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Effects of Different Substrates on the Growth and Yield of Tomato Plants

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Abstract
The need to provide an alternative media (substrate) for household production of tomatoes is highly imperative as availability of land for farming is becoming scarce in cities due to urbanization. This work examined the effects of substrates on growth and optimum fruits yield of tomatoes. Tomatoes were planted in three different substrates; Soil + Rice Ash (SoR) (v/v: 50:50), Sawdust + Rice Ash (SdR) (v/v: 50:50), Soil + Poultry Droppings (SoP) (v/v: 80:20), and Soil only. All treatments were laid out in a Completely Randomized Design with three replications. Parameters taken include plant height (PH), number of fruits (NoF), fruit weight (FW), chlorophyll content (CC) and root weight (RW). Data collected were analysed using analysis of variance (SAS 9.4 version) and means were separated using least significant differences at 5% level of significance. The PH, NoF, FW, CC, and RW differed significantly among treatments and ranged from 27.9±4.9 cm (soil) to 83.4±4.9cm (SoR), 6.8±1.8 (soil) to 18.0±1.8 (SoR), 131.9±64.1g (SdR) to 400.9±64.1g (SoR), 22.8±1.6 (soil) to 35.5±1.6 (SoR), and 1.6±1.1g (SdR) to 7.6±1.1g (SoR), respectively. The soil plus rice ash substrate (treatment) outperformed all other substrates in terms of all parameters considered and thus recommended for household producers and small-scale farmers who want to improve their produce via organic practice to meet the demand of the populace without necessary going for poultry manure.

Keywords: Tomatoes, Substrate medium, Growth, Yield, household
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Introduction

Tomato, which belongs to the Solanaceae family, is one of the most pertinent and recognized vegetable fruits that has nutritionally gained attention among other fruity crops globally. Besides, the comparatively short cultivation period of the crop coupled with its nutritive potential have made it economically important to the household, society and the nation as large. Consumption of tomatoes as part of our daily meal reduces the risk of some diseases associated with deficiency of vitamins, protein and carbohydrate due to its richness in these classes of food (Shankara et al., 2005). Therefore, it is of no doubt that tomatoes are among the fruit vegetables which are highly consumed locally and globally nearly every day.

Following Egypt which was ranked the highest tomato-producing country in Africa is Nigeria, the second largest producer and 14th in the world, with annual production of 2.3 million tons from 1.4 million hectares of land (FAO, 2011). Currently, Nigeria takes the third largest importer of tomato paste, and thus has not been included on the official list of countries that export tomatoes and its products. Most of our markets in Nigeria are receiving tomatoes from the Northern parts of the country and neighboring countries which include Ghana and Benin. Despite the massive production of tomatoes locally, the

country yet experiences inadequacy in critical inputs, deficiency of modern technology and lack of fertile soil due to continuous usage which resulted in low yield and productivity (Ugonna et al., 2015).
Over the last few decades, ever increasing world population and rural-urban migration have resulted to the swift modern agricultural practices like use of hybrid varieties, excessive use of inorganic fertilizer, hydroponics, aeroponics, irrigation methods and pesticides. Although, the adoption of modern agricultural techniques produces high yield, which cuts the requirement of food shortage, some problems associated with these methods have been identified which include infertility of soil, emergence of new variants of pests and diseases and health related problems (Butler and Oebker, 2006). Soils rich in inorganic components significantly affect the quality and yield of the crop as compared to infertile soil (Eifediyi and Remison, 2010). In Nigeria with a population of over 250 million, tomatoes' production needs to keep on increasing to meet the demand which outweighs the supply.

Besides, open field agriculture is difficult to practice in some parts of the country as it occupies large space, is disturbed by herdsmen, and requires laborious work and large supply of water for sustainability during dry season. Moreover, soilless farming method which could have been introduced as alternative method for stress-free farming are being constrained by lack of adequate capital required for setting up the hydroponics, nutrient solution and technical know-how (Butler and Oebker, 2006). Fertile soil is regarded as the backbone for successful plant growth and good harvest, but most urban and industrial dominated areas lack the required soil for growing desired crops due to their unfavorable geographical or topographical conditions (Aatif et al., 2014).

Organic manure is a continuous source of energy that restores the used soil, enhances the survival of microorganisms, provides minerals to the plants and minimizes the application of inorganic fertilizer with increase in crop productivity (Kaith and Bhardwaj, 2009). Water retaining capacity of sandy soil and drainage of clay soil majorly depend on the presence of organic manure (Ojeniyi, 2000). Crops produced through organic manure taste good and are safe from health-related problems because they are free from toxic molecules released by the chemicals and residual inorganic fertilizers. Poultry manure, which has been in usage since ancient times is economical, environmentally friendly and provides organic-based nutritional source for crops. Application of poultry manure at 10-50 t ha^{-1} impacts positive effects on the physico-chemical attributes of soil (Ewulo *et al.*, 2008). The vegetative growth, physiological response and yield of crops is determined by the nutrient's composition of poultry manure (Osvald et al., 2001).

The low yield of a particular crop may be attributed to deficiency of nitrogen and other macro nutrients in the soil which hinder or reduce the availability of other mineral nutrients. It is obvious that produce obtained through organic materials is globally accepted and enjoyed and has gained an increase in demand. The most important benefit enjoyed by people consuming organically grown food is not only the avoidance of toxic accumulation in the body that is due to the intake of pesticide residual, but also the fact that it provides a palatable taste and extends the shelf life of perishable crops.

Materials and Methods

Study Locations and Seed Source
This research was carried out at the Department of Crop Protection and Environmental Biology, University of Ibadan. Variety of tomatoes UC83A (*Lycopersicon esculentum* Mill.) seed bought from National Horticultural Research Institute, Ibadan were planted on three different substrates.

Preparation of Substrates
Three substrates were used for the research and the topsoil was used as a control. Two out of the three substrates were prepared by mixing equal volume of Soil and Rice Ash (SoR), equal volume also of Saw dust and Rice Ash (SdR), while the third substrate was at 8:2 of Soil and Poultry dropping (SoP) respectively.
Following the thorough mixing of the substrates was the addition of 4 kg poultry dropping to each treatment excluding the control, and 3 kg of each was dispensed into the pots. The pots containing substrate were all left for two weeks before transplanting was done on them.

Raising of Seedlings
Following the preparation of all the substrates, a sample of 2 kg was taken from each substrate for raising seedlings. Two weeks after planting,

seedlings were transferred into the corresponding substrate planting pots and data taking commenced.

Experimental Design
The experiment was conducted in a completely randomized design (CRD) having three replications and three treatments (substrates). Each pot was filled with 3 kg of substrates and then arranged in the screen house.

Data Collection and Statistical Analysis
Data were taken on, Plant height, Number of branches, Number of leaves, Number of nodes, Number of flowers, Number of fruits, Total fruit yield of the crops and Biomass yield. All the collected data were analyzed using ANOVA (SAS 9.0 version) and difference in the treatment means was determined using the Least Significant Difference (LSD) at 5% level of significance.

Results

Plant height (cm)
Results obtained showed that the plants grown in soil + rice ash were the tallest (83.42±4.91cm), but the height was not significantly different from that of the ones grown on soil + poultry dropping (71.42±4.91cm). However, both plants grown on soil+rice ash and soil+poultry dropping were significantly taller than the plants grown in saw dust + rice ash (27.92±4.91cm) and soil only (control) (29.50±4.91cm), respectively (Table 1).

Number of leaves
The number of leaves produced by plants grown on soil + rice ash was the highest (142.67±15.26), though it was not significantly different from that of the ones produced by plants grown on soil + poultry dropping (137.08±15.26). However, both plants grown on soil+rice ash and soil+poultry dropping produced significantly higher number of leaves than the plants grown on saw dust + rice ash (52.50±15.26) and soil (48.42±15.26), respectively.

Number of flowers
The number of flowers produced by the tomato plants grown on soil + rice ash (21.25±1.44) was significantly higher than those of the remaining treatments, while the lowest number of flowers was obtained in the plants grown on saw dust + rice ash (10.83±1.44).

Table 1: Influence of substrates on the Plant height (cm) per plant, number of leaves, and number of flowers per plant of the tomato

Treatments	Plant height (cm)	Number of leaves	Number of flowers
Soil+Rice Ash+Poultry dropping	83.417a	142.67 a	21.250 a
Soil+Poultry dropping	71.417a	137.08 a	16.667 b
Saw dust+Rice ash+Poultry dropping	27.917b	52.50 b	10.833 c
Soil only (Control)	29.500b	48.42 b	14.167 bc
LSD(0.05)	13.743	42.729	4.0383
SE	4.91	15.26	1.44

Means with the same alphabet down the groups are not significantly different from each other at 5% level of significance. LSD: Lead Significant Differences

Number of nodes

The highest number of nodes produced was recorded in the plants grown on soil + rice ash (13.42±1.49), although, it was not significantly higher than the number of nodes produced by the plants grown on soil + poultry manure (11.42±1.49). However, the nodal production in soil + rice ash and soil + poultry dropping was significantly higher than the number of nodes produced by the plants grown on soil (6.00±1.49) and saw dust + rice ash (5.17±1.49) respectively (Table 2).

Number of branches

The number of branches produced by the tomato plants grown on soil + rice ash (5.17±0.34) was significantly higher than that of the plants grown on the remaining treatments, while the lowest number of branches was obtained in the plants grown on saw dust + rice ash (0.00±0.34).

Stem girth (mm)

The longest stem girth was recorded in the plants grown on soil + rice ash (7.54±0.41mm), although, it was not significantly different from the girth recorded by the plants in soil + poultry manure (6.79±0.41mm). However, the stem girth of the plants grown in soil + rice ash and soil + poultry dropping were significantly longer than the ones grown on soil (2.77±0.41mm) and saw dust + rice ash (2.08±0.41mm) respectively.

Table 2: Effects of substrates on the number of branches, number of nodes and stem girth at harvest per plant of tomato

Treatments	Number of nodes	Number of branches	Stem girth (mm)
Soil+Rice Ash+Poultry dropping	13.417a	5.1667a	7.5367a
Soil+Poultry dropping	11.417 a	3.6667b	6.7875a
Saw dust+Rice ash+Poultry dropping	5.167 b	0.0000c	2.0775b
Soil only (Control)	6.000 b	0.0833c	2.7658b
LSD(0.05)	4.1664	0.9657	1.1614
SE	1.49	0.34	0.41

Means with the same alphabet down the groups are not significantly different from each other at 5% level of significance. LSD: Lead Significant Differences

Number of fruits

The highest number of fruits produced was recorded in soil + rice ash (18.00±1.75) which was not significantly higher than the fruits produced by plants grown in soil + poultry manure (13.33±1.75). However, the fruits produced by plants grown on soil + rice ash were significantly higher than the ones produced by plants grown in saw dust + rice ash (10.50±1.75) and soil (6.75±1.75), respectively. There was no statistically significant difference between the number of fruits in plants grown on soil + poultry manure (13.33±1.75) and those in plants grown on saw dust + rice ash, and between those produced by plants grown on saw dust + rice ash and on soil only (Table 3).

Fruit weight (g)

The weight (g) of the tomato fruits produced in soil + rice ash (400.87±64.11) g was not statistically different from soil + poultry manure (300.88±64.11) g but was significantly heavier than the ones produced in saw dust + rice ash (131.93±64.11) g and in soil (161.99±64.11), respectively. There were no significant differences amongst the weights of fruits produced in soil + poultry dropping, saw dust + rice ash and in soil alone (Table 3).

Dried leaves' weight (g)

The dried leave weight of the plants grown in soil + rice ash (34.96±4.96g) was significantly heavier than the rest of the treatments, which were not significantly different from each other.

Root weight (g)

The heaviest root weight (g) was obtained in the plants grown on soil + rice ash (7.63±1.06) g though it was not statistically different from those of soil + poultry dropping (6.41±1.06) g. However, both plants grown on soil + rice ash and on soil + poultry dropping had root weights that were significantly higher than those of the plants grown in saw dust + rice ash (1.59±1.06) g and on soil only (2.48±1.06) g.

Chlorophyll content

The chlorophyll content of the plants grown on soil + rice ash (35.48±1.58) was not significantly different from that of the ones grown in soil + poultry dropping (34.31±1.58). However, both the chlorophyll contents of plants grown in soil +

rice ash and soil + poultry dropping were significantly higher than the ones grown in saw dust + rice ash (28.78±1.58) and in soil alone (22.78±1.58), respectively.

Table 3: Effects of substrates on the number of fruits, fruit weight and chlorophyll content

Treatments	Number of fruits	Fruit weight	Chlorophyll content	Dried leaf weight (g)	Root weight (g)
Soil+Rice Ash+Poultry dropping	18.000a	400.87a	35.483a	34.958a	7.633a
Soil+Poultry dropping	13.333ab	300.88ab	34.308a	16.042b	6.408a
Saw dust+Rice ash+Poultry dropping	10.500bc	131.93b	28.433b	5.600b	1.592b
Soil only (control)	6.750c	161.99b	22.783c	3.133b	2.483b
LSD(0.05)	4.8917	179.5	4.4203	13.875	2.9781
SE	1.75	64.11	1.58	4.96	1.06

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

Discussion

In this study, the best plants were observed to be those grown on a substrate mixture of topsoil and rice ash. This could be due to the possession of high potassium content and high organic matter by the two substrates which are being supplied by the rice ash to the plant thereby supporting the growth rate (Tjokorde et al., 2019). However, this result disagrees with the finding of Rodriguez-Ortega et al. (2017) which says that plants grown in soilless system had the highest number of leafs, stem biomass and large total area. In a similar vein, Okalebo et al. (2001) reported that the combined application of maize stover, which is organic, and poultry manure gave a significant increase in plant height.

In terms of yield features of the plant, soil and rice ash or soil plus poultry manure were the best. The highest number of leaves which was observed on the plants grown on the soil plus rice ash and soil poultry manure agrees with the results obtained by Silva et al. (2003), who reported that poultry waste leads to increase in leaf number and size.

The highest number of branches per plant that was observed in seeds grown on soil +rice ash was due to the high concentration of nutrients present in the substrate which enhanced the growth of the plant. Same results that were observed by soil plus poultry manure is similar to the findings of Adesina et al. (2004); Aliyu (2003) and Alabi (2006) who stated that poultry manure increased the vegetative growth of pepper plants and augmented the nutrients uptake**.** The genetic make-up of a crop and environmental factors also play a significant role on the growth of plants (Young et al.,2004). Seeds cultivated both on soil plus rice ash and soil plus poultry droppings showed no significant difference regarding the stem girth. However, soil +rice ash produced higher stem girth (7.53) compared to soil + poultry manure (6.78). This result validates the similarity in nutrient compositions of the two substrates. Saw dust plus rice ash supported the least stem girth produced by the seeds grown on them. Olubanjo and Alade (2018) also reported that rice husk produced the highest stem girth when tomato was irrigated on different substrates. The combination of soil, rice ash, and poultry dropping may have increased the number of fruits and weight of fruits on plants. This could be because organic manure generally improves the physical, chemical, and biological properties of the soil, which consequently stimulates soil microbial activities that help with plant nutrient release and crop health.

There was no significant difference between the number of nodes produced by seeds grown on soil plus rice ash and soil plus poultry manure. However, those seeds cultivated on former had higher number of nodes (13.417) than those cultivated on the latter (11.417). No significant difference was between the plants grown on soil plus rice ash and those grown on poultry manure with respect to number of nodes. This could be attributed to the high water holding capacity and organic matter of the substrates which support the growth indices of the plants. Titiloye et al. (1986) in their study in southern Nigeria, found out that there was a significant increase in the crop growth rate of maize plant with the application of poultry dropping than in the control plots and in plots where other tropical organic waste materials were used.

Seeds grown on soil +rice ash had the highest mean fruit number of 18.00 while those planted on the soil alone had the least mean number of 6.75. Mean fruit number of 13.33 was obtained when seeds were planted on soil +poultry dropping as compared to those grown on saw dust plus rice ash which yielded 10.50 on the average. This finding is like that of Olubanjo and Alade (2018) where the least number of fruits per plant was recorded for seeds growing on the soil alone while the highest was recorded for those grown on rice husk substrate. The characteristics of the crop, as indicated by the quantity of flowers, leaves, nodes, and stem girth, all show a favorable association with each other and with agricultural growth. Therefore, for the crop to grow as best it could, nutrient absorption from the soil plus rice ash plus chicken droppings was sufficient.

Fruits obtained from seeds grown on soil + rice ash had the highest weight with the mean weight of 400.87g. This result might be attributed to the high level of total nitrogen and magnesium, which enhance fruit formation, in the rice ash as compared to other substrates (Osvald et al., 2001). Unlike seeds grown on saw dust rice + ash and on soil alone, which produced no significant differences with respect to the mean fruit weight, those planted on poultry dropping weighted higher after the soil + rice ash substrate. The increase in fruit weight of soil poultry dropping + might be due to high level of macro and micronutrients available in poultry litter, which is needed for photo assimilates, and thus enhanced amount of light intensity trapping by the crop which resulted in maximum fruit yield. It was reported that the high level of poultry manure is a rich source of nutrients for crops (Adediran et al., 2003). The tomato plant that was initially slow in growth later had a speedy grown after getting well established. This outcome is consistent with research by Olaniyi (2010) and Olubanjo and Alade (2018), who found that the plant grew taller initially, reached a maximum, and then began to decline once more. As a result, the chart created by charting height, leaf count, and node count against the number of weeks after planting has an oblique S shape. In a similar report, Smaling et al. (2002) stated that poultry manure application has positive influence on assimilate production which invariably has direct bearing over dry matter production per plant unit area.

Conclusion

The result of the experiment showed that seeds planted on soil plus rice ash and soil poultry dropping had the highest growth indices in both morphological and yield analysis. With this result, soil rice ash is affirmatively recommended for household producers and small-scale farmers who want to improve their produce via organic practice to meet the demand of the populaces without necessarily going for poultry dropping.

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