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EVALUATION OF GRAVEL AS A GROWTH MEDIUM ON WATER QUALITY, FISH PERFORMANCE AND GREEN PEPPER YIELD IN A MEDIA BASED AQUAPONICS SYSTEM IN AWKA, ANAMBRA STATE

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ABSTRACT

Aquaculture has been a sustained source of food security and poverty alleviation for Nigerian families. While fish and vegetables have long been staples of Nigerian meals, aquaponics is a relatively recent practice in the country. The objective of this research was to examine the impact of gravel as a growth medium on water quality metrics, plant output, and fish production in a media-based aquaponics system. The fish tanks were stocked with catfish (Clarias gariepinus), while the gravel growth bed was filled with pepper (Capsicum annuum) plants. Over the course of the 24-week research period, weekly observations of pH, dissolved oxygen, nitrate, nitrite, ammonia, and temperature were made in order to assess the water quality parameters. Data on biomass accumulation, fruit yield, and plant development were recorded every week. The height of green pepper started from week 1 at 20.5cm to 32 cm at week 11 showing a steady growth, the number of leaf started from 4 in week 1 to 45 at week 11, and showing growth as well. On the other hand, the leaf area grew from 5cm^2 at week 1 to 42cm^2 at week 11. At the conclusion of the study, fish growth, feed conversion ratio (FCR), and survival were measured. Green pepper showed a steady growth suggesting that gravel is a good medium. The gravel media maintained a steadier pH range of 6.92. Gravel kept its pH more constant, which would be advantageous for fish culture.

Keywords: Gravel, Green pepper, Aquaponics, Fish

1.0 INTRODUCTION

Aquaponics is a synergistic integrated system that results from the mutual link between hydroponics and aquaculture, where fish and plants cohabit in a balanced ecosystem. Fish excrement and leftover fish feed create nutrients in fish farming wastewater that are utilized as fertilizer for hydroponically grown plants (Nuwansi, 2021; Handayani, 2020). Beneficial microbes reside inside the sustainable aquaponic environment, which promotes plant development and purifies the water, which is then used again to produce fish (Wongkiew *et al.,* 2017). Nitrifying bacteria, which change ammonium into nitrate, the easily absorbed type of nitrogen that plants use for growth and production are a typical example. In aquaponic systems, the recycling of nutrients in symbiotic relationships lessens the impact on the environment by reducing the discharge of nutrient effluent into water bodies (Greenfeld, 2019). As a result, the aquaponic system is a sustainable method of producing food from both plants and aquaculture. In underdeveloped nations with limited land and labor, the aquaponic system may be able to alleviate the scarcity of food production (Ambrosio, 2019; Diatin, 2021). Establishing the plant growing space is crucial to ensuring the system's sustainability (Zainal, 2021). In aquaponic systems, three popular hydroponic designs are utilized: media beds, also called ebb-and-flow beds; nutrient film technique (NFT); and deep-water culture (DWC), also called raft beds (Oladimeji, 2020). Many substrates, including gravel, sand, perlite, hydroton, volcanic rocks, and cocopeat, are frequently utilized as

growing media in aquaponic systems (Putri, 2021; Fox 2010). The performance of the aquaponic system depends on the choice of media substrate, which acts as a bioremediation bed where beneficial bacteria can settle and as a medium for plants to grow and sustain (Xu, 2022). When selecting an aquaponic media substrate, a number of factors should be taken into account, including pH buffering properties, water retention, porosity for biological filtration, weight and structure, prices, and availability. One of the most well-liked and extremely profitable annual herbaceous vegetable crops is the capsicum (***Capsicum annuum)*** popularly known as bell pepper or sweet pepper. It is grown outdoors as an irrigated or rainfed crop. Approximately 40% of the veggies consumed globally are pepper (HCDA, 2010). The majority of peppers grown in temperate and tropical regions are members of the botanical species Capsicum annuum which is believed to have originated in Mexico and Central America. After tomatoes, it is the second most significant vegetable in the world.

But there are still a lot of things that are typically regarded as waste that could serve as a substitute for growth medium that are utilised in the traditional sense, thereby turning waste into wealth. These materials include plastics, periwinkle shells (PWS), and palm kernel shells (PKS). These are by-products from the aquaculture and agricultural industries that are not edible. They are often disposed of in piles for decomposition or burned to provide energy. According to Mo *et al.* (2016), stockpiling these byproducts in open dump sites or landfills leads to pollution and other environmental issues. One of the possible solutions to these problems would be finding alternative uses for the by-products as a form of waste management. Agriculture continues to be a vital industry in Nigeria for both revenue-generating and food security. However, issues including soil deterioration, water shortage, and land scarcity frequently impede the productivity and profitability of traditional farming methods. A potential answer to these problems is aquaponics, an integrated system that combines soilless plant cultivation (hydroponics) with fish farming (aquaculture). Aquaponics is still a relatively new idea in Nigeria, despite its potential advantages, and there is a dearth of localized research on system component optimization, especially with regard to the growth media utilized for plant production. In aquaponics systems, choosing the right growth medium is essential since it has a direct impact on plant growth, nutrient availability, and water quality. The main aims of this paper are: to assess the effects of gravel on water quality parameters including PH, dissolved oxygen, nitrate, nitrites, ammonia, phosphate and temperature in aquaponics system, and to determine the influence of the growth media on plant growth parameters, such as leaf number, plant height and leaf area for green pepper.

2.0 METHODOLOGY

2.1 Study Area

This study was conducted at Ikedi's Farm behind the New Government House Awka. The land area was measured to be 20.90 m^2 (15ft by 15ft). The coordinates for the back of the new Anambra State Government House (near Aroma Junction) in Awka are approximately **6.209° N, 7.078° E,** placing it in the vicinity of Aroma Junction.

2.2 Site Preparation and Field Layout

The site for the research was cleared of existing vegetation and levelled. The actual construction work covers an area of about 15 m^2, but the total area of land acquired and cleared is 20 m^2.

2.2.1 Layout of the system and stages of development

The system was laid out in a randomized complete block design (RCBD). This experimental design helps to account for potential sources of variability and allows for the evaluation of multiple factors and their interactions. There were 3 blocks and 3 replicates for each treatment in the Randomized Complete Block Design (RCBD) setup. All treatments were included in each block to take into consideration the experimental area's varied environment. Even though just one growth medium 'gravel' was assessed, RCBD was used to reduce the impact of spatial variation, such as variations in light, temperature, and water flow, increasing the accuracy and dependability of the findings. The stages involved in setting up of the media base Aquaponics system using IBC tank, are as described in Figure 1 where the first stage involves purchase of tank, cut a 1m height from the top of the plastic IBC tank, invert the cut out and place it at the top to have a base for the grow bed as shown in after cut, then add gravel or into the grow bed at the top before planting.

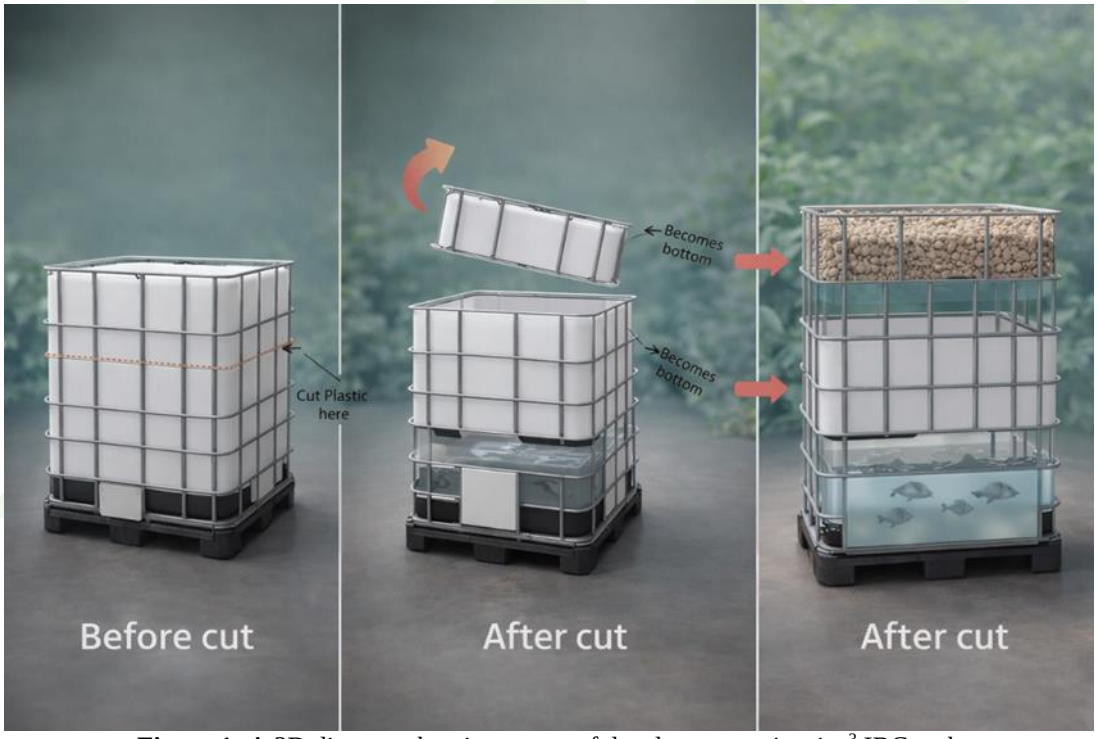

Figure 1: A 3D diagram showing stages of development using 1m^3 IBC tank

2.1.2 The Media:

The medium used for this study is gravel, the Gravel were sourced from local gravel transporters in Awka, Anambra state Nigeria. The gravels were autoclaved at 100 ^oC for 1 hour to reduce microbial load of these materials. Thereafter, they were rinsed in clean water and sun-dried (12 hours) before being placed in planting troughs with the 0.2 m^3 grow bed.

2.2 Materials used

Some of the materials used for the construction of the media-based aquaponics system for African catfish and green pepper are shown in Table 1.

Table 1: Materials used for constructing the Media-based aquaponic system

S/N	Materials	Quantity
1	Fish net	3
2	lubricant	1
3	Net pot	3
4	Submersible water pump (0.5watt)	3
5	Biofilter medium	3
6	Plastic intermediate bulk container (IBC)tanks	3
7	Gravel,volcanic (4-20mm)	750 litre
8	0.5 hp pump	1
9	bucket	3
10	Pepper seed	72
11	Measuring tape	1
12	Electric box (waterproof)	3
13	Lumber (8*1)	21m
14	Pipe wrench	3
15	Cable tie	3
16	Work gloves	1
17	hammer	1
18	Saw (baby grinder)	1
19	Sealing rubber washer(1mm)	1
20	Polyethylene pipe (1, 1.5 mm)	9mm
21	PVC pipe (1 mm)/(1 mm)/ (110 mm)	7.5 m/0.8 m/0.9 m
22	PVC elbow (1 mm)/ (1 mm × 1 in) female	5/3
23	PVC coupler, straight (1 mm)/PVC enlarger (40–25 mm)	6/3
24	PVC connector, T (1 mm)/ barrel connector, V-type (1 in)	2/3
25	PVC endcap/stopper (1 mm)	4
26	PVC barrel connector, B-type (1 in)	3
27	PVC (1 mm × 1 in) female	3

3.0 RESULTS AND DISCUSSION

3.1 Effect of the Growth Media on Water Quality Parameters

As shown in Figure 2 below, the study's culture species appear to be unaffected by the higher temperatures and lower pH than the trade-off value suggested by Tyson *et al.* (2008) for fish, plants, and nitrifying bacteria in an aquaponics system. All the physico-chemical parameters in the fish rearing tanks (Table 2) were within the recommended range for aquaculture as stated by Boyd, (2007) and Ajani *et al.* (2011). In actuality, the fish raised in the aquaponics system increased in weight from 50gm to 1400gm in just six months. Therefore, it may be concluded that these circumstances are within acceptable bounds for the catfish and pepper aquaponics system since a sustained growth was attained and no nutritional deficiency or disease was visually noticed in the plants and catfish, respectively.

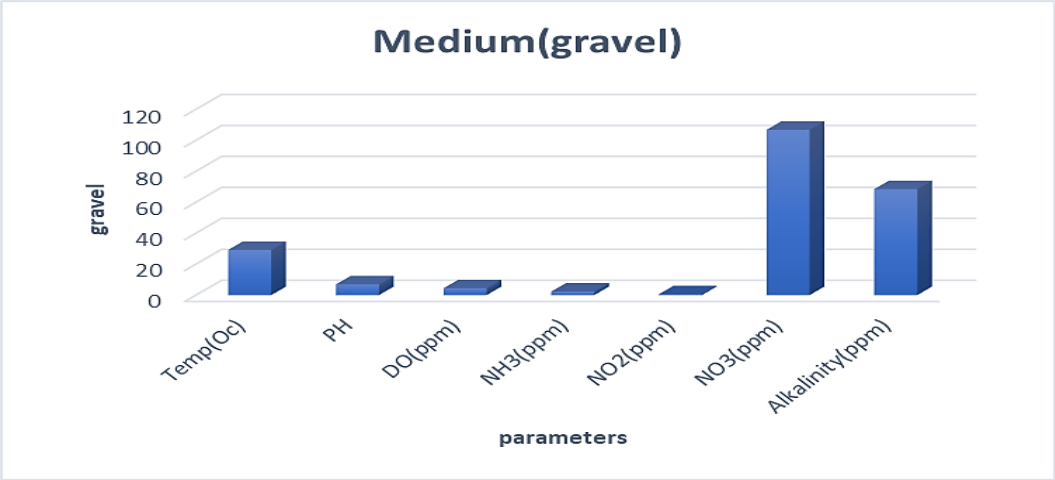

Figure 2: Effects of some water parameters on gravel as the growth medium

3.2 Effect of gravel as a growth medium on green pepper yield

Additionally, Bosma *et al.* (2017) state that the selection of a vegetable for an aquaponics system is determined by three factors: market demand, the ease of producing fish and vegetables in an aquaponics system, and the compatibility of nutrient input and requirements. As a result, only a small number of plants, such as lettuce, cucumbers, peppers, tomatoes, eggplant (with particular care), and root crops like carrots, have been successfully cultivated in aquaponics systems (Roosta, 2014). The first requirement of Boxman *et al.* (2017) is generally satisfied by the considerable market demand for tomatoes and pepper. The production and harvestable biomass of crops in an aquaponics system are strongly correlated with nutrient availability, possibility, and ease of uptake in addition to variables like air, water, temperature, and light (Roosta and Hamidpour, 2011; Liang and Chien, 2015).

3.2.3 Height of pepper on media

The graph (Fig. 3) shows the weekly growth of pepper plants over a period of several weeks. The gravel grown green pepper exhibits steady and consistent growth over time. Summarily, the graph gives insights into how gravel growth media can influence the growth and development of pepper plants over time.

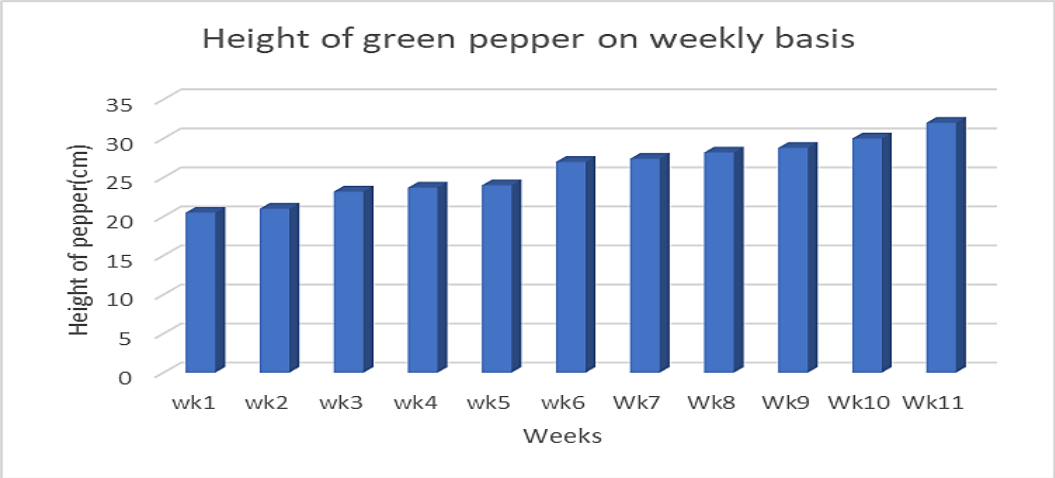

Figure 3: The height of the green pepper on a weekly basis

3.3 Number of Leaves developed on a weekly basis for pepper on gravel growth media

Fig 4 below indicates the number of leaves developed on weekly basis for green pepper under gravel grow bed. However, as weeks progress, distinct differences emerge. Gravel-grown peppers exhibit slower but steady leaf growth. Overall, the graph highlights how the growth media can impact the leaf development of pepper plants over time.

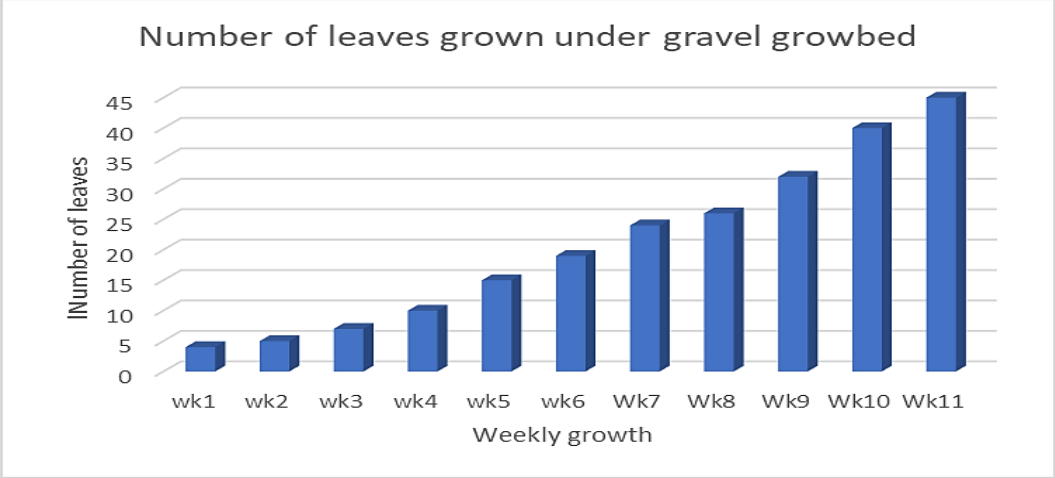

Figure 4: The number of leaves developed on weekly basis

3.4 Leaf Area developed every week for pepper on different media

Figure 5 below shows a graphical representation of the leaf area developed for green pepper over several weeks. The pepper grown under gravel bed cultivation shows fast growth at the initial but slower and steadier growth at the mid-period.

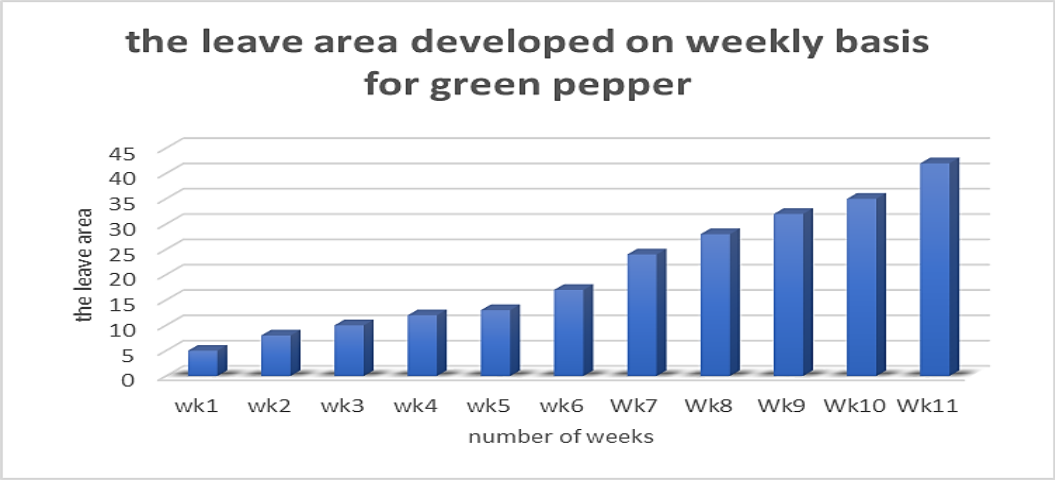

Figure 5: The leaf area developed for green pepper

3.5 The average weekly weight of fish

At first, the graph (Fig. 6) indicated a slow rise in fish average weight over the course of the week. This implies that the fish have been growing gradually over time. However, there is a discernible increase in the rate of weight gain about the halfway point of the observation period, as shown by a steeper slope on the graph. Optimal feeding conditions or other beneficial environmental elements may coincide with this fast growth phase. As the fish got closer to their maximum size or as the environment changed, the rate of weight gain started to plateau near the conclusion of the observation period. Overall, the graph shows periods of consistent growth as well as any notable variations in growth rate, offering insightful information on the fish population's growth trajectory throughout time.

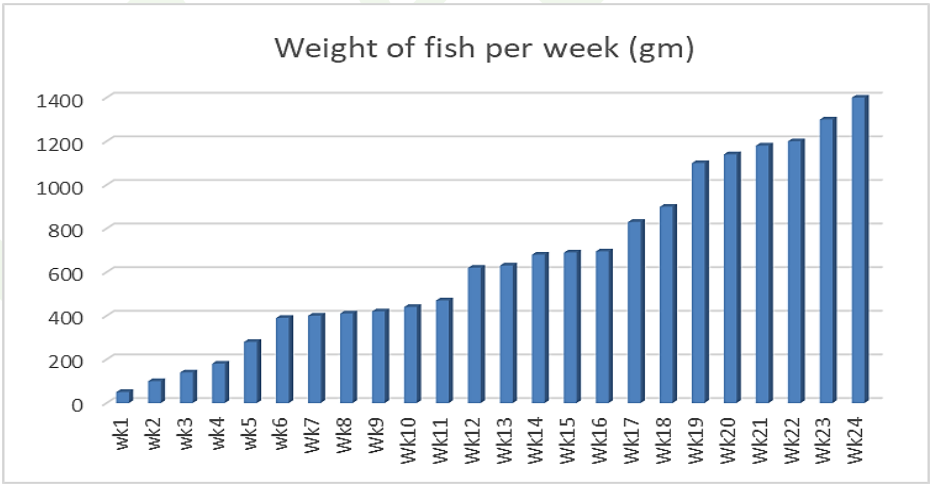

Figure 6: Growth of fish per week under gravel grow-bed

4.0 CONCLUSION

This study shows that GRV (gravel) is an appropriate medium bed for aquaponics pepper production that yields the best results. These materials are an inexpensive and easily accessible substitute for substrates that are typically chosen because they are unconventional and regarded as waste. With the growing popularity of aquaponics systems in sub-Saharan Africa, it is hoped that

more waste may be transformed into riches by finding new applications in production systems. This research will advance knowledge of how various growth media affect plant productivity and water quality in an aquaponics system for catfish, tomatoes, and peppers. These results will help aquaponics practitioners choose growth media wisely, thereby improving the sustainability and efficiency of their systems. It is, however, advised to use cleaned, inert gravel with a diameter of 10-20 mm (ideally 12–16 mm) for the process of biofiltration and aeration of plant roots. The water's quality needs to be kept within the following acceptable ranges: 25-30°C, pH 6.5-7.2, dissolved oxygen 6-8 mg/L, ammonia < 0.5 mg/L, nitrite < 0.5 mg/L, and nitrate 40–150 mg/L. For the system to remain stable in tropical circumstances, the density of fish stockings must not be more than 25 kg/m^3.

4.1 Contributions to knowledge

The performance of gravel as a growth medium in a media-based aquaponics system in trocal circumstances in Awka, Anambra State, is examined empirically in this study, which advances knowledge by offering location-specific data. It provides evidence-based guidance for a cheap, easily accessible medium and assesses its combined impacts on fish efficiency, water quality, and green pepper yield. The results serve as a reference for upcoming comparative and commercial aquaponics research and offer basic information for the long-term growth of aquaponics in southeast Nigeria.

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