Development of Greenhouse with Root Dipping Technique Hydroponics Structure to Test the Performance of Jute Mallow

Obafemi O. Olubango, Oluwafemi D. Adaramola, and Adebolu E. Alade

ABSTRACT

An agriculture system known as hydroponic is a modern-day agricultural practice. Since it does not require soil for crops to grow, it is therefore referring to as soilless farming. It is a good alternative for producing healthy crops and vegetables, free from soil-borne pathogens as it is not growing on soil. Does every crop perform well on hydroponic systems? To know this answer, we carried out this experiment to test the performance of jute mallow in a newly developed greenhouse and root dipping hydroponic systems developed at the Department of Agricultural and Environmental Engineering experimental farm at Oba-nla, Federal University of Technology, Akure, Nigeria. To compare its growth, we planted them on raised soil beds even though plants perform better on raised soil beds above on the ground soil. To compare the growth parameter of all plants we collected data of plant height, stem girth, and leaf number. We also measured the yield for each crop at the end of the experiment. The crops performed well on root dipping hydroponic systems than conventional planting systems (soil). The results showed that the root dipping system for jute mallow gave the highest plant height (19.79 cm), the number of leaves (30.93), and stem girth (0.4450 cm) while the soil conventional farming system for this vegetable gave the lowest plant height (17.99 cm), the number of leaves (27.96) and stem girth (0.4159 cm) respectively. Higher yields were also recorded from the root dipping system for vegetables while conventional farming had the least yield. The root dipping system for this vegetable recorded significantly higher fruit weight (133.52 kg) fresh weight of stem (195.29 kg) and fresh weight of root (79.34 kg) respectively while conventional farming had the least fruit weight (121.81 kg), fresh weight of stem (177.12 kg) and fresh weight of root (72.32 kg) respectively. The different treatment applied affects the physiological appearance and the yields of the crops significantly ($p < 0.05$) couple with its physicochemical features. The fruits and vegetables' mineral and proximate composition were within the recommended range by World Health Organization (WHO) but were significantly ($P < 0.05$) affected by the effects of the treatment as a result of its physicochemical features. From the result of this investigation, it, therefore, suggested that soilless agriculture should be practiced and invested in by farmers and entrepreneurs most especially in environments where there is no availability of arable land for planting for fresh availability of vegetables and fruits all year round.

Keywords: greenhouse, hydroponic, jute mallow, growth, yield, quality.

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I. INTRODUCTION

The word hydroponics comes from two Greek words 'hydro' meaning water and 'ponos' meaning labour [1]. This was first used in 1929 by Dr. Gericke, a California professor who began to develop what previously had been a laboratory technique into a commercial means of growing plants. The U.S. Army used hydroponic culture to grow fresh food for troops stationed on infertile Pacific islands during World War II. By the 1950s, there were viable commercial farms in America, Europe, Africa, and Asia. Hydroponics, otherwise known as the soilless farming technique, is a method of

planting using nutrient solutions [2]. This solution includes all essential nutrient elements that plants might need to grow to maturity with or without the use of supporting mediums like soil, fiber, vermiculite, peat moss, etc. This system of farming has been recognized as a reliable method of planting fruits and vegetables as well as ornamental crops. According to findings of research carried out by Olubango and Alade [3]; Olubango and Alade [4]; Olubango and Alade, [1] vegetables such as cayenne pepper, Tomatoes and African spinach were planted using drip hydroponic system. The result of the yields was significant compared to conventional farming system. Because of the ban placed on the use of methyl bromide in soil used for conventional farming, there has been an increase in demand for

hydroponically grown crops in the last few years. The reasons for the increase in agricultural activities and products are as a result of increased demand for foodstuffs for the growing population and need for self-sufficiency and food protection demand achievement in Nigeria as much as possible. Soil and water have been major constraints in achieving this food supply and nations demands aside other factors. A large percentage of arable lands in Nigeria is encountered with problems of lack of soil nutrient. This at the same time affects the nutritive value of the crops. Because of this, it is important to look at the new way of growing crops to get crops of more nutritive values. In previous years, special attention has been given to the production of agricultural products. In non-conventional agriculture, especially soilless planting systems of all kinds of plants.

Hydroponic farming is an improved system of farming that ensures even distribution of nutrients and provides exclusive supervision of the farm. Previous researchers indicate that the groundwork for hydroponic farming should be drained easily; it must be ventilated with good ability and capacity for the preservation of water, and it must be equally free from weeds. Besides, synthetics materials are recommended for groundwork instead of organic sources. Soilless agriculture has a lot of benefits such as high performance, reduce labour, and work simplicity. Although, it requires adequate expertise and high investment. With the advent of civilization and/or technologies, a reduction in the availability of per capita land has been the major challenge of conventional farming. In 1960, 3 billion populations all over the world per capita land estimate was 0.5 ha but with 6 billion people, it is only 0.25 ha and by 2050, it will reach at 0.16 ha [5]. Because of the increase in the rate of urbanization and industrialization as well as climate change effects which have resulted in global warming, this has consequently affected arable land. Also, the fertility of the soil has reached the level of saturation. This has further affected the productivity level coupled with the increased amount of applied fertilizer. Other factors which threaten increased in food production under conventional farming are poor soil fertility in some of the cultivable areas; less chance of natural soil fertility build-up by microbes due to continuous cultivation; frequent drought conditions and unpredictability of climate and weather patterns; increase in temperature; river pollution, poor water management and wastage of huge amount of water, a decline in groundwater level, and so on. Hydroponic systems can either be liquid or aggregate. Liquid systems have no supporting medium for the plant roots, whereas aggregate systems have a solid medium of support. Hydroponic systems are further categorized as open (once the nutrient solution is delivered to the plant roots, it is not reused) or closed (surplus solution is recovered, replenished, and recycled). Further continuous cultivation of crops has resulted in poor soil fertility, which in turn has reduced the opportunities for natural soil fertility build-up by microbes. This situation has led to poor yield and quality. Also, conventional crop growing in soil (Open Field Agriculture) is difficult as it involves large space, a lot of labour, and a large volume of water. And in some places like metropolitan areas, the soil is not available for crop growing. Another serious problem experienced of recent is

the difficulty to hire labour for conventional open-field agriculture. Soil is the medium through which plants and weeds grow naturally. This medium provides support, nutrients, air, water, and so on for plants to grow successfully. However, most often, these soils carry a pathogen that can cause serious limitations for the growth of the plant. Their pathogen involves disease-causing organisms and nematodes. There are also other factors such as unsuitable soil reaction, unfavorable soil compaction, poor drainage, degradation due to erosion, etc. are some of the limitations of using soil as a medium for plant growth. Crops grown through soilless farming have the opportunity to get optimal yield and growth to conventional ways of planting crops. Hydroponics or soilless farming techniques provide means of the measure over soil-borne diseases and pests, which is most prevalent in the tropics where the life cycles of these organisms continue uninterrupted and thereby causing threat crops. Rather than engaging in activities such as soil amelioration and sterilization, which are costly and time-consuming, it can be avoided with the aid of soilless farming. It is a system of farming that offers a clean working situation and thus making hiring labour very easy. In soil, plants waste a tremendous amount of energy in developing a large root system to search for moisture and nutrients. When grown hydroponically, the root is bathed with nutrients dissolved in water. This way their energy can be redirected into the production of more foliage, flowers, fruits, and vegetables. Plants grown hydroponically are healthier because they receive a well-balanced diet. They are more vigorous because little energy is wasted searching for water and nutrients. As a result, hydroponically grown produce is larger, tastier, and more nutritious than the same produce grown in soil. This work aims to grow jute mallow using root dipping technique hydroponic farming method to test the effect of inorganic nutrient solution.

II. MATERIALS AND METHODS

A. Study Areas

The study was conducted in a greenhouse and open field planting (for yield comparison) at the Agricultural and Environmental Engineering department at Obanla in Federal University of Technology, Akure (lat. 7°17'N, long. 5°8'E, and altitude of 388 m a.s.l.). It is a tropical rainforest zone of southern Nigeria, which is characterized by the distinct wet and dry seasons of the average annual temperature of about 31 °C (min 26.9 °C and max. 34 °C). The relative humidity ranges between 68% to 86% during the rainy season and less than 50% during the dry season [1].

B. Constructional Materials

The choice of materials and quantities for the construction of a greenhouse and drip hydroponic structure used for this experiment are summarized in Table I, Table II, Table III, and Table IV as given below.

TABLE I: MATERIALS OF CONSTRUCTION FOR THE VARIOUS PARTS OF THE GREENHOUSE

Sections	Materials of Construction
Footings	Concrete (gravel, sand, and water) was used for the foundation.
Column	Iron pipe of different sizes and planks were used for the frame.
Glazing	The material used as wall covering for this greenhouse was. wire mesh and net so that there would be natural ventilation.
Truss/Roofing	Irons, Planks, and Plastic roofing sheets were used.

TABLE II: MATERIALS OF CONSTRUCTION AND SIZES OF THE VARIOUS PARTS OF THE ROOT DIPPING TECHNIQUE HYDROPONIC STRUCTURE

Sections	Materials of Construction
Frame	2"×2" planks as frame for the planting structure, 2" x 2" planks as frame for the reservoir.
Reservoir	50 liters' buckets were used as reservoir for nutrient solution, 5 liters' bowl for recovering the excess solution.
Connection Fittings	2" PVC Pipes, Controls, Couplings, Stoppers, T-connectors, Elbow, Abro gums.

TABLE III: SIZES/QUANTITIES OF MATERIALS USED FOR THE CONSTRUCTION OF THE GREENHOUSE

Materials with Sizes	Quantities
2" Square pipe	16
1" Square Pipe	4
2 Flat Bar	1
Electrode	1
Hinges	4
2" × 3" Planks	20
1" × 2" Planks	20
1" × 6" Planks	10
Iron Net	2 rows
Nails/Screw	5 kg
Sand	5 kg
Gravel	25 kg
Cement	25 kg
Plastic Corrugated Roofing Sheet	1 bundle

TABLE IV: SIZES/QUANTITIES OF MATERIALS USED FOR THE CONSTRUCTION OF ROOT DIPPING TECHNIQUE HYDROPONIC STRUCTURE

Materials with Sizes	Quantities
2" × 2" Planks	6 pieces
2" PVC Pipes	12 pieces
4" Clips	12
Control switch	6
50 liters Bowl	3
1/2" PVC Pipes	3
1/2" Elbow	10
3/4" x 1/2" T-connector	4
Bowl (5 litres)	3
1/2" Caplock	30
Abro gum	2
Male and female socket	1
4" Blog	12
1/2" T connector	30
3/4" Pipes	1
3/4" Adaptor	1

C. Design of Greenhouse

The greenhouse was designed by calculating for the entire structural members such as footings, columns, and truss. Footings were designed to sustain the applied loads, moments, and forces and the induced reactions and to ensure that any settlement that may occur shall be as uniform as possible and the safe bearing capacity of soil is not exceeded. Section design of the column members was carried out by adopting code reference section design – BS

5950: Part 1. This was done for every member that constitutes the greenhouse. The column structure of the greenhouse is of dimension 4100 mm × 3060 mm with height at the front elevation being 2050 mm and at the back is 1750 mm using materials such as 2" square pipe, crew, nails, etc. as constructional member of the greenhouse. Section design of the truss loading members was carried out by adopting code reference section design BS 648 for dead load; BS 6399 for imposed load and CP 3 Chapter V: Part 2:1972: Table III and VIII for Wind loading. This was done for every truss member that constitutes the greenhouse.

D. Construction of Greenhouse

The construction of the greenhouse was carried out following the structural design analysis and orthographic and isometric view as shown below. The materials of construction are specified in Table I and Table II. Each component was constructed with proper tolerance, dimension, and specification as indicated in Fig. 1 and Fig. 2. The footings are the base of the greenhouse. The whole weight of the structure rests on the footings. These were excavated to the size of 300 mm by 300 mm and depths of 50 mm with the aid of spade and digger and cast using a concrete mix of ratio 1:2:4. The frame is the skeleton of the greenhouse, and it sustains the whole weight of the structure. The frames were cut with the aid of a hand saw from square pipes and planks to the dimension specified in the drawing. The joints of the frames were track-welded, nailed, checked for level, and full-welded after checking with the electrode. Nets were used as covering materials for the frame. The nets were nailed to the square pipes with the aid of a hammer and raced with planks. The truss is constructed with planks of different sizes. It is a sloping flat truss type that slopes toward the back elevation of the structure. The plastic corrugated roofing sheets were used to cover the truss.

Fig. 1. Orthographic View of the Greenhouse.

Fig. 2. Isometric and Exploded View of the Greenhouse.

E. Construction of Root Dipping Technique Hydroponic Planting Structure

The construction of the root dipping technique hydroponic farming structure was carried out following the orthographic and isometric view as indicated in Fig. 3 and Fig. 4. Each component was constructed with proper tolerance, dimension, and specification as indicated in the drawing. The root dipping technique hydroponic farming structure was made from the materials indicated in Table III and Table IV. The plank served as the frame/tower in which the hydroponic planting structure rests. Before the construction of the tower for the soilless farming system, it is important to measure the required space for the drawn hydroponic structure. The stand/tower was constructed using 2" × 2" planks. A saw was used to cut the planks while a hammer was used to nail the pieces of the planks together. The front side of the horizontal supports was 1" lower than the other side to ensure proper drainage. After the stand/tower was constructed, the 4" × 6" plastic bowls were laid on the frame. 1" diameter holes were drilled in the bowls to hold and through which the plants were dipped into the nutrient solution. These were done using a power drill and a 1" diameter hole saw.

F. Experimental Procedures and Measurements

First, a container was selected for the nutrient solution. The container was made of plastic and rectangular except metal. A black plastic sheet of at least 0.15 mm thickness was placed as a lining inside the boxes to avoid leakage and to reduce the light. The depth of the box is about 25–30 cm to provide enough solution as well as enough space above the solution for the root to absorb oxygen. A board (made of PVC) is required to place on the container to prevent light penetration and support to the plant. The planting pots are also fixed on this board. The number of holes in the board to fix the pots depends on the crops and spacing required for optimization. An additional hole will be made for air circulation and refilling. Seedlings are transplanted in plastic pots. Some holes were made at the bottom and on the sides of the plastic cups for roots to emerge and for the nutrient solution to seep into the potting material. A small piece of the net was placed inside the pots to prevent potting materials from falling into the solution. 2/3rd of the container was filled with nutrient solution. The pots with the plants were fitted onto the board and were placed on top of the box. Only the bottom 2 cm of the pots was submerged in a nutrient solution. The above steps complete the formation of a non-circulating hydroponics system. One-third (1/3) of the young root system must be in the air and the rest will be floating/dipping in the nutrient solution. During crop growth, when the solution level in the container goes down, the ion concentration may increase. Such an increase is detrimental to plant growth. When this condition is observed, the remaining solution was siphoned out and refilled with fresh solution. It is necessary to know the meteorological parameters of the area the soilless farming technique is being carried out and the control experiment during the period of the research. The data such as temperature, rainfall, and relative humidity were monitored directly from the greenhouse during the growing season with Max-Min Thermo Hydro model: CTU7635. Collection

of similar data (rainfall, temperature, and relative humidity) were collected from the meteorological department, Federal University of Technology, Akure located about 200 m away from the study site within the period of March-August 2017 for proper comparison with climatic data observed within the greenhouse. The data collection on growth and yield of the crop was taking a week after planting and this continued every week until maturity. The physiology characteristics of the crop such as plant height, number of leaves, stem girth, etc. including biomass yield were taken and calculated. Samples of Jute mallow vegetables were collected from each plant stand. Leaves of the vegetable were plucked and cleaned by rinsing with deionized water. The samples were freshly stored in the refrigerator (4-8 °C) for chemical analysis in the laboratory. The proximate composition of these vegetables was determined using [8] procedure for the determination of moisture content, ash content, protein, crude fiber, fat, and energy [8]. The mineral elements comprising sodium, calcium, potassium, magnesium, and iron were determined according to the method of [16] and [26] with some modifications [6]. 2.0 g of each of the processed samples was weighed and subjected to dry ashing in a well-cleaned porcelain crucible at 550°C in a muffle furnace. The resultant ash was dissolved in 5.0 ml of HNO₃/HCL/H₂O (1:2:3) and heated gently on a hot plate until brown fumes disappeared. To the remaining material in each crucible, 5.0 ml of de-ionized water was added and heated until a colourless solution was obtained. The mineral solution in each crucible was transferred into a 100 ml volumetric flask by filtration through Whatman No.42 filter paper and the volume was made to the mark with deionized water. This solution was used for elemental analysis by atomic absorption spectrophotometer. A 10 cm long cell was used and the concentration of each element in the sample was calculated on percentage (%) of dry matter i.e., mg/100 g sample [9]. All the data collected from the observations were averaged and subjected to analysis of variance (ANOVA) at 95% significant level to evaluate the effect of planting systems on the crops using Minitab 17 statistical analysis software where the systems were compared using least significant differences (LSDs) at $p < 0.05$.

III. RESULTS AND DISCUSSION

A. Physicochemical Properties of Soil Used for Conventional Farming of the Crops

The physicochemical properties of the soil where the vegetables were planted are given in Table V. The soil at the experimental far showed it is loamy sand in texture through particle size analysis. The ability of soil to supply and hold nutrients is linked to the number of parking spaces for nutrients on soil particles. The soil sample has a high permeability level. This result to more water and nutrient been drained easily and not available to plants at the end. There is low content of organic matter in the soil sample as reflected by (2.98g/kg) which is below WHO standard ratings. The typical amount of organic matter in the soil varies from <1% in ordinary soil to 90% in both peat soil and between 15 to 20% in mineral soils [10], [15]. Organic matter obtained in soil was within this range. The mean

moisture content of the soil is 8.70% (Table V). Moisture content is related to organic matter; it helps to improve the structures of the soil as well as water and nutrient holding capacity, supports soil microbes, and protects soil from erosion and competition. The total nitrogen of soil is 0.14 g/kg. Nitrogen is an important building block of proteins, nucleic acids, and other cellular constituents that are essential for all forms of life. Soil pH is a measure of a soil solution's acidity and alkalinity that affects nutrient solubility and availability in the soil. The pH of the soil is strongly acidic with a mean value of 5.3 which is considered suitable and better performance of vegetables [15], [21], [30]. However, Soil pH levels near 7 are optimal for overall nutrient availability, crop tolerance, and soil microorganism activity. Soil pH can be modified by using chemical amendments [15]. The available Sodium (Na), Potassium (K), Calcium (Ca) and Magnesium (Mg) with mean values as shown in Table V were relatively low compared to the ratings of WHO for the ecological zone [20]. A soil's ability to hold and supply nutrients is related to its cation and anion exchange capacities; these revealed there is a need for amendment in form of fertilizer or nutrient solution application to improve the growth and the yield of the vegetables planted on the soil.

TABLE V: AVERAGE PHYSICO-CHEMICAL PROPERTIES OF THE SUBSTRATES

Parameter	Soil Samples	WHO (1996) Ratings
Moisture Content	8.7%	-
Water Holding Capacity	14	-
Total Porosity	86	-
Permeability	High	-
Bulk Density	1.41 g/cm ³	-
Clay	9.5%	-
Silt	3.8%	-
Sand	86.7%	-
pH	5.3	7
EC	425 µS/cm	-
Organic Carbon	1.73	-
Organic matter	2.98 g/kg	3.00 g/kg
Total Nitrogen	0.14	10-12
Fe	188.1 g/kg	20 mg/kg
Mn	24.4 mg/kg	200 mg/kg
Zn	37.1 mg/kg	50 mg/kg
Cu	5.46 mg/kg	10 mg/kg
Pb	0.82 mg/kg	0.01 mg/kg
Na	0.34 mg/100g	0.002 mg/kg
K	0.06 mg/100g	1500 mg/kg
Ca	2.11 mg/100g	200 mg/kg
Mg	0.84 mg/100g	320.00 mg/kg

B. Meteorological Conditions

Table VI and Table VII show the agro-climatic conditions outside and inside the greenhouse. The relative humidity inside the greenhouse is lower than the outside greenhouse while the temperature inside the greenhouse is higher than the environmental ambient temperature. These agreed with findings of [20] that ambient temperature is always less than the inside temperature of the greenhouse while relative humidity is vice versa and that there were fluctuations in temperature and relative humidity profile inside the greenhouse. These were attributed to the greenhouse being covered by a net and transparent roofing sheets that resulted in changes in temperature and relative humidity inside and outside the greenhouse during the period of the experiment.

TABLE VI: AGRO CLIMATIC DATA OF FUTA DURING THE PERIOD OF THE EXPERIMENT

Month	Rainfall (mm)	Rel. Humidity (%)	Temp. (°C)
March	59.0	61.0	26.5
April	111.0	72.0	30.0
May	126.0	71.0	27.5
June	128.0	80.0	26.0
July	137.0	83.0	27.5
August	129	84.0	21.5

Source: WASCAL (2017).

TABLE VII: AGRO CLIMATIC DATA INSIDE THE GREENHOUSE DURING THE EXPERIMENT

Month	Rainfall Humidity (%)	Temperature (°C)
March	52	27.0
April	68	31.0
May	64	29.5
June	67	26.5
July	69	28.5
August	75	22.0

Mean of minimum and maximum value of the relative humidity and temperature.

C. Plant Height, Number of Leaves and Stem Girth of Jute Mallow as Influenced by Different Planting System

Using the root dipping method for jute mallow, there were statistically significant differences ($p < 0.05$) among the plant height compared conventional planting system. Fig. 3 shows the jute mallow plant height for both planting methods throughout the planting period. The height of the plants increased as the plants grow. However, in testing for the differences among the pair of means, using LSD (0.05) as shown in Table VIII, jute mallow planted using root dipping hydroponic system has the highest mean plant height of 19.79 cm while that planted conventionally has the mean plant of 17.99 cm. This agreed with findings of [1], [23] which states that plants grown hydroponically had the greatest vegetative growth, characterized by high leaf and stem biomass and large total area. There was no significant difference between the mean plant height of jute mallow planted using root dipping technique and conventional. In terms of physiological features of the plant, the root-dipping technique can be recommended because it gave higher plant heights than the conventional system [14]. However, the differences in plant height could be because of irrigation/nutrient time application and difference in environmental conditions at which the plants were grown and other nutrients. The number of leaves of jute mallow planted using two different planting systems is presented in Fig. 4. The number of leaves increased as the plants grow. There was a significant difference ($p < 0.05$) in the mean number of leaves with the planting system. However, testing for the differences among the pair of means, using LSD (0.05) as shown in Table VIII, the mean highest number of leaves was recorded from the hydroponic system (30.93) while the conventional system had the least mean value of (27.96). This agreed with findings of [23] which states that plants grown hydroponically had the greatest vegetative growth, characterized by their high leaf and stem biomass and large total area. The statistical analysis showed a significant difference in the number of leaves planted in both planting systems. There is no significant difference in the mean number of leaves of jute mallow planted using the

two systems of planting. In terms of physiological features of the plant, either of the systems could be recommended because the number of leaves from them produces the highest yield. Therefore, the differences in the number of leaves could be as a result of irrigation/nutrient application time and a difference in the environmental condition of where the plants were grown. The stem girth of the tomato plant on the substrates is presented in Fig. 5. The stem girth increased as the plant matures or ages. The statistical analysis showed a significant difference ($p < 0.05$) in the stem girth planted on the substrates. However, testing for the differences among the pair of means, using LSD (0.05) as shown in Table VIII, the mean highest stem girth was recorded from the hydroponic system (0.4450 cm) while conventional had the least value (0.4159 cm). This agreed with findings of [23] which states that plants grown hydroponically had the greatest vegetative growth, characterized by their high leaf and stem biomass and large total area. There is no significant difference in the mean stem girth of using the two planting systems. In terms of physiological features of the plant, either system could be recommended because the stem girths from these systems produce the highest yield. However, the differences in stem girth could be because of irrigation time and difference in physicochemical parameters nutrient solution and that of the soil used in conventional farming for this crop. The growth parameters can be seen to be increasing as the plants grow. The jute mallow plant growth pattern shows an initial slow growth and then accelerated as observed in Fig. 3-5 after the normal slow establishment of the plant. This result agreed with the findings of other researchers [18]; [17] who found that the plant showed growth in height at the beginning rather slowly, increasing to a maximum then slow down again so that the chart obtained by plotting height, number of leaves and stem girth against weeks after planting is an oblique 'S' in shape. Hydroponic production of crops in greenhouses has increased dramatically in recent years. This is because the system allows nutrition and irrigation to be controlled more efficiently, which generates higher yields [13], [25], [32]. Generally, this result agreed with the findings of [28] that hydroponically grown crops produced higher yields than the conventional growing system in greenhouse vegetable production. Also, hydroponic farming promotes alternatives to the use of soil. Indeed, this system has promoted remarkable vegetative growth [22]. This behaviour may be attributed to the great growth of the crop as represented by their plant height, the number of leaves, and stem girth. Thus, assimilation of nutrients solution was efficient as affirmed by [22].

TABLE VIII: PLANT HEIGHT, NUMBER OF LEAVES, STEM GIRTH OF JUTE MALLOW GROWN ON ROOT DIPPING HYDROPONIC AND CONVENTIONAL PLANTING SYSTEM

Planting Systems	PH (cm)	NOL	SG (cm)
RDS	19.79A	30.93A	0.4450A
CS	17.99A	27.96A	0.4159A

Means that do not share a letter are significantly different at $p < 0.05$ according to Fisher's Least Significance different (LSD). PH=Plant Height; NOL=Number of Leaves; SG= Stem Girth; RDS=Root Dipping System; CS=Conventional System.

Fig. 3. Plant Height (cm) of Jute Mallow Planted on Two Different Planting Systems.

Fig. 4. Number of Leaves of Jute Mallow Planted on Two Different Planting Systems.

Fig. 5. Stem Girth (cm) of Jute Mallow Planted on Two Different Planting Systems.

D. Yield and Biomass Components of Jute Mallow as Influenced by Root Dipping Hydroponic and Conventional planting system

The fresh weight of leaves, stem, root, and seed of jute mallow plant as influenced by root dipping hydroponic and conventional planting systems are presented in Fig. 6. Root dipping has the highest value of these parts of the plant. Although, there was no significant difference in fresh weight of leaves, stem, and root in both systems as shown in Table 9. At the end of the experiment, regardless of the planting system, the plants grown hydroponically had the greatest vegetative growth, characterized by their high leaves, stem, and root biomass value.

TABLE IX: YIELD AND BIOMASS COMPONENTS OF JUTE MALLOW AS INFLUENCED BY HYDROPONIC AND CONVENTIONAL PLANTING SYSTEM

Planting System	FWL	FWST	FWR	FWSD
RDS	133.52a	195.29a	79.34a	89.40a
CS	121.81a	177.12b	72.32a	78.54a

Means that do not share a letter are significantly different at $p < 0.05$ according to Fisher's Least Significance different (LSD). FWL=Fresh weight of leaves; FWST=Fresh weight of stem; FWR=Fresh weight of root; FWSD= Fresh weight of seed.

Fig. 6. Yield and Biomass Components of Jute Mallow with Root Dipping Hydroponic and Conventional Farming Method.

E. Water and Nutrient Consumption of Jute Mallow Plants with Both Planting Systems

Based on direct measurements and application of water to the plants, the total amount of water consumed by the jute mallow plants with 7 plants with root dipping system was 57.038 liters of water with nutrients from March to August, 2017. The jute mallow plants consumed the highest volume of water between the 14th and 16th weeks after planting. This is because of the increased number of leaves and at the flowering stage. In the treatment, 120.80 g of nutrient elements were added to these volumes of water used by jute mallow using a root dipping hydroponic system.

F. Proximate Analysis and Mineral Composition of Jute Mallow Vegetables with Different Planting Systems

The outcomes of the proximate analysis and mineral contents of jute mallow vegetables with root dipping hydroponic planting system and the conventional system are as shown in Table X. The composition of the mineral nutrient such as sodium, potassium, calcium, and magnesium from the hydroponic system showed significant influence by root dipping techniques to that of the soil while iron showed no significant difference. There is an irregularity in the value of nutrients gotten in the research of this vegetable with these planting methods. The jute mallow on root dipping has higher nutritive values than the conventional system that was used as a control measure except in iron. The differences in the content of nutritive values of this vegetable using on planting system are a result of effects of the environment at which they were planted. The contents of the following minerals: magnesium, calcium, sodium, potassium, and iron on the vegetable using both systems showed that potassium had the highest values in all as indicated in Table X. These findings agreed with the results of [12] and [25] in whom their experiments showed the nutrient elements in some vegetables and that

the highest value was in potassium while iron has the least values. These nutrient elements were above the quantity that can be found in normal field planting of this plant according to the World Health Organization (WHO) as shown in Table X. The increase in these values might have been because of the inorganic nutrient added to the solution. The superlative values of this vegetable as a source of important nutrients needed in the food are shown by the value of the nutrients [11]. The number of minerals needed for human health development in the edible portion of food plants can be affected by methods of crop production as a case of a conventional planting system. Calcium helps the formation of bones [29], [31], while iron in the diet serves as a good source in the formation of blood in the body of a man [35]. Leafy vegetables had great strength for adding minerals, bioactive compounds, and health-promoting substances to the human body. The commercial production of these crops for a certain dietary purpose can be possible in order to meet people's demand. The level of moisture content, ash content, crude protein, fat, fiber, and energy values of jute mallow indicated a highly significant influence by the root dipping planting method. There are irregularities in the nutritional values gotten in this research of this vegetable using both planting methods. The jute mallow on root dipping planting method recorded higher values of these parameters more than the conventional planting method. Jute mallow production is currently on the increase in Nigeria partly in recognition of its food values as a source of essential bodybuilding proteins, vitamins, and minerals [7], [33]. Protein assists in the building up of new cells in the body and improve growth. Fat in the diet is used as a source of energy in the body [28]. Leafy vegetables are the source of macro and micronutrients that play a major role in maintaining healthy living [34]. Protein assists in the building up of new cells in the body and enhances growth. Fat in the diet serves as a source of energy in the body of a man [28].

TABLE X: PROXIMATE ANALYSIS AND MINERAL COMPOSITION OF JUTE MALLOW VEGETABLE USING ROOT DIPPING HYDROPONIC AND CONVENTIONAL PLANTING SYSTEM (VALUES PER 100 G EDIBLE PORTION, FRESH WEIGHT BASIS)

Parameters	% MC	% Ash	% Protein	% Fibre	% Fat	Energy (KJ/g)
RDS	76.57a	1.14a	26.45a	8.53a	8.84a	453.55a
CS	73.15c	1.10b	25.54c	8.43c	8.12c	451.47c
WHO	25 – 50	-	-	-	-	-

Energy (KJ/g)	% Mg	% Ca	% Na	% P	Fe (mg/kg)
453.55a	4.60a	43.33a	12.50a	71.74a	1.09a
451.47c	4.57b	42.84b	12.46b	70.55b	1.09a
-	0.032	0.02	0.015	0.035	20

Means that do not share a letter are significantly different.

Mg: Magnesium; P: Phosphorus; Na: Sodium; Ca: Calcium; Fe: Iron; MC: Moisture content. RDS= Root Dipping System; CS= Conventional System; WHO=World Health Organisation.

IV. CONCLUSION

Jute mallow yielded significant results under the root dipping hydroponic method of farming with respect to plant height, stem girth, number of leaves, biomass, and yield of the plants compared to conventional farming. Considering the result, it is obvious that planting jute mallow using a

root-dipping system must be given serious consideration since the significant effect of the planting system was recorded for total biomass and yield values. Based on the result, it is concluded that this system of farming will support the 2030 Sustainable Development Goals of zero hunger agenda by providing home grown vegetables all year round. It will in turn empower the youths and women and thereby improve the economy of the nation. The use of root dipping technique hydroponic farming did not only give the highest growth but also gave the highest yield of jute mallow. It is equally shown from this research that jute mallow is a nutritious food that makes available a sufficient quantity of nutrients required for good body function, maintenance, and recreation. We discovered that nutrient compositions in the vegetables under root dipping hydroponic were within recommendations. Vegetables are a poor source of fat that makes them good food for obese people. It is a good source of fiber and can reduce the level of high cholesterol in the body. With the recommended level from literature, it was found that the vegetables under root dipping hydroponic are good sources of iron and calcium.

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