EFFECT OF COMPOST-BASED MANURE ON THE YIELD AND BIOMASS OF LETTUCE THROUGH HYDROPONICS SYSTEM IN UNIVERSITY OF AFRICA TORU-ORUA, NIGERIA.

Matthew, A. A[1], Fobiri, E. T.[2], and Anem I.[3].

1. Department of Crop, Soil and Pest Management, Faculty of Agriculture, University of Africa, Toru-Orua, Bayelsa State, Nigeria.
2. Department of Crop, Soil and Pest Management, Faculty of Agriculture, University of Africa, Toru-Orua, Bayelsa State, Nigeria.
3. Department of Animal Production and Health, Faculty of Agriculture, University of Africa, Toru-Orua, Bayelsa State, Nigeria.

Correspondence author email: webicloud4krist@gmail.com matthew.augustine@uat.edu.ng

ABSTRACT

This study aimed to determine the effects of compost-based manure on the yield and biomass of lettuce cultivated using hydroponic systems in University of Africa, Toru-Orua. The lettuce plants were grown in a Constructed Hydroponic System (CHS), using a continuous solution and growth media, it saved cost and was eco-friendly, especially when using organic manure as a source of nutrient for agricultural production. In this research, four different types of manure were used as nutrient sources: organic fertilizer: composted (cow dung and chicken manure), inorganic fertilizer (NPK 20:10:10) and liquid organic fertilizers were used the CHS for 70 days. The growth parameters evaluated included plant height, leaf number, root length, and average fresh weights of the lettuce plants. Results showed that lettuce plants grown in cow dung(T2) and poultry manure(T1) had similar plant height, while those grown in cow manure had the highest leaf number followed by poultry manure which thought observation had the most succulent leaves and NPK 20:10:10(T4). However, lettuce plants grown in composted poultry manure produced the highest root length and lettuce plants with the highest average fresh weight was the synthetic fertilizer, NKP 20:10:10 with (27.44g), followed by Poultry manure and cow dung which was (24g and 19.67g). This study demonstrated that composted cow dung and poultry manure compete favorably with synthetic fertilizer NPK 20:10:10 and are effective as a nutrient source for lettuce grown through hydroponic systems in the University of Africa Toru-Orua. This suggests that the use of composted manure as a nutrient source for hydroponic lettuce production can help reduce dependence on chemical fertilizers and promote sustainable agriculture practices in the region.Moreover, poultry manure and cow dung manure had the lowest cost of production due to the University poultry farm and cattle herdsmen close to the experimental area. The usefulness of other animal local manure should be investigated further.

Keywords: Organic manure, Constructed Hydroponics System, lettuce, number of leaves.

IJAFS 2022 (10).12:1832 - 1842

INTRODUCTION

Lettuce (*Lactuca sativa*) is an annual plant of the family *Asteraceae*. It is most often grown on the ground as a leaf vegetable, but sometimes for its stem and seeds. Lettuce is most often used for

salads, although it is also seen in other kinds for food, such as soups, sandwiches, and wraps; it can also be grilled. One variety, the *woju* or asparagus lettuce is grown for its stems, which are eaten either raw or cooked. In addition to its main use as a leafy green, it also gathered religious and medicinal significance over centuries of human consumption.

Lactuca sativa is a member of the Lactuca (lettuce) genus and the Asteraceae (sunflower or aster) family. Lettuce grows well in spring and fall in most regions. Lettuce seedlings will even tolerate a light frost. Temperatures between 45F and 60F are ideal. Because lettuce grows quickly, the best approach is to plant a small amount at a time, staggering your plantings. Lettuce was first cultivated by the ancient Egyptians succulent leaves and oil-rich seeds. Lettuce is easily cultivated, although it requires relatively low temperatures to prevent it from flowering quickly. It can also be plagued by numerous nutrients deficiencies, as well as insects and mammal infestation, fungal and bacterial diseases. Lettuce is a rich source of vitamin K and vitamin A, and a moderate source of foliate and iron. Contaminated lettuce can cause bacterial, viral and parasitic outbreaks in human, including E. coli and Salmonella. Most vegetables are grown on small piece of land in urban centers if available or on soilless medium. This practice is referred to as homestead farming.

The idea of homestead farming comes to play because population is on the rise, with over 200million people. Nigeria has the largest population in Africa, Demographic projection has shown that Nigeria might experience a constant increase in the next decades. By 2050, it is forecasted that the population will grow to over 377million people compare to where it is now (D., Dokua Sasu, 2022). This indicates that price of food produce will also increase and there will be minimal land space for cultivation due to increased urban development.

Homestead farming or backyard farming is a system for the production of subsistence crops (in soil or soilless practices) for the cultivator and his/her family. This is becoming very important because of food insecurity status in urban centers. Homestead farming is convenient and makes available fresh and healthy vegetables for cooking. In the case there is no available land for cultivation, soilless homestead farming becomes the only option for vegetable production, which is the focus of this project.

Soilless culture, therefore include aeroponics, aquaponics, and hydroponics, is considered as one of the more innovative agricultural strategies to produce more from less, in order to feed the estimated 11 billion people in the world by 2100 (Lal, R., 2016). Aeroponics is a promising technology that grows plants with their root systems exposed to a nutrient mist in a closed chamber (Jones, J.B, 2014). Research has shown that Vegetables can be grown on soilless medium, especially in cities where there is no land for cultivation, hence the need to explore the use of hydroponics to produce vegetables.

Hydroponics is therefore the technique of growing plants using a water-based nutrient solution rather than soil, and can include an aggregate substrate, or growing media, such as vermiculite, coconut coir, or perlite. Hydroponic addresses critical challenges which includes the interconnected challenges of climate change, extensive agricultural soil degradation leading to loss of arable land, coupled with a rising urbanized population, threaten global food security,

Hydroponics which is a system of crop cultivation without soil, offers an innovative solution for sustainable food production by preserving soil and land resources (Hayes,TB.; Hansen, M. 2017). This system is versatile and can range from passive, low-input systems to high-tech, fully automated systems, with system design easily adapted to local contexts. Hydroponic system can be implemented in areas that rely mainly on imported food products and are thus especially prone to food insecurity due to low availability of agricultural land or poor soil quality, such as deserts, dry coastal belts, and urban areas.

METHODOLOGY

Description of The Study and The Study Area

This research was conducted as an experimental study to test the effect of compose-based media on yield and biomass of Lettuce in a hydroponics system The study was carried out at the University of Africa, Toru-Orua, Sagbama Local Government Area (SALGA) of Bayelsa State. The State covers an area of about 21,110 square kilometers with more than three quarters of this area covered by water. Sagbama is a Local Government Area in Bayelsa State, Southern part of Nigeria. The site was free from direct rainfall and was open to sunlight time of the day. During the period of the experiment, the weather condition of the University was relatively dry with the day time temperature that ranges from 32˚C in the early morning to 24˚C at night.

Materials Used for the Study

The materials used in this study were the following: coco pit, nursery tray, buckets, plastic bottles, water, seeds of lettuce, organic waste such as (poultry droppings, Cow dung), organic liquid fertilizer, NPK 20:10:10, ball pen, Notebook, camera.

Source of Materials

The seeds of lettuce were sourced from a reliable company named Afritropic located in Abuja. Cocopit were obtained from UAT farms, the Buckets and plastic bottle, was gotten from Local residents of Toru-orua, organic waste (poultry droppings) from UAT farms, Cow dung was from abattoir at (Sagbama junction, the organic liquid fertilizer, NPK 20:10:10 was gotten from reliable source and source of water was from the university of Africa Borehole.

Experimental Design

The experimental design was a Completely Randomize Designed. The potted/ buckets factor was composed of different types of organic matter: poultry manure (T1), Cattle manure (T2), Organic Liquid Fertilizer (T3), and a positive control with NPK 20:10:10 (T4). The experimental area was under a building and the layout of the Treatments were 4, poultry manure (PM), cow manure (CM), organic liquid fertilizer (OLF) and inorganic treatment NPK. The Treatment was subdivided into three (3) replications, which makes up 12 buckets. Each Buckets contains (4) plants which adds up to 48 plants.

Preparation of Materials

Chicken manures were sourced from University of Africa Toru-Orua, Bayelsa state, Nigeria. Cow manure was sourced from abattoir at (Sagbama junction, Bayelsa state, Nigeria), where it was left outside and exposed to the external environment for 1–6 months prior to use.

Formulation of The Nutrient Solution

The method of Kratky was used in the nutrient formulation and container use.

Poultry manures were weighed (200g) and transferred into a 20 litres bucket of tap water, Cow manure was also weighed(200g) in 20litres bucket of tap water, Organic Liquid fertilizer was measured in (40ml) and mixed with 20litres bucket of tap water and NPK 20:10:10 was weighed in (50g) and transferred into 20liters bucket of water, each treatment was replicated thrice.

Planting of Lettuce

The seeds of lettuce were planted in nursery trays containing coco-pit as a medium for germination to take place.

After germination, the three weeks old seedlings (15 - 20 cm) seedlings were transferred into the non-circulating hydroponic systems (soilless system) containing different formulations of nutrient solution with cocopit as a medium for firmness.

Image 7: planted lettuce

Data Gathered

The data gathered are the following:

1. **Height: The** height of the representative lettuce plants will be measured from the ground up to the tip of the standing plants 3rd week before transplanting and every week after transplanting (cm).
2. **Number of leaves**: The number of leaves of the representative plants will be counted from the ground up to the tip of the standing plants at once every week after transplanting.
3. **Average plant weight:** The average weight of **l**ettuce variety will be done after harvesting in order to get its average plant weight.
4. **Average root length:** The average root length of lettuce**.** The measurement will be taken in centimetres from the base of the plant to the tip of the roots. Root development will be observed as the project progresses. Root development will give vital information on how the lettuce will respond to water stress.
5. **Harvest:** The weight of lettuce in representative plants were measured by using a weighing scale during priming

6. **Actual itemized expenses**: The cost of production had included the supplies and materials which consisted of the lettuce seeds, buckets, organic wastes. The total expenses were determined by adding all expenses include during the conduct of experiment.
7. **Cost and return analysis:** The gross income was obtained from the sales of the lettuce at harvest. The ROI was obtained by dividing the net profit to the amount of expenses multiplied by 100. $ROI = \frac{Net\ Profit}{Expenses} x\ 100$

RESULTS AND DISCUSSION

Effect of different fertilizers application on number of leaves of lettuce.

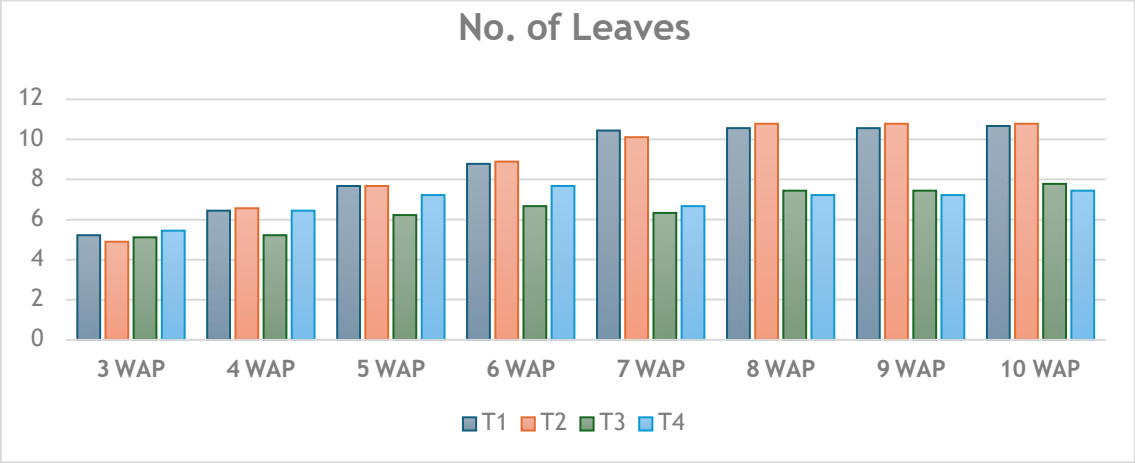
The results suggest that the treatments significantly influenced the growth of lettuce. At 6 WAP and 9 WAP, T2 has the highest number of leaves, followed by T1, T3, and T4. Similar studies have been conducted on the effects of different types of organic fertilizers on the growth and yield of lettuce. This is co-current with a study by Islam et al., (2019) who discovered that the application of cow manure and poultry droppings significantly increased the growth and yield of lettuce compared to inorganic fertilizer. Also, Sarker *et al.*, (2018) reported similar results, with cow manure and poultry manure showing better growth and yield performance of lettuce compared to chemical fertilizers.

However, some studies have also reported the negative effects of organic fertilizers on the growth of lettuce. A study by Chen *et al.*, (2018) found that the application of excessive amounts of organic fertilizer caused phytotoxicity, leading to stunted growth and reduced yield of lettuce. Therefore, it is important to carefully determine the appropriate application rate of organic fertilizers to avoid toxicity and achieve optimal growth and yield.

Overall, the results suggest that cow dung-based compost and poultry manure have a positive effect on lettuce growth compared to organic liquid and NPK fertilizers. However, more studies are needed to determine the optimal application rates for each fertilizer type and to assess their long-term effects on the soil and plant health**.**

Table 1: Number of Leaves
Figure 4.1: Effect of different fertilizers application on number of leaves of lettuce

Treatments	3 WAP	4 WAP	5 WAP	6 WAP	7 WAP	8 WAP	9 WAP	10 WAP
T1	5.22^{ab}	6.44^{b}	7.67^{b}	8.78^{c}	10.44^{b}	10.56^{b}	10.56^{b}	10.67^{b}
T2	4.89^{a}	6.56^{b}	7.67^{b}	8.89^{c}	10.11^{b}	10.78^{b}	10.78^{b}	10.78^{b}
T3	5.11^{ab}	5.22^{a}	6.22^{a}	6.67^{a}	6.33^{a}	7.44^{a}	7.44^{a}	7.78^{a}
+4	5.44^{b}	6.44^{b}	7.22^{b}	7.67^{b}	6.67^{a}	7.22^{a}	7.22^{a}	7.44^{a}



Effect of different fertilizers application on plant Height (cm) of lettuce.

Table 2 Plant Height:

The results shows that treatment T1 (poultry manure) and T2 (cow dung) had similar plant height values over the period of observation. Similarly, treatment T4 (NPK 20:10:10) had similar plant height values compared to T1 and T2. These results suggest that poultry manure, cow dung, and NPK 20:10:10 could be equally effective in promoting lettuce height in hydroponic systems.
Contrastingly, treatment T3 (organic liquid fertilizer) had lower plant height values compared to the other treatments across all weeks. This suggests that the organic liquid fertilizer used in this study was not as effective as poultry manure, cow dung, and NPK 20:10:10 in promoting plant growth and height in hydroponic systems.

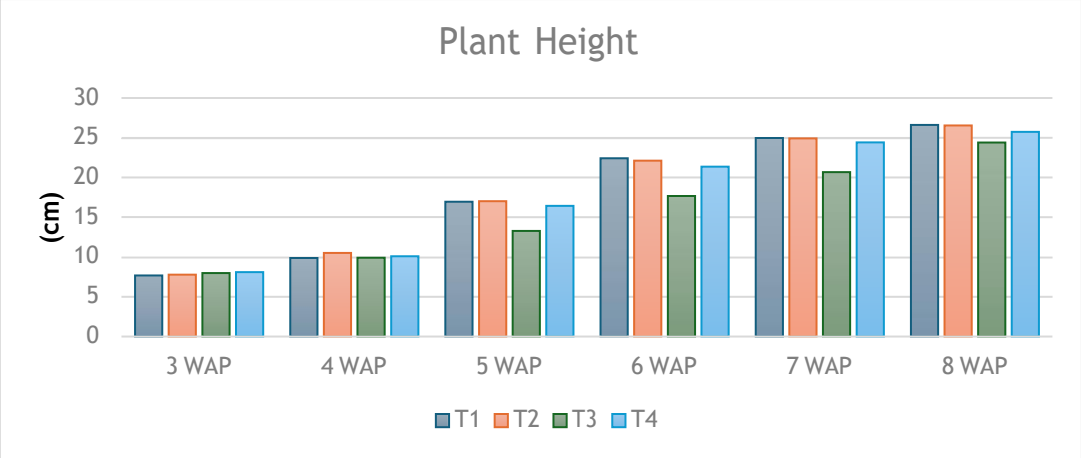
These findings are consistent with the study by Sarker *et al.*, (2018) who reported that organic fertilizers such as poultry manure and cow dung significantly improved lettuce yield compared to chemical fertilizers. However, the findings are not consistent with the study by Chen *et al.*, (2018), which reported that organic fertilizers were not as effective as chemical fertilizers in promoting plant growth and yield.

In summary, the results suggest that composted poultry manure, cow dung, and NPK 20:10:10 may be more effective in promoting the growth of lettuce in hydroponic systems compared to organic liquid fertilizer. However, more research is needed to corroborate these findings.

	Table 2: Plant Height					
Treatments	3 WAP	4 WAP	5 WAP	6 WAP	7 WAP	8 WAP
T1	7.67^{a}	9.87^{a}	16.94^{b}	22.41^{b}	24.97^{b}	26.61^{b}
T2	7.78^{a}	10.51^{a}	17.01^{b}	22.12^{b}	24.91^{b}	26.54^{b}
T3	7.98^{a}	9.91^{a}	13.28^{a}	17.67^{a}	20.67^{a}	24.40^{a}
T4	8.09^{a}	10.09^{a}	16.42^{b}	21.35^{b}	24.41^{b}	25.74^{b}

Figure 4.2: Effect of different fertilizers application on plant Height (cm) of lettuce .

Figure 2: Represents the mean plant Height of lettuce under different treatments at different weeks after planting (WAP) used in Hydroponic system. T1 represents Poultry Manure, T2 represents Cow Manure, T3 represents Organic Liquid Fertilizer and T4 represents NKP 20:10:10).



Effect of different fertilizers application on Root Length (cm) of lettuce.

Table 3 represents the mean Root Development of lettuce under different treatments at different weeks after planting (WAP) used in Hydroponic system)**.**

From Table 3, it is evident that all treatments resulted in gradual increase in root length at different weeks after planting (WAP). Poultry manure (T1) resulted in the highest root length values in all three weeks, followed by cow dung (T2) and the synthetic fertilizer (T4), while the organic liquid fertilizer (T3) had the lowest values.

Several studies investigated the effect of compost or manure-based fertilizers on the growth of lettuce plants. A study by Milfont *et al.*, (2015) compared the effects of different types of organic fertilizers on the growth of lettuce plants. The results of the study indicated that the use of cow manure compost significantly increased above-ground biomass of the lettuce plants compared to synthetic fertilizers. Qadir *et al.*, (2016) investigated the role of poultry manure on agricultural crops and found that the use of poultry manure significantly increased root length, shoot length, and biomass of the crops studied.

Based on these studies, it appears that the findings of this study, where poultry manure and cow dung resulted in increased root length compared to synthetic and organic fertilizers are similar. It is important to note that there are differences in experimental conditions and other factors that might impact the results. Therefore, further research on this subject is needed to draw definitive conclusions.

It is also worth mentioning that while measuring root length, it is also essential to evaluate other plant growth parameters, such as plant height, leaf development, and biomass accumulation to better understand the impacts of different fertilizers on growth and yield of lettuce.

Overall, the results of this study suggest that the use of compost or manure-based fertilizers such as poultry manure and cow dung could positively impact lettuce root development in hydroponic

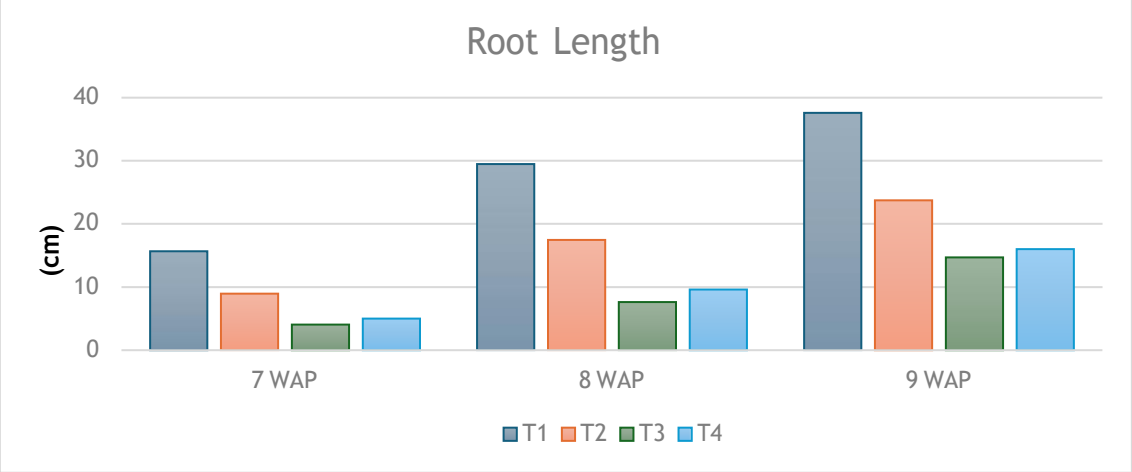
systems in southern Nigeria. Additional research under varied conditions is warranted to determine the optimal fertilizer regimen that would result in increased growth and yield of lettuce.

Table 3: Root Length

Treatments	7 WAP	8 WAP	9 WAP
T1	15.66^{c}	29.47^{c}	37.58^{c}
T2	8.93^{b}	17.44^{b}	23.73^{b}
T3	4.04^{a}	7.60^{a}	14.69^{a}
T4	5.00^{a}	9.60^{a}	16.00^{a}

Figure 4.3: Effect of different fertilizers application on Root length (cm) of lettuce.

Figure 3 represents the mean Root Length (cm) of lettuce under different treatments at different weeks after planting (WAP) used in Hydroponic system. T1 represents Poultry Manure, T2 represents Cow Manure, T3 represents Organic Liquid Fertilizer and T4 represents NKP 20:10:10).



4.5. Effect of different fertilizers application on Average plant weight (gram) of lettuce at harvest.

The table represents the mean average plant weight of lettuce at harvest under different treatments at different weeks after planting (WAP) used in Hydroponic system.

From the table above, it is clear that all treatments resulted in an increase in the average plant weight at Harvest which is the 10th week after planting (WAP). The synthetic fertilizer (T4) resulted in the highest average plant weight at 27.44 grams, followed by poultry manure (T1) and cow dung (T2), while the organic liquid fertilizer (T3) had the lowest average plant weight at 14.22grams. These results suggest that the synthetic fertilizer NPK 20:10:10 was the most effective in increasing plant weight. Similar studies have investigated the effect of different types of fertilizers on the growth and yield of lettuce. Kim *et al.*, (2019) found that the use of organic fertilizers, such as chicken manure and swine bedding, significantly increased the yield and biomass of lettuce compared to chemical fertilizers. However, a study by Tei and Mazzoncini (2011) found that the use of organic fertilizers alone did not result in significant increases in the yield of lettuce, but the combination of organic and chemical fertilizers did. Based on these studies, it is possible that the use of manure-based fertilizers such as poultry manure and cow dung did not result in the highest

plant weight in this study due to differences in experimental conditions and other factors that might impact the results.

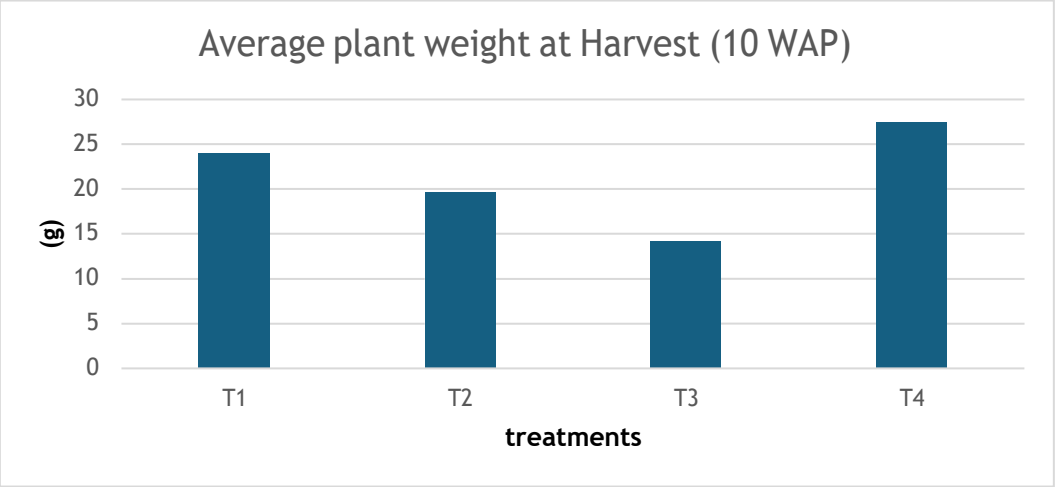
It is also important to consider other factors that might impact the growth and yield of lettuce in hydroponic systems in southern Nigeria, such as temperature, pH, light intensity, and water quality. Further research is needed to determine the optimal fertilizer regimen and other growth conditions that would result in increased growth and yield of lettuce in hydroponic systems in southern Nigeria.

Table 4: Average plant weight at Harvest

Treatments	10 WAP
T1	24.00[a]
T2	19.67[a]
T3	14.22[a]
T4	27.44[a]

Figure 4.4: Effect of different fertilizers application on Average plant weight (g) of lettuce at harvest

Figure 4 represents the mean Average plant weight of lettuce at harvest under different treatments at the 10th week after planting (WAP) used in Hydroponic system. T1 represents Poultry Manure, T2 represents Cow Manure, T3 represents Organic Liquid Fertilizer and T4 represents NKP 20:10:10).



Actual itemized expenses and cost analysis of the Research

The cost of each treatment was calculated and compared. Poultry Manure was gotten for free, followed by cattle (500 Naira/30kg), N.P. K 20:10:10 was (1000 Naira/2kg) and the highest treatment price was liquid organic fertilizer which was (1500/litre).

All manure has a lower cost production especially local animal manure. It is

cheaper and easier to get in a production area because it has huge quantities in that area. Local manures are given free or sold in a low price while commercial chemical fertilizer need to be bought or ordered from the merchant. Using local manure as a hydroponic solution for growing plant is an added value on farm residues.

Other items used for the Research where 25Liters paint buckets which was gotten from Local residents for 200each (2400 naira/12 buckets), 48 bottles that cost (2400 naira), lettuce seed (8,000 Naira), coco pit (1500 Naira), It all summed up to a Total of (17,300 Naira). The total expenses were determined by adding all expenses include during the conduct of experiment.
The gross income was obtained from the sales of the lettuce at harvest which was #30,000 Naira. The ROI was obtained by dividing the net profit to the amount of expenses multiplied by 100. $ROI = \frac{30,000}{17,300} x\ 100 = 173.4$

CONCLUSION

Hydroponics system can be an effective way of producing vegetables in urban areas as population increases. Compost-based manure is a popular organic fertilizer that is used in hydroponics systems to provide plants with essential nutrients. The use of compost-based manure has been shown to increase the yield and biomass of crops, as well as the nutrient content and quality of crops.

The use of organic fertilizer in hydroponics systems may offer a sustainable and environmentally friendly solution to increasing the yield and biomass of lettuce while reducing the environmental impact of soil degradation and the raising urbanized population.

From this research, poultry manure generally outperformed other sources of organic manure and it had a competitive advantage when compared with the treatment NPK 20:10:10 especially in Root development and average plant weight respectively. From observation, poultry manure can be used in the stead of NPK 20:10:10 because it is relatively affordable to farmers and available. Therefore, poultry manure is highly recommended to produce lettuce in Hydroponics system. Also, further research is needed to determine the optimal composition and application rate of compost-based manure for lettuce plants grown using hydroponics in University of Africa Toru-Orua.

REFERENCE

Hayes,T.B and Hansen, M. E. (2017). Organic Manure for Vegetable Production under Hydroponic Conditions in Arid Namibia. Int. Sci. Technol. J. Namib. 2017, 5, 3–12.

Islam, M., Ferdous, J., Jahan, S., & Mahmud, T. (2019). Influence of different organic amendments on the growth and yield of lettuce. Journal of Agricultural Science and Technology, 21(6), 1419-1430.

Jones, J.B., Jr., (2014) *Complete Guide for Growing Plants Hydroponically*; CRC Press: Boca Raton, FL, USA.

Kim, S.-H., Kim, D.-S., Lee, J.-S., Park, J.-H., Cho, D.-H., Choi, Y., and Lee, S.-C. (2019). Effect of Organic and Chemical Fertilizers on Yield and Quality of Hydroponic Leaf Lettuce. Horticulturae 5, 51.

Lal, R. (2016). Feeding 11 billion on 0.5 billion hectare of area under cereal crops. *Food Energy Security.* 2016, *5*, 239–251.

Milfont, M.O., Carvalho, J.G., Sales, T.A., de Oliveira, I.P., and Fernandes-Júnior, P.I. (2015). Effect of different organic fertilizers on the growth and production of lettuce. Revista Brasileira de Engenharia Agrícola e Ambiental 19, 568-573.

Qadir, G., Khan, A.S., and Abbas, S.Q. (2016). Effect of varying amounts of poultry manure on the growth and biomass production of radish (Raphinus sativus L). Journal of Biodiversity and Environmental Sciences 8, 189-195.

Sarker, B. C., Akter, M., Ferdoushi, A., & Uddin, M. H. (2018). Comparative study of organic and inorganic farming: effect of vermicompost and chemical fertilizer on growth and yield of lettuce plant. Journal of Agriculture and Life Sciences, 1(2), 17-23.