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Analysis of the Utilization of Hydroponic Media in Welsh Onion (*Allium fistulosum L.*) Cultivation

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Abstract

The food crisis is characterized by an acute increase in food hazards and net malnutrition. One contributing factor to such a circumstance is the decline in food production. In 1627, a novel farming method called hydroponics, which involves growing plants with water assistance, was introduced. Subsequent investigations have revealed that hydroponic cultivation could yield plants of comparable quality to those grown in soil media. Therefore, the present research explored the benefits of hydroponic media in cultivating leek plants. Two containers were used in this study: the first container was not subjected to the application of pesticides, while the second was watered with onion peel vegetable pesticides twice a week. The results of the leek plants cultivation experiment conducted using the hydroponic media demonstrated that the plants achieved a maximum height of 22.8 cm, with only 3 out of 17 failing to survive.

Keywords: *Allium fistulosum L.*, Cultivation, Hydroponic media

Introduction

In Indonesia, various species of the *Allium* genus are commonly cultivated, including *Allium ascalonicum L.* (shallot), *Allium sativum L.* (garlic), *Allium fistulosum L.* (Welsh onion), *Allium cepa L.* (onion), *Allium porrum L.* (leek), *Allium schaenoprasum L.* (chives), and *Allium odorum L.* (Chinese chives). However, two species, namely *Allium schaenoprasum L.* (chives) and *Allium odorum L.* (Chinese chives), are rarely grown in Indonesia. Additionally, certain species such as *Allium ampeloprasum L.* (wild leek), *Allium chinense G. Don* (Chinese onion), and *Allium tuberosum L.* (Chinese leek) cannot be cultivated in the country (Amnah et al., 2019). The bioactive compounds found in medicinal plants are well known for their responsible role in biological activities (Kautsar et al., 2021).

The *Allium* genus encompasses numerous highly valued types and has been used as food ingredients, ornamental plants, and medicinal components for a considerable period. These plants are in high demand both in the international and domestic markets. However, their production in Indonesia is limited, and not all species can thrive. Consequently, particular types need to be imported to fulfill the needs of the Indonesian population (Amnah et al., 2019).

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While some species can grow in Indonesia, the quantity is insufficient to meet the community's demands. It is because most farmers reside in lowland areas, which are not conducive to the growth of the *Allium* genus. These plants thrive best in highland regions. Therefore, plant breeding techniques can be employed to develop lowland cultivars to increase production. These cultivars should possess desirable traits such as large size, attractiveness, disease resistance, and short harvest periods (Amnah et al., 2019).

Leek is one of the types of complementary vegetables and seasonings required by various segments of society at any given time. The harvested area for spring onions in Indonesia has increased yearly due to promising marketing prospects. This commodity demonstrates a positive trend in its growth. The production and marketing of fresh leeks are not limited to the domestic market; they are also extended to international demands for export, such as Singapore and the Netherlands. Furthermore, the need for leeks is expected to increase along with the population growth rate, primarily driven by food and beverage manufacturing companies, particularly those producing instant noodles that utilize leeks as a flavoring agent. The development of leek production in Indonesia is on an upward trajectory. From 2015 to 2016, onion production of leeks experienced an average annual growth rate of 4.96%. In 2016, the total production reached 537,921 tons (Simamora et al., 2020).

Currently, the practice of inland aquaculture neglects the carrying capacity of the aquatic environment, leading to a decline in the quality of estuary ecosystems (Martuti et al., 2021). Welsh onion (*Allium fistulosum L.*) has been cultivated in China and Japan for centuries. It is a perennial plant cultivated annually for one season or biennially for two seasons. Unlike tuber-producing plants, leeks have long, round, hollow leaves that resemble pipes. Its flower structure is similar to that of shallots, with white flowers. The seeds start white when young and turn black as they mature (Saputri et al., 2020).

Exploration of plant secondary metabolites through adventitious root culture is a focal point in improving the commercial industry. Numerous studies have reported successful large-scale commercial production of adventitious root culture (Kusuma et al., 2023). Welsh onion, or the Leek plant (*Allium ampeloprasum* or *Allium porrum*), is a vegetable belonging to the genus *Allium*. The measured part of the Welsh onion is the long leaf sheath, often mistakenly referred to as the stem. The Welsh onion used in this study was a heirloom plant, specifically cultivars (varieties) preserved for generations in traditional environments.

Leek plants can be harvested when they have tillers and are two months old. Higher production can be achieved when the plants grow vigorously and have tillers. To achieve optimal production, it is crucial to provide the plants with proper care, from planting maintenance to fertilization (Banjarnahor, 2022).

Therefore, continuous innovations are being developed to increase corn yields, ensuring food security and supporting the national economy. These innovations can be introduced to various aspects of corn cultivation through different approaches, including optimizing the cultivation technology package offered to farmers (Djufry et al., 2022).

The global human population is increasing each year, reaching

approximately 83 million, which poses challenges in optimizing land use and preserving biodiversity. Environmental issues arise with the growing demand for water, food, and agricultural land, impacting human health, agriculture, and crop yields. Soil, the primary and readily available medium for agriculture, is mainly affected by increased erosion, compaction, and degradation, leading to unfavorable topographical conditions and ultimately limiting agricultural productivity (Wang et al., 2022).

Hydroponic farming systems have recently become a promising method for growing terrestrial plants. Such a system does not rely on soil but uses water as the primary medium. Typically, hydroponic systems utilize rock wool and cotton as planting media. This agricultural cultivation technique offers the advantage of not requiring soil, allowing for the efficient use of limited land space. It has emerged as a promising solution to meet the food demands of the rapidly growing global population (Chen et al., 2020).

One of the benefits of hydroponic farming is that it can be implemented in various locations, such as yards, houses, roofs, and other available land. Unlike traditional soil-based planting, hydroponics reduces pest and disease issues and generally yields products of better quality, resulting in higher selling prices. Furthermore, the ability to operate in limited spaces contributes to creating green and aesthetically pleasing environments (Siregar et al., 2021). Hydroponics has witnessed significant development and is currently being adopted by many Indonesian farmers (Tjahjono et al., 2021).

A comparative study conducted by Cheng et al. (2022) examining the life cycles of aquaponics and hydroponics revealed that aquaponics had a 45% lower environmental impact than hydroponics, as determined by a life cycle assessment (LCA). The substantial electricity consumption, lighting requirements, and air pump usage in hydroponic systems could have negative environmental implications. Additionally, the production of fish food and fertilizers could further contribute to its environmental footprint. Therefore, aquaponics offers a more environmentally friendly alternative.

However, hydroponics presents a viable solution for regions with low groundwater availability, such as the Kingdom of Saudi Arabia (KSA), which is predominantly characterized by harsh desert conditions with limited access to rivers or lakes. With an annual rainfall of less than 100 mm, irrigation water with medium to high salt content is commonly used. Research conducted by Tola et al. (2022) demonstrated that the *Valouro-RZ* and Feisty-Red tomato cultivars could be successfully grown using a hydroponic system that utilized irrigation water with a salinity level of up to 6.0 dS m^{-1}.

Research Method

Several stages are involved in producing hydroponic plants, including seeding, grafting, preparing media, understanding nutrition, testing water pH, regulating plant nutrition, and waiting for harvest. The nursery stage is critical in ensuring the production of high-quality plants (Doni et al., 2020).

The procedure employed in this study is as follows:

Hydroponic system construction

(1) Cut the rock wool into pieces corresponding to the number of Welsh

onion seeds. Lightly press the center of each rock wool piece with a toothpick to create a hole for the Welsh onion seeds. (2) Place one Welsh onion seed into each hole. (3) Submerge the rock wool in a container filled with ample water, ensuring it does not flood. (4) Place the container in a sunny location and let it sit for one week. Make sure that the water does not completely dry out. (5) After one week, separate the Welsh onion seeds germinating from those that have died. (6) Prepare a hydroponic container with several pots equal to or more than the number of germinated seeds. (7) Pour clean water into the container, filling it to half its volume. (8) Add hydroponic nutrient water (*AB Mix*) to the container. (9) Insert a piece of hydroponic wick into each pot, ensuring it can absorb water and moisten the rock wool. (10) Place each rock wool piece into its corresponding pot. (11) Label each pot with a number for easy measurement and identification.

Nutrition is also crucial as it serves as a food source for microorganisms. Hence, insufficient nutrition inhibits the growth of these microorganisms and hampers their ability to produce a significant number of cells during cultivation (Hermansyah et al., 2015).

Seeding is a critical step in the hydroponic growing process. It involves placing plant seeds onto a planting medium, such as rock wool scraps shaped into cubes, and planting the seeds within it (Priyadi & Putri, 2022).

Furthermore, it is crucial to protect nurseries from rainfall, particularly heavy downpours that can cause damage to the seedlings. Excessive rain can lead to the breakage of emerging seedlings, resulting in their failure to thrive (Narasimman et al., 2022).

The height of the plants was measured from the surface of the rock wool to the top of the Welsh onion. Additionally, information regarding the color and condition of the *Allium fistulosum L.* was recorded. These measurements were taken weekly, specifically every Wednesday, spanning six weeks.

Figure 1. *Rock wool used for Allium fistulosum L. seeds(Source: Sirait et al., 2023)*

In this study, the first container was maintained without pesticides, whereas the second was subjected to biweekly watering with onion peel vegetable pesticides. Plant height measurements were promptly recorded in a *Microsoft Excel* spreadsheet during the data collection process. In this regard, ten tables were created, with five dedicated to each container. Each table documented the growth and height comparison of individual plants from one week to another. The average plant height was calculated based on the average height of all its leaves.

Results and Discussion

The results of applying the hydroponic system to the cultivation of *Allium fistulosum L.* are presented below.

Figure 2. *The average plant height in Container 1 without pesticide*

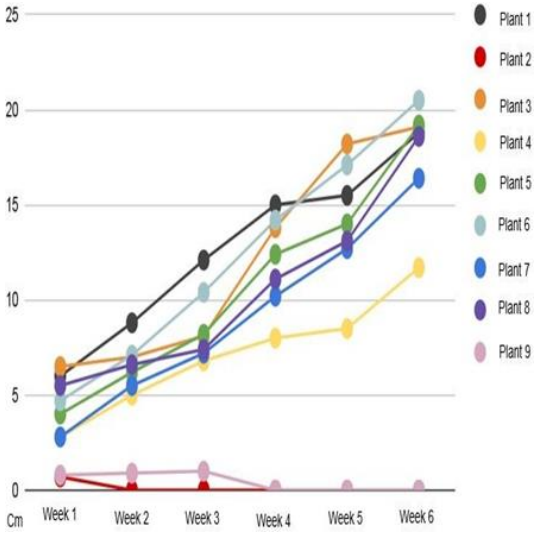
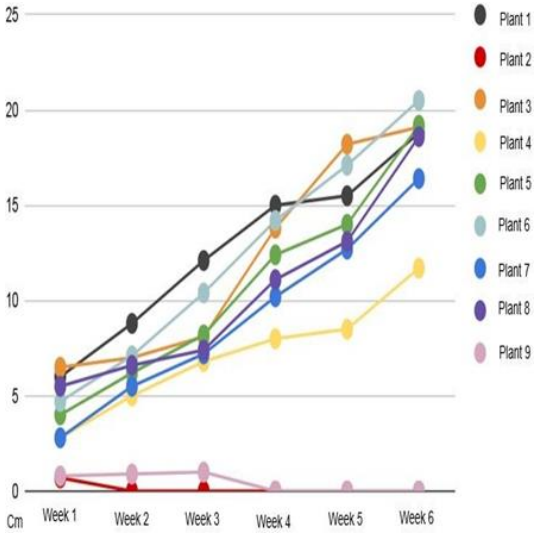


Figure 3. *The average plant height in Container 1 with pesticide*



In Container 1, the maximum plant height reached 20.5 cm in the sixth week, specifically with the sixth plant. On the other hand, in Container 2, the maximum height observed was 22.8 cm in the sixth week, with the fifth plant.

Before the sixth week, two plants (the second and the ninth) in Container 1 died, while only one plant (the eighth) in Container 2 died. This condition could be attributed to various factors, such as being planted too deep, insufficient sunlight, or excessive sowing of leek seeds. Additionally, the following changes were observed in other plants:

1. In the fifth week, the third leaf of the seventh plant in Container 1 dried up.
2. In the sixth week, the third leaf of the third plant and the first leaf of the fourth plant in Container 1 experienced dryness.
3. In the sixth week, several plants in Container 1 experienced dryness on their leaves.

The height growth of plants in Container 1 showed a relatively even distribution over weeks. However, in Container 2, the height growth was not evenly distributed.

Hydroponics is an efficient farming method that offers numerous advantages, making it a viable solution for cultivation on limited green land (Fuada et al., 2023). In hydroponics, plants are grown without soil, relying on water to fulfill their nutritional requirements. Compared to plants grown in soil, hydroponic plants consume less water. Hence, this method is particularly suitable for areas with limited water supply (Aji et al., 2021). Hydroponics is primarily practiced in urban farming, where water is used as a growing medium instead of soil. This approach is considered environmentally friendly as it helps preserve soil quality and minimize waste that can harm the surrounding ecosystem (Julian, 2022).

In hydroponics, the choice of planting medium is crucial as it must effectively accommodate the nutrients that plants absorb (Komaludin, 2018). According to Putra et al. (2019), some of the advantages of hydroponic cultivation are as follows:

1. Vegetables grown through hydroponics are not in direct contact with the ground, producing cleaner and healthier produce.
2. Hydroponic vegetables are less susceptible to pests and diseases, as the nutrient solution can be precisely tailored to meet the plants' needs.
3. Hydroponics requires less land compared to traditional farming methods.
4. Hydroponically grown crops have a higher market value.
5. Hydroponic vegetables can be consumed in a fresh state immediately after harvest.

Due to the continuous development of science and technology, several theories must be revised (Sirait et al., 2021). In this regard, pesticide residues in the environment are perceived as detrimental to direct use or application. Pesticides targeted at specific entities, such as plants and soil, can be transported through water or air; the residues can also enter the food chain (Amilia et al., 2016).

The impact of chemical residues can

lead to the proliferation of new pests and cause significant environmental damage (Kantikowati et al., 2021). To address this issue, environmentally friendly pesticides, including well-known organic vegetable pesticides, have been developed. Accordingly, botanical pesticides have been created to mitigate the negative effects associated with synthetic pesticide treatments. Organic pesticides derived from specific plants possess various properties, such as killing, attracting, repelling, anti-feeding, poisoning, and growth inhibition (Kantikowati et al., 2021). It suggests the possibility of degradation of the vegetable pesticides used, which may have resulted in instability in plant height development during the final weeks of the experiment.

In this study, researchers employed a botanical pesticide derived from fermented shallot skins. Red onion skins, typically considered organic waste contributing to environmental pollution, can be used as a botanical pesticide and plant growth regulator. They contain the active acetogenin, a phytochemical (Arifan et al., 2021).

According to the findings of previous research (Rohmat et al., 2021), shallot skins contain substantial amounts of acetogenin, which functions as an anti-feeding agent and, in smaller quantities, acts as a stomach poison for insect pests. Hydroponic media optimizes the utilization of vegetable pesticides to protect leek plants, as the pesticides are not wasted as they would be in soil media.

Pesticide residues pose a risk to plant growth and food safety. In a study conducted by Shumei et al. (2022) on hydroponic wheat plants, experiments were carried out to investigate the absorption of triadimefon through wheat roots, primarily via the apoplastic pathway. Most of the absorbed triadimefon was found to be distributed in the air-soluble fraction (66.7-76.0%), which was then transferred to wheat shoots and leaves. Fungicide accumulation was mainly influenced by the adsorption of fungicides into the soil and showed a positive correlation with fungicide concentration in the in situ pore water (CIPW).

The choice of planting media could influence the height and growth of leaves. It was observed that chives grown in a water-based medium exhibited greater height and faster growth of new leaves compared to *Allium fistulosum L*. The increased water content absorbed by leeks facilitated faster cell growth, resulting in optimal leaf height and new leaf growth. Moreover, sufficient water absorption reduces drought risk, promoting smooth photosynthesis and chlorophyll formation (Awali, 2020).

However, a study conducted by Musfal (2017) on the effect of mycorrhizae and ameliorants on leeks grown in volcanic ash-polluted soil revealed that leeks reached a height of 77.3 cm within 2.5 months without the use of mycorrhiza and ameliorants. In contrast, in the present study, the tallest leek plants that were not sprayed with pesticides only reached a height of 20.5 cm within 1.5 months. One of the factors that might have influenced plant height was the climate or temperature. Musfal's research was conducted in Karo Regency, where the average temperature was lower than in Medan City. The optimal environmental temperature for leek growth is between 18 and 25 degrees Celsius.

Hydroponic farming is being developed to achieve improved, faster, and environmentally friendly harvest results. Udovicenko et al. (2021) designed a light industrial building with a hydroponic farming system to serve as a facility in rural areas of northern Canada. The purpose of this facility was to enhance access to fresh food in regions characterized by unfavorable climates and limited transportation options. The design process encompassed several key steps: 1) review of existing buildings, 2) estimation of design loads for the system, including temperature and humidity control, adequate lighting, airborne carbon, and water, 3) optimization of hybrid renewable energy systems using a multi-objective genetic algorithm to minimize operational costs and emissions, and 4) a comparison of costs and greenhouse gas (GHG) emissions between the proposed agricultural operation and traditional food supply chains. This development demonstrated that the cost of producing lettuce was comparable to that of traditionally imported lettuce, thus showcasing the potential to provide fresh food at competitive prices within the community.

Conclusion

Hydroponic farming can maximize its effectiveness by monitoring various factors, including pH levels in the running water, temperature, humidity, and other relevant aspects. This comprehensive approach is crucial for achieving optimal plant growth and development in hydroponic systems (Ciptadi et al., 2018).

The choice of water as a growing medium, as opposed to soil, significantly affected the growth and conditions of *Allium fistulosum L.* (leek) plants. One notable effect was the accelerated growth rate of *Allium fistulosum L.* due to the increased water absorption, leading to faster cell growth compared to pesticide-free *Allium fistulosum L.* plants. The accompanying graph demonstrated that hydroponic cultivation with pesticide application was comparable in growth to pesticide-free cultivation, with plant height in pesticide-free containers showing consistent distribution over weeks. Moreover, the final crop yield was also satisfactory.

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