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Proceeding Paper

Germination, Growth and Yield Responses of Eggplant and Okra Grown on Anthill and Termite Mound Soils †

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Abstract: Determining the physicochemical properties of anthill and termite mound soils and their combinations with ordinary top soil and the assessment of their effects on the germination, growth and yield performance of eggplant and okra under screenhouse conditions, were the goals of this study. The six soil treatments used are as follows: (I) pure anthill soil (AHS), (II) pure termite mound soil (TMS), (III) top soil (control) (TS), (IV) anthill +top soil (AHS + TS), (V) termite mound +top soil (TMS + TS), and (VI) anthill + termite mound soils (AHS + TMS). The physicochemical properties of these treatments were analyzed. A standard seed-germination experiment arranged in a completely randomized block design (30 seeds per treatment per tested crop) was carried out in a screenhouse. For the growth experiment, a pot experiment arranged on top of tables using a completely randomized design (CRD) was carried out in the screenhouse and the growth and yield were determined at seven (eggplant) and eight (okra) weeks. The results show that all treatments are acidic with pH, ranging from 3.3 to 4.5. The treatment containing anthill and anthill soils had higher EC (µS/CM), organic carbon (%), nitrogen (%), and phosphorus (%) compared to the control (top soil). Treatment had a significant ($p < 0.05$) effect on the germination indices of eggplant and okra. Enhanced seed germination was obtained with eggplant and okra seeds sown in ordinary top soil amended with anthill soil compared to the control. The growth and yield of eggplant and okra were significantly ($p < 0.05$) affected by treatment. Generally, eggplant and okra grown using anthill soils (alone or mixed) had taller plants, bigger stem girth and leaf area, and a higher number of leaves per plant compared to those grown on top soil. Eggplant and okra grown on anthill and termite mound soils and their combinations with ordinary top soils had heavier fresh whole plant and root biomass compared to the control. It can be concluded that these results indicate that anthill and termite mound soils can serve as cheap alternative sources of nutrients for the cultivation of common vegetables by smallholder farmers in southern Sierra Leone.

Keywords: anthill; eggplant; okra; termite mound; smallholder; southern Sierra Leone

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1. Introduction

Vegetable production in sub-Saharan Africa plays an important role in food security and poverty reduction. Although vegetables are an important emerging cash crop for the agricultural sector in Sierra Leone, their production and marketing systems are facing many challenges. Soil-nutrient capital is steadily depleting and the population of Sierra Leone is increasing, with farmers incapable of adequately improving the soil due to the limitation of accessible productive lands, preventing fallowing. Thus, the main strategy employed for improving agricultural productivity in Sierra Leone is the application of inorganic fertilizers. However, the potential success of this strategy is low due to problems of accessibility and affordability for smallholder farmers. In a review by Chisanga et al. [1], the authors postulate that anthills have been utilized as a choice of low-external-input farming strategy for soil fertility challenges in some African countries. In recent years, anthill and termite mound soils have been introduced to farmers in Niger, Zimbabwe, and Uganda to grow fruits and vegetables on top of anthills, while farmers in southern Zambia dig and collect soil from anthills and use it as an option to improve their soil fertility at the farm level [2]. However, there is isolated scientific evidence to show the performance and quantities of anthill and termite mound soils that need to be applied in a hectare in order to attain optimum crop yields at the farm level in sub-Saharan Africa. The practice of anthill and termite mound soil utilization is becoming common amongst the financially challenged smallholder farmers involved in conservation agriculture and other tillage systems in some African countries [2]. In Sierra Leone, the practice of anthill and termite mound soil utilization is not common amongst smallholder farmers, who only concentrate on the verge of termite mounds to grow vegetables and cereals. There is a need to evaluate the potential of anthill and termite mound soils as alternative nutrient sources instead of expensive and environmentally unfriendly synthesized fertilizers. In Sierra Leone, anthills and termite mounds are abundantly available in almost all the agro-ecological areas of the country. However, so far, little or no study has evaluated the use of anthill and termite soils as sources of nutrients for the production of common vegetables in Sierra Leone. Therefore, the aim of this study was to analyze the physicochemical properties of anthill and termite mound soils and assess the germination, growth, and yield responses of common vegetables such as eggplant and okra. The objectives were as follows: (I) to analyze the physicochemical properties of different combinations of anthill and termite mound soils, (II) to evaluate the seed germination response of eggplants and okras to different combinations of anthill and termite mound soils and (III) to evaluate the growth and yield response of eggplant and okra to different combinations of anthill and termite mound soils under screenhouse conditions.

2. Materials and Methods

2.1. Study Area

The experiments were conducted during the second cropping season (September) in 2020. The experiments were laid out in a screenhouse at the agriculture experimental field of the School of Agriculture and Food Sciences (SOAS), Njala campus, Kori chiefdom, Moyamba district, southern Sierra Leone. Njala University is located at an elevation of 54 m above sea level at latitude 8°6 N and longitude 12° W of the equator in the Moyamba district.

In the Moyamba district, anthill and termite mound soils are abundant and widely distributed in the various chiefdoms, including the Kori chiefdom, where anthill and termite mound sites can be easily seen within and around farms in villages. At the agriculture experimental field where this study was carried out, anthill and termite mound sites are visibly present and abundant.

2.2. Planting Materials

The eggplant and okra (Lady's finger) seeds used in this experiment were obtained from the Ministry of Agriculture and Forestry, Youyi Building, Freetown. In Sierra Leone. Anthill nests and termite mounds were harvested within and around the Njala communities, including the experimental site in Njala. Only abandoned anthill nests and termite mounds were harvested. The nests and mounds were placed in bags and transported to the screenhouse, where they were crushed and ground into powder and used as soil samples for the experiment. On the other hand, the top soil was obtained from a secondary forest next to the experimental site. The top soil was taken 0–20 cm depth using a soil auger for nutrient analysis. For each vegetable, sixty (60) pots were used, with six trays filled with well ground and crushed ant hill soil, termite soil, and topsoil to fill the trays and pots for the experiments.

2.3. Experimental Setup and Treatment

For the germination trials, six (6) trays were used to sow eggplant and okra seeds, and each tray contained different soil treatments. The six different soil treatments are as follows: (i) anthill soil (AHS), (ii) termite mound soil (TMS), (iii) top soil (TS) (control), (iv) ant soil +top soil (AHS +TS), (v) termite mound soil +top soil (TMS +TS), and (vi) anthill soil + termite soil (AHS +TMS). For the combined soil treatments, equal quantities of each soil type (1:1) were thoroughly mixed (homogenized) for the proper germination and growth experiments. The nursing process was done through the drilling method and was done on the 27 August 2020 in metal trays, and the germination experiment duplicated under screenhouse conditions. A standard seed-germination experiment arranged in a completely randomized block design (30 seeds per treatment) was carried out. After the seeds were sown, the soil treatments were moistened regularly (watering done twice a day (morning and evening)) and the number of germinated seeds counted and recorded for each treatment.

Upon the completion of the germination experiment, the germinated seedlings were transplanted into pots containing the respective six soil treatments. The pots were arranged on top of tables using a completely randomized design (CRD). Water was applied to the potted seedlings until their field capacity moisture level was reached, followed by incubation for a period of 3 days. Thereafter, the seedlings were irrigated manually every twenty-four hours, and this was done twice a day (early morning and late evening). No exogenous fertilisation was applied throughout the experimental period.

2.4. Physicochemical Properties on Anthill and Termite Mound Soils

The physicochemical analysis of the treatments used in this study was done at the Sierra Leone Agricultural Research Institute (SLARI) at the Njala University Njala campus and, due to limited resources, only the following parameters were determined: Soil pH and Electrical conductivity, Soil Texture, Total Nitrogen (%), Total Phosphorus (%), and Carbon (%), and measurements were collected in accordance with the American Public Health Association's guidelines [3].

2.5. Data Collection

Here, seeds sown were observed basically for data collection, taking considerable note of the seeds that germinated per day. At three (3) days after nursing, the number of seeds that had germinated were counted and recorded per treatment. Germination indices, including germination percentage (G%), germination index (GI), and germination rate index (GRI), were calculated from germination data according to Olisa et al. [4].

2.6. Growth Data Collection

The following growth parameters were measured: plant height, stem diameter, and number of leaves. For each treatment, ten (10) plants of each tested crop were harvested (eggplant at 7 weeks after planting and okra at 8 weeks after planting) and the fresh and dry weights of the whole plant and root biomass were recorded. The weights were determined using a weighing digital balance. To determine dry weights, plant organs were oven-dried at 60 °C for a period of two days and weighed.

2.7. Data Analysis

All data collected were subjected to one-way analysis of variance (ANOVA) using the STATISTICA software version 12 (Stat Soft Inc., Tulsa, OK, USA) and means were separated using the Duncan Multiple Range Test (DMRT) at a 0.05 level of significance.

3. Results and Discussion

3.1. Soil Analysis

From Table 1, the interactive effect of equal proportions of termite mound and ordinary top soil (TMS + TS) showed the highest pH (H_2O) (4.5) and pH (KCL) of (3.8) and top soil (control) with the lowest pH. Anthill soils (AHS) showed the highest electrical conductivity (119 µS/CM) and top soil amended with anthill soil had the highest (%) organic matter content (4.3%) and (%) nitrogen (0.65%). Top soil amended with termite mound soil had the highest phosphorus content (395.8%) and anthill and termite mound mixed (AHS + TMS) had the highest concentration of potassium (4.6%) compared to top soil alone (control).

Table 1. Physicochemical Properties Analysis anthill and termite mound soils.

	Treatments					
Soil Chemical Property	**AHS**	**TMS**	**TS**	**AHS + TS**	**TMS + TS**	**AHS + TMS**
pH(H_20)	4.3	4.3	3.8	4.4	4.5	4
pH(KCL)	3.6	3.6	3.3	3.5	3.8	3.4
Electrical conductivity (µS/CM)	119	85	110	25	29	25
Organic C (%)	4.2	3	4.1	4.3	3.7	3.8
Total Nitrogen (%)	0.41	0.45	0.34	0.65	0.31	0.56
Total Phosphorus (%)	116	152.4	127.2	152.4	395.8	251.4
Available potassium (%)	2.2	2.3	2.1	2.2	3.5	4.6
Soil Physical Property (%)						
Sand	49.4	47.4	49.4	51.4	51.4	55.4
Silt	20	14	18	20	18	16
Clay	30.6	38.6	32.6	28.6	30.6	28.6

Table 1 demonstrates that the physical soil analysis is based on the proportions of sand, silt, and clay. Ordinary top soil amended with termite mound soil (TMS + TS) had a higher amount of sand (55.4%) and clay (30.6%) compared to top soil (49.4% and 18%, respectively), and this trend was mirrored by anthill soil alone with respect to the silt content. Taken together, results obtained in this study show that anthill and termite mound soils (either alone or in combination with top soil) have the potential to serve as a nutrient source for plant growth and development. These results are in line with findings from other studies where the physicochemical properties of anthill and termite mound soils were analyzed and reported [2,5]. Nyamangara et al. [6] observed that organic fertilizers, such as anthill soil, buffer soils from acidification better than mineral fertilizers and suggested that farmers who use them would benefit from the potential hydrogen (pH) moderation effect, which, in turn, would ensure the availability of nutrients, such as phosphorous, that usually become locked up in acidic soils.

3.2. Effect of Anthill and Termite Mound Soils on Germination Indices of Eggplant and Okra

The seed germination of eggplant and okra was significantly ($p < 0.05$) affected by the soil treatments in this study. According to Table 2, the highest seed germinations (80.8% and 82.2%) were obtained with eggplant and okra sowed in ordinary top soil amended with anthill (AHS + TS) treatment compared to those treated with ordinary soil (TS) (control), which were the lowest (72.8%). Relative to the control, the second highest were those treated with termite mound soil alone (TMS) for eggplant (79.6%) and okra (81.7%), followed by those treated with anthill soil alone (AHS) (78.8%).

Similarly, the treatment also affected the germination index in this study. According to Table 2, the highest seed germination index was obtained with eggplant (4.9) and okra seeds (4.9) sowed in termite mound soil and ordinary top soil amended with anthill (AHS + TS) treatment compared to the control, which were the lowest (4.3 and 4.4, respectively). The smaller the GI value of seeds, the faster is their rate of germination [7]. Interestingly, seeds sown in an anthill mixed with ordinary soil (AHS + OS) showed the highest seed germination percentage (82.2%) but had the lowest germination rate of seeds (with highest GI value (4.93)). However, there was no significant differences in the GRI values among the treatments. Anthill soils in combination with top soil or termite mound soil significantly affected the germination indices of eggplant and okra. This finding is in line with reports that anthill soils are noted to have a wide range of microbes (bacteria) and nutrients that are known to enhance seed germination and plant growth [7,8]. In agreement with this view, Niranjan et al. [9] reported a positive influence of two strains of *Bacillus* on the germination and growth of pearl millet.

Table 2. Effect of anthill and termite mound soils on the germination indices of eggplant and okra.

	Germination Indices					
	Eggplant			Okra		
Treatment	G%	GI	GRI	G%	GI	GRI
Anthill Soil (AHS)	80.8a	4.7a	0.05a	78.8a	4.7b	0.05a
Termite Mound Soil (TMS)	79.6a	4.9a	0.05a	81.7a	4.9a	0.05a
Top Soil (TS)	72.8b	4.3b	0.01a	72.8b	4.4c	0.02a
Anthill + Top Soil (AHS + TS)	79.2a	4.9a	0.05a	82.2a	4.9a	0.05a
Termite Mound Soil + Top Soil (TMS + TS)	74.3b	4.4b	0.05a	74.3b	4.6b	0.05a
Anthill + Termite Mound Soil (AHS + TS)	72.1b	4.6ab	0.05a	76.2b	4.6b	0.05a
F-Statistics	2.266 *	1.456 *	0.0878 ^{ns}	2.2678 *	1.2678 *	0.0889 ^{ns}

Values (Mean) followed by similar letters in a column are not significantly different at * $p \leq 0.05$, and ^{ns} = not significant.

3.3. Effect of Anthill and Termite Mound Soils on Growth and Yield of Eggplant and Okra

According to the findings of this investigation, generally, it was observed that anthill and termite mound soils, either alone or in combination with top soil, significantly ($p < 0.05$) affected the measured growth parameters of eggplant and okra under screenhouse conditions. For example, eggplant and okra grown on top soil amended with anthill (AHS + TS) had taller plants (40.0 cm and 11.9 cm, respectively), thicker stem girth (3.09 cm and 2.29 cm, respectively), and a higher number of leaves (6.6 and 6.4, respectively) compared to the control (Figure 1).

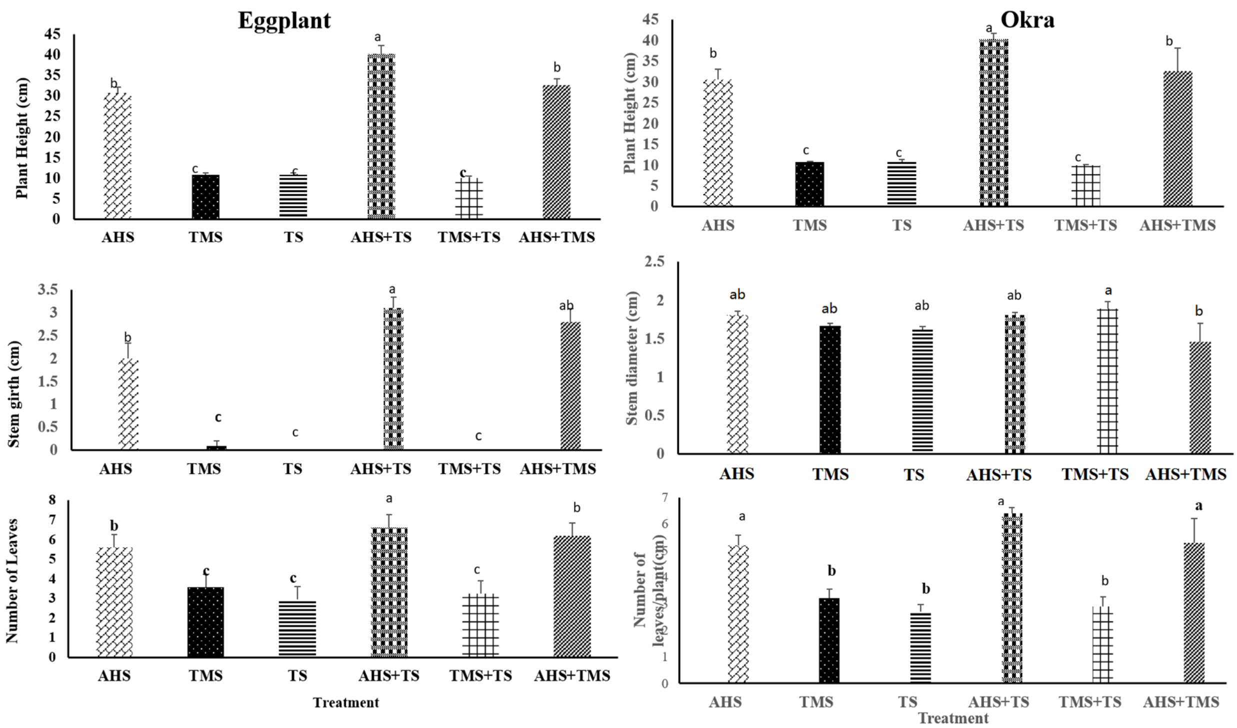

Figure 1. Effect of anthill soil and termite soil on measured growth parameters of eggplant (7 weeks) and okra (8 weeks). Values (Mean) followed by similar letters in a column are not significantly different at * $p \leq 0.05$.

In response to the treatments, above and below-ground biomass (fresh and dry weights) per plant were determined. Plants treated with anthill soil alone or in combination with termite mound soil and top soil recorded heavier fresh and dry whole plant and root weights for eggplant (50.2 g and 12.0 g, and 33.4 g and 20.1 g, respectively) and okra (50.5 g and 8.7 g, and 22.0 g and 8.7 g, respectively) compared to the control (14.6 g and 1.3 g, respectively) (Figure 2). These results seem to suggest that anthill and termite soils within and around the Moyamba district in southern Sierra Leone have the potential to enhance the growth of eggplant and okra. This finding is in agreement with reports that anthill soil has the potential to positively influence the growth and yield of plants [3,4,10].

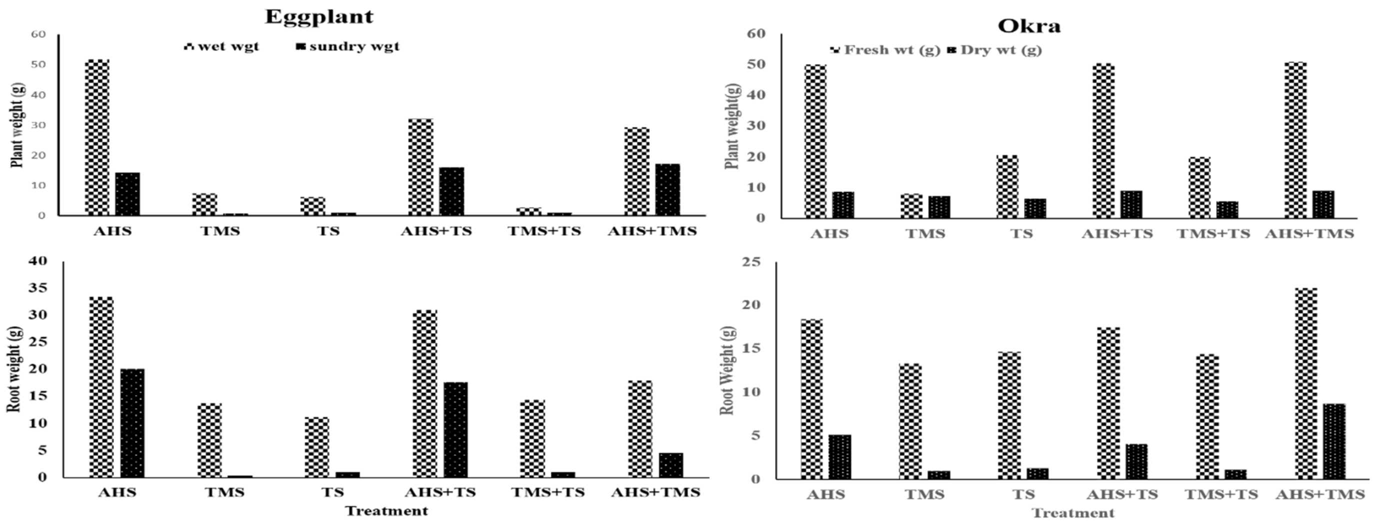

Figure 2. Effect of anthill and termite soils on the yield components of eggplant (7 weeks) and okra (8 weeks).

4. Conclusions

This study has shown that anthill soil and a mixture with either termite mound soil or top soil can have a significant effect on the germination, growth, and yield of eggplant and okra under screenhouse conditions. Anthill and termite mound soils within and around the Moyamba district in southern Sierra Leone can serve as a cheaper and environmentally-friendly alternative source of nutrients for improving crop yield and development, especially for resource-poor smallholder farmers.

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