Effect of Organic Soil Amendments on Growth and Yield of *Amaranthus viridis* L.

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KEYWORDS

Amaranthus viridis,
Organic soil amendments,
Poultry manure,
Rice straw and husk,

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ABSTRACT

A pot experiment was carried out to evaluate the effect of some soil organic amendments on the growth and yield of Amaranthus viridis L. in Ifite-Ogwari, Ayamelum L.G.A. of Anambra State. The study was laid out in a completely randomized design (CRD) with seven treatments and replicated three times. The treatments were Topsoil (T1) , Rice husk +Topsoil (T2), Rice Straw + Rice Husk + Topsoil (T3), Rice Straw + Topsoil (T4), Rice Straw + Topsoil + Poultry Manure (T5), Rice Straw + Rice Husk + Topsoil + Poultry Manure (T6), Rice Husk + Topsoil+ Poultry Manure(T7). Each soil amendment combination were mixed in the ratio of 3:2:1; where Topsoil represented the 3 parts, Rice straw and/or Rice husk represented the 2 parts, and Poultry manure represented the 1 part. In situations where rice husk and rice straw were mixed, the two parts was in the ratio of 1:1 for each of the rice residues. The treatments were separated using the least significant difference (LSD) at 5% probability level. The addition of organic soil amendments, particularly those involving poultry manure (PM), had positive effects on the growth parameters and yield of A. viridis. The RS+TS+PM treatment consistently showed promising results in terms of plant height, leaf number, leaf area, stem girth, and leaf yield. Since the RS+TS+PM treatment gave the highest yield, it is recommended that farmers use this mixture for growing A. viridis due to its nutrient content.

INTRODUCTION

Most developing countries rely on starch-based foods as staple sources of energy and protein, contributing to protein deficiency (Adeniyi *et al*., 2012). In Nigeria, vegetables are crucial for providing proteins, vitamins, minerals, and essential amino acids (Poonia and Upadhayay, 2015). However, fresh vegetables have become expensive, even in rural areas like Ifite-Ogwari, due to inadequate knowledge of their nutritional values and low soil fertility (Falodun and Edafe, 2020). Inorganic fertilizers, though initially effective, are costly and environmentally harmful, making them impractical for poor farmers (Ojeniyi and Owolabi, 2009; Shiyam and Binang, 2011). Organic manure is a more sustainable alternative for the vegetables especially *Amaranthus viridis.*

Amaranthus viridis L. commonly called "green" belongs to the Amaranthaceae family. It is also known as slender or green amaranth. The crop is an annual plant reaching 20–90 cm in height, with ovate to trapezoid leaves and terminal and axillary spikes (Odugbemi, 2008). Its growth and yield are dependent on the type of fertilizer used for the production and fertility status of the soil among other factors.

Poultry manure is a very good soil amendment, rich in organic matter and nutrients, though its composition varies with factors souch as the source of manure, feed of the birds, age and condition of the birds, storage,

handling of manure, and litter used (Fereidooni *et al*., 2013). Poultry waste consists of droppings from poultry, wasted feed, broken eggs, feathers, and sometimes sawdust from poultry floors. It also includes dead birds and hatchery waste, all of which are rich in protein and have substantial amounts of calcium and phosphorus due to elevated levels of mineral supplements in their diet (Awasthi *et al*., 2019).

Rice residues, such as straw and husk, are important natural resources that improve soil physical, chemical, and biological properties (Naresh, 2013). However, managing rice straw is challenging due to its high silica content, making it a poor feed for animals (Mandal *et al*., 2004). Rice straw is unique among cereal straws for being low in lignin and high in silica, contributing to higher straw value with rice yield (Van Soest, 2006). Efforts in plant breeding have focused on developing short varieties with higher grain yield, reducing straw quantity but not nutritive value (Van Soest, 2006).

Rice husks are valuable for waste utilization and cost reduction in domestic and industrial processing. Widely available in rice-producing countries like China and India, rice husk content ranges from 16-25% of paddy (Della *et al*., 2002; Giddel *et al*., 2007; Soltani *et al*., 2015). Annually, approximately 500 million tonnes of paddy are produced globally, with India contributing around 24 million tonnes of rice husk per year (Shwetha *et al*., 2014). Rice husk ash (RHA), a by-product of rice husk, is produced in large quantities and poses disposal and environmental challenges due to its low density and less commercial interest (Pode, 2016). Rice husk is high in ash content compared to other biomass fuels, with silica content in RHA varying from 83-98% (Adam *et al*., 2006; Rozainee *et al*., 2008; Pode, 2016). The high silica content makes it valuable for industrial applications. Rice husk is used as an organic fertilizer to improve productivity and water use efficiency in fields (Govindarao, 1980; Ebaid *et al*., 2007; Badar and Qureshi, 2014). It enhances nitrogen and other macro and micro-element absorption, improving dry matter production and translocation from source to sink (Ebaid *et al*., 2005; El-Refaee *et al*., 2006; Ebaid *et al*., 2007). Rice husk is also transformed into organic fertilizer through vermicomposting (Lim *et al*., 2012; Shak *et al*., 2014) which can be valuable for production of vegetables.

Given the environmental impact of burning rice residues in Ifite-Ogwari, research is needed to utilize these materials effectively. This study aimed to provide insights into using rice residues for vegetable cultivation, benefiting both rural and urban populations.

MATERIALS AND METHODS

Experimental Site: The experiment was carried out at Ifite-Ogwari during the dry season of January to March, 2023. Ifite-Ogwari is in Ayamelum Local Government Area, Anambra state, South Eastern Nigeria.

Seed Source: The seeds of *A. viridis* L. was obtained from registered seed outlet at Ama Orie market, a market situated at Ifite-Ogwari. The seed was obtained dry from the seller in the market.

Potting Container: Cement bags which are 0.0375 cubic meters (m^3) [75 cm x 50 cm x 10 cm] were washed thoroughly, half filled with the topsoil, poultry manure and rice residues depending on the treatment and replication. These treatments were also mixed accordingly and watered once every day for two weeks to allow them decompose before the actual planting of the *A. viridis* L. seeds. In each of the bags, a total of three filled custard bucket measuring 2 kg each was used for the media.

Sowing Of Seeds: Ten seeds of *A. viridis* L. were sown/planted in each bag and was thinned down to five plants at two weeks after emergence.

Treatments and experimental design: The treatments comprised: T1 = Topsoil (control), T2 = Rice Husk + Topsoil, T3 = Rice Husk + Rice Straw + Topsoil, T4 = Rice Straw + Topsoil, T5 = Rice Straw + Topsoil + Poultry Manure, T6 = Rice Husk + Topsoil + Poultry Manure, T7 = Rice Straw + Rice Husk + Topsoil + Poultry Manure. The media were composed of three parts of topsoil, two parts of rice residues and one part of poultry manure for each pot according to treatments Therefore, the experiment had a total of seven treatments. The experimental design was completely randomized design (CRD) with 3 replications.

Experimental layout: The experimental pots served as plots and were arranged in a row of seven pots, each was replicated three times making it a total of twenty-one (21) pots for the experimental set up .It was lined up according to the treatments and spaced 1m apart from each pot with 5cm plant spacing distance from each other in the experimental pot. The whole media was properly covered with a mosquito net to avoid insect pest attack.

Media processing and preparation: Rice Straw was obtained from Ebiggy rice farm located close to the Faculty of Agriculture, Ifite-Ogwari Annex. After collection/arrangement the straws was churned with cutlass and then taken to a local garri processing site for grinding in other to obtain a uniform/finer granule. Rice Husk was obtained from the rice milling site at Isi-Udala, Ifite-Ogwari. Topsoil was obtained from a one year fallowed area in other to obtain soils with high nutrient content which is located at Nnamdi Azikiwe University, Faculty of Agriculture Annex farm, Ifite-Ogwari.

Weeding: Weeding was carried out two times by hand picking at 4 and 8 weeks after Transplanting.

Harvesting: The mature vegetables were harvested using a sharp kitchen knife at 6 weeks until the end of its production cycle. Each stem was trimmed 15 cm from the base to ensure a uniform cut across all pots.

Data Collection on Plant Parameters

Growth parameters: The leaf length, width and plant height were measured using a meter rule in centimetre (cm) and the readings were taken from first to fifth week after emergence respectively. The number of leaves was determined by visual counting. To determine the leaf area, the length and width of the broadest leaf were measured with a meter rule, applying a correction factor (K=0.785) (Pandey and Palni, 1997). The stem girth was measured using a measuring tape in centimetre (cm) and the readings were also taken from the first to fifth week after emergence.

Yield parameters: The leaves were harvested fresh and weighed using a sensitive scale calibrated in grams to get the yield.

Weed parameter: Number of weeds were counted and recorded, total weed, dry weight and fresh weight were counted and measured with a sensitive scale.

Statistical Analysis: The analysis of variance (ANOVA) was carried out using Genstat 2011 Statistical software, 4th Edition and where significant differences are observed, the least significance difference (LSD) test at 5% probability level was used to compare the treatment means**.**

RESULTS

Physicochemical properties of the experimental soil, poultry manure, rice husk and rice straw utilized during the study

Table 1, showed the results gotten from analyzing rice straw, top soil, poultry manure and rice husk used for the experiment. The results obtained showed that the textural class of the soil was sandy loam which indicated that the water holding capacity of the soil was moderate and the sand percentage was 67.60%, the pH indicated that the soil was slightly acidic (5.85). Available Phosphorus was 6.27 while calcium, magnesium, potassium and sodium respectively are 2.60, 1.80, 0.29, and 0.13. For the Poultry manure the pH is also acidic with pH of 4.27 while calcium, magnesium, potassium and sodium respectively are 1.20, 2.07, 0.86, and 0.41. For Rice Husk the pH is acidic with pH level of 5.21 while calcium, magnesium, potassium and sodium respectively are 1.09, 2.31, 0.23, and 0.27. For Rice straw the pH is slightly basic with pH level of 8.10 calcium, magnesium, potassium and sodium respectively are 1.32, 1.80, 0.11, and 0.13.

Effect of some organic soil amendment on the height of *Amaranthus viridis* L.

The effect of some organic soil amendment on the height of *A. viridis* is presented in Table 2. The results indicated that there is a significant difference ($P<0.05$) in the height of plant in the treatment samples and the control up to 5 WAT. However, the mixture of RS+TS+PM gave the tallest plants at 37.54 in the fifth week with a mean value of 17.57 while the shortest plant was recorded in plant grown in the RS+TS at 11.71 in the same fifth week with a mean value of 5.75.

Table 1: The physical and chemical properties of the soil at experimental site, rice husk and rice straw in Ifite-Ogwari in 2023.

Properties	Soil	Poultry Manure	Rice husk	Rice straw
Physical				
Sand (g/kg)	67.60	-	-	-
Silt (g/kg)	20.00	-	-	-
Clay (g/kg)	12.40	-	-	-
Textural class	sandy loam	-	-	-
Chemical				
pH (H_2O)	5.85	4.27	5.21	8.10
Available Phosphorus (mg/kg)	6.27	0.46	0.180	0.070
Nitrogen (g/kg)	0.40	1.26	0.29	0.25
Organic carbon (g/kg)	1.49	3.13	2.69	2.01
Organic matter (g/kg)	2.57	-	-	-
Calcium (cmol kg^{-1})	2.60	1.20	1.09	1.32
Magnessium (cmol kg^{-1})	1.80	2.07	2.31	1.80
Potassium (cmol kg^{-1})	0.29	0.86	0.23	0.11
Sodium (cmol kg^{-1})	0.13	0.41	0.27	0.13
Exchangeable Acidity (cmol kg^{-1})	1.10	-	-	-
ECEC (cmol kg^{-1})	5.92	-	-	-
Base saturation (BS) (%)	81.4	-	-	-

ECEC= Effective Cation Exchange Capacity

Table 2: Effect of some organic soil amendments on the height (cm) of *Amaranthus viridis* at Ifite-Ogwari in 2023.

	Weeks After Transplanting					
Treatment	**1**	**2**	**3**	**4**	**5**	**Mean**
RH+RS+TS	1.06	4.05	6.98	15.40	18.39	9.18
RH+TS	1.12	3.09	5.61	10.32	12.42	6.51
RH+TS+PM	0.40	3.46	5.21	17.38	31.13	11.52
RS+RH+TS+PM	0.95	1.00	2.72	15.34	29.10	9.82
RS+TS	0.80	2.36	4.43	9.44	11.71	5.75
RS+TS+PM	1.12	6.43	13.21	29.54	37.54	17.57
TS (Control)	1.21	8.21	14.46	21.45	29.70	15.01
$LSD_{(0.05)}$	0.06	0.45	0.17	0.083	2.31	

Effect of some organic soil amendment on the number of leaves of *A. viridis* L.

The effect of some organic soil amendment on the number of leaves of *A. viridis*, showed that there was no significant differences in the number of leaves from 1 to 3 WAT but was significantly different at 4 and 5 WAT in all amended soils (Table 3). The number of leaves of plants grown in RH+RS+TS and RH+TS mixtures grew from 3-4 leaves while that of other amendments and control doubled in 1-2 weeks after transplanting. Additionally, the number of leaves in the soil mixture of RS+TS+PM almost tripled from 3-8 in just 2 weeks after transplanting. At the end of the fifth week, RS+TS+PM recorded the highest number of leaves at 32.0 with a mean value of 15.87 while the lowest was recorded in plant grown in RS+TS mixture at 8.33 with the mean value of 5.53.

Effect of some organic soil amendment on the leaf area of *Amaranthus viridis* L.

The leaf area of *A. viridis* recorded a significant difference ($P<0.05$) in all the amendments (Table 4). The result obtained showed that the soil mixture of RS+RH+TS+PM had 0.02 cm^2 in the first week and the leaf area measured 0.05 cm^2 in the second week. However, by the end of the fifth week, the leaf area significantly increased to 60.0cm^2 surpassing that of the four other reviewed plant components. Plants grown in the soil

components having RS+TS+TM had the highest leaf area after 5 weeks at 107cm^2 with a mean value of 40.73.On the flip side, plant with the lowest leaf area of 6.0cm^2 and the lowest mean value of 2.43 was grown in the soil mixtures having RS+TS.

Table 3: Effect of some organic soil amendments on the number of leaves of *Amaranthus viridis* at Ifite-Ogwari in 2023.

	Weeks After Transplanting					
Treatment	**1**	**2**	**3**	**4**	**5**	**Mean**
RH+RS+TS	3.00	4.00	7.00	9.00	12.67	7.13
RH+TS	3.00	4.00	7.00	7.67	9.33	6.20
RH+TS+PM	2.00	4.00	6.00	11.33	16.33	7.93
RS+RH+TS+PM	2.83	4.00	5.00	15.67	22.00	9.90
RS+TS	2.00	4.00	6.00	7.33	8.33	5.53
RS+TS+PM	3.00	8.00	12.00	24.33	32.00	15.87
TS (Control)	4.00	8.00	13.00	14.67	15.67	11.07
LSD $_{(0.05)}$	NS	NS	NS	3.87	5.45	

Table 4: Effect of some organic soil amendments on the leaf area (cm^2) of *Amaranthus viridis* at Ifite-Ogwari in 2023

	Weeks After Transplanting					
Treatment	**1**	**2**	**3**	**4**	**5**	**Mean**
RH+RS+TS	0.32	1.00	1.86	6.71	13.40	4.66
RH+TS	0.27	0.98	1.79	3.94	6.20	2.64
RH+TS+PM	0.09	1.86	6.14	25.99	48.80	16.58
RS+RH+TS+PM	0.02	0.05	1.35	37.16	60.00	19.71
RS+TS	0.16	0.71	1.36	3.90	6.00	2.43
RS+TS+PM	0.37	13.38	21.35	61.15	107.4	40.73
TS (Control)	1.35	7.85	13.40	70.31	86.9	35.96
LSD $_{(0.05)}$	0.07	1.13	0.94	3.21	9.39	

RH = Rice husk, RS = Rice straw, TS = Top soil, PM = Poultry manure

Effect of some organic soil amendment on the stem girth (cm) of *A. viridis* L.

The effect of some organic soil amendment on the stem girth (cm) of *A. viridis* is presented in Table 5. The result obtained showed that, there is no significant different ($p>0.05$) in the effect of the organic soil amendment in the stem girth at week after transplanting across all media and control. But, the stem girth had significant differences ($P<0.05$) from the second to the fifth week after transplanting. Increase of the stem girth was moderate from week 2-3 and week 4-5 throughout the reviewed period both in the media samples and the control. By the end of the fifth week, stem girth in the soil mixed with RS+TS+TM was the biggest at 5.73cm and mean value of 2.82 while that of RS+TS medium was the lowest at 2.63 with a mean value of 1.46.

Effect of some organic soil amendment on the leaf yield of *A. viridis* L.

There was significant difference ($P<0.05$) in the effects of organic soil amendment on the yield of *A viridis* during the first harvest (Table 6). Three organic plant mixture recorded a higher leaf yield more than that of the Topsoil (TS) used as the control (23.60g). Organic soil mixture with the components RS+TS+PM has the highest yield of 47.10g per plant. This was followed by RS+RH+TS+PM soil components recording 39.0g yield per plant leaf and RH+TS with 31.30g yield per plant leaf. On the contrary, plants grown in soil mixtures of RS+TS recorded the lowest yield per plant leaf with each plant leaf at only 3.10g. Plant leaves in soil mixtures of RS+TS+PM and RS+TS recorded the highest and lowest Net yield of 0.1413/m2 and 0.0146 respectively in the first harvest.

Table 5: Effect of some organic soil amendments on the stem girth (cm) of *A. viridis* at Ifite-Ogwari in 2023.

	Weeks After Transplanting					
Treatment	**1**	**2**	**3**	**4**	**5**	**Mean**
RH+RS+TS	0.10	0.90	1.12	2.90	3.90	1.78
RH+TS	0.10	0.89	1.13	2.73	2.96	1.56
RH+TS+PM	0.10	0.89	1.13	3.83	4.36	2.06
RS+RH+TS+PM	0.12	0.87	1.07	4.33	4.76	2.23
RS+TS	0.10	0.90	1.12	2.56	2.63	1.46
RS+TS+PM	0.10	1.25	1.94	5.10	5.73	2.82
TS (Control)	0.20	1.22	1.92	4.16	4.36	2.37
LSD $_{(0.05)}$	NS	0.01	0.01	0.33	0.49	

RH = Rice husk, RS = Rice straw, TS = Top soil, PM = Poultry manure, NS = Not significant

Table 6. Effect of some organic soil amendments on the leaf yield of *A. viridis* at Ifite-Ogwari in 2023.

	First harvest	
Treatment	**Total Yield/plant (g)**	**Net Yield/m^2 (kg)**
RH+RS+TS	5.20	0.0151
RH+TS	31.30	0.0152
RH+TS+PM	6.70	0.1171
RS+RH+TS+PM	39.00	0.0938
RS+TS	3.10	0.0146
RS+TS+PM	47.10	0.1413
TS (Control)	23.60	0.0709
LSD $_{(0.05)}$	16.12	0.069

RH = Rice husk, RS = Rice straw, TS = Top soil, PM = Poultry manure, NS = Not significant

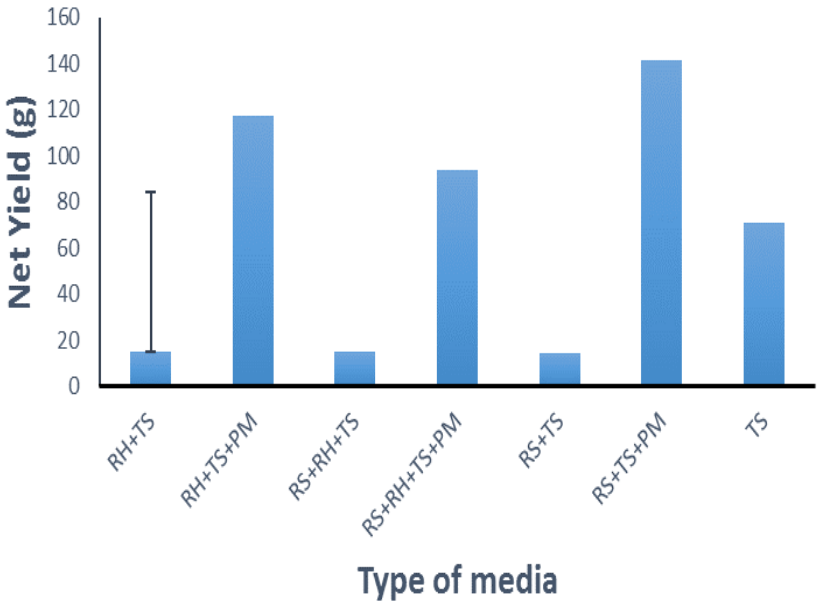


Figure 1: Effect of some organic soil amendments on the leaf yield of *A. viridis* at Ifite-Ogwari in 2023.

The vertical line represent the LSD bar. RH = Rice husk, RS = Rice straw, TS = Top soil, PM = Poultry manure

DISCUSSION

Height of *A. viridis* L

The study indicated that all treatments significantly affected the plant height of *Amaranthus viridis*, with an average height of 9.18 cm across all weeks. T7 (Rice Husk + Topsoil + Poultry Manure) and T6 (Rice Straw + Rice Husk + Topsoil + Poultry Manure) showed slower initial growth but substantial increases by the fifth week, reaching 31.13 cm and 29.10 cm, respectively. T5 (Rice Straw + Topsoil + Poultry Manure) was the most effective for promoting plant height. These results align with Oyedeji *et al*. (2014), who reported that poultry manure and its mixtures enhance the growth and yield of amaranths.

Number of leaves of *A. viridis* L.

The study observed that the plant in T3 (Rice Husk + Rice Straw + Topsoil) gradually increased its number of leaves from 3 in the first week to 12.67 by the fifth week, averaging 7.13 leaves. Similarly, the plant in T2 (Rice Husk + Topsoil) increased from 3 to 9.33 leaves over the same period. The results indicated that organic soil amendments had varying effects on the leaf number of *Amaranthus viridis*. Treatments such as RS+TS+PM and RS+RH+TS+PM significantly promoted leaf growth, supporting findings by Oyedeji *et al*. (2014) on the benefits of poultry manure mixtures.

Leaf area of *A. viridis*

The study revealed that T3 (Rice Straw + Rice Husk + Topsoil) plants experienced a gradual increase in leaf area, starting at 0.32 cm² in the first week and reaching 13.40 cm² by the fifth week, with an average of 4.66 cm². Similarly, T2 (Rice Husk + Topsoil) showed an increase from 0.27 cm² to 6.20 cm² over the same period. In contrast, the control group (T1) exhibited consistent growth, starting at 1.35 cm² and reaching 86.90 cm² by the fifth week, with an average of 35.96 cm². The results indicated that organic soil amendments had varied effects on the leaf area of *A. viridis*, with treatments like RS+RH+TS+PM and RS+TS+PM significantly promoting leaf development, as supported by Barau *et al*. (2018).

Stem girth of *A. viridis* L.

The showed found that T3 (Rice Straw + Rice Husk + Topsoil) plants gradually increased their stem girth from 0.10 cm in the first week to 3.90 cm by the fifth week, averaging 1.78 cm. Similarly, T2 (Rice Husk + Topsoil) showed an increase from 0.10 cm to 2.96 cm over the same period. The results indicated that organic soil amendments had varied effects on the stem girth of *Amaranthus viridis*. Treatments like RS+TS+PM significantly promoted stem girth growth, while others showed moderate or gradual increases, as noted by Akparobi (2009) and Barau *et al*. (2018).

Leaf yield of *A. viridis*

In summary, the organic soil amendments had varying effects on the leaf yield of *A. viridis*. Treatments like RS+TS+PM resulted in higher leaf yields and net yields, indicating their potential to enhance the productivity of the crop. The result was in agreement with findings of Akparobi (2009) in horticultural crops and that of Barau *et al*., (2018) in which they reported that higher yield response of crops due to organic manure application could be attributed to improved physical and biological properties of the soil resulting from the added manure.

CONCLUSION AND RECOMMENDATION

The growth and yield of *Amaranthus viridis* were significantly influenced by the growing medium. Treatments such as RS+TS+PM (rice straw, topsoil, and poultry manure) and RH+TS+PM (rice husk, topsoil, and poultry manure) resulted in higher plant heights compared to other treatments. The control group (TS) showed moderate plant height growth. RS+TS+PM and RS+RH+TS+PM treatments showed higher leaf numbers compared to other treatments, with the control group (TS) also exhibiting a good number of leaves. RS+TS+PM treatment resulted in the highest leaf area, indicating enhanced leaf growth and expansion. Other treatments showed varying levels of leaf area growth. RS+TS+PM treatment resulted in the highest stem girth, indicating significant stem growth, while other treatments showed moderate to gradual increases in stem girth. RS+TS+PM treatment also resulted in the highest leaf yield and net yield per square meter, with RH+TS and RS+RH+TS+PM treatments showing relatively higher leaf yields.

Overall, the results suggest that the addition of organic soil amendments, particularly treatments involving poultry manure (PM), had positive effects on the growth parameters and yield of *A. viridis*. RS+TS+PM consistently showed promising results in terms of plant height, leaf number, leaf area, stem girth, and leaf yield. However, further statistical analysis and interpretation are necessary to establish the significance of these observations and determine the most effective treatment for optimizing the growth and yield of *A. viridis* in the given context.

Since Treatment 5 (RS+TS+PM) gave the highest yield, it is recommended that farmers use this mixture for growing *A. viridis* due to the presence of necessary nutrients needed for optimum growth. Additionally, it is suggested that these media be used a second time to ascertain how long the nutrients can sustain the growth and yield of *A. viridis*.

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