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Abundance and diversity of Arbuscular mycorrhizal fungal (AMF) communities associated with cassava (*Manihot esculenta* Crantz) rhizosphere in Abengourou, East Côte d'Ivoire

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Soils from four different cassava cropping fields (Aniansué 1, Aniansué 2, Dramanekro 1, Dramanekro 2) were analyzed to evaluate abundance and diversity of Arbuscular Mycorrhizal Fungi associated with cassava rhizosphere in Abengourou, East Côte d'Ivoire. It was shown that the soils in the cassava cropping fields were all acidic with low levels of available phosphorus (P). A total of 29 species belonging to six different genera (*Acaulospora, Ambispora, Claroideoglomus, Gigaspora, Glomus* and *Scutellospora*) were found at Aniansué 1, 28 species belonging to six different genera (*Glomus, Claroideoglomus, Acaulospora, Ambispora, Gigaspora, Pacispora*) were found at Aniansué 2, 30 species belonging to six different genera (*Glomus, Acaulospora, Ambispora, Gigaspora, Pacispora, Scutellospora*) were found at Dramanekro 1 and 27 species belonging to five different genera (*Glomus, Acaulospora, Ambispora, Gigaspora, Scutellospora*) were found at Dramanekro 2. The genus *Glomus* was dominant at each cassava cropping field. Spore densities were high, positively correlated with both soil pH and Mg^{2+}, but negatively with available P. Trap culture revealed good infection potential for all soils. The frequencies of mycorrhizal roots were more than 93% for all field soils.

Key words: Arbuscular mycorrhizal fungi, abundance, diversity, cassava rhizosphere, Abengourou, East Côte d'Ivoire.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is an Euphorbiaceae originally from South America (Charrier and Lefevre, 1988). This plant has become one of the dominant starchy stables in humid lowlands of the tropics (Oyetunji and Osonubi, 2007). It is an important food's source for 800 billion people worldwide (Hahn and Keyser, 1985) and is Africa's second most important crop in terms of consumed calories (Yaninek and Schulthess, 1993). Cassava has better growth conditions in either loamy or sandy soils moderately fertile. This plant can therefore grow in marginal areas (Yaninek and Schulthess, 1993). In Côte d'Ivoire, cassava cropping covers all agricultural

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regions (Camille, 1984). As such, cassava is the second most important culture after yam in Côte d'Ivoire. In all ecosystems, soil microbial communities play an important role in crop productivity and Arbuscular mycorrhizal fungi are a good example. arbuscular mycorrhizas (AM) are associations formed between the roots of most terrestrial plant species and a group of specialized soil fungi (Smith and Read, 2008). The formation of AM has a significant impact upon plant growth and nutrition, with bi-directional exchange of inorganic nutrients [phosphorus (P), zinc (Zn) and others] and carbon between both partners (Cavagnaro, 2008; Marschner and Dell, 1994). It has been demonstrated that plants can receive up to 100% of their P via the mycorrhizal pathway, and 4 to 20% of plant carbon can be transferred to the fungi (Cavagnaro et al., 2008; Jakobsen and Rosendahl, 1990). These transfer of resources between the plants and fungi have profound effect on plant growth, nutrition and ecology, and have been the focus of considerable interest (Smith and Read, 2008; Plenchette et al., 1982, Pearson and Tinker, 1975). AMF can improve both plant growths under low fertility conditions, improve plant water balance and help plants to be established in new areas (Jha et al., 2011). Several studies showed that cassava roots establish mycorrhizal association (Sieverding, 1989a; Oyetunji and Osonu, 2007). There have been a number of studies from Nigeria on the impact of AMF on cassava growth in alley inter-cropping systems with hedgerow woody legumes (Atayese et al., 1993; Osonubi et al., 1995; Fagbola et al., 1998a, b; Oyetunji et al., 2003; Liasu et al., 2006). In South Africa, studies have shown that the rhizosphere of cassava in Limpopo and Mpumulanga contain *Acaulospora scrobiculata, Glomus rubiforme and Gigaspora* sp1 whereas the Mpumulanga soils yielded *Acaulospora scrobiculata, Acaulospora mellea, Acaulospora tuberculata, Glomus etunicatum, Glomus rubiforme, Gigaspora* sp 2 and *Scutellospora* sp (Straker et al., 2010). Earlier, studies on the growth of cassava in tropical South American ecosystems have shown that the plant was moderately to highly mycotrophic depending on AMF species colonizing the plant (Sieverding, 1989b) and the size of the cuttings used (Habte and Byappanahalli, 1994). These studies showed clear cut evidence that AMF play an important role in increasing the sustainability of cassava cropping (Cardoso and Kuyper, 2006). In Côte d'Ivoire study focusing on AMF in 1982 showed that this symbiotic association was present in different ecosystems, whatever the variety of cassava, soil type and cropping systems (Savary, 1982). However current distribution and abundance of AMF are the result of contemporary ecological processes (Shukla et al., 2009) that are under control of several factors such as soil chemical properties, soil disturbance and above-ground vegetation (Yang et al., 2010; Sturmer and Siqueira, 2011). It means that updated studies should address the ecology of AMF in different cassava cropping systems in Côte d'Ivoire. In this study we were interested in the quantification and the description of AMF communities in cassava cropping systems in Abengourou, East of Côte d'Ivoire, where cassava is grown as both subsistence and cash crop (Ndabalishye, 1995).

MATERIALS AND METHODS

Soil sampling

Soil sampling took place in December during the dry season. Soil samples were taken from four cassava fields (Table 1) at least 3 Km away from each other. Soils from around the stem in the tuber /root region of each field were collected. These samples resulted from a mixture of 12 primary samples collected according to the diagram proposed by Huang and Cares (2004) and brought up to the laboratory.

Soil physico-chemical analyses

Air-dried soils were used to determine soil chemical and physical characteristics. Soil pH was determined according to Pansu and Gautheyrou (2003a). Organic carbon was assessed after the method by Walkley and Black (1934) and soil N by the Kjeldahl method (MacDonald, 1977). Soil cationic exchange capacity (CEC) and total P were determined respectively using the method by Duchaufour (1977), Pansu and Gautheyrou (2003b). Soil available phosphorus was determined after Olsen (1952) and soil textural classes using French standards of soil classification (ISO, 1991).

Trap pot cultures

Trap pot cultures were established using soils directly sampled from cassava fields. 100 g of field soils were mixed with 600 g auto-claved (110°C, 2 Kg/cm^2, 3 h) compost's substrate in one liter pot (1l). *Vigna unguiculata* seeds were surface sterilized with sodium hypochlorite (10% v/v) for 10 min and thoroughly rinsed with sterilized water. After germination, seedlings were selected for uniform size and then transplanted into pots (three per each field sample). These pots were placed in a greenhouse. Trap cultures were grown for 70 days, and then soil core samples (50 g) were taken from each pot for AMF spores extraction.

Arbuscular mycorrhizal fungal (AMF) spore isolation

AMF were isolated by spore extraction from soil samples or trap culture. Spores were extracted by wet-sieving and decanting (Gerdemann and Nicolson, 1963) using sieve with different sizes (45, 90, 125 and 500 µm) and the modified sucrose density gradient centrifugation method (Walker et al., 1982).

Arbuscular mycorrhizal fungal (AMF) spore density

AMF spores were counted using binocular magnifying glass (EUROMEX Holland STO 11738). Spore density was expressed in terms of unit mass of dry soil. Discrimination was made between healthy and non-healthy spores based on color and appearance. Species occurrence was determined as the number of fields where a particular species was found divided by the total number of fields.

Arbuscular mycorrhizal fungal (AMF) spore identification

Semi-permanent microscope slides of representative spores were made using polyvinyl alcohol-lacto-glycerol (PVLG) mounting medium with and without Melzer's reagent (Koske and Tessier, 1983; Morton et al., 1993). AMF Identification was based on spore's morphological characteristics as described by Schenck and Pérez

Table 1. Geographical coordinates of the study sites.

Site	Point	Geographical coordinates		
		Number	W	Alt (m)
Aniansué 1 (Ab 1)	Ab 1/1	06°40.335'	003°38.962'	166
	Ab 1/2	06°40.344'	003°38.939'	164
	Ab 1/3	06°40.338'	003°38.976'	164
Aniansué 2 (Ab 2)	Ab 2/1	06°39.866'	003°41.130'	170
	Ab 2/2	06°39.897'	003°41.111'	167
	Ab 2/3	06°39.846'	003°41.101'	164
Dramanekro 1 (Ab 3)	Ab 3/1	06°42.640'	003°37.056'	176
	Ab 3/2	06°42.624'	003°37.080'	176
	Ab 3/3	06°42.622'	003°37.089'	177
Dramanekro 2 (Ab 4)	Ab 4/1	06°41.816'	003°38.318'	151
	Ab 4/2	06°41.847'	003°38.299'	154
	Ab 4/3	06°41.860'	003°38.275'	152

(1990), INVAM collection (INVAMhttp://invam.caf.wvu.edu/myc_info), by Blaszkowski (http://www.agro.ar.szczecin.pl/~jbaszkowski/) and the revision of Glomeromycota genera proposed by Oehl et al. (2011). AMF spores were examined using an optic microscope (EUROMEX Holland CSL/CKL). Spores were photographed using a digital camera (CANON IXUS 130 14.1 Mega Pixels).

Data analyses

Spore density (= spore abundance) in a soil sample was expressed as the number of AMF spores per gram of soil (spores g^{-1}). Data were subjected to ANOVA of Kruskal-Wallis to test differences in spore density, mycorrhizal root intensity, relative abundance and diversity within fields. Mean separation was calculated after U Mann-Whitney test at the 0.05 level of probability. The relationship between AMF parameters and soil chemical properties was determined by Principal Component Analysis (PCA) and Spearman correlation analysis. The analyses were carried out using STATISTICA 7.1.

RESULTS

Soils from the cassava cropping fields harbored diverse physical structures

Soils collected in Abengourou had various textures according to the cropping fields (Figure 1). Soils in Aniansué 1 and Aniansué 2 were sandy loam. However, Aniansué soils 2 had a high proportion of fine slit. Soils in Dramanekro 1 were loam while the one in Dramanekro 2 were slit loam with a high proportion of fine silt. Soil pH from the four fields ranged from 5.5 to 6.4 showing that the soils were all acidic (Table 2). Soil Nitrogen content ranged from 0.25 to 0.32%. The level of C/N was 8.27 for Dramanekro 2 showing that there was a quick decomposition of organic matter. However the C/N values ranged from 9.06 to 10.60 at Aniansué 1, Aniansué 2 and Dramanekro 1 showing good organic matter decomposition in these soils. However the cassava cropping fields contained high proportion of organic matter ranging from 3.92 to 5.41%. The CEC levels in the different soils were high showing the evidence of good cation transfer capacities. In terms of available phosphorus, the soils in Aniansué 2 were the richest while the ones in Aniansué 1, Dramanekro 1 and Dramanekro 2 were the poorest.

Soils in the cassava cropping fields contained high Arbuscular mycorrhizal fungal (AMF) spore densities

Proportion of healthy spores, AMF spore densities (spores number g^{-1}soil) directly from fields and after trap culture were compared (Figure 2). For Aniansué 1 and Aniansué 2 there were no significant differences between the proportions of healthy spores and those of non-healthy spores. However for Dramanekro 1 and Dramanekro 2 the proportions of healthy spores were higher than the proportions of non-healthy spores. Densities of healthy spores directly from the cropping fields ranged from 11 spores/g to 20 spores/g (Figure 3). Aniansué 1 and Dramanekro 2 had the highest density (20 spores/g) of healthy spores and Aniansué 2, the lowest. For all fields, after trap culture, healthy spore density increased. However, there were no significant differences between different fields after trap culture.

Soil physical-chemical characteristics impact Arbuscular mycorrhizal fungal (AMF) spore abundance

In order to evaluate the impact of both soil structures and chemical characteristics on spore densities, a first approach

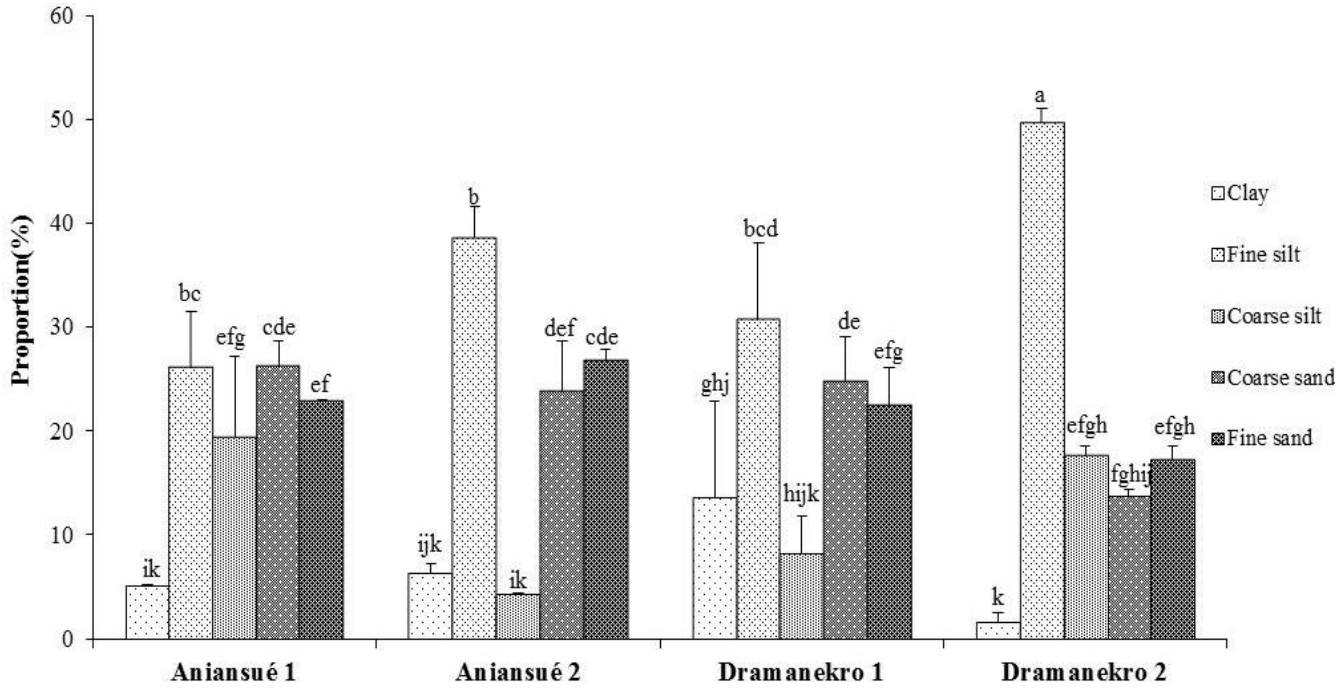

Figure 1. Structure of different soils in cassava cropping fields. Data were reported as means and standard errors of three replicates. Averages with different letters were significantly different at 5% level

Table 2. Soil physic-chemical characteristics at different cassava cropping fields.

Sites	Aniansué 1	Aniansué 2	Dramanekro 1	Dramanekro 2
pH water	$6.41^{b} \pm 0.04$	$5.50^{a} \pm 0.25$	$5.87 \pm {}^{ab}0.29$	$6.27^{ab} \pm 0.11$
C (%)	$2.67^{a} \pm 0.20$	$3.15^{a} \pm 0.1$	$2.28^{a} \pm 0.52$	$2.68^{a} \pm 0.31$
N (%)	$0.28^{a} \pm 0.02$	$0.30^{a} \pm 0.01$	$0.25^{a} \pm 0.04$	$0.32^{a} \pm 0.02$
C/N	$9.49^{ab} \pm 0.81$	$10.60^{b} \pm 0.39$	$9.06^{ab} \pm 0.6$	$8.27^{a} \pm 0.37$
O.M %	$4.59^{a} \pm 0.34$	$5.41^{a} \pm 0.24$	$3.92^{a} \pm 0.89$	$4.61^{a} \pm 0.54$
Total P (ppm)	$448.0^{a} \pm 30.29$	$399.92^{a} \pm 5.6$	$419.57^{a} \pm 88.3$	$381.33^{a} \pm 10.7$
Available P (ppm)	$22.62^{a} \pm 1.94$	$55.95^{b} \pm 3.89$	$23.57^{ab} \pm 4.66$	$29.76^{ab} \pm 7.78$
CEC (cmol.kg^{-1})	$20.67^{ab} \pm 1.3$	$23.67^{b} \pm 0.14$	$17.92^{a} \pm 1.47$	$18.6^{a} \pm 0.84$
Ca^{2+} (cmol.kg^{-1})	$2.71^{ab} \pm 0.9$	$2.27^{a} \pm 0.12$	$2.81^{ab} \pm 0.29$	$3.18^{b} \pm 0.17$
Mg^{2+} (cmol.kg^{-1})	$1.69^{ab} \pm 0.16$	$1.38^{ab} \pm 0.17$	$1.17^{b} \pm 0.13$	$1.84^{a} \pm 0.10$
K^{+} (cmol.kg^{-1})	$0.11^{a} \pm 0.01$	$0.20^{b} \pm 0.01$	$0.16^{ab} \pm 0.02$	$0.24^{b} \pm 0.04$
Na^{+} (cmol.kg^{-1})	$0.46^{c} \pm 0.03$	$0.33^{bc} \pm 0.04$	$0.15^{a} \pm 0.05$	$0.18^{ab} \pm 0.03$
V(%)	$24.14^{b} \pm 0.43$	$17.67^{a} \pm 1.3$	$23.90^{b} \pm 0.85$	$29.27^{c} \pm 0.14$

All the values are means of the three replications (n = 3). Means with different letters were significantly different at 5% level.

using principal component analysis of all factors was made. This model showed that the factors 1 and 2 represented 28.05 and 26.78% respectively of the global variability (Figure 4). Healthy spore density was positively correlated to the axis 1. Concerning soil parameters, only coarse silt, pH, Ca^{2+} and Mg^{2+} were correlated to this axis. Pearson correlation confirmed that only soil coarse silt, pH and Mg^{2+} were significantly correlated with spore densities (Table 3).

Cassava cropping fields harbored diverse Arbuscular mycorrhizal fungal (AMF) communities

After spore morphotyping, it was shown that different genera comprising *Acaulospora, Ambispora, Glomus, Claroideoglomus, Pacispora, Gigaspora* and *Scutellospora* were found in the cassava cropping fields of which the genus *Glomus* was dominant (Figure 5). In terms of species composition, 29 species were found at

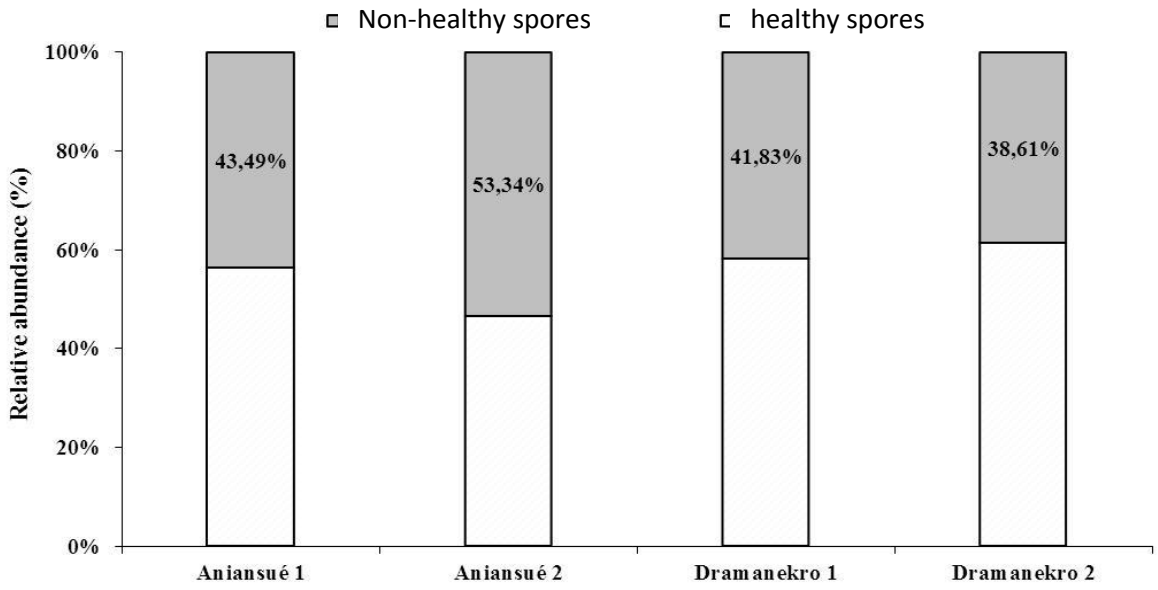

Figure 2. Proportion of healthy and non-healthy spores in different soils from cassava cropping fields. Bars are averages of three repetitions. Averages with different letters were significantly different at 5% level.

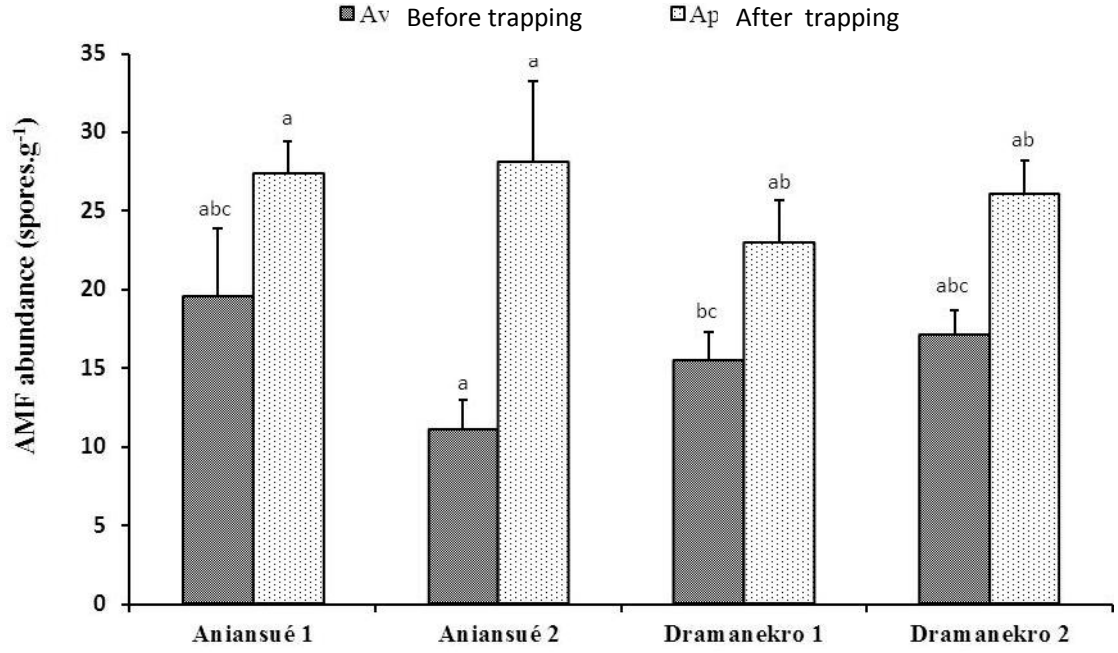

Figure 3. Density of healthy spores in different cropping fields and after trap culture. Bars are averages of three repetitions. Averages with different letters were significantly different at 5% level.

Aniansué 1, 28 at Aniansué 2, 30 at Dramanekro 1 and 27 at Dramanekro 2 (Table 4). Concerning their occurrence, some species were common to the four cropping fields (*Acaulospora paulinae, A. scrobiculata, A. undulata, Ambispora leptotichia, Ambispora* sp 1, *Glomus glomeratum, G. intraradices, Glomus* sp 2, sp 3 *and* sp 5). The species most frequently encountered at Aniansué 1 were *Claroideoglomus etunicatum, G. intraradices, G. microcarpum, Glomus* sp 2*, Acaulospora rehmii* while at Aniansué 2 the species most frequently encountered were *C. etunicatum*, *Glomus* sp 3, *A. rehmii*, *Ambispora* sp 1, *G. intraradices and Glomus* sp 2. The species most frequently encountered at Dramanekro 1 were *Ambispora* sp 1, *Glomus clavisporum*, *G. macrocarpum* while at Dramanekro 2 it was *G. intraradices* and *G. aggregatum* (Figure 6).

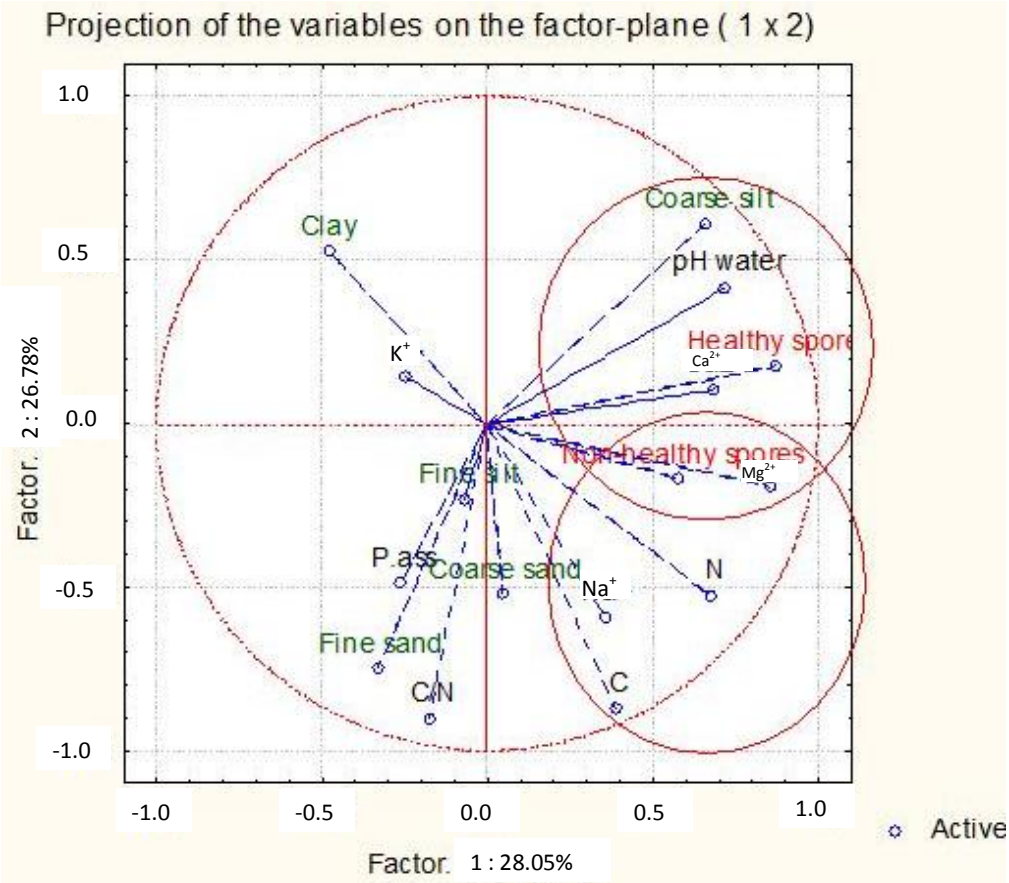

Figure 4. Relationship between soil physico-chemical characteristics and spore densities by Principal Component Analysis.

Table 3. Spearman correlation between soil parameters and spore density.

Variable	Coarse silt	pH	Ca^{2+}	Mg^{2+}
Spearman *R*	0.74	0.69	0,53	0,63
p	0.006	0,012	0,075	0,028

Correlations are significant at $p < 0.05$

DISCUSSION

In this study, we were interested in the quantification and the description of AMF communities in four cassava cropping soils in Abengourou, East Côte d'Ivoire. The four fields' soils were all acidic with different physical and chemical composition. Despite the different structural and chemical differences of the cropping fields, they all harbored AMF spores. The AMF spore densities were higher compared to the values obtained in cassava fields in South America (Sieverding, 1989b) and those obtained in Benin for yam fields (Tchabi, 2008). These results are not surprising since it had been shown that acidic soils are favorable to spore development (Kelkar and Bhalerao, 2013). Moreover, it was shown that these soils contained low levels of available phosphorus, a condition also that promotes spore growth and development (Weissenhorn and Leyval, 1996; Whu, 2006; Katsunori et al., 2008). This study showed that soil physical characteristics such as soil coarse silt was positively correlated with AMF spore density. This study confirmed that the proportion of silt in the soil was positively correlated with AMF (Amal et al*.,* 2013). It was shown that soils pH from the cropping fields were positively correlated to spore density. Moreover, soil nutrient contents such as Mg^{2+} was positively correlated to spore densities. There were also lots of non-healthy spore in soils directly isolated from fields. The proportions of non-healthy spores were more than 38% for each site. This could be explained by several reasons. Firstly, tillage disrupts the cycle of fungi, secondly infection of AMF spores by saprophytic fungi (Antunes et al., 2008; Rousseau et al., 1996; INVAM, 2013). Abengourou is a tropical humid forest area and such allow better spore attached. Then Soils in ecosystems often contain low numbers of living spores (Brundrett and Kendrick, 1988; Gay et al*.,* 1982; Schenck and Kinloch, 1980). However, this did not affect the high infection potential of all soils from cassava copping fields. Consequently, healthy

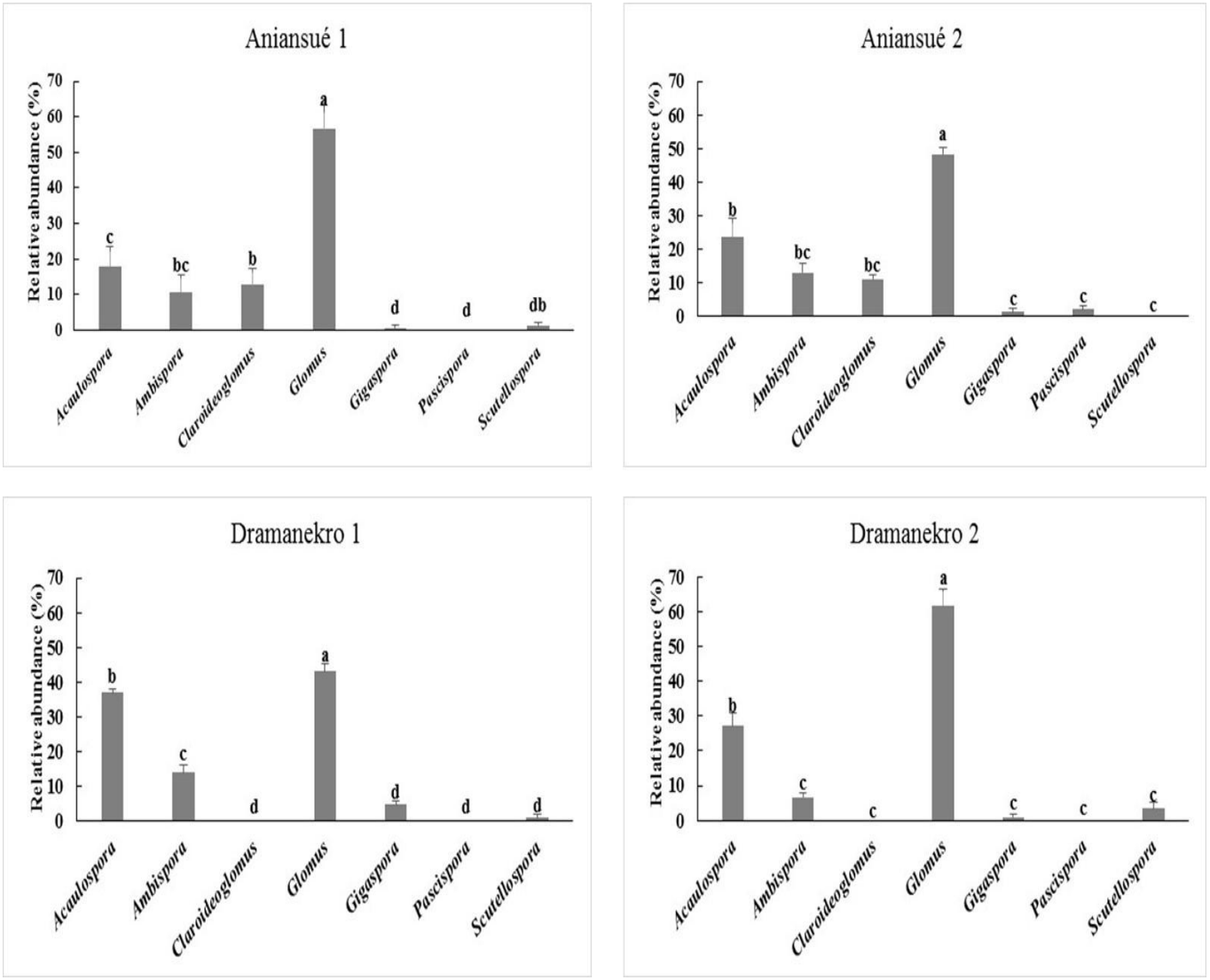

Figure 5. Relative abundance of AMF genera at each cassava cropping field. Proportions with different letters were significantly different at 5% level.

Table 4. Global occurrence and relative abundance of AMF species at each cassava cropping field.

Specie	Proportion of species at each site (%)				Occurrence (%)
	Aniansue 1	Aniansue 2	Dramanekro 1	Dramanekro 2	
Acaulospora denticulata Sieverd. & S. Toro				3.52	25
A. elegans Trappe & Gerd.			2.11		25
A. excavata Ingleby & C. Walker	1.41	2.11	2.11		75
A. foveata Trappe & Janos		2.11	4.23	2.11	75
A. gedanensis Błaszk.	0.70		4.23	2.11	75
A. paulinae Błaszk.	2.82	3.52	4.93	2.11	100
A. rehmii Sieverd. & S. Toro	7.04	7.75		3.52	75
A. scrobiculata Trappe	2.82	4.93	4.93	4.93	100
A. thomii Błaszk		0.70	2.11		50
A. undulata Sieverd.	2.11	0.70	3.52	3.52	100
Acaulospora sp1	1.41	0.70			50

Table 4. Contd.

Acaulospora sp2		0.70			25
Acaulospora sp3	0.02	3.52			50
Acaulospora sp4			1.41	2.11	50
Acaulospora sp5			3.52	2.11	50
Ambispora callosa Sieverd.	1.41	0.70		1.41	75
A. leptoticha Schenck & G.S.	2.82	3.52	1.41	3.52	100
Ambispora sp 1	4.93	6.34	15.00	5.63	100
Ambispora sp 2	1.41				25
Glomus albidum Walker & Rhodes			2.11		25
G. agregatum Schenck & Koske				6.34	25
G. aureum Oehl & Sieverd.		2.82	2.11	3.52	75
G. glomeratum Sieverd.	3.52	0.70	3.52	5.63	100
G. geosporum Nicolson& Gerd.	2.11				25
G. badium Oehl. Redecker & Sieverd.	2.82				25
G. clavisporum Trappe		4.93	5.63		50
G. fasciculatum Gerd. & Trappe	1.41			4.23	50
G. intraradices Schenck & G.S.	9.15	6.34	4.23	13.38	100
G. microcarpum Tul. & C. Tul.	7.04				25
G. clarum Nicolson & Schenck	2.11				25
G. macrocarpum Tul. & C. Tul.	5.63	4.93	5.63	2.11	100
G. sinuosum Gerd. & B.K. Bakshi	3.52			5.63	50
Glomus sp 1	2.11	5.63			50
Glomus sp 2	8.45	6.34	4.23	3.52	100
Glomus sp 3	4.93	7.75	3.52	1.41	100
Glomus sp 4	2.82			1.41	50
Glomus sp 5	2.11	2.82	2.11	4.23	100
Glomus sp 6		2.82	3.52		50
Glomus sp 7		2.82	1.41	2.11	75
Glomus sp 8			2.11	4.93	50
Glomus sp 9		0.02	3.52		50
Claroideoglomus etunicatum Oehl et al	12.68	13.38			50
Pacispora scintillans Rose & Trappe			1.41		25
Pacispora sp 1		0.70			25
Gigaspora margarita Becker & Hall			1.41		25
Gigaspora sp 1			1.41	1.41	50
Gigaspora sp 2	0.70		1.41		50
Gigaspora sp 3		0.70			25
Scutelospora sp 1			1.41		25
Scutellospora sp 2				3.52	25
Scutellospora sp 3	1.41				25
Species richness	**29**	**28**	**30**	**27**	

spore densities after trap culture were higher than this of healthy spores directly from sampled soils. These soils could be a good source of inoculum, since these results confirmed that trap culture increase the proportion of viable spores (Stutz and Morton, 1996). This infection potential may be improved by the establishment of viable spore's banks per culture of AMF in greenhouse or and in laboratory. Biotechnological tools could help to protect biodiversity and to increase infectivity of these AMF. In addition spores are not the only organs of propagation of AMF. Propagules of AMF include spores, root fragments containing hyphae and vesicles and soil hyphae (Biermann and Lindermann, 1983; Tommerup and Abbott, 1981). The spores of AMF are the important type of propagules but their numbers are often poorly correlated with mycorrhizal formation in soils (Abbott and Robson, 1984; Abbott and Robson, 1991; Ebbers et al., 1987; McGee, 1989; Mukerji and Kapoor, 1986; Schmidt and Reeves, 1984). This could explain the poor spore density correlation with mycorhizal frequency. The

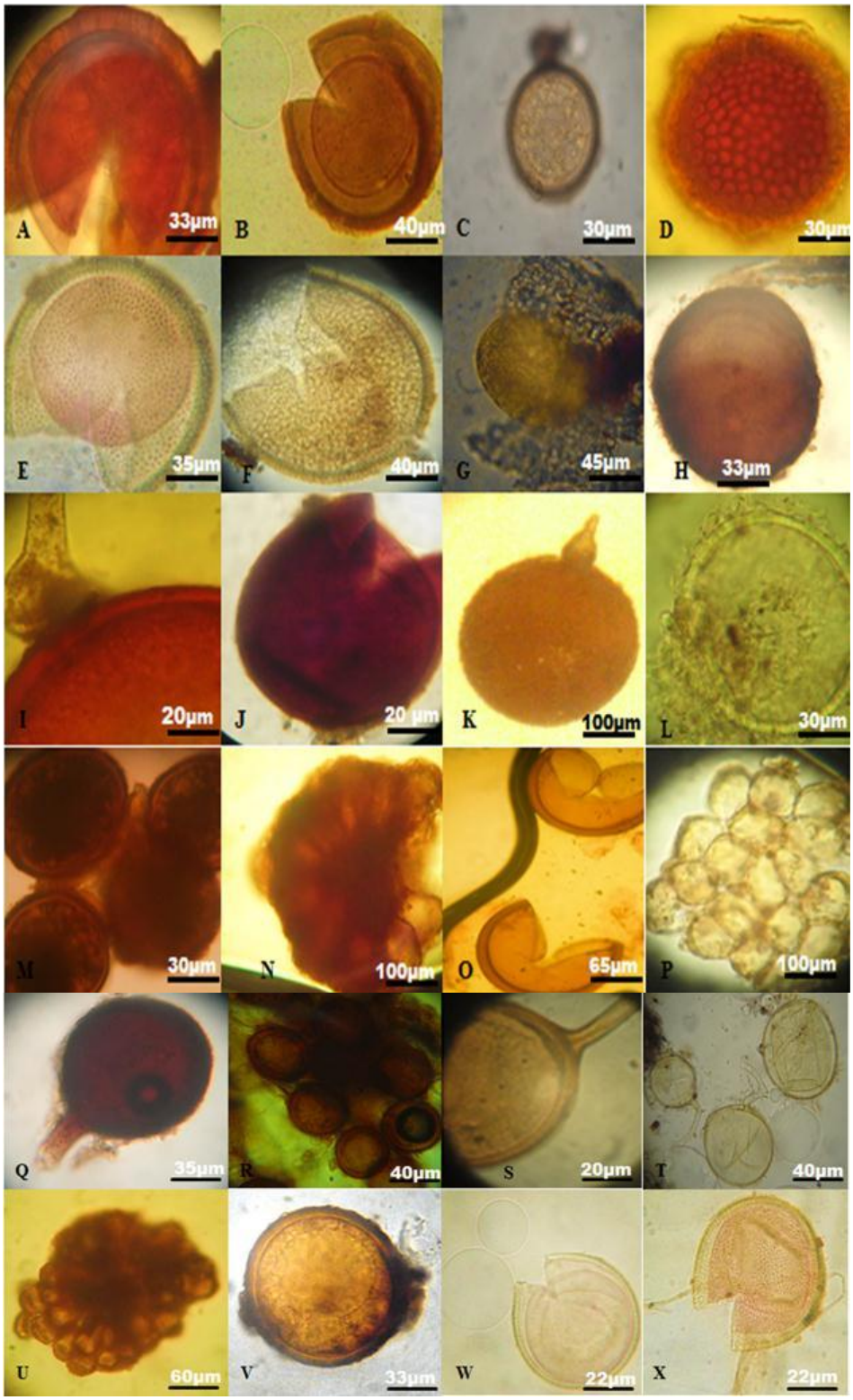

Figure 6. Example of AMF spores isolated from the cassava cropping fields and identified by morphotyping **A-** *Acaulospora sp.* **1, B-** *A. thomii*, **C-** *A. undulata*, **D-** *Acaulospora sp.2*, **E-** *A. scrobiculata*, **F-** *A. denticulate,* **G-** *Ambispora* sp. 1, **H-** *Ambispora leptoticha,* **I-** *Gigaspora margarita*, **J-** *Scutellospora* sp, **K-** *Gigaspora* sp. 1, **L-** *Glomus clarum,* **M-** *G. badium*, **N-** *G. sinuosum,* **O-** *G. geosporum*, **P-** *G. microcarpum*; **Q-** *Glomus* sp 1, **R-** *G. intraradices*; **S-** *G. aureum*, **T-** *G. aggregatum;* **U-** *G. clavisporum*; **V-** *Claroideoglomus etunicatum*, **W-** *Acaulospora gedanensis*, **X-** *A. rehmii*.

cassava cropping field presented high spore abundance and AMF species with high variability. In present study, some common (*Acaulospora paulinae, A. scrobiculata, A. undulata, Ambispora leptotichia, Ambispora sp.*1*, G. intraradices, G. glomeratum, Glomus* sp. 2*,* sp 3 and sp 5) as well as some different AMF species were found associated with Abengourou cassava cropping fields. These results suggested that AMF composition changed with soil edaphic factors and agricultural systems. Generally in the Côte d'Ivoire and particularly in Abengourou cassava fields were made on plots repeatedly used for other crops. Such practices may affect AMF community structure. However Abengourou soils have good conditions for spore development.

The high AMF diversity found in Abengourou region reflects results from earlier studies in Côte d'Ivoire (Wilson et al., 1992) and in other tropical areas, such as Benin (Tchabi, 2008), East Africa (Mathimaran et al., 2007) and India (Muthukumar and Udaiyan, 2000). It can be concluded that cassava culture is strongly associated with AMF as reported by Sivierding (Sieverding, 1989b). The pre-dominant occurrence of *Glomus* species showed their remarkable adaptation to tropical conditions. The cycle of genus *Glomus* seems not to be too affected by plowing unlike minority genera (*Gigaspora, Scutellospora and Pacispora*) (Sieverding, 1990; Miller et al., 1995; Jansa et al., 2002; Oehl et al., 2003). For this study, *G. intraradices* was found at all fields with high frequency while *Claroideoglomus etunicatum (= Glomus etunicatum)* was found with relatively high frequency at Aniansué 1 and Aniansué 2. *G. etunicatum* was reported to be an extremely widespread species within different ecotypes (Becker and Gerdemann, 1977). *G. etunicatum* was found earlier in Côte d'Ivoire in Terminalia plantations (Wilson et al., 1992). *Glomus clarum (=Glomus manihotis)* a most strong invasive, effective and competitive AMF species associated with cassava (Sieverding and Toro, 1989) was found only in the site Aniansué 1. *Acaulospora scrobiculata* found at all sites was considered as a facultative symbiont (Straker et al., 2010) adapted to a wide range of soils and host species.

This study could allow the settlement of AMF inoculation technology with ubiquitous species like *G. intraradices.* In fact*,* it was reported that inoculation with *G. intraradices* could improve salt tolerance of micro propagated cassava clones (Carretero et al*.*, 2008) and the resistance of these clones to transplant stress and increase their shoot and root biomass (Carretero et al., 2009).

Conclusion

Our study indicates that in Abengourou, cassava culture was associated with AMF. AMF Spores densities were high at all sites and it had been noted a large variability of species. Results suggested that population of AMF, frequency of occurrence and distribution varied with the site. The genus *Glomus* was dominant at all sites while the genera *Gigaspora, Scutellospora* and *Pacispora* were in minority. Mycotrophic crops such as cassava in cropping systems may be necessary to maintain the biodiversity of AMF. However considering all the constraints faced by AMF in their natural environments, development of biotechnological tools, which entail selection of efficient native AMF ecotypes and their incorporation into bio-fertilizers, may facilitate restoration of AMF community in this region.

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