DETERMINATION OF MINERAL NUTRIENT COMPOSITION OF FISH TANK EFFLUENT AND ITS EFFECT ON GROWTH AND YIELD OF BULB ONION, *ALLIUM CEPA*

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DECLARATION

This dissertation is my original work and has never been presented for a degree in any other university.

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This dissertation is dedicated to my Aunt Miss Nabirye Teddy, my lovely wife Rebbecca and children Maria and Favour.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ABBREVIATIONS AND ACRONYMS

ANOVA	:	Analysis of Variance
APHA	:	American Public Health Association
°C	:	Degrees Celsius
Cadmium	:	Cadmium
Chromium	:	Chromium
cm	:	Centimeter
CRBD	:	Completely Randomized Block Design
DAP	:	Di-ammonium Phosphate
DF	:	Degrees of Freedom
EC	:	Electrical Conductivity
FAO	:	Food and Agriculture Organisation
g/kg	:	Grams per kilogram
GM	:	Gross Margin
K	:	Potassium
Kg	:	Kilogram
LA	:	Leaf Area

LSD	:	Least Significant Difference
MAAIF	:	Ministry of Agriculture, Animal Industry and Fisheries
mg/L	:	Milligrams per Liter
ml/L	:	Milliliters per Liter
N	:	Nitrogen
NAADS	:	National Agricultural Advisory Services
NaOH	:	Sodium Hydroxide
NARL	:	National Agricultural Research Laboratories
NARO	:	National Agricultural Research Organization
Ni	:	Nickel
NPK	:	Nitrogen, Phosphorus, and Potassium
P	:	Phosphorus
Pb	:	Lead
pH	:	Potential of Hydrogen
S.E	:	Standard Error
t/ha	:	Tons per hectare
TDS	:	Total Dissolved Solids

TSS	:	Total Suspended Solids
USh	:	Ugandan Shillings
WAT	:	Weeks After Transplanting
$\mu S/cm$	:	MicroSiemens per centimeter

ABSTRACT

Fish tank effluent has been reported as a cheap bio-fertiliser, and increases soil physico-chemical properties, hence improving soil fertility thus high production of bulb onion. A study was conducted to determine mineral nutrient composition of fish tank effluent and its effect on growth and yield of bulb onion, *Allium cepa L*. at Kyambogo University. The study determined the physico-chemical properties of fish tank effluent at different concentrations, effect of fish tank effluent concentration on growth and yield of bulb onion and assessed the gross margin of bulb onions grown under different concentrations of fish tank effluent. Treatments included 0, 100, 200 and 400 ml/L, and were laid out in a Completely Randomized Block Design with six replications for two trials. Data was collected; on Electro conductivity (EC), Total Dissolved Solutes (TDS), Total Suspended Solids (TSS), Nitrogen (N), phosphorus (P) and potassium (K), growth, yield and gross margin. Data collected was analysed by One Way ANOVA for objective one and two using Genstat statistical package (15th edition). Gross margin was computed using excel 2017 version. All results on physico- chemical properties varied significantly ($P < 0.05$) among fish tank effluent concentration. Highest mean EC, TDS, and TSS were recorded in 400 ml/L being 559.00 ± 0.00/L µS/cm, 368.33 ± 0.33 mg/L, and 5033.33 ± 33.33 mg/L respectively, while the same treatment had the lowest pH (6.56 ± 0.30). Highest mean N, P and K (0.43 ± 0.09, 0.06 ± 0.01 and 0.08)% were recorded from 400ml/L while the lowest (0.02 ± 0.01, 0.01 ± 0.00 and 0.01)% from 0ml/L. At the final week (12WAT), effluent concentrations did not significantly ($P > 0.05$) affect mean leaf area as a key growth parameter. The highest mean yield (26.84 ± 0.69 t/ha) was from plots treated with 200 ml/L and the lowest (14.49 ± 1.22t/ha) from 0 ml/L. The highest gross margin (71.76%) was from 200ml/L while the lowest (64.26%) was from 0 ml/L. In conclusion, physico-chemical properties varied among the different concentrations. Fish tank effluent concentration did not significantly affect growth parameters, significantly affected bulb onion yield, bulb height and harvest index but none significant on bulb onion diameter. Fish tank effluent at a concentration of 400 ml/L is recommended as a bio-fertilizer, for having highest amounts of physico-chemical properties. Fish tank effluent at concentration of 200 ml/L is recommended for better bulb onion growth, yield and gross margin in bulb onion production. Further studies on comparison of tank fish effluent and other different types of aquaculture systems should be under taken in bulb onion production.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

The Alliaceae is regarded as a separate family that includes *Allium* plants and their relatives. The genus *Allium* contains roughly 750 species, with the most significant edible *Allium* crops being the onion, Japanese bunching onion, leeks, and garlic (Eksi *et al*., 2020). Onion (*Allium cepa* L.) is also one of the most important commercial vegetable crops, and widely grown in almost all over the world (Khokhar, 2017).

Kamble and Kathmale (2015), the western Tien Shan region of China, Afghanistan, Tajikistan, and Uzbekistan, as well as western India, Western Asia and the Mediterranean Sea region are secondary onion development centers. China was the world's top producer of onions, with 31.19% of the crop, followed by India with 28.51% and the United States of America with 3.96% (FAO, 2019). Over 50 billion pounds of onions were produced in 2019 in China and India, while Egypt is the leading producer in Africa (3.85%), followed by Sudan (2.40%) and Algeria (2.02%).

In East Africa, Tanzania is the leading producer of onions, followed by Kenya and then Uganda. In Uganda, there is large scale production (5 – 10 acres) especially in Sebei region, which comprises the districts of Kapchorwa, Bukwo and Kween as well as the neighboring districts of Bulambuli, Sironko, Mbale in Bugisu Sub-region, as well as Southwestern areas around Kabale, Kisoro, Kanungu, Rukungiri, Kasese, Rubirizi and Kabalore small scale onion production is carried out on 1 to 3 acres in the Districts of Mubende, Mityana, Luwero, Hoima, Masindi and Kamuli (The New Vision, 23/June/2020).

Farmers from small-scale and large-scale use bulb onions to get high-income and consume it as a vegetable crop in every meal (Sura *et al*., 2022). Green onion leaves are prepared in some parts of West Africa before being used to form fermented, sun-dried balls that are later used as edible spice (Ulian *et al*., 2020). The most suitable edible portion of onion is the bulb (modified-stem) consists of thickened scale leaves (Oku *et al*., 2019).

According to Cozzolino *et al*. (2021), the extracted onion distillate, also known as "Onion oil," is frequently employed in food preparations as a spice and flavoring for savory goods. Teshika *et al*. (2018) reported that bulb onion is considered as an integral part of the preparation of all food items. In addition, onion extracts are used as anti-browning agents as well as beneficial food additives (Lante *et al*., 2020).

According to Fruscella *et al*. (2023), compounds from onions offer a variety of positive health effects, including anti-carcenogenic, anti-platelet, anti-hrombotic, asthmatic, and antibacterial actions. Extracts of onion is used for anticancer agents with the effects of antioxidants (Alzandi *et al*., 2021). It also reduces glucose by 25 percent (Pradeep and Srinivasan *et al*., 2017). Onions are used to treat boils and blisters, and in homeopathic medicine, it is used to treat hay fever and diarrhea in many underdeveloped nations (Dwamena *et al*., 2023). Nitrogen among the essential nutrients for growth of onions especially when it is controlled and released in the soil. At harvest, the bulbs contain 65% of the total nitrogen in the above-ground biomass, whereas the leaves contain 35% (Geisseler *et al*., 2022). Increase in water supply is another requirement which increases growth and yield of onions until a highest value is obtained (Wakchaure *et al*., 2018).

Potential yield of onion in semi-arid regions is reduced by abiotic factors such as soil infertility which causes up to 60% yield loss, poor agronomic practices and biotic factors such as planting low yielding varieties, insect pest, and diseases (Mrema *et al*., 2021). According to Shura *et al*. (2022) low productivity of onion production is due to low fertility of soil, inappropriate fertilizer rate, lack of improved varieties and poor management practices. Change in climatic conditions such as extreme temperatures which cause excessive evaporation of soil moisture, very heavy rainfall in some parts of the country (Kagorora *et al*. 2021) affect growth and yield on onions.

Giller and Andriesse (2015) Land use change issues have had a devastating impact on Ugandan soils. The original tropical rainforests gave way to savannah, which in turn gave rise to nearby farms, building sites, locations for burning charcoal, and other non-agricultural uses. Andriesse and Giller (2015) assert that the cumulative effect of this kind of land use transition significantly affects land degradation, which is an additional component causing climate change. Additional contributing issues include excessive use of chemical fertilizers, persistent monocropping, poor agricultural methods, and overgrazing, which compacts the soil (Deche *et al*., 2022). The two main practices that cause soil deterioration among Uganda's smallholder farmers are continuous tillage and monocropping. According to Fatumah *et al*.

(2020), these inefficient agricultural practices have a detrimental effect on soil because they increase surface runoff, decrease infiltration, and alter soil structure and biodiversity. FOA, (2022) stated that Ugandan farmers more especially in Kumi, Bulambuli, and Namutumba Districts received training on the best practices on soil management like correct fertilizer application rate, timely planting, soil testing, timely weeding, mulching fertilizer combinations and blended fertilizers for specific crops which included manure and urea; Di-ammonium Phosphate (DAP) and urea and fertilizer with micronutrients- nitrogen, phosphorus, and potassium (NPK).

According to a study by Nabyonga *et al*. (2022b), inorganic fertilizers have been used for a considerable amount of time throughout the world. An estimated 285 million tonnes of nutrients were needed globally for NPK, of which 245 million tonnes were delivered. In response to the global campaign for fertilizer use, it is projected that this amount will have reached 317 million tonnes in 2020 (FAO, 2017).

Organic fertilizers have less detrimental impacts on the environment and can therefore protect nature, they are strongly recommended worldwide. In addition to increasing the amount and quality of food through increased nutritional content, organic fertilizers show resilience and stability in the face of climate change (Raimi *et al*., 2017). Additionally, useful, organic fertilizers increase soil fauna and organic matter overall, enhancing the quality of the soil. Additionally, crops are more variable due to the fact that organic fertilizers often preserve natural pollinators like birds and insects (Bernstein and Wiesmann, 2019).

The utilization of animal manures, sludge, municipal solid waste, and agricultural waste is common among farmers globally due to the growing demand for organic products (Barnossi *et al*., 2020; Chew *et al*., 2019). Musa *et al*. (2020) wastewater from fish ponds is used as a potential irrigation source for raising vegetables around the sites which are directly or indirectly consumed by human beings. Fish pond effluent has adverse effects on soil health and crop productivity due to presence of high concentration of physico-chemical properties such as total dissolved solutes, total suspended solids, electroconductivity, nitrogen, phosphorus, potassium, cadmium (Cd), nickel (Ni), lead (Pb) and chromium (Cr).

Fishpond effluent can be used as irrigation water in the production of bulb onion thus improving the gross margin of bulb onion yield. The income from selling fish effluent can offset costs of obtaining water and inorganic fertilisers. Fish pond effluent has the potential to add substantial amounts plant nutrients like nitrogen, phosphorus potassium among others thus reducing the need for commercial fertilizers for crops (Musa *et al*., 2020).

Several studies have revealed that soil fertility is declining resulting into low production of bulb onion and low gross margin among bulb onion farmers. Also different scholars in their studies stated that fish pond effluent supplies irrigation water, essential physico-chemical properties such as nitrogen, phosphorus potassium among others which sustains the soil for a long period of time without getting leached hence continuous production of bulb onions.

However, there is limited information on the amounts of physico-chemical properties of fish tank effluent at different concentrations, effect of fish tank effluent concentration on growth and yield of bulb onion and gross margin of bulb onions grown under different concentrations of fish tank effluent. In addition, it has been observed that the addition of vital crop nutrients like nitrogen, phosphorus, and potassium by fish pond effluent considerably increases soil fertility. This enhances growth, yield, and profit margin from bulb onion sales. This study therefore, aimed at determining mineral nutrient composition of fish tank effluent and its effect on growth and yield of bulb onion, allium cepa.

1.2 Statement of the Problem

Fish effluent is considered as an organic fertiliser for growing vegetables thus safe for the human health (Khater *et al*., 2015). Fish effluent is used as bio-fertiliser because it is rich in physico-chemical properties such as EC, TDS, TSS, pH, Nitrogen, phosphorus and potassium (Qi *et al*., 2020). Bulb onions are source of ingredients in food (Lante *et al*., 2020). Ashagrie *et al*. (2021) reported that Bombay red is widely grown onion variety under irrigation in Ethiopia due to its higher bulb yield and earliness. However, the unfertile soil and dry conditions for long period of time have increasingly affected crop production in Africa (Bisbis *et al*., 2018; Weil and Sanchez, 2015). In Uganda, low production of bulb onion is due to insufficient soil nutrients (Nabyonga *et al*., 2022a). However, there is inadequate information on physico-chemical parameters and how to formulate standards of fish tank effluent, insufficient information on the effect of fish tank effluent concentration on growth, yield and gross margin of the bulb onion. Therefore, a study aimed at generating information on physico-chemical properties of fish tank effluent, effect of fish tank effluent concentration on growth, yield and gross margin of the bulb onion.

1.3 Objectives of the study

1.3.1 General objective

The purpose of the study was to assess the mineral nutrient composition of fish tank effluent and its effect on the growth and yield of bulb onions.

1.3.2 Specific Objectives

i. To determine and quantify physico-chemical properties of fish tank effluent at different concentrations.
ii. To assess the effect of fish tank effluent concentration on growth and yield of bulb onion.
iii. To determine the gross margin of bulb onions grown under different concentrations of fish tank effluent.

1.3.3 Research Hypotheses and Research Question

i. Different concentrations of fish tank effluent have different quantities of physico-chemical properties.
ii. Concentration of fish tank effluent has an effect on growth and yield of the bulb onion.

Research question: What is the gross margin of bulb onions grown under different concentrations of fish tank effluent?

1.4 Justification of the study

Fish tank effluent is known to contain a variety of macro and micronutrients essential for plant growth, including nitrogen, phosphorus, potassium, and trace elements. By determining and quantifying the mineral nutrient composition of fish tank effluent at different concentrations, this research will be in position to provide insights into how those nutrients can enhance growth, yield and gross margin of the bulb onion, a widely consumed vegetable that is rich in compounds beneficial for human health. Utilising fish tank effluent in bulb onion production can also mitigate the environmental impacts associated with both aquaculture waste disposal and synthetic fertiliser use which harm harmful organisms in the soil.

1.5 The Scope of the Study

This study involved tilapia fish effluent collected from concrete fish tank ponds at Kyambogo University. The study was limited to analysis of physico-chemical properties of fish tank effluent at the concentrations of 0, 100, 200, and 400 ml/L of the effluent. Also assessed was the effect of the fish tank effluent concentration on growth and yield of the bulb onion. Gross margin of bulb onion grown under open field treated with varying concentrations of fish tank effluent was also determined.

1.6 Significance of the Study

This study intended to address the knowledge gap especially limited information on physico-chemical properties of fish tank effluent and its effect on growth and yield of the bulb onions. The findings of the current study will be useful to aquaculture farmers who may reap from the effluent as a bio-fertiliser to bulb onion farmers.

Farmers will also benefit directly by accessing a cheaper source of bio-fertilizer, moreover, which is safer to the environment than the artificial fertilizers. Researchers will utilize findings from this study in formulating new research ideas for improving agricultural productivity. Finally, policy makers will be able to use the findings of the study to support the development of further research and extension programs on the use of fish tank effluent concentration in the production of bulb onion.

CHAPTER TWO

LITERATURE REVIEW

2.1 Importance of Onion, *Allium cepa*

Bulb onions are one of the most important vegetable crops grown worldwide and have a significant economic impact on the agricultural industry. They are a major cash crop for many farmers and contribute to the local and global economy through production, distribution, and trade (Ekşi *et al*., 2018). Bulb onions are used in a wide range of dishes, including soups, stews, salads, sauces, and raw preparations. Onions add flavor, aroma, and texture to dishes and they are used for their culinary versatility and ability to enhance the taste of other ingredients (Li *et al*., 2020). Bulb onions are a good source of essential nutrients, including vitamins (C and B-complex), minerals (potassium, phosphorus, magnesium), and dietary fiber. They also contain phytochemicals such as flavonoids and sulfur compounds that have antioxidant, anti-inflammatory, and health-promoting properties (Augusti, 2020). Mahmood *et al*. (2021) study revealed that bulb onions contains bioactive compounds which improves on the health of human beings through improving cardiovascular health, reduced risk of chronic diseases for example (cancer and diabetes), and enhances immune function.

2.2 Production Constraints of Onions

Pest infestations and disease outbreaks are significant constraints on bulb onion production. Common pests affecting onions include thrips, onion maggots, and nematodes, while diseases such as downy mildew, bacterial rots, and fusarium can cause yield losses and quality deterioration (Anik and Salam, 2015). Poor soil drainage, high salinity, and nutrient deficiencies can limit onion growth and development. Furthermore, unfavorable weather affects bulb formation and overall crop output, including dryness, severe rainfall, and temperature variations (Dumitru *et al*., 2023). Weed pressure is a common constraint in onion fields, as competition for nutrients, water, and light can reduce onion yields and quality (Ayinde and Obalola, 2017). Improper post-harvest handling and storage practices can lead to significant losses in bulb onion quality and quantity. Factors such as mechanical damage, storage temperature, humidity levels, and disease development can impact the shelf life and marketability of harvested onions (Emana *et al*., 2017). Limited market access, price variability, poor infrastructure such as potted roads in rural areas limit transportation of yield onions to the market, poor pricing strategies, and market demand can affect the economic sustainability of onion farming operations (Miassi *et al*., 2018).

2.3 Status of soil fertility and fertiliser use in Uganda

Raimi *et al*. (2017) soil fertility in Uganda is declining due to continuous cultivation, poor farming practices, and limited use of organic and inorganic fertilisers thus limiting crop production on a large scale. Bationo *et al*. (2020) indicated that smallholder farmers in Uganda face challenges in accessing affordable and quality fertilisers. Limited knowledge about appropriate fertiliser use and application methods among farmers also contributes to low fertiliser adoption rates in the country. The Ugandan government has implemented several initiatives to promote sustainable soil fertility management and increase access to fertilisers for smallholder farmers. The National Agricultural Advisory Services (NAADS) program and the National Fertilizer Policy aim to enhance soil fertility and boost agricultural productivity through improved fertiliser use (Kasimbazi, 2020). Research institutions and agricultural extension services in Uganda, such as the National Agricultural Research Organization (NARO) and the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), play a crucial role in providing technical support, training, and advisory services to farmers on soil fertility management and fertiliser use. Masso *et al*. (2017) study revealed that despite the challenges related to soil fertility and fertiliser use in Uganda, there are opportunities for sustainable intensification and increased agricultural productivity. Integrated soil fertility management approaches, use of organic inputs, and targeted fertiliser subsidies for smallholder farmers are some of the strategies that can help address these challenges.

2.4 Safety of fish tank effluent for fertilizer use

Fish pond effluent is rich in nutrients such as nitrogen, phosphorus, and potassium, which can enhance soil fertility and crop productivity (Green, 2022). Chiquito-Contreras *et al*. (2022) study revealed that fish pond effluent as fertilizer contains heavy metal contamination such as lead, mercury, and cadmium which can adversely affect soil quality and crop safety. Fish pond effluent contains microbial pathogens such as bacteria, viruses, and parasites which is harmful to soils, posing a risk to crop quality and human health if not properly managed (Abd-Elmaksoud *et al*., 2021). The discharge of fish pond effluent into water bodies or onto agricultural fields can lead to eutrophication, water pollution, and soil degradation. Proper management practices, such as nutrient monitoring, effluent treatment, and application guidelines, are essential to minimize the environmental impact of using fish pond effluent as fertilizer (Kumar *et al*., 2014). Jana *et al*. (2018) study revealed that effective regulation and monitoring of fish pond effluent use in agriculture are crucial for ensuring the safety and sustainability of this practice. Government policies, guidelines, and quality standards for fish pond effluent as fertilizer should be developed and enforced to protect human health, soil quality, and the environment.

2.5 Intensive aquaculture systems and waste water effluent

According to Leal *et al*. (2016) the intensive fish culture system involves stocking fish at a high density and feeding them just a meal that is nutritionally balanced to suit their nutrient needs. Quality fish feeds are essential to the success of intensive aquaculture because they affect both fish development and, to some extent, bacterial growth in the system (Jambo *et al*., 2019). The scarcity of water, land, and labor resources are major factors in increasing intensive fish farming system (Kaleem *et al*., 2021). The need for quick production of market-sized fish to meet the demand of an increasing population in African countries has contributed to development of intensive fish farming system (Soliman and Yacout, 2016c). The cages range in size from little ones of about $32m^3$ to bigger ones of about $600m^3$. Rural areas also employ smaller cages (2-4 m^3) hung in drainage canals (Mehrim *et al*., 2016). Intensive aquaculture can produce many fish in a small amount of space, but it seldom happens without effective fish seed production (Soliman and Yacout, 2016b).

2.6 Physico-chemical proprieties of fish farm effluents

Several studies have been conducted on the physico-chemical properties of fish farming effluents including pH, EC, TDS, TSS, among others (Omeir *et al*., 2019c; Makori *et al*., 2017; Leal *et al*., 2018). For instance, from a study by Onuorah *et al*., (2022), the mean pH (5.62) of the effluent sample was reported to be relatively lower than that of the unpolluted soil (6.20). According to Kabeto *et al*., (2020) findings revealed that the pH effluent sample was higher than that of unpolluted soil. However, the desirable pH range for fish tank effluent is 6.5 – 9.5 while the acceptable range is 5.5 – 10.0 (Cristóvão *et al*., 2015).

Electrical conductivity is an indicator of water quality and soil salinity. Onuorah *et al*. (2022) reported that the conductivity value of the fish effluent was higher than unpolluted soil. The total dissolved solids, were higher in fish pond effluent sample 21.18 mg/l than unpolluted water (2.12 mg/L) (Onuorah *et al*., 2022). Rodrigues *et al*. (2019) reported that farmers use feeds to supplement pond nutrients which increase total dissolved solids. The total suspended solids of the effluent sample (20.50mg/l) was higher than unpolluted soil (1.76 mg/L). Coldebella *et al*. (2017) reported that the accumulation of low biological oxygen demand results in organisms to be stressed and suffocated, hence increasing the total suspended solids (Anyanwu and Solomon, 2015).

Nitrate is the final product of the biological oxidation of ammonium with oxygen into nitrite followed by the oxidation of these nitrites (Maia and Moura, 2014). It is among the essential nutrients needed for the growth of plants. Fish effluent has high total nitrogen for high production of vegetables (Onuorah *et al*., 2022). The same study revealed that the mean phosphate value was higher in the effluent sample than the unpolluted soil (Onuorah *et al*., 2022).

For plants to flourish, soil must contain a moderate amount of nitrogen; however, too much nitrogen reduces plant growth and production (Najera *et al*., 2015). According to the study's findings, total nitrogen levels in the soil after fish pond wastewater deposits ranged between 1.26 and 2.10 g/kg, while levels in control soil samples used by farmers ranged between 0.95 and 1.11 g/kg, with values between 6.86% and 7.73%. Najera *et al*. (2015) study revealed that the amount of nitrogen found in the soil may have come from fish meals as well as other sources, including bacteria and feces present in the ponds. When deposited on the soil, this nitrogen would have a direct impact on soil fertility. Fish effluent sediment contain higher concentration K and organic matter which is essential for growth and yield of plants (Goggin, 2022). Fish effluent is rich in potassium which improves on soil fertility for crop production (Omeir *et al*., 2019).

2.7 Effect of fish tank effluent on growth of the bulb onion

Kaab *et al*. (2020) noted that fish pond effluent provides water requirement of plants and also improves the availability of nutrients in the soil which in turn increases all plant growth parameters unlike places where it has not been applied (Metwally, 2021). In order to provide the nitrogen that plants need for growth, soil and fertilizer supplies can be mixed (Coelho *et al*., 2019). The study by Akindele *et al*. (2022) indicated that sweet pepper grown in plots treated with fish pond effluent resulted into highest percentage of leaves, stem girth, biomass, sweet pepper production, root weight, and leaf area compared to zero application.

Leaf area is directly related to the amount of light that can be intercepted by plants. It is an important variable. Leaf Area is crucial to theoretical production ecology since it is used to forecast photosynthetic primary production, evapotranspiration, and crop growth. Leaf area and light interception have been found to have an inverse exponential relationship that is linearly related to the primary production rate (De Mattos *et al*., 2020). Leaf area is seasonal and varies with plant activity, with the maximum leaf area occurring in spring during leaf production and the lowest leaf area occurring in late summer or early fall during leaf senesce and potential shading Guli *et al*. (2015). Application of highest volume of effluent produced the highest yield of lettuce when compared to the lowest amounts. This proved that applying fish pond water to plants during growth directly boosts the development of the leaf area of onion plants. Increased photosynthesis occurring across a greater leaf area is the cause of this (Fruscella *et al*., 2023c). Kaab *et al*. (2020) revealed that fish effluent increases fresh and dry weight of shoot and roots thus a high biomass of vegetables like onion, leaf numbers and stem height of onions. It also improves soil quality, reduce environmental pollution and reduces usage of ground water contamination (Zohry *et al*., 2022). Fish effluent contains high nutrients which enhanced highest biomass of lettuce (Fruscella *et al*., 2023).

2.8 Effect of fish tank effluent on yield of the bulb onion

When crops are watered with fish effluents, previous studies have shown a considerable improvement in crop yields as well as an increased water usage efficiency (Abdelraouf, 2017). Metwally *et al*. (2021c) study revealed that fish effluent increased fresh and dry yields of onion. Similar results were observed by Limbu *et al*. (2017) for Chinese cabbage, which yielded 80% more with fish effluent irrigation than under conventional farming. Additionally, Coldebella *et al*. (2017) reported that using aquaculture for plant irrigation increased tomato yield parameters from while using well (ground water) for plant irrigation resulted in lower yield. Gebretsadik and Dechassa (2016) revealed that application of farm yard manure at a high rate resulted into the highest harvest index compared to control. Soliman *et al*. (2020) reported that the application of fish pond water increased the yield of bulb onions. Omeir *et al*. (2019) reported that the application of fish pond water also increased the growth rate and improved the quality of garden purslane, sweet basil, radish, and cucumber crops. Additionally, using fish pond water as a source of fertilizer results in increased yields of fresh lettuce leaf (Maucieri *et al*., 2019).

2.9 Effect of fish tank effluent on Gross Margin of bulb onion plants

Gross margin percentage is total revenue minus total variable costs and multiplied by one hundred (Nariswari and Nugraha, 2020). Ammattikorkeakoulu, (2015) stated that gross margin represents a percentage on how much a company gains from total sales revenue after the production costs have been deducted. The higher gross margin percentage, the more the company gains from each sales towards its other costs (Von Bach and Kalundu, 2020). Khatun *et al*. (2022) noted that poultry manure produced the highest yield thus highest gross return compared to zero application. Getu *et al*. (2017) noted that fish effluent can be used in the production of onions hence reducing the cost of artificial fertilizer as well as managing the farming with less amount of water, thus high gross margin. In Egypt, a study by Abdel *et al*. (2018) revealed that fish pond water as the sole source of fertilization rather than chemical fertilizers significantly increased average net income of onion, estimated at about U$ 662.49/ha.

2.10 Limitations of the reviewed literature and knowledge gap

Most studies reviewed on mineral nutrient composition of fish tank effluent and its effect on growth and yield of bulb onion showed significant effect. However, there are no studies that have been done on the mineral nutrient composition of fish tank effluent and its effect on growth and yield of bulb onion Secondly, fish tank effluent as a biofertiliser is not common on Ugandan markets and some other African countries. Besides that, most studies have concentrated on use of artificial fertiliser such as NPK in the production of bulb onion. These inorganic fertilisers negatively affects important soil living organisms such as earth worms in soils and causes toxicity of soil thus causing low soil productivity hence low production of bulb onion. Lastly, inorganic fertilisers also increase the cost of production among onion farmers. Despite high nutrient content in the fish tank effluent, the failure to utilize it in appropriate quantities lead to low expected yields of bulb onions. Therefore, the study sought to establish the appropriate quantities/ crop specific rates of fish tank effluent for onion production and gross margin for each application rate.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental site / Study area description

The field experiment was conducted at the Kyambogo University farm (Latitude: 0.348485/N 0^0 20’ 54.547’’ and Longitude: 32.633384 / E 32^0 38’ 0.18’’) for two trials; first trial (October to December 2022), and second trial (March to May 2023). Table 3.1.1 presents the physico-chemical properties of soil at the experimental site determined from the soil samples following the procedure described by Apori *et al*. (2021), with slight modification.

Table 3.1: Physico-chemical properties of soil at the experimental site at the onset of the two trials of the study

Parameter	Trial One	Trial Two
N (%)	0.09	0.07
P (%)	0.10	0.10
K (%)	0.00	0.01
Sand (%)	24	26
Silt (%)	29	25
Clay (%)	30	27
Textural Class	Clay loam	Clay loam

3.2 Experimental treatments and research design

The study was conducted through two trials; Trial One (October to December, 2022) and Trial Two (March to May, 2023). For each trial, the experiment had four treatments of varying fish tank effluent concentrations: 0, 100, 200 and 400 ml/L. The 0ml/L treatment, which was tap water only served as control. Following the procedure by Gebremichael *et al*. (2017), a Randomized Complete Block Design (RCBD) with six replicates was used (Plate 1). Each experimental plot measured 2 x 3m ($6m^2$) and the distance between plots was 1m. Onion seedlings were planted at a spacing of 15 x 40 cm. Each plot had four rows and a total of 60 plants. Five liters from each fish tank effluent concentration was loaded in a watering can and applied per plot at an interval of two days for twelve weeks after transplanting.

Plate 1*: Layout of the experimental field*

3.3 Data collection methods

3.3.1 Determination of physico-chemical properties of the experimental fish tank effluent

3.3.1.1 Collection of effluent samples

Fish tank effluent (Plate 2) was collected by using a 5L bucket and dispensed to fill a sterile 20L Jerry cans. The effluent was then diluted with tap water into three concentrations of 100, 200, and 400 ml/L to reduce excessive concentration of physico-chemical properties such as nitrogen, phosphorus, potassium, EC, TDS, TSS and pH in the effluent. This could help in formulating the appropriate standards of fish tank effluent with essential nutrients for bulb onion production.

Samples of the diluted effluent were taken to the Biology Laboratory, Kyambogo University and duplicated into three replications for analysis of pH, EC, TDS and TSS. The three replicates per effluent sample and soil were taken to NARO's National Agricultural Research Laboratories (NARL), Kawanda for analysis of N, P and K. Tap water was included to serve as the control.

Plate 2*: Fish Tanks at Kyambogo University Farm (A) and the Reservoir where Fish Tank Effluent was collected (B)*

3.3.1.2 Determination of Nitrogen (N), Phosphorus (P) and Potassium (K) in the experimental fish tank effluent

Nitrogen (N): This was determined using the method by Kjeldahl (1883) Kirk, (1950). A 5ml portion of each fish tank effluent concentration and tap water (control treatment) was measured and added into a digestion tube. To each of the digesting tubes, a Kjeldahl catalyst tablet was added, including the blanks and followed by 5ml of concentrated sulphuric acid. The digestion tubes were placed onto the block digester and temperature raised gradually from room temperature to about 330^{o}C for 6 hours to avoid overly violent reaction and to allow water to be driven off from the digestion mixture. A typical heating sequence at 200^{o}C for 30 mins, 250^{o}C for 30 mins and 350^{o} for 1 and 30mins for the reaction of the digestion time.

The digestion tubes were allowed to cool, shaken, until no more sediment was dissolving. The tubes were further allowed to cool as the acidic digestion solution would absorb ammonia from the air and cause errors. Deionized water was added after the digest had been transferred to 50ml volumetric cylinders. Digest of 10mls measured and then distilled using a mark ham distillation apparatus. Forty percent (40%) of NaOH solution was used and 4% of Boric acid solution was also used to collect the ammonia generated from the distillation process. Normal HCl solution of 0.02N was titrated to get volume of NH^{+} generated in (cm^{3}). The amount N in the sample was then derived as:

N% = (V1-V2) x N x F X 0.014 x 100/S

Where; V1 = Titre for sample (ml)

V2 = Titre for blank (ml)

N= Normality of standard HCl solution (0.02)

F= factor of standard HCl solution (1.5)

S = Measurement of sample taken (5 ml)

Phosphorus (P): Using U-Vis- spectrophotometer**.** Digest of 1ml was calibrated for reading with U-Vis to get concentration of P and converted to % P.

Potassium: A flame photometer was determined following the procedure by (Rhoades, 1983). Digest of 1ml was calibrated for reading in the flame photometer to get concentration of potassium and was converted to percentage % (K).

3.3.1.3 Determination of pH, Electrical conductivity, Total Dissolved Solids, and Total Suspended Solids of the Experimental Fish Tank Effluent at varying concentrations

pH: Following procedures by Uysal *et al*. (2019), the pH was determined in fish effluent concentrations using Mettler Toledo meter (Mettler Toledo Co., Switzerland). The pH meter while using pH buffers of 4.0 and 7.0. Effluent concentration sample was introduced into a sterile beaker to the required mark, the meter was switched on and left for few minutes to stabilize and the electrode was lowered into the sample thereafter, the steady value of the meter was recorded as the pH of the sample.

Electrical conductivity (EC): Following the procedure by Uysal *et al*. (2019), the EC was determined using Mettler Toledo meter. A sample of fish tank effluent concentration sample was poured into a beaker to the required mark. The meter was switched on and left for few minutes to stabilize. The electrode was then lowered into the sample and monitored, after which the steady value of the conductivity meter was recorded.

Total Dissolved Solids (TDS): Following procedure by Onuorah *et al*., (2022) as described by (APHA, 2005). Whitman filter paper was used to filter the well-mixed sample.100ml of each fish tank effluent concentration was transferred into a weighed evaporating dish and evaporated to dryness on a steam bath. The evaporated sample was dried for one hour in an oven at 180^oC. It cooled in a desiccator and reweighed. The amount of Total dissolved solids (TDS)

TDS (mg/l) = (A-B/C) x1000

Where A = weight of dried residue + dish; B = weight of dish; and C = volume of filtrate used.

Total Suspended Solids (TSS): Following procedures by Onuorah *et al*. (2022) as described by (APHA, 2005), Clean, dried conical flasks were ignited at 105^oC for 30 seconds in an oven, allowed to cool, weighed and kept. Each of the effluent sample was measured into each of the weighed conical flasks and evaporated to dryness in an oven. They were allowed to cool and then re-weighed. The amount of Total suspended solids (TSS) in the sample was computed as follows:

TSS (mg/l) = (A-B/mL sample) x1000

Where A = weight of flask+ dried residue (mg); and B = weight of flask (mg)

3.3.2 Effect of Fish tank Effluent on Growth and Yield of the Bulb Onion

3.3.2.1 Seedling establishment, field preparation and crop management

Following procedure described by Gebremichael *et al*. (2017), onion seeds were sown in a nursery bed on a well-prepared seedbed and all recommended management practices were applied as required until they were ready for transplanting after six weeks into the experimental field. The first planting trial was conducted from October to December, 2022 and second trial (March to May 2023).

The field was slashed by using slashers and demarcated using a tape measure, strings and pegs. Primary cultivation was done with a hand hoe to remove weeds and open the soil. Secondary cultivation followed by using a hand hoe to break hard soil clods, remove weeds and levelling of the soil. Weeding was carried out whenever necessary. The experimental field was enclosed by strings and red taps were attached to scare away monkey pests.

3.3.2.2 Growth Parameters

Growth parameters were assessed following the procedure by Dwamena *et al*. (2023) with slight modification. Five onion bulb plants were randomly sampled in each experimental unit for data collection on the different parameters, measured and recorded by using a pen in an organised data book at two-week intervals until physiological maturity. They included, plant height, number of leaves, leaf length, leaf width, leaf diameter and biomass. Leaf area was computed as a derivative of leaf length and width.

(i) **Plant height:** This was measured in centimeters (cm) using a ruler from the soil surface to the top of the longest leaf (Plate 3).

Plate 3*: Data collection on Plant Height*

(ii) **Number of leaves:** Leaves per plant were counted and recorded in a data book

(iii) **Leaf Length:** of the longest leaf: This was measured from the base to its apex,

(iv) **Leaf diameter:** which is the highest diameter of the longest leaf was measured using a Vernier caliper.

(v) **Biomass:** This was obtained by weighing fresh weight of the bulb onion plant through using an electronic weighing scale.

(vi) **Leaf area (LA):** This was computed following procedure by Juan *et al*. (2013) as per the following formula:

LA = 0.837 (Length x width)

Where 0.837 is the correction factor.

Rate of senescence: Loss in leaf number of onion plants was counted and recorded at an interval of two weeks

3.3.2.3 Yield Parameters of Onions (Bulb based parameters)

(i) **Bulb length** of five randomly selected bulb onions from each experimental unit per treatment was measured using a meter ruler and data was recorded using a pen in an organized data book.

(ii) **Diameter of the bulb** was measured on randomly selected bulb onions from each experimental unit per treatment using a Vernier caliper and data was recorded in an organized data book using a pen.

(iii) **Bulb weight** was measured by weighing randomly five selected bulbs of onions from each experimental unit per treatment and weighed using a digital electronic balance (Plate 4) and results obtained were extrapolated to yield per hectare following Mohanty, (2017) procedure.

Plate 4*: Weighing bulb onions*

(iv) **Harvest index** was measured as a ratio of selecting randomly five dry bulbs weight to total dry biomass yield per plant as described by (Fruscella *et al*., 2023b).

3.3.3 Determination of the gross margins of bulb onions grown under fish tank effluent

The gross margin was determined following the procedure described by (Munezero *et al*. 2023). Whereby: Gross margin (GM) = Gross Income (A) minus Total Variable Costs (B). The gross income was calculated through multiplying total output by survey market price, while total costs were obtained by addition of total variable costs which included 4kg of seeds, different concentrations of fish tank effluent, and labour for all activities of the research project. Gross margin was converted into percentage for each trial (A-B) x 100% (Nariswari and Nugraha, 2020).

3.5 Statistical Data Analysis

During data analysis; physico chemical properties of fish tank effluent concentration, were subjected to Shapiro-Wilk test for Normality according to Ghasemi and Zahediasl (2012)., EC, pH, TDS, TSS, N, P, K, Plant height, number of leaves, leaf Area, Senescence, Biomass, bulb height, bulb diameter, yield and harvest index, skewed positively. In order to check for homogeneity, the data were converted to log base ten and then examined individually for the first and second trials using the Barlett test (Barlett, 1937). Thereafter data for all trials was imported into Genstat 2015 version using importer wizard then statistically one-way Anova was run to compare means of fish tank effluent concentration, effect of fish tank effluent concentration on growth and yield of bulb onion. Means were Separated by using LSD at 5% level of significance. Finally, the gross margin was calculated and converted into percentage by use of Microsoft recorded in table using micro soft excel version 2017.

CHAPTER FOUR

RESULTS

4.1 Physico-chemical properties of fish tank effluent

Generally, fish tank effluent concentration significantly ($P < 0.05$) influenced presence of average pH, EC, TDS and TSS (Table 4.1). The highest pH was recorded in the control treatment which was tap water (0ml/L effluent concentration) while the lowest was recorded in 400 ml/L. The mean EC varied among treatments and increased with increasing concentration corresponding to the treatments of 0 ml/L and 400 ml/L, respectively (Table 4.1). On the other hand, Fish tank effluent also significantly ($P < 0.05$) affected N, P and K. The highest concentration of Nitrogen, potassium and phosphorus was observed in 400 ml/L and the lowest in 0ml/L (Table 4.2).

Table 4.1: **Physico-properties of fish tank effluent at different concentrations**

Effluent Concentration (ml/L)	**Physico-chemical properties**			
	pH	**EC (µS/cm)**	**TDS (mg/L)**	**TSS (mg/L)**
0	8.49 ± 0.06^{c}	191.30 ± 0.06^{a}	125.58 ± 0.16^{a}	200.33 ± 0.11^{a}
100	7.63 ± 0.03^{b}	222.33 ± 0.33^{b}	147.33 ± 0.12^{b}	1066.67 ± 88.19^{b}
200	7.49 ± 0.11^{b}	264.33 ± 0.33^{c}	175.33 ± 0.12^{c}	2133.33 ± 33.33^{c}
400	6.56 ± 0.30^{a}	559.00 ± 0.00^{d}	368.33 ± 0.33^{d}	5033.33 ± 33.33^{d}
P. Value (5%)	0.001	0.001	0.001	0.001
D.F	3	3	3	3
LSD	0.538	0.774	0.746	163.059

Means within a column with the same letter are not significantly different at 5% Fisher's protected L.S.D

Table 4.2: Mean concentration of N, P and K of the different concentrations of experimental fish tank effluent

Effluent Concentration (ml/L)	N (%)	P (%)	K (%)
0ml	0.02 ± 0.01^{a}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}
100ml	0.02 ± 008^{ab}	0.03 ± 0.01^{ab}	0.04 ± 0.01^{ab}
200ml	0.38 ± 0.09^{b}	0.04 ± 0.01^{b}	0.06 ± 0.01^{bc}
400ml	0.43 ± 0.09^{b}	0.06 ± 0.01^{c}	0.08 ± 0.01^{c}
P.Value	0.027	0.003	0.007
D.F	3	3	3
L.S.D (5%)	0.258	0.020	0.034

Means within a column with the same letter are not significant different at 5% Fisher's protected L.S.D

4.2 Effect of fish tank effluent Concentrations on growth of the bulb onion

Plant height: Fish tank effluent concentration did not significantly ($P > 0.05$) affect mean bulb onion plant height in all weeks after transplanting (Figure 1). Generally, mean plant height in all fish tank effluent concentrations increased exponentially from 2 WAT to 10 WAT. From the 10 WAT mean plant height in plants treated with 200ml/L decreased in other effluent concentration increased at a decreasing rate up to the final week (12WAT) (Figure 1). At the final week after transplanting (12 WAT), the highest mean plant height was observed in onion bulb plants treated with 400ml/L of fish tank effluent concentration while the lowest was obtained in 0ml/L (Figure 1).

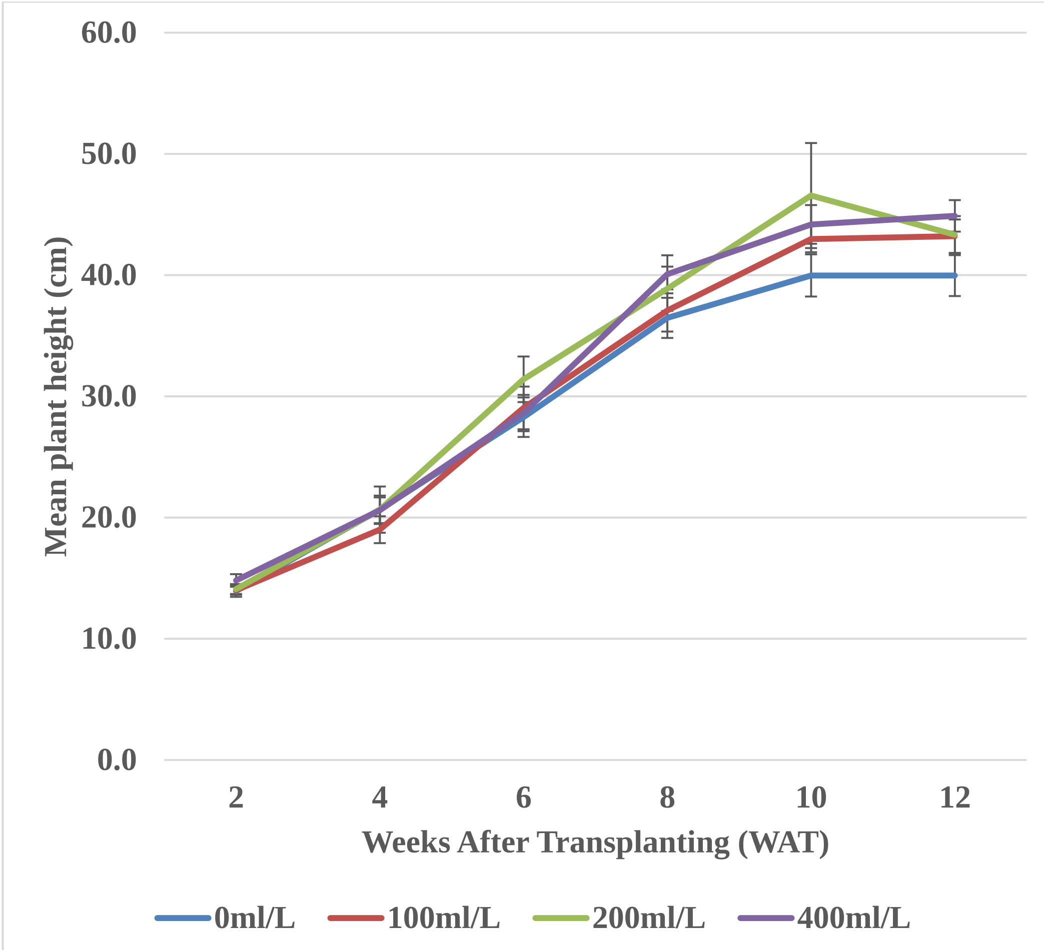

Figure 1: *Mean height of bulb onion plant under different fish tank effluent concentration over a twelve-week period after transplanting. (2WAT; P = 0.469, LSD = 1.219; 4WAT P = 0.752, LSD = 3.580; 6WAT P = 0.402, LSD = 3.975; 8WAT P = 0.273, LSD = 4.051; 10WAT P = 0.316, LSD = 7.016; 12WAT P = 0.073, LSD = 3.764)*

Number of Leaves: Fish tank effluent concentration did not significantly ($P > 0.05$) affect average number of leaves at all sampling accessions at 2, 4, 6, 8, 10 and 12 WAT (Figure 2). Generally, mean number of leaves increased steadily from 2 to 10 WAT. After 10 WAT, it continued to increase but at a decreasing rate in onion plants treated with 200 ml/L and 0ml/L. On the other hand, the mean number of leaves started decreasing in plants treated with 100 ml/L after the 10 WAT 400 ml/L (Figure 2). The highest mean number of leaves was recorded in plants treated with 200 ml/L and the lowest was in 0 ml/L at 12 WAT (Figure 2).

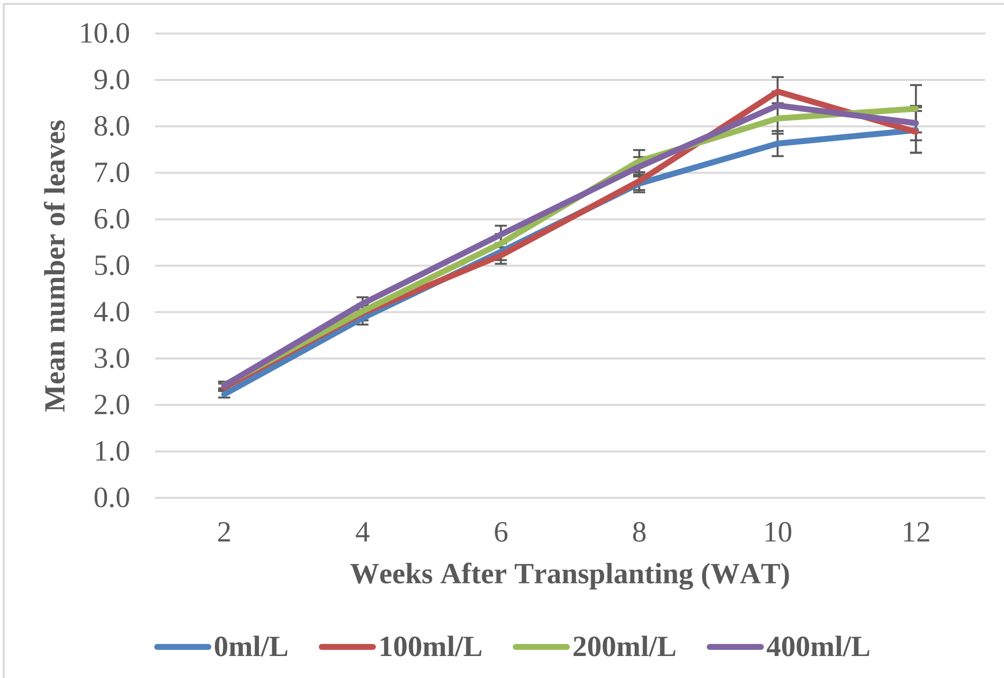

Figure 2: *Mean number of bulb onion Leaves under different fish tank effluent concentration over a twelve week period after transplanting. (2WAT; P = 0.190, LSD = 0.201; 4WAT P = 0.439, LSD = 0.383; 6WAT P = 0.232, LSD = 0.465; 8WAT P = 0.200, LSD = 0.529; 10WAT P = 0.046, LSD = 0.804; 12WAT P = 0.849, LSD = 1.228)*

Leaf Area: Fish tank effluent concentration did not significantly ($P < 0.05$) affect mean leaf area in all weeks after transplanting. Generally, mean leaf area of bulb onion plants increased steadily from the time of data collection (2 WAT) up to 10 WAT (Figure 3). Mean Leaf area under bulb onion plants treated with 100ml/L decreased while in other effluent concentration increased at low rate up to final week after transplanting (12WAT). At the final week (12 WAT), the highest mean leaf was observed in plots treated with fish tank effluent concentration of 400 ml/L and the lowest was obtained in 0ml/L (Figure 3).

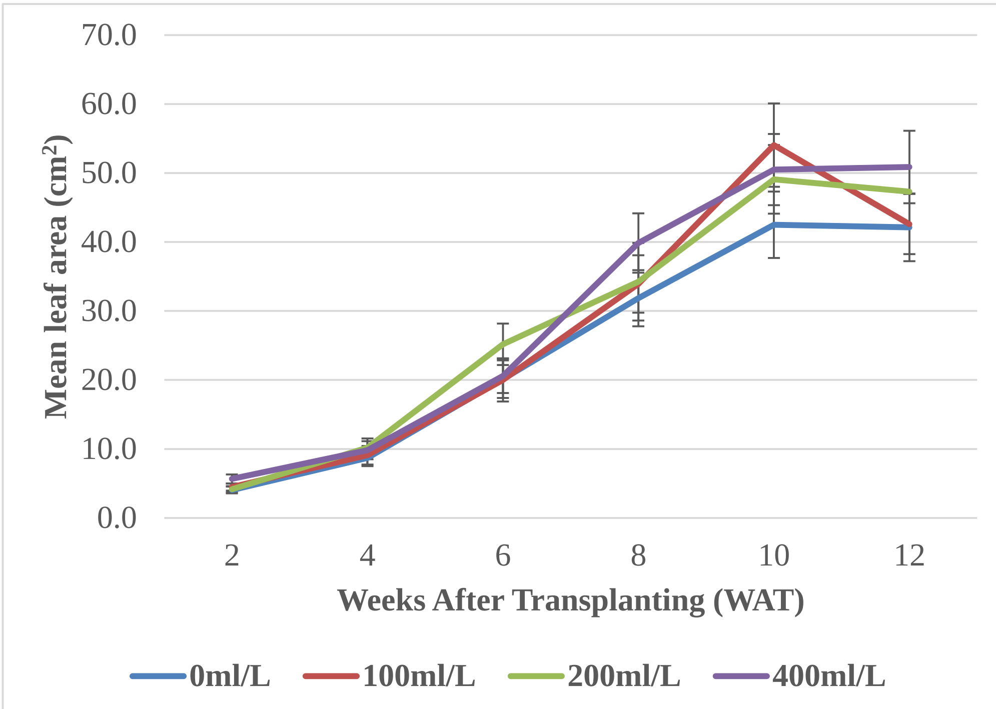

Figure 3*: Mean Leaf Area of bulb onion under different fish tank effluent concentration over a twelve week period after transplanting. (2WAT; P = 0.120, LSD = 1.470; 4WAT P = 0.82, LSD = 3.430; 6WAT P = 0.436, LSD = 7.233; 8WAT P = 0.473, LSD = 0.10.417; 10WAT P = 0.423, LSD = 13.892; 12WAT P = 0.474, LSD = 12.63)*

Senescence: Fish tank effluent concentration significantly ($P < 0.05$) affected mean senescence at 4WAT while a non-significant ($P > 0.05$) effect in 2, 6, 8 and 12 WAT (Figure 4). There was unstable relatively constant mean senescence of leaves from

2 to 8 WAT. After the 8 WAT, mean senescence increased rapidly up to 10 WAT in all concentrations of fish tank effluent concentration. From the 10 WAT to the final week (12 WAT) mean senescence in onion bulb plants treated with 100ml/L and 0 ml/L decreased at a low rate. There was a low increase at a decreasing rate of mean leaf senescence in onion bulb plants treated with 400ml/L and 100ml/L (Figure 4). The highest mean senescence of leaves was observed in plots treated with 400 ml/L while the lowest was seen in 0ml/L (Figure 4).

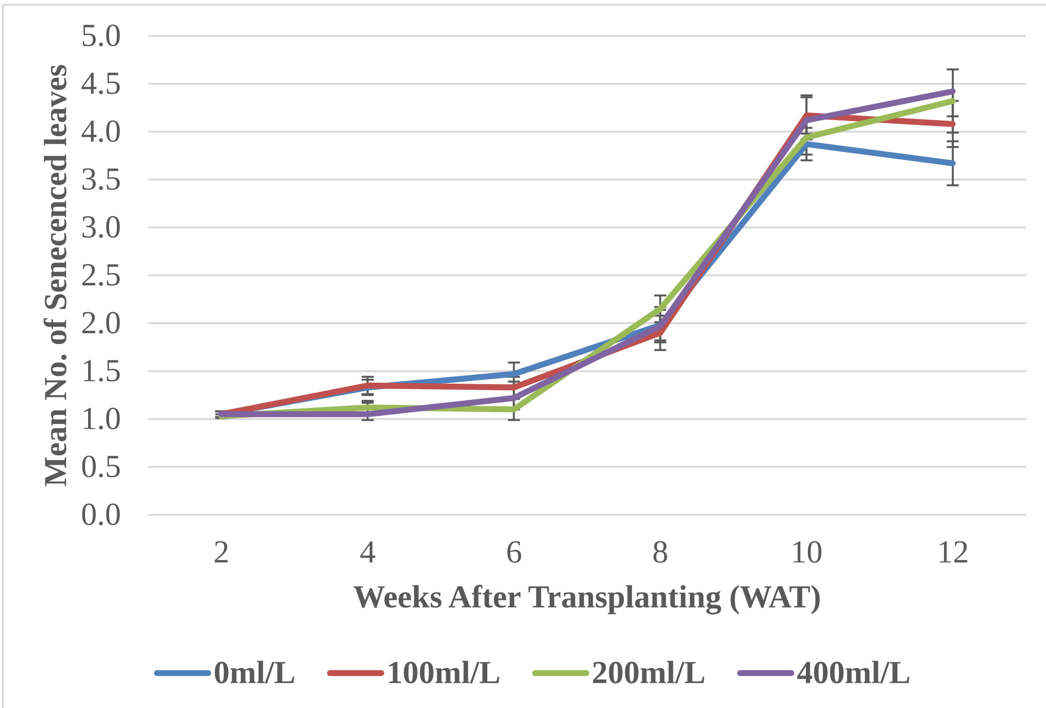

Figure 4: *Mean Leaf Senescence of bulb onion under different fish tank effluent concentration over a twelve-week period after transplanting. (2WAT; P = 0.964, LSD = 0.076; 4WAT P = 0.009, LSD = 0.214; 6WAT P = 0.123, LSD = 0.314; 8WAT P = 0.738, LSD = 0.457; 10WAT P = 0.596, LSD = 0.500; 12WAT P = 0.170, LSD = 0.715)*

Biomass: Fish tank effluent concentration affected mean biomass significantly ($P < 0.05$) in the 2 WAT but not significant ($P > 0.05$) in the 4, 6, 8, 10 and 12 WAT (Figure 5). Generally, mean biomass of bulb onions increased rapidly from 2 WAT up to 10 WAT in all concentrations while mean biomass for plants treated with 100 ml/L and 200 ml/L increased gradually from 2 WAT up to 10 WAT. From the 10 WAT, mean biomass in plots treated with 100ml/L increased at a decreasing rate while in other concentrations it kept on increasing steadily up to the final week 12 WAT (Figure 5). At the final week (12 WAT), the highest mean biomass was obtained in bulb onion plants treated with 200 ml/L while the lowest was obtained in 0ml/L (Figure 5).

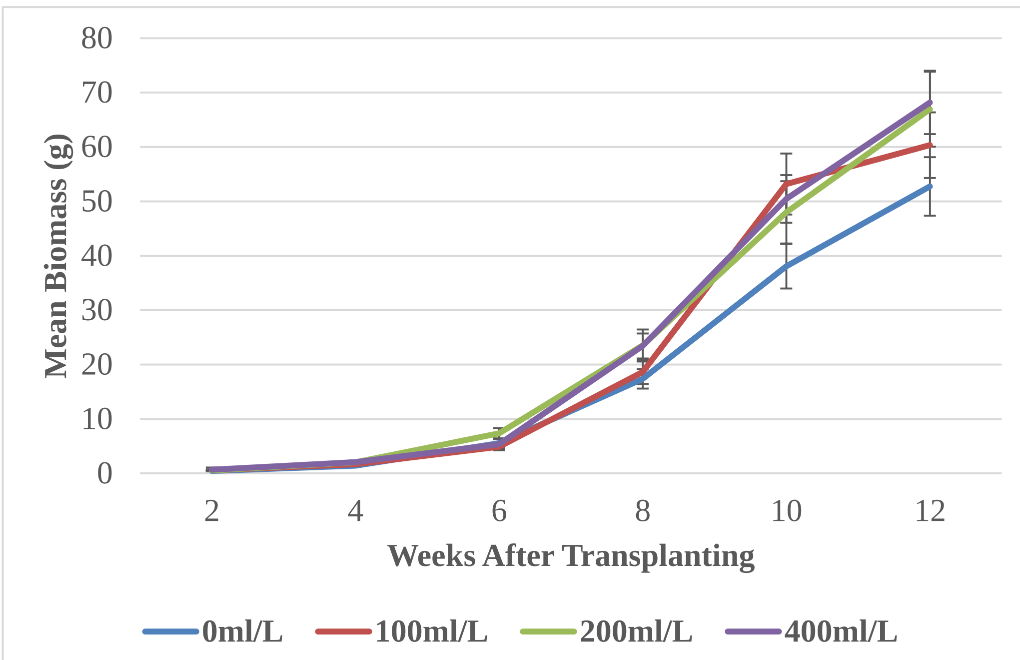

Figure 5*: Mean biomass of bulb onion under different fish tank effluent concentration over a twelve-week period after transplanting. (2WAT P = 0.005, LSD = 0.134; 4WAT = 0.173, LSD = 0.661; 6WAT P = 0.072, LSD = 1.965;*

8WAT P = 0.063, LSD =5.674; 10WAT P = 0.077, LSD = 12.063; 12WAT; P= 0.117, LSD = 14.035)

4.3 Effect of Fish Tank Effluent Concentration on yield of the bulb onion

***Bulb height*:** Fish tank effluent concentration affected mean bulb height significantly ($P < 0.05$) (Table 4.3). Mean bulb height varied among effluent concentration with the highest recorded in plots treated with 400 ml/L and the lowest in 100 ml/L (Table 4.3).

Table 4.3: Mean Bulb Height under different fish tank effluent concentrations

Effluent Concentration (ml/L)	Mean Bulb Height(± S.E) (cm)
0	5.41 ± 0.15^{a}
100	5.25 ± 0.14^{a}
200	5.52 ± 0.14^{ab}
400	5.88 ± 0.14^{b}
P. Value	0.004
Df	3
LSD (5%)	0.342

Means with the same letters within a column are not significantly different at 5% Fishers protected L.S.D

Bulb Diameter: The findings of the study revealed that fish tank effluent concentration did not significantly ($P > 0.05$) affect mean bulb diameter. Mean bulb diameter varied among effluent concentration (Table 4.4). The highest mean bulb diameter was observed in plots treated with 400 ml/L while the lowest was observed in plots treated with 100 ml/L

Table 4.4: Mean Diameter of bulb onion under different Fish Tank Effluent Concentrations

Effluent Concentration (ml/L)	Mean Bulb Diameter (± S.E) (cm)
0	6.89 ± 0.27^{a}
100	6.65 ± 0.22^{a}
200	7.09 ± 0.29^{a}
400	7.16 ± 0.28^{a}
P. Value	0.264
Df	3
LSD (5%)	0.555

Means with the same letters are statistically not significantly different at 5% Fisher's protected L.S.D

Yield: Fish tank effluent concentrations significantly ($P < 0.05$) affected mean yield of bulb onions (Table 4.5). The yield varied among effluent concentration. The highest mean bulb yield was from plots treated with 200 ml/L whereas the lowest was from plots treated with 0 ml/L (Table 4.5).

Table 4.5: Mean Yield of Bulb Onion under different Fish tank effluent Concentrations

Effluent Concentration (ml/L)	Mean Bulb Yield(± S.E)(t/ha)
0	14.49 ± 1.22^{a}
100	19.87 ± 1.38^{ab}
200	26.84 ± 0.69^{c}
400	23.73 ± 2.53^{bc}
P. Value	0.001
Df	3
LSD (5%)	4.643

Means with the same letters within a column are not significantly different at 5% Fishers protected L.S.D

Harvest Index: Findings of the study revealed that fish tank effluent concentration significantly ($P < 0.05$) affected mean harvest index (Table 4.6). Generally, mean harvest index varied among effluent concentration with the highest recorded from plots treated with 400 ml/L while the lowest from the control (Table 4.6).

Table 4.6: Mean Harvest Index (HI) obtained under different Fish tank effluent Concentrations

Effluent Concentration (ml/L)	Mean Harvest Index
0	0.60 ± 0.02^{a}
100	0.72 ± 0.05^{b}
200	0.65 ± 0.02^{ab}
400	0.69 ± 0.01^{ab}
P. Value	0.019
Df	3
LSD (5%)	0.078

Means with the same letters within a column are not significantly different at 5% Fisher's protected L.S.D

4.4 Gross margin of fish tank effluent concentrations in the production of bulb onion

Findings of the study revealed that gross margin of bulb onion plants treated with fish tank effluent concentration was above 50%. The highest gross margin was observed in plots treated with 200 ml/L while the lowest was obtained in plots treated with 0ml/L (Table 4.7).

Table 4.7: Gross margin of fish tank effluent concentrations in the production of the bulb onion

	Fish tank Effluent Concentration (ml/L)			
Description	**0**	**100**	**200**	**400**
Output (kg/)	14,490	19870	26840	23730
Price/ Kg (Ush)	2500	2500	2500	2500
Revenue (A)	**36,225,000**	**49,675,000**	**67,100,000**	**59,325,000**
Costs				
Seed 4kg @ Ush 112,000	448,000	448,000	448,000	448,000
Effluent (Ush)	0	3,000,000	6,000,000	12,000,000
Labour (Ush)	12,500,000	12,500,000	12,500,000	12,500,000
Total Cost (B)	**12,948,000**	**15,948,000**	**18,948,000**	**24,948,000**
Gross Margin / Profit = (A-B)	23,277,000	33,727,000	48,152,000	34,377,000
Gross Margin % (A-B)/A x 100%	**64.26**	**67.90**	**71.76**	**57.95**

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Physico-chemical properties of fish tank effluent

The pH in fish tank effluent concentration varied significantly. The highest (8.49 ± 0.06) pH was recorded in 0 ml/L while the lowest (6.56 ± 0.30) was registered in 400ml. Findings of the current study revealed that as effluent concentration increases, the pH decreases. According to the results, the pH of the effluent alone might have been acidic due to high concentration of ammonia from the decomposed fish droppings, remains of dead fish, rotten food which was not eaten by fish and decomposing planktons in fish tanks. Therefore, the dilution of fish tank effluent with tap water decreased the pH by making it acidic. Findings of the current study are in line with that of Cristóvão *et al.* (2015) who reported that the desirable pH range for fish tank effluent is 6.5 – 9.5 while the acceptable range is 5.5 – 10.0. on the contrary, the findings of this study were in disagreement with Kabeto *et al*. (2020) and Onuorah *et al*. (2022) noted that pH of fish effluent was higher than tap water (treatment 0 ml/L).

The electro conductivity in effluent concentration significantly varied. The highest EC (559.00 ± 0.00 µS/cm) was observed in 400 ml/L of fish tank effluent while the lowest (191.30 ± 0.06 µS/cm) was observed in 0 ml/L. The findings of the current study revealed that the highest concentration of fish tank effluent had a lot of mineral solutes compared to other concentrations. The highest EC in fish effluent could be attributed to presence of minerals released due to decomposition of dead remains of fish, fish droppings, fish feed concentrates, lime materials such as calcium carbonate and weathered stones and plant materials which were added in fish tanks as fish feeds. Therefore, as dilution of the effluent increases the electro conductivity decreases. The findings of the current study is in accordance with Onuorah *et al*. (2022) and Rodrigues *et al*. (2019) who reported that the electro-conductivity in fish effluent is due to concentration of mineral nutrients from feeds, liming materials and decomposing planktons.

The Total Dissolved Solutes (TDS): Total Dissolved Solutes in fish tank effluent concentration significantly varied. The highest (368.33 ± 0.33 mg/l) TDS was registered in 400 ml/L of fish tank effluent while the lowest (125.58 ± 0.16 mg/l) was in 0ml/L. The presence of total dissolved solutes in effluent concentrations could be due to mineral solutes from fish feeds such as concentrates which were fed on the fish and later released as droppings, also fish feed which was not consumed by the fish and settled at the ground of fish tanks. Therefore, the highest concentration of fish tank effluent had more mineral solutes compared to zero effluent. The findings of the study is in consistent with that of Onuorah *et al*. (2022), who found that the total dissolved solids in fish pond effluent were higher than in unpolluted water. Rodrigues *et al*. (2019) argued noted that farmers supplement pond nutrients with food to raise total dissolved solids.

The Total Suspended Solids (TSS) in effluent concentration significantly varied. 400 ml/L had the highest total suspended solids (5033.33 ± 33.33 mg/l) while the lowest (200.33 ± 0.114mg/l) was observed in 0 ml/L effluent concentration. The highest total suspended solids could be attributed to accumulation of organic materials from fish droppings, unconsumed food by the fish and planktons in fish tanks. Therefore, fish effluent contained organic materials which may be rich in nutrients for crop growth compared to 0 ml/L (tap water alone) with the lowest total suspended solids. The findings of the study is in support with that of Onuorah *et al*. (2022) who reported that the total suspended particles of the effluent sample were higher than those of tap water. Tiwari and Pal. (2022) reported that the suffocated and dead living organisms in pond water increase organic matter content hence an increase in total suspended solids. Anyanwu and Solomon, (2015) also reported similar findings.

Generally, all fish tank effluent concentrations and control treatment had N, P and K at varying concentrations. The highest (0.43 ± 0.09%) concentration of N was in 400 ml/L while the lowest (0.02 ± 0.01%) was in 0ml/L. The highest (0.06 ± 0.01%) concentration of P was in 400 ml/L whereas the lowest (0.01 ± 0.00%) was in 0 ml/L. The highest (0.08 ± 0.01%) concentration of K was in 400 ml/L while the lowest (0.01 ± 0.00%) was in 0ml/L. Results of the current study indicated that presence of N, P and K in fish effluent concentrations could be coming from the decomposed fish droppings, planktons in fish tanks and nutrients from fish concentrates which were supplied to fish as food.

The findings of the current study concur with that of Onuorah *et al*. (2022) who stated that fish effluent had more total nitrogen, phosphorus, than tap water. Similarly, Zhang *et al*. (2020) reported that organic fertilisers contain high levels of nitrogen that stimulates chlorophyll biosynthesis process. Relatedly, Zhang *et al*.

(2020) noted that Organic fertilisers such as vermi-compost and cow manure contain high levels of nitrogen. Findings of the current study are in line with Oni *et al*. (2013) who stated that fish pond effluent contains phosphorus. In their study, Onuorah *et al*. (2022) also found that the mean phosphate value was higher in effluent sample than unpolluted soil. The current study findings is in agreement with Goggi, (2022) who noted that fish effluent sediment contain higher concentration of potassium compared to control.

5.1.2 Effect of fish tank effluent concentration on growth of bulb onion

Plant height: The results of the current study indicated that at the final week (12 WAT), the tallest plants were recorded in plots treated with 400 ml/L while the shortest were in the control plots. The tallest bulb onion plants might be attributed to sufficient total dissolved solutes, nitrogen, and water from 400ml/L fish tank effluent concentration which is involved in the synthesis of nucleic acids and amino acids, which are necessary for cell division hence an increase in bulb plant height compared to plants treated with 0ml/L. The findings of the study is in line with Kaab *et al*. (2020) and Metwally (2021c) who noted that fish pond effluent provides water and supplies plant growth nutrients compared to places where it is not applied.

Number of onion bulb leaves: Generally, mean number of leaves did not significantly vary among effluent concentrations over time. However, mean number of leaves was highest in plots treated with 200 ml/L while the lowest was in 100ml/L fish tank effluent at the final week after transplanting. This could be attributed to readily available nitrogen and water from fish tank effluent which is involved in the synthesis of nucleic acids and amino acids necessary for cell division thus increased growth of leaves compared to sole application. Findings of the current study is in line with Kaab *et al*. (2020) who stated that fish pond effluent provides water and nutrients for growth of vegetable leaves. On the other hand, the present findings disagree with Akindele *et al*. (2022) whose study revealed that highest number of leaves were recorded in the treatment with the highest percentage of fish pond effluent.

Leaf Area: Generally, fish tank effluent concentrations did not affect leaf area of bulb onion plants significantly. At the final week after transplanting plots treated with 400 ml/L had the highest leaf area ($50.87 \pm 5.25cm^2$) and lowest ($42.12 \pm 4.91cm^2$) was obtained from 0ml/L. This could be attributed to sufficient nitrogen, which increased cell division thus increased leaf area for higher photosynthesis to take place compared to 0ml fish tank effluent leaf area. The results of the current study is in agreement with Fruscella *et al*. (2023) who noted that application of highest concentration of fishpond effluent increased leaf area development hence a large leaf area of leaves for photosynthesis.

Senescence: Mean senescence of bulb onion leaves was not significant among fish tank effluent concentration at the final week (12 WAT). Mean senescence was highest in plots treated with 400 ml/L and lowest in plots treated with 0ml/L. this implied that 4ml/L might be attributed to highest pH (6.56 ± 0.30) and total dissolved solutes (368.33 ± 0.33 m/L) which caused acidic conditions in the soil thus causing senescence of bulb onion leaves at a highest rate compared to any other effluent concentration.

Biomass: Mean biomass was not significant among fish tank effluent concentrations in all weeks after transplanting. The highest mean biomass (68.18 ± 5.82g) was obtained in plants treated with 400 ml/L of fish tank effluent and the lowest (52.75 ± 5.38g) biomass was obtained in 0ml/L respectively. This could be attributed to presence of adequate nitrogen, phosphorus and potassium in fish tank effluent concentration, which enhanced cell division and development of large and heavy bulbs hence development of highest bulb biomass. Findings of the study is in agreement with Kaab *et al*. (2020) whose study revealed that fish effluent significantly increased fresh and dry weight of shoot and roots thus a high biomass of vegetables. Zohry *et al*. (2022) noted that fish pond effluent improves soil fertility which might have caused growth of high biomass in plots treated with 400ml/L, 200 ml/L and 100 ml/L compared to 0 ml/L.

5.1.3 Effect of fish tank effluent concentration on yield of bulb onion

Bulb height: Fish tank effluent concentration significantly affected mean bulb height. The highest (5.88 ± 0.14cm) and lowest (5.41 ± 0.15cm) mean bulb onion height was observed in plots irrigated with 400 ml/L and 100 ml/L. The highest mean bulb height could be due to excess nitrogen and potassium from fish tank effluent which increased vegetative growth of leaves thus increased assimilate production and allocation to bulb height. Findings of the current study is in line with Limbu *et al*. (2017) and Jayathilake *et al.* (2002) whose studies revealed similar results that high rate of organic matter increased yield bulb components.

Bulb diameter: Mean bulb diameter was not significant among fish tank effluent concentration. The highest (7.16 ± 0.28cm) mean bulb diameter was observed in plots irrigated with 400ml/L and the lowest (6.65 ± 0.22cm) was obtained in plots treated with 100 ml/L. The highest bulb diameter in plots treated with 400ml/L could be attributed to nitrogen and potassium in effluent concentration, which increased growth of many leaves that participated in the manufacture of carbohydrates and was translocated into development of widest bulb diameter compared to other treatments. Results of the current study were in line with Soliman *et al*. (2020) who stated that high rate of farmyard manure provided growth and yield nutrients that increased bulb diameter. Limbu *et al*. (2017) in there study revealed similar results that high rate of fish pond effluent increases onion bulb diameter.

Bulb onion Yield: Mean bulb onion yield was significant among fish tank effluent concentration. The highest (26.84 ± 0.69 t/ha) mean bulb onion yield was obtained in plots treated with 200 ml/L while the lowest (14.49 ±1.22) in 0ml/L. The highest bulb onion yield could be attributed to sufficient potassium pH, EC, TDS, TSS and water from effluent concentration of 200 ml/L unlike 0ml/L had less yield nutrients thus lowest yield. The highest yield in trial two, could also be attributed to adequate yield nutrients in 100 ml/L of effluent concentration unlike 0ml/. The findings of the study is in line with Abdelraouf, (2017) whose study revealed a significant increase in crop yields when crops are irrigated with fish effluents. Metwally *et al*. (2021c) reported higher yields in Oregano in both aquaponics and hydroponics. Similarly, Coldebella *et al*. (2017) noted an increase in tomato yield when watered with fish effluent compared to zero irrigation, while Limbu *et al*. (2017) observed comparable results in barley.

Harvest Index: Fish tank effluent concentration significantly affected mean harvest index. The highest (0.72 ± 0.05) in plots treated with 100ml/L while the lowest (0.60 ± 0.02) was from 0ml/L. The highest harvest index might be attributed to sufficient essential growth nutrients especially nitrogen, phosphorus and potassium from fish effluent concentration which increased the synthesis of chlorophyll and amino acids hence resulting to more translocation of photosynthesis from leaves to bulb and causing an increase in bulb weight thus highest harvest index. The results of the study were in accordance with Gebretsadik and Dechassa, (2016) who noted that application of farmyard manure at a high rate resulted into the highest harvest index compared to control.

5.1.4 Gross margin of fish tank effluent concentrations in the production of the bulb onion

The results of the present study indicated that 200 ml/L of fish tank effluent concentration contributed to production of bulb onions which resulted into a highest percentage (71.76%) of gross margin followed by 100ml/L, 0ml/L and 400ml/l (67.90, 64.26 and 57.95). The differences in gross margin among fish tank effluent concentration could be attributed to differences in amounts of physico-chemical properties such as (N, P, K, TDS, TSS and electrical conductivity) and costs of production like fish tank effluent.

Findings of the study were in line with Getu *et al*. (2017) who noted that fish effluent can be used in the production of onions hence reduces the cost of artificial fertilizer as well as managing the farming with less amount of water thus high gross margin.

Findings of the current study is also in line with Abdel *et al*. (2018) whose study revealed that fishpond water as the sole source of fertilization rather than chemical fertilizers significantly increases net income of onion estimated at about U$ 662.49/ha in Egypt. Khatun *et al*. (2022) reported that fish pond water contains nitrogen, phosphorus and potassium which increases growth and yield of bulb onions thus highest income compared to zero application.

5.2 Conclusions

Physico-chemical properties of fish tank effluent in the different concentrations of 100ml/L, 200ml/L, 400ml/L and 0ml/L (treatment) determined included; pH, EC, TDS, TSS, N, P and K. The physicochemical properties in the different concentrations were significant.

The effect of fish tank effluent concentration on growth parameters (plant height, number of leaves, leaf area, leaf senescence and biomass of bulb onion). Fish tank effluent concentration did not significantly affect all growth parameters at final week 12 WAT.

Effect of fish tank effluent concentration on yield parameter of bulb onion (Yield, Harvest Index, bulb height and diameter). Fish tank effluent concentration significantly affected mean yield of bulb onions, bulb onion height, harvest index did not significantly affect bulb diameter.

Effect of fish tank effluent concentration on Gross margin of bulb onion. All fish tank effluent concentrations had varying effect on gross margin of bulb onion yield.

5.3 Recommendations

- Fish tank effluent especially at the concentration of 400 ml/L is highly recommended as a bio-fertilizer soil amendment for improvement of soil properties due to the richness in physico-chemical properties.

- Fish tank effluent at concentration of 200 ml/L is highly recommended for better bulb onion growth and yield

- Bulb onion farmers should use 200ml/L of fish tank effluent concentration in order to earn high income because it had the highest gross margin

- Further studies should be undertaken involving fish effluent from different types of aquaculture systems to establish the best source of nutrients for growth and yield of bulb onions as well as improved soil health.

REFERENCES

Abd-Elmaksoud, S., Abdo, S. M., Gad, M., Hu, A., El-Liethy, M.A., Rizk, N., Marouf, M. A., Hamza, I. A., & Doma, H. S. (2021). Pathogens removal in a sustainable and economic High-Rate Algal Pond Waste water Treatment system. *Sustainability*, *13* (23), 13232. http://doi.org/10.3390/su132313232

AbdEl Magid, H. A. A., Hala, H. A. A., & Mohamed, A. M. M. (2018). Economic Study the Efficiency of Water Resource Usage (Case Study). *Alexandria Journal of Agricultural Sciences*, *63*(3) , 149–155. https://doi.org/10.21608/ alexja. 2018. 81830

Abdelraouf, R. E. (2017). Reuse of fish farm drainage water in irrigation. In The handbook of environmental chemistry (pp. 393-410). https://doi.org/ 10.1007/698-2017-92

Akindele, A. J., Olufayo, A. A., & Faloye, O. T. (2022). Influence of borehole and fish wastewater on soil properties, productivity and nutrient composition of sweet pepper (Capsicum annum). *Shengtai Xuebao*, 42(1), 5662. https://doi.org/10.1016/j.chnaes.2021.02.002

Alzandi, A. A., Naguib, D. M., & Abas, A. M. (2021). Onion Extract Encapsulated on Nano Chitosan: a Promising Anticancer Agent. *Journal of Gastrointestinal Cancer*, 53(1), 211-216. https://doi.org/10.1007/s12029-020-00561-2

Ammattikorkeakoulu, S. (2015). *Improving Gross Profit Margin in a quick service restaurant*. Theseus. https://www.theseus.fi/handle/10024/88543

Anik, A. R., & Salam, M. A. (2015). Determinants of adoption of improved onion variety in Bangladesh. *DOAJ (DOAJ: Directory of Open Access Journals)*. https://doi.org/10.12895/jaeid.20151.259

Apori, S. O., Byalebeka, J., Murongo, M., Ssekandi, J., & Noel, G. L. (2021). Effect of co-applied corncob biochar with farmyard manure and NPK fertilizer on tropical soil. *Resources, Environment and Sustainability,* 5, 100034. https://doi.org/10.1016/j.resenv.2021.100034

Ashagrie, T., Belew, D., & Nebiyu, A. (2021). Influence of planting date and bulb size on yield and quality of onion (Allium cepa L.) seed production. *Cogent Food & Agriculture*, *7*(1). https://doi.org/10.1080/23311932.2021.1908656

Augusti, K. T. (2020). Therapeutic and medicinal values of onions and garlic In *CRC Press eBooks* (pp.93108). https://doi.org/10.1201/9780429355752-5

Ayinde, O. E., & Obalola, T. O. (2017). Effect of socioeconomic characteristics and income status on onion farmers risk attitude in Sokoto State, Nigeria. *Agricultura Tropica Et Subtropica*, *50* (3), 141-146. https://doi.org/10.151 5/ats-2017-0015

Bationo, A., Singh, U., Dossa, E., Wendt, J., Agiyin-Birikorang, S., Lompo, F., & Bindraban, P. (2020). Improving Soil Fertility through Fertilizer Management in Sub-Saharan Africa. In *CRC Press eBooks* (pp. 67–102). https://doi.org/10.1201/9780429471049-4

Bisbis, M. B., Gruda, N., & Blanke, M. (2018). Potential impacts of climate change on vegetable production and product quality A review. *Journal of Cleaner production*, 170, 1602-1620. https://doi.org/10.1016/j.jclepro.2017.09.224

Chen, D. S., Betz, J., Yaffe, K., Ayonayon, H. N., Kritchevsky, S., Martin, K. R., Harris, T. B., Purchase-Helzner, E., Satterfield, S., Xue, Q. L., Pratt, S., Simonsick, E. M., & Lin, F. R. (2015). Association of Hearing Impairment with Declines in Physical Functioning and the Risk of Disability in Older Adults. *Journals of Gerontology - Series A Biological Sciences and Medical*

Chiqito-Contreras, R. G., Hernandez-Adame, L., Alvarado-Castillo, G., De j Martinez-Hernande, M., Sanchez-Viveros, G., Chiquito-Contreras, C. J., & Hernandez-Montiel, L. G (2022). Aquaculture Production System and waste Management for Agriculture Fertilization A review. Sustainability, 14 (12), 7257. https://doi.org/10.3390/su14127257

Coelho, J. J., Hennessy, A., Casey, I., Woodcock, T., & Kennedy, N. (2019). Responses of ryegrass, white clover, soil plant primary macronutrients and microbial abundance to application of anaerobic digestates, cattle slurry and inorganic N-fertiliser. Applied Soil Ecology, 144, 112 122. https://doi .org/10.1016/j.apsoil.2019.07.011

Coldebella, A., Gentelini, A. L., Piana, P. A., Coldebella, P. F., Boscolo, W. R., & Feiden, A. (2017). Effluents from Fish Farming Ponds: A View from the Perspective of Its Main Components. *Sustainability*, 10(2), 3. https:// doi.org/10.3390/10.3390/su10003

Cozzolino, R., Malorni, L., Martignetti, A., Picariello, G., Siano, F., Forte, G., & De Giulio, B. (2021). Comparative analysis of volatile profiles and phenolic compounds of Four Southern Italian onion (Allium cepa L.) Landraces. *Journal of Food Composition and Analysis*, 101, 103990. https://doi.org/10.1016/j.jfca.2021.103990

Cristóvão, R. O., Botelho, C. M., Martins, R. J., Loureiro, J. M., & Boaventura, R. A. (2015). Fish canning industry wastewater treatment for water reuse – a case study. *Journal of Cleaner Production*, 87, 603-612. https://doi .org/10.1016/j.jclepro.2014.10.076

Deche, A., Assen, M., Damene, S., & Legass, A. (2022). Effects of different cropping and land management practices on the quality of irrigated soils of the Upper Awash Basin, Central Rift Valley of Ethiopia. *Ochrana PriRody Slovenska/EkoloGia*, 41(2), 101-112. https://doi.org/10.2478/eko-2022-0011

De Mattos, E.M., Binkley, D., Campoe, O. C., Alvares, C. A., & Stape, J.L. (2020). Variation in canopy structure, leaf area, light interception and light use efficiency among Eucalyptus clones. *Forest Ecology and Management*, 463, 118038. https://doi.org/1016/j.foreco.2020.118038

Dumitru, E. A., Berevoianu, R. L., Tudor, V. C., Teodorescu, F., Stoica, D., Giucă, A., Ilie, D., & Sterie, C. M. (2023). Climate change Impacts on Vegetable crops: A Systematic review. *Agriculture, 13*(10), 1891. https://doi.org/10. 3390/ agriculture13101891

Dwamena, H., Tawiah, K., Danquah, E., Darkey, S., Asante, M., Peprah, C., Frimpong, T., Marfo, P., Serwaa, A., Marno, P., Amponsah, S., Agyeman, K., Asante, M., Karim, A., & Frimpong, F. (2023, December 28). *Productivity of onion (Allium cepa L.) as influenced by composted poultry manure and fishpond waste in an aquaponics based food system*. https://www.ajol.info/index.php/gjas/article/view/261455

Eksi, G., Ozkan, A. M. G., & Koyuncu, M. (2020). Garlic and onions: An eastern tale. *Journal of Ethnopharmacology*, 253, 112675. https://doi.org/10.1016/j.jep.2020.112675

Emana, B., Sefa, V. A., Kebede, D., Nenguwo, N., Ayana, A., & Mohammed, H. (2017). Assessment of postharvest losses and marketing of onion in Ethiopia. *International Journal of Postharvest Technology and Innovation, 5*(4), 300. https://doi.org/10.1504/ijpti.2017.092466

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Fruscella, L., Kotzen, B., Paradelo, M., & Milliken, S. (2023). Investigating the effects of fish effluents as organic fertilisers on onion (Allium cepa) yield, soil nutrients, and soil microbiome. *Scientia Horticulturae, 321*, 112297. https://doi.org/10.1016/j.scienta.2023.112297

Fruscella, L., Kotzen, B., Paradelo, M., & Milliken, S. (2023b). Investigating the effects of fish effluents as organic fertilisers on onion (Allium cepa) yield, soil nutrients, and soil microbiome. *Scientia Horticulturae*, 321, 112297. https://doi.org/10.1016/j.scienta.2023.112297

Getu D, Amare, F., Berhanu T; Kinfo, H., & Terefe, T. (2017). Evaluation of Integrated Fish Farming with Chicken and Vegetables in Silte District of Southern Ethiopia. *Advance Research Journal of Multi-Disciplinary Discoveries I*, *17*(Hussein 2009), 20–27.

Geisseler, D., Ortiz, R. S., & Diaz, J. (2022). Nitrogen nutrition and fertilization of onions (Allium cepa L.)–A literature review. *Scientia Horticulturae*, 291, 110591. https://doi.0rg/10.1016/j.scienta.2021.11091

Goggin, B. J. (2022, June 1). Freshwater Integrated Multi-Trophic Aquaculture (FIMTA): Applying criteria for plant selection and the effect of plant species on the bioremediation of aquaculture effluent .https://unbscholar.lib.unb .ca/items/bbb3584de6-b84c-38b9272efe5

Green, B. W. (2022). Fertiliser use in aquaculture. In *Elsevier eBooks* (pp. 29-63). https://doi.org/10.1016/b978-12-821598-2.00012-6

Guli·Jiapaer, N., Liang, S., Yi, Q., & Liu, J. (2015). Vegetation dynamics and responses to recent climate change in Xinjiang using leaf area index as an indicator. Ecological Indicators, 58, 64-76. https://doi.org/10.1016/j.eco lind.2015.05.036

https://www.fao.org/uganda/news/detail-events/en/c/1178145/ Retrieved from the internet on 5th/Jan/2022

Jana, B. B., Mandal, R.N., & Jayasnkar, P. (2018). Wastewater management through aquaculture. In *Springer eBooks*. https://doi.org/10.1007/978-981-10-7248-2

Kabeto, S., Tolera, S., & Woldemichael, E. (2020, June 29). Evaluation of treatment efficiency of waste stabilization pond and its effluent toxicity in Hawassa University, Southern Ethiopia. http://ejol.ethernet.educ.et/index.php/EAJHBS/article/view/1489

Kagorora, J. P. K., Kansiime, M. K., Owuor, C., & Tumwine, J. (2021). A review of some aspects of Uganda's crop agriculture: Challenges and opportunites for diversified sector output and food security. *CABI Working Paper*, *26*(October), 23. *Sciences*, *70*(5), 654–661. https://doi.org/10.1093/gerona/glu207

Kaleem, O., & Sabi, A. B. S. (2021). Overview of aquaculture systems in Egypt and Nigeria, prospects, potentials, and constraints. *Aquaculture and Fisheries*, 6 (6), 535-547. https://doi.org/10.1016/j.aaf.2020.07.017

Kamble, B. M., & Kathmale, D. K. (2015). Effect of different levels of customized fertilizer on soil nutrient availability, yield and economics of onion. *Journal of Applied and Natural Science*, 7(2), 817-821. https://doi.org/10.31018/jans.v7i2.688

Kasimbazi, E. (2020). Legal and regulatory framework for the agriculture sector in Uganda. In *International yearbook of soil law and policy* (pp. 55–78). https://doi.org/10.1007/978-3-030-36004-7_4

Khater, E. G., Bahnasawy, A. H., Shams, A. E. S., Hassaan, M. S., & Hassan, Y. A. (2015). Utilization of effluent fish farms in tomato cultivation. Ecological Engineering, 83, 199-207. https://doi.org/10.1016 /j.ecoleng. 2015.06.010

Khokhar, K. M. (2017). Environmental and genotypic effects on bulb development in onion – a review. *The journal of Horticultural Science & Biotechnology*,92(5),448454.https://doi.org/10.1080/14620316.2017.1314199

Kirk, P. L. (1950). Kjeldahl method for total nitrogen. *Analytical Chemistry*, *22*(2), 354-358. https://doi.org/10.1021/ac60038a038

Kumar, D., Hiremath, A. M., & Asolekar, S.R. (2014). Integrated Management of Wastewater through Sewagw Fed Aquaculture for Resource Recovery and Reuse of Treated Effluent: A case Study. *APCBEES Procedia*, 10, 74-78. https://doi.org/10.1016/j.apcbee.2014.10.019

Lante, A., Tinello, F., & Mihaylova, D. (2020). Valorization of onion extracts as anti-browning agents. *Food Science and Applied Biotechnology*, *3*(1), 16. https://doi.org/10.30721/fsab2020.v3il.87

Leal, J. F., Neves, M. G. P. M. S., Santos, E. B. H., & Esteves, V. I. (2016). Use of formalin in intensive aquaculture: properties, application and effects on fish and water quality. *Reviews in Aquaculture*, 10(2), 281-295. https://doi.org / 10.1111/raq.12160

Li, Q., Wang, Y., Mai, Y., Li, H., Wang, Z., Xu, j., & He, X. (2020). Health Benefits of the Flavonoids from Onion: Constituents and Their Pronounced Antioxidant and Anti-neuroinflammatory Capacities. *Journal of Agricultural and Food Chemistry*, 68(3), 799-807.https://doi.org/10.1021 /acs.jafc.9b07418

Mahmood, N., Muazzam, M. A., Ahmad, M., Hussain, S., & Javed, W. (2021). Phytochemistry of Allium cepa L. (Onion): An Overview of its Nutritional and Pharmacological Importance. *Scientific Inquiry and Review*, 5(3), 41-59. https://doi.org/10.32350/sir/53.04

Maia, L. B., & Moura, J. J. G. (2014). How biology handles nitrite. *Chemical Reviews*, 114(10), 5273-5357. https://doi.org/10.1021/cr400518y

Makori, A. J., Abuom, P.O., Kapiyo, R., Anyona, D. N., & Dida, G. O. (2017). Effects of water physico-chemical parameters on tilapia (Oreochromisni loticus) growth in earthen ponds in Teso North Sub- County, Busia County. *Fisheries and Aquatic Sciences*, 20 (1). https://doi.org/10.1186 /s41240-017-0075-7

Masso, C., Nziguheba, G., Mutegi, J., Galy-Lacaux, C., Wendt, J., Butterbach-Bahl, K., Wairegi, L., & Datta, A. (2017). Soil fertility management in Sub-Saharan Africa. In *Sustainable agriculture reviews* (pp.205231) https:// doi.org/10.1007/978-3-319-58679-3_7

Maucieri, C., Nicoletto, C., Zanin, G., Birolo, M., Trocino, A., Sambo, P., Borin, M., & Xiccato, G. (2019). Effect of stocking density of fish on water quality and growth performance of European Carp and leafy vegetables in a low-tech aquaponic system. PloS One, 14 (5), e0217561. https: // doi.org/10.1371/journal.pone.0217561

Mehrim, A., Refaey, M., El-Shebly, A., & Behery, M. (2016). Impact of mono or polyculture systems on water quality, growth performance and economic efficiency of Oreochromis niloticus (Linnaeus, 1758) and Hypophthalmich thys molitrix (Valenciennes, 1844). *Egyptaian Journal of Aquatic Biology and Fisheries*, 20 (1), 77-90. https://doi.org/10.21608/ejabf.2016.2288

Metwally, R. A., Soliman, S. A., Latef, A. a. H. A., & Abdelhameed, R. E. (2021c). The individual and interactive role of arbuscular mycorrhizal fungi and Trichoderma viride on growth, protein content, amino acids fractionation, and phosphatases enzyme activities of onion plants amended with fish waste. *Ecotoxicology and Environmental Safety*, 214, 112072. https://doi.org/10.1016/j.ecoenv.2021.112072

Miassi, Y. E. S., Dossa, F. K., & Banzou, K. (2018). *Onion (Allium Cepa) production in urban and Peri-Urban areas: Financial performance and importance of this activity for market gardeners in Southern Benin*. https://hal.science/hal-01821821/

Mohanty, S., Sahu, G. S., Dash, S. K., Pradhan, S. R., Mangaraj, S., & Nahak, S. (2017). Integrated nutrient management for seed production in French bean (Phaseolus vulgaris L.). International Journal of Current Microbiology

International Journal of Current Microbiology and Applied Sciences, *6* (10),3295-3303. https://doi.org/10.20546/ijcmas.2017.610.386

Mrema, E., Mtunda, K., & Mbise, V. (2021). Influence of fertilization on growth and yield of onion under semi-arid conditions. *International Journal of Vegetable Science*, 28 (4), 366-373. https://doi.org/10.1080/19315260 .2021.1977756

Munezero, E., Adewale, C. I., Okello, D. M., & Mugonola, B. (2023). Profit efficiency analysis of red onions production in Sironko district of Uganda. *CogentFood & Agriculture*, *9*(1) https://doi.org/10.1080/233 11932.2023.2222516

Musa, J. J., Dada, P. O. O., Adewumi, J. K., Akpoebidimiyen, O. E., Musa, E. T., Otache, M. Y., & Yusuf, S. (2020). Fish pond effluent effect on physicochemical properties of soils in southern Guinea Savanna, Nigeria.*OAlib*, 07(01), 1-15. https://doi.org/10.4236/0alib.1105990

New Vision 23/June/2020. https://www.newvision.co.ug/news/1521373/grow-onions-taste-money

Nabyonga, L., Basamba, T. A., Nyakoojo, C., & Ssenku, J. E. (2022). Impediments to agricultural production in Uganda and measures to enhance soil fertility utilizing organic soil amendments: A review. *Cogent Food & Agriculture*, 8(1). https://doi.org/10.1080/23311932.2022.2113051

Nabyonga, L., Basamba, T. A., Nyakoojo, C., & Ssenku, J. E. (2022b). Impediments to agricultural production in Uganda and measures to enhance soil fertility utilizing organic soil amendments: A review. *Cogent Food & Agriculture*, *8*(1). https://doi.org/10.1080/23311932.2022.2113051

Nájera, F., Tapia, Y., Baginsky, C., Figueroa, V., Cabeza, R., & Salazar, O. (2015). Evaluation of soil fertility and fertilisation practices for irrigated maize (Zea mays L.) under Mediterranean conditions in Central Chile. *Journal of Soil Science and Plant Nutrition, ahead,* 0. https://doi.org/10.4067/s0718-95162015005000008

Nariswari, T. N., & Nugraha, N. M. (2020). Profit growth : impact of net profit margin, gross profit margin and total assests turnover. International Journal of Finance & Banking Studies, 9(4), 87-96. https://doi.org/10.20525/ijfbs. v9i4.937

Oku, S., Ueno, K., Tsuruta, Y., Jitsuyama, Y., Suzuki, T., Onodera, S., Maeda, T., & Shimura, H. (2019). Sugar accumulation and activities of enzymes involved in fructan dynamics from seedling to bulb formation in onion (Allium cepa L.). Scientia Horticulture, 247, 147-155. https://doi.org/10.1016/j.scienta.2018.12.013

Omeir, M. K., Jafari, A., Shirmardi, M., & Roosta, H. (2019b). Effects of Irrigation with Fish Farm Effluent on Nutrient Content of Basil and Purslane. *Proceedings of the National Academy of Sciences, India, Section B: Biological Sciences/Proceedings of the National Academy of Sciences,* *India, Section B: Biological Sciences*, 90(4), 825-831. https://doi.org/10.1007/s40011-019-01155-0

Omeir, M. K., Jafari, A., Shirmardi, M., & Roosta, H. (2019b). Effects of Irrigation with Fish Farm Effluent on Nutrient Content of Basil and Purslane. *Proceedings of the National Academy of Sciences, India, Section B: Biological Sciences* 90(4), 825-831. https://doi.org/10.1007/s40011-019-01155-0

Omeir, M. K., Jafari, A., Shirmardi, M., & Roosta, H. (2019c). Effects of Irrigation with Fish Farm Effluent on Nutrient Content of Basil and Purslane. *Proceedings of the National Academy of Sciences, India, Section B: Biological Sciences* 90(4), 825-831. https://doi.org/10.1007/s40011-019-01155-0

Onuorah, S., Nwanyanwu, N. A., & Okoye, N. P. (2022). Impact of palm kernel oil mill effluent on the soil's physicochemical characteristics and growth of tomato plant. Malaysian *Journal of Science and Advanced Technology*, 66-72. https://doi.org/10.56532/mjsat.v2i2.43

Pradeep, S. R., & Srinivasan, K. (2017). Amelioration of hyperglycemia and associated metabolic abnormalities by a combination of fenugreek (Trigonella foenum-graecum) seeds and onion (Allium cepa) in experimental diabetes. Journal of Basic and Clinical Physiology and Basic & Clinical Physiology & Pharmacology, 28(5), 493-505. https: //doi .org/10.1515/jbcpp-2015-0140

Qi, D., Yan, J., & Zhu, J. (2020). Effect of a reduced fertilizer rate on the water quality of paddy fields and rice yields under fishpond effluent irrigation. Agricultural Water Management, 231,105999.https://doi.org/10.1016/ j.agwat.2020.105999

Raimi, A., Adeleke, R., & Roopnarain, A. (2017). Soil fertility challenges and Biofertiliser as a viable alternative for increasing smallholder farmer crop productivity in sub-Saharan Africa. *Cogent Food & Agriculture, 3* (1)1400933. https://doi.org/10.1080/23311932.2017.1400933

Raimi, A., Roopnarain, A., & Adeleke, R. (2021). Biofertilizer production in Africa: Current status, factors impeding adoption and strategies for success. *Scientific African*, 11, e00694. https://doi.org/10.1016/j.sciaf.2021.e00694

Rodrigues, C. G., Garcia, B. F., Verdegem, M., Santos, M. R., Amorim, R. V., & Valenti, W. C. (2019). Integrated culture of Nile tilapia and Amazon river prawn in stagnant ponds, using nutrient-rich water and substrates. Aquaculture, 503, 111-117. https://doi.org/10.1016/j.aquaculture.2018.12. 073

Shura, G., Beshir, H. M., & Haile, A. (2022). Improving onion productivity through optimum and economical use of soil macronutrients in Central Rift Valley of Ethiopia. *Journal of Agriculture and Food Research*, 9, 100321. https://doi.org/10.1016/j.jafr.2022.100321

Soliman, A. I., Morad, M., Wasfy, K. I., & Moursy, M. (2020). Utilization of aquaculture drainage for enhancing onion crop yield under surface and sub surface drip irrigation systems. *Agricultural Water Management*, 239, 106244. https://doi.org/10.1016/j.agwat.2020.106244

Soliman, N. F., & Yacout, D. M. M. (2016a). Aquaculture in Egypt: status, constraints and potentials. Aquaculture International, 24(5), 1201-1227. https://doi.org/10.1007/s10499-016-9989-9

Soliman, N. F., & Yacout, D. M. M. (2016b). Aquaculture in Egypt: status, constraints and potentials. *Aquaculture International*, 24(5), 1201-1227. https://doi.org/10.1007/s10499-016-9989-9

Soliman, N. F., & Yacout, D. M. M. (2016c). Aquaculture in Egypt: status, constraints and potentials. *Aquaculture International*, 24(5), 1201-1227. https://doi.org/10.1007/s10499-016-9989-9

Teshika, J. D., Zakariyyah, A. M., Zaynab, T., Zengin, G., Rengasamy, K. R., Pandian, S. K., & Fawzi, M. M. (2018). Traditional and modern uses of onion bulb (Allium cepaL.): a systematic review. *Critical Reviews in Food Science and Nutrition*, 59 (sup1), S39-S70. https://doi.org/10.10 80 /10408398.2018.1499074

Tiwari, A. K., & Pal, D. B. (2022). Nutrients contamination and eutrophication in the river ecosystem. In *Elsevier eBooks* (pp. 203-216). https://doi.Org /10.1016/b978-0-323-85045-2.00001-7 lian, T., Diazgranados, M., Pironon, S., Padulosi, S., Liu, U., Davies, L., Howes, M. R., Borrell, J. S., Ondo, I., Pérez-Escobar, O. A., Sharrock, S., Ryan, P., Hunter, D., Lee, M. A., Barstow, C., Łuczaj, Ł., Pieroni, A., Cámara-Leret, R., Noorani, A., Mattana, E. (2020). Unlocking plant resources to support food security and promote sustainable agriculture. *Plants, People, Planet*, 2(5),421-445. https://doi.org/10.1002/ppp3.10145

Uysal, E., Liv, L., & Akcadag, F. (2019). Proficiency testing for determination of pH and electrolytic conductivity in water and soil samples. *Journal of Chemical Metrology*, 13(2), 29 – 38. https://doi.org/10.25135/jcm.31.19.11.1439

Von Bach, H. J. S., & Kalundu, K. M. (2020). An econometric estimation of gross margin volatility: a case of ox production in Namibia. *Agrekon, 59*(4), 401–411. https://doi.org/10.1080/03031853.2020.1822893

Wakchaure, G., Minhas, P., Meena, K. K., Singh, N.P., Hegade, P. M., & Sorty, A. M. (2018). Growth, bulb yield, water productivity and quality of onion (Allium cepa L.) as affected by deficit irrigation regimes exogenous application of plant bio regulators. *Agricultural water Management*, 199, 1-10. http://doi.0rg/10.1016/j.agwat.2017.11.026

Zohry, A. E., & Ouda, S. (2022). Fish farms effluents for irrigation and fertilizer: Field and modeling studies. In *Springer eBooks* (pp. 43-66). https://doi.org/10.1007/978-3-030-93111-73