica rapa*. However, the result of the study by Li et al., 2014 less shading stimulates plant growth but also improves plant quality, especially compactness.

In the study by Ezziddine et al. (2021), the performance of nutrient solution on plant yield, fresh weight, water consumption, and nutrient content in leaf tissue showed no significant difference in the interactions of plant yield. The study showed that nutrients recovered can be utilized as fertilizer, thereby reducing the dependency on mineral fertilizer in a hydroponic system.

Economic impacts are the greatest during drought events that are projected to increase in frequency and intensity as a result of climate change. Therefore management of good yields should be a key consideration when evaluating agricultural drought risk reduction (Foster et al., 2015).

In the study of Yan et al. (2019) the low temperature is one of the most important abiotic factors inhibiting growth, productivity, and distribution. Based on the result it is concluded from this experiment that the cultivar has a higher ability to respond to cold stress (chilling and freezing stresses).

Conclusions

The researcher found out in this study that the effects of varying light intensities had varying effects on lengths, width, height, number of leaves and yield types of nutrient solutions had a relationship to the growth and development of *Brassica rapa.*

The control group and the groups were treated with one two layers

Recommendations

Based on the findings of this study, the following recommendations are given:

A. For possible action to take for *Brassica rapa* to grow in hydroponics:
   1. A cultivar should provide a nursery for growing seeds to establish and a greenhouse to control the factors of infestation of pests to plants.
   2. A cultivar should use the right nutrient solution to grow *Brassica rapa*.
   3. A cultivar should use the proper nutrient solution to grow *Brasicca rapa* in hydroponics.
   4. A cultivar should use three layers of black covers of the net to improve the growth and development of *Brassica rapa*.

B. For further study:
   1. Future researchers may conduct a wider scope related to the growth and development of other plants grown in a hydroponics system.

2. Conduct a hydroponic system grown in vertical method and investigate factors the factors affecting the growth and development of *Brassica rapa.*

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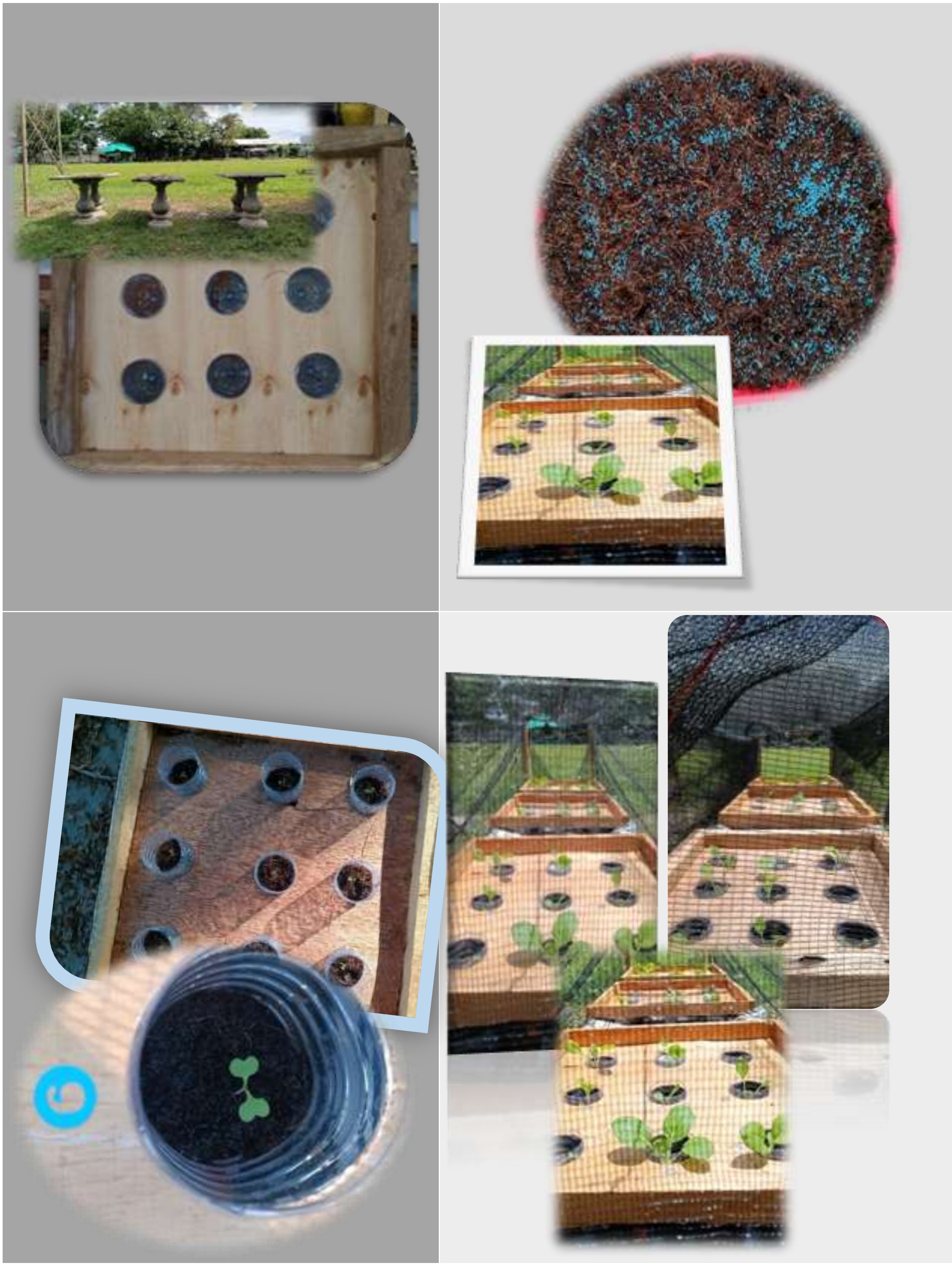
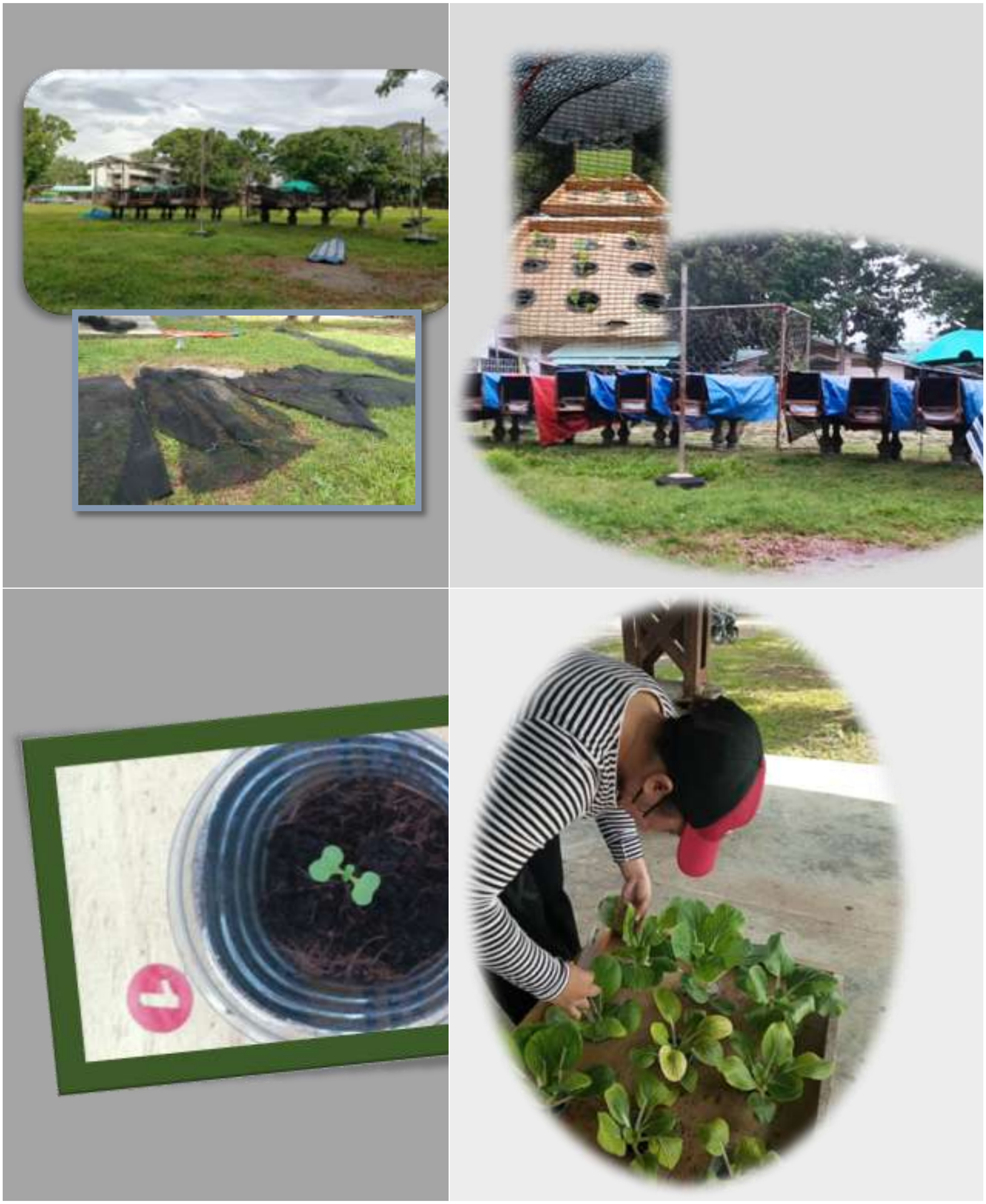
Appendices





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