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Research Article

Growth and Yield Response of Okra Under Root Dipping Hydroponic and Conventional Farming System

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Abstract Food insecurity becomes one of the topmost global challenges of the United Nations 2030 agenda. This could be curbed through soilless farming techniques. This research involves comparing growth and yield response of okra under root dipping hydroponic and conventional farming system. The growth parameter considered are plant height, stem girth and leaf number. The yield for each crop were measured at maturity. The results showed that root dipping system for okra gave the highest plant height (38.03 cm), number of leaves (116.30) and stem girth (0.52 cm) while conventional farming system of okra gave the lowest plant height (31.81 cm), number of leaves (81.50) and stem girth (0.45 cm) respectively. There is a significant higher fruit weight of (20.26 kg), fresh stem weight of (28.27 kg) and fresh root weight of (19.91 kg) respectively using root dipping hydroponic compared to conventional farming with fruit weight of (19.96 kg), fresh stem weight of (19.55 kg) and fresh root weight of (19.55 kg) respectively. The physiological appearance and the yields were significantly ($P<0.05$) affected by the various treatments with its physicochemical features. The proximate and mineral composition of the okra were within the recommended range by World Health Organization (WHO) but were significantly ($P<0.05$) affected by the treatments effects as a result of its physicochemical features. This research showed that soilless farming of root dipping technique is alternative for growing okra and source of income to teaming population that want to engage in okra farming.

Keywords: Root-Dipping, Hydroponic, Okra, Growth, Yield, Quality

Introduction

The Babylonians had hanging water culture gardens considered one of the seven wonders of the ancient world (El-Ramady et al., 2014). During this era, Egyptian hieroglyphs tell of the people growing plants in water culture. After 400 years, plant culture techniques were developed to study the mineral nutrition requirements of plants. These techniques, known as "water culture", were the beginnings of what later became "hydroponics". The greenhouse industry expressed an interest in using "hydroponic" instead of conventional soil culture because, over time, greenhouse soils would have problems with soil structure, fertility and pests. Small-scale laboratory techniques were modified to accommodate large-scale commercial crop production. W.F. Gericke (U.C. Berkley) experimented with nutriculture on a large scale and coined the term "hydroponics". A technology for growing plants (without soil) using a complete nutrient solution (water and mineral nutrients) with or without the use of an aggregate medium (sand, gravel, perlite, rockwool, etc.) to provide mechanical support for the roots refers to as hydroponic (Olubanjo and Alade, 2018). Commercial hydroponic operations appeared throughout the world in Italy, Spain, France, England, Germany, Sweden, the USSR and Israel. However, hydroponics was not widely accepted since the techniques used incorporated concrete growing beds which were expensive to construct. With the advent of plastics an interest in hydroponics was renewed. Thereafter, there is a renewed interest in hydroponics. Today, hydroponics is used throughout the world for production of food. At present, there are approximately 30,000 acres of commercial hydroponics operations world-wide, of which the U.S. has about 800 acres. Growing in a greenhouse is the best in the countries around the world lacking enough fertile land, having short growing seasons, or lacking water for irrigation. Hydroponic systems can range from the raft system where the plants' roots are totally submerged in a nutrient solution to a drip system timed to irrigate cactus and many variations. Nutrients used in hydroponic systems are either manufactured or organic. Since plants only absorb nutrients in their inorganic form, hydroponic operations use manufactured nutrients which are usually made by combining two or more naturally occurring chemicals. The problem with organic hydroponics is that the organic materials must be acted upon by microbes and turned into an inorganic form that the plant can use. This not only takes time but can be very complicated. However, a lot of thought and effort is being put toward developing a consistently successful system. Currently people wishing to go organic are using compost tea, work castings, or aquaponics where fish are raised in tanks and their nutrient-enriched water is run through a hydroponic system. The plants in the hydroponic system use the nutrients out of the water, essentially cleaning it, and the cleaned water is returned to the fish. This makes it a mini-eco-system. While this system does work, one has to remember that you are trying to maintain and balance two different systems. In other words, twice as much work and twice as many chances for something to go wrong. If a crop will grow in soil, it will grow in hydroponics as long as you come close to its normal growing conditions in nature.

Commercially, crops are picked for their high return on investment. For that reason, the major hydroponic crops are tomatoes, okra, cucumbers, peppers, herbs, leaf lettuce, and flowers. In fact, most developed countries of the world import several hundred pounds of these crops daily. Okra (Abelmoschus esculentus (L.) Moench) known in many English-speaking countries as lady's fingers (Abidi, et al., 2014). The crop is widely cultivated throughout the year in the tropics. Okra is a nutritious vegetable which plays important role to meet the demand of scanty vegetable in the market. In 2009-2010, the total world area under cultivation was 0.43 million hectares and the production stood at 4.54 million tons and Nigeria 387 ha production area while the production is 1, 039, 000 Mt and the productivity was 2.70 M t ha-1 (Benchasri, 2012). However, this crop has not much been considered for cultivation under soilless farming system in Nigeria. The aim of this research work is to determine the growth, yield rate, proximate and mineral composition of okra vegetable using root dipping technique hydroponic farming method under the influence of inorganic nutrient solution and open filed (conventional) farming.

Materials and Methods

Study Areas

The study was conducted between March and August, 2019 inside greenhouse and conventional farming system at Agricultural and Environmental Engineering department, Federal University of technology, Akure, Nigeria (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 characterised by distinct wet and dry season with mean annual temperature of about 310C (min 26.90C and max. 340C). The relative humidity ranges between 68% to 86% during the rainy season and less than 50% during the dry season (Olubanjo and Alade, 2018).

Experimental Procedures and Measurements

A plastic container was selected for nutrient solution. A black plastic sheet of at least 0.15 mm thickness was placed as 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 placed on the container to prevent light penetration and support to the plant. The planting pots are also fixed to this board. An additional hole was made for air circulation and refilling. Seedlings are transplanted in plastic pots. Some holes were made at the bottom and on sides of the plastic cups for roots to emerge and for the nutrient solution to seep into the potting material. A small piece of net was placed inside the pots to prevent potting materials falling into the solution. 2/3rd of the container was filled with nutrient solution. The pots with the plants were fitted on to the board and was placed on top of the box. 2 cm of the pots was submerged in nutrient solution. One-thirds of the young root system was in the air and the rest was floating/dipping in the nutrient solution. During crop growth, when the solution level in the container goes down, the ion concentration increased. Such increase is detrimental to plant growth. When this condition is observed, the remaining solution was siphoned out and refilled with fresh solution. The meteorological parameters in the greenhouse and the control experiment during the period of the research was observed. 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 meteorological department, Federal University of Technology, Akure located about 200 m away from the study site for proper comparison with climatic data observed within the greenhouse. Data collection on plant height, number of leaves, stem girth, number of flowers, number of fruits, total fruit yield of the crops and biomass yield were measured and evaluated. Samples of okra vegetable was plucked and cleaned by rinsing with deionised water. The samples were freshly stored in the refrigerator (4-8 C) for proximate and mineral composition analysis of these vegetables using AOAC, (2000) procedure for the determination of moisture content, ash content, protein, crude fibre, fat, energy and sodium, calcium, potassium, magnesium and iron according to the method employed by Shahidi et al, (1999) and Nahapetian and Bassir (1975) with some modifications by (Akubugwo et al., 2007) (Asibey-Berko and Tayie, 1999). All the data collected from the observations were averaged and subjected to analysis of variance (ANOVA) at 95% significant level using Minitab 17 statistical analysis software where the systems were compared using least significant differences (LSDs) at $p<0.05$.

Results and Discussion

Plant height, number of leaves and stem girth of okra as influenced by root-dipping and conventional planting system

The plant height of okra showed no statistically significant differences ($p<0.05$) among the mean plant height on the hydroponic and conventional farming. However, testing for the differences among the pair of means, using LSD (0.05) as shown in Table 1, Okra planted on the root-dipping hydroponic method has the highest mean plant height of 38.03 cm while that planted conventionally had the least mean plant height of 31.81 cm. Generally, the plant height increased as the plant aged (Figure 1). In terms of physiological features of the plant, okra planted hydroponically could be recommended because the plant height from this planting method produced the highest yield. The differences in plant height could be as a result of irrigation, nutrient time application and difference in environmental factors (Ewatola and Fasanmi, 2015).

The number of leaves of okra showed no statistically significant differences ($p<0.05$) among the mean number of leaves of both the planting system. However, testing for the differences among the pair of means, using LSD (0.05) as shown in Table 1, okra planted on root-dipping hydroponic has the highest mean number of leaves of 116.3 while that planted on the soil has the least mean number of leaves of 81.50. Generally, the number of leaves increased as the plant aged (Figure 2). In term of physiological features of the plant, root-dipping system could be recommended because the number of leaves from this produced the highest yield. The differences in number of leaves could be as a result of irrigation, nutrient availability to the plants time and other environmental factor.

The stem girth of okra plant showed no statistically significant differences ($p<0.05$) among the mean stem girth with both systems. However, testing for the differences among the pair of means, using LSD (0.05) as shown in Table 1, okra planted on the hydroponic system has the highest mean stem girth of 0.52 cm while that planted on the soil has the least mean stem girth of 0.45 cm. Generally, the stem girth increased as the plant aged (Figure 3). In term of physiological features of the plant, hydroponically grown crops could be recommended because the stem girth from this substrate produces the highest yield. The differences in stem girth could be as a result of irrigation time and other environmental factors.

The growth parameters can be seen to be increasing with age. Okra plants growth pattern show an initial slow growth and then accelerated as observed in Figures 1- 3 after the normal slow establishment of the plant. This result agreed with the findings of Olaniyi and Fagbayide, 1999 and Olaniyi et al., 2010 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. The positive response and increased in growth parameters of these plants with applied nutrient solution using root dipping hydroponic system might be due environmental condition of the plants and the right quantities of nutrients required by the plants. This revealed the vital role played by the nutrient solution in soilless farming crop production (Olaniyi and Ojetayo, 2010).

Yield and biomass components of okra as influenced by root dipping hydroponic and conventional planting system

The number of flowers, number of fruits, fruit weight per plant and total fruit yield per hectare of okra as influenced by both planting system is presented on Figure 4. Although, there was no significance difference for the number of flowers using both systems, higher value was recorded for root dipping (15.99 cm) while conventional system gave the least value (12.40 cm) as shown in Table 2. The fruit yield per plant and total fruit yield were not significant difference among with the system. The highest value was recorded from root dipping hydroponic while conventional gave the least value. The low value of yield obtained for conventional might be due to non-development of flowers into fruits as most of the flowers did not developed into fruit (Mathowa et al., 2014). Most of the flowers were dried up and fell off or usually form tiny fruits which shriveled up and fall off without further development which was prevented in case of root dipping soilless farming inside the greenhouse.

The fresh weight of leaves, stem and root of okra plant as influenced by both planting system is presented in Figure 5. Root dipping system has the highest value of these component 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 3. This agreed with findings carried out that most experiments comparing different substrates for horticultural crops indicate that the differences were not marked (Voca et al., 2007, Makinde et al., 2009, Borowski and Nurzy?ski, 2012). At the end of the experiment, regardless of the planting system, the plants grown on root dipping system had the greatest vegetative growth, characterized by their high leaves, stem and root biomass value.

Proximate analysis and mineral composition of okra under the planting systems

The results of the proximate analysis and mineral composition of okra using both planting system is presented in Table 4. The mineral nutrient composition such as sodium, potassium, calcium, magnesium and iron from root dipping showed significant difference. There is inconsistency in the nutritional values obtained in the study of okra with both planting system. Okra on root dipping hydroponic system recorded higher nutritional values more than conventional system. This agreed with findings of Barbosa et al., (2015) whom found that plants from a soilless culture had higher percentage of nutritive values compared to plants harvested through conventional system as affirmed by result shown in Table 4. The outstanding nutritive values of okra make it a special source of nutrient needed in the diet (Habtamu et al. 2015) Calcium aids the formation of bones, while iron in the diet serves as a source of blood formation to the body of a man (South pacific foods, 1995, Onwordi, et al., 2009). These nutrient elements were above the World Health Organization (WHO) as shown in Table 4. The variation in the nutritive values of these plants using both system might be because of environmental effect in which the crops were grown (Idowu and Kadiri, 2013, Ukom and Obi, 2018). This agreed with study of Russo (1996) that distribution of minerals needed for human health in the edible portion of plants can be affected by production method.

The percentage of moisture content, ash content, crude protein, fibre, fat and energy values of okra showed significant influenced by root dipping planting system. There is inconsistency in the nutritional values obtained in the study of okra with both systems. Okra on root dipping recorded higher values of these parameters more than conventional system.

Conclusion

Okra yielded significant results under 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 using root-dipping system, okra must be given serious consideration since significant effect of planting system was recorded for total biomass and yield values. Based on the result, it is concluded that the use of root dipping technique hydroponic farming system did not only give highest growth but also gave the highest yield. It is equally shown from this research that okra are nutritious foods that provide sufficient amount of nutrients needed for normal body function, maintenance and reproduction. It was found that nutrient compositions in the vegetables under root dipping hydroponic were within recommendations. Vegetables are poor source of fat that make them good food for obese people. They are good source of fibre and can decrease the concentration of high cholesterol level in body. Comparing the mineral content with recommended level, it was found that this vegetable tested for cultivation under root dipping hydroponic are good sources of iron and calcium. For optimum fresh yield of the vegetables and economy of land space for farming where land is a limiting factor, root dipping hydroponic system can be recommended.

Table 1: Plant height, number of leaves, stem girth of Okra plants grown on root dipping hydroponic and conventional planting system

Planting System	Plant height (cm)	Number of leaves	Stem girth (cm)
Root-Dipping System	38.03A	116.30A	0.52A
Conventional System	31.81A	81.50A	0.45A

Means that do not share a letter are significantly different at $p < 0.05$ according to Fisher's Least Significance different (LSD).

Table 2: Yield components of Okra as influenced by root-dipping hydroponic and conventional farming method

Farming Techniques	No. of Flowers	No. of Fruits	Fruit weight
Root-dipping	14.60a	10.200a	31.798a
Conventional	12.40a	8.60a	29.50a

Means that do not share a letter are significantly different at $p < 0.05$ according to Fisher's Least Significance different (LSD).

Table 3: Biomass components of okra as influenced by root-dipping hydroponic and conventional farming method

Farming Tech	Fresh weight of leave	Fresh weight of stem	Fresh weight of stem
Root-Dipping	20.26a	28.27a	19.91a
Conventional	19.96a	19.55a	19.55a

Means that do not share a letter are significantly different at $p < 0.05$ according to Fisher's Least Significance different (LSD).

Table 4: Proximate analysis and mineral composition of okra 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)	% Mg	% Ca	% Na	% P	Fe (mg/kg)
Root dipping method	61.30b	3.43b	33.83c	8.49ab	10.63 b	667.95b	4.82c	51.92a	26.20a	86.38a	0.92ab
Conventional method	63.18a	3.52a	35.47a	8.52a	10.83a	668.15a	4.92b	51.83b	24.55a	86.30a	0.93a
WHO Values	25 –50	-	-	-	-	-	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

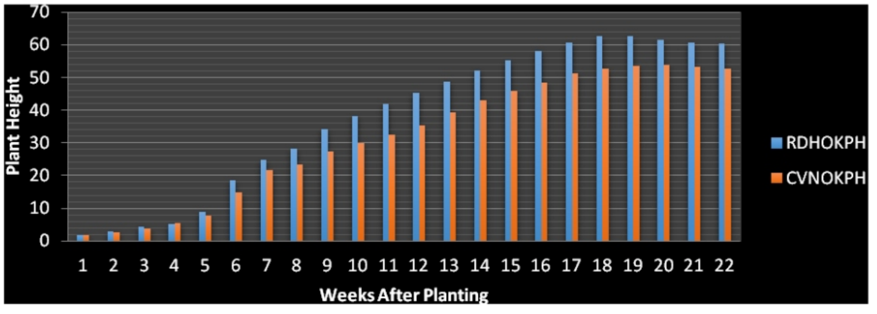

Figure 1: Plant height (cm) of okra planted on two different planting systems

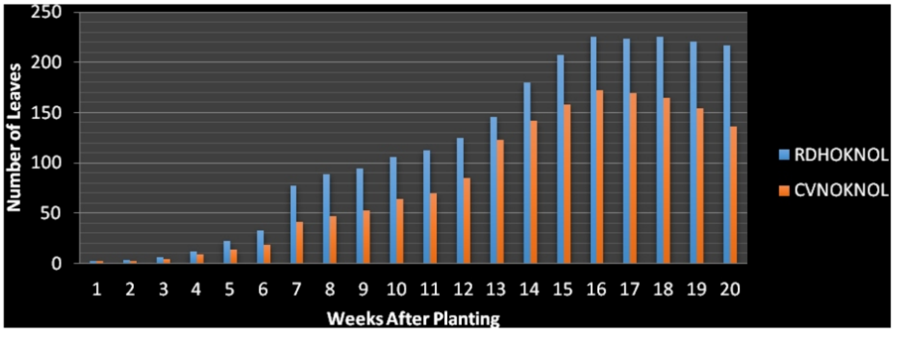

Figure 2: Number of leaves of okra planted on two different planting systems

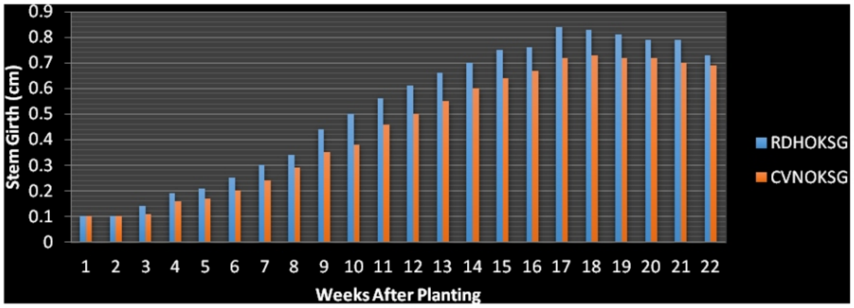

Figure 3: Stem Girth (cm) of okra planted on two different planting systems

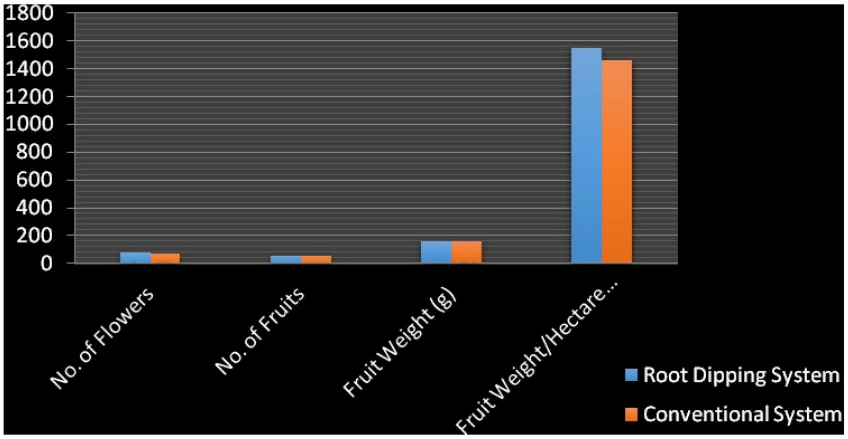

Figure 4: Yield components of okra with root-dipping hydroponic and conventional farming method

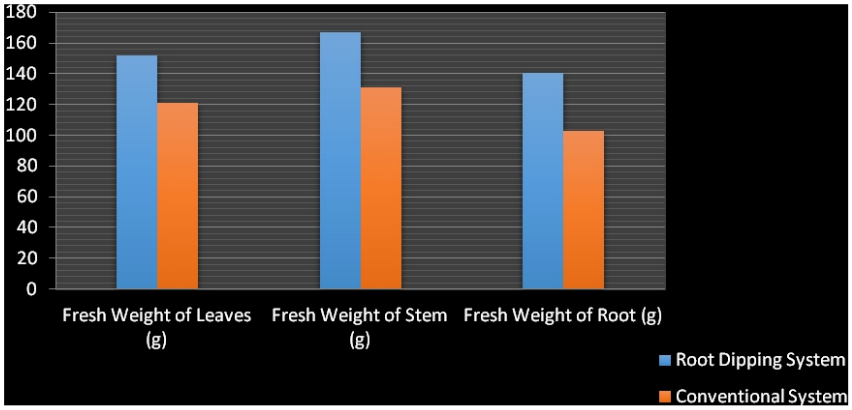

Figure 5: Biomass components of okra with root-dipping and conventional farming method

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