Impact of Varied Compost Rates on Arbuscular Mycorhhiza Fungi in Rhizosphere Soils of *Capsicum chinense* (Habanero Pepper)

ABSTRACT

The population and diversity of soil organisms are important factors in maintaining soil fertility and quality. The aim of this study was to determine the impact of varied compost rates on Arbuscular Mycorrhiza Fungi, rhizosphere soils of Capiscum chinense. Soil samples were treated with various concentrations of compost (0 g, 200 g, 400 g, 600 g. 800 g and 1000 g). Systematic method of random sampling was used to collect soil samples from the rhizosphere of the various soils of different compost rates using a spade and hand trowel at a depth of 0-10cm. Results showed significant difference ($P<0.05$) in the Arbuscular Mycorrhiza Fungi (AMF) across all compost rates. AMF population ranged from 67 – 100 g/dwt respectively with the highest AMF population observed under 400 g(100 g/dwt, while the lowest AMF population was recorded under 600 g/dwt. Results for microbial diversity showed variation across all compost rates. A total of four AMF species were extracted from the rhizosphere of the soils. Acaulospora spp was the most predominant AMF in the studied soils. Highest microbial diversity was observed under the 1000 g. Conversely, lowest microbial diversity was found under 0 g compost rates. All six compost rates had effect on the AMF population but 1000 g exerted the most effect. These effects could be as a result of compost passive by-product of nutrient uptake, Root structure and soil organisms.

Introduction

Globally, and particularly in the tropics, agricultural land degradation is increasing. It is characterized as the temporary or permanent loss of soil productivity brought on by human-induced activities. (Mbagwu *et al.,* 2003). By strictly banning the use of synthetic fertilizers, compost is a cost-effective and sustainable method that lessens the harmful effects of chemical fertilization (Ye *et al*., 2020). Compost provides microorganisms with vital nutrients (Reeve *et al*., 2016). Compost has a lot of benefits for the soil which ranges from soil organic carbon enhancement, soil health improvement, high agronomic productivity (Hafifah *et al*., 2016), soil microbial biomass and activity enhancement.

Arbuscular mycorrhizae (AM) are symbiotic associations formed between terrestrial plant roots and soil fungi of glomeromycota (Smith and Read, 2008). In this symbiotic association, Arbuscular mycorrhizae fungi acts as an extension of root system and increase the surface area that is used for nutrient absorption (Smith and Read 2008). Arbuscular mycorrhNumerous advantages of compost for the soil include increased soil microbial biomass and activity, improved soil health, increased soil organic carbon, and high agronomic production (Hafifah et al., 2016).

According to Smith and Read (2008), arbuscular mycorrhizae (AM) are symbiotic relationships that develop between the roots of terrestrial plants and glomeromycota soil fungus. In this symbiotic association, Arbuscular mycorrhizae fungi act as an extension of root system and increase the surface area that is used for nutrient absorption (Smith and Read 2008). Plants and arbuscular mycorrhizae (AM) fungus develop symbiotic relationships that improve water and nutrient absorption (Smith & Read, 2008). The colonization and community structure of AM fungi can be greatly influenced by compost rates (Cozzolino *et al.*, 2015). According to research, while high compost rates can result in a reduction in soil microbial diversity, adequate compost rates can promote AM fungus colonization and plant growth (Cozzolino *et al*., 2015; Zhang et al., 2023). The process by which AMF create spores, known as sporulation, is essential to the survival and spread of AMF colonies. By offering a consistent supply of organic matter and nutrients—both essential for spore production—compost addition can promote sporulation (Smith & Read, 2008). This study therefore evaluates the impact of varied compost rates on Arbuscular Mycorhhiza Fungi in rhizosphere soils of *Capsicum chinense*.

Materials and Method

Description of Study Area

The study was conducted at the Department of Crop and Soil Science screen house, University of Port Harcourt, Abuja campus, between June and September 2024. The site is located between latitude 400° 31 N and 50° 00 N and longitude 6° 45 E and 70° 00 E. The map of the study locations is presented in Fig. 1.

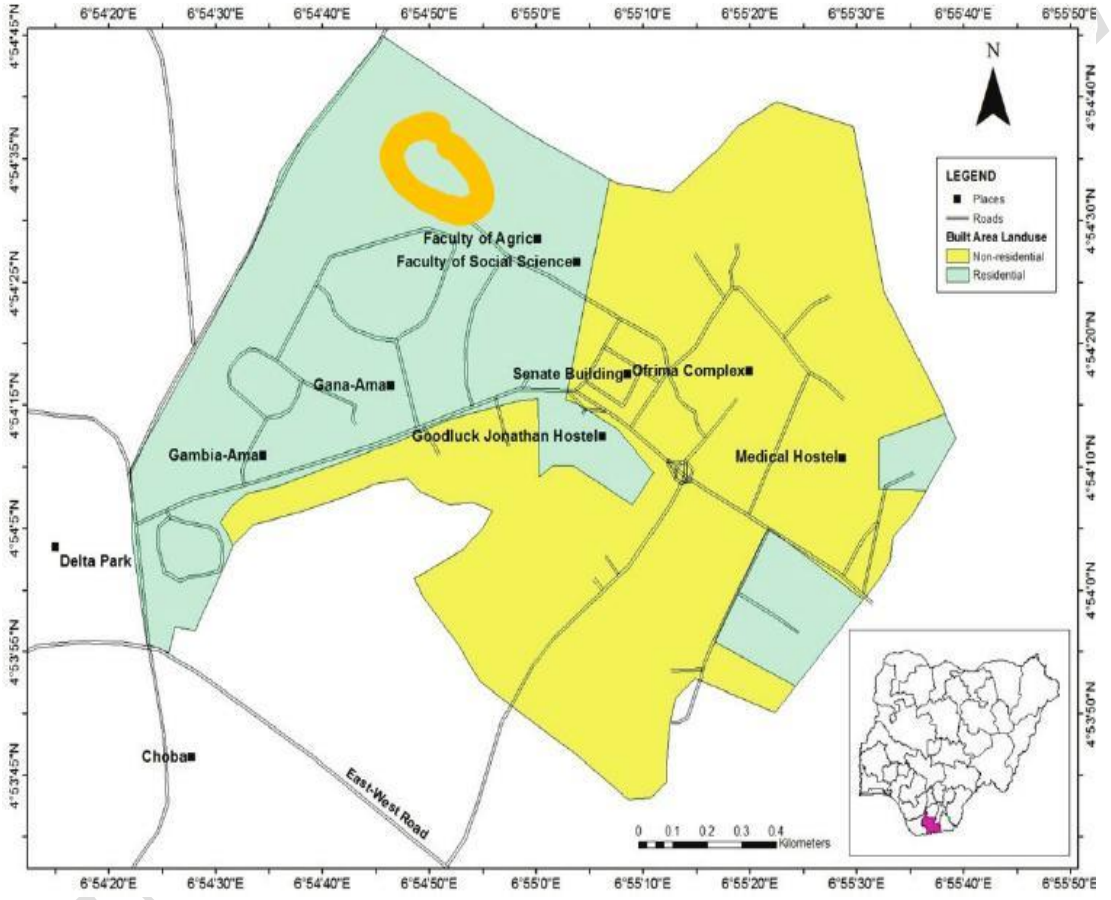


Fig. 1. Map of University of Port Harcourt (Coverage in Orange Circle)

Sample Collection

Soil samples and the compost soils were collected from the rhizosphere of *C. chinense* and transferred into different bags according to the following concentrations: 0 g (soil without any compost, i.e., the control), 200 g, 600 g, 800 g and 1000 g. The samples were collected using hand

trowel and hand glove at a depth of 0 to 10 cm. A total of 20 experimental samples including the initial soil and compost were collected, packaged in a well labelled polyethene bag and was transferred to the laboratory for mycorrhizal analysis. The experimental set-up is presented in Plate 1.

Plate 1: Experimental set-up of the Treatment

Extraction of AMF Spores

The AMF fungal spores were separated from the soil by wet sieving and decanting techniques as described by Gashua *et al.* (2015). Fifty grams (50 g) of rhizosphoheric soil samples was mixed in 200 ml of distilled water in a large beaker. After 1 hour, the content of the beaker was decanted

through sieves which were arranged in a descending order from 200µm to 25 µm size. The process was repeated thrice until the upper layer of the soil suspension was transparent. The retained material on the sieve was decanted into a beaker with a stream of water and estimation of spores was carried out by modified method of Gaur and Adholeya (1994)

Identification of Mycorrhiza Fungi

Identification of AMF spores was performed by morphological observation of colour, shape, size, hyphal attachment, spore ornamentation and spore reaction towards Miezers solution under a dissecting microscope (Schubler and walker 2010).

AMF Root Colonization

For the analysis of mycorrhiza colonization in the plants, the root samples were washed free of soil and cut into 1cm long bits, cleared in 2.5% KOH at 90ºc for 20 to 30 minutes, rinsed in water, acidified with 5N Hcl and stained in lacto phenol containing 0.05% tryphan blue (Phillips and Hayman 1970) 50 segments approximate stained root samples were mounted on slides and examined for AMF colonization under a compound microscopy at 10 x 10 magnification. Percent root colonization was calculated (Dhar and Mridha 2012). Percent root colonization was determined using the following formula; % root colonization= (Number of positive segments ÷ Number of segments observed) x 100.

Results

Results on the individual Arbuscular Mycorrhiza Fungi (AMF) species identified from the rhizosphere soils of *C. chinense* under the different compost rates are presented on Table 1. A total

of five AMF morphological types were identified belonging to five different genera; *Acaulospora, Rhizophagus, Gigaspora, Enthrophospora,* and *Funnelisformis*. *Acaulospora* was observed to have the highest population of AMF spores under all compost rates ranging from 33.00 – 45.00 g/dwt, except under the 600 g compost rate where *Rhizophagus* had the highest spore number of 53 g/dwt. *Gigaspora and Enthrophospora* were almost absent under all compost rates except under 0 g, 200 g, and 400 g, where 2 and 4 spores/100 g of soil was recorded respectively.

The mycorrhiza genera followed the order; *Acaulospora>Rhizophagus>Funnelisformis>Enthrophospora>Gigaspora* for spore abundance/100 g of soil respectively (Table 1).

Results of the total AMF population/spore numbers in the rhizosphere soils of *C. chinense* under the different compost rates are presented on Figure 1. AMF spore numbers ranged from 67.00 – 100.00 g/dwt under the different compost rates. The Highest spore number (100 g/dwt) was recorded under the 400 g compost rate, while 200 g had the lowest (67.00 g/dwt), 0 g, 600 g, and 800 g of compost were observed to have the same AMF population of 87.00 g/dwt. AMF spore numbers were significantly different ($P<0.05$) under the different compost rates and followed the order, 400 g> 0 g> 600 g and 800 g >1000 g >200 g respectively, (Table 1).

Results of the Total Root Count, Total Root Colonized and Percentage AMF colonization are presented on Table 2. The roots of *C. chinense* at 0 g, 200 g and 400 g compost rates were infected by mycorrhiza fungi hyphae with values of 10.00 and 11.00 respectively, while 800 g and 1000 g compost rates were not infected even though spores of some species were recorded to be present in their rhizosphere soils. Total number of roots ranged from 104 – 109, while the total root infected ranged from 0.00 – 11.00 and Percentage AMF colonization ranged from 0.00 – 10.24

under the various compost rates respectively. The highest % AMF colonization (10.24 %) was observed in soils with 400 g followed by 200 g with a value of 9.18 %, then 0 g at 8.41 %.

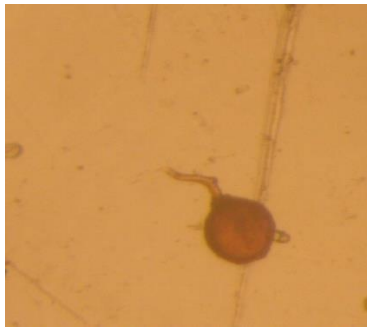
Table 1: Arbuscular Mycorhhiza Fungi Population/ Spores Numbers

Treatment	Acaulospora spp	Rhizophagus spp	Enthrophospora spp	Funneliformis spp	Gigaspora spp	Spores g/dwt
0 g	43.00c	25.00c	3.00b	19.00d	0.00a	87.00c
200 g	33.00a	20.00a	5.00c	12.00a	0.00a	67.00a
400 g	45.00d	23.00b	0.00a	17.00c	4.00b	100.00c
600 g	32.00a	53.00e	0.00a	17.00c	0.00a	87.00d
800 g	42.00c	24.00bc	0.00a	22.00e	0.00a	87.00c
1000 g	37.67b	28.00d	0.00a	14.00b	0.00a	78.00b

Means with the same letters were not significantly different at $p<0.05$

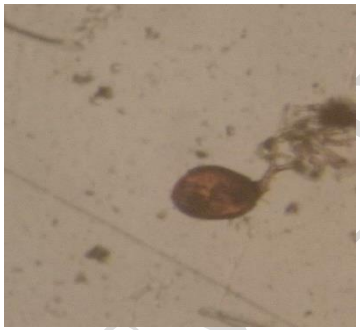
The five AMF morphological types of five different genera; *Acaulospora, Rhizophagus, Gigaspora, Enthrophospora*, and *Funnelisformis* is presented in Plate 2.

Soils with compost rates of 600 g 800 g and 1000 g recorded no AMF colonization. The % AMF colonization followed the order 400 g>200 g>0 g>600 g, 800g and 1000 g under the various compost rates respectively (Fig. 2).



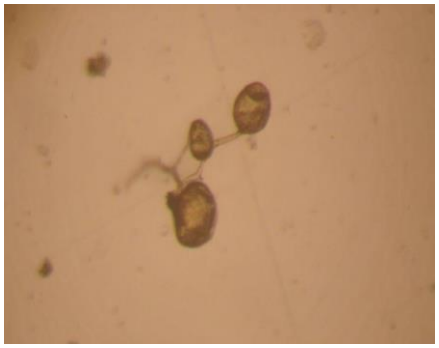
Acaulospora spp

Enthrophospora spp

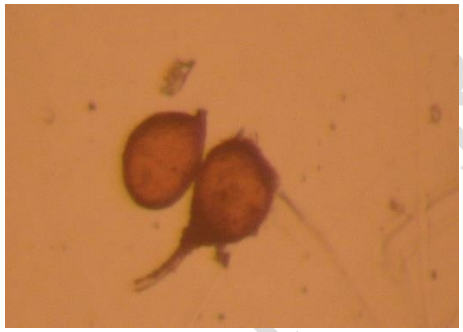


Funnelisformis spp

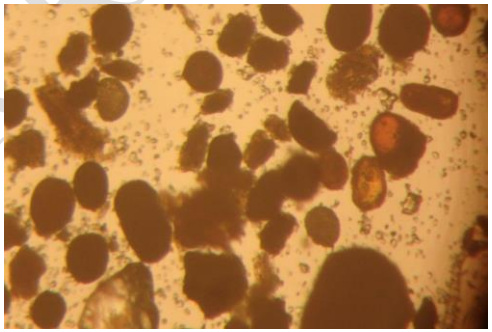
Scutelospora spp



Gigaspora spp



Rhizospora spp



AMF Spores

Plate 2: AMF Species Identified Under the Different Compost Ra

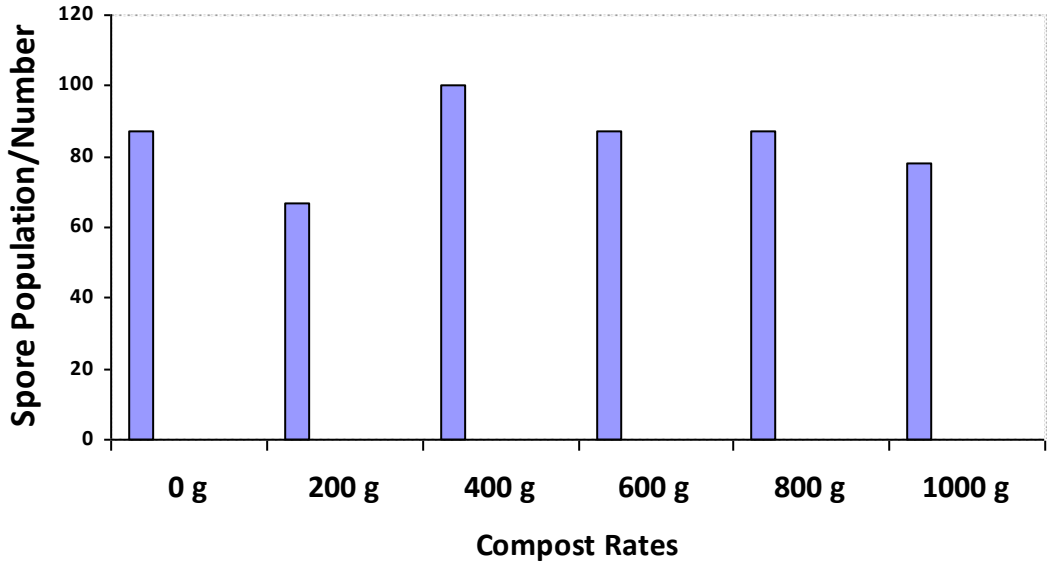


Fig. 2: AMF spore Numbers under the different compost rates

Table 2: Root Colonization of Arbuscular Mycorrhiza Fungi

Treatment	Total root count	Total root infected	% AMF
0 g	104.00a	10.00b	8.41b
200 g	109.00cb	10.00b	9.18b
400 g	107.00b	11.00b	10.24c
600 g	1O9.00c	0.00a	0.00a
800 g	1O8.00bc	0.00a	0.00a
1000 g	104.00a	0.00a	0.00a

Means with the same letters were not significantly different at p<0.05

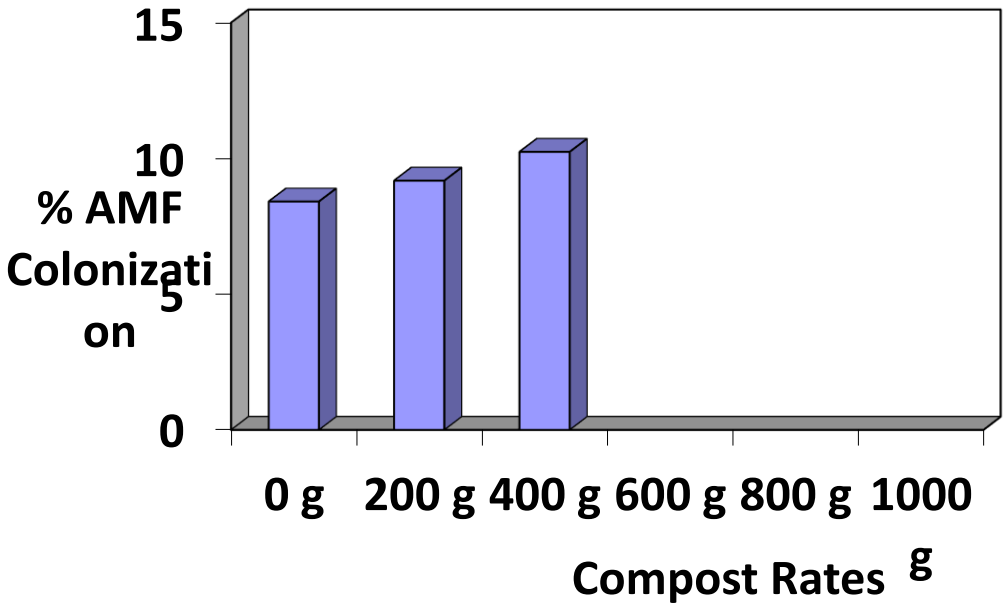


Fig. 3: Percentage (%) AMF Colonization

Discussion

The arbuscular mycorrhizal fungi (AMF) spore population in soil is 6 spores per gram of dry weight, whereas compost has no detectable AMF spores. This indicates that soil has a higher potential for mycorrhizal colonization, which is further supported by the percentage of AMF colonization: 57.55% in soil compared to 0% in compost. Mycorrhizal fungi play a crucial role in enhancing plant nutrient uptake, particularly phosphorus (Smith & Read, 2008). From the results, there were variations in the AMF population and spore numbers across the various compost rates, this could be as a result of the randomization of the pots in the screen house environment as reported by (CIRID, 2012), who observed that number of AMF spores increased significantly when in a cool environment. AMF spore numbers were recorded in the following order under

various compost rates; 400 g>0 g, 600 g and 800 g>1000 g>200 g, this is in agreement with findings by Hindumathi and Reddy (2011) who reported a significantly varying population of AMF spores under different compost rates. The stimulation and germination of Mycorrhiza spores and increase in infection percentage could be attributed to the compost rates and general soil environment. 200 g compost rates recorded a low population of spore compared with 400 g which recorded the highest, the reason could be as a result of the differences in the compost rates, nature of *C. chinense* crop and positioning within the screen house; causing the soil around the rhizosphere to be exposed to sun rays, thereby leading to dryer soils compared to other pots inside the screen house placed away from sun rays, such dry soils reduces the effectiveness and population of AMF spores as observed by Yang *et al*., (2016)

The diversity of AMF within roots of *C. chinense* may be affected by physiological conditions in the environment. It was observed that under all compost rates, *Acaulospora* was the most occurring, it had high values compared to others, this may be related to their smaller spore size, which allows them to easily produce more spores in a short period of time, this is in agreement with Zhao *et al.,* (2003). *Acaulospora* and *Rhizophagus* were the most predominant AMF genera in the study, this is in agreement with previous studies by Snoeck *et al.,* (2010) who stated that, *Acaulospora* and *Rhizophagus* species are widely distributed regardless of the type and intensity of disturbance in different positions of the environment. Whereas, *Acaulospora* is reported to be dominant in least disturbed environments such as screen houses. Gracias (2005) assessed the AM fungal diversity in various plants and tree species from India and reported a rich diversity of AMF species in plant and trees generally, this indicates that these fungi play a vital role in the growth and survival of plants species. The diversity of species concept is difficult to apply in AMF, which

are poorly differentiated morphologically and mainly characterized by environmental sequence (Bruns *et al.,* 2018)

The present study showed that not all compost rates studied were colonized by Arbuscular Mycorrhiza Fungi. However, the AMF colonization status varied significantly depending on the rate of compost applied which is consistent with the results of studies on AMF of various compost rates when compared by Dhar *et al.,* (2012). It was observed that 400 g compost rate had the highest percentage of AMF colonization and this could be as a result of better nutrient uptake especially the less mobile element, improved N-nutrient due to synergetic interaction among AMF spores, and better adaptation to both biotic and abiotic stress and also because of its numerous spreading branches, which allows water and nutrient absorption. This is in agreement with results reported by Cavagnero *et al.* (2017), who stated that root colonization with AMF has the potential to enhance *C. chinense* uptake of relative immobile nutrients. The 400 g, 200 g, and 0 g had a good mycotrophic status and Arbuscular Mycorrhiza Fungi were colonized in their roots, this is in agreement with the report by Terrer *et al.,* (2019), who stated that the main function of AMF is to enhance the nutrient uptake of elements like K, Ca, Mg, and CEC by host plants, improving the nutrient level and promoting plant growth. Roots of *C. chinense* at 600 g, 800 g, and 1000 g compost rates were observed to have 0.00 % AMF colonization, this could be as a result of insufficient compatibility, host plant resistance, competition from other microorganisms and environmental conditions (Smith & Read 2008, Brundett *et al.,* 2009) Similar variations in AMF colonization have also been found in other type of plants Cong *et al.,* (2010).

Conclusion

In conclusion, the present study has shown that varying compost rates have a profound impact on the abundance and activity of arbuscular mycorrhizal fungi. More so, higher compost rates were associated with increased AMF diversity and improved soil structure, which in turn could promote better growth and yield of *C. chinense*. Specifically, the study found that moderate to high compost rates significantly enhanced AMF colonization and sporulation, which could lead to improved nutrient uptake and plant growth.

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