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Assistance: Innovation In Organic Waste Management As A Hydroponic Media Substrate Building A Green Future

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Abstract

Organic waste management is becoming increasingly important in responding to current global environmental challenges. In this context, this community service aims to explore the potential for using organic waste as a substrate for hydroponic media in building a greener agricultural future in a sustainable system. The use of organic waste as a substrate for hydroponic media has great potential in supporting plant growth, because it contains available N, P_2O_5, K_2O and C-organic nutrients which are sufficient for plant growth and development. Plants grown in organic waste-based substrates show comparable or even better growth compared to plants grown in conventional substrates. The use of organic waste in hydroponic farming also has a positive impact on the environment. More effective management of organic waste helps reduce environmental pollution and greenhouse gas emissions. This community service program has also succeeded in increasing public awareness and knowledge about organic waste management and hydroponic technology. Thus, the use of organic waste as a substrate for hydroponic media offers great potential in improving organic waste management, increasing agricultural productivity, and reducing negative impacts on the environment. This activity makes a real contribution to building a more sustainable agricultural future and contributes to global efforts in facing increasingly complex environmental challenges.

Keywords: green-future, hydroponics, media-substrate, and organic-waste.

1. INTRODUCTION

The use of renewable and sustainable natural resources is becoming increasingly important in responding to current global environmental challenges. One resource that is increasing and requires effective handling is organic waste. Organic waste, which mainly comes from kitchen waste, agriculture and other agricultural activities, has great potential to be reused in various fields, including agriculture (Priyadi, et al., 2023[a]). In an agricultural context, organic waste has long been used as compost material to increase soil fertility. However, with the development of modern agricultural technology, the use of organic waste is not only limited to making compost, but has also begun to be explored as a substrate in hydroponic farming systems. Hydroponic systems, which are soil-free farming methods that use nutrient solutions as a growing medium, offer the potential to increase water and nutrient use efficiency, while minimizing negative environmental impacts (Vinci & Rapa, 2019).

Utilizing organic waste as a substrate in a hydroponic system has various potential benefits. First, this can help reduce the amount of organic waste entering temporary and final disposal sites, reduce environmental pollution, and improve overall organic waste management (Awad et al., 2017). Second, the use of organic waste in a hydroponic system can increase the availability of food resources by utilizing limited land and improving agricultural productivity (Elsallam et al., 2021; Kumari et al., 2018). This hydroponic media substrate is made from raw materials based on local wisdom, available abundantly and continuously as waste (organic waste) and goat dung. This hydroponic media substrate is not only cheap and easy to manufacture (using engineering technology), it is also a green media because it can chelate dangerous heavy metal contamination and microplastics by auto-chelating through the –COOH functional group of humus substances (humic acid and fulvic acid) contained in goat dung. This chelation causes heavy metal contamination, and microplastics contained in the media and irrigation water cannot be absorbed by plant roots; so food products produced by cultivated plants are relatively safe, as a result non-carcinogenic and carcinogenic clinical impacts do not occur in humans who consume them (Priyadi, et al., 2023[b]). This hydroponic media substrate

made from organic waste and goat dung is multi-use, namely: 1) as a hydroponic growing medium, 2) as a provider of balanced plant nutrition, 3) as an organic chelating agent, and 4) as a fresh product of plant origin is relatively safe.

Hydroponic farming has become increasingly popular as a promising alternative to meet the world's growing food needs, while facing increasingly complex environmental challenges. In a hydroponic system, plants are grown without using soil, but are grown in a subsidized nutrient solution, which allows better control over plant growing conditions such as water availability, nutrients, and the environment. This approach has been proven to be efficient in the use of resources and can increase crop yields (Khan, 2018).

One of the key components in a hydroponic system is the substrate or growing medium used to anchor and support the plant's root system. In an effort to build a greener and more sustainable agricultural future, selecting environmentally friendly and recyclable substrates is a major concern. Hydroponic media substrates that are commonly used include gravel, coco fiber, and rockwool. However, the use of these materials is often still associated with environmental problems such as the use of chemicals in their production or the difficulty of the recycling process. In this context, the use of organic waste as a substrate for hydroponic media offers an interesting solution. Organic waste, often considered waste, can be turned into a valuable resource in hydroponic farming. This approach not only helps in overcoming organic waste management problems, but can also increase the fertility of the planting medium and the quality of crop yields. Additionally, the use of organic waste in hydroponic systems has the potential to reduce dependence on non-organic materials and fossil fuels, thereby helping to build a greener and more sustainable agricultural future (Patil et al., 2020).

The description above can be used as a basis for formulating problems related to the innovation "using organic waste as a substrate for hydroponic media to build a greener future". This community service activity was carried out at a temporary waste disposal site in Singopuran - Katasura - Sukoharjo Regency involving employees and management leaders, in February – March 2024. Short-term goals as targets: 1) provide education and assistance to temporary rubbish dump – Singopuran, Kartasura employees on how to use organic waste as a substrate for hydroponic media; 2) evaluate the technical and economic feasibility of using organic waste as a substrate for hydroponic media; and 3) collect data on the nutrient content of total N, P_2O_5, K_2O and C-organic in hydroponic media substrates and long bean harvests in a hydroponic system using organic waste as a substrate. Medium-term goals as targets: 1) develop methods and technology for producing organic waste into optimal and efficient hydroponic media substrates. 2) expand the collaboration network with local governments and the community to promote the use of organic waste as a media substrate in hydroponic farming. Long-term goals as targets: 1) encourage widespread adoption of the use of organic waste as a substrate for hydroponic media at local, regional and national levels. 2) increasing agricultural productivity and welfare of farmers and/or hydroponic enthusiasts through the application of organic waste-based technology. 3) contribute to climate change mitigation efforts by reducing greenhouse gas emissions through more effective organic waste management (Newell et al., 2021); and 4) contribute knowledge and experience as a model for the global community in building a greener, more sustainable agricultural future.

2. METHODOLOGY

a. Problem-solving framework

1) Identify the problem:
   - The low level of awareness is caused by the lack of information available about the benefits and processes of using organic waste in hydroponic farming.

- Lack of technical knowledge and skills caused by lack of access to relevant training and education.
- Challenges in managing organic waste are caused by the lack of infrastructure and resources to process organic waste into suitable hydroponic media substrates.

2) Designing community service programs:
   - Design a structured and measurable counseling and assistance program regarding the use of organic waste as a substrate for hydroponic media.
   - Formation of a working team consisting of agricultural experts, local government, educational institutions and local communities to design and implement programs effectively.
3) Program implementation:
   - Carrying out outreach activities and field assistance regarding the use of organic waste as a substrate for hydroponic media in various relevant locations.
   - Provide technical assistance and support to farmers and communities in implementing learned practices.
4) Evaluation and dissemination of results:
   - Evaluate program effectiveness by measuring increases in knowledge, changes in attitudes, and implementation of new practices.
   - Regularly monitor the progress and impact of the program to identify potential for improvement and further development.
   - Disseminate information and program results through various communication channels such as seminars, workshops and scientific publications.
   - Share experiences and learnings from the program with other stakeholders to encourage the adoption of more sustainable practices in hydroponic farming.
   - Opening up industrial opportunities with innovations in processing organic waste and goat dung using grinding and forming technology into environmentally friendly cube-shaped hydroponic substrates (stone organic trash) to build a greener future.

b. Results and discussion

The results of this community service activity show that the use of organic waste as a substrate for hydroponic media has great potential in building a greener and more sustainable agricultural future. The following are the main results obtained:

1) Superior quality hydroponic substrate. Hydroponic media substrates are made from organic waste using modern technology, showing adequate nutrient content for plant growth and development.

Table 1. Content of N, P, K and C-organic nutrients in hydroponic media substrates.

Diversity	Content (%)
N total	2,14
P_2O_5	1,40
K_2O	1,51
C-organic	16,42

2) Satisfactory harvest yields: Plants grown in organic waste-based substrates also produce harvests of satisfactory quantity.

Table 2. The potential of hydroponic media substrates in supporting plant production (fresh products from plants – long beans) in drip irrigation cultivation systems.

Diversity	Pod Yield		
	Length (cm)	Number	Weight (g)
SMH_POC$_1$	54,59	31,00	990,33

SMH_POC_2	55,99	34,33	979,93
SMH_POC_3	54,74	32,33	1.001,23

Information:

- HMS_LOF_1 = combination of hydroponic media substrate with liquid organic fertilizer made from banana stems, application concentration 2.25% with 7 days intervals.
- HMS_LOF_2 = combination of hydroponic media substrate with liquid organic fertilizer made from rice stalks, application concentration 2.25% with 7 days intervals.
- HMS_LOF_3 = combination of hydroponic media substrate with liquid organic fertilizer made from reed leaves, application concentration 2.25% with 7 days intervals.
- The number and weight of the pods referred to is the average of 12 plants in pots, where each pot contains 3 long bean plants.

3) Positive impact on the environment: The use of organic waste as a substrate for hydroponic media has a positive impact on the environment. More effective organic waste management helps reduce the amount of waste entering landfills, as well as reducing greenhouse gas emissions from burning waste and preventing uncontrolled wild decomposition (S. Priyadi et al., 2024). This is in line with global efforts to reduce environmental pollution and tackle climate change. This hydroponic media substrate is not only cheap and easy to manufacture (using engineering technology), but it is also a green media because it is able to chelate dangerous heavy metal contamination and microplastics by auto-chelating through the –COOH functional group of humus substances (humic acid and fulvic acid) contained in goat droppings. This chelation causes heavy metal contamination, and microplastics contained in the media and irrigation water cannot be absorbed by plant roots; so food products produced by cultivated plants are relatively safe, as a result non-carcinogenic and carcinogenic clinical impacts do not occur in humans who consume them.

c. Composition of ingredients and manufacturing techniques

Methods for making hydroponic media substrates, including the materials used and work instructions in making hydroponic media substrates:

a) Raw materials, including:
   - Small pieces of organic waste materials are obtained from the output of automatic machines that sort organic and plastic materials at TPS – Singopuran – Kartasura – Sukoharjo – Central Java.
   - Goat dung (pre-manure) is obtained directly from breeders in the Singopuran area.
   - Biostarter – decomposers in question is a consortium of active decomposer microbes that are created naturally as organic waste decomposers.

b) Work instructions for making a biostarter – decomposers organic waste:
   - Prepare 1 liter of waste leachate water (natural), obtained from the natural decomposition of organic waste,
   - Prepare 1 kg of brown sugar thinly sliced,
   - Prepare 1 liter effective microorganism (EM-4),
   - Prepare 1 liter of well water (non-chlorine),
   - Mix thinly sliced brown sugar with water, and stir until evenly mixed into a homogeneous solution,
   - To the brown sugar–water solution, add leachate and EM4, and stir until it becomes a homogeneous solution,

- Incubate the solution for 2 x 24 hours in a tightly closed container at room temperature,
- Become an active culture of microorganisms as a starter – decomposers of organic waste that is ready to be used.
- Below is a flow diagram of the production (Figure 1).

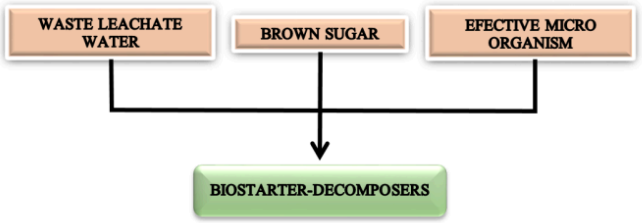

Figure 1. Flow chart for making a biostarter– decomposers organic waste

c) Work instructions for making hydroponic media substrate:
- Prepare 6 quintals of small pieces of organic waste,
- Prepare 6 quintals of goat dung (pre-manure),
- Prepare 3 liters of biostarter – decomposers,
- Prepare 3 liters of well water (non-chlorine),
- Mix the biostarter-decomposers with water, until it becomes a homogeneous solution,
- Mix with a shovel the three ingredients (small pieces of organic waste, goat dung, and biostarter–decomposers) which have been diluted until evenly distributed,
- Condition the mixture in bulk mounds in the form of rectangular blocks with a height of no more than 20 cm,
- Cover the bulk mound tightly with a tarpaulin, and tie it with raffia around the sides,
- After 1 week, open the tarpaulin cover and stir the bulk pile with a shovel, until the part that is in the bottom layer is in the top layer,
- Cover the bulk mound/mound again tightly with a tarpaulin, and tie it with raffia around the edges,
- After one week, open the tarpaulin again, it becomes a Hydroponic Media Substrate, and is ready to be used for cultivation,
- Take a sample of hydroponic media substrate to analyze N-total, P_2O_5, K_2O and C-organic.
- Below is a production flow chart (Figure 2).

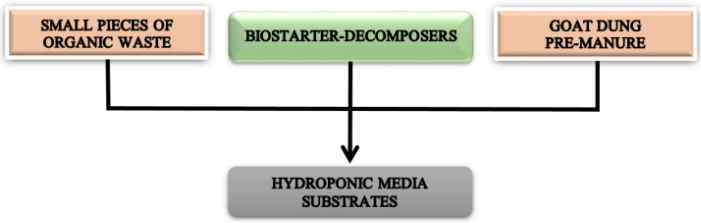

Figure 2. Flow chart for making hydroponic media substrates from organic waste

Below is a picture of the stages of activities for making hydroponic media substrates made from organic waste.

Figure 3. Small pieces of organic waste that comes out of an automatic waste sorting machine

Figure 4. Activities of mixing goat dung (pre-manure) with small pieces of organic waste

Figure 5. Activities of mixing biostarter – decomposers with the media substrate material

Figure 6. Bulk mixing activity of hydroponic media substrate after 1 week of decomposition

Management of organic waste into hydroponic media substrates using modern decomposition technology provides various significant benefits in the context of environmental sustainability and modern agriculture. Following are some of the main benefits of managing organic waste into hydroponic media substrates with modern decomposition technology:

a) Utilizing organic waste can reduce the amount of waste that goes to temporary or final disposal sites, thereby reducing negative impacts on the environment.
b) Modern renewable technology makes it possible to process and manufacture hydroponic substrates from organic waste using an environmentally friendly process.
c) Using a hydroponic media substrate that is rich in natural nutrients from organic waste, the need for chemical fertilizers can be reduced. This can reduce the negative impact of using chemical fertilizers on human health and the environment, as well as reduce production costs for farmers.

d) Efficient management of organic waste to produce hydroponic substrates can help reduce greenhouse gas emissions resulting from the decomposition of organic waste in landfills. This contributes to climate change mitigation efforts globally.
e) Reusing organic waste as a substrate for hydroponic media can help improve soil quality in nutrient-poor or degraded areas. This organic substrate can increase soil fertility and increase the soil's capacity to store water and nutrients, which supports plant growth in non-ideal environments.

Although managing organic waste into hydroponic media substrates with modern renewable technology offers many benefits, there are several obstacles that may be faced in its implementation. Here are some possible obstacles to consider:

a) Cost and technological accessibility, to convert organic waste into hydroponic media substrates may require significant initial investment in processing equipment and infrastructure. This can be an obstacle, especially in areas with limited resources or on a small scale.
b) Availability of technology, processing organic waste into hydroponic media substrates may not be available or not easily accessible. This may be a barrier to the widespread adoption of this practice.

3. CONCLUSION

This community service activity illustrates the importance of using organic waste as a substrate for hydroponic media in building a greener and more sustainable agricultural future. From this activity, several conclusions can be drawn:

a) Great potential for using organic waste: The use of organic waste as a substrate for hydroponic media shows great potential in supporting plant growth. Plants grown in organic waste-based substrates grow well, and can even exceed plants grown in conventional substrates.
b) Satisfactory harvest results: The harvest results from plants grown in organic waste-based substrates also show satisfactory quantities. This shows that organic waste can provide sufficient nutrition for plants.
c) Positive impact on the environment: Using organic waste as a substrate for hydroponic media is not only beneficial for plant growth, but also has a positive impact on the environment. More effective management of organic waste helps reduce the amount of waste entering landfills and reduces greenhouse gas emissions.
d) Challenges and opportunities: Even though it has great potential, the implementation of using organic waste as a substrate for hydroponic media is also faced with several challenges, such as the quality and composition of organic waste, as well as support from various stakeholders. However, with cooperation between government, farmers and communities, as well as continuous research, these challenges can be overcome, and opportunities to build greener and more sustainable agriculture can be maximally utilized.

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