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ORIGINAL RESEARCH

Effect of Nutrient Sources on The Yield and Phytochemical Composition of Jute Mallow (*Corchorus olitorius*) Cultivated Using Hydroponic and Geoponic Methods

Alege, G. O.[1]*, Adehi, P. A.[1], Musa, A. L.[1] and Ossai, P. C.[2]

[1]Department of Biotechnology, Federal University Lokoja, Kogi State.
[2]Department of Industrial Chemistry, Federal University Lokoja, Kogi State.

*Corresponding author: gbenga.alege@fulokoja,edu.ng

Abstract

Jute mallow (*Corchorus olitorius*) is a leafy vegetable rich in protein, fiber, omega-3 fatty acids, and essential vitamins. However, traditional soil-based cultivation of this crop is limited by poor soil fertility, nutrient deficiencies, and environmental variability, thereby necessitating innovative approaches such as hydroponics to enhance yield and enable year-round production. This study therefore assessed the impact of different nutrient sources on the yield of *Corchorus olitorius* grown using two hydroponic systems compared to the traditional soil-based cultivation method. Specifically, plants were grown using Nutrient Film Technique (NFT) and Drip hydroponic methods with five different nutrient sources (master blend, master mix, compost, fish effluent, and water) while plants were grown in the soil for geoponic cultivation. Data were taken on growth attributes like plant height, stem diameter, and number of leaves. In addition, pigments such as chlorophyll a, chlorophyll b, total chlorophyll, and carotenoids in the leaves were quantified. Similarly, phytochemical parameters including alkaloids, glycosides, saponins, tannins, phenols, and flavonoids were measured. The results revealed that *Corchorus olitorius* grown with Master Mix under NFT exhibited superior growth while those grown with Master Mix under Drip technique had highest pigment contents. Similarly, Master Mix under NFT and Master Blend under Drip systems produced the highest phytochemical contents. This study highlighted the need for regular monitoring of electrical conductivity (EC) and pH during hydroponic farming, to prevent salt stress and acidification. Findings from this study revealed that hydroponic cultivation, when supplied with the appropriate nutrient source, has the potential to significantly improve the yield and nutritional quality of Jute Mallow (*Corchorus olitorius*) compared to conventional soil cultivation.

Keywords: *Corchorus olitorius*, Hydroponic, Geoponic, Pigments, Phytochemicals

Introduction

Jute Mallow (*Corchorus olitorius*), a member of the Malvaceae family, is widely cultivated in tropical and subtropical Africa for its edible leaves and fiber (Masiala et al., 2024). It is traditionally consumed as a leafy vegetable among the Yoruba people of southwestern Nigeria, where it is known as 'Ewedu' (Akinwande et al., 2024). Totin et al. (2024)

reported that beyond Nigeria, jute mallow is an important leafy vegetable across several African countries including Côte d'Ivoire, Benin, Liberia, Ghana, Cameroon, Sudan, Uganda, Kenya, Zambia, and Zimbabwe. Nutritional analyses reveal that jute mallow leaves are rich in pro-vitamin A (β-carotene), vitamins A and C, omega-3 fatty acids, protein, fiber, and essential minerals such as calcium, iron, potassium, and magnesium (Ndhlovu et al., 2025). Baiyeri (2024) reported high protein and fiber content of the vegetable, while Koeder and Perez-Cueto (2024) and Sarkar et al. (2023) asserted that these nutrients often exceed those found in common leafy vegetables such as spinach and kale. These outstanding nutritional qualities made jute mallow a valuable crop for combating malnutrition in vulnerable populations (Akinwande et al., 2024; Sarkar et al., 2023).

Despite its nutritional benefits, research on the yield and production of *Corchorus olitorius* remains limited. Pholoma et al. (2024) noted that this is partly due to its status as a neglected and underutilized crop in Africa, where it often grows as a volunteer plant rather than being intentionally cultivated. Maroyi et al. (2024) added that this limits its production potential and the research attention it receives. Alam et al. (2024) further explained that the crop's seasonal growth patterns and the dominance of exotic high-yielding vegetables have contributed to its lower research emphasis. Traditionally, jute mallow is grown using soil-based (geoponic) cultivation methods, which face several challenges including poor soil fertility, inadequate nutrient supply, soil-borne diseases, and environmental variability (Goh et al., 2023; Mohite and Pathade, 2024; Yan et al., 2024).

Hydroponic farming offers a promising alternative to traditional cultivation. Sousa et al. (2024) described hydroponics as a soilless method that grows plants in nutrient-rich water, allowing year-round production, improved nutrient management, and reduced labor requirements. Kumar et al. (2024) and Olayemi et al. (2024) emphasized that hydroponics can overcome environmental and economic constraints commonly encountered in traditional farming and may help reduce conflicts over land use, such as those between farmers and herders. Fuentes-Peñailillo et al. (2024) reported that hydroponic farming has been successfully adopted in industrialized countries like the United States and parts of Europe, where it has increased food production and created employment opportunities, especially for youth and retirees. However, Folorunso et al. (2024) observed that despite these benefits, hydroponic systems remain underdeveloped and underutilized in Nigeria.

While previous studies have evaluated the impact of organic and inorganic fertilizers on soil-grown jute mallow, Akpeji et al. (2024) identified lack of data on nutrient efficiency under hydroponic systems, which limits optimization of production. Olubanjo et al. (2023) stressed the need to assess how different nutrient sources affect yield and phytochemical composition of jute mallow grown hydroponically compared to traditional geoponic methods. Nakachew et al. (2024) and Valenzuela et al. (2024) also emphasized that investigating nutrient effects across cultivation systems is essential to identify optimal practices that improve both yield and nutritional quality of crops. This study aims to assess the effects of nutrient sources on the yield of *Corchorus olitorius* cultivated under hydroponic systems compared to those grown using traditional geoponic techniques.

Materials and Methods

The study was conducted in the screen house of the Department of Biotechnology, Federal University Lokoja. Improved seeds of *Cochorus olitorius* were obtained from Ministry of Agriculture, Lokoja, Kogi State while hydroponic nutrients were obtained as shown in Table 1.

Table 1: Source of Nutrient for the Study

S/N	Nutrient	Source
1.	Fish effluent	Absas fish farm, Zone 8 Lokoja
2.	Compost	Ministry of Agriculture, Lokoja
3.	Master mix (Local nutrient)	Farm Hydroponic Nigeria Ltd, Kubwa, Abuja
4.	Master blend (Imported nutrient)	Farm Hydroponic Nigeria Ltd, Kubwa, Abuja
5.	Tap water	Federal University Lokoja borehole
6.	Geoponic	Soil from research site

Fabrication and Setting up of Nutrient Film and Drip Hydroponic Systems

The Nutrient film and Drip techniques were manually fabricated and set up using Polyvinyl Chloride (PVC) plastic and Jerry cans according to the methods outlined by Graves (1983) and Hendrawan et al. (2024) respectively. The physicochemical composition of the soil used for geoponic study is shown in Table 2.

Table 2: Physicochemical Compositions of the Soil Used for Geoponic Study

Property	Value
Sand	44 %
Silt	36 %
Clay	20 %
Soil Color	Dark brown
Soil Structure	Loose
Porosity	39.3 %
Water Holding Capacity	48.5 %
pH	6.6
Organic Carbon	1.70 %
Organic Matter	1.72 A
Electrical Conductivity (EC)	0.4 dS/m
Available Nitrogen (N)	228 mg/kg
Available Phosphorus (P)	14.1 mg/kg
Available Potassium (K)	175 mg/kg

Experimental Design and Planting of Seeds of Cochorus olitorius

The Complete Randomized Design (CRD) comprising of six treatments with three replicates per treatment was adopted for the study. The seeds of C*ochorus olitorius* were planted into 10L black plastic bags filled with cocopeat as growing medium using Drip hydroponic method. 4-inches plastic PVC pipe with thickness of 200microns were used to construct the Nutrient Film Technique (NFT). The traditional soil-based study (geoponics) was conducted by filling black poly pots with 10 liters of soil.

Application of Nutrient Solutions

Solutions of Master Mix and Master Blend hydroponic nutrients were prepared according to manufacturer's specifications. Undiluted fish wastewater and compost solution served as organic nutrient sources while tap water from Federal University Lokoja borehole was used as negative control for the study. Corresponding nutrient sources were manually circulated or irrigated in the hydroponic systems on daily basis. Plants grown geoponically were watered every 2 days as suggested by Ullah et al. (2021).

Measurement of pH and Electrical Conductivity (EC) of the Nutrients

The HANNA PHEP pocket sized meter was used to measure the pH, and the portable E-1 TDS and EC meter was used to measure the electrical conductivity (EC) of the nutrient each time fresh solutions of the nutrients were prepared and applied to the plants. Same records were taken 2 weeks after the plants have grown in the different setups (Samarakoon et al., 2006).

Measurement of Morphological Attributes

Morphological parameters such as plant height, stem diameter and numbers of leaves were taken in triplicate weekly till maturity at four (4) weeks according to Silva-Filho et al. (2024).

Quantification of Pigment Contents of the Plants

Chlorophyll A, chlorophyll B, total chlorophyll and Carotene were quantified using methods outlined by Priyadharshana et al. (2022). The absorbance values are then used in established equations to calculate the concentrations of each pigment, with total chlorophyll determined by summing chlorophyll a and b (Zonouri, 2014).

Quantification of Phytochemical Compositions of the Plants

The alkaloids, glycosides, saponins, tannins, phenols and flavonoids contents were quantitatively analyzed using Spectrophotometer as outlined by Patil and Godbole (2024). For spectrophotometric analysis, colorimetric methods were employed with Dragendorff's reagent used for the quantification of alkaloids, while the phenol-sulfuric acid method was applied for glycosides at 490 nm absorbance. Saponins were quantified using the foaming index technique, while tannins and phenols were quantified using the Folin-Ciocalteu method, with absorbance measured at 765 nm. Additionally, flavonoid contents were quantified using the aluminum chloride method at 430 nm. The concentrations of each phytochemical were calculated based on standard curves generated from known concentrations of reference compounds. Each phytochemical attribute was quantified in triplicate.

Data Analysis

Data collected in triplicate on morphological and phytochemical attributes were analyzed using Analysis of Variance (ANOVA) using the Statistical Package for Social Science (SPSS) version 23. Means that showed significant differences were separated using the Least Significant Difference (LSD) method at $P \leq 0.05$. Variations in pH and electrical conductivity (EC) were illustrated using bar charts.

Results

Plants grown with Master Mix using the Nutrient Film Technique (NFT) consistently outperformed those grown with other nutrient sources throughout the period of study [Table 3). In contrast, plants grown with compost using the Drip system exhibited minimal increases in plant height, particularly from Week 1 to 3. However, the Geoponically grown plants had poor growth starting from Week 3.

Plants grown using Master Mix under Drip system had the highest chlorophyll A (15.37 mg/g), chlorophyll B (11.64 mg/g), total chlorophyll (27.01 mg/g) and Carotenoids (5.28 mg/g) [Table 4 and Plate 1]. In contrast, plants grown with water using NFT had the least chlorophyll A (0.67 mg/g), chlorophyll B (0.82 mg/g), total chlorophyll (1.49 mg/g), and carotenoid level (0.61 mg/g). Generally, plants grown using Drip technique had more pigments compared to those grown using NFT and soil-based methods.

Plants grown with Master Mix under the Nutrient Film Technique (NFT) had the highest alkaloid content (3.36 mg/g), which was significantly greater than that of other treatments (Table 5). In contrast, plants grown with water circulated under NFT showed the lowest alkaloid content (2.03 mg/g). Similarly, glycoside levels were significantly higher in plants grown with Compost using NFT (2.32 mg/g), whereas those grown with water as the nutrient source under NFT had the lowest glycoside concentration (0.82 mg/g). Regarding saponins, plants cultivated with Master Mix under NFT recorded significantly higher levels (9.23 mg/g), while those grown with Compost NFT (6.31 mg/g) and Fish Effluent Drip (6.38 mg/g) had the lowest concentrations. Tannin content was significantly higher in plants grown with Compost using the Drip technique (3.44 mg/g), whereas Fish Effluent used as a nutrient source under NFT resulted in plants with the least tannin levels (1.02 mg/g). Phenol content was markedly higher in plants grown with Master Blend using the Drip method (53.73 mg/g), compared to the lowest phenol content observed in plants grown with

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Fish Effluent under NFT (16.99 mg/g). Finally, flavonoid content was significantly higher in plants grown with Master Blend using NFT (2.83 mg/g), while those grown with Compost under NFT produced the least flavonoid levels (0.06 mg/g).

All the nutrient sources used in growing plants in this study significantly increased the Electrical Conductivity (EC) (Figure 1). Remarkably, Master blend under NFT showed the most pronounced increase from 62 ppm to 226 ppm after growing the plants in them. Likewise, compost under NFT showed significant increase from 56 ppm to 133 ppm following growth of the plants. In contrast, a slight increase in EC from 43ppm to 45ppm was recorded for soils used for geoponic cultivation of *Corchorus olitorius*.

Master Mix under NFT had significant drop in pH from 6.3 to 5.4. Conversely, compost under NFT maintained a stable pH of 6.3 while Master mix and Master blend under Drip systems had increase in pH (Figure 2). The pH of soil used for geoponic cultivations dropped from 7.5 to 6.5 after the growth of the plants over a period of 4 weeks.

Table 3: Effects of Different Nutrient Sources on Morphological Characteristics of *Corchorus olitorius* under Hydroponic and Geoponic Cultivations

Nutrient Source	WEEK 1			WEEK 2			WEEK 3			WEEK 4		
	PH (cm)	SG (cm)	NL	PH (cm)	SG (cm)	NL	PH (cm)	SG (cm)	NL	PH (cm)	SG (cm)	NL
Fish Effluent NFT	3.80^{bcd}	0.30^{bc}	3.67^{bc}	5.40^{bcde}	0.30^{de}	4.67^{bcd}	7.00^{cde}	0.37^{def}	7.00^{bc}	9.83^{cd}	0.37^{de}	6.00^{c}
Water NFT	4.23^{abcd}	0.60^{a}	5.67^{ab}	7.60^{abcd}	0.63^{ab}	7.33^{b}	10.33^{bc}	0.50^{cde}	4.67^{c}	10.43^{cd}	0.53^{cde}	7.67^{c}
Compost NFT	3.50^{bcd}	0.53^{abc}	4.00^{abc}	4.53^{bcde}	0.30^{de}	5.00^{bcd}	9.97^{bcd}	0.43^{def}	5.67^{c}	10.13^{cd}	0.57^{cde}	6.00^{c}
Master Mix NFT	6.77^{a}	0.63^{a}	6.00^{a}	11.27^{a}	0.80^{a}	10.67^{a}	18.80^{a}	1.13^{a}	23.00^{a}	37.70^{a}	1.80^{a}	37.67^{a}
Master Blend NFT	6.37ab	0.50^{abc}	5.33^{abc}	9.50^{ab}	0.57^{abc}	7.67^{b}	13.47^{b}	0.80^{bc}	12.33^{b}	22.07^{b}	0.93^{bc}	19.33^{b}
Fish Effluent Drip	3.57^{bcd}	0.57^{ab}	4.33^{abc}	7.43^{abcd}	0.37^{cde}	5.33^{bc}	2.50^{e}	0.23^{df}	3.33^{c}	6.17^{cd}	0.30^{de}	2.67^{c}
Water Drip	2.20^{cd}	0.27^{c}	3.67^{bc}	4.33^{cde}	0.27^{de}	3.67^{cd}	5.67^{de}	0.23^{df}	2.67^{c}	5.83^{cd}	0.33^{de}	3.00^{c}
Compost Drip	1.30^{d}	0.40^{abc}	3.33^{c}	2.00^{e}	0.13^{e}	3.00^{cd}	2.93^{e}	0.20^{df}	4.33^{c}	8.63^{cd}	0.43^{de}	3.67^{c}
Master Mix Drip	4.17^{abcd}	0.57^{ab}	5.00^{abc}	5.00^{bcde}	0.30^{de}	5.67^{bc}	4.70^{e}	0.67^{bcd}	6.67^{bc}	14.67^{bc}	0.73^{bcd}	7.33^{c}
Mater Blend Drip	4.53^{abc}	0.57^{ab}	5.33^{abc}	7.93^{abc}	0.50^{bcd}	7.00^{b}	5.90^{de}	0.87^{ab}	8.67^{bc}	20.83^{b}	1.07^{b}	8.67^{c}
Geoponics	2.87^{cd}	0.30^{bc}	3.67^{bc}	2.73^{de}	0.23^{e}	2.00^{d}	2.50^{e}	0.13^{f}	3.00^{c}	3.67^{d}	0.23^{e}	3.67^{c}
LSD Values	0.35	0.03	0.23	0.61	0.04	0.47	0.93	0.06	1.11	1.80	0.09	1.82

*Means with the same alphabets in the same column are not significantly different at 5% level of significant

Key: NFT=Nutrient Film Technique, PH: Plant height, SG: Stem girth, NL: Number of leaves, LSD: Least Significant Difference.

Table 4: Effects of Different Nutrient Sources on Chlorophyll contents of *Corchorus olitorius* under Hydroponic and Geoponic Cultivations

Nutrient Source	Chlorophyll A (mg/g)	Chlorophyll B (mg/g)	Total Chlorophyll (mg/g)	Carotenoid (mg/g)
Fish Effluent NFT	3.97^{d}	2.71^{fg}	6.68^{e}	1.24^{ef}
Water NFT	0.67^{g}	0.82^{h}	1.49^{g}	0.61^{g}
Compost NFT	10.69^{b}	8.17^{c}	18.86^{c}	3.25^{c}
Master Mix NFT	2.14^{f}	2.54^{fg}	4.68^{f}	1.47^{de}
Master Blend NFT	1.71^{f}	2.07^{g}	3.78^{f}	0.62^{g}
Fish Effluent Drip	4.98^{c}	2.35^{fg}	7.33^{e}	1.70^{de}
Water Drip	2.89^{e}	4.16^{e}	7.05^{e}	0.74^{fg}
Compost Drip	11.03^{b}	8.94^{b}	19.97^{b}	4.21^{b}
Master Mix Drip	15.37^{a}	11.64^{a}	27.01^{a}	5.28^{a}
Mater Blend Drip	1.22^{fg}	2.98^{f}	3.87^{f}	1.90^{d}
Geoponics	10.67^{b}	6.78^{d}	17.45^{d}	3.43^{c}
LSD Values	0.85	0.59	1.43	0.27

*Means with the same alphabets in the same column are not significantly different at 5% level of significant

Keys: NFT=Nutrient Film Technique, LSD: Least Significant Difference.

Table 5: Effects of Different Nutrient Sources on Phytochemical Attributes of *Corchorus olitorius* under Hydroponic and Geoponic Cultivations

Nutrient Source	Alkaloids (mg/g)	Glycosides (mg/g)	Saponins (mg/g)	Tannins (mg/g)	Pheno (mg/g
Fish Effluent NFT	2.26^{cde}	0.86^{g}	7.24^{d}	1.02^{i}	16.99
Water NFT	2.03^{e}	0.82^{g}	6.70^{g}	1.18^{h}	19.15
Compost NFT	2.97^{b}	2.32^{a}	6.31^{h}	3.20^{b}	25.80
Master Mix NFT	3.36^{a}	2.17^{b}	9.23^{a}	2.83^{e}	17.18
Master Blend NFT	2.38^{cd}	1.26^{e}	8.22^{b}	3.07^{d}	18.79
Fish Effluent Drip	2.99^{b}	1.78^{d}	6.38^{h}	1.28^{g}	25.96
Water Drip	2.06^{de}	1.05^{f}	7.01^{e}	2.85^{e}	31.40
Compost Drip	2.31^{cd}	1.88^{d}	7.22^{d}	3.44^{a}	29.90
Master Mix Drip	2.23^{cde}	1.06^{f}	6.86^{f}	2.64^{f}	28.89
Mater Blend Drip	2.45^{c}	2.04^{c}	7.35^{c}	1.31^{g}	53.73
Geoponics	2.97^{b}	1.08^{f}	7.15^{d}	3.20^{c}	28.24
LSD Values	0.08	0.09	0.14	0.92	1.75

*Means with the same alphabets in the same column are not significantly different at 5% level of significant

Keys: NFT=Nutrient Film Technique, LSD: Least Significant Difference.

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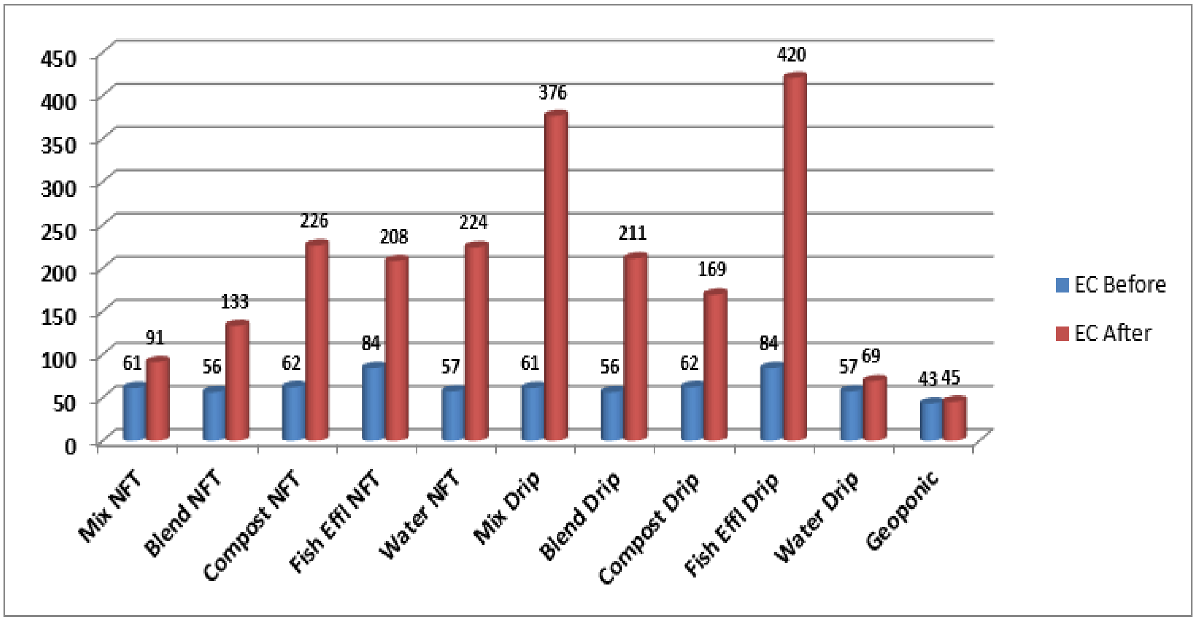

Figure 1: Electrical Conductivity before and After Growth of *Corchorus olitorius* in the Different Nutrient Source

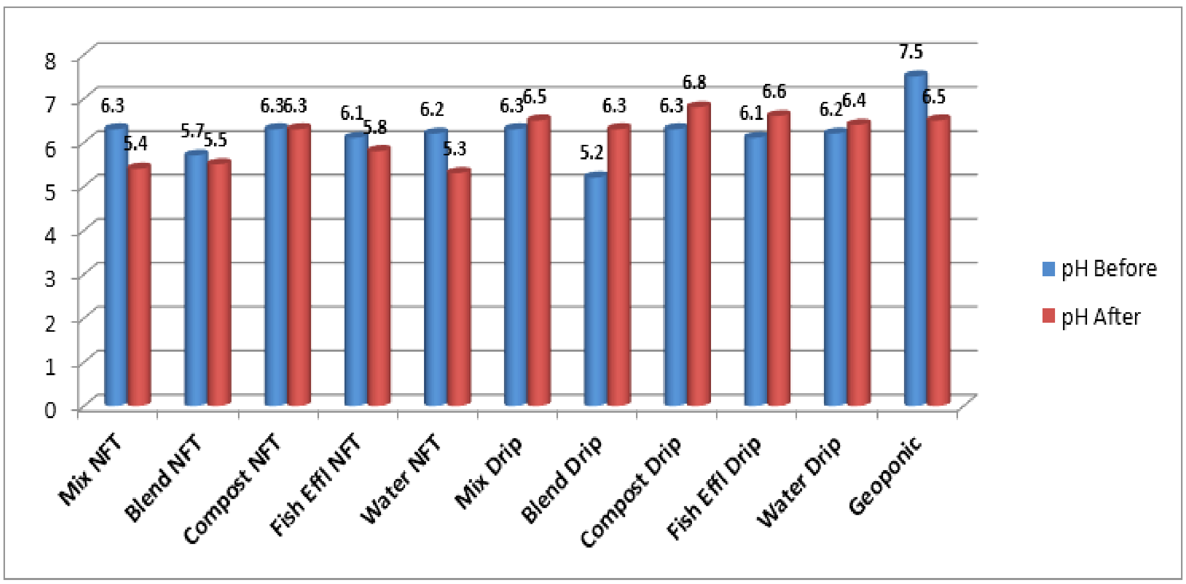

Figure 2: Electrical Conductivity Before and After Growth of *Corchorus olitorius* in Different Nutrient Sources

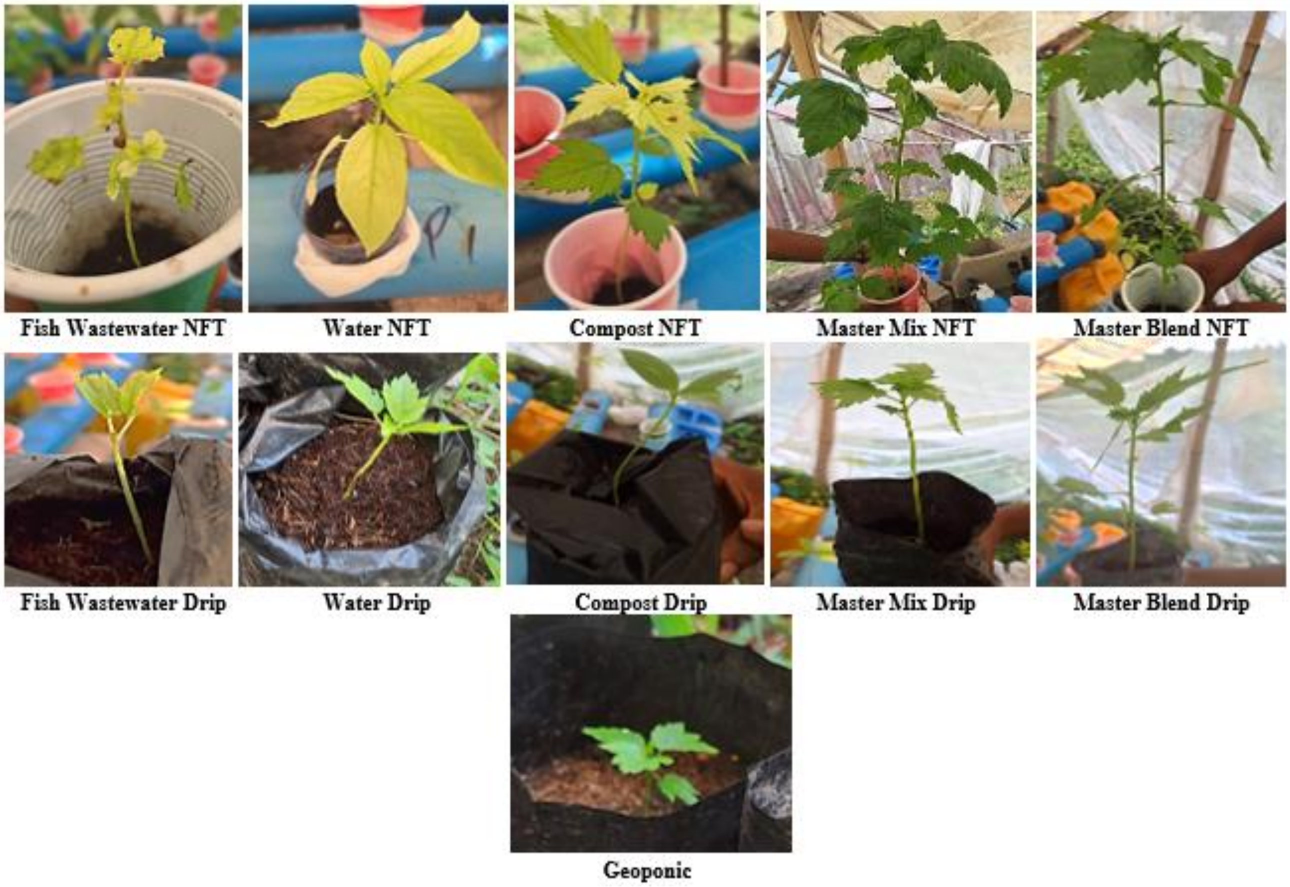

Plate 1: *Corchorus olitorius* grown with different Nutrient Sources at 4 Week After Planting

Discussion

Palmitessa et al. (2024) and Nitu et al. (2024) attributed the enhanced growth of *Corchorus olitorius* grown with Master Mix under the Nutrient Film Technique (NFT) to the continuous supply of balanced nutrient and optimal oxygen availability to roots which is a major advantage of hydroponic systems. Zaili et al. (2024) confirmed that NFT improved nutrient uptake efficiency and promoted vigorous vegetative growth by maintaining a thin, oxygen-rich nutrient film that stimulated root activity. In contrast, plants grown with compost under the Drip technique showed slower initial growth, especially in the first week which is consistent with the report of Piccolo and Drosos (2025), who noted that organic nutrients are released slowly, limiting early growth of crops.

Manimozhi and Krishnamoorthy (2025) suggested that the superior growth in NFT and Drip systems compared to soil cultivation was due to precise nutrient delivery. Conversely, Mishra (2025) explained that poor growth in geoponic plants from Week 3 resulted from poor nutrient mobilization, uneven distribution, and inadequate root aeration.

This study also found significant differences in chlorophyll and carotenoid contents among plants grown with different nutrient sources and methods. Plants grown with Master Mix under Drip system had significantly higher chlorophyll a, chlorophyll b, total chlorophyll, and carotenoid levels, while water-grown NFT plants had the lowest pigments. Ali et al. (2023) and Chenard et al. (2005) emphasized that chlorophyll production depends on nutrients like nitrogen, magnesium, and iron.

Nutrient sources and cultivation methods also influenced phytochemical contents. Tan et al. (2023) reported that optimized hydroponic nutrient solutions increased bioactive compounds like alkaloids, saponins, phenols, and flavonoids by enhancing nutrient uptake and metabolism. Suryawanshi et al. (2021) suggested that the high alkaloid levels in plants grown with Master Mix under NFT could be linked to improved nitrogen availability, a key alkaloid precursor. Jan et al. (2023) noted that nutrient deficiency peculiar water under NFT could limit production of secondary metabolites.

All hydroponic nutrient sources showed significant increases in Electrical Conductivity (EC) after cultivation, reflecting salt and nutrient accumulation typical in closed or semi-closed systems (Cho et al., 2023; Tammam et al., 2023). Mielcarek et al. (2024) explained that such EC fluctuations are common in recirculated hydroponics. In contrast, geoponics showed a slight EC increase from 43 to 45 ppm, likely due to soil’s buffering capacity minimizing salt fluctuations (Arwenyo et al., 2023). These significant EC changes highlight the need for regular monitoring to maintain nutrient balance and prevent salt stress.

Notable pH fluctuations occurred during *Corchorus olitorius* growth across various nutrient sources and cultivation methods. Khanna et al. (2023) attributed the pH decline from 6.3 to 5.4 in the Master Mix under NFT to plant root exudation of hydrogen ions (H^+) and uptake of cations such as ammonium and potassium, which acidified the nutrient solution. Philippot et al. (2024) noted that microbial activity and nutrient transformations also contributed to this acidification. Conversely, compost under NFT maintained a stable pH of 6.3, likely due to the buffering capacity of organic matter (Jeon et al., 2023). Ma et al. (2022) explained that the drop in pH from 7.5 to 6.5 in geoponic systems resulted from root exudates, nitrification, and cation uptake.

Conclusion

This study revealed that *Corchorus olitorius* grown with Master Mix under the Nutrient Film Technique (NFT) exhibited superior growth performance, while plants grown with Master Mix under Drip technique had the highest chlorophyll a, chlorophyll b, total chlorophyll, and carotenoids. In contrast, plants grown with water or fish effluent under NFT recorded the least pigment and phytochemical contents, whereas Master Blend under Drip and Master Mix under NFT systems produced plants with the highest phytochemical contents. This study revealed the need for regular monitoring of EC and pH especially under hydroponic farming to prevent salt stress and acidification. Further study should focus on optimizing nutrient formulations for improved growth and phytochemical accumulation across hydroponic systems.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

Authors Contribution

AGO conceptualized the study. APA and OPC designed the study. AGO, APA and OPC collected the data. AGO performed the data analysis; APA and OPC interpreted the data. APA prepared the first draft of the manuscript, reviewed by AGO and OPC. All authors contributed to the development of the final manuscript and approved its submission.

Disclosure of conflict of interest

There is no conflict of interest

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