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THE INFLUENCE OF DIFFERENT GROWING MEDIA ON THE GROWTH OF WATER SPINACH (IPOMEA REPTANS Poir) USING AQUAPONIC TECHNOLOGY

Clarasita Renadevisari Marifel Sukma, Auliya Tuhfatul Mardliyah, Fidela Nur Azizah Handono, & Aprinia Dian Nurhayati*

Departement of Biology, Faculty of Mathematics and Natural Sciences,
Universitas Negeri Malang, Indonesia

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*Corresponding author: aprinia.dian.fmipa@um.ac.id

Abstract

This research aims to determine the best-growing medium to support the growth of water spinach plants using aquaponic technology. The study used a non-factorial Completely Randomized Design (CRD) method. There were four types of planting media treatments, namely, rockwool (control), cocopeat (P1), pasir malang (P2), and burnt husk (P3), there were five growth parameters observed (plant height (cm), number of leaves, stem diameter (mm), wet weight (gr), and leaf color) were monitored once a week starting from 7 HST to 28 HST. Data were analyzed using variance at a confidence level of 5% and continued with the Duncan test (DMRT) at a level of 5%. The results showed that the type of growing medium affects the growth of water spinach. pasir malang provided the best results for all plant parameters. However, it was not significantly different from burnt husk, except for stem diameter, where pasir malang differed significantly from the other treatments. Rockwool, pasir malang, and the burnt husk produced better and healthier leaf colors compared to cocopeat.

Keywords*: Aquaponic; Growing Water Spinach; Planting Media*

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INTRODUCTION

Indonesia continues to experience a growing population each year. The population of Malang City increased from 846,126 people in 2022 to 847,182 people in 2023 (BPS Kota Malang, 2023). Rapid population growth drives economic, social, cultural, and food development. This also leads to land-use conversion, resulting in a decrease in agricultural land (Sajuri *et al*., 2022). Data from the Malang City Food Security and Agriculture shows that the area of paddy fields decreased from 994 hectares in 2022 to 985 hectares in 2023, while the area of non-paddy agricultural land also decreased by 39 hectares compared to 2021 (Malang, 2022).

The shrinking of agricultural land in urban areas can threaten food security, reduce local food production, and potentially lead to food shortages (Gultom & Harianto, 2022). Food security efforts are essential to prevent a food crisis in urban communities (Sedana & Permini, 2023). In this context, innovation is needed to address these issues, one of which is through urban farming. This concept can enhance community self-sufficiency in meeting food needs despite limited land availability (Abror *et al*., 2022). Previous studies have shown that urban farming can significantly contribute to food security in cities by utilizing limited space and efficient technology (Pratiwi *et al*., 2021). This research continues that theme by investigating the cultivation of water spinach, one of the most popular vegetables in Indonesia, which can be grown in urban environments using aquaponics.

The implementation of large-scale aquaponics supports the green economy by creating new job opportunities and promoting innovation in sustainable agricultural technology (Körner *et al*., 2021). Currently, aquaponic technology has advanced with the incorporation of automation systems and sensors. This implementation has been demonstrated by Miranto *et al*. (2021), who designed a cultivation system for tilapia and water spinach using aquaponic technology monitored through Supervisory Control and Data Acquisition (SCADA). This system enhances the success rate of cultivation by enabling real-time monitoring of parameters such as temperature, humidity, water levels, and pH.

The use of aquaponics can be a practical way to enhance urban community empowerment by utilizing simple land and equipment. Research by Fauza *et al*., (2021) shows that communities can use basic materials such as tarps, wood, and used plastic bottles to create a Deep Flow Technique (DFT) aquaponic system with satisfying results. Aquaponics is also more effective than polybag planting due to the nutrients provided by fish metabolism and the sufficient availability of water (Efendy *et al*., 2022).

The success of plant cultivation in aquaponic systems heavily relies on the selection of appropriate growing media (Sinulingga *et al*., 2015; Utami *et al*., 2015). Growing media in aquaponics play a role in maintaining root moisture, storing nutrients as needed by plants, and filtering fish waste from the water (Irawan *et al*., 2023). The growing media must be capable of retaining moisture, offering good durability, and resisting degradation (Sasmita & Haryanto, 2018).

The aquaponics system implemented at the Malang City Food Security and Agriculture Office typically uses rockwool as the growing medium due to its water retention capacity, optimal aeration, and support for root growth (Solihin & Syadiah, 2021). However, rockwool has drawbacks, such as its limited availability, relatively high cost, and environmental impact (Lestari *et al*., 2022). This study uses cocopeat, pasir malang, and burned rice husks as growing media due to their affordability, availability, and abundant supply. Cocopeat can retain ammonium because of its high fiber density (Miska & Arti, 2020). Pasir malang and burned rice husks provide good porosity for holding water and nutrients (Ramijan *et al*., 2023). Therefore, the selection of these growing media is relevant for aquaponic systems as they effectively absorb nutrients and support plant growth, offering advantages over rockwool.

Previous studies have explored the efficiency of aquaponics, including types of growing media to enhance plant yields and fish health. This research adds a focus on the impact of different growing media on the growth of water spinach and highlights the need for further research on alternative, environmentally friendly, and readily available growing media for water spinach in aquaponic systems.

RESEARCH METHODS

The research was conducted from April to May 2024 at the Mini Food Estate Dispangtan in Malang City, located at Jl. Ahmad Yani Utara No. 202, Polowijen, Blimbing District, Malang City.

Materials and Eqiupment

The materials needed for the research include tilapia broodstock, fish feed, water spinach seedlings, rockwool growing media, cocopeat, pasir malang, and burned rice husks. The equipment required includes pipes, water pumps, racks, net pots, flannel cloth, rulers, calipers, and digital scales.

Research Design

This study employs a Completely Randomized Design (CRD), assuming external factors are homogeneous with four treatments of different growing media: cocopeat, pasir malang, burned rice husks, and rockwool as the control. Each treatment is replicated six times, with each replication consisting of five water spinach plants, resulting in a total of 30 water spinach plants per treatment for observation.

Research Procedures

The stages of cultivating water spinach in an aquaponic system are as follows:

1. Preparation of the aquaponic system.

The aquaponic system is cleaned, especially the pipes and fish tanks, to ensure good water flow with consistent volume and optimal functioning of components. The aquaponic installation is located in an open area with evenly distributed and homogeneous sunlight, and it is protected by a transparent canopy.

2. Preparation of equipment and materials

Equipment and materials are prepared before planting, including installing flannel cloth at the bottom and around the net pots to hold the growing media. The seeds used are "Rajawali" brand water spinach seeds, known for their superior quality with a purity of 98% and a germination rate of 90%. The tilapia used are broodstock aged over 1 year, with a total of 83 fish.

3. Selection of growing media

All types of growing media are prepared and then placed into the net pots up to the surface but not too full (cocopeat, pasir malang, and burned rice husks). Rockwool is placed directly into the net pots, ensuring they are of the same size.

4. Preparation of water spinach seeds

Before planting, water spinach seeds are selected based on their physical condition and prepared according to the quantity required for each replication.

4. Planting water spinach seeds.

Planting is done by creating shallow holes in each net pot. The selected seeds are placed into the holes, with each net pot containing five seeds. The holes are then covered, and the media is moistened with water.

5. Maintenance and observation.

Maintenance and observation are conducted over 4 weeks, with measurements taken weekly (on days 7, 14, 21, and 28). Growth data for each measured parameter are observed and recorded in observation sheets every week. Plant growth results are also documented with a camera and compiled into a single folder.

6. Harvesting

Harvesting is done on day 28 by removing the net pots from the aquaponic system. The net pots are then cut and separated from the water spinach roots. The roots are cleaned with water to remove any remaining growing media. Finally, the plants are weighed and each parameter is measured for the last time.

Research Variables

In this study, several variables will be observed and measured, including:

1. Plant height (cm)

Measurement is done with a ruler, measuring from the base of the stem to the tip of the highest leaf stalk. This measurement is taken weekly from days 7 to 28 after sowing (DAS).

2. Stem diameter (mm)

Stem diameter is measured at the base of the plant stem using a digital vernier caliper (150 mm). This measurement is taken weekly from days 7 to 28 DAS.

3. Number of Leaves

The number of leaves is recorded from fully developed leaves. Counting is done weekly from days 7 to 28 DAS.

4. Leaf color

Leaf color is observed visually. This observation is conducted weekly from days 7 to 28 DAS.

5. Wet weight (gr)

All parts of the plant, including leaves, stems, and roots, are weighed using a digital coffee scale 3 kilograms (0.1 grams) at harvest, on day 28 DAS.

Data Analysis

Data are tested for normality using the Shapiro-Wilk test, followed by the Levene's test for homogeneity of variances. If the data distribution is normal and variances are homogeneous, an ANOVA test will be conducted with a significance level of 0.05. This is followed by Duncan's Multiple Range Test (DMRT) with a 95% confidence level.

RESULTS AND DISCUSSION

Water Spinach Plant Height

The Duncan's test at a 5% significance level indicates that the type of growing media has a significant effect on the height of water spinach plants from days 7 to 28 after sowing (DAS). The pasir malang growing media produced the highest average plant height, which was significantly different from cocopeat and rockwool, but not significantly different from burned rice husks. On day 28 DAS, the pasir malang media was significantly different from the burned rice husks.

Table 1. Height (cm) Data for Water Spinach Plants Across Different Planting Media

Planting Media	Average Height Plant (cm)			
	7 DAS	**14 DAS**	**21 DAS**	**28 DAS**
Control	1,028[a]	1,354[a]	1,721[a]	1,672[a]
P1	1,037[a]	1,808[ab]	1,969[a]	2,304[a]
P2	1,812[b]	3,288[c]	4,135[b]	5,151[c]
P3	1,803[b]	2,597[bc]	3,213[b]	3,656[b]

Note: In a given column, identical letters above the numbers indicate that the values are not significantly different based on the Duncan test at a 5% significance level.

The differences in growth are attributed to the varying characteristics of each planting medium. Rockwool is smooth, lightweight, and foam-like (Rohmayani *et al*., 2022). Cocopeat has a soil-like form and texture with fine granules and can retain water 6-8 times its weight (Khoirunnisa *et al*., 2021). Pasir malang is porous, lightweight, and resembles small pebbles with fine pores (Ashraf & Junita, 2020). Burnt husk is lightweight, easily retains water, doesn't clump easily, and has good porosity (Rahmah & Febriyono, 2021).

The rockwool and cocopeat planting mediums result in lower average growth height because both are dense and less porous, which does not provide sufficient air spaces for roots to absorb nutrients optimally. Rockwool has high water retention, which can lead to excessive moisture and root rot. Its dense fiber structure can inhibit root growth. According to (Indra *et al*., 2020), cocopeat is known to have water-holding capacity, leading to low aeration within the medium, which affects oxygen diffusion to the roots and can hinder root growth and nutrient absorption in plants.

The similarity in characteristics between the two planting mediums, pasir malang and burnt husk, is a factor in the lack of significant differences between them. This aligns with (Shofiyah *et al*., 2017), who stated that porous planting media can facilitate optimal root growth. The formation and development of good roots can also be supported by planting media that is not too dense (Tator *et al*., 2023). When roots develop well, the absorption of nutrients in water spinach plants will also be more optimal, and water spinach can grow well. Pasir malang planting medium can absorb nitrogen from fish metabolism, which the plant roots can use as nutrients for growth (Rahmat *et al*., 2017).

Number of Leaves for Water Spinach

The results of the DMRT test showed that the type of planting medium significantly affected the number of water spinach leaves from 7 to 28 days after planting. Pasir malang produced the highest average number of leaves, which was significantly different from cocopeat and rockwool, but not different from burnt husk (Table 2).

Table 2. Number of Leaves Data for Water Spinach Plants Across Different Planting Media

Planting Media	Average Number of Leaves			
	7 DAS	14 DAS	21 DAS	28 DAS
Control	0,533[a]	2,600[a]	7,800[a]	13,233[a]
P1	0,967[a]	5,133[b]	11,933[a]	19,367[a]
P2	2,200[b]	8,067[c]	20,500[b]	34,833[b]
P3	1,867[b]	7,367[bc]	18,867[b]	34,333[b]

Note: In a given column, identical letters above the numbers indicate that the values are not significantly different based on the Duncan test at a 5% significance level.

The insignificant difference in the number of water spinach leaves between pasir malang and burnt husk is due to the similar characteristics of these two media. Pasir malang and burnt husk have many pores for nutrient absorption, thereby supporting optimal growth (Febriani *et al*., 2021). Sand as a planting medium has been shown to positively influence the growth and production of eggplants and tomatoes, according to research conducted by (Putra *et al*., 2013). Based on the research by (Gaso *et al*., 2022), burnt husk planting medium significantly affects and produces the highest number of leaves in water spinach because burnt husk has a loose structure that can retain water and absorb nutrients well, promoting leaf growth.

The number of plant leaves also correlates with the plant's height growth. This aligns with the statement by (Almahdi *et al*., 2022) that as a plant grows taller, the number of leaves also increases, as leaves grow from the stem nodes. Tables 1 and 2 show that water spinach plants grown in pasir malang medium have the highest average height growth and number of leaves, though the difference is not significant compared to burnt husk.

Pasir malang and burnt husk planting media have good porosity, allowing excess water to drain easily (Damayanti & Hemanto, 2015). According to (Yenisbar *et al*., 2020), one of the factors that make a good planting medium is its sufficiently porous characteristics, which allow oxygen to reach the roots optimally.

Porous planting media provide a good balance between air space and water space. Plants need both for optimal growth—air space for oxygen and water space for the absorption of water and nutrients (Indra *et al.*, 2020). This is consistent with the statement by (Ivanka *et al.*, 2021) that a good supply of oxygen supports root development and the optimization of nutrient absorption in water spinach in an aquaponic system, which then stimulates carbohydrate formation and the growth of new shoots like leaves. In contrast, rockwool and cocopeat planting media do not have porous properties. Structurally, cocopeat and rockwool are denser, less porous, and have high water retention capacity, potentially leading to excessive moisture and inhibiting plant growth.

Stem Diameter of Water Spinach

The results of the 5% Duncan test showed that the type of planting medium affected the stem diameter of water spinach from 7 to 28 days after planting. Burnt husk produced the highest average stem diameter at 7 days after planting, which was significantly different from cocopeat and rockwool, but not significantly different from pasir malang. At 14 to 28 days after planting, pasir malang had the highest average stem diameter, which was significantly different from the other media (Table 3).

Table 3. Stem Diameter Data of Water Spinach Plants Across Different Planting Media

Planting Media	Average Stem Diameter (mm)			
	7 DAS	**14 DAS**	**21 DAS**	**28 DAS**
Control	0,564[a]	0,579[a]	0,876[a]	0,702[a]
P1	0,753[ab]	0,835[ab]	0,984[a]	1,291[ab]
P2	1,035[bc]	1,676[c]	2,383[c]	2,629[c]
P3	1,235[c]	1,211[bc]	1,776[b]	1,757[b]

Note: In a given column, identical letters above the numbers indicate that the values are not significantly different based on the Duncan test at a 5% significance level.

The use of various planting media also affects stem diameter, in line with the research by Utami *et al*. (2015), which showed that the type of planting medium influences plant growth, including stem diameter. Pasir malang produced the largest average stem diameter of water spinach compared to other media, due to its physical properties and effectiveness as a planting medium.

Pasir malang has a firm and stable structure that efficiently supports root growth, allowing for better nutrient and water absorption (Wahyuningsih &

Fajriani, 2016). This stimulates the development of a strong and extensive root system, which in turn supports stem growth. The ability of pasir malang to maintain moisture and provide optimal aeration helps roots access oxygen freely for metabolic processes, creating an ideal environment for plant growth (Nora *et al*., 2020). Pasir malang as a planting medium can provide ample pore space, allowing plants to access nutrients available in the aquaponic system (Putra *et al*., 2013).

From the average stem diameter measurements, it can be seen that rockwool has the lowest average. This may be due to the dense and less porous structure of rockwool, which makes air exchange and drainage less optimal. This structure also reduces the efficiency of plant roots in absorbing nutrients and water. Cocopeat and burnt husk also produced lower average stem diameters than pasir malang because the light and less dense texture and structure of cocopeat and burnt husk provide less support for plant roots, which in turn can limit stem growth.

Wet Weight of Water Spinach

Based on the results of the Duncan test at the 5% level, the type of planting medium had a significant effect on the wet weight of water spinach measured at 28 days after planting (Table 4).

Table 4. Wet Weight Data (gr) of Water Spinach Plants Across Different Planting Media

Planting Media	Average Wet Weight (gr)
Control (*Rockwool*)	17,043[a]
P1 (*Cocopeat*)	24,800[a]
P2 (Pasir malang)	42,213[b]
P3 (Burnt Husk)	51,197[b]

Note: In a given column, identical letters above the numbers indicate that the values are not significantly different based on the Duncan test at a 5% significance level.

Burned rice husks produced the highest average wet weight of water spinach, which was significantly different from cocopeat and rockwool, but not significantly different from pasir malang (Table 4). The high average wet weight of water spinach in burned rice husks indicates a larger total mass, reflecting better plant health and vitality. Adequate nutrient availability significantly influences plant growth and tissue development. This finding aligns with research by Nurhadiah & Sarigar (2021), which indicates that the wet weight of plants is also affected by the use of burned rice husks as a growing medium.

Burned rice husks provide essential organic matter for plants, being rich in fiber, with a high pH and containing various nutrients such as phosphorus, potassium, silicon, and carbon (Sujana, 2023). Phosphorus, calcium, and magnesium are crucial for accelerating root growth. These nutrients also play significant roles in protein formation, accelerating flowering and seed maturation, and supporting the plant's assimilation and respiration processes.

Wet weight is related to the effectiveness of nutrient absorption in plants. Table 4 shows that water spinach grown in burned rice husks media had a higher average wet weight compared to other media, but not significantly different from pasir malang. This indicates that both burned rice husks and pasir malang are more effective in absorbing and flowing fish residues that act as nutrients for water spinach (Warjoto *et al*., 2020). A high wet weight often indicates that the plant has adequate water supply and is not experiencing drought. Larger plants will have a higher weight due to more water storage, and high biomass is influenced by good tissue growth, including leaves, stems, and roots (Febriani *et al*., 2021).

Pasir malang did not show significant differences from burned rice husks because both are porous. The coarse structure and large grains of pasir malang allow for rapid water flow, preventing water logging around the roots that could lead to root rot and reduced wet weight. Nora *et al*. (2020) also state that pasir malang is often chosen as an alternative growing medium to replace soil, due to its ability to increase porosity, improve soil aeration, and retain moisture without holding excessive water. Proper moisture retention supports optimal plant growth (Wahyuningsih & Fajriani, 2016).

Cocopeat and rockwool can effectively retain moisture and provide good aeration, but if not managed properly, they can become too wet and cause anaerobic conditions around the roots, leading to pathogen development and root rot (Zailani *et al*., 2024). This condition impedes the plant's nutrient and water absorption. Overall, media that maintain proper moisture levels, provide adequate nutrients, and ensure good aeration will result in plants with optimal wet weight, reflecting optimal health and growth.

Leaf Color

Visual observation of the leaf color of water spinach from days 7 to 28 after sowing (DAS) showed that plants in the rockwool, pasir malang, and burned rice husks media had healthy green leaves. In contrast, plants grown in cocopeat displayed some yellowing leaves. This difference in leaf color could be attributed to several factors, including the composition of the growing media and the presence of pests. The yellowing may be caused by the tannin content in cocopeat, which inhibits the absorption of nutrients, particularly nitrogen, obtained from fish waste in the aquaponic system. Nitrogen deficiency in plants affects the process of chlorophyll and protein formation, leading to premature leaf yellowing (Muzuna *et al*., 2021).

Figure 1. A.Yellowing Leaves of Water Spinach Plants; B. Water Spinach Plants Infested with White Aphids
Source: Personal Documentation (2024)

In addition to tannin content, the yellowing of water spinach leaves grown in cocopeat can also be caused by white aphid infestations. White aphids are common pests that attack water spinach, leading to yellowing or yellow spots on the leaves (Muzuna *et al*., 2021). These pests damage the mesophyll tissue of the leaves, causing chlorosis or loss of chlorophyll, which reduces the efficiency of photosynthesis. As a result, the plants cannot produce enough energy for growth, disrupting the entire metabolic process, including nutrient absorption and biomass formation.

White aphids were found on water spinach plants in cocopeat growing media because cocopeat effectively retains moisture, increasing the humidity around the plants. According to Kase *et al*. (2023), the moisture content of cocopeat can reach up to 70%. This high humidity creates ideal conditions for white aphids to thrive, making the plants more susceptible to pest attacks. These pests can also spread to other plants through vector insects like ants or bees, which carry the eggs or adult aphids (Muzuna *et al*., 2021).

Based on the overall results from all parameters, growing water spinach in an aquaponic system using pasir malang and burned rice husks produces more vigorous plants compared to rockwool and cocopeat. Pasir malang and burned rice husks are also relatively cheaper and could be the best options for urban farmers in Malang City. These media are lightweight and easy to use, supporting efficient space management, especially in urban areas with limited land. Potential challenges include ensuring the availability of these media, as access to these materials may be limited in urban environments. This can be addressed by collaborating with local suppliers or agricultural groups to help ensure a consistent supply.

CONCLUSION

The optimal growth of water spinach in terms of height, number of leaves, and wet weight was found in the pasir malang growing media. This result was not significantly different from the burned rice husks media but showed significant differences from the rockwool and cocopeat media. The best stem diameter was produced by the pasir malang media, which was significantly different from all other treatments. The rockwool, pasir malang, and burned rice husks growing media resulted in better leaf color for water spinach compared to cocopeat. Among all the media, the most effective for cultivating water spinach in an aquaponic system are pasir malang and burned rice husks.

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