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Responses of *Brassica rapa* "Bokchoy" to Varying Light Intensities Grown Under Hydroponic System

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ABSTRACT

Climate change compounds matters because agriculture is dependent on land. Soilless system production is attractive since it allows for the use of unproductive land for agriculture while reducing water use. The light intensities in one-, two-, and three-layer treatments affect Brassica rapa growth and development, according to the discussion and conclusions. The three-layer net group outgrew the one-layer control group in terms of growth and development. Brassica rapa's development and maturity were influenced by light intensities. Plant growth and yield improve as the number of Brassica rapa layers increases. Varying effects on plant output, fresh weight, water consumption, and leaf tissue in the intensities of light. The study discovered that light had an impact potentially in Brassica rapa in hydroponic systems. The temperature of the environment can stymie development, manufacturing, and diffusion. The findings indicate that the cultivar is more resistant to light stress.

INTRODUCTION

It would appear to be self-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. This is due to the fact that it is anticipated that the population of the world will increase in the coming years. The growing loss of rich soil surface as a result of environmental degradation and trends toward urbanization considerably complicates the predicament that already exists. It is important to take into consideration the intensification of production cycles as well as the monoculture approach, both of which helped to enable the spread of a variety of diseases and the development of disorders with associated those diseases. In an era marked by dramatic climate change, the fact that agricultural operations are extremely reliant on the availability of land only serves to further exacerbate the problem. In this aspect, the possibility to use land that is no longer productive owing to pollution or pathogen issues for agricultural uses while simultaneously minimizing the amount of water that is used makes production using soilless systems an appealing alternative. In addition, it is essential to point out that the application of this kind of technology constitutes a constructive response toward the development of agriculture that is less harmful to the environment, in addition to being a practical tool in the context of the worldwide problem of ensuring adequate food supply (Satterthwaite et al., 2010). An agricultural method known as hydroponics has been the focus of a significant amount of research as it pertains to the production of vegetables. Research on hydroponics was initially pioneered by the University of the Philippines at Los Baos, and several Filipino academics are currently at the forefront of their fields. 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, which will result in a reduction in the costs associated with the food supply chain. This approach not only offers a commercially viable paradigm for agriculture, but also a model that is environmentally sustainable. Brassica rapa, which is a popular product that is sold on the market, was utilized in the study as an important component that was used. It is common practice to include the leaves, which can be consumed, in dishes like as stews and soups. Pechay (Brassica rapa) is typically offered as part of a meal alongside other vegetables, seafood, or meat when it is prepared for consumption at establishments such as restaurants or even in private homes.

Eastern Asia places a significant emphasis on the consumption of this vegetable. It is the most often cultivated vegetable in China, particularly in the country's northern regions, and other key locations of production, such as Korea, including China. Therefore, it can be consumed raw or simply cooked, and it is also utilized in the preparation of kimchi, which is a fermented side dish that is consumed.

Brassica rapa Environmental Stress

Brassica rapa is an annual biennial herb, cultivated worldwide, and most adapted to temperate climates. It is commonly cultivated in many countries as an edible vegetable and for the production of vegetable oil for the growing population. However, the fluctuation 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 content in medicinally important *Brassica rapa* (IIyas et al., 2022).

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Brassica is an important vegetable group worldwide that is impacted by biotic and abiotic stresses. Results showed response expression after abiotic stress treatments indicating higher potentials. Results presented herein suggest that chitinase genes may be useful resources in the development of stress-resistant Brassica (Ahmed et al., 2012).

In experiments under controlled conditions, it was investigated the effects of water stress. The yield and yield components were mainly affected by water shortages. The results demonstrated a marked reduction when water deficit occurred from anthesis to maturity (Champolivier & Merrien, 1996).

In a study, the reason for plant diseases could be the reason of disease in different parts of a plant such as the leaf, root, and stems, however, leave is one of the most important institutes to be observed to identify and detect infection. The study showed covers different factors which is the reason for abiotic and biotic stress (texture, shape, and size) in plants (Kaur & Gautam, 2021).

The effects of salt and drought factors on the growth, physiological and biochemical responses of Brassica rapa, a greenhouse experiment was conducted with different levels of salinity.

The result showed that individual drought and salt stress conditions have negatively affected the plant growth including the shoot, root fresh, and dry weights when applied separately. On the other hand, the combination of drought and salinity enhanced the adverse effects of each stress factor (Sahin et al., 2018).

Salinity is one of the major abiotic stresses affecting Brassica crop production. In the investigations (Pavlovic et al., 2018) into the physiological, biochemical, and hormonal components of the short-term salinity treatments in seedlings, with particular emphasis on the biosynthesis and metabolism of auxin. Observed changes in biochemical stress markers in reductions in seedling fresh weight and root growth, decreased photosynthesis rate, and increased levels of reactive oxygen species.

A study that evaluates the strategies for coping with arsenic toxicity by the mine species, and compares results obtained from plants exposed to arsenic present in contaminated soil and with a hydroponic solution. The result showed basic differences in plant responses to arsenic depending on growth conditions with respect to uptake, root0to-shoot translocation, distribution, and detoxification.

When grown in soil, it accumulated the highest amount of Arsenic in roots and shoots relative to other species, however, when exposed to arsenic in hydroponics, it had lower Arsenic in hydroponics, it had lower Arsenic concentrations (Zabludowska et al., 2009).

Factors that limit the prospect of sustainable production, such as levels of calcium in the soil, below the plowed zone. This may prevent root elongation and expose the crop to drought stress. Experimental data have shown variability for low-Calcium tolerance among and within cultivars (Spehar & Souza, 1995).

In saline soil conditions the availability and uptake of Ca2+ are reduced that resulting in the loss of membrane integrity and other disorders associated with Ca2+ deficiency in plants. The efficiency in uptake and utilization of calcium under saline conditions. In research from Arshad et al. (2012) efficient uptake and utilization of calcium under saline conditions may be better able to withstand saline conditions in the field. The response to salinity and low Ca2+ has usually been done against salinity alone. Physical growth parameters in shoot length, root length, and shoot and root fresh weights were decreased significantly due to salinity and low calcium. Hence, the study proves that certain genotypes can better uptake and utilize calcium than under low calcium supply which improves salt under saline conditions.

Root growth is inhibited by proton rhizotoxicity in low ionic strength media when the pH of the medium is lower than Quantitative Trait Locus (QTL) analysis. The study that indicates different genetic factors regulate mechanisms of resistance and Aluminum resistance indicates that there is no simple relationship between the genetic factors controlling each trait (Ikka et al., 2007).

A hydroponic experiment was conducted to evaluate the role of potassium and silicon in mitigating the deleterious effects of NaCl on plant genotypes differing in salt tolerance. The result showed K and Si enhanced salt tolerance in plant genotypes it was ascribed to decreased Na+ concentration and increased K+ with a resultant 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-established carcinogen that is contaminated by half of the Environmental Protection Agency (EPA). The X-ray absorption spectroscopy (XAS) results for this study showed that some of the supplied Cr (VI) were uptaken by the roots, however, the data analysis of the plant tissues demonstrated 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.

Sunlight

Require solar radiation to grow. Sunlight is absorbed by plant leaves and used as an energy source for photosynthesis. The ability of a crop to absorb sunlight is determined by the leaf surface or leaf area index. The ability of a crop to collect sunlight is enhanced when it has a full canopy (McKenzie, 2017).

Photosynthesis is the process by which plants produce food. It occurs when a plant collects carbon dioxide, nutrients, and water through pores in its branches, stems, and leaves.

The light energy initiates a chemical reaction that degrades the carbon dioxide and water molecules. This process generates a sugar called glucose as well as oxygen. Glucose provides oxygen and is broken down by chloroplast organelles, which contain a green substance called chlorophyll, which gives the leaves their green hue. Due to sunshine exposure, both the "full sun" and "some sun" plants were able to enable for photosynthesis (Measuring Plant Growth with Sunlight, 2019).

When plants receive insufficient sunlight, photosynthesis slows and the plant begins to climb upward and stretch its stems to reach for the sunshine. This process is easily seen in both plants that received partial and restricted sun. Plants grew longer stems and expanded their reach toward the sun (Measuring Plant Growth with Sunlight, 2019b).

Sunlight concentration and transmission for daylighting is a burgeoning technique of direct solar energy consumption. To address the cooling problem during high irradiation, a solar concentrating and transmission system was devised and tested. The study found that using extensive shade as a cooling technique to ensure a safe temperature range was achievable.

A study looked into the morphological changes, photosynthetic responses, and gene expression of plants in response to intense sunlight. The results demonstrated that bright sunshine increased the expression of the gibberellin biosynthesis gene and affected plant morphology. Plants grown in direct sunlight also showed increased shoot growth, stem elongation, and branching. As a result, higher expression of photosynthetic genes and photosynthesis rate have a favorable effect. The strategy that led to the improvement of plant leaf photosynthetic efficiency was a method to boost light energy consumption, which reduced chloroplast senescence caused by surplus light energy (Cao et al., 2021).

Light and dryness will boost the biomass and glucosinolate synthesis of Brassica rapa. Experiments with prolonged light exposure improved plant growth. Plants subjected to a combination of drought and long light conditions grew in the same way as control plants. Plants exposed to lengthy light produced more glucosinolates, however, dryness had no effect on glucosinolate production. The data indicate that lengthy light exposure was employed to boost both 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 have a variety of effects on plant growth. The effects of heat on photosynthesis, in which plants consume carbon dioxide to make oxygen, are the most visible. According to Colorado State University Extension experts, these processes accelerate as temperatures rise.

The two processes become imbalanced when temperatures reach unacceptably high levels. Temperature has a wide range of effects on plants, which are impacted by factors like as exposure to sunshine, height, the variation between day and night temperatures, and proximity to surrounding structures (Dyer, n.d.).

Holcman and Sntelhas (2012) investigated the effect of different color shade screens on several climatic variables in a greenhouse covered with low-density polyethylene. The testing revealed that the treatment with a black screen had the lowest solar radiation transfer.

Temperature is a major component influencing plant development. Warmer temperatures projected as a result of climate change, as well as the possibility of more extreme temperature occurrences, will have an impact on plant productivity.

Other than selecting plants, there are few adaptation methods available to cope with temperature variations during this developmental period. Warm temperatures accelerated phenological development in controlled environment tests but had no influence on leaf area or vegetative biomass when compared to normal temperatures.

As a result, warmer temperatures had the greatest impact during the reproductive stage of development, and grain yield in maize was dramatically reduced compared to a normal temperature regime in all situations.

Temperature effects are exacerbated by water deficits and excess soil water, demonstrating that understanding the interaction of temperature and water will be required to develop more effective adaptation strategies to offset the impacts of greater temperature extreme events associated with a changing climate Hatfield and Prueger (2015).

Drought events, which are expected to become more frequent and intense as a result of climate change, have the largest economic impact.

As a result, while assessing agricultural drought risk reduction, good yield management should be a primary factor (Foster et al., 2015).

According to Yan et al. (2019), one of the most important abiotic variables affecting growth, productivity, and distribution is low temperature. Based on the results, it is inferred that the cultivar has a greater ability to respond to cold stress (chilling and freezing stresses).

METHODOLOGY

Research Site

The study was undertaken at Midsayap, North Cotabato, the 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 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:

T0 = Control group (*Brassica rapa* in SNAP Hydroponic with the normal environmental conditions)

T1 = SNAP Hydroponic System with different light intensities

T2 = SNAP Hydroponic System with different levels of nutrient solution

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.

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 (Santos and Ocampo, 2002)

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.

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.

SNAP 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.

Temperature

The normal condition of the environment per treatment was 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 growth and length records of the *Brassica rapa* was kept using the daily logbook with the given datasheets.

Treatment Method

Light Intensity

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

The different intensities are as follows:

T0 = under normal environmental condition
T1 = under the cover of two layers of mosquito net
T2 = under the cover of three layers of mosquito net
T3 = under the cover of four layers of mosquito net

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

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 by 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. The 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.

Treatment of Data

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, N1 – 30 ml/box of nutrient solution A, N2 –with nutrient solution B 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 AND DISCUSSION

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

Table 1: 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	
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

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)	

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 number 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.

Table 3: Growth and Yield Responses of Brassica rapa to Varying Light Intensities.

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 interplay with the number of leaves in Brassica rapa.

Table 4: Growth and Yield Response of Brassica rapa to Varying Nutrient solution.

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 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 (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.

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)*

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.

CONCLUSION

The following discussion and implications focus on 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. These treatments were compared to one another in terms of the number of layers present. When compared to the control group with one layer of net covering, the experimental group with three layers of coverage demonstrates much better growth and development than the control group.

The findings lend credence to the hypothesis put up by Hatfield and Rueger (2015), which states that temperature is the key factor that determines the rate at which plants mature.

The likelihood of more extreme temperature events, along with the warmer temperatures that are anticipated as a result of climate change, will have an effect on plant productivity. At this developmental stage, the only adaptation strategy that is available to cope with temperature extremes is to pick plants.

There are very few alternative adaptation techniques accessible. Warm temperatures sped up the rate of phenological development in experiments conducted in controlled environments; nevertheless, there was no impact on the total leaf area or vegetative biomass when compared to temperatures that were typical.

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