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Nutrient Composition And Evaluation Of Modular Aeroponics Components For Small Scale Seed Yam Production

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Abstract
Yam stores relatively longer than most root crops and this attribute have gained it recognition as a food security crop in Nigeria. More effort has been put into its research and production as evident by numerous government interventions over the years. However, inadequate access and high cost of seed yams have prevented farmers from intensive sustainable production. New technologies to increase and make available quality seed yams to farmers can boost yam production, increase food security and improve farmers livelihoods. In this regard, Nutrient composition and evaluation of modular aeroponics components system for small scale seed yam production was carried out. The objective is to design to formulate accurate nutrient solution and evaluate the components of the modular aeroponics system for the production of seed yam also to evaluate the feasibility of generating seed yams from modular aeroponics system. Results of the technical evaluation of these system showed that all the installed components worked perfectly according to their specifications. The results of directly planted vines were impressive as plants and vines suspended in air continued growing normally with the development of new roots and shoots. Within 10 days, more than 50% of the vines produced roots and in week 3 after planting, 85–100% of the direct vine cuttings produced roots on the aeroponics system. Agronomic evaluation of vines planted on the modular aeroponics system showed a progressive growth in all the parameters measured indicating the functionality of the system. The study demonstrates the potentials of the system in the production of clean materials for small medium scale seed yam production venture.

Keywords: Nutrient media, evaluation, components, modular, aeroponcis system, small scale, yam.

Introduction
Yams (*Dioscorea spp.*) are among the most important staple foods in the world, especially in some parts of the tropics and subtropics. It belongs to the family Dioscoreaceae (genus Dioscorea). Yams are native to tropical regions throughout the world. They are cultivated for their edible tubers, which in some species can grow up to about 2.4 m long and weigh up to 45 kg (Okigbo and Ogbonnya, 2006). Yam is largely carbohydrate and is one of the cheaper sources of the nutrient to humans (FAO 2010). Yams are major sources of nutrients (carbohydrates, phosphorus, calcium) and vitamins such, iron and vitamins such as thiamine, riboflavin, and vitamins B and C (Coursey, 1967). Yam is one of the most important dietary sources of energy produced within the tropics and plays a major role as a food and trade commodity in Nigeria. It stores relatively longer than most root crops (e.g. cassava), availing itself on the market for a considerable part of the year. There are a lot of challenges with yam production in Nigeria, chief among them being unavailability and high cost of seed yams. Growing yams in Nigeria is labor intensive and land demanding because of its over reliance on traditional production techniques. Furthermore, farmers rely on traditional method of milking for seed generation. The size of ware yam harvested usually depends on the size of sett used in its cultivation. Farmers therefore prefer using whole setts, however big or small for planting. To generate such

whole setts, farmers use a technique known as "milking". This process involves early harvesting of ware yams to pave way for a second tuber that can be used as seed only in early maturing varieties. After "milking", if the second tuber regrowth is not met with favorable weather conditions, the farmers cannot get enough seed to use in the next season's planting, thus having to leave a substantial part of the ware yam as seed for planting. The slow technology for seed yam production is one of three obstacles which stand in the way of cost reduction and expansion in yam production; others are the high labor requirement and problems of pests and diseases.

New technologies for growing foods that are not overly dependent on soils and water are becoming not only a distinct advantage, but a necessity. The modular aeroponics and hydroponics technologies have been demonstrated in several ways to be a significantly more water- and energy-efficient means for food production. Hence, the modular aeroponics technology is being adapted for use in this research to propagate seed yam. In modular aeroponics, plants are grown in an air or mist environment without engaging soils or any soil aggregate or soil medium (Kalu and Erhabor, 1992). Aeroponics gives room for easy access to plant roots since it is not planted in any aggregate media. The growth chamber and fertigation system employed in aeroponics also give room for complete regulation of the root zone setting, including temperature, humidity, pH, nutrient concentration, mist application frequency and duration. Plants grown using aeroponics often show signs of accelerated growth and early maturity (Nugali et al., 2005). These abilities have made the technology a popular research tool for studying root growth and nutrient uptake. Aeroponically generated seed yams can improve the seed multiplication ratio of yams and thus make available more seed yams on the market. It can also reduce disease incidence of seed yams which results in yield losses. Aeroponics, if successfully used in the propagation of seed yams, can significantly increase the incomes of farmers, improve access to quality seed yams all year round (by making it more accessible and affordable to commercial growers and small-scale farmers) and reduce the production costs of yams. This would improve farmers' livelihood and also enhance food security in the country.

Objectives of the Study

i. To design and construct small modular aeroponics system for the production of seed yam.

ii. To evaluate the nutrient and feasibility of generating seed yams from modular aeroponics system.

Materials and Methods

Aeroponic Systems Design

The requirement of this aspect was to design fully functional, low-cost modular aeroponic growth system that is pressurized with misters (power-dependent).

Systems design of the power-dependent modular aeroponic system

The power-dependent or pressurized aeroponic system (PAS) utilized electrical power in its operations. It utilized a high-pressure pump which was used to atomize the water through small orifice misters to create water droplets of about 50 microns or less in diameter. Fertigation was automatically timed using irrigation timers at twenty minutes on and ten minutes off.

Component Description of the Pressurized Aeroponics System

The system designed has components which makes the operating system effective. These components are described as follows.

This describes the materials used for the construction. Each component is described separately and dimensioned in S.I. Metric Units.

Growth/misting chamber

The growing chamber consists of a polystyrene box of 0.5 m x 0.4 m x 0.3 m covered with black on the inside to avoid the penetration of light into the chamber. Avoiding light into the chamber prevents the growth of algae in the root zone. The box was constructed to stand on rectangular wooden tables; 2 m x 0.8 m x 0.8 m high.

An outlet PVC pipe (25 mm) was connected at the central bottom of the growth chamber to drain excess nutrient solution for onward collection of the excess solution back into the feed tank for recycling.

Seedling holder

The seedling holder consisted of the tray lid of the polystyrene box fitted with silicone to prevent air entry into the growth chamber. Circular openings 10.5 cm between columns and 10.4 cm between rows were punched on the lid (resulting in 15 holes per lid) with a 16 mm copper pipe resulting in a hole of 16 mm diameter. These spaces were fitted with 16 mm PVC pipes 10 cm in length, inside these pipes were fitted styrofoam to hold the vine cuttings.

The pipe network

There were two types of pipe connections in the system: the inlet or feed pipes and the outlet or drain pipes. The inlet/feed pipe comprised a 16 mm PVC pipe linking the pumps to the growth chambers via bends and risers. A 16 mm pipe cut to a length of 2 m was fitted through to the two polystyrene boxes. Inside each polystyrene box, a mister was fitted on this pipe to fertigate the chamber. One end of the pipe was fitted with an end cap whilst the other end was joined by a bend to a 1.2 m high riser which was in turn connected to a 16 mm bend to link the connection from the feed tank.

The outlet or drain pipes were made up of 20 mm and 25 mm diameter PVC pipes. The main outlet from the polystyrene box was made up of a 25 mm pipe which was later reduced to 20 mm before finally connecting it to the feed tank. Beneath the last polystyrene box in a series connection, a pipe length of 20 cm was connected by 25 mm equal bend. This linked up with a 25 mm elbow pipe joined by an equal tee draining pipe connecting the two polystyrene which subsequently flow until the final drain linking the feed tank.

Misting / Sprinkler system

The misting system comprised of the feed tanks, feed and drain pipes and the mister. Water pumped from the feed tank was conducted to the misters for root misting through the feed pipes.

The feed pipes were 16 mm in diameter. An inflow PVC (16 mm) pipe was positioned 10 cm below the seedling holder through the sides of the polystyrene box and equipped with 360º pattern misters centered from each side of the growing chamber and with the sprinkler. The mister dispersed water particles and discharges them via a high velocity vortex action. A drain duct was punched (centered) on the bottom of the polystyrene box to drain and clean the system.

Electrical and pumping system

The electrical system consisted of an incoming power (240 V power cable) connected to wiring connection which led to solenoid switch that controlled an electric pump and irrigation timers.

The power rating of the pumps used was 0.37 kW at 0.5 hp. It took a full load current of 2.6 A at a rated voltage of 220 V. Its maximum head was 38 m with a maximum discharge of 42 l/min. A 25 mm PVC suction pipe was coupled from the feed tank through a 25 mm valve socket to a 25 mm delivery pipe outside the feed tank. A riser made up of 25 mm PVC pipe cut to a length of 1m, was connected by 25 mm equal bend from the delivery pipe outside the feed tank to a 25 mm valve socket fitted to the inlet valve of the pump. The outlet valve of the pump was fitted with a 25 mm valve socket connected to a 25 mm PVC pipe 20 cm in length. The PVC pipe was further connected to a union joint. From the union joint was connected another 20 cm length of a 25 mm PVC. A 25 mm ball valve was fitted to this pipe to prevent undesired gravity flow into the pump and its pipe network. The ball valve was opened to allow forward flow out of the pump. It was closed to also prevent reverse flow into the pump. From this connection, the pipe was then reduced with a 25 mm x 16 mm reducer that connects the 16 mm feed pipes linking the growth chamber.

Irrigation timers

Fertigation of plants in this system was automated with the help of irrigation timers. The timers used were the ABB brand, A16-30-10. It had an operating voltage of 220 V, rated frequency 50/60 Hz, runs for 20 minutes and reset time of 10 minutes. It worked at an ambient temperature of -10~+50 ºC and an ambient humidity of 85 %.

Yam Aeroponics Media

Aeroponics is the process of growing plants in an air or mist environment without the use of soil or aggregate medium (known as geoponics). It is sometimes considered a type of hydroponics, since water is used in aeroponics to transmit nutrients. Yam Aeroponics media is a nutrient media that is used to supply nutrients to the Yam vines planted in the Aeroponics boxes for Yam multiplication through the Aeroponics system (AS). It is made up of the following chemical components:

❖ Potassium Nitrate (KNO3)
❖ Magnesium Sulphate (MgSO4)
❖ Iron EDTA (Fe- EDTA)
❖ Manganese EDTA (Mn- EDTA)
❖ Calcium Nitrate (CaNO3)
❖ Ammonium Phosphate (NH4PO4)
❖ Boron (B)
❖ Ammonium Nitrate (NH4NO3)

pH range = 5.5 – 6.5

Generation of Explants for Vine Cuttings

Explants used for the vine cuttings were generated in a screen house at the Biocrops Biotechnology Limited Nigeria. The planting materials used were two varieties of yam, namely TDr 95/18544 and TDa 2014.

The soil media used was sterilized to avoid introducing weeds and pathogens into the screen house and subsequent infection of the plants and treated with water containing fungicide (Mancozeb). Other materials would be sourced from local market.

Propagation and Crop Nutrient Management

Transplanting using vine cuttings was done when the explants reached the active meristematic stage. The planting was done using two node cutting to ascertain rooting and tuberisation. All cuttings were washed with sterilized water. In planting the two node cutting, one of the nodes was bared of all leaves. The cuttings were inserted into the holes with the leaves left above the holding tray and held in place by low density foam. Cuttings were planted at a spacing of 10 cm x 10 cm on the trays of the aeroponic units. Fertigation was carried out by misting the nodes and subsequently, roots of the plant during its growing period for the whole period of planting. The same nutrient solution (as per treatment) was used to fertigate the boxes of the pressurised system. A 50l nutrient tank was used for the experiment at floor level and used to store the nutrient solution for pumping and distribution through the closed system. A 0.5 hp surface pump was used to dispense the nutrient solution through the system using 16 mm PVC pipe. Inside each container (serving as growth chambers), a 16 mm pipe irrigation line was placed on which was installed the misters.

Nutrient monitoring was conducted using pH meter. Data was collected on parameters such as pH and nutrient solution. Corrections were made to the pH and when needed by either adding more nutrients or diluting nutrient solution with pipe-borne water to keep the pH in the range of 5.5 - 6.5, the ideal values for aeroponics growth. The growth chambers of the pressurized aeroponics system had two mister each installed. An irrigation timer (as has been described), for automation of pump activities was used for irrigation scheduling.

Results

Chamber

The growth chamber houses the roots of the plants and serves as the enclosing medium for nutrient delivery and drainage. Their dimensions are usually dependent on the type of crop and production purposes. Growth chambers are made opaque to avoid the penetration of light into the root chamber, thus mimicking some soil properties. The growth chamber houses the roots of the plants and serves as the enclosing medium for nutrient delivery and drainage. Their dimensions are usually dependent on the type of crop and production purposes.

Drainage system

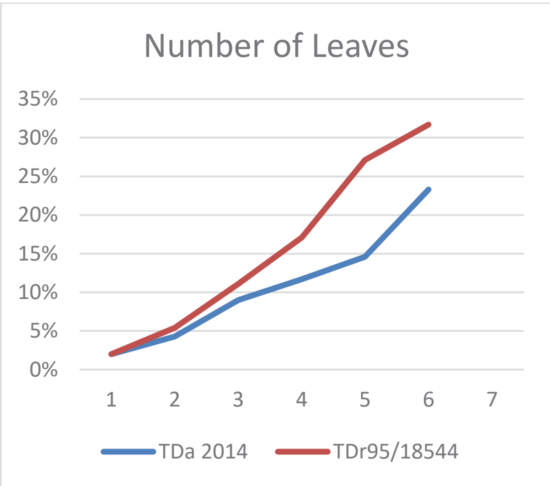
The drainage system was designed to specification to accommodate the proper pipe network, sprinkler and pumping system respectively. The drainage system also considers the slope of the chamber for effective recycling of the nutrient media which is powered by the electrical system.

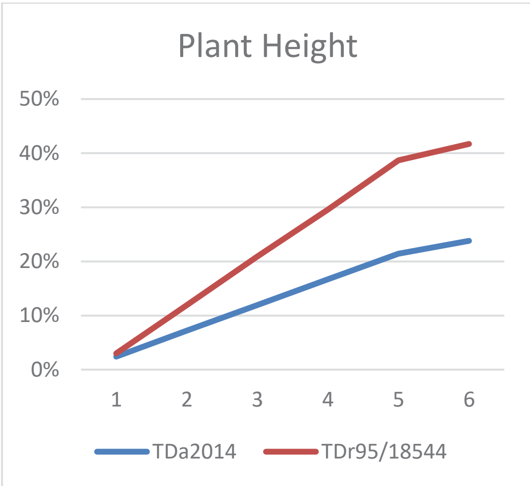
Electrical system

The electrical system is an essential component of the modular aeroponics system, the failure and success of the system depends on it. The timing of the system to regulate the amount of nutrient media distributed per time is essential for the growth and development of the plant after various programing and installations the best time for the system to run successfully was 20mintue ON and 10mintue OFF which runs for 24hours/7days.

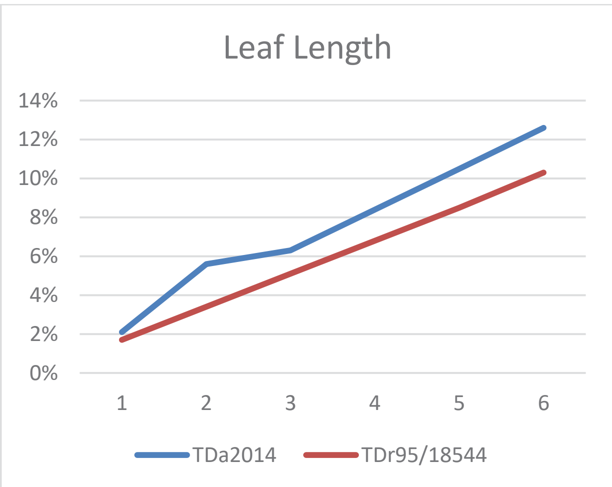
Agronomic performance of yam vine grown in a modular aeroponics system

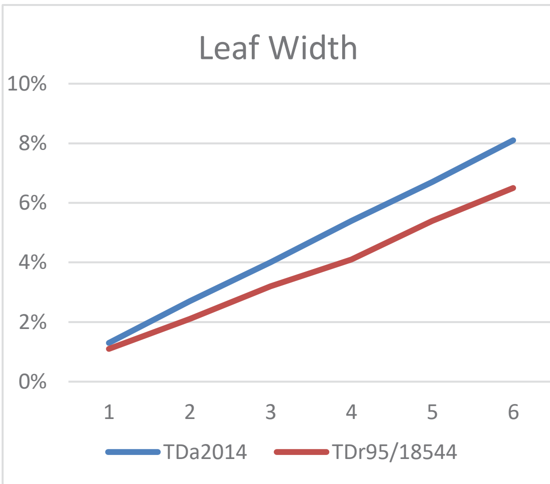
Growth response two varieties of yam TDr 95/18544 and TDa 2014. planted in modular aeroponics system are presented. The steady growth trend of all the measured parameters indicates the system's ability to support growth and development of the vines planted. It was also indicative of the functionality of the constructed modular aeroponics system.





Number of leaves of yam vine grown in the system. Number of plant height of yam vine grown in the system.





Leaf Length of yam vine grown in the system. Leaf width of yam vine grown in the system.

Discussion

The construction the modular aeroponics system composed of 2 boxes for seed yam production. The layout of the boxes, 0.5 m in length and 0.4 m wide, with 0.3 m space between two adjacent boxes. The tops of the boxes are covered with Styrofoam, 0.4 m thick, corresponding to 2 tables/box perforated at 10 cm × 10 cm, giving 15 planting holes/table (100 cm^2/plant). One of the boxes was perforated at a density of 10 cm × 10 cm to test the higher density of 30 holes/table (100 cm^2/plant).

Aeroponics Seed Yam Experiment

The experiment of seed yam production using aeroponics technique started with the following: Preparation of pre-rooted plants. When the experiment started the only source of vines was the breeding seedlings, 5 months old (raised from true seeds) that had been transplanted. One-node vines were cut from the seedlings and planted in black plastic pots for pre-rooting. Three different substrates were used, i.e., river sand, carbonized rice husks, and a mixture of 50% of both river sand, organic manure and carbonized rice husks). The two-node vines were directly planted were cut from another seedling and was transplanted to the newly constructed modular aeroponics system. Vine cuttings was made and directly planted on the modular aeroponics system which also exhibited vigorous growth to confirm the result of direct yam vine planting on the modular aeroponics system. The fertilizers used were Ammonium nitrate, Potassium nitrate, Calcium sulphate, Magnesium sulphate, Boric acid, and EDTA (iron).

Preliminary Findings

The results of directly planted vines were impressive as plants and vines suspended in air continued growing normally with the development of new roots and shoots. Within 10 days, more than 50% of the vines produced roots and in week 3 after planting, 85–100% of the direct vine cuttings produced roots on the aeroponics system. The International Institute of Tropical Agriculture (IITA 2013) aeroponics yam experiment is the first successful experience of the use of direct vine cuttings in an aeroponics system. Base on the results of the yam vines, new sets of improved yam genotypes (TDa 291; TDa 98/01176; TDr 89/02475; TDr 02665; TDr 95/18544; TDr 95/19177 and TDr 98/19158). Vines of all these genotypes grew well in aeroponics but the best was TDr 95/18544 in terms of percentage survival and growth performance.

Summary

Yam is one of the most important dietary sources of energy for households in West-Africa. Yam stores relatively longer than most root crops and this attribute have gained it recognition as a food security crop in Nigeria. More effort has been put into its research and production as has been seen by numerous government interventions over the years. However, inadequate access and high cost of seed yams have prevented farmers from intensive sustainable production. New technologies to increase and make available quality seed yams to farmers can boost yam production, increase food security and improve farmers' livelihoods. In this regard, modular aeroponics system was constructed and evaluated. The evaluations were carried out to assess the technical and agronomic performance of the systems, its advantages and uses in research as well as its limitations. Also, a general overview is given on the types of modular aeroponics systems based on their components, accessories and operation.

The conclusion made from the research and proposes areas for further research as well as recommendations for policy makers.

Conclusion

The modular aeroponics system was developed to enhance and optimize the rapid multiplication of seed yams. A well designed modular aeroponics system should be efficient in water/nutrient distribution, water and energy use. The modular system can also be adapted for use with other crops to boost food production and security even in the face of climate change, population growth and limited access to farm lands. In designing and setting up the systems, all items were procured and bought locally.

Thus, in disseminating the technology, all items needed for the set-up of the systems could be easily procured. The system, thus, has far proven to be better in terms of financial capabilities and comparable in terms of production to the power-dependent system.

The potential benefits herein discussed such as rapid rooting and tuberisation, high multiplication ratios and economically sound production gives these systems the potential to revolutionizes seed yam production.

Recommendations

Aeroponics can be recommended to producer organizations, national seed production programs, private companies, individual farmers or other institutions with interest in seed production. However, before such recommendations are made, it is important to take notice of the following discussions for future research.

Research on the technical and agronomic aspects of the modular aeroponics system, particularly when focused on intensification of the production edge beyond the current multiplication ratios (Growing media and fertilizer doses, age of explants at time of cutting vines, plantlet density, crop duration as well as development of some special cultivation techniques and use of biofertilizers) should also be conducted. The research could be based on customized management by variety (i.e. timings of fertigation, duration of each fertigation incidence), intensive management to hasten multiple tuberisation and shoot biomass, and improved control of the growing environment (temperature and humidity control). Consideration should be made that mini-tuber production represents only one critical stage in the seed yam production network. Production of the mini-tubers would therefore have to be scheduled to meet the season's seed yam production calendar.

Healthy planting materials should always be used in the initial propagation of mini-tubers to always ensure healthy harvests. Thus, further research to devise ways of cultivating explants for generating disease-free vine cuttings should be conducted. To use the aeroponics technology for the first time, it is recommended to combine the modular aeroponics technology with other conventional methods to prevent losses that can arise from unforeseen eventual collapse of the modular aeroponics system. Policies that can enhance rapid dissemination of these technologies should be put in place to enhance speedy dissemination and adoption of the modular aeroponics technologies for rapid multiplication of seed yams.

References

1. Coursey, D. G. (1967). Yams, an account of the nature, origins, cultivation and utilization of the useful members of the Dioscoreaceae. Tropical Agriculture Series. Longmans: London.
2. Food and Agricultural Organization Year Book. (FAO, 2010). Quality declared planting materials: Protocols and standards for vegetatively propagated crops. Accessed online at http://www.fao.org/3/a-i1195e.pdf on 28/04/2018
3. International Institute of Tropical Agriculture (2013). Growing seed yam in the air. In IITA weekly Bulletin No 2175 of 3-7.
4. Kalu, B. A. and Erhabor, P. O. (1992). Production and economic evaluation of white Guinea yam (Dioscorea rotundata) minisetts under ridge and bed production systems in a tropical Guinea Savanna location, Nigeria. Tropical Agriculture 69: 78–82.
5. Okigbo, R. N. and Ogbonnaya, U. O. (2006). Antifungal effects of two tropical plant extracts (Ocimum gratissimum and Aframomum melegueta) on post-harvest yam rot. African Journal of Biotechnology 5: 9. 727-731 Pp.