BUSITEMA UNIVERSITY, NAMASAGALI CAMPUS
FACULTY OF NATURAL RESOURCES AND ENVIRONMENTAL SCIENCES

Assessment of the performance and economics of spinach (*spinicia oleracea*) in the aquaponics system.

BY
NAMUYANJA REBECCA
BU/UG/2020/0271

A research report submitted
to the Faculty of Natural Resources and Environmental Sciences in partial fulfilment of the requirements for the award of the degree of Bachelor of Science in Natural Resources Economics
of Busitema University

FEBRUARY 2024

DECLARATION

I ………………………... Hereby declare that the work in this research dissertation is entirely a result of my own effort and has never been submitted to any other institution of higher learning for the award of Bachelor's degree

SIGNATURE............................ DATE......................................

APPROVAL

This is to certify that NAMUYANJA REBECCA developed this proposal under my supervision and guidance. I am therefore recommending that this report be submitted.

Signature: ………………………………………… Date: …………………………………

Dr. SYLVIE TEBITENDWA MUWANGA

(SUPERVISOR)

DEDICATION

I dedicate this thesis to God Almighty for His unlimited grace and a scholarship HE gave unto me to study a bachelor’s degree. In addition, I dedicate this work to my parents, brothers & sisters lecturers and friends.

ACKNOWLEDGEMENTS

I am thankful for the laboratory assistance gained from the staff members of Maritime institute, Busitema University, Kamuli Uganda. I am mainly appreciative for the efforts from Mr. Sentongo Oscar, Mr. Bill Kiconco and Miss Nakandi who helped me during laboratory analysis and sample collection on time. Special thanks go to Dr. Tebitendwa Sylvie Muwanga, Lecturer Busitema University who has been with me from the time of the proposal development to this time when the thesis is accomplished. I am really thankful for your guidance, encouragement and more especially, editing my work and providing me with the relevant literature. Lastly but not least, I appreciate my friends Cedric Byalebeka and Latifah Nakyanzi who assisted me with their computers to finish this thesis.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

1. RAS-recirculating aquaculture systems

2. UV-Ultra violet

3. DO - Dissolved Oxygen

4. EC - Electrical Conductivity

5. TDS - Total Dissolved Solids

6. TSS - Total Suspended Solids

7. NH_4^+-N - Ammonium-Nitrogen

8. NO_3^--N- Nitrate-Nitrogen

9. NO_2^--N- Nitrite-Nitrogen

10. PO_3^--P- Soluble Reactive Phosphorus

11. APHA - American Public Health Association

13. P - Productivity

14. m - meters

15. CBR-cost benefit ratio

16. mg/L - milligrams per lite

17. cm-centimetre

18. ha-hactares

ABSTRACT

This study aimed to assess the performance and economics of spinach (*Spinicia oleracea*) in the aquaponics system. The objectives of the study were to: determine the physico-chemical water quality fed into the hydroponics system, determine the growth of spinach using, estimate the productivity of spinach plants over a growth cycle, and determine the economic costs in terms land area requirement and investment cost of a establishing an aquaponics system. Three 5L plastic containers and a 10L water tank were used for vegetable bed spinach and sampled weekly. Results revealed that the water quality of monitored parameters was 30.55±22.94 ^{o}C, 2.29±1.56 mg/L,7.0±6.4, 203±111µS/cm and 111±74 mg/L were recorded as temperature, DO, PH, Electrical Conductivity and total dissolved solids respectively while nutrient concentration was 18.67±8.5 mg/L, 1.9±0.11mg/L, 0.35±0.29 mg/L and 0.35±0.29 mg/L for soluble reactive Phosphorus, ammonium nitrate, nitrite nitrogen and nitrate nitrogen respectively. The average plant height and leaf breadth recorded were 7.0 ± 4.0 cm and 3.5 ± 0.1 cm respectively. The total production of spinach was high estimated at 0.73 tons/ha/42 day. These results suggest potential application of the aquaponics to supplement food production especially in high density areas likely in urban and peri-urban centres.

CHAPTER ONE

INTRODUCTION

1.1 Background

Food insecurity and malnutrition are major global issues and recently, a reported 11.7 % of the global population is facing food insecurity at severe levels (SOFI, 2022). Thus, highly productive and low-cost plant cultivation systems that are capable of meeting the food requirements of the ever-increasing human population but presenting minimal environmental impacts are necessitated.

Aquaponics is sought as a promising solution to address food insecurity and environmental sustainability by converting waste into resource under the theory of circular economy (Blidariu et al., 2013). The aquaponics technique essentially couples fish production in recirculating aquaculture systems (RAS) and crop production in hydroponics (Nichols and Savidov, 2012). Although quite little studied especially in rural settings in the developing countries, the aquaponics principle has added advantages over independent operation of either aquaculture or hydroponic systems. For instance, in a symbiotic relationship, the waste produced by fish due to metabolic activity and uneaten food in water tanks, which could become toxic for the fish if not cleaned, is used directly or converted by bacteria into useful nutrients for plants. Consequently, as plants assimilate these nutrients, the water is treated and is recycled back to the fish tank (Liang and Chien, 2013; Chaves et al., 1999). This results into a system that not only saves water critical for water scarce areas but also produces minimal or zero waste discharge to the environment(Goddek *et al.*, 2020). Most importantly, the aquaponics system provides potential for replication for nutritional cultivation of fish and a variety of vegetables all year round for commercial application as well as backyard gardening for elevated food security and poverty alleviation (Danaher *et al.*, 2011). More so,('Aquaponics-Farming-Helps-Ugandan-Women-Regain-Lost-Livelihoods-From-The-Pandemic-Image-4-768x512', no date) asserts that the aquaponics systems generate higher yields in a smaller space, which is a huge advantage over traditional agriculture.

Despite the aforementioned merits, the success of the aquaponics technology is highly dependent on a choice of suitable plant species (Krastonova et al., 2022). Hence, several plants are recommended for application in aquaponics and these include: spinach, lettuce, basil and cabbage

REFERENCES.

Ajapnwa, A. *et al.* (2017) 'Efficiency and productivity analysis of vegetable farming within root and tuber-based systems in the humid tropics of Cameroon', *Journal of Integrative Agriculture*, 16(8), pp. 1865–1873. Available at: https://doi.org/10.1016/S2095-3119(17)61662-9.

'Aquaponics-Farming-Helps-Ugandan-Women-Regain-Lost-Livelihoods-From-The-Pandemic-Image-4-768x512' (no date).

Atique, F., Lindholm-Lehto, P. and Pirhonen, J. (2022) 'Is Aquaponics Beneficial in Terms of Fish and Plant Growth and Water Quality in Comparison to Separate Recirculating Aquaculture and Hydroponic Systems?', *Water (Switzerland)*, 14(9). Available at: https://doi.org/10.3390/w14091447.

Bernard, K. (2021) 'Performance of Aquaponics Technologies in the Albertine Region, Western Uganda', *Journal of Aquaculture Research and Development*, 12(6), pp. 1–17. Available at: https://lens.org/111-293-996-279-079.

Danaher, J.J. *et al.* (2011) 'Effect of a Parabolic Screen Filter on Water Quality and Production of Nile Tilapia (Oreochromis niloticus) and Water Spinach (Ipomoea aquatica) in a Recirculating Raft Aquaponic System', *International Journal of Recirculating Aquaculture*, 12(1), pp. 35–53. Available at: https://doi.org/10.21061/ijra.v12i1.1353.

Devi Singh, A.K.D., Yogesh Kumar, P.S.R. and Sandip Kumar Chandraker, A.K.V. (2017) 'Effect of NPK on Plant Growth, Yield and Quality of Capsicum (Capsicum annum L.) c.v. Swarna Under Shade Net Condition', *International Journal of Current Microbiology and Applied Sciences*, 6(4), pp. 1007–1013. Available at: https://doi.org/10.20546/ijcmas.2017.604.125.

Endut, A. *et al.* (2009) 'Effect of flow rate on water quality parameters and plant growth of water spinach (Ipomoea aquatica) in an aquaponic recirculating system', *Desalination and Water Treatment*, 5(1–3), pp. 19–28. Available at: https://doi.org/10.5004/dwt.2009.559.

Endut, A. *et al.* (2011) 'Nutrient removal from aquaculture wastewater by vegetable production in aquaponics recirculation system', *Desalination and Water Treatment*, 32(1–3), pp. 422–430. Available at: https://doi.org/10.5004/dwt.2011.2761.

Gao, Y. *et al.* (2023) 'No 主観的健康感を中心とした在宅高齢者における 健康関連指標に関する共分散構造分析Title', *Aleph*, 87(1,2), pp. 149–200. Available at: https://repositorio.ufsc.br/xmlui/bitstream/handle/123456789/167638/341506.pdf?sequence=1&isAllowed=y%0Ahttps://repositorio.ufsm.br/bitstream/handle/1/8314/LOEBLEIN%2C LUCINEIA CARLA.pdf?sequence=1&isAllowed=y%0Ahttps://antigo.mdr.gov.br/saneamento/proeesa/90.

Goddek, S. *et al.* (2015) 'Challenges of sustainable and commercial aquaponics', *Sustainability (Switzerland)*, 7(4), pp. 4199–4224. Available at: https://doi.org/10.3390/su7044199.

Goddek, S. *et al.* (2020) *Correction to: Aquaponics Food Production Systems*, *Aquaponics Food Production Systems*. Available at: https://doi.org/10.1007/978-3-030-15943-6_25.

Hussain, T. *et al.* (2015) 'Effect of water flow rates on growth of Cyprinus carpio var. koi (Cyprinus carpio L., 1758) and spinach plant in aquaponic system', *Aquaculture International*, 23(1), pp. 369–384. Available at: https://doi.org/10.1007/s10499-014-9821-3.

Khastini, R.O. *et al.* (2019) 'Microbial consortia effects on the yields of water spinach in milkfish aquaponics system', *IOP Conference Series: Earth and Environmental Science*, 383(1). Available at: https://doi.org/10.1088/1755-1315/383/1/012040.

N.Y Zainun, M.. M.S. (2018) 'Council for Innovative Research', *Journal of Advances in Mathematics*, 10(February 2014), pp. 1201–1229.

Nguyen, T.P.D. *et al.* (2022) 'Growth and Quality of Hydroponic Cultivated Spinach (Spinacia oleracea L.) Affected by the Light Intensity of Red and Blue LEDs', *Sains Malaysiana*, 51(2), pp. 473–483. Available at: https://doi.org/10.17576/jsm-2022-5102-12.

Petrea, S.M. *et al.* (2013) 'Vegetable Production in an Integrated Aquaponic System with Rainbow Trout and Spinach', *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Animal Science and Biotechnologies*, 70(1), pp. 45–54. Available at: https://doi.org/10.15835/BUASVMCN-ASB:70:1:9485.

Power For All (2020) ‘Powering Agriculture eBooklet’.

‘Prospect of aquaponics for the sustainable development of food production in urban’ (2018) *Chemical Engineering Transactions*, 63, pp. 475–480. Available at: https://doi.org/10.3303/CET1863080.

Roy, M. *et al.* (2013) ‘Feasibility study of aquaponics in polyculture pond’, *World Applied Sciences Journal*, 23(5), pp. 588–592. Available at: https://doi.org/10.5829/idosi.wasj.2013.23.05.74168.

Shafahi, M. and Woolston, D. (2014) ‘Aquaponics: A Sustainable Food Production System’, in *Volume 3: Biomedical and Biotechnology Engineering*. Montreal, Quebec, Canada: American Society of Mechanical Engineers, p. V003T03A073. Available at: https://doi.org/10.1115/IMECE2014-39441.

Somerville, C. *et al.* (2014) ‘Small-scale aquaponic food production- Integrated fish and plant farming’, *FAO Fisheries and Aquaculture*, p. 262.

Surnar, S.R., Sharma, O.P. and Saini, V.P. (2015) ‘Aquaponics : Innovative farming’, *International Journal of Fisheries and Aquatic Studies*, 2(4), pp. 261–263.

Vandam, D.A. *et al.* (2017) ‘Growth and tissue elemental composition response of spinach (Spinacia oleracea) to hydroponic and aquaponic water quality conditions’, *Horticulturae*, 3(2). Available at: https://doi.org/10.3390/horticulturae3020032.

Zappernick, N. *et al.* (2022) ‘Techno-economic analysis of a recirculating tilapia-lettuce aquaponics system’, *Journal of Cleaner Production*, 365. Available at: https://doi.org/10.1016/j.jclepro.2022.132753.