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(IJIREV)**www.gaexcellence.com/ijirev**COMPARATIVE STUDY OF WATER SPINACH
GROWTH UNDER HYDROPONIC AND SOIL-BASED
CULTIVATION**Nurulakidah Adnan^{1*}, Nur Syahirah Norhisyam², Siti Baiyyan Hamidi³, Ammar Zafri Alias⁴¹Pusat Asasi Stem, Universiti Malaysia Terengganu, Malaysia akidah.adnan@umt.edu.my <https://orcid.org/0009-0001-0905-3323>²Pusat Asasi Stem, Universiti Malaysia Terengganu, Malaysia a5981@ocean.umt.edu.my <https://orcid.org/0009-0004-0245-2497>³Pusat Asasi Stem, Universiti Malaysia Terengganu, Malaysia a6332@ocean.umt.edu.my <https://orcid.org/0009-0005-5537-0476>⁴Pusat Asasi Stem, Universiti Malaysia Terengganu, Malaysia a5344@ocean.umt.edu.my <https://orcid.org/0009-0009-7260-9724>

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Abstract:

Water spinach is a highly popular vegetable in Malaysia and is widely used in culinary applications. Demand for this vegetable continues to rise. Home cultivation is also gaining public interest, allowing owners to harvest their own produce. Various cultivation methods are available today, including hydroponics and soil-based planting. This study compares these two methods to determine which yields faster results. Plant height serves as the key indicator to assess which method is easier and more efficient. However, success ultimately depends on the nutrients provided and the suitability of the soil conditions. The study was conducted over a four-week period. For the soil-based method, a mixture of organic soil and biochar soil was used, with seeds planted in five polybags. Water spinach was irrigated daily and supplemented with NPK fertilizer weekly and effective microorganism (EM) solution every two weeks. For the hydroponic method, a passive system consisting of plastic bottles, net pots, and rockwool cubes was used, with five net pots, each containing one seed planted in a rockwool cube. A nutrient solution containing NPK fertilizer and EM was manually stirred daily. The height of water spinach was recorded weekly, and final growth parameters were measured after four weeks. The results showed that hydroponic cultivate of water spinach show greater high of water spinach than soil grown. The average height of hydroponic grown of height water spinach increased from 5.70 cm in Week 1 to 16.05 cm

in Week 4, representing an increase of 10.35 cm. The height of water spinach using soil based increased from 3.33 cm to 7.65 cm, representing an increase of 4.32 cm. By Week 4, the height of water spinach using hydroponic were 8.40 cm taller than the soil-grown cultivation. The hydroponic grown water spinach faster, with greater plant height than soil-grown plants. Soil-grown plants demonstrated steady growth, although one sample showed a slight decrease in plant height, possibly due to differences in nutrient availability and environmental conditions. Overall, the hydroponic method demonstrated greater efficiency in water spinach growth production.

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Keyword:

Agriculture, Effective Microorganism, Hydroponic, NPK Fertilizer, Water Spinach



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Introduction

Water spinach (*Ipomoea aquatica*), commonly known as a kangkung, it's an important vegetable widely consumed in Malaysia. It's can growth in warm and humid condition. Its relatively rapid growth and adaptability to different cultivation systems. That why water spinach suitable for both soil-based and hydroponic cultivation. The growth and productivity of water spinach are influenced by water availability, nutrient supply, growing media, and cultivation conditions (Wang et al., 2022). Wang et al. (2022) demonstrated that water management can influence the growth and biomass accumulation of water spinach, highlighting the importance of appropriate cultivation conditions.

Nowadays, people are increasingly aware of how to grow vegetables, however, many are still unaware of which planting methods are best suited to specific vegetables for achieving rapid and healthy growth. Therefore, this study introduces and compares two commonly used cultivation methods, that is soil-based cultivation and hydroponic cultivation. These two methods are evaluated to determine their effectiveness in promoting vegetable growth and development. Soil-based cultivation has been widely used by farmers for many years. However, as time has passed, hydroponic cultivation has gained increasing attention among people who are interested in gardening and growing their own vegetables. Hydroponics is considered a simple and practical cultivation method, as it does not require traditional soil and can be adapted to various growing environments.

Conventional soil-based cultivation remains a widely used method for vegetable production because plants can obtain water and nutrients from the soil environment. In contrast, hydroponic cultivation is a soilless method in which water spinach receives nutrients through a prepared nutrient solution, such as NPK fertilizer and effective microorganisms (EM).

In contrast, hydroponic cultivation very popular because it does not require soil and can be easy to manage. Plant growth in hydroponic systems depends on the nutrient solution supplied to the roots, which may contain essential nutrients such as nitrogen, phosphorus, and potassium (NPK). Payumi et al. (2022) stated different nutrient compositions in a nutrient film technique (NFT) system and found that nutrient composition significantly affected the growth and productivity of water spinach. Similarly, Putri et al. (2024) illustrate that both growing medium and nutrient composition influence the growth and production of hydroponically cultivated water spinach. In overall, these studies said that the nutrient in the plant and the design of hydroponic will influence the growth of water spinach.

Alam et al. (2022) show that soil cultivation can produce greater vegetative growth than some hydroponic or aquaponic conditions. Therefore, it is important to compare both methods under the same experimental conditions to determine which method provides better plant growth. Simple and low-cost hydroponic systems are particularly useful because they can be easily built and managed for educational, household, and small-scale cultivation. Therefore, this study compares the growth of water spinach cultivated using soil and hydroponic methods. Plant height as the main indicators for comparison. The study can help determine a suitable cultivation method for small-scale vegetable production.

Literature Review

Characteristic of Water Spinach Growth

Water spinach (*Ipomoea aquatica* Forssk.) is a leafy vegetable. It is widely cultivated and consumed in tropical regions, particularly in Southeast Asia. The plant is characterized by its rapid growth, succulent stems, and high production of edible leaves and shoots. Recent literature describes water spinach as a fast-growing, semi-aquatic perennial herb that can be cultivated within approximately 5–7 weeks under suitable environmental conditions (Purayil et al., 2025). This indicates that water spinach is a fast-growing vegetable that is well suited to tropical regions.

Water spinach is well adapted to warm and humid conditions. It can grow in waterlogged and moist soil. Situation of growth is very suitable, especially in tropical environments. The cultivation of water spinach is typically influenced by environmental conditions, temperature, and soil and water conditions. Wang et al. (2023) found that prolonged exposure to high temperatures can reduce plant growth, root development, and photosynthetic activity in water spinach. This shows that even though water spinach can stand with high temperatures, the environment conditions still important for optimal growth.

Water availability is another important factor affecting the growth of water spinach. Wang et al. (2022) investigated the effects of water management on water spinach growth and found that different water conditions influenced plant development and biomass accumulation. Other researcher state that waterlogged cultivation significantly improved water spinach growth, including leaf number, stem diameter, root development, and yield, compared with conventional dryland cultivation (Peng et al., 2024). With all this finding, it shows that the important of water management in maximizing he growth of water spinach.

Soil Based Cultivation (Conventional Method)

Soil-based cultivation is a conventional method for growing water spinach (*Ipomoea aquatica*) in which the soil acts as a physical support for the plant and provides a medium for water and nutrient. Water spinach is cultivated in soil and its particularly suited to moist and enough water conditions. The characteristics of the soil can influence plant growth and development. Therefore, appropriate soil management is very important to produce a good water spinach.

Nutrient in soil is one of the important factors that affect the water spinach growth. Plants require essential nutrients, such as nitrogen (N), phosphorus (P), and potassium (K), for vegetative growth and development. Mohd Noor et al. (2022) said that the effects of organic, inorganic, and compound fertilizers on water spinach and found that fertilizer treatments affected plant height. Their study also showed that organic fertilizer produced growth comparable to inorganic fertilizer, while the combination of organic and inorganic fertilizer provided favourable conditions for water spinach growth. Tajudin et al. (2021) investigated the effects of organic and inorganic fertilizers on water spinach grown in two different soil types. Their findings showed that the application of organic amendments, including biochar and chicken manure, together with NPK fertilizer, improved plant growth and soil properties such as pH and total organic carbon. Therefore, this finding tells us that the use of an organic and NPK fertilizer can improve the soil condition structure. Its also can support the growth of water spinach.

Water availability is another important factor in soil-based cultivation. Peng et al. (2024) compared traditional dry land cultivation with waterlogged soil cultivation and found that waterlogged conditions increased leaf number, stem diameter, root weight, and overall yield. This information gives a good suggestion that water management should be carefully when cultivating water spinach in soil. Zailani et al. (2023) highlighted nitrogen uptake as an important consideration in water spinach cultivation and noted that water spinach requires relatively high-water availability, which may contribute to nutrient loss from the soil during watering. This finding investigated the use of NPK fertilizer can improve nutrient availability in a controlled planting medium.

Hydroponic Cultivation

Hydroponic cultivation is a soilless method of growing plants. The roots of water spinach receive water and nutrients directly from a prepared nutrient solution. Nutrients can be supplied through the nutrient solution according to plant requirements. Wang et al. (2024) said that hydroponic systems can improve water and nutrient-use efficiency through controlled nutrient supply and water recirculation. Nutrient management is an important factor for hydroponic cultivation because plant growth depends directly on the composition of the nutrient solution. Fathidarehnijeh et al. (2024) show that proper nutrient can maintain suitable nutrient concentrations and improve plant growth. Ranjha et al. (2024) state that hydroponic cultivation has gained attention in urban areas where space for conventional agriculture is limited. Payumi et al. (2022) demonstrated the application of hydroponic cultivation to water spinach using an NFT system, highlighting the importance of nutrient supply for water spinach growth. In overall insufficient nutrients can affect plant development hydroponic cultivation. But its also can give several advantages, such as better nutrient control, efficient use of water and space, and cultivation without soil. These advantages make it better for comparing the growth of water spinach with soil-based cultivation.

Nutrient Supported with NPK

Nutrient supported by NPK is an important factor affecting the growth and development of water spinach (*Ipomoea aquatica*). Nitrogen (N), phosphorus (P), and potassium (K) are essential nutrients that support vegetative growth, root development, and plant physiological processes (Mohd Noor et al., 2022; Tajudin et al., 2021). Mohd Noor et al. (2022) said that the different fertilizer treatments significantly affected the plant height of water spinach, with combined organic and inorganic fertilizer providing favourable growth conditions. Tajudin et al. (2021) stated that the combination of biochar, chicken manure, and NPK fertilizer produced the highest average plant growth in water spinach grown in two soil types. Putri et al. (2024) demonstrated that nutrient composition influenced the growth and production of hydroponically cultivated water spinach. These findings indicate that appropriate NPK is important for maintaining nutrient availability and supporting water spinach growth.

Effective Microorganisms (EM)

Effective Microorganism (EM) are mixture of beneficial microorganisms. They are used widely in agriculture. In specific, EM is used to support plant growth rates. EM contains microorganisms such as lactic acid bacteria, yeasts, photosynthetic bacteria, and other microorganisms (Yap & Al-Mutairi, 2023). Javaid and Bajwa (2011) discussed that the EM application improved shoot biomass and enhanced nitrogen, phosphorus, and potassium nutrition under certain fertilizer treatments. Mayer et al. (2010) reported that EM application alone did not significantly improve crop yield or soil quality in their four-year field experiment. Therefore, EM may be considered as a supplementary treatment that may support nutrient availability and plant growth.

Plant Height as Growth Indicators

Plant height is a simple indicator used in this research for evaluating the growth of water spinach (*Ipomoea aquatica*). Payumi et al. (2022) measured plant height at different stages of growth to evaluate water spinach cultivated under different nutrient compositions in an NFT hydroponic system. Their findings show that differences in nutrient composition affected the growth of water spinach. Firdausi et al. (2023) evaluated plant height, together with other growth characteristics, when investigating different growing media for water spinach cultivated using a deep-flow technique (DFT) hydroponic system. Their study demonstrate that nutrient conditions influenced the growth performance of water spinach. Putri et al. (2024) also included plant height as one of the growth parameters when evaluating different growing media and nutrient compositions for hydroponically cultivated water spinach. Their show that the plant height is a commonly used as s parameter for assessing the growth response of water spinach to different cultivation conditions. Previous hydroponic studies have reported final plant heights ranging from approximately 17.58 cm to 25.98 cm after three weeks, depending on nutrient composition (Payumi et al., 2022). Mohd Noor et al. (2022) reported that water spinach grown under a soil-based polyculture system achieved mean plant heights ranging from 42.51 ± 1.58 cm to 52.82 ± 6.10 cm, depending on the fertilizer treatment.

In conclusion, the height of the water spinach is a main suitable indicator, as the plant's growth over four-week period, it can be easily monitor and measured. This will allow clear analysis by comparing hydroponic and soil-based cultivation methods.

Methodology

This study compares the plant height of water spinach using hydroponic and soil-based method.

Preparation of Material, Chemical and Apparatus

For the soil cultivation system, five polybags measuring 12×12 cm were prepared and filled with a mixture of organic soil and biochar soil and the hydroponic system, two 1.5-L plastic bottles were prepared and modified as passive reservoirs. Net pots containing rockwool cubes were used to support seed germination. The chemicals were prepared for both cultivation methods included NPK 16:16:16 fertilizer and Effective Microorganism (EM) solution. NPK fertilizer is used as a source of macronutrients and EM solution will support the microbial activity. A cylinder is used to measure and dilute the fertilizer and EM solution correctly, while a digital scale is used to weigh the soil and biochar.

Experimental Labelling and Replicates

Each experimental was labelled with different number. The labels is used to distinguish between the soil-based and hydroponic cultivation systems and their replicates. The soil treatment was labelled from S1 until S5, while the hydroponic treatment was labelled H1 until H5. The labels were placed on the polybags and hydroponic containers.

Record Initial Data and Begin the Experiment

The initial plant height was recorded for each replicate. A ruler was used to measure the plant height from the surface of the soil to the tip of the tallest leaf. The measurements were taken especially in the morning, it's because to maintain the consistency. All data were recorded clearly in a data sheet, and the labels of each replicate were checked in order to avoid errors during data collection and analysis.

The soil and hydroponic systems were regularly monitored to ensure healthy plant growth. The environmental conditions and nutrient supply were monitor throughout the experiment. For the hydroponic system, the nutrient solution was checked. The water level was also monitored and maintained when necessary. The bottles, net pots, and growing area were kept clean to prevent contamination. For the soil-based system, the plants were watered daily to maintain sufficient soil moisture. The soil was gently loosened, while any weeds in the s oil were removed to reduce competition for nutrients and water. These maintenance activities were carried out throughout the four-week experimental period. This is because to ensure that both cultivation systems were properly managed and that plant growth effectively.

Harvest Water Spinach

After four weeks of cultivation, all water spinach plants from both hydroponic and soil-based systems will be harvested. The harvesting process will be carried out simultaneously. The final height of the water spinach will be measured and recorded using a ruler. To evaluate the growth performance of the water spinach, the measurement will do accurately, and the observation for both cultivations will be analysed. So that the different between both methods will be obtained.

Result and Discussion

Table 1 show the height of water spinach was increased over the four-week period under the hydroponic cultivation. There is an improvement of the height of water spinach over the four weeks. Among the five sample, H2 recorded the highest final height of 26.03 cm, and it followed by H4 at 16.07 cm. H3 and H5 reached 16.07 cm and 15.03 cm respectively. While H1 show the lowest final height at 8.07 cm. Over the four weeks, we can identify the average height of hydroponically grown water spinach increased from 5.70 cm in Week 1 to 16.05 cm in Week 4, representing an increase of 10.35 cm. Based on previous researcher, the hydroponic systems can improve nutrient and water-use efficiency through controlled nutrient delivery and water recirculation (Wang et al., 2024).

Table 1: Table of Water Spinach height using Hydroponics Cultivation

Group of Plants	Week 1	Week 2	Week 3	Week 4
H1	1.03	2.03	2.10	8.07
H2	7.90	9.00	15.13	26.03
H3	4.27	5.13	6.13	15.07
H4	6.40	7.10	10.17	16.07
H5	8.90	10.13	14.13	15.03
Average	5.70	6.68	9.53	16.05

Overall, the reading indicate that the hydroponic method supported the growth of water spinach throughout the four-week period successfully. But the differences in the height of water spinach among the replicates suggest that each sample may have responded differently to the growing conditions or nutrient availability. H2 and H4 demonstrated the best growth performance, while H1 showed the lowest growth. Fathidarehnijeh et al. (2024) show that proper nutrient can maintain suitable nutrient concentrations and improve plant growth.

Table 2 show that the height of water spinach increased from Week 1 to Week 4. Among the five samples, S3 recorded the highest final height of 8.50 cm, followed by S1 at 8.03 cm and S5 at 7.83 cm. S2 reached 7.57 cm, while S4 recorded the lowest final height of 6.33 cm.

Table 2: Table of Water Spinach height using Soil Based Cultivation

Group of Plants	Week 1	Week 2	Week 3	Week 4
S1	3.37	6.00	7.17	8.03
S2	4.13	5.27	7.60	7.57
S3	4.20	6.00	8.20	8.50
S4	1.17	4.17	5.17	6.33
S5	3.80	5.20	6.53	7.83
Average	3.33	5.33	6.93	7.65

For the soil-based cultivation, the average plant height increased from 3.33 cm in Week 1 to 5.33 cm in Week 2, 6.93 cm in Week 3, and 7.65 cm in Week 4. Over the four weeks, we can identify the average height of water spinach increased by 4.32 cm from Week 1 to Week 4. indicating steady growth throughout the four-week cultivation period. Overall, the soil-based

method also supported the growth of water spinach throughout the four-week period successfully. But the differences in plant height were observed among the plant groups, indicating that each sample may have responded differently to the soil and environmental conditions. From the previous researcher, Mohd Noor et al. (2022) said that the effects of organic, inorganic, and compound fertilizers on water spinach and found that fertilizer treatments can affected the height of water spinach.

By comparing the height of water spinach cultivated using hydroponic and soil-based methods, there is a difference in average plant height. It was observed at Week 4. The average plant height of water spinach grown by hydroponic reached 16.05 cm, while the soil-based plants grown at average height of 7.65 cm. This shows a difference of 8.40 cm between the two cultivation methods. The average height of the hydroponically cultivated plants was approximately two times greater than that of the soil-based plants.

Conclusion

Based on Table 1 and Table 2, both hydroponic and soil-based cultivation methods supported the growth of water spinach over the four-week experimental period. However, the hydroponic method showed better overall growth performance compared with the soil-based method. The average plant height for the hydroponic method increased from 5.70 cm in Week 1 to 16.05 cm in Week 4. In comparison, the average plant height for the soil-based method increased from 3.33 cm to 7.65 cm over the same period. This shows that the hydroponic grown plants achieved a substantially greater final average height. Among the hydroponic plants, H2 recorded the highest final height of 26.03 cm. For the soil-based method, S3 recorded the highest final height of 8.50 cm. Therefore, the hydroponic plants generally demonstrated faster and greater height growth than the soil-grown plants.

Overall, the results indicate that the simple hydroponic system was more effective in the growth of water spinach than the soil-based cultivation method during the four-week experimental period. The higher average plant height observed in the hydroponic system suggests that the direct supply of nutrients through the nutrient solution may have supported better plant growth under the conditions of this experiment. This finding is consistent with previous study indicate that different fertilizer treatments significantly influenced the growth of water spinach, highlighting the importance of nutrient availability and fertilizer management in plant development (Mohd Noor et al. ,2022).

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