

# Diversity of Arbuscular mycorrhizal fungi in University of Port Harcourt, Port Harcourt in Southern Nigeria

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**Abstract:** Arbuscular mycorrhiza fungi (AMF) are important obligate symbionts in majority of cultivated plant species in colonizing roots and supporting plant growth. This study was carried out to identify and characterize indigenous arbuscular mycorrhizal fungal spores in selected farms behind the Faculty of Agriculture, University of Port Harcourt, Port Harcourt in southern Nigeria. Three crops (cassava, maize, fluted pumpkin and Amaranth as Control) were selected for this study. Rhizosphere soil and root sub-samples were collected per crop from topsoil (0 – 15 cm) and subsoil (15 – 30 cm). The samples collected were prepared and subjected to various analysis to determine the soil physicochemical properties. Wet sieving and decanting method was employed for extraction of AM fungal spores while slide method was used for estimation of degree of colonization. Taxonomic identification of spores was also carried out by matching the descriptions provided by International Collection of Vesicular AM fungi (INVAM). Data were subjected to analysis of variance (ANOVA) using XLSTAT 2022 version package. Ecological Indices such as Isolation Frequency, Relative Spore Density, Shannon-Weaver Index of Diversity and Simpson's Dominance Index were calculated. The result showed that six genera were identified as follows: *Glomus*, *Acaulospora*, *Gigaspora*, *Entrophospora*, *Diversispora* and *Scutteslopora*. The Soil pH of the entire study area ranged between 5.93 - 6.35 which falls within the suitable pH range for AMF distribution. The exchangeable cations, soil pH, available phosphorus, potassium, clay content; were among the main factors responsible for the variation in AMF community structure. The percentage root colonization among the crops ranged as follows: maize (51.94 percentage), cassava (48.46 percentage), fluted pumpkin (42.93 percentage) and control (15.63 percentage) which implies maize and cassava were more mycotropic and will respond to mycorrhizal inocula than fluted pumpkin. Generally, the root mycorrhizal colonization degree and spore density were significantly higher ( $P \leq 0.05$ ) in topsoil than subsoil across all identified genera. Both *Glomus* with isolation frequency (IF) of 66.76 and *Acaulospora* (IF = 53.87) were classified as dominant genera; *Gigaspora* (IF = 38.96), *Entrophospora* (IF = 39.57), *Scutteslopora* (IF = 34.87) were classified as common genera while *Diversispora* was a rare genus (IF = 2.78). The superiority of *Glomus* in soils may be related to its functional relevance and ease of propagation in soil ecosystem. AMF source of biofertilizer could be adopted as alternative source of soil amendment for cultivation of crops especially maize, cassava and fluted pumpkin which are staple food in the sampled location.

**Keywords:** Mycorrhiza, fungi, isolation frequency, spore density, colonization

## INTRODUCTION

Soil is an important natural resource for agriculture and industrial development of a nation. The importance of soil is seen in human, plants and animals. Due to several anthropogenic and natural factors, the soil may become degraded and its' productivity consequently lowered (Bhardwaj *et al.*, 2014). Soil management for improved agricultural

productivity is an integral part of land management which may focus on differences in soil types and soil characteristics to define specific interventions aimed at enhancing soil quality. In Port Harcourt city of Nigeria, most farmers make use of organic and inorganic fertilizers in order to enhance good crop and soil productivity. Continuous usage of inorganic fertilizer can lead to ground water pollution which cause eutrophication of water bodies because they are often leached from the soil quickly (Akpan *et al.*, 2020). Inorganic fertilizer contain salt which can lead to soil acidity thereby causing harmful effect of plants while the organic fertilizer takes longer time to show results in plant during their developmental stage. Organic fertilizer is also more expensive than inorganic fertilizer. It is in this regard that effort have been channelized towards the production of high-quality crops in sustainable manner without causing damage to the environment through agricultural practices in form of application of Arbuscular mycorrhizal fungal (AMF) which are eco-friendly, encourage plant growth and promote overall wellbeing of microbial community.

Arbuscular mycorrhizal fungi (AMF) belong to glomeromycota phylum/division, from the kingdom of fungi. AMF are obligate endophytic symbionts forming an association with a wide variety of host plants. In the association, the plant provides an ecological niche and carbohydrate to the fungus while the fungi improve plant growth and yield through enhanced mineral uptake. It implies that AMF is a good alternative as natural Soil amendment without deleterious effect unlike the inorganic fertilizer. Unfortunately, there is dearth of information on identification and characterization of indigenous arbuscular mycorrhizae in University of Port Harcourt Park. Therefore, the objective of this is study is to identify and characterize the AMF in soils of the study area whose outcome will serve as

a recommendation tool for peasant farmers on crop adaptability and performance based on the type and availability of indigenous AMF in such region.

## MATERIAL AND METHODS

The experiment was conducted at the selected farms behind Department of Crop and Soil Science, University of Port Harcourt which is located at Latitude 4°54N and longitude 06°55E with an average temperature of 27 °C, relative humidity of 78 % but decreases slightly in dry season and an average rainfall ranging from 2500 mm – 4000 mm per annum (Atijegbe *et al.*, 2013)

The area has a biomass rainfall pattern with a long rainfall season between March and July and a short rainy season from September to early July after a short spell in August and a longer period from December to February (Akande *et al.*, 2010).

## SAMPLE COLLECTION

Three test crops which include Cassava, Maize, Fluted Fluted Pumpkin and Amaranth (Control) were selected for the study. Three healthy plants were randomly sampled per crop. Three sub-samples were collected per variety on each spot in the farm. The choice of wild Amaranth as Control was based on the work of Hirsch and Kapulnik (1998) who reported that members of the Cyperaceae, along with Brassi-caceae, Caryophyllaceae, Juncaceae and Amaranthaceae, are assumed to lack mycorrhizal association or it is found only very rarely. While sampling, care was taken to trace the crop roots, which were identified by its white colour and distinct phenolic odor emitted upon crushing. Per crop, approximately 1 kg of soil (including roots) were collected from depth of 0 – 15 cm depth for topsoil and 15 – 30 cm depth for subsoil respectively.

There were four sampling points in each field. At each sampling point, four 250 g sub-samples were collected within about 5 m<sup>2</sup>

each, mixed and pooled to produce composite soil sample. In each Location, three spots were sampled; both root and soil samples were collected and composite samples were obtained after thorough mixing for analysis. The samples were packed in polyethylene bags, labeled and brought to the laboratory. Root samples were freshly processed whereas soil samples were stored at 4 °C until analyzed. The uncultivated soil samples were collected as control for each sampled location. 100 g air-dried soil was employed for extraction of AM fungal spores while 250 g was utilized for nutrient analysis.

### SOIL ANALYSIS

Routine soil analysis was carried out as follows: Particle size distribution by hydrometer method as modified by Udo *et al.*, (2009). Soil pH was determined in 1:1 (soil: water) ratio using a glass electrode pH meter. Total Nitrogen by Kjeldahl digester method (IITA, 1979). Organic matter by the wet oxidation methods of Walkey and Black as outlined by Nelson and Somers, (1982). Available Phosphorus by Bray No 1 method (Bray and Kurtz, 1945). Exchangeable bases Ca, Mg, K and Na were leached from the soil sample using  $\text{NH}_4\text{O}_4$  buffered at pH 7.0. The exchangeable Na and K contents in the extracts were determined using the atomic absorption spectrophotometer (Chapman, 1965). Exchangeable acidity ( $\text{Al}^{3+}$  and  $\text{H}^+$ ) by method of IITA (1979). Effective Cation Exchangeable Capacity by summing up the exchangeable bases and exchangeable  $\text{Al}^{3+}$  as outlined by Udo *et al.*, (2009)

### PROCESSING OF ROOTS AND ESTIMATION OF ROOT COLONIZATION (RC)

Roots were cleared and stained according to method provided by Phillips and Hayman (1970). Hundred root segments for each sample were randomly selected for microscopic observation and estimation of the degree

of colonization was carried out using slide method (Giovannetti and Mosse, 1980). Total root colonization by AM fungi was expressed in percent.

### EXTRACTION, QUANTIFICATION AND IDENTIFICATION OF AM FUNGI

Wet sieving and decanting method (Brundrett *et al.*, 1994) was employed for extraction of AM fungal spores and sporocarps from the rhizosphere soil sampled while the Separation of AMF spores into morphological groupings after extraction from soil was done as described by Brundrett *et al.*, (1994).

### SPORE DENSITY QUANTIFICATION

Spore density of AM fungi was quantified using Gaur and Adholeya (1994) method. Spore density was expressed as total number of spores recorded/100g rhizosphere soil. Taxonomic identification of spores was also carried out by matching the descriptions provided by International Collection of Vesicular AM fungi (<http://invam.caf.wvu.edu>).

### ECOLOGICAL AMF DIVERSITY INDICES

To determine differences in the structure of the AMF communities on different crops, the following parameters were calculated: The Isolation Frequency (IF) of occurrence was calculated as the percentage of samples in which a genus or species occurred among all samples and it reflects the distribution status. Relative Density (RD) was defined as the ratio between the spore densities of a particular genus or specie to the total AMF spore densities and it shows the degree of sporulation ability of different AMF in a given soil. The important Value (IV) was used to evaluate the dominance of the AMF species based on IF and RD and was calculated as  $\text{IV} = (\text{IF} + \text{RD})/2$ . An  $\text{IV} \geq 50\%$  indicates that a genus or species is dominant;  $10\% < \text{IV} < 50\%$  applies to common genera or species; an  $\text{IV} \leq 10\%$  indicates that a genus or

species is rare (Chen *et al.*, 2012). The Shannon-Weaver index ( $H'$ ) of diversity was calculated with the formula:  $-\sum [(n_i/n) \ln (n_i/n)]$ , where  $n_i$  is the number of individuals of species of  $i$  and  $n$  is the number of all individuals of all species. Simpson's dominance index ( $D$ ) was calculated with the formula  $D = \sum [(n_i/n)^2]$

## STATISTICAL ANALYSIS

Statistically, the data obtained were subjected to analysis of variance (ANOVA) using XLSTAT 2022 version package and means were separated using Duncan Multiple Range test (DMRT) at 5 % probability level.

## RESULTS AND DISCUSSION

### Spore Density of Arbuscular mycorrhizal fungi

The spore density (SD) of the identified genera is presented in Table 1. A total of six genera were identified and isolated in this study, namely: *Acaulospora*, *Diversispora*, *Entrophospora*, *Gigaspora*, *Glomus* and *Scutelospora*. The present results with respect to quantitative distribution of AM fungi spore of various studied sites showed a great deal of variations [*Diversispora* (0.00) *Glomus* Maize topsoil (30.04)]. The results of this study are favoured by the findings of Anwar and Jalaluddin, (1993) who reported that variations in the quantitative distribution may be due to the different soil physico-chemical condition such as pH, texture and mineral nutrients. Similarly, several scientists from different countries including Australia, New Zealand (Mosse and Bowen, 1984) Scotland (Daft and Nicolson, 1974), Pakistan (Sharief *et al.*, 2005; Nasrullah *et al.*, 2010) have confirmed that AM fungi spore vary considerably from place to place according to physical and chemical nature of the soil.

Generally, the topsoil of maize (30.04) and cassava (18.83) recorded the highest SD which is significantly higher than the rest SD values

among the sampled crops. The anatomical differences in root structure may influence AMF development and be responsible for the differences observed in RC percentages especially as maize recorded the highest average RC among the sampled crops. This is in tandem with the findings of Brundrett and Kendrick (1990) who reported that characteristics of root surface besides the anatomical structure of the roots may also influence the early stages of the plant-fungus interaction.

### Percentage Colonization of identified Genera (% RC)

In the present investigations, the extent of root colonization varied among the sampled crops from *Diversispora* (0.00 %) to *Glomus* (51.94 %) as presented in table 2. Those variations may be attributed to the differential preference of the AM fungi to various species as reported by Khade and Rodrigues (2009). The percentage colonization of identified genera is presented in Table 2. *Acaulospora* recorded the highest % RC in topsoil of maize (41.63), followed by topsoil of cassava (37.46) and its least value in subsoil of Control (6.48). *Gigaspora* recorded highest % RC in topsoil of maize (32.63) followed by % RC of topsoil of cassava. This result indicates that both the maize and cassava are more dependant on the AM fungi associations compared with fluted pumpkin and the control. This observation agrees with findings of Bennie (1996) who reported that maize and cassava have greater ability for nutrient absorption, to attend to the nutrient needed for plant growth. Characteristics of root surface besides the anatomical structure of the roots may also influence the early stages of the plant-fungus interaction (Brundrett and Kendrick, 1990). The anatomical differences in root structure may influence AMF development and be responsible for the differences observed in RC percentages especially as maize recorded the highest average RC among the sampled crops.

**Table 1: Spore Density of identified Genera**

Crop	Depth	<i>Acaulospora</i>	<i>Diversispora</i>	<i>Entrophospora</i>	<i>Gigaspora</i>	<i>Glomus</i>	<i>Scutelospora</i>
Fluted Pumpkin	Top	8.833c	0.00c	4.07d	13.22d	11.13f	9.82b
	Sub	11.52b	0.00c	7.00b	9.19e	14.17e	7.24c
Maize	Top	21.09a	0.00c	6.94b	24.65a	30.04a	18.13a
	Sub	8.74c	0.00c	5.65c	16.37c	23.69b	17.50a
Cassava	Top	19.80a	0.00c	8.78a	18.83b	21.89c	9.35b
	Sub	12.72b	0.00c	3.35e	9.20e	17.78d	6.61c
Control	Top	7.57d	1.11a	2.33f	11.50d	17.17d	6.56c
	Sub	6.26d	1.67a	1.74f	3.28f	8.43g	4.35d

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

**Table 2: Percentage colonization of identified Genera**

Crop	Depth	<i>Acaulospora</i>	<i>Diversispora</i>	<i>Entrophospora</i>	<i>Gigaspora</i>	<i>Glomus</i>	<i>Scutelospora</i>
Fluted Pumpkin	Top	24.94d	0c	16.48c	26.27c	42.93d	22.13 c
	Sub	18.50e	0c	12.00d	6.48e	29.89f	20.07d
Maize	Top	41.63a	0c	35.33a	32.63a	51.94a	27.32a
	Sub	24.85d	0c	24.98b	8.037	38.13e	24.32b
Cassava	Top	37.46b	0c	35.72a	30.22b	48.46b	15.00e
	Sub	31.31c	0c	16.82c	8.26d	45.83c	13.33e
Control	Top	8.70f	2.72a	8.20e	10.69d	15.63g	6.48f
	Sub	6.48f	2.63a	5.02f	9.74d	5.44h	4.87g

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

All the % RC of the sampled genera were significantly higher than the Control % RC value (5.02). This observation is in tandem with the findings of Gupta *et al.*, (2002) who reported increased percentage of root colonization in plants inoculated with AMF compared with respective controls of non-inoculated plants.

Ecological Indices for the identified Genera Ecological indices is presented in Table 3 below.

### Isolation frequency (IF)

The range of Isolation frequency which reflects the distribution status of the identified organism recorded its highest value in *Glomus* (66.76), followed by *Acaulospora* (53.52), *Gigaspora* (38.96), *Entrophospora* (39.57), *Scutelospora* (34.87) and *Diversispora* (2.78).

The Dominance of *Glomus* as observed in the present study is in agreement with

the findings of many other workers Bi *et al.*, (2019) and Xu *et al.*, (2017) who reported that *Glomus* was dominant genus across the entire their sampled locations. The predominance of *Glomus spp.* under varying soil conditions might be due to the fact that they are widely adaptable to the varied soil conditions and survive in acidic as well as in alkaline soils (Pande and Tarafdar, 2004). Previous reports have shown that the dominant AMF species will continue to maintain its leading position across a continuous gradient from open sand prairie to closed oak-hickory forest (Benjamin *et al.*, 1989). The superiority of *Glomus* in soils may be related to its functional relevance, host-specificity preference, adaptation, and ease of propagation in the soil ecosystem (Cui *et al.*, 2016; Wang *et al.*, 2019). In fact, *Glomus* is the most common and largest genus within the phylum Glomeromycota (Rodrigues *et al.*, 2020).

### Important Value (IV)

The result of the Important Value in the study area implies that *Glomus* (50.98), was classified as dominant genus (IV > 50 %), *Gigaspora* (30.83), *Scutellospora* (25.99), *Acaulospora* (36.81), and *Entrophospora* (24.09) were all classified as Common genera due their range (IV < 50 %) while *Diversispora* (2.54) was classified as rare genera due their range (IV < 10 %) as described by Chen *et al.*, 2012.

With respect to crop types, the genera *Glomus*, *Giaspora*, *Scutellospora*, *Aculospora* and *Entrophospora* were encountered in almost all the crops. However, the genus *Diversispora* was recovered only in Control. This observation of *Diversispora* recorded only in Amaranth is in agreement with the findings of Tilla *et al.*, (2014) who reported that *Diversispora* was recovered only in Sorghum among the various assessed crops. Similar results were found by Radhika and Rodrigues (2010) in samples of soils cultivated with thirty-six medicinal plant species. However, the great diversity of AMF found in this study indicates that the plants studied form a symbiotic-mandatory association with the AMF, regardless of the period analyzed.

### Mycorrhizal Relative Density

The Relative Density which reflects the degree of sporulation ability of different AMF in a given soil, recorded the highest value in *Glomus* (35.2 %), followed by *Gigaspora* (22.7 %), *Acaulospora* (20.1 %), *Scutellospora* (17.1 %), *Entrophospora* (8.6 %) and *Diversispora* (2.3%)

Table 3: Ecological Indices of the Study Area

AMF GENERA	IF	RD (%)	IV	H'	D
<i>Glomus</i>	66.76	35.2	50.98	0.355	0.075
<i>Gigaspora</i>	38.96	22.7	30.83	0.328	0.044
<i>Scutellospora</i>	34.87	17.1	25.99	0.288	0.024
<i>Acaulospora</i>	53.52	20.1	36.81	0.312	0.034
<i>Diversispora</i>	2.78	2.3	2.54	0.026	0.000
<i>Entrophospora</i>	39.96	8.6	24.09	0.184	0.005

IF= Isolation Frequency, RD = Relative Spore Density, IV = Important Value, H' = Shannon-Weaver Index of Diversity, D = Simpson's Dominance Index, AMF = Arbuscular Mycorrhizal Fungi.

### Physicochemical properties of Soil

The clay content was highest in Control (9.965) followed by that of fluted pumpkin (8.111) and then maize (4.665) and cassava (5.687). The clay value for control is significantly higher than that of fluted pumpkin which is also higher than those of cassava and maize respectively. However, there is no significant different in clay value of maize and that of cassava. It was observed in the results of the study that sandy soil stimulated the development of mycorrhizal association while clayey soil inhibited it. The good soil aeration is a prerequisite for optimum AMF development (Saif, 1981). This observation is in tandem with the findings of Sylvia and Williams (1992) who reported that sandy soils are usually more porous, warmer, drier, and less fertile than those of a finer texture and these conditions have direct and indirect effects on AM fungi. In general, clayey soils are more fertile than sandy soil because clay has a higher capacity for adsorbing ions from the soil solution (Malavolta, 1980). In this study high cationic exchange capacity was observed in the clayey soil and this greater nutrient concentration could have limited AMF development, as shown in several studies (Weissenhorn and Leyval 1996; Eason *et al.*, 1999). Additionally, the mechanical impediment, caused by a finer soil texture, favors the deposition of suberin on the epidermis (Wilson and Robards, 1978), which increases resistance to infection by AM fungi (Koske and Gemma, 1995). With reduced space between the soil particles, mechanical stress on the roots is increased, so that breakage of the cortical layers is increased and the colonization sites are lost. This could have reduced the dependence of the host plants on the mycorrhiza.

As evident from the results, the soil pH of studied sites is slightly acidic (5.93 - 6.35) among all three sampled locations which falls within the suitable pH range for AM fungi distribution. This favours the findings of Kamal

and Prasad, (1995) who reported that the optimum pH for spore germination is between slightly acidic (5.5 - 6.5) to alkaline (8.6) which is suitable for AMF spore population.

It has been reported by Porter and Robson, (1987) also that soil pH is a major determinant of the distribution of AM fungal spores. The varying soil pH may affect the development and functioning of AM by altering the concentration of many nutrients and toxic ions in soil solutions as well as hydrogen ions (Muthukumar *et al.*, 1994). This can be explained by the fact that *Glomus* which dominated the study area prefers slightly acidic or neutral soil pH (Da Silva *et al.*, 2004) and this preference might be explained by the generally slightly soil pH in the study area as aforementioned which often leads to AM fungi communities being dominated by *Glomeraceae* species (Wang *et al.*, 2019). The Scholars, Guo and Gong (2014) also observed soil pH as the principal factor in shaping the AM fungi composition in a salt-stressed ecosystem because soil pH affected spore germination and hyphal growth (Gai *et al.*, 2004). The available phosphorus recorded highest value in maize (11.750), followed by cassava (11.368), fluted pumpkin (11.255) while the Control (11.090) had the least value. All the values of Phosphorus were significantly higher as arranged above. Significant differences in the community structure of soil AMF were observed between the various plants Phosphorus and Control. This supports the findings of some scholars who reported that Phosphorus under low phosphorus nutrition, low P content of plants could correlate with a decrease in phospholipids levels; and increase in root member permeability would favors mycorrhizal infection (Graham *et al.*, 1981).

The Al<sup>3+</sup> in the study area varied as follows: 0.192 cmolkg<sup>-1</sup> (Cassava) to 0.661 cmolkg<sup>-1</sup> (Control). This implies that there was a variation of Al<sup>3+</sup> among the various evaluated crops. The variation is in agreement with the findings of Fageria and Baligar, (2008)

Table 4: Soil properties of the Study area

ID	Sand	Clay	Silt	pH	Av.P	TN	OC	K	Na	Mg	Ca	CEC	Al <sup>3+</sup>	H+	ECEC	BS
Crop																
C1	86.317 a	8.111 b	7.643 b	6.35a	11.255c	0.135a	1.330 a	0.292a	0.488 a	1.836 a	3.894 a	6.514a	0.196b	0.959a	7.669 a	85.084a
C2	87.589 a	4.665 c	8.007 b	6.24a	11.750a	0.134a	1.071 b	0.239b	0.415 b	1.594 b	4.099 a	6.274b	0.358b	0.951a	7.583 a	81.136b
C3	81.426 b	5.687 c	7.304 b	6.20a	11.368b	0.122b	1.013 bc	0.300a	0.531 a	1.941 a	3.896 a	6.638a	0.192b	0.991a	7.821 a	84.396a
C4	82.787 b	9.965 a	10.611a	5.93b	11.090d	0.116b	0.946 c	0.261ab	0.386 b	1.904 a	4.022 a	6.474ab	0.661a	0.756b	7.891 a	82.762b
Soil Depth																
D1	85.541 a	7.633 a	8.195 a	6.23a	11.599a	0.127a	1.099 a	0.291a	0.478 a	1.768 a	4.034 a	6.511a	0.405a	0.991a	7.801 a	82.286a
D2	83.519 b	6.581 b	8.587 a	6.13a	11.132a	0.127a	1.081 a	0.256b	0.432 a	1.869 a	3.921 a	6.439b	0.299b	0.837b	7.681 a	84.286b

Means followed by the same letter within a column are significantly different according to Duncan's New Range Test at 5% probability level. Soil, ID = Identity, D1 = Topsoil, D2 = Subsoil, C1 = Fluted pumpkin, C2 = maize, C3 = Cassava, C4.

who reported that the degree of toxicity by  $Al^{3+}$  varies widely depending on the species of grasses, growth conditions, Al concentrations and exposure time (Fageria and Baligar, 2008). Another explanation is that AM fungi is more sensitive to all the changes that take place in the legume-grass mycorrhizosphere as production of exudates and pH changes, which lead to Al chelation and retention, favoring mycorrhizal crops (especially maize and cassava) more than fluted pumpkin and control.

### Effect of Soil Depth on AM Fungi Population

The present study revealed sudden decrease in AMF spore counts with depth due to the loamy sand texture which reflects the occurrence of spore density. So, soil texture is an important characteristic for the occurrence and colonization of AM fungi spore density. In this study, root mycorrhizal colonization degree and spore density were significantly higher in the topsoil (0 - 15 cm) soil than in the subsoil (15 - 30 cm) across all the identified genera. Similar results were earlier obtained by Wu *et al.*, (2012) in the rhizosphere of Citrus unshiu. Such differences are accountable to the fact that AMF are aerobic fungi and the surface soil possesses higher capacity of air exchange than sub-surface soil (Wu *et al.*, 2014). This decline was attributed to a reduction in oxygen availability with depth as evidenced by decreasing redox potential which is not suitable for the viable VAM spore germination and growth, thus, registering higher AMF diversity of surface soil versus sub-surface soil. The possible factors behind depleted propagule density may be, the low soil fertility, organic matter, soil texture, soil moisture and severe soil compaction.

### CONCLUSION

In conclusion, the results of the study revealed that AMF abundance and diversity were high in the area studied. *Acaulospora*, *Gigaspora*, *Entrophospora*, *Scuttelospora* were classified as

common genera, *Glomus* as a dominant genus and *Diversispora* as a rare genus. Also, it was observed that *Glomus* was the most common genus in all surveyed crops. Maize and Cassava are more mycotropic and will respond to mycorrhizal inocula than Fluted pumpkin. Also, the study revealed that some of the factors evaluated had a significant influence on spore density and root colonization by AMF. The crop type, soil texture, soil pH, phosphorus, clay,  $Al^{3+}$  levels were identified as the factors influencing the intra-radical development of AM fungi. This study provides insights into the potentially functionally active genera in soil which can be adopted for the selective application of AMF species as soil reclamation biofertilizer inocula.

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