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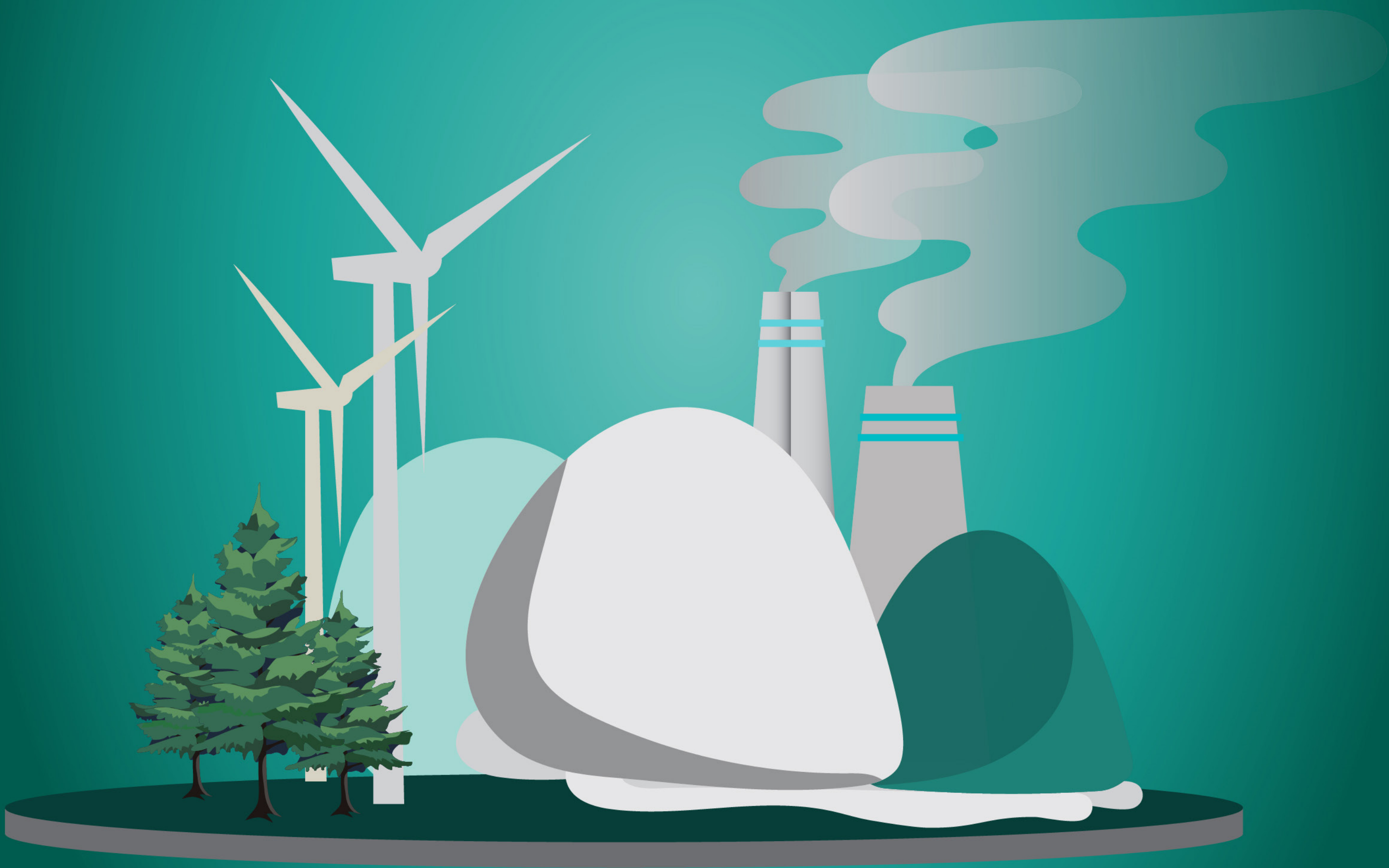

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Effects of Varying Nutrient Solution to *Brassica Rapa* "Bokchoy" Grow Under Hydroponic System

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ABSTRACT

The fact that farming is dependent on available land becomes even more complex when the climate is changing drastically. From this perspective, soilless system production is advantageous since it allows farmers to utilize land that has been unproductive due to pollution or illness, while simultaneously reducing the quantity of water consumed. According to the discussion and conclusions that accompany the results, the growth and development of *Brassica rapa* are affected by the nutrients it receives in treatments. The concentrations of nutrient solutions have a significant impact on the growth of *Brassica rapa.* As the number of *Brassica rapa* layers increases, the *Brassica rapa* yield increases and improves, particularly in terms of plant yield. The effects of nutritional solutions on plant growth, fresh weight, water consumption, and the number of nutrients in leaf tissue demonstrated that the interactions between factors are not the same. According to the findings of the study, the collected nutrients could be used as fertilizer. Therefore, hydroponic systems will require less mineral fertilizer. The environmental temperature is one of the most important abiotic factors that could slow down the process of development, production, and spread. Based on the data, it is feasible to conclude that the cultivar is more resistant to cold stress.

INTRODUCTION

Hydroponics is an agricultural method for growing vegetables that have been studied in depth. Hydroponics research began at the University of the Philippines at Los Baños, and several Filipino scholars are now at the top of their fields. What hasn't been done yet, and this is why this research is important, is to use hydroponics in cities, anywhere, or on rooftops, and to come up with a competitive business model that connects local production to local consumption, which lowers the costs of the food supply chain. This model is not only a good way to do business in agriculture, but it is also a good way to do business that will last. *Brassica rapa*, which is a common item sold on the market, was an important part of the study. Its leaves can be eaten and are often used in soups and stews.

Brassica rapa is a herb that grows back every year and grows best in temperate climates. In many countries, it is grown as a vegetable that can be eaten and to make vegetable oil to feed the growing population. But changes in temperature have a big effect on how plants grow and develop and how they make bioactive compounds. A study of how cold stress affects the germination of seeds, the growth of biomass, and the amount of biosynthesis in medicinally important *Brassica rapa* (IIyas et al., 2022).

Brassica is a group of vegetables that are important all over the world and are affected by both biotic and abiotic stresses. The results showed that the response expression was higher after treatments for abiotic stress. The results suggest that chitinase genes could be helpful in making Brassica plants that can handle stress (Ahmed et al., 2012).

Researchers looked at the effects of water stress in controlled experiments. Water shortages mostly hurt the yield and the parts of the yield. The results showed a big drop when there wasn't enough water from anthesis to maturity (Champolivier & Merrien, 1996).

In a study, the cause of plant diseases could be in different parts of the plant, like the leaf, root, or stem. However, the leaf is one of the most important places to look for signs of infection. The study looked at different things that cause abiotic and biotic stress in plants (Kaur & Gautam, 2021).

In a greenhouse experiment, different levels of salinity were used to study the effects of salt and drought on the growth, physiology, and biochemistry of *Brassica rapa*. The results showed that both drought and salt stress had a negative effect on plant growth, as measured by the fresh and dry weights of the shoots and roots. On the other hand, the bad effects of each stress factor were made worse when drought and salinity were both presentsSahin et al., 2018).

Salinity is one of the most important environmental factors that affect the growth of Brassica crops. Pavlovic et al. (2018) looked into the physiological, biochemical, and hormonal effects of short-term salinity treatments on seedlings, with a focus on how auxin is made and broken down. Changes in biochemical stress markers were seen in the seedlings' fresh weight and root growth, as well as in the rate of photosynthesis and the number of reactive oxygen species.

A study that looks at how mine species deal with arsenic toxicity and compares the results from plants exposed to arsenic in contaminated soil and from plants grown in a hydroponic solution. The results showed that how plants take in arsenic, move it from the roots to the leaves, distribute it, and get rid of it depends on the growth

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conditions. When grown in soil, it had the most arsenic in its roots and shoots compared to other species. However, when grown in hydroponics, it had less arsenic in its roots and shoots than when grown in soil (Zabludowska et al., 2009).

There are things below the plowed zone that make it less likely that production will be sustainable, such as the amount of calcium in the soil. This could stop the roots from getting longer and make the crop more vulnerable to drought. Experiments have shown that low-calcium tolerance can be different between and within cultivars (Spehar & Souza, 1995).

When there is a lot of salt in the soil, it is harder for plants to find and take up Ca2+. This causes membranes to break down and other problems that are caused by a lack of Ca2+ in plants. How well calcium is taken in and used when the environment is salty. Arshad et al. (2012) found that plants that take in and use calcium well in salty environments may be better able to handle salty conditions in the field. Most of the time, the response to high salt and low Ca2+ has been done against high salt alone. Due to low calcium and high salinity, the length of the shoot, the length of the roots, and the fresh weight of the shoot and roots all decreased by a lot. So, the study shows that some genotypes are better able to take in and use calcium when there is less calcium available, which makes salt better in salty conditions.

When the pH of the medium is lower than Quantitative Trait Locus (QTL) analysis, proton rhizotoxicity stops roots from growing. The fact that the mechanisms of resistance and aluminum resistance are controlled by different genes shows that there is no simple link between the genes that control each trait (Ikka et al., 2007).

In a hydroponic experiment, the role of potassium and silicon in reducing the bad effects of NaCl on different plant genotypes with different salt tolerances was tested. The results showed that K and Si made plant genotypes more resistant to salt stress. This was due to less Na+ and more K+, which improved the K+/n ratio, which is a good way to measure how well plants can handle salt stress (Ashraf et al., 2010).

Chromium (Cr) is a well-known cancer-causing substance that is found in half of the EPA's drinking water (EPA). The X-ray absorption spectroscopy (XAS) results for this study showed that some of the supplied Cr (VI) was taken up by the roots. However, the analysis of the plant tissues showed that it was completely turned into Cr (III) in the leaf tissues (Aldrich et al., 2003).

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, and 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.

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., 2021).

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 rapa* 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).

METHODOLOGY

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.

Research Design

The study employed a strip-plot design. As a result, it is deemed to have an equal selection of each *Brassica rapa* with three replications. The following will be the treatments:

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 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. It was used to measure the height, length, and width of the leaves of *Brassica rapa*.

Timer. It was used to regularly monitor the collection of data.

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

Power of Hydrogen (pH) Tester. It was used 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 sprouted, there were 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, there were 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 water was 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

After being grown for 10 days, the seedlings were transferred to a growing box with a polyethylene plastic container and were 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 growing box (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 stores and releases nutrients as needed, yet it has a tendency to retain calcium, magnesium, and iron. This means that it needs to supplement crops 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 cup is 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.

Nutrient Solution Application

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*. 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 treatment was 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.

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.

The different levels of nutrient solution used are as follows:

C_0 = normal

C_1 = Nutrient Solution A (NutriHydro)

C_2 = Nutrient Solution B (Yamasaki)

C_3 = Nutrient Solution C (SNAP)

Data Gathering Procedure

The data were gathered in accordance with the methodology used in the study 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* was 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 leaves of *Brassica rapa* were counted per plant for 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 growth of *Brassica rapa* with the length measured with varied time (8 am, 12 pm, and 5 pm) temperature and determined the relationship within the result. Hence, specimen temperature was monitored by the researcher to investigate and observe.

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 were employed to determine the relationships.

Experimental Design and Analysis

The strip plot design was used in this study. The light intensities (T0 – under normal environmental condition, T1 – the wooden frame that will scaffold the one layer of mosquito net, T2 – wooden frame that will scaffold the three layers of mosquito net), was the vertical and the amount of nutrient solution (N0 – no nutrient solution A, N1 – 30 ml/box of nutrient solution B, N2 –with Yamasaki 30 ml/box nutrient solution, and N3 with SNAP with 30 ml/box nutrient solution C). Each treatment was replicated three times.

The ANOVA was employed in the strip-plot design that was used to analyze the data for the comparison of each treatment, a 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.

RESULTS

Effects of Varying Light Intensities

As evidenced by an f-ratio of 6.40 and a p-value of 0.00,

Table 1: A Differences in the Varying Light Intensities in the Numbers of Leaves on *Brassica rapa*

Source	SS	df	MS	
Between-treatments	107.08	3	35.69	F =6.40*
Within-treatments	2651.80	476	5.57	
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 exhibited a statistically significant difference between the varying of one, two, and three layers. The ANOVA test revealed a significant difference in the amount of leaves developed by *Brassica rapa* when light intensity was varied across one, two, and three layers.

For pairwise comparisons of treatment in layers based on ANOVA data. T0 (M = 3.54) was substantially different (p = 0.00) from T1. T0 was significantly different (p = 0.03) from the mean of T2 with two layers of net covered (M = 4.45), but T1 was considerably different (p = 0.03) from the mean of T3 with three layers of net covers (M = 5.07). T0 and T3, T1 and T2, and T2 and T3 comparisons, on the other hand, revealed no significant changes. Light intensities had a significant effect on the growth and development of *Brassica rapa*. However, some treatments had no effect on growth and development when compared to others.

Interactions of Varying Light and Nutrient Solutions

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) in the 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.

Length (r = 0.834), width (r = 0.909), height (r = 0.896), number of leaves (r = 0.911), and yield of *Brassica rapa* are correlated with growth and development, according to the data. As a result, the growth and maturity of *Brassica rapa* interacted with the different light intensities used by each group. Consequently, when *Brassica rapa* light intensities increases as light, width, height, the number of leaves, and yield all increase.

The analysis revealed that there was a substantial difference (p <.05) in the total number of leaves produced by each treatment as well as by each individual treatment

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_0 = 3.54 M_1 = 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)*
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)

Table 3: Relationship of Length, Width, Height, Number of Leaves, and Yield in the Varying Light Intensities

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)*

Table 4: Relationship of Length, Width, Height, Number of Leaves, and Yield in the Varying Types of Nutrient Solutions

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)*

Table 5: Growth and Yield Response of *Brassica rapa* to Varying Nutrient solution.

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

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

(F-statistics = 16.76). Because of this, the quantity of leaves produced by each treatment is significantly different due to the differences in the nutritional solution. There is a statistically significant gap between the sample means of T0 (M = 3.54) and T1, which has a value of 4.81; T0 (M = 3.54) and T3, which has a value of 5.28; T1 (M = 4.81) and T2 (M = 3.59); and T2 (3.59) and T3, which has a value of 5.28. As a result, it has been established that the applied nutrient solution had an effect on several groups and had a significant effect on the growth and production of plants in both the control group and the treatment group. There was also no discernible change found between T0 (M = 3.54) and T2 (M = 3.59), as well as T1 (M = 4.81) and T3 (M = 5.28). In light of this finding, a comparison of the treatments used within these groups revealed that the growth and yield were unaffected by the various types of applied solutions, despite the fact that these solutions were of different types.

Interactions of Varying Light and Nutrient Solutions

There was a substantial correlation between the light and nutrient solution intensities that the *Brassica rapa* was exposed to and its subsequent growth and development. The findings provide credence to the findings of Ilyas et al., 2022, which state that variations in temperature have a significant impact on the growth and development of plants as well as the generation of bioactive chemicals. An examination of the impact that cold stress has on seed germination, the accumulation of biomass, and the production of biosynthesis. The findings revealed that response expression occurred after abiotic stress treatments, indicating that greater potentials were present. Ahmed et al., 2012 about the creation of stress-resistant *Brassica rapa*. The consequences of water stress were explored through a series of studies conducted under carefully monitored conditions. Water was the primary factor that determined the yield components. The findings revealed a significant decrease whenever there was a water shortage between anthesis and maturity (Champolivier & Merrien, 1996).

Table 5: Pos Hoc Analysis of the Differences in Growth and Yield

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)*	

Response of *Brassica rapa* in Growth and Yield

Brassica rapa yield production exhibits stronger growth and development responses, particularly in plant yield, as the number of the plant layers net increases. However, the study discovered that increased net layers showed not only accelerated plant growth but also improved plant quality, particularly in terms of compactness.

Also, there were significant differences between the effects of nutritional solution on plant yield, fresh weight, water utilization, and the number of nutrients in leaves. The investigation demonstrated that the recovered nutrients are suitable for use as fertilizer. This means that less mineral fertilizer can be used in a hydroponic system. Droughts, which are anticipated to worsen and occur more frequently due to climate change, have the greatest impact on the economy. Consequently, managing good yields should be the first priority when considering agricultural drought risk mitigation (Foster et al., 2015).

Likewise, the study by Yan et al. (2019) demonstrates that low temperature is one of the most significant non-living elements that inhibit growth, productivity, and spread. The results of this experiment indicate that the cultivar is better able to withstand cold stress (chilling and freezing stresses).

CONCLUSIONS

Temperature is an essential component in plant growth. As a result of climate change, temperatures are anticipated to rise, and more extreme temperature events are possible. This affects plant development in controlled trials with net layers and various types of nutritional solutions. Warm temperatures provided a significant effect on improved phenological development. Also affected are the leaf area and vegetative output relative to normal temperatures.

Changes in temperature have a significant impact on plant growth and development. According to the findings, higher potentials were seen following abiotic stress treatments. The development of stress-resistant *Brassica rapa* was the result of controlled experiments in which the effects of various nutritional solutions and controlled settings on plant growth and development varied. The found nutrients can be utilized as recommended nutrients for *Brassica rapa*, Consequently, in hydroponic systems, less mineral fertilizer, less water usage, and a *Brassica rapa* resistant to high temperatures were created.

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