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Small-scale Aquaponics and Hydroponics Systems: Pak Choy and Spinach Growth Rate Comparison

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Abstract: Kelantan International Organic Research Centre (KORC) used small-scale aquaponic and hydroponic systems to test their suitability for dwarf Pak Choy and spinach planting. For the KORC, the conventional soil planting method is often ineffective due to monkey attacks and high temperatures on open farming. This research will test the efficacy of Kelantan Biotech Corporation (KBC) Sdn Bhd's own product, BioHijja Effective Microbe (EM) solution in hydroponics planting. Aquaponics and hydroponics systems using were used to grow dwarf Pak Choy and spinach. To compare the quality of Grabbit seeds sold by KBC to other brands, the germination time and yield of both brands were observed. To compare the efficiency of aquaponics and hydroponics planting methods, the height and number of leaves of plants were measured after 7 days. Compared to other brands, Grabbit had lower seed quality dwarf Pak Choy and higher seed quality spinach. Moreover, the BioHijja EM hydroponics system outperformed the aquaponics system in terms of plant height difference around 0.7cm and 5 news leaf for Grabbit and JC Garden Pak Choy, respectively. As a result, other brands of dwarf Pak Choy seeds could be surveyed to

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replace the low seed quality supply from the Grabbit brand at KBC. However, using bio-pesticides along with relocating the project base to an area with better air circulation should be considered to improve the accuracy of future findings.

Keywords: Aquaponics, Biohijja EM Hydroponics, Seeds Quality, Plant Growth Rate

1. Introduction

Many challenges had arisen as a result of the traditional soil planting method for varying crops on the land, such as pest attack, soil fertility reliance, and fluctuating weather climate. Thus, at the Kelantan International Organic Research Centre (KORC), a research centre owned by Kelantan Biotech Corporation Sdn Bhd (KBC), an alternative crop planting method was tested using BioHijja Effective Microbe (EM) hydroponics and aquaponics with tilapia fish as the ultimate nutrient source for the planting of dwarf Pak Choy and spinach [1].

Hydroponics is a method of cultivating plants that does not require the use of soil [2]. Aquaponics, on the other hand, is a planting method that combines aquaculture and hydroponics in a bio-intergrated system [3], [4], [5]. The advantages of both hydroponics and aquaponics include the ability to grow crops without solid media, which saves up to 20% of growing space, less-hassle harvesting, and water conservation [6], [7]. The hydroponics system is easier to set up, whereas the aquaponics system allows for a symbiotic relationship in which fish wastes are converted into nitrates, which are then uptaken by the plant roots as a source of essential growth nutrients [2]. However, the disadvantages of both systems are that hydroponics requires technical knowledge and skill to monitor ideal system conditions, whereas aquaponics requires a relatively high startup cost when compared to traditional planting methods [8], [9].

Besides examining the most suitable alternative method for Pak Choy and spinach planting at KORC between aquaponics and hydroponics, this research also opted to test the efficacy of KBC's main product, BioHijja EM solution onto hydroponics planting, and the quality of Grabbit gardening seeds sold at KBC to the customers. BioHijja EM solution is a product of KBC which comprised of photosynthetic bacteria, lactic acid bacteria, yeast, actinomycete, fermentation fungi, molasses and water in ideal ratio which acts as organic fertilizer for the plants to boost plant growth and overall health.

The quality of seeds was compared between the Grabbit brand sold by KBC and other brands on the market by observing the duration of seed germination and the yield of successful germination. Second, the growth rate of dwarf Pak Choy and spinach planting was observed in this study in terms of plant height and number of leaves to compare the efficiency of the planting method between aquaponics and BioHijja EM hydroponics. The expected outcomes of this study were that the Grabbit brands of dwarf Pak Choy and spinach seeds were of higher quality than others on the market, and that the BioHijja EM hydroponics planting method outperformed aquaponics as an alternative for conventional soil planting at KORC.

2. Methodology

2.1 Materials

The plant species studied in this study included dwarf Pak Choy and half red amaranth (spinach). These two plants were among the KBC products that were suitable for aquaponics and hydroponics planting, and they have a relatively short harvesting duration (35 days) when compared to other plants. Seeds from Grabbit (GB) and JC Garden (JC) were chosen for dwarf Pak Choy, while spinach seeds from Grabbit and TRIO Garden (TR) was studied for the research.

The aquaponics system required the following apparatus: 8 red tilapia fish, a 10-gallon aquarium with aerator pump, fish feed, GB dwarf Pak choy and spinach seedlings, JC dwarf Pak choy and TR spinach seedlings, net cup with wire hanger, coconut husk, granite, and sponge as shown as in **Figure 1a**.

In an aquaponics system, tilapia fish were used to supply nutrients to the plant. Tilapia is a low-cost hardy fish that requires little maintenance when compared to other aquatic animals [10]. They live in warm freshwater and have a higher tolerance for pH levels.

Meanwhile, the apparatus needed for the hydroponics system, as shown in **Figure 1b**, included a 10L transparent container with proper covering, an aerator pump, and 8 small plastic cups with 8 fitting sponge, GB dwarf Pak choy and spinach seedlings, JC dwarf Pak choy and TR spinach seedlings, 100mL BioHijja EM solution, and 100g organic fertiliser wrapped in cling film.

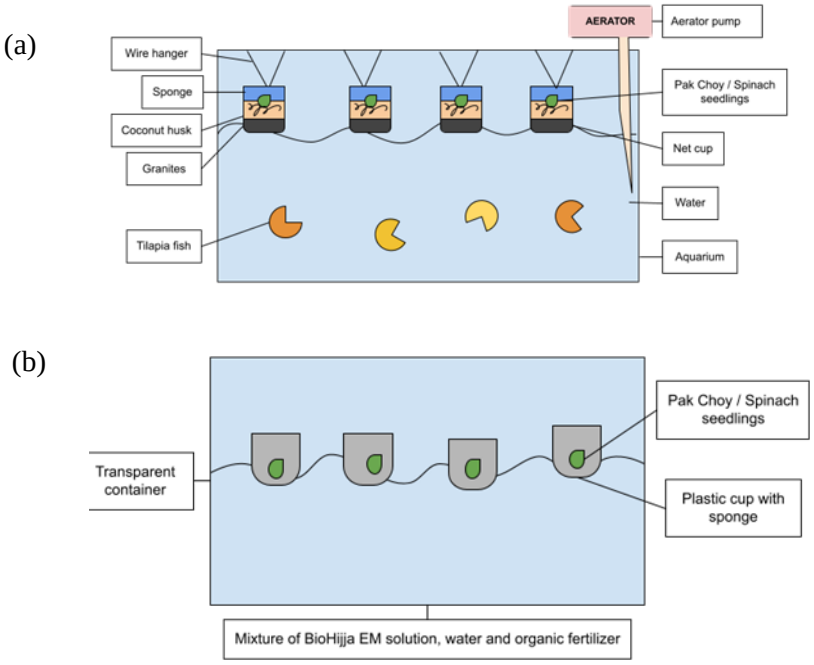


Figure 1: Apparatus set up of (a) aquaponics and (b) BioHijja EM hydroponics system

2.2 Preparation Phase

The wet paper towel method was used to germinate dwarf Pak Choy and spinach seeds from GB, JC and TR brands, which was more effective and easier than the sowing method [11]. Wet paper towel method allows a pathogen-free environment through supplying of controlled heat and moisture to the seeds inside an enclosed container, compared to the sowing method that requires sterilization of soil prior to sowing to avoid contamination of seeds. Besides, wet paper towel is also enabling easy control to the adequate moistuization giving to the seeds for proper germination compared to sowing method which might lead to overwatering which cause rotting of seeds. **Figure 2** shows how the seeds were kept in an enclosed, warm, and dark place for about two weeks before being transplanted.

Furthermore, the aquaponics and hydroponics system was installed at the project's chosen base location by assembling the necessary aquarium and container. Tilapia fish were transferred to the aquarium while a 5L water: 100mL BioHijja EM solution: 100g organic fertiliser solution was added to the hydroponics container prior to seedling transplantation.

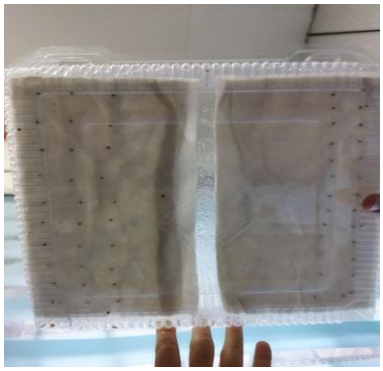


Figure 2: Wet paper towel seeds germination method

2.3 Implementation Phase

The germinating seeds were ready to be transplanted into the net cup once the seeds start sprouted on the wet paper towel. Germinated seedlings of dwarf Pak choy from GB and JC brands, and germinated seedlings of spinach from GB and TR brands were transplated into cups. Both type of Pak choy and spinach seedlings from each different brands were duplicated and settled separately in both aquaponics and hydroponics systems, as shown in **Figures 3a and 3b**, respectively.

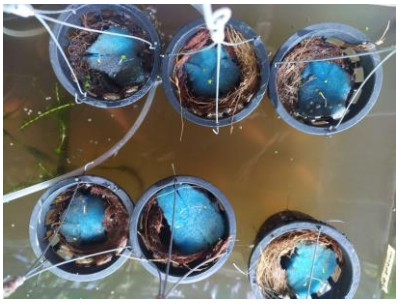
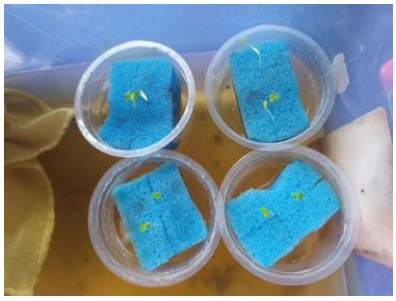
(a)  (b) 

Figure 3: Seedlings transplanted in the (a) aquaponics and (b) hydroponics system

2.4 Observation Phase

The observation was carried out at KORC by focusing on two research findings: the comparison of seed quality between Grabbit brand and others on the market, and the comparison of growth rate between aquaponics and hydroponics planting methods.

For the comparison of seed quality, two aspects were observed: the time it took dwarf Pak Choy and spinach seeds from GB, JC and TR to germinate, and the yield of successful seed germination (%), as stated in **Eq.1**.

$$\text{Yield of successful seeds germination (\%)} = \frac{\text{Count of successfully germinated seeds}}{\text{Total count of seeds in a batch}} \qquad \textbf{Eq. 1}$$

Meanwhile, for the comparison of growth rates between aquaponics and hydroponics, two aspects were observed which were the rate of increase in plant height and the number of leaves within 7 days.

3. Results and Discussion

This section discussed all of the research project's findings, with two main focuses being the comparison of seed quality between Grabbit and other brands, and the comparison of dwarf Pak Choy and spinach growth rate through aquaponics and hydroponics planting.

3.1 Seed quality comparison

The seed's quality was determined by two observations along with the seeds germination phase which was the duration it took for seeds to germinate, and the yield of successful germination from a total count of 40 seeds in each batch. The results of observation were normalized to percentage (%) yield of successful germination over time as shown in **Figure 4**.

As clearly shown in **Figure 4**, the value of normalized percentage yield of successful germination over time for JC Garden Pak choy (JC-PC) was higher at 6.071 compared to Grabbit Pak choy (GB-PC) at 3.571. This indicated that there were a total of 6 JC-PC seeds successful to germinate within one day period, compared to only 3 for GB-PC. Meanwhile for spinach, the result from normalized percentage yield of successful germination over time shown that value for Grabbit spinach (GB-SP) is higher at 11.563, compared to TRIO spinach (TR-SP) at 10.938. This means that there would be 11 GB-SP seeds been germinated per day, which is greater than TR-SP that successfully germinate 10 seeds per day.

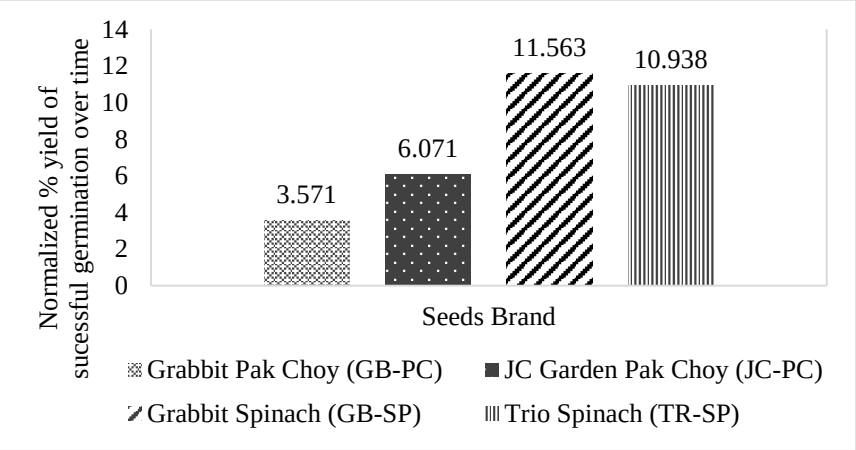


Figure 4: Normalized percentage yield of successful germination over time

Overall, a comparison of the germination period used and the yield of successful germination results revealed that the Grabbit brand from KBC had lower seed quality of dwarf Pak Choy in the market compared to JC Garden. However, spinach seeds quality from the Grabbit brand were higher compare to TRIO brand spinach seeds from other brands.

3.2 Growth rate comparison

Plant growth rates were tested for one week to determine the efficiency of Pak Choy and spinach planting by using aquaponics and hydroponics systems as an alternative to conventional soil planting. Two aspect of plant growth rate were measure to determine the effectiveness of the system which is plant height and number of leaves from day 1 to day 7 after transplanting into both system. **Figure 5** representing different in plant height from both aquaponics and hydroponics systems. Meanwhile, **Figure 6** shown the total count of newly grown leaves from aquaponics and hydroponics systems.

According to the data in **Figure 5**, ¾ of plants in BioHijja EM hydroponics planting system had higher height difference compared to plants in aquaponics planting system, except the only JC Garden Pak choy (JC-PC) which shown that plant in aquaponics had greater increase in height at 0.5cm than

that in hydroponics system at 0.2cm. Grabbit Pak choy (GB-PC) marks the highest heigh difference of 0.7cm compared to other plants which are less than 0.7cm. This result indicated that BioHijja EM hydroponics system is more suitable to be used for growing of Pak choy and spinach at KORC.

According to **Figure 6** illustrating the total count of newly grown leaves, BioHijja EM hydroponics growned JC Garden Pak choy (JC-PC) showed the highest count of new leaves from Day 1 to Day 7 which is total of 5 new leaves, compared to JC-PC in aquaponics system which had only 4 new leaves. The rest of plants all had shown similar count of newly grown leaves between aquaponics and hydroponics planting systems, with overall counts stated that Pak choy has grown more new leaves (more than 4 new leaves) compared to spinach (2 leaves) in both aquaponics and hydroponics systems.. This result suggested that Pak choy is more suitable for aquaponics and hydroponics planting than spinach at KORC.

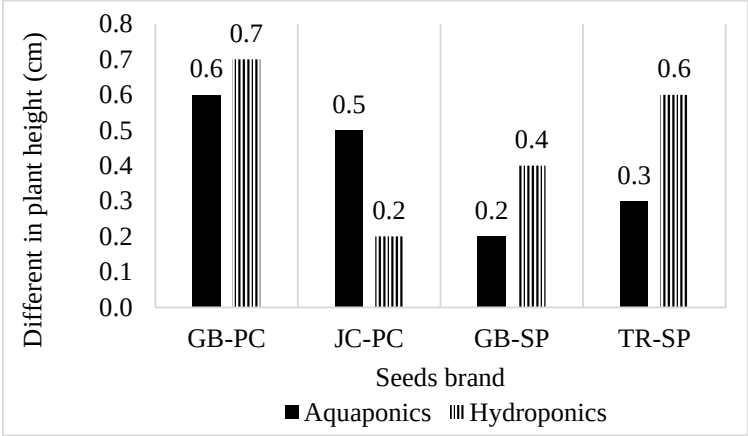


Figure 5: Different in plant height against aquaponics and hydroponics systems

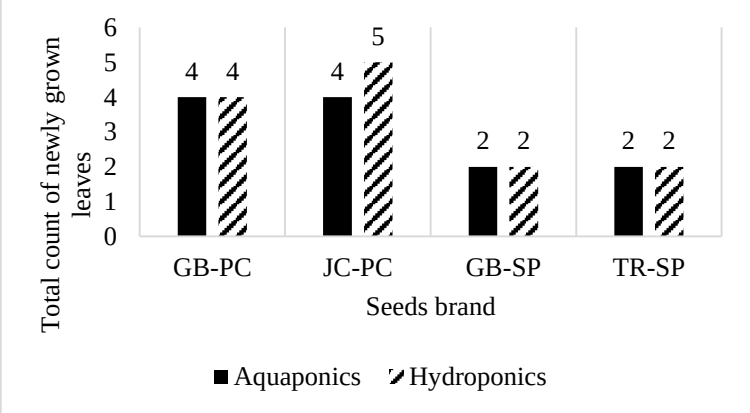


Figure 6: Total count of newly grown leaves against aquaponics and hydroponics systems

4. Conclusion

As a result, it can be concluded that hydroponics planting using BioHijja EM solution produce a higher plant growth rate compare to aquaponics. This could be because a sufficient and consistent amount of nutrient is provided to Pak choy and spinach to meet the requirements for plant growth, as opposed to aquaponics, which uses fish waste as the nutrient source for planting, which could be insufficient or overloaded to support optimal plant growth. Finally, hydroponics planting with BioHijja EM solution as the nutrient source could be an option for Pak choy planting at KORC.

Several issues arose throughout the project, including fungus and pest attack in both aquaponics and hydroponics systems, as well as a failure to keep the pH in both systems at an ideal level for plant growth. As a result, suggestions such as relocating the project base to an open space with good air circulation and adequate shading from direct sunlight, as well as strict monitoring of the ideal pH level for both systems, will be considered for further research.

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References

[1] E. Pantanella, M. Cardarelli, G. Colla, E. Rea, and A. Marcucci, "Aquaponics vs. Hydroponics: Production and Quality of Lettuce Crop," Acta Horticulturae, vol. 927, pp. 887-893, February 2012.

[2] Max, "Hydroponics vs. Aquaponics - A Complete, and Honest Comparison," TREES.com, 1 February 2021. [Online]. Available: https://www.trees.com/gardening-and-landscaping/hydroponics-vs-aquaponics. [Accessed 30 May 2021].

[3] R. Davis, "Aquaponics vs Hydroponics: A complete overview," Grow Food Guide, 19 March 2020. [Online]. Available: https://growfoodguide.com/aquaponics/aquaponics-vs-hydroponics/. [Accessed 30 May 2021].

[4] E. Okemwa, "Effectiveness of Aquaponic and Hydroponic Gardening to Traditional Gardening," International Journal of Scientific Research and Innovative Technology, vol. 2, no. 12, pp. 21-49, December 2015.

[5] T. V. Simon Goddek, "Comparison of Lactuca sativa growth performance in conventional and RAS-based hydroponic systems," Aquaculture International, vol. 26, p. 1377–1386, 10 August 2018.

[6] DYNA-GRO, "Hydroponics: Advantages and Disadvantages," DYNA-GRO, 2021. [Online]. Available: https://dyna-gro.com/hydroponics-advantages-and-disadvantages/. [Accessed 7 June 2021].

[7] A. Frost, "The Sustainability of Tilapia Aquaponics: A Case Study," Master's Practicum, University of Michigan: Ann Arbor: 1-38, pp. 4-8, December 2019.

[8] N. Sharma, S. Acharya, K. Kumar, N. Singh, and O. P. Chaurasia, "Hydroponics as an advanced technique for vegetable production: An overview," Journal of Soil and Water Conservation, vol. 17, no. 4, pp. 364-371, 2019.

[9] R. Ben-Hamadou, "Hydroponics: Innovative Option for Growing Crops in Extreme Environments-The Case of the Arabian Peninsula (A Review)," Open Access Journal of Agricultural Research, vol. 4, December 2019.

[10] B. Akter, S. C. Chakraborty, and M. A. Salam, "Aquaponic production of Tilapia (Oreochromis niloticus) and water spinach (Ipomoea aquatica) in Bangladesh," Research in Agriculture, Livestock and Fisheries, vol. 5, no. 1, pp. 93-106, April 2018.

[11] K. V. Druff, "Germinating Seeds in Paper Towel Method (10 Tips)," Bunny's Garden, 24 February 2021. [Online]. Available: https://www.bunnysgarden.com/germinating-seeds-in-paper-towel/. [Accessed 21 May 2021].