

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/333058682>

Cultivating *Ocimum basilicum* in a hydroponics deep-water culture (DWC) system using dried vermicompost powder as the nutrient source

Technical Report · May 2019

DOI: 10.13140/RG.2.2.31871.66725

CITATIONS

0

READS

1,048

1 author:



Henrique Sánchez

Veolia Water Technologies AB

8 PUBLICATIONS 15 CITATIONS

SEE PROFILE



Cultivating *Ocimum basilicum* in a hydroponics deep-water culture (DWC) system using dried vermicompost powder as the nutrient source

Henrique Sánchez

May 13th 2019

Malmö, Sweden

Abstract

Traditional mineral hydroponic solutions are resource intensive and energy demanding, while also producing a lot of waste, so there is a demand to find more sustainable alternatives of nutrient sources for soilless cultivation.

A proof-of-concept experiment was designed in Malmö, Sweden. A deep-water culture (DWC) system with 12 L of tap water was set up with 6 basil seedlings (*Ocimum basilicum*) and an air pump with air stone for aeration and mixing. Upon starting, 140 mL of dried and crushed vermicompost powder was added and mixed and no further water or vermicompost powder was added for the remainder of the experiment. The objective was to test if the nutrients available in the original vermicompost would be available in soluble form after the drying and crushing processes, and with minimal surface area available in the DWC system for any potential biological activity. An additional advantage of drying and crushing vermicompost to obtain such a powder is in reducing existing biological activity, creating a more stable product for ease of storage and transport. This creates a more stable product with reduced risk of insect propagation or mold development in the vermicompost.

The experiment continued for 50 days, and by the end the plants were visibly healthy, had grown to a full size, and showed no signs of discoloration or deficiencies. However, aphids (*Aphidoidea*) were found in plants occasionally due to external contamination, and initial plant growth showed leaf discoloration.

In conclusion, this proof-of-concept experiment has shown that a DWC hydroponics system can work for the production of herbs such as basil using a stable, processed form of vermicompost dissolved in water as the nutrient solution.

Keywords: basil, hydroponics, vermicompost, nutrient solution, deep-water culture, organic

1. Introduction

Current mineral based hydroponic solutions provide great control in soilless cultivation, and great optimization at the different stages of growth for a variety of plants. However, they have raised sustainability concerns as they are resource intensive and energy demanding, while also producing a lot of waste. The activities involved in the production of mineral based hydroponic solutions include: mining, ore treatment, chemical processing, and transportation. The whole process requires fossil fuels, electricity, chemicals, and water, to produce the nutrient solution. On the other hand, mining waste, greenhouse gases, and wastewater are also produced as a consequence (Dumitrescu, 2013).

Vermicomposting is a process where food waste is decomposed with the help of aerobic and anaerobic bacteria as well as red worms (*Eisenia fetida*). The resulting product from such decomposition, known as vermicompost, reduces levels of contaminants and tends to hold more nutrients over a longer period (Ndegwa *et al*, 1999).

As the resulting product from vermicomposting has a high water and nutrient content, if it is not sealed from the outside environment, it may make an ideal substrate for the developing stages of several insects' life cycles, which may create a pest management issue. Furthermore, the high water content is an additional cost in the transportation compared to the cost of dried vermicompost. As such, a dried vermicompost would be more stable as a preserved by-product, and would save on transportation costs and environmental impacts. On the other hand, crushing the dried vermicompost to a powder would make its nutrients mix more easily in solution.

This proof-of-concept system had the goal to test if the nutrients available in the original vermicompost would be available in soluble form after drying and crushing processes, and with minimal surface area available in the DWC system for any potential biological activity. The chosen plant species was the herb basil (*Ocimum basilicum*) as it has higher nutrient demands than lettuce, relatively quick growth rate when compared to fruiting plants, and is a popular herb used in cooking.

It was hypothesized that the plants would be able to grow in this system, however with some signs of nutrient deficiencies, since it was not clear that all necessary macro and micronutrients would be soluble and plant available. It was also unclear if the initial amount of vermicompost powder added would be enough for the amount of plants, the type of plants, and their full growth.

The results from this proof-of-concept can enable future applications, since processing of vermicompost in the described method can enable its long-term storage and transportation. Its use as a hydroponics solution would highlight the advantages of hydroponic cultivation, such as faster growth and reduced water use. Lastly, a clear path from food waste to a sustainable nutrient source would be mapped in the soilless agriculture industry.

2. Materials & Methods

The experiment took place at Hemmaodlat's office. Hemmaodlat is a Swedish Non-governmental organization located in Malmö, Sweden, with the goal of teaching hydroponic and aquaponic concepts, enabling interested citizens to grow part of their own food at home, and researching novel methods of plant cultivation

The proof-of-concept was designed out of existing materials at Hemmaodlat's office. An overview of the system can be seen in Figure 1. The deep-water culture (DWC) component consisted of a white IKEA KUGGIS box (approximately 13.65 L) and a lid with 6 holes drilled in, an air pump (HAILEA IPX1 ACO-9601) and an air stone for oxygenation, and net pots in the lid holes for the placement of the herb seedlings. Above the DWC component was a fluorescent light OSRAM LumiLux Cool Daylight HO 80W/865 operating during 16 hours per day, for optimal plant growth.

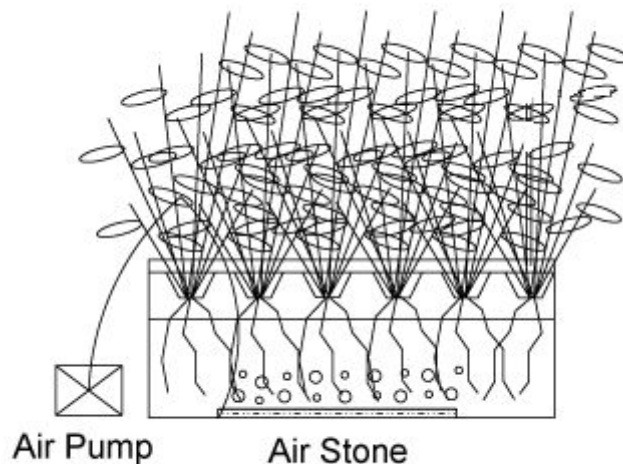


Figure 1: Proof-of-concept overview showing container, air pump, air stone, and plants.

The vermicompost was produced by using the OikoSol open-source vermicomposter 1.0 instructions (Sanchez, 2016) and adding red worms (*Eisenia fetida*). The vermicomposter was fed typical kitchen biological waste material such as herb stalks and leaves, potato peels, onion and garlic skin, banana peels, clementine and orange peels, and other vegetable waste such as aubergine, zucchini and tomato. No meat, fish, and dairy waste was added. Once the vermicompost was visually homogeneous (typically after 2 months), the worms were separated from the vermicompost, and the worm-free vermicompost was placed in oven trays and heated at 100°C for 2-3 days, producing aggregates of brittle dry vermicompost. The dry vermicompost aggregates were then crushed to a powder using a kitchen mixer. Eye, nose, and mouth protection was used when handling the powder due to its small fine nature and potential for eye and lung irritation.

To make the nutrient solution, 140 mL of the vermicompost powder was measured and mixed in a jar with 1 L tap water, then adding it to the DWC system and filling up with tap water to a total of 12 L. The amount of vermicompost powder was added to achieve an electrical conductivity (EC) of 0,6 mS/cm as a starting point. pH and EC were measured weekly throughout the experiment with HM Digital PH-80 and HM Digital COM-80 meters respectively. These two parameters were measured as they are the standard parameters measured in hydroponic solutions. EC is an indication of the number of nutrient salts available for plant uptake in a solution, and the pH indicates how such nutrient salts may be more available or not by the plant.

The basil seeds were Emily Batch N from Nelson Garden and were sowed in sponge-cubes in a flood and drain tray using Nelson Garden “hydroponisk näring” one-part solution as the nutrient solution (total EC = 0,6 mS/cm). Once the seedlings had at least a second pair of leaves, they were moved into the DWC system and the experiment began.

3. Results

During the 50 days of data collection it was possible to observe continuous growth and development of the basil seedlings into fully grown basil plants. The overall progress can be seen in Figure 2. In Figure 5, the final pictures were collected from the system before its operation ended. The EC and pH were measured weekly and their variation can be seen in Figure 6.



Figure 2: System start-up on March 20th 2019 (left) and the last day of system operation on May 8th 2019 (right).

After the first week, on March 27th 2019 the first signs of aphid infestation and leaf discoloration began to appear, as visible in Figure 3. It is believed that the aphids originated from a nearby infestation, as the experiment was not isolated from other plants in the room. The discoloration increased in almost all seedlings throughout the experiment, as seen in Figure 4.



Figure 3: Early signs of aphid infestation (circle) and leaf discoloration (arrow) on March 27th 2019.



Figure 4: Leaf discoloration across all seedlings. Top left (April 3rd), top right (April 10th), bottom left (April 17th), and bottom right (April 25th).

The aphids were managed using three methods: a spinosad solution, neem oil, and Pyretrin. The first method used Monterey Garden Insect Spray, a spinosad containing solution for control of foliage feeding pests. The solution was mixed at a concentration of 15 mL/L and each seedling was individually submerged in the final solution. Later, the initial Monterey solution was mixed with Neem oil in a similar concentration and also by submersion. Lastly, after insufficient pest control from the previous solutions, a mix of water and Pyretrin at a concentration of 2% seemed to substantially reduce the number of aphids.



Figure 5: Final pictures of the plants before the experiment was ended, on May 8th 2019.

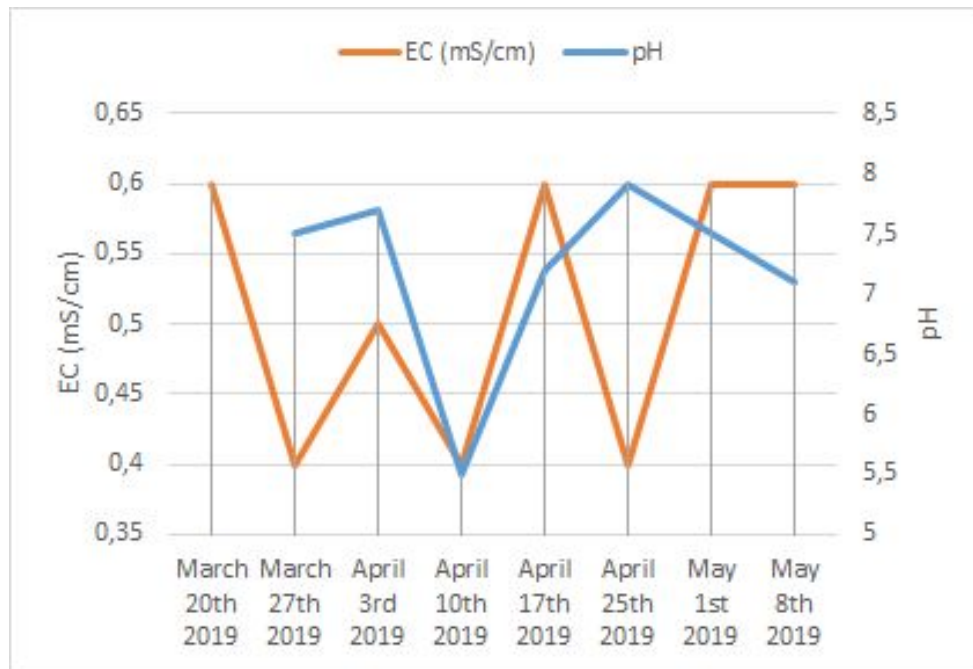


Figure 6: Variation of EC and pH during the 50 days of operation, between March 20th and May 8th 2019.

4. Discussion

It is believed that both the aphids and a slow dissolving of the vermicompost powder may have resulted in the discoloration present in almost all seedlings throughout the experiment.

It was also observed that two of the seedlings had noticeable less growth than the remaining four. This is believed to have resulted from poor light placement and subsequent lower Photosynthetic Active Radiation levels for the two affected seedlings. After better light placement, no leaf discoloration became visible, as seen in Figure 5.

Additionally, in Figure 6 there was a sharp decrease in the pH level on April 10th. One possible explanation for this is that the value is simply an outlier. However, it could also be possible that some biological activity such as nitrification was taking place in the surface area available by the roots, resulting in a drop in pH.

In conclusion, this proof-of-concept shows that a deep-water culture hydroponics system has potential for the production of herbs such as basil using a stable form of vermicompost dissolved in water as the nutrient solution.

The results from this proof-of-concept can enable future applications, since processing of vermicompost in the described method can enable its long-term storage and transportation. Its use as a hydroponics solution would highlight the advantages of hydroponic cultivation, such as faster growth and reduced water use. Lastly, a clear path from food waste to a sustainable nutrient source would be mapped in the soilless agriculture industry.

Further experiments could explore possibilities to optimize the growing process and account for uncertainties by considering the following ideas:

- Confirming the results with a greater number of plants, and with simultaneous control groups, both in regular water and using mineral hydroponic solutions.
- Attempting a pure passive approach, or Kratky, without the use of an air pump and air stone.
- Trying different amounts of vermicompost powder in different concentrations and water volumes, with different plants.
- Using different sources of vermicompost originating from different variations of food waste to potentially create recipes for different plant stages.
- Checking if leaf discoloration still emerges in the plant tissue and if such is a result of lighting conditions, concentration of nutrients, pests, or a combination of these.

5. References

Dumitrescu, Vlad A. (2013). *Comparative analysis of biogas slurry and urine as sustainable nutrient sources for hydroponic vertical farming*. Water and Environmental Studies, Department of Thematic Studies, Linköping University, Sweden. ISRN: LIU-TEMAV/MPSSD-A—13/007—SE

Ndegwa, P.M.; Thompson, S.A.; Das, K.C. (1999). [Effects of stocking density and feeding rate on vermicomposting of biosolids](#) (PDF). Bioresource Technology. 71: 5–12. doi:[10.1016/S0960-8524\(99\)00055-3](https://doi.org/10.1016/S0960-8524(99)00055-3)

Sanchez, Henrique (2016). [Vermicomposter](#) (PDF). OikoSol.