ASSESSMENT OF LIFESPAN OF PREPARED GROWTH MEDIA FOR GREENHOUSE VEGETABLE PRODUCTION

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Adekeye, S. A., Olla, O. O, Salman, S. I., Haruna, A. A., Ilevbaoje, O. O. and M. B. Makanjuola
Department of Land and Water Engineering
National Centre for Agricultural Mechanization (NCAM)
P. M. B. 1525, Ilorin, Kwara State, Nigeria.

ABSTRACT

Agricultural production in Nigeria faces numerous challenges such as erratic weather patterns, pests and diseases, insecurity, etc. Greenhouse technology offers a promising solution to mitigate these challenges and ensure consistent food production. The longevity and effectiveness of prepared growth media are critical factors influencing the productivity and sustainability of greenhouse vegetable production. This study examined the lifespan of a growth media prepared from top soil and cured poultry dropping. The two components were mixed in ratio 3:1 by weight and sterilized with heat at 150^0C. This was used to grow two seasons of cucumber and tomatoes consecutively for two years under controlled conditions which minimized the loss of nutrients to the environment. Macro-nutrients such as nitrogen, phosphorus, potassium, magnesium and calcium were analyzed using standard procedure with reference to Association of Officer Analytical Chemists (AOAC). The results showed that nitrogen and phosphorus in the used media reduced to 0.15 from 0.42 and 0.050 from 0.051, a depletion of 64.29% and 1.96%, respectively while nutrients such as potassium, calcium, magnesium and zinc were reduced to 15.35 mg/kg, 19.05 mg/kg, 8.15 mg/kg and 0.76 mg/kg, respectively. With the levels of the nutrients left after using the growth media for growing vegetables for two years, it will take 3 years before leaving a concentration below 200 mg/kg required to raise vegetable. The concentration of Phosphorous and Zinc will be sufficient to raise vegetable beyond three years. The media is needed to be augmented with an organic source that is rich in Potassium and Magnesium in order to meet the vegetable demand. Therefore, the growth media prepared as prescribed in this research can be used for three years to produce vegetables in a Greenhouse with minimized nutrient loss.

Keywords: Agricultural production, Growth media, Greenhouse vegetables, Nutrient retention.

1. INTRODUCTION

There are numerous advantages in growing vegetable crops in greenhouses and protected spaces without daylight, compared with the traditional production (open-field). In greenhouses, it is possible to control the climate conditions, plant nutrition, and other necessary installations, or automation of production process. This enables all-year round and/or off-season production, which is increasingly in demand in markets all over the world. It particularly goes for vegetables crops typical of warm season (tomatoes, cucumbers, peppers), but also for those of cool season like lettuce, spinach, radishes and broccoli (Dubravka and Zarko, 2022).

Soil is normally considered as the fine earth which covers land surfaces as a result of the in situ weathering of rock materials or the accumulation of mineral matter transported by water, wind, or ice. The distinctive feature of soil is that, to this weathered mineral material is added organic material (Chesworth, 2008). This organic material may be both living and dead. The dead organic matter includes little altered and freshly added dead plant roots and leaf. Other materials include plant litter, dead fauna, and organic material in various stages of decomposition. It ranges from little modified and relatively fresh materials to the complex decomposed material called humus. It is this mixture of mineral and organic material which gives the soils their distinctive characteristics (Nortcliff *et al.*, 2006).

Plants, like all other living things, need food for their growth and development. Plants require 16 essential elements. Carbon, hydrogen, and oxygen are derived from the atmosphere and soil water. The remaining 13 essential elements (nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, zinc, manganese, copper, boron, molybdenum, and chlorine) are supplied either from soil minerals and soil organic matter or by organic or inorganic fertilizers (Silva and Uchida, 2000).

Soil depletion occurs when the components which contribute to fertility are removed and not replaced, and the conditions which support soil's fertility are not maintained. This leads to poor crop yields. In agriculture, depletion can be due to excessively intense cultivation and inadequate soil management (Pradeep, 2020). One of the major causes of soil fertility decline is land degradation which is caused through the different agents such as soil erosion, deforestation, overgrazing, sedimentation, continuous farming and pollution (Sims and Wander, 2002). The major causes to soil erosion and sedimentation are not only high intensities of rainfall and floods but the problem is much aggravated by deforestation and overgrazing, in the absence of the two, soil erosion and sedimentation will remain to the minimum (Demeke, 2003).

Field soils are generally unsatisfactory for the production of plants in greenhouse. This is primarily because soils do not provide the required nutrient needed to satisfy the demand of crops. To improve this situation, soil growing media have been developed. Soil is the basic natural medium for growing plants and is indeed the cheapest source. Loamy and porous soil, rich in organic matter with neutral pH (around 7) is good for the growth of plants. Soil is mixed with farmyard manure in different ratio for better aeration, water-holding capacity and nutrient supply to the plants but it is difficult to maintain the nutritive status, pH and water-holding capacity of soil as per the requirements of a particular crop for long duration (FAO, 2013). Therefore, it is important to determine how long growth media can be used for cultivation of a particular crop in the greenhouse environment. This research therefore aims to assess the lifespan of prepared growth media for greenhouse vegetable production.

2. MATERIALS AND METHODS

2.1 Study Area

This research was carried out at National Centre for Agricultural Mechanization (NCAM) Integrated Farm Project Greenhouse (NIFAP), Ilorin, Kwara State. Ilorin is situated on Longitude 4^o35^1East and Latitude 8^o 29^1 North with an altitude of 370 m above sea level. The mean annual rainfall is about 1,200 mm while the rainfall distribution is bimodal. The rainfall season spans from April through October with a dry spell in the month of August.

2.2 Preparation of Growth media

The top soil used was collected between 0 and 30 cm depth around NCAM Greenhouse on a plot of land used for vegetable production at Land and Water Engineering Department Experimental site, using a standard core sampler. It was allowed to air dry to a moisture content of 4%. The soil was pulverized and sieved with standard laboratory test sieve of 2.36 cm sieve size to allow soil particles belonging to soil textural classes and remove stones.

The poultry dropping used was collected at Poultry farm at NCAM Integrated Farm Project (NIFAP). It was air dried, pulverized and sieved with laboratory test sieve of 2.36 cm sieve to improve the quality and ease of use by removing large debris.

The top soil was thoroughly mixed with cured manure at the ratio of 3:1 (soil: manure) by weight. The mixture was heated by fire for 30 minutes in an NCAM made automatic garri fryer to an average temperature of about 150^{o}C to prevent the destruction organic matter and soil minerals. The heated mixture is allowed to cool down and the prepared media bagged in black polythene bag with some holes to allow drainage of excess water. Each bag (60 cm x 50 cm x 70 cm) was filled to the quarter mark of about 30cm depth with the media.

2.3 Tomatoes and cucumber cultivation

Planting of tomatoes was done in seedling tray, filled with a soilless media made up of coconut core fiber and wood materials and spent 28 day in nursery. Transplanting was done by planting a seedling inside a bag of prepared growth media with a space of 50 cm between bags and 75 cm between the rows. A drip irrigation of about 250 litres of water was supplied to the greenhouse of 192m^2 on a daily basis. Staking was done at a plant height of 30 cm. Weed and pest control were done according to standard practices of tomatoes cultivation. No application of inorganic fertilizer since manure was incorporated into the growth media. The tomatoes plant start flowering at about 6 to 7 weeks after transplanting and harvesting started after 4 weeks of flowering. The harvesting continues until 6 to 8 month for a complete life cycle. The cultivation of tomatoes was twice on the prepared growth media i.e. two seasons of tomatoes cultivation on the growth media before cucumber was introduced on the same media.

The cultivation of cucumber followed almost the same procedures, except the fact that the planting was done directly on the bag containing growth media with a seed per bag maintaining the same plant and rows distance as tomatoes. Staking was done at a plant height of 30cm; weed and pest control followed the same procedures as cultivation of tomatoes. The fruit production started 50 days and continued till 70 days after planting. The lifespan of cucumber is about 10 weeks. The cultivation of cucumber was done twice on the growth media before sampling the media for analysis.

2.4 Sampling

The sample A is a freshly prepared plant media that has not been used as a control. Sample B is growth media which has been used for complete two years for the growth of two seasons of tomatoes and two seasons of cucumber. While the sample C is natural soil within 30 cm depth around the greenhouse from which the growth media was prepared.

2.5 Analysis of samples

Three Samples each were collected from the materials used to prepare growth media (soil and poultry dropping), the natural soil in greenhouse, and the growth media before and after usage for two season of cultivation of tomatoes and cucumber, consecutively. Nitrogen, Phosphorous, Potassium, Calcium, Zinc, Magnesium and pH were analyzed from the samples at the Land and Water Engineering Laboratory, NCAM with reference to analytical manuals by AOAC, 2012. The available Nitrogen was determined by sample digestion with Potassium permanganate after which digestion and titration were carried out to determine the percentage of nitrogen present. The other minerals were analyzed by Ammonium carbonate digestion and instrumental analysis was carried out by spectrometry methods using Atomic Absorption Spectrophotometer and Flame Photometer. The sample pH was determined by electrochemical method using calibrated pH meter.

Soil physical properties carried out were Bulk density, Soil organic matter and Water holding capacity using gravimetric method (Rashmi and Shrivastava, 2023). The shear strength and cone index of the planting medium used for this experiment were also determined using shear vane (C041-A) and Cone penetrometer (Eijeikamp penetrologger: 06.15.SA).

3. RESULTS AND DISCUSSION

The Table 1 contains the results of chemical properties of the growth media used for cultivation of vegetable (B), control (A) and natural soil (C) around the greenhouse.

Table 1. Chemical properties of the growth medium

Samples	N (%)	P (%)	K (mg/kg)	Ca (mg/kg)	Zn (mg/kg)	Mg (mg/kg)	pH
A	0.42	0.051	15.80	21.20	0.81	8.15	6.50
B	0.15	0.050	15.35	19.05	0.76	7.91	6.30
C	0.10	0.043	14.75	18.50	0.65	7.82	6.30

3.1 Results of Chemical Properties of the Growth Media

Soil pH

Table 1 shows the results of the soil pH. The results showed that the pH reduced from 6.5 for freshly prepared media to 6.3 for the same growth media after two years of cultivation with tomatoes and cucumber under greenhouse management. This reduction in pH may not be unconnected with some of the nutrients absorbed by the plants. Table 2 shows that at these pH, the soil is slightly acidic and important nutrients such as nitrogen, phosphorus, potassium are still readily available. Other important elements such as calcium, magnesium and sulphur will also be available if present in the media.

Table 2. Soil pH classification and nutrient availability

pH	*Classification*	*Available Nutrient*
4.0-5,5	*Strongly acidic*	*Fe, Mn, B, Cu and Zinc*
6.0-6.5	*Slightly acidic*	*N, P, K, S, Ca and Mg*
6.5-7.0	*Very Slightly acidic*	*N, P, K, S, Ca and Mg*
7.0-7.5	*Very Slightly alkaline*	*N, P, K, S, Ca and Mg*
7.5-8.0	*Slightly alkaline*	*N, P, K, S, Ca and Mg*
8.0-8.5	*Medium alkaline*	*Mo*
8.5-10	*Strongly alkaline*	*Mo*

Source: FAO (2013)

Nitrogen

The concentrations of Nitrogen in the freshly prepared growth media (sample A) was 0.42 percent, which is equivalent to 4,200 mg/kg though slightly less than plants requirement of 0.5 percent as recommended by Robert, 2004 but greater than 0.02 percent (200 mg/kg) needed by tomatoes and other greenhouse vegetable (Richard, 2019). At the end of the two years of growing two seasons of tomatoes and the two seasons of cucumber, the nitrogen content in the growth media of Sample (B) reduced to 0.15 percent (1,500 mg/kg), meaning 64.28 percent of the original content were used for cultivation of cucumber and tomatoes in these two years. The media at the end of the two years was still fertile than the natural soil in the same environment. This implies that further usage of the growth media for the cultivation of vegetable can still be recommended because the quantity of available nitrogen is greater than 200 mg/kg (Richard, 2019). Therefore the remaining nitrogen concentration in the media can still accommodate the growth of vegetable for another year. Inferably the growth media prepared in this form can be used for three years for the growth of vegetable especially tomatoes and cucumber before the nitrogen level in it can go below a required level for vegetables putting into consideration that the growth media is used under a controlled weather conditions like Greenhouse where water supply is under control to avoid leaching of minerals.

Phosphorous

In the table 1, Results showed that the concentrations of the available Phosphorous in the freshly prepared growth media (A) was 0.051 % equivalent to 510 mg/kg which is lower than 0.1% (1000 mg/kg) recommended by Robert, 2004 for total plant nutrition but higher than 8.92 mg/kg needed by tomatoes and other greenhouse vegetables (IFA, 1992). The rate at which the phosphorous depleted from growth media is lower than Nitrogen. The result of the concentration of phosphorous in Sample B is 0.050% (500 mg/kg) shows that about 2 % of original content of phosphorous was used for the cultivation of vegetable for the two years. This implies that the concentration of phosphorous in the growth media can support the growth of vegetable many years after which the available nitrogen must have been exhausted. The concentration of phosphorous in the sample C is greater than 0.01% which was the best result obtained by Oladoye *et al.* (2019) when he investigated the Phosphorus forms and distributions in soils under selected land use practices, the natural soil around NCAM greenhouses is lower in phosphorous concentration when compared with fresh and used growth media but fall within the required ranges of phosphorous needed for vegetables cultivation (IFA, 1992).

Calcium, Magnesium and Zinc

Calcium and Magnesium do not belong to the three most important nutrients but are also needed in substantial quantity for proper growth of plant. According to FAO, 2013 about 40-80 mg/kg of Magnesium are needed for proper plant growth. The magnesium that was obtainable from fresh and used medium is far below the required quantity. The media should be supplemented with Magnesium source for proper growth of the vegetables. The results displayed in table1 showed that the freshly prepared growth media and the used samples had calcium concentrations of 21.20 mg/kg and 19.05 mg/kg, respectively. The samples have enough calcium above 10 mg/kg as recommended by IFA (1992). The rate of consumption of Calcium for the two year of vegetable cultivation on the growth media was 10.54 percent. This showed that presence of calcium in the growth media will be enough for vegetables cultivation above five years. Zinc is needed as a micronutrient in very minute quantity. The quantity present with respect to table 1 will be sufficient for the growth of vegetable (IFA, 1992).

Table 3. Soil fertility classification

Soil Fertility Class	**Available Extractable Nutrient**		
	Phosphorus (P) (mg/kg)	**Potassium (K) (mg/kg)**	**Magnesium (Mg) (mg/kg)**
Very Low	< 5	< 50	< 20
Low	5-9	50-100	20-40
Medium	10-17	100-195	40-80
High	18-25	175-300	80-180
Very High	> 25	> 300	> 180

Source: FAO (2013)

3.2 Physical Properties of the Growth Media

Soil physical properties significantly impact fertility and crop productivity in several ways. Table 4 shows that the average bulk density of the freshly prepared growth media, the used media and the soil from which the media was prepared had average bulk densities of 1.02, 1.11 and 1.14, respectively, these are within the range of 1.0 to 1.6 g/cm3 bulk densities to obtain good soil aeration, root development and crop productivity (Hamza, and Anderson 2005). These values show that the level of compaction in the various soils is relatively low and suitable for effective root growth and development. The results of the Cone Index of the media also revealed 2 kPa, 20 kPa and 50 kPa, respectively for media A, B and C. The cone index is also a measure of the resistance per unit area to be encountered by plant root during penetration. These results revealed that the growth media still maintain a good cone Index, even after being used for production under irrigated greenhouse tomato and cucumber production for two seasons. Similarly, Table 4 shows the shear stress of the soil samples A, B and C to be 4 kPa, 18 kPa and 60 kPa, respectively. The results still showed that the amount of force required per unit area to shear the media apart by plant root is minimal, though a little higher than that of the freshly prepared media. This result showed that the growth media still maintained good structure, even after being used for production under irrigated greenhouse condition for two years. The water holding capacity (WHC) of the media A, B and C was also found to be 25%, 20% and 14%, respectively; this might not be unconnected with a decrease in organic matter content due to usage. The result shows that the used media still possess adequate capacity to hold water to sustain plant growth.

Table 4. Result of soil physical properties

Sample codes	Average Bulk Density (g/cm^3)	Average CI (kPa)	Average Soil Shear Stress (kPa)	WHC (%)
A	1.02	2	4	25
B	1.11	20	18	20
C	1.35	50	60	14

4. CONCLUSION

The information gathered from this research showed that the first nutrient that will be used up from the growth media prepare as described in this research is nitrogen and will take three years. Other nutrients like Phosphorous, Calcium and Zinc can spend more than three years before they are exhausted while the media has to be fortified with organic materials that are rich in Potassium and Magnesium to make up for their deficiency in the media. Therefore the growth media prepared as prescribed in this research can be used for three years for the cultivation of tomatoes and cucumber before it can be replaced. Further research is needed in this area to narrow down the usage to a single vegetable in order to know the rate at which each nutrient is depleted in the growth media for a specified crop under controlled environmental conditions.

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