EVALUATION OF MEDIA AND COMPOSTING DURATION ON THE GROWTH AND YIELD OF CONTAINERIZED TOMATO: AN APPROACH TO SUSTAINABLE FOOD PRODUCTION

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ABSTRACT
In Nigeria, agricultural land faces constant depletion due to continuous cropping and competition from urban development. Urban areas suffer from severe land scarcity as available land is utilized for industrial and recreational purposes. Smarter, sustainable farming methods are essential to conserve agricultural soil and maintain crop yield. Thus, an experiment was conducted from December 2016 to June 2017 to investigate the impact of different composting media and durations on containerized tomato cultivation. Four media compositions were tested, including rice husk dust, topsoil, poultry manure, and river sand, in various ratios. The experiment involved composting the media for either eight or six weeks. Results showed that tomato growth increased over time and varied among treatments. Media significantly influenced growth parameters, with T4 performing the best overall. However, T3 yielded the highest fruit weight due to its high topsoil content. Soilless medium (T1) performed poorly due to low nutrient content and slow decomposition of rice husk. Composting duration alone did not significantly affect tomato growth and yield, but the interaction of media and composting duration revealed that T2 composted for eight weeks yielded the best results.

Keywords: Tomato, Growth, Growth media, Composting, Sustainable and Food Production.

1. INTRODUCTION
The world population is likely to hit 8.6billion in 2030, 9.8billion in 2050 and 11.2billion in 2050 (Lamprigi et al, 2019). Therefore, to cope with the expected rapid population increase, production and availability of adequate, high quality food will be one of the biggest challenges to face humanity in the next century (Viola *et a*l, 2016).

However, the intensification of agricultural production which has led to increased productivity has however significantly increased the environmental footprint of agriculture leading to a number of environmental impacts associated with changes in land use, etc. (Christian *et al*, 2009). These are agriculturally related environmental issues which have drawn the attention of the scientific community toward agricultural sustainability (Lamprigi et al, 2019).

Sustainable agriculture has three major objectives which are to achieve a healthy environment, to attain economic profitability and lastly for social and economic equity. Everyone involved in the food system, including food growers, have a role to play to ensure an agricultural sustainability system. (Gail Feenstra et al. 2021). Practices such as conservation farming which combines no or minimum soil disturbance, soil cover, diversification of crops, are beneficial to humans and to the biophysical environment (Willy M. et al., 2023).

However, the claim that conservative agriculture would improve crop yield remains controversial in the sub-Saharan Africa given to the various factors inhibiting its adoption by smallholder farmers such as increased weed pressure due to reduced tillage, poor market for legumes which discourages farmers from including it in their crop rotation and crop residues being used as animal feed which hampers the mulching principle (Descheemaeker K., 2020).

On the other hand, according to Raphael A. A. et al, 2019, urbanisation has led to continuous loss of agricultural land to non-agricultural uses through the annexation of cheaper lands in the urban peripheries by non-agricultural users. The United State farms have dropped in amount by roughly 70% since the 1930s. Farms have continued to disappear despite the growing demand for local foods. Therefore, container farms are a good piece of technology that provides solutions for food production in the future. It works well in both urban and rural settings and is an easy way to incorporate sustainable practices (Freight Farm, 2021).

Growing tomatoes in containers is an alternative to growing them in the ground. A garden sometimes is not big enough to plant everything desired or maybe one is living in an apartment and does not have access to a garden area. Growing tomatoes especially for family sustenance does not require much space. It can grow well in media containers as long as water, nutrients and sunlight are provided. It is good to know that little or no soil can be used in the production of tomatoes. This goes to relieve our soils of the myriad of uses for which they are on a daily basis. This also goes to support the concept of Smart Sustainable Farming, an idea that proposes conservation of our fixed natural resources (e.g. soil), creating maximum output with the least amount of these resources. The composition of a growing medium is greatly influenced by the particular plants being grown (Siti Fatimahwati M. et al., 2022).

Plant species differ considerably in their need for water and nutrients, and therefore need different kinds of growing media to provide the best growing conditions. Due to this, a wide range of different kinds of growing media are available in the market (Joseph M. Craine, Ray Dybzinski., 2013).

An ideal potting medium should be free of weeds and diseases, heavy enough to avoid frequent tipping over and yet light enough to facilitate handling and shipping. The media should also be well drained and yet retain sufficient water to reduce the frequency of watering. Other parameters to consider include cost, availability, consistency between batches and stability in the media over time. Selection of the proper media components is critical to the successful production of plants.
Composting assures that the decomposition heat is well dissipated and provides nutrients in readily available forms for crop utilisation. Nitrogen is usually tied up during the decomposition

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of materials of high C-N ratio like saw dust and rice husk. Composting, however, liberates nitrogen previously fixed in the medium and those accumulated in the body of the decomposing microorganisms. This cannot be achieved if the duration of media composting is not long enough. Different materials used as media substrates, due to their varying C-N ratio, require different amounts of time to be fully decomposed and ready to be used as a growth medium.

Hence, the objectives of this study were to:

Determine the media composition that best supports sustainable cultivation of tomatoes with little or no soil requirement and

The impact of duration of composting of growth media on the growth and yield of tomato in a soilless medium as well as a media with different soil compositions

Ascertain the possibility of using little amount of soil or an entirely soilless medium to grow tomatoes in order to reduce the high demand on soil and improve agricultural resilience and food sustainability.

2. LITERATURE REVIEW

Solanaceae is an important family of vegetables made up of about 75 genera and 2000 species (Purseglove, 1968). Other members of this family include pepper (*Capsicum annum*), eggplant (*Solanum melongena*), tobacco (*Nicotiana tabacum*), etc. It is grown on more than 5 million hectares, worldwide (Srinivasan, 2010). Wild tomato species are native to Western South America. There are two competing hypotheses of the origin of domestication of tomato, one supporting a Peruvian origin, the other, supporting a Mexican origin (Peralta and Spooner, 2007). However, according to Salunkhe *et al*. (1987), tomato originated from the Andean zone (Perú-Ecuador-Bolivian area) but its first cultivation was in Mexico (Uddain *et al*., 2009). Tomato is one of the most popular and widely grown commercial vegetable crops in the world (Sharma *et al.*, 2015; Isack and Limo, 2015). It is second most consumed after potato, ranks first among the processing crops and undeniably the most popular garden crop (Kalia and Palanysamy, 2014). It is famous for its nutritive and medicinal value (Opena *et al.*, 1990).

Tomato fruits are consumed fresh or processed (Eivazi *et al*., 2013, Shereni *et al*., 2015) and are a source of minerals and vitamins (Wilcox *et al*., 2003; Perkins-Veazie *et al*., 2007; Uddain *et al*., 2009; Eivazi *et al*., 2013). The red fruit contains lycopene, a carotenoid that helps to prevent cardiovascular diseases and cancers (Giovannucci, 1999; Giovannucci *et al*., 2002; Perkins-Veazie *et al*., 2007). Selective breeding managed to refine the tomato into a very nutritious state filled with vitamin A, C, E, antioxidants and more.(http://www.vegetablefacts.net/vegetable-history/history-of-tomatoes/,20/07/2017). Cooking tomatoes more than doubles the effectiveness of the lycopene they contain, while a small amount of olive oil, such as what you would add in a pizza or tomato sauce, intensifies the protective effect further. Tomato when cooked has been found to help prevent prostate, lung, stomach, pancreatic, colorectal, oesophageal, oral, breast and cervical cancers. Numerous other studies have found that tomatoes help to dissolve animal fat in butter, cheese, eggs, pork, beef and many deep fried foods, preventing hardening of the arteries, while the high potassium content helps in reducing high blood pressure, a major risk factor for coronary heart diseases and stroke. The plant is a cornucopia of health remedies and, among the Incas of South America and some tribes of Papua New Guinea, the fresh leaf of the tomato plant, crushed with some water into a poultice, was even applied as an antibiotic to infected areas of the body. To relieve bloodshot eyes, Chinese doctors suggest eating 1 or 2 fresh tomatoes first thing in the morning on an empty stomach. Tomato is excellent for cleaning and rejuvenating the skin, restores vitality for persistent fatigue, and restores the health of the liver (www.holisticonline.com/herbal-med/_herbs/h_tomato-healing-benefits.htm, 05/01/2024).

3. CULTURAL PRACTICES IN THE PRODUCTION OF TOMATO

Crop and variety Selection

Selection of vegetable kinds and varieties for production is the initial step in the development of a successful vegetable farming operation. Although vegetables are widely adaptable, successful production in a given area will be influenced by limiting factors: water, hail, wind, temperature, light, nutrition and markets. Variable levels of limiting factors limit yields or reduce potential for profitability. Therefore, base crop selection on the availability of these factors within a given location and growing season is important. It is good to always select adapted varieties having the highest levels of disease and/or insect resistance, good horticultural characteristics and market appeal. Selecting the best variety is critical for success.

Mulching

Schonbeck and Evanylo (1997) reported that mulch treatment apparently affected early tomato yield by influencing temperature regime but affected later yields by modifying soil moisture levels. Early yields were generally highest with black plastic mulch and lowest in organic mulches, with paper mulch intermediate. Akintonye *et al*. (2005) in their experiment to determine the effect of different live mulches on the growth and yield of tomato using cucumber and pumpkin reported that the cucumber mulched tomato gave a significantly higher yield than the pumpkin mulched tomato. The pumpkin live mulch treatment was a poor treatment combination as it had a deleterious effect on tomato yield, but it controlled weeds more effectively than other live mulch crops used in the study. The results suggest that cucumber will provide a good combination with tomatoes in a live mulch production system.

Staking, pruning and caging

Because of their trailing habit, some tomato plants (indeterminate type) can grow 2-2.5m tall and therefore need support while determinate plants are better suited to cages because they need only minimal support. Common cages are constructed of thick galvanised wire shaped like an inverted cone. Stakes should be set in the ground at least 30cm deep for stability.

Staked and pruned tomato plants tend to produce fewer tomatoes, but the fruits that result will be larger, healthier and earlier (Tips for Tomato Staking, Caging and Pruning (mygardenlife.com) 06/01/2024). Staking or caging can be established at the time of planting. Staking keeps developing tomato fruit off the ground, while caging lets the plant hold itself upright.

Medial requirement/preparation

The mixture and proportions used to create potting mixes are determined by: container size - container depth directly affects the percentage of the growth medium that is filled with air at container capacity; growth environment - a growth medium for plants grown in a greenhouse, where control of the moisture level is possible, can have a greater water-holding capacity than a medium for plants exposed to natural rainfall distribution; the plant's requirements and the propagators experience. There are many disadvantages to using garden soil (loam) in media mixes. Garden soil is heavy, inconsistent in quality, not uniform and not sterile. Various other materials may be mixed instead to create "soilless" media to be used in container propagation. Good mixes all share some common characteristics. "Soilless" media are composed of an organic component (e.g. sphagnum peat moss, bark or wood chips) and a coarse mineral component (e.g. sand, pumice, perlite, or vermiculite) which are lightweight and help improve drainage and aeration. (Michael Maher et al., 2008).

Climatic and growth requirement of tomato

Tomatoes are a warm season crop. It can't be grown successfully in places of higher rainfall. Optimum temperature for seed germination is 26 to 32^{0}C while that for its cultivation is 15 to 27^0 C. If fruits are exposed to direct sunlight, their tops may turn whitish yellow & become leathery in texture. This is common in late varieties during the hotter season. This condition is known as sun – scald. Sandy loam soil with a well-drained clay sub-soil is best suited for tomatoes. Light soils are good for early variety while clay loam or silt loam soils are well suited for heavy yield for late variety. Tomato grows at pH 6.0 to 7.0 satisfactorily. The soil should be well prepared and levelled by ploughing the land 4 - 5 times before planting (Climate and Soil Requirement for Tomato Cultivation - agriinfo.in, 06/01/2024).

Propagation

Generally, tomatoes are propagated from seeds. These seeds are raised in the nursery under a shade or indoors for 6 to 8 weeks. It can be a ground nursery or a container nursery which should be watered before the seeds are sown. For container nursery, 2 to 3 seeds are sown 1/4-inch deep in the soil in each pot. Germination should occur within one week of seeding.

Watering becomes less frequent once after sprouting. More plants are killed by too much water (that rots the roots) than by too little water, so watering is done sparingly after the plants sprout (https://www.almanac.com/plant/tomatoes , 15/08/2017). Transplanting of the seedlings is done in a site with full sun and well-drained soil. Tilling of the soil and manure application is done two weeks before transplanting for best results. Hardening off of seedlings is done a week before they are transferred to the main field. This is done by gradually exposing the plants to the sun, starting in a partially shaded area and gradually extending the number of hours the plants stay outside each day.

Fertilizer application

To grow successfully, tomatoes need nitrogen, phosphorus, potassium, potash, calcium, and magnesium, along with other trace minerals (http://www.tomatodirt.com/tomato-fertilizer-kinds.html, 17/08/2017). The fertilizer requirements of tomato are high and it needs frequent fertilizer applications. Fertilizer is applied two weeks prior to first picking and again two weeks after first picking. (https://www.almanac.com/plant/tomatoes, 15/08/17). Once a plant is established in the garden, a phosphate-concentrated application (such as 0-46-0 commercial fertilizer) every 6-8weeks increases tomato production. Bone meal, with an analysis of 4-12-0, is a good organic source of phosphorus. When a tomato plant sets fruit, it is good to start a systematic fertilization program and feed it every three weeks. (http://www.tomatodirt.com/tomato-fertilizer-kinds.html, 17/08/2017). When fertilizing tomato plants, be careful that you don't use too much nitrogen. This will result in a lush, green tomato plant with very few tomatoes.

(https://www.gardeningknowhow.com/edible/vegetables/tomato/tomato-fertilizer.htm, 17/10/2017). Growing tomato with drip irrigation ensures optimum plant growth and yields and allows for easy fertilizer application during the growing season (https://extension.psu.edu/tomato-production. Tomato production, 17/10/2017). Tonfack *et al*. (2009) reported that potassium nutrition was generally improved when plants were supplied with organic fertilization. However, the use of organic matter in the systems of culture should be promoted. It allows keeping soil fertility, while improving soil structure and availability of mineral elements. In fact, the increase in soil organic matter to optimum levels is a key aspect of any organic production system (Gaskell *et al*., 2000). Gianquinto and Borin (1990) found that application of manure is very favorable to the high yield of industrial tomato.

Harvesting and Marketing of tomato

Timing of harvest of tomatoes depends upon end market requirements and local practices. Tomato is a climacteric crop and picking can start at the mature-green stage, but practices that harvest before this can result in fruit that has poor colour and flavour once ripened. Thus, most fresh fruit is picked when the colour is turning from green to tarnish-yellow particularly if it is to be shipped to a considerable distance. Cluster tomatoes are picked when the least mature fruit on the truss begins to show red colour. This helps ensure uniformity when the crop reaches the consumer.

Flavour, colour, shape and texture are all important characteristics of fresh tomatoes. Fruit also needs to be clean and clear of blemishes such as decay or disease. They should be of uniform shape, symmetry and size. Tomatoes need to be bright and uniform in colour, without green shoulders or immature green spots or blotches. Firmer tomatoes are less prone to damage and have a longer shelf life. Higher levels of calcium in the cell wall will improve fruit firmness and as a result, transportation and storage characteristics. Increasing storage temperature and using ethylene can bring ripening forward.

There are a wide range of processed tomato products on the market, from canned tomatoes, juice, soup, sauce, paste, ketchup, pulp to puree. In growing and processing tomatoes, it is important to remember that there is a very limited number of food processors who purchase tomatoes and they are generally only sold under contract (https://extension.psu.edu/tomato-production, Tomato production, 17/10/2017)

Tomato marketing is a profitable venture but the major constraints are lack of storage facilities, price instability, and transportation problems. Frequency of purchase showed that majority of the tomato marketers purchase their stock every four weeks, majority preserve their stock by exposing them to the air, majority sold on baskets (Economics Of Wholesale Marketing Of Tomato Fruits In Ibadan Metropolis Of Oyo State, Nigeria | Journal of Agriculture, Forestry and the Social Sciences (ajol.info) ,06/01/2024).

World production of tomato

The tomato category is the world's largest vegetable category, representing 16%. It is also a very fast growing category with an increase in production of 49% between 2000 and 2013. The tomato industry is one of the most advanced, globalized and innovative horticultural industries. Most of the world's production is located in the temperate zones but cultivation practices and the overall organization and focus of the industry vary between countries. The global annual production of tomato (fresh and processed) increased by about 300% during the last four decades and in 2005; it was estimated by FAO at about 123 million tons with a total production area of about 4.5million hectares. China, the European Union (EU-25), USA and Turkey are the leading producers (https://www.researchgate.net/publication/40111122 tomato production,16/08/17). Global tomato production is currently around 130 million tons, of which 88 million are destined for the fresh market and 42 million are processed. The top 5 largest tomato producers are: China, EU, India, US and Turkey. They account for 70% of global production. (http://www.hortibiz.com/item/news/tomato-production-facts-around-the-world/, 16/08/17).

Effect of media on growth and yield of tomato and other crops

The quality of the media used in growing containerized crop production is largely influenced by physical, chemical and biological properties (Wilson *et al*., 2001; Grigatti *et al*., 2007; Herrera *et al*., 2008), the growing environment and plant management (Nwofia and Okwu, 2015). Growing media is a source and reservoir of plant nutrients (Indriyani *et al*., 2011). It also anchors the root system and therefore supports the plant (Abad *et al*., 2005). A good growing media should be composed of a mixture that is tender enough for seeds to easily germinate, retains moisture, drains excessive water and provides sufficient plant nutrients for seedling growth and development (Abad *et al*., 2002; Bilderback *et al*., 2005; Olle *et al*., 2012; Olaria *et al*., 2016).

Several growth media had been evaluated on various plants by previous researchers (Atiyeh *et al*., 2000; Manenoi *et al*., 2009; Indriyani *et al*., 2011; Bhardwaj, 2013; Kumar *et al*., 2016). A wide range of growth media or substrates of different origin are used in vegetable production. Some media are of natural origin while others are produced artificially in factories (Verdonck *et al*., 1982; Olle *et al*., 2012; Bhat *et al*., 2013). Growth media can include organic materials such as peat, compost, tree bark, coconut fibre, vermicompost, rice husk ash, or inorganic materials such as perlite and vermiculite (Grunert *et al*., 2008; Nair *et al*., 2011; Vaughn *et al*., 2011). The growth media from organic materials are usually used in greenhouses to produce bedding plants and vegetable transplants (Atiyeh *et al*., 2000). Mineral soil or sand is also used for growing vegetables (Olle *et al*., 2012; Mathowa *et al*., 2014a) and tree seedlings (Sekepe *et al*., 2013; Mathowa *et al*., 2014b; Mathowa *et al*., 2014c).

Bot (2008) confirms the fact that selection of the appropriate medium of growth for potted flowering plants (in this case *Zinnia elegans* cv. Blue point) was very important from an aesthetic and marketing point of view. The medium must ensure the production of plants of the required quality on a cost effective basis. In his study, he found that leaf manure mix (silt + leaf manure + coconut compost; 1:1:1) produced significantly the maximum number of flowers per plant while the maximum flower size was obtained with coconut compost. However, silt alone (a cheaper growth medium) produced flowers earliest with the longest blooming period while the number of flowers per plant and size of flowers was only significantly smaller than the other media studied. Therefore, keeping cost of production in view, silt was also a good candidate as a growth medium for *Zinnia elegans* cv. Blue Point. Adeniran (2005) reported that germination and growth of lettuce improved when hygromix was supplemented with composts compared to when composts alone were used and at the same time addition of a higher rate of compost suppressed germination and depressed yield. Muhammad *et al*. (2016) observed that when peat, compost and traditional practising media (soil, sand and farm yard manure) were used in equal proportions in 1:1:1 ratio, there was maximum germination percentage (95), seedlings shoot length (26.67 cm), seedling height (35 cm), seedling vigour index (3325) and minimum days to emergence (15.33). Maximum dry matter accumulation (34.80%) was recorded when peat was used alone. Maximum benefit cost ratio (2.70) is calculated for T_0: traditional practising media (soil, sand and farmyard manure in 1:1:1 ratio). Optimum growth of tomato seedlings was observed when peat, compost and traditional practising media were used in equal proportions. They concluded that soil media containing a mixture of equal proportions of farm yard manure, compost and canal silt are recommended for raising tomato seedling, as their combination improved both germination and subsequent growth compared to soil media used alone. Farm yard manure is not recommended to be used alone in raising tomato seedlings since it has high concentrated nutrients which lower seedling growth. Ahmad *et al.* (2004) and Turhan *et al.* (2007) found that the best medium for the growth of saffron was a mixture containing manure with its double application, above and below the corms.

Different materials for mixing media have different roles they play. Peat is usually included in a mix to increase the water-holding capacity or to decrease the weight. Substances have been extracted from sphagnum peat which inhibits the growth of fungi associated with damping off. Coir (Coconut Fibre) is a relatively new organic amendment primarily used in the greenhouse industry. Coir contains more lignin and less cellulose than peat; it is more resistant to microbial breakdown. Another material is softwood bark. Pine bark is preferred over hardwood bark since it resists decomposition and contains fewer leachable organic acids. Composting bark typically takes 5 to 7 weeks. Manures have some disadvantages which include possible high salts, fine particle size and weed seeds. The advantages include the nutrient contribution and potential improvement in media physical properties. Plant-based composts provide a low-cost media amendment. Critical issues to consider are the availability and consistency of the product and the particle size. Particle sizes for plant-based compost can be either too large or too fine depending on the source material and composting process. Rice hulls are available in a variety of forms including fresh, aged, carbonised, composted and parboiled. Fresh rice hulls are typically avoided as container substrates because of residual rice and/or weed seed. Parboiled rice hulls (PRH) are produced by steaming and drying rice hulls after the milling process, which results in a product that is free of viable weed and/or rice seed. Despite being an organic compound, rice hulls consist mainly of lignin, cutin and insoluble silica, providing a slow breakdown of particles and therefore making them an appropriate substrate for long-term crop production. Research conducted at the University of Arkansas indicates that amending pine bark with up to 40% PRH will not significantly decrease plant growth or increase the volume or frequency of irrigation for container-grown plants after one and two growing seasons. A number of researchers have demonstrated that PRH is a suitable alternative to perlite in greenhouse substrates. In bedding plant trials at the University of Arkansas, the highest shoot and root growth occurred for plants grown in substrates containing 20% to 30% PRH. Fresh rice hulls are light in weight and are useful to increase drainage and aeration. Fully composted rice hulls will hold more water than unprocessed hulls. Either fresh or composted rice hulls have a high Mn content which could be toxic to the crops. Cotton gin trash is another organic waste product that is readily available (Growing Media for Container Production Part I - Components and Mixes (Greenhouse and Nursery Series) - FSA6097 (uada.edu) 06/01/2024).

Research has shown that the use of sewage sludge generally increases the heavy metal contents in compost: comparable results were reported by Wuest *et al*. (1995) in experiments involving aged mushroom compost. Concerning the plant growth, positive correlations between the leaf area and the shoot dry weight have been reported by Tremblay and Senecal (1988). The increase in plant biomass production with the use of compost as a growing media component has been previously reported (De Lucia, 2009). Macronutrient availability improves with compost addition to media: this is in agreement with Stellacci *et al* (2013) in the growth of containerized Quercus Ilex. Ostos *et al*. (2008) found that the P uptake was notably enhanced in Pistacia lentiscus cultivation with increasing use of sewage sludge compost. Pinamonti *et al*. (1997) found significant increases in the N, P, and K contents in cucumber, tomato, and strawberry plants grown in peat-sewage sludge compost media. Falahi-Adrakani *et al*. (1987) reported that cabbage and broccoli accumulated greater amounts of N and K from the composted sewage sludge amended medium.

Composting usually takes 6-12 months, depending on how often you mix it. The more often you mix/turn the compost the faster it will mature i.e. the materials will decompose. Turning is the act of aeration affected by evenly lifting and dropping, and mixing the materials being processed. Frequent turning and mixing of heap, particularly during the initial stages of decomposition intensifies the activities of microorganisms. When turning is frequent, problems associated with odour and flies are minimal. Compost treated this way should be ready for maturing within two or three weeks depending on the size of the heap, frequency of turning, initial C/N ratio and moisture content. (Miller and Norman, 1995). Decomposition is complete when there is no observable rise in temperature (P. U. Chukwudi, personal communication, 02/12/2016) and the compost is ready when it is dark brown and soil-like. Actual time for composting will depend on the mixture, season and climate. In the tropics, composting time is generally less than in the temperate region because of the high ambient air temperatures obtained in the former. Generally, factors affecting decomposition of media materials include composition and particle size of organic matter, C/N ratio, microorganisms involved, pH, aeration and moisture content (P. I. Ezeaku, personal communication, 11/06/2017).

4. MATERIALS AND METHODS

Description of the study location

The field experiment was conducted in the Teaching and Research Farm of the Department of Crop Science, University of Nigeria, Nsukka. The site is situated at lat 06^0 52^1 N long 07^0 24^1 E and 400m above sea level (masl). Its climate is characteristically sub-humid tropical with mean annual total rainfall of about 1600mm of which distribution is bimodal with peaks during July and October in the first and second phases respectively. Mean minimum temperature is 21.8^0C and relative humidity ranges between 70 and 80% (Oko-Ibom and Asiegbu, 2006). The experiment lasted for a period of seventeen weeks, beginning from 14^{th} December, 2016 to 6^{th} of June, 2017.

Field preparation

The four media ratios were mixed, bagged and properly labelled. After two weeks, the second set of the same media was prepared. The mixtures were turned every two weeks. The first set of media was allowed to decompose for eight weeks while the second set was decomposed for six weeks. The mixtures were put in polyethylene bags up to three quarters full and the treatments were randomly placed 1m x 1m on a field already cleared of grasses and weeds.

Experimental design and treatment

The four media composted for two different durations gave a total of eight treatments. They were each replicated seven times and in each bag were allowed to grow, one tomato plant giving a total of 57 plant populations.

The four media used were;

T1 = rice husk dust + poultry manure + river sand (3:2:1)
T2 = topsoil + poultry manure + river sand (3:2:1)
T3 = top soil + poultry manure + river sand (2:3:1)
T4 = topsoil + poultry manure + river sand (1:2:3)

Cultural operations

Planting: tomato seeds (tima variety) were purchased from the market and a total of five seeds were sown in each polyethylene bag and later thinned to one plant per bag at three weeks after planting.

Watering: this was done twice daily at the initial growth stage due to dryness of the weather and subsequently done once when humidity became higher.

Weeding: weeds that grew on the ground around the polyethylene bags were cleared regularly with machete and hoe.

Pest control: the grasshoppers that attacked the tomato plant were controlled by hand picking.

Harvesting: harvesting was done manually, starting exactly eighty-three (83) days after planting.

Data collection

The following parameters were collected on the crop:

Emergence data – days to first emergence, 50% emergence and 100% emergence were taken

Plant height –the height of each plant was measured from ground level to the leaf apex using a 100 cm measuring tape

Stem girth – this was measured at 1 cm above ground level using a micrometre screw gauge

Number of branches – this was obtained by counting the number of branches per plant

Number of trusses - the total number of trusses per plant was obtained by counting

Number of flowers – the total number of flowers was counted

Fruit weight - the fruits from each plant were harvested and weighed on a weighing balance every two days, starting from the first fruit ripening

Plant height, stem girth, number of branches, number of trusses, number of flowers and weed data were taken at 4 weeks, 6 weeks and 8 weeks after planting.

Statistical analysis

All data collected were statistically analyzed using the procedure outlined by Steel and Torrie (1980) for a Complete Randomized Design using GENSTAT (2009).

Separation of treatment means for statistical significance was done using Fisher's Least Significant Difference (LSD) at 5% probability level as outlined by Obi (1986).

5. RESULT

Table 1 shows that there was no significant difference among the treatments in first seedling emergence but in 50% emergence, the seedlings in topsoil + poultry manure + river sand, in the ratio 1:2:3 (T4) emerged faster than the rest of the media at 7.63 days followed by rice husk dust + poultry manure + river sand, in the ratio 3:2:1 (T1) at 7.77 days and then top soil + poultry manure + river sand, in the ratio 2:3:1 T3 and topsoil +poultry manure + river sand, in the ratio 3:2:1 (T2), in that order. T1 also differed significantly from the rest of the media with 100% emergence after 7.50 days.

Table 1: Main effect of nursery media (M) on days to seedling emergence in tomato (*Solanum lycopersicon* L.)

M	FE	50%E	100%E
T1	7.64	7.77	7.50
T2	10.50	11.98	12.24
T3	7.93	7.92	10.37
T4	6.65	7.63	7.88
F-LSD$_{(0.05)}$	NS	1.509	1.31

FE= first seedling emergence, 50%E= 50% emergence, T1= rice husk dust + poultry manure + river sand (3:2:1), T2= topsoil + poultry manure + river sand (3:2:1), T3= topsoil +poultry manure + river sand (2:3:1), T4= topsoil +poultry manure + river sand (1:2:3), LSD= least significant difference, NS= not significant.

Table 2 shows that composting for 8 weeks significantly differed from composting for 6 weeks at p=0.05. First seedling emergence for 8 weeks of decomposition was faster at 6.61 days than 6 weeks of composting at 9.71 days. A significant difference was also recorded for both 50% and 100% emergence rates.

Table 2: Duration (D) of composting of nursery media on days to seedling emergence in tomato (*Solanum lycopersicon* L.)

D(weeks)	FE	50%E	100%E
6	9.71	9.82	10.87
8	6.61	7.82	8.13
F-LSD$_{(0.05)}$	2.185	1.062	0.923

FE= first seedling emergence, 50%E= 50% emergence, T1= rice husk dust + poultry manure + river sand (3:2:1), T2= topsoil + poultry manure + river sand (3:2:1), T3= topsoil +poultry manure + river sand (2:3:1), T4= topsoil +poultry manure + river sand (1:2:3), LSD= Fisher's least significant difference, NS= not significant.

Table 3 shows that interaction of media and duration of composting had no significant difference in the first seedling emergence of tomato but there was a significant effect in 50% and 100% emergence rates. T3 composted for eight weeks had 50% emergence at 7 days while T1 composted for 8 weeks had the fastest 100% emergence also at 7 days. The least performance was obtained in T2 which had 14 days, 15.96days and 15.98days for FE, 50%E and 100%E respectively.

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Table 3: Interaction effect of nursery media (M) and duration of composting on days to seedling emergence in tomato (*Solanum lycopersicon* L.)

M	D(weeks)	FE	50%E	100%E
T1	6	8.57	7.33	8.00
	8	6.71	8.20	7.00
T2	6	14.00	15.96	15.98
	8	7.00	8.00	8.50
T3	6	10.29	9.00	11.74
	8	5.57	6.83	9.00
T4	6	6.00	7.00	7.75
	8	7.14	8.28	8.00
$F\text{-}LSD_{(0.05)}$		NS	2.13	1.86

FE= first seedling emergence, 50%E= 50% emergence, T1= rice husk dust + poultry manure + river sand (3:2:1), T2= topsoil + poultry manure + river sand (3:2:1), T3= topsoil +poultry manure + river sand (2:3:1), T4= topsoil +poultry manure + river sand (1:2:3), F-LSD= Fisher's least significant difference, NS= not significant.

In table 4, T4 consistently differed significantly from the rest of the media with the longest plant height and highest number of leaves; T3 had the stem girth at 4 weeks after planting. The same trend was observed at 6 weeks after planting with T4 topping in all the three growth parameters and then T3 and T2. The least performance was once again seen in T1.

Table 4: Effect of media on growth response pattern of tomato (*Solanum lycopersicon* L.)

	4 weeks after planting			6 weeks after planting			8 weeks After planting		
M	PH	SG	NoL	PH	SG	NoL	PH	SG	NoL
T1	22.20	0.66	41.40	31.70	1.03	91.00	40.70	1.24	122.1
T2	28.10	0.87	65.20	46.30	1.27	111.00	49.80	1.59	173.40
T3	27.20	0.98	65.50	44.30	1.30	140.00	57.50	1.50	187.80
T4	35.40	0.93	96.30	47.90	1.44	179.00	60.00	1.74	231.40
$F\text{-}LSD_{(0.05)}$	9.16	0.21	29.49	9.85	0.18	57.90	9.37	0.19	55.60

M= media, PH=Plant height, SG= stem girth, NoL= number of leaves, LSD= least significant difference, T1= rice husk dust + poultry manure + river sand (3:2:1), T2= topsoil + poultry manure + river sand (3:2:1), T3= topsoil +poultry manure + river sand (2:3:1), T4= topsoil + poultry manure + river sand (1:2:3), F- LSD= Fisher's least significant difference, NS= not significant.

Duration of composting of media has no significant effect on the growth response pattern of tomato as shown in table 5, except in stem girth at 8 weeks after planting were 8 weeks of composting produced a larger stem girth of 1.59cm compared to 1.44cm stem girth in 6 weeks of composting.

Table 5: Effect of duration of composting of nursery media (D) on growth response pattern of tomato (*Solanum lycopersicon* L.)

	4 weeks after planting			6 weeks after planting			8 weeks after planting		
D(weeks)	PH	SG	NoL	PH	SG	NoL	PH	SG	NoL
6	27.00	0.84	60.70	44.20	1.29	131.00	54.10	1.44	189.60
8	29.40	0.87	73.60	40.90	1.24	130.00	49.90	1.59	167.7
F-LSD$_{(0.05)}$	NS	NS	NS	NS	NS	NS	NS	0.13	NS

D= duration of composting, PH=Plant height, SG= stem girth, NoL= number of leaves, F-LSD= Fisher's least significant difference.

Table 6 shows the interaction of media and duration of composting; at 4 weeks after planting, T4 composted for 6 weeks significantly differed from the rest in terms of plant height (39.70), number of leaves (118.00) while T3 composted for 8 weeks had the largest stem girth. At 6 weeks after planting, there was no significant difference in plant height and number of leaves but T4 composted for 6 weeks had the largest stem girth followed by T3 composted for 8 weeks. At 8 weeks after planting, there was no significant difference in plant height, but T4 composted for 6 weeks had the highest number of leaves followed by T2 composted for 8 weeks.

Table 6: Interaction effect of nursery media and duration of composting on growth response pattern of tomato (*Solanum lycopersicon* L.)

		4 weeks after planting			6 weeks after planting			8 weeks after planting		
M	D(weeks)	PH	SG	NoL	PH	SG	NoL	PH	SG	NoL
T1	6	27.50	0.79	48.10	36.50	1.08	118.00	43.80	1.27	158.00
	8	16.50	0.54	35.4	26.80	0.98	64.00	37.60	1.22	86.3
T2	6	23.80	0.78	42.8	44.40	1.22	84.00	52.80	1.30	144.4
	8	32.40	0.95	87.70	48.10	1.31	138.00	46.80	1.87	202.3
T3	6	17.00	0.67	34.00	43.10	1.16	116.00	57.50	1.46	182.4
	8	37.50	1.29	97.00	45.50	1.44	163.00	57.50	1.54	193.1
T4	6	39.70	1.14	118.00	52.60	1.64	204.00	62.10	1.75	273.7
	8	31.10	0.72	74.50	43.20	1.23	155.00	57.80	1.73	189.2
F-LSD$_{(0.05)}$		12.95	0.30	41.70	NS	0.25	NS	NS	0.26	78.69

M= media, D= duration of composting, PH=Plant height, SG= stem girth, NoL= number of leaves, T1= rice husk dust + poultry manure + river sand (3:2:1), T2= topsoil + poultry manure + river sand (3:2:1), T3= topsoil +poultry manure + river sand (2:3:1), T4= topsoil +poultry manure + river sand (1:2:3), F-LSD= Fisher's least significant difference, NS= not significant.

In table 7, T4 significantly differed from the rest of the media with 27.4 branches at 4WAP followed by T2 with 21.8 and then T3 and T1. At 6 weeks after planting, T4 also had a higher number of branches, number of trusses and number of flowers. T2 and T3 were in the same range of performance followed by T1. 8 weeks after planting, the order of performance for number of branches and number flowers is T4>T3>T2>T1 but for number of trusses, the order was T4>T2>T3>T1.

Table 7: Effect of nursery media (M) on the yield components of tomato (*Solanum lycopersicon* L.)

	4 weeks after planting			6 weeks after planting			8 weeks after planting			
M	NoB	NoT	NoF	NoB	NoT	NoF	NoB	NoT	NoF	FWt
T1	12.00	1.38	4.30	19.10	2.54	10.10	33.60	4.33	12.30	2.60
T2	21.80	2.40	10.00	35.30	4.50	17.50	49.50	7.53	19.80	46.30
T3	21.40	1.91	8.80	36.20	4.54	17.10	57.40	7.08	20.40	52.20
T4	27.40	2.45	9.20	42.20	5.83	21.00	62.10	7.92	30.10	30.60
$F\text{-}LSD_{(0.05)}$	6.88	NS	NS	10.45	1.604	7.00	9.83	1.85	8.08	37.87

M=media, NoB=number of branches, NoT= number of trusses, NoF= number of flowers, FWt= fruit weight, T1= rice husk dust + poultry manure + river sand (3:2:1), T2= topsoil + poultry manure + river sand (3:2:1), T3= topsoil + poultry manure + river sand (2:3:1), T4= topsoil + poultry manure + river sand (1:2:3), F-LSD= Fisher's least significant difference, NS= not significant.

Table 8 shows that duration of composting has no significant effect on the yield parameters except for the number of branches at 8 weeks after which composting for 8 weeks yielded more number of branches (52.00) in the tomato plant. There was also no significant effect in fruit weight.

Table 8: Effect of duration of composting (D) on the yield components of tomato (*Solanum lycopersicon* L.)

	4 weeks after planting			6 weeks after planting			8 weeks after planting			
D(weeks)	NoB	NoT	NoF	NoB	NoT	NoF	NoB	NoT	NoF	FWt
6	20.30	1.65	7.80	32.20	4.28	15.80	49.30	6.27	20.70	22.2
8	21.00	2.42	8.40	34.30	4.43	17.00	52.00	7.16	20.60	43.7
$F\text{-}LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS	6.95	NS	NS	NS

D= duration of composting, NoB=number of branches, NoT= number of trusses, NoF= number of flowers, FWt= fruit weight, LSD= least significant difference.

In table 9, at 4 weeks after planting the interaction of media and duration of composting had no significant effect on of branches, number of trusses and number of flowers but at 6 weeks after planting, T2 composted for 8 weeks recorded the highest number of branches of 46.2 followed by T4 composted for 6 weeks, T2 and lastly T1 composted for 8 weeks. For number of trusses, T4 composted for 6 weeks topped in performance followed by T2 composted for 8 weeks, T3 composted for 8 weeks and lastly T1 composted for 8 weeks. Performance in number of flowers was in the order T2 composted for 8 weeks> T4 composted for 6 weeks> T4 composted for 8 weeks> T3 composted for 8 weeks> T3 composted for 6 weeks> T1 composted for 6 weeks> T1 composted for 8 weeks. At 8 weeks after planting, the order of performance was T4 composted for 8 weeks> T2 composted for 8 weeks > T3 composted for 6 weeks> T4 composted for 6 weeks> T3 composted for 8 weeks> T1 composted for 6 weeks> T2 composted for weeks> T1 composted for 8 weeks. This interaction also had no significant effect on fruit weight.

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Table 9: Interaction effects of media and duration of composting on the yield components of tomato (*Solanum lycopersicon* L.)

		4 weeks after planting			6 weeks after planting			8 weeks after planting			
M	D(weeks)	NoB	NoT	NoF	NoB	NoT2	NoF	NoB	NoT	NoF	FWt
T1	6	14.10	1.00	6.40	24.00	3.33	13.50	42.30	4.67	17.60	5.30
	8	9.90	1.75	2.20	14.30	1.75	6.60	24.90	4.00	7.00	0.00
T2	6	15.80	2.01	8.00	24.40	3.00	9.00	36.20	5.25	11.440	18.20
	8	27.80	2.80	12.00	46.20	6.00	26.00	62.80	9.80	28.30	74.40
T3	6	22.70	1.03	7.20	39.30	3.80	16.40	61.90	6.17	20.60	38.00
	8	20.10	2.80	10.50	41.00	5.29	17.70	53.00	8.00	20.30	66.50
T4	6	28.70	2.57	9.40	41.00	7.00	24.30	57.00	9.00	33.40	27.30
	8	26.20	2.33	9.00	43.50	4.67	17.70	67.20	6.83	26.80	34.00
F-LSD$_{(0.05)}$		NS	NS	NS	14.77	2.27	9.89	13.91	2.62	11.43	NS

M= media, D= duration of composting, NoB=number of branches, NoT= number of trusses, NoF= number of flowers, FWt= fruit weight, LSD= least significant difference, T1= rice husk dust + poultry manure + river sand (3:2:1), T2= topsoil + poultry manure + river sand (3:2:1), T3= topsoil + poultry manure + river sand (2:3:1), T4= topsoil + poultry manure + river sand (1:2:3), F-LSD= Fisher's least significant difference, NS= not significant

6. DISCUSSION

The treatment T4, top soil+ poultry manure + river sand (1:2:3) performed better in terms of first seedling emergence and 50% emergence than other treatments. This could be as a result of proper combination of the components of the medium which allowed aeration of the medium. This is followed by T1, rice husk dust +poultry manure +river sand (3:2:1) which also had the best performance for 100% emergence. Probably because fresh rice hulls are light in weight and are useful to increase drainage and aeration (Sterrette, 2001). The light weight of the medium could have enhanced easy shooting out of the plumule. This result is not in line with the findings of Nwofia *et al.* (2015) who stated that there was slow seedling emergence and growth in rice husk compared to top soil and sawdust. T2, topsoil + poultry manure + river sand (3:2:1) had the longest days to emerge due probably to the weight of the material which might have posed some problem to the shooting out of plumule from the medium.

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Growth medium is known to have a large effect on the value of potted ornamental plants (Vendrame et al., 2005). In this study, there was a significant effect of media in the growth parameters checked i.e. plant height, stem girth and number of leaves. T1 had the lowest plant height, stem girth and number of leaves. This could have been due to the high amount of ash contained in rice husk which could result in reduction in the population of bacteria that helps in decomposition of materials in the soil (Bougnom *et al*., 2009). However, the works of Jeon *et al*. (2010), Milla *et al*. (2013) and Badar *et al* (2014) revealed that rice husk could be a very good soil substitute when used in a carbonised form. In addition, the low growth of tomato on rice husk dust could be due to the low nitrogen content of the rice husk as reported by Kumar et al. (2012) who estimated the nitrogen content of rice husk to be less than 0.24% compared to its ash content (about 29%). Similar results were reported by Agbo and Omaliko (2005) and Nwofia and Okwu (2015) that rice husk do not support optimum growth of plants. Okunlola and Ogungbite (2016) opined that the use of rice husk as supplement for the growth of *S. liberica* on top soil and sandy soil and in the nursery may not yield good result for *S. liberica*. Meanwhile, T4 had the tallest plants, the largest stem girth and the highest number of leaves. This is probably due to the right combination of top soil, poultry manure and river sand (1:2:3). The high proportion of river sand in the medium makes it porous, well aerated and easily drainable (Sterrett, 2001). It also shows that optimum growth of tomato can be obtained in a growth medium containing little amount of topsoil in a mixture with other components. This result agrees with the findings of Sampson *et al.* (2014) who reported that during topsoil scarcity, cocoa seedlings can be raised in a mixture of sand and topsoil (1:1) and nutrient shortfalls provided for by application of foliar fertilizer.

T4 also had the highest number of branches, number of trusses and number of flowers but the eventual yield obtained in terms of fruit weight was highest in T3, top soil+ poultry manure + river sand (2:3:1) followed by T2, top soil+ poultry manure + river sand (3:2:1). This is probably due to a greater proportion of poultry manure and topsoil in T3 and T2 respectively, than the rest of the media. Poultry manure and topsoil contribute more nutrients to the media and result in greater fruit yield as Sterrett (2001) reported that manure contributes nutrients and potential improvement in media physical properties. Also, yield is the net result of various interactions such as soil characters (in this case, growth medium), weather parameters, crop weed competition, leaf area and various metabolic and biochemical interactions taking place during crop growth. Therefore, the rate and type of metabolic and chemical reactions that took place in the different media as a result of the difference in the proportion of top soil, poultry manure and river sand may have affected yield.

The poor yield seen in T1 was probably due to low nutrient content of rice husk dust dusk and incomplete decomposition of the substrate. Rice husk dust consists mainly of lignin, cutin and insoluble silica, providing a slow breakdown of particles and therefore is slow in releasing nutrients to the plant (Sterrett, 2001).

From the results obtained, seedlings raised in media composted for eight weeks had a faster emergence of 6.61 days than seedlings composted for six weeks. This could mean that the longer the period of composting, the faster the emergence rate of tomato. On the other hand, duration of composting of media in this experiment had no significant effect on either the growth parameters (except in stem girth at 8 weeks after planting) or the yield parameters (except in number of branches at 8 weeks after planting) where eight weeks of decomposition gave larger stem girth and higher number of branches than six weeks. The reason for this lack of influence could be the short range of difference in duration of composting which could not cause a major difference in the properties of the media. It is also possible that the decomposition process was completed at or before six weeks such that there were eventually no further differences in the media properties.

The effect of interaction of media and duration of composting shows that T4 composted for six weeks had faster emergence rate, longest plant height, largest stem girth, highest number of leaves, highest number of branches, highest number of trusses and highest number of flowers at both six weeks and eight weeks after planting. Nevertheless, there was no significant interaction effect on the fruit weight of tomato. This means that only the media affected the growth and yield of tomatoes and not the duration of composting.

7. CONCLUSION

The implication of the results obtained from the study is that T4 which had the least amount of topsoil performed better in both growth and yield components but the best yield was obtained in T2. This means that little or no soil can actually be used as a container medium to grow tomatoes with the right materials mixed in the right proportion. The soilless medium (rice husk dust + poultry manure + river sand) could actually be improved by the addition of fertilizer to supplement nitrogen and other nutrients. Rice husk can also be burnt before being used as a growth medium in order to hasten the release of nutrients for plant growth. It is also clear that the decomposition process of rice husk dust is slow, therefore further studies should be carried out to ascertain the adequate period of decomposition of rice husk for best results on plant growth and yield. Also, further studies on the effect of duration of composting of media should allow enough difference in the two durations.

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