Agrosystems and Mycorrhizae of Plantain (*Musa* AAB subgroup) in the Forest Region of Kisangani in DR Congo: Abundance and Diversity

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Abstract
Although DR Congo is the global centre of plantain diversity (Musa, AAB subgroup), the arbuscular mycorrhizal fungi (AMF) associated with plantain have not yet been studied in the forest region of Kisangani. This study assessed the abundance and the diversity of AMF in plantain cultivated in different agrosystems. The study addressed also the relation between AMF diversity and plantain vigour as well as the impact of soil characteristics on AMF population. Soil samples were collected from 24 plantain fields from secondary forest, fallow and homegardens. Plantains from fallow exhibited the highest mycorrhizal root colonization followed by those from forest and homegardens. But, the rhizosphere of plantains in forest had a higher amount of AMF spores than those located in fallow and in homegarden. The mycorrhizal root colonization and the AMF spore number were higher in vigorously growing plantain plants than in non-vigorously growing plantain plants. Gigasporaceae (20.4 %) has a positive correlation with plantain fields in forest and in homegardens with a strong link to organic matter, organic carbon, phosphorus and sand content. Glomeraceae (77.5%) was related to plantain fields located in fallow and in forest where the level of silt, nitrogen and hydraulic conductivity was high. Acaulosporaceae (2.1%) did not show any particular correlation with any soil parameters. This study shows that plantain located in forest and fallow agrosystems, and plantain growing vigorously harbour most mycorrhizae in the forest region of Kisangani .

Keywords: Agrosystem, AMF, Kisangani, plantain

Systèmes Agricoles et Mycorhizes du Plantain (*Musa* AAB.) dans la Région Forestière de Kisangani en RD Congo: Abondance et Diversité

Résumé
Bien que la RD Congo soit le centre mondial de la diversité du plantain (Musa, sous-groupe AAB), les champignons mycorhiziens à arbuscules (CMA) associés au plantain n'ont pas encore été étudiés dans la région forestière de Kisangani. Cette étude a évalué l'abondance et la diversité

des CMA pour les plantains cultivés dans différents agrosystèmes. De plus, l'étude a évalué la relation entre la diversité des CMA et la vigueur des plantains ainsi que l'impact des caractéristiques du sol sur les populations des CMA. Les échantillons de sol ont été collectés dans 24 champs de plantain situés en forêt secondaire, en jachère et en jardin de case. Les plantains en jachère ont présenté la plus forte colonisation mycorhizienne des racines, suivis par ceux de la forêt et du jardin de case. Mais, la rhizosphère de plantains en forêt avait plus de spores des CMA que celle prélevée en jachère et dans le jardin de case. La colonisation mycorhizienne des racines et le nombre de spores des CMA étaient plus élevés pour les plantains à croissance vigoureuse que pour les plantains à croissance non vigoureuse. La famille mycorhizienne des Gigasporaceae (20,4 %) a été positivement corrélée aux champs de plantains situés en forêt et dans les jardins de case, caractérisés par la matière organique, le carbone organique, le sable et la teneur en phosphore. La famille des Glomeraceae (77,5%) était corrélée aux champs de plantain situés en jachère et en forêt où le limon, l'azote et la conductivité hydraulique étaient élevés. La famille des Acaulosporaceae (2,1 %) n'a montré aucune corrélation particulière avec les paramètres du sol. Cette étude montre que les plantains cultivés en forêt et en jachère, et les plantains vigoureux présentent le meilleur potentiel mycorhizien dans la région forestière de Kisangani.

Mots clés: Agrosystème, Champignons mycorhiziens à arbuscules (CMA), Kisangani, plantain

Introduction

Plantain is one of the most important crops in the forest region of Kisangani, DR Congo. It is the second most important crop after cassava; and plays a very important role in the food security and the income generation for the people (Dhed'a *et al.,* 2008). Small producers cultivate plantain mainly for home consumption and local markets. Nevertheless, with an ever increasing demography and significant urbanization in the region, plantain has become an important cash crop which contributes to increase the income of farmers (Dhed'a *et al.,* 2019). Plantains are generally grown in homegardens, fallows and old secondary forests in DR Congo (Onautshu, 2013). In fallows and secondary forests, plantain cropping is associated with slash-and-burn agrosystem causing quickly yield declines not just because of pests and diseases but due to low soil fertility (Swennen and Vuylsteke, 2001). The rapid decline in soil fertility is one of the major constraints causing the plantain yield decline (Lassoudière, 2007). The shorter periods of fallow periods and increasing overexploitation of land due to population growth have resulted in reduced soil fertility (Laurène *et al.,* 2007; Ocimati *et al.,* 2013). The essential minerals for the proper development of plantain are nitrogen, phosphorus, potassium, calcium and magnesium (Laprade and Ruiz, 1999). In the homegardens, household waste and organic manure are applied to improve the soil fertility keeping production stable.

Several studies have demonstrated the impact of the Arbuscular Mycorrhizal Fungi (AMF) on the improvement of mineral uptake and growth of plantain and banana (Yano-Melo *et al.,* 1999; Declerck *et al.,* 1995**;** Jaizme-Vega and Azcon, 1995; Declerck *et al.,* 1994**),** resistance to drought and salinity, abiotic stresses such as aluminium toxicity (Rufyikiri *et al.,*2000), biotic stress caused by nematodes as *Radopholus similis* and *Pratylenchus coffeae* (Elsen *et al.,* 2003b; Elsen, 2002; Jaizme-Vega and Azcon, 1995), *Fusarium oxysporum* f.sp. *cubense,* the causal agent of

Panama disease (Jaizme-Vega *et al.,*1998) and *Cylindrocladium spathiphyllum,* causing the root disease. The AMF interactions with pathogens result in a decrease in pathogen populations and disease severity on plantain plants (Jefwa *et al.,* 2010; Plenchette *et al.,* 2005). Mycorrhizal plant dependence varies also in relation to the plantain cultivar (Declerck *et al.,* 1995). AMF colonisation also improves growth, yield and plant vigour including transplant shocks, and plays a major role in the aggregation of soil particles by improving structure, reducing erosion and increasing microbial activity (Gagné, 2010).

Studies conducted in Guadeloupe (French West Indies) documented that bananas are usually associated with AMF (Declerck, 1996). But tropical soils limit agricultural yields because of low mineral input, toxicities (Al, Mn), and by phosphorus fixing ability (Sieverding, 1990). Therefore, Elsen *et al.,* (2003a) mention that from a physiological point of view, it is well recognized that AMF can increase nutrient absorption, especially elements with low mobility in the soil such as

To date, the absence of publications on plantain AMF in the forest region of Kisangani confirms the need to explore this domain. Moreover, it is essential to determine agrosystems with an excellent plantain mycorrhizal potential and to identify the best AMF association for plantain cultivation in the Kisangani region.

This study assumes that the AMF abundance and diversity differ between different plantain agrosystems. In addition, the most vigorous plantain plants are expected to have a higher AMF abundance and diversity than non-vigorously growing plantain. Finally, we expect that soil characteristics have an influence on the plantain AMF abundance and the diversity.

Materials and Methods

The study was carried out in the region of Kisangani city (0°31'N, 25°11'E, 390 m), Tshopo province in DR Congo. Four sites were chosen. These are the sites located in the village Masako (0°36'N, 25°15'E, 420 m) on the Buta former road, in Madula village (0°22'N, 25°23'E, 427 m) on the Kisangani-Lubutu road, in Ofumbola village (0°20'N, 24°55'E, 495 m) on the Kisangani-Opala road and Yaboya village (0°34'N, 24°52'E, 386 m) on the Kisangani-Yangambi road.

Observations were made on six plantain cultivars (*Musa* AAB subgroup): Adili, Akoto, Libanga Lifombo, Libanga Likale, Litete and Tala Lola, respectively. All cultivars were characterized by Adheka *et al.* (2018).

Twenty four plantain fields, divided into eight per agrosystem, were investigated in the secondary forest, in fallow and in homegarden. In the farmers' fields explored in secondary forest and in fallow, plantain was planted semi-permanently (2 to 4 years) in association with one or more crops (maize, cassava, sweet potato, rice, …). The shoots of plantains harvested from neighboring fields were planted without defined spacing (about 400 plants per ha) on cleared and burnt land. The areas were variable, from less than one hectare to several hectares, depending on the capacity of each farmer. Weeding was carried out regularly. Particularly, plantain in the forest was often the first crop planted after cutting down undergrowth and young trees. Some trees (diameter greater than 40 cm) were kept in the fields as shade and to fertilize the soil through leaf fall. In the fallow, with 3 to 5 years old, the plantain was planted in full light, after total clearing of the vegetation, no additional nutrient supply was made. In secondary forest as in fallow, the fields were burned during the preparation of the ground, the soil quickly lost its fertility few years after cultivation.

In homegarden, plantain was planted in permanent system of culture (10 years or more), very diversified, in association with other crops, on small areas (from a few square meters to tens of square meters), with non-incinerated soil. The shoots were not eliminated after the harvest, the plantains were then found in a very high density clump, because cultural care was less frequent. The high fertility of the soil was due to household waste, kitchen ashes, livestock excrement, accumulated around the tufts. The mineralization of the whole enriched the soil with nutrients. The good physicochemical conditions of the soils make homegardens to be maintained for several years.

Plantain plants that were small were considered to be non-vigorous, while those that had normal growth were considered to be vigorous. The comparison was done between plantain plants that were of the same age. In each class of age, plantain plants were classified into two equitable groups of vigour in relation with their diameter of the pseudostem and the plant height, which were systematically measured. The diameter of the pseudostem was measured at the base of the pseudostem and the plantain height from the base to the level of the insertion of the two latest functional leaves.

In total 132 samples were collected for mycorrhizal determination and edaphic analysis, respectively. Hundred twenty samples of 200g fresh weight each containing plantain roots and rhizosphere soil were taken to analyse the mycorrhizal root colonization and to describe the AMF spores. In each agrosystem, twenty samples were collected on vigorous plantain plants and twenty other on non-vigorous ones.

The soil parameters were measured from 12 samples (400g per sample) collected in 12 plantain fields (four per agrosystem). Soil parameters determined included the granulometry (sedimentation method, 1988), organic carbon and organic matter (Walkey and Black method, 1992), phosphorus (Bray 2 method, 1945), total nitrogen (Kjeldahl method, 1992), the soil pH and hydraulic conductivity (Potentiometric method, 1988).

Table 1: Plantain cultivars (*Musa* AAB sub group) found in farmers' fields

Plantain Cultivars	Description
Adili	French Medium, pendulous bunch: Dark green pseudostem and fingers with blunt apex
Akoto	French Giant, pendulous bunch: Quasi-blunt finger apex; pendulous
Libanga lifombo	False Horn Medium plantain cultivar
Libanga likale	Prototype of False Horn. At maturity, the bunch looks pendulous, asymmetric in finger orientation, pointing to sub-horizontal
Litete	French giant, pendulous bunch: Dark green pseudostem and fingers
Tala lola	Horn plantain cultivars: Dwarf form Ikpolo, horizontal to erect fingers, always green when immature

The degree of mycorrhizal root colonization was evaluated by staining plantain root fragments (Trouvelot *et al.,*1986). A scale of 0 to 5 was used with 0 corresponding to the absence of mycorrhization and 5 corresponding to at least 90% mycorrhization. The observations were carried out under Motic AE31 inverted microscope at 10x and 40x magnifications.

Among the five methods described by Utobo *et al.* (2011) for estimating the soil mycorrhizal potential, the *spore enumeration method* was adopted because of its operational efficiency and practical advantages. The description of the AMF spores families was carried out according to Omar *et al.* (1979) and Schenck and Pérez (1987). The soil spore isolation protocol was based on the physical principles of serial sieving and centrifugation of the soil aqueous solution.

The data were analysed with the R package (v.4.2.0). Data that were normally distributed and had homogeneous variances were subjected to Analysis of Variance (ANOVA), Student *t*-test and correlation test. The AMF parameters were analysed by two-way ANOVA. The Tukey HSD test was applied for multiple comparisons of group means. The analysis based on direct ordination methods (canonical redundancy analysis) showed the affinities between the AMF families and the soil characteristics.

Results

Soil parameters

The soil texture was dominated by sand (51%) with a low clay (10%) and silt (39%) content in the three agrosystems. The soil chemical characteristics also vary slightly between the agrosystems studied (Table 2).

The degree of the mycorrhizal root colonization in the different agrosystems is presented in Figure 1.

The plantain roots harvested in fallow had a higher degree of mycorrhizal root colonization than those from the forest and homegarden. Moreover, vigorous plantain plants show also a higher degree of mycorrhizal root colonization than non-vigorous plantains (at 5%, Student *t*-test: p = 0.04682, t = 2.8415).

Mycorrhizal spores

Three AMF families were identified based on the morphological characteristics of the spores found in the soil samples.

The AMF spore identification was limited to mycorrhizal families and their genera. The spores were classified according to colour and shape (Table 3). The main characteristics identified in spore types A1 are attributed to Glomeraceae. Those observed in spore type A2 belong to Gigasporaceae. The spore types A3 are allocated to Acaulosporaceae.

Table 2: Soil parameters of plantain fields

Agrosystems	% Clay	% Silt	% Sand	% OC	% OM	% P	% N	pH (H_20)	pH (KCI)	H.con
Fallow	0.6	4.5	4.9	0.82	1.42	14.7	8.21	4.0	3.7	435
Forest	1.5	3.4	5.0	2.59	4.74	16.0	4.35	4.2	3.8	331
Homegarden	0.9	3.6	5.5	1.96	3.36	15.7	4.12	5.4	4.3	355

Legend. OC: Organic Carbon, OM: Organic Matter, P: Total Phosphorus, N: Total Nitrogen, H.con : Hydraulic conductivity (microsiemens/cm)

The analysis based on direct ordination methods (canonical redundancy analysis) reveals the affinities between the AMF families and the soil characteristics. The soil physical characteristics explain that 64% the variation of the AMF spores number (R^2= 0.641) while chemical characteristics account for up to 77% (R^2=0.775).

Gigasporaceae has a strong positive correlation with forest plantain fields for which the level of organic matter, organic carbon and phosphorus is more pronounced. This family can also be linked to homegarden fields characterised by an acid pH and sand. On the other hand, Glomeraceae is strongly related to fallow plantain fields as well as those in

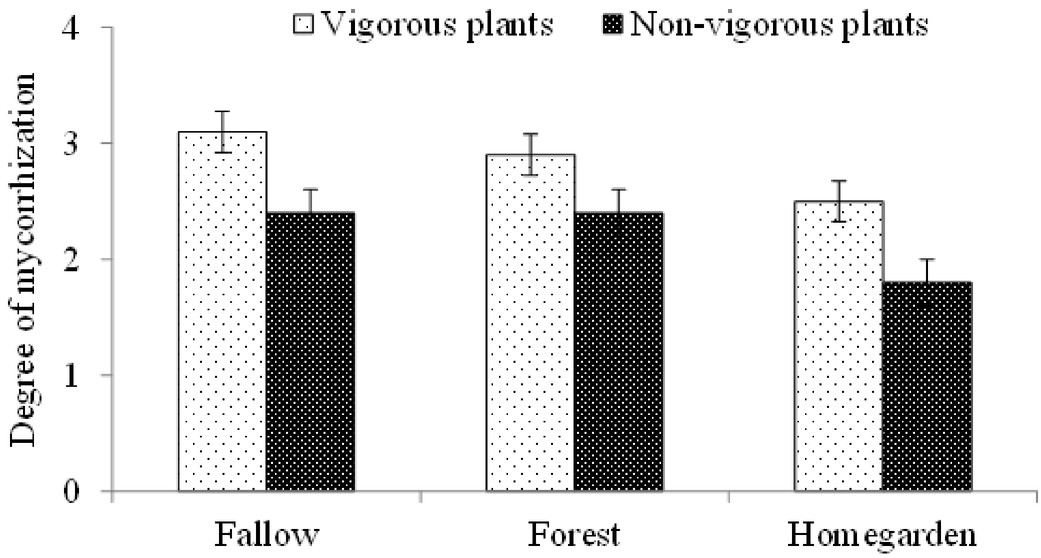

Figure 1. Degree of mycorrhizal roots colonization in plantain

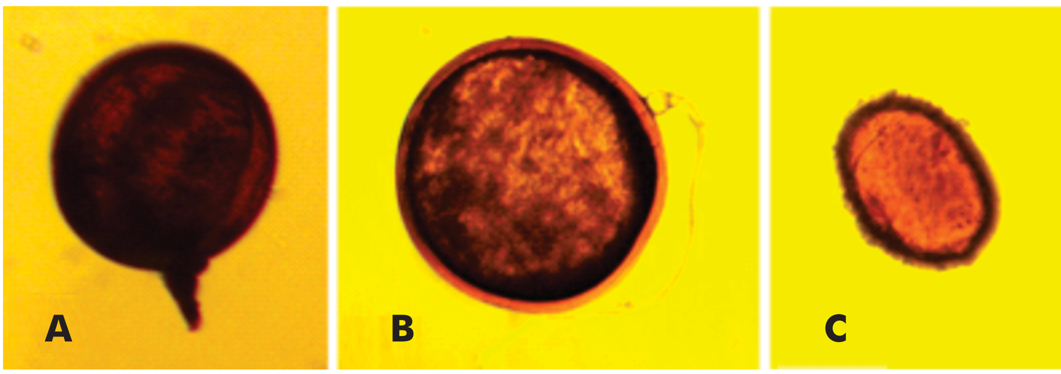

Figure 2: Representative spores of different AMF families. A1: Spore of Glomeraceae; A2: Spore of Gigasporaceae; A3: Spore of Acaulosporaceae

Table 3: Description of studied AMF spores

Type	Shape	Colour	Diameter (µm)	Other characteristics	AMF Family
A1	Spherical and ellipsoidal with spore saccules	Dark yellow	60 - 180	With cylindrical hyphaes in suspension, found in clusters	Glomeraceae
A2	Spherical	Ochre	200 - 360	Always solitary, in bulbous suspension	Gigasporaceae
A3	Ovoid with dent	White and black	–	With very flexible internal wall	Acaulosporaceae

forests where the level of silt, nitrogen and hydraulic conductivity is high. Acaulosporaceae does not reveal any particular affinity with the soil characteristics.

The results in Table 4 reveal that plantain fields in the forest followed by those in fallow have higher AMF spore abundance than homegarden ones. In addition, the family of Glomeraceae is the most abundant followed by Gigasporaceae and Acaulosporaceae. The difference is very significant between agrosystems ($p = 0.00037$) and between AMF families ($p = 0.00609$). The post-ANOVA analysis showed a significant difference between all the agrosystems compared two by two.

Glomeraceae was most prevalent in all agrosystems, but mainly in forest and fallow plantain fields. Gigasporaceae has higher occurrence in forest and homegarden than in the fallow plantain fields. Acaulosporaceae is less represented compared to the other families. In the studied agrosystems, the plantain fields with vigorous plant have relatively higher number of AMF spores than those with non-vigorous plants.

There was no significant differences observed between plantain cultivars in relation to the number of AMF spores in the three agrosystems.

The Libanga Likale cultivar, followed by Akoto, has more AMF spores, especially those of the family of Glomeraceae. The other four cultivars have almost the same AMF spores number of this mycorrhizal family. The families of Gigasporaceae and Acaulosporaceae are less abundant in all plantain cultivars. The AMF spores number varies in relation with the plantain field age.

The new plantain fields have more AMF spores than the old ones. This study reveals that the new plantain fields were in the forest and fallow while the homegarden was characterized by old plantain fields. The age classes of plantain fields have no significant influence on AMF spore numbers ($p = 0.442$).

Discussions

The AMF abundance and diversity in agrosystems

Regarding the degree of mycorrhizal activity, fallow and forest plantain plants roots were more mycorrhized than those from homegardens. According to Jaizme-Vega and Azcon (1995), the age of the plantation has a negative influence on the banana mycorrhization. Our study only assessed the

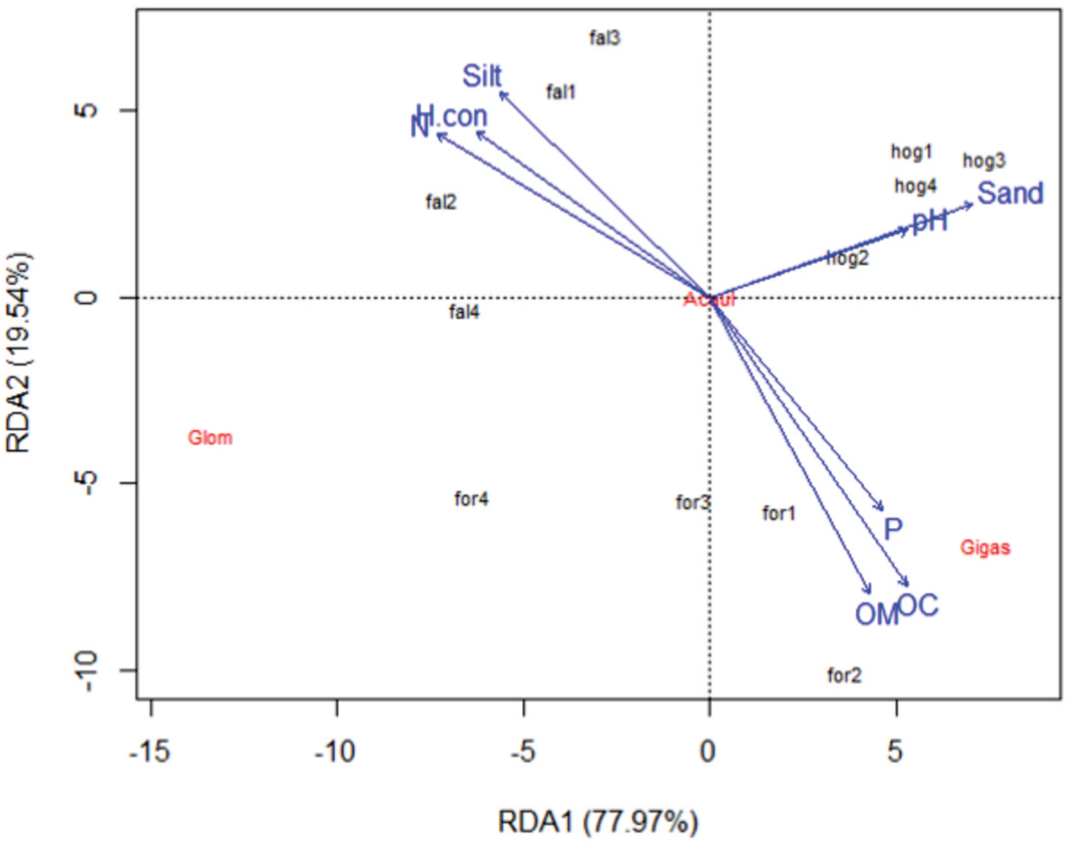

Figure 3: Affinities between AMF families and plantain fields soil characteristics

Legend:
Acaul, Gigas, Glom: AMF family of Acaulosporaceae, Gigasporaceae and Glomeraceae, respectively.
fal1, fal2, fal3 and fal4: plantain fields located in fallow.
for1, for2, for3 and for4: plantain fields located in forest.
hog1, hog2, hog3 and hog4: plantain fields located in homegarden

relation between plantain plants age and AMF spores number, not plantain plants age and mycorrhizal root colonization which could more facilitate comparison with the mentioned authors' assertion. We observed that the homegarden was characterized by old plantain fields and more fertile soil. Thus, the low mycorrhizal root colonization in homegarden could be due to their age and soil fertility.

The differences found in number of AMF spores was significant between the considered agrosystems: fields in forest followed by fallow ones had more AMF spores than those in homegarden. Pierart (2012), argues that sporulation is the results of unfavourable environmental conditions. This because AMF spores help the fungus to survive in the soil while waiting for favourable conditions for endo-mycorrhizal symbiosis. Although the three agrosystems studied are in the same tropical hot and humid climate conditions with same temperature and rainfall, fallow and forest plantain fields underwent a drastic influence due to cultural practices such as slash-and-burn, weeding and ploughing during at least 5 years each. These have facilitated the most adapted AMF species to colonize these two agrosystems more rapidly. Cultural practices, particularly the slash-and-burn practice, which is frequent in Kisangani region agrosystems, have had an adverse effect on the diversity of AMF taxa and cause a shift to more adapted taxa that no longer undergo competition as mentioned by Abbott and Robson (1991). These authors argue that the physico-chemical soil changes inherent to cropping practices have a decisive influence

Table 4: AMF spores relative abundance in different agrosystems

AMF spores Abundance	Glom-eraceae	Gigasp-oraceae	Acaulos-poraceae	Sum	Average	Relative abundance (%)
Fallow	1542	95	42	1679	559.7	32.84
Forest	1440	515	29	1984	661.3	38.8
Homegarden	983	433	34	1450	483.3	28.36
Sum	3965	1043	105	5113	-	100
Average	1321.7	347.7	35	-	-	-
Relative abundance (%)	77.55	20.4	2.06	100	-	-

The AMF spores number in relation to the plantain plants vigour is presented in Figure 4

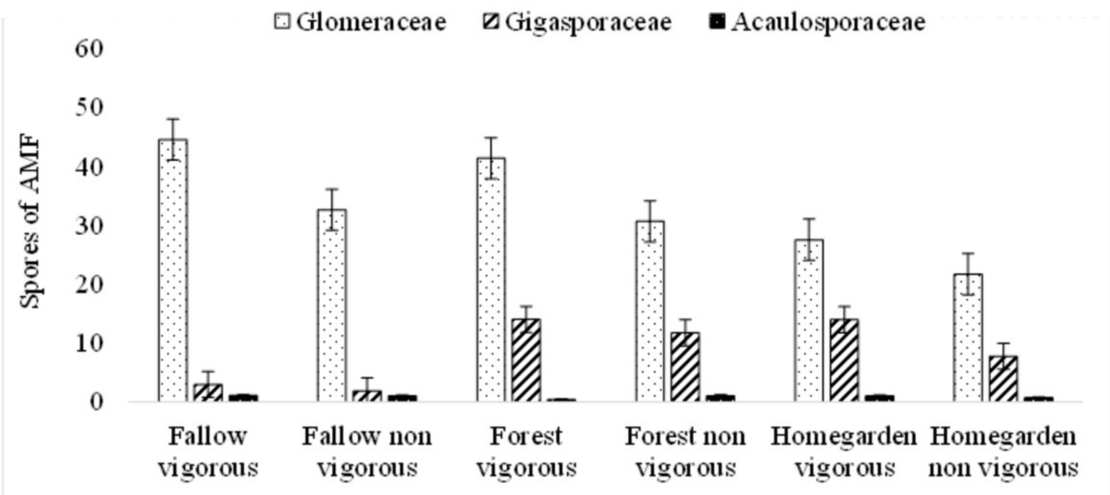

Figure 4: Spore number of 3 AMF families in relation with plantain plants vigour

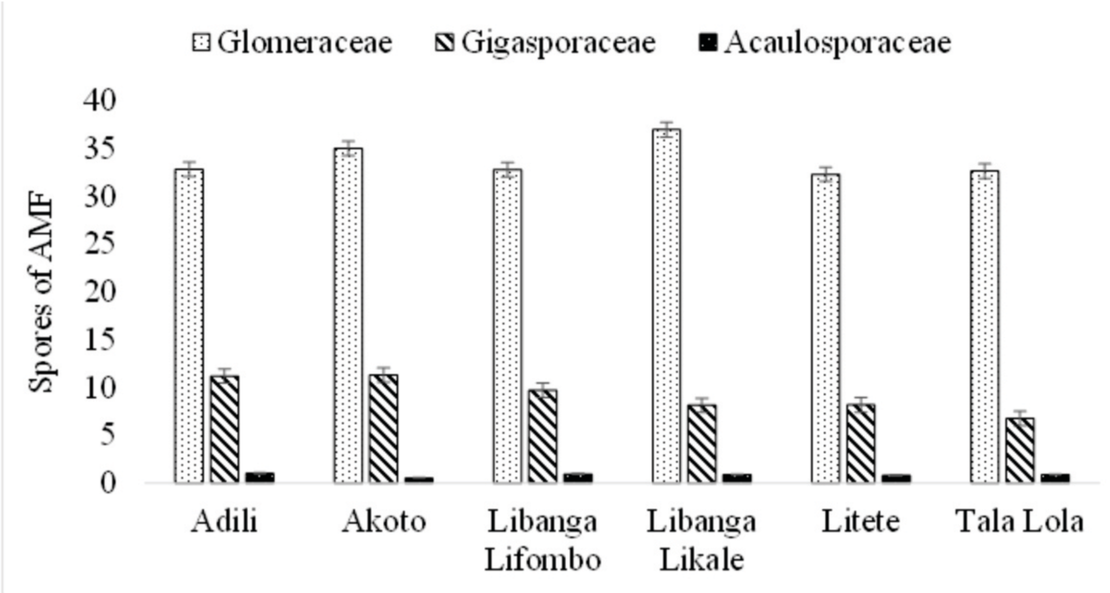

Figure 5: Spore number of 3 AMF families in relation with plantain cultivar

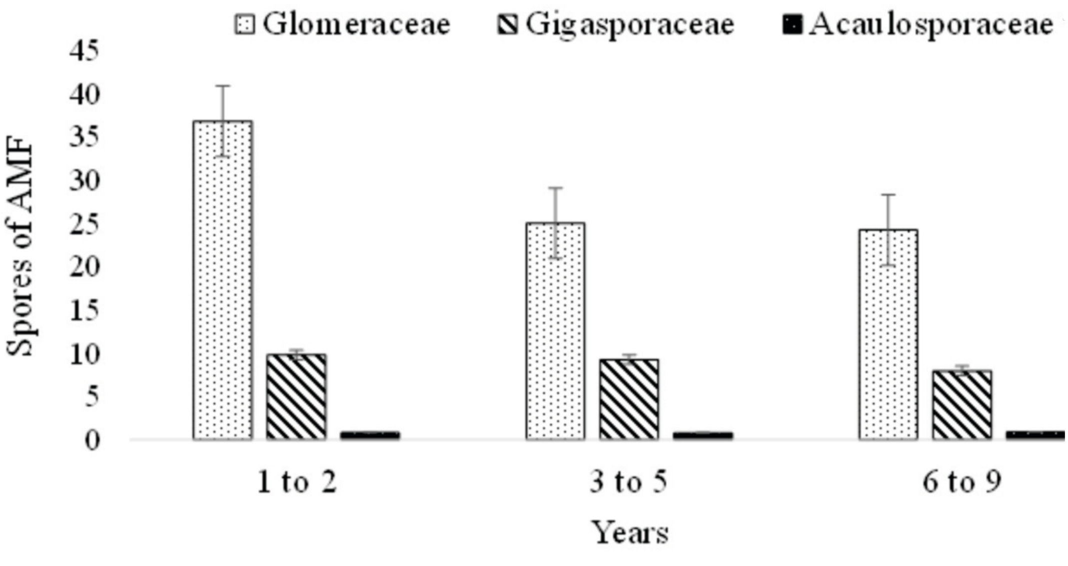

Figure 6: Spore number of 3 AMF families in relation with the plantain field age

on mycorrhizae. The AMF presence in all natural soils types is explained by a wide variety of strains and mycorrhizal species, and not always by their respective populations.

With regard to AMF families, Glomeraceae was more represented in all agrosystems than Gigasporaceae and Acaulosporaceae. This is in agreement with the observations of Lakshmipathy *et al.* (2012). In a study carried out in six land use types (natural forest, grassland, acacia plantations, cardamom plantations, coffee plantations and paddy fields) in the Niligiri Biosphere of the Western Ghats in South India, these authors found a large species number belonging to the family of Glomeraceae. Thus, among the 56 species of AMF identified during the pre-monsoon season and the 67 species identified in the post-monsoon season, the species *Glomus fasciculatum* was the most abundant, followed by *G. geospore* and *G. mosseae.* Furthermore, Declerck (2011) mentioned that Glomeraceae, to which the genus *Glomus* belongs, is the most abundant and most common AMF group. In our study, forest and fallow agrosystems revealed a high relative abundance but do not have much diversity. Disturbances due to repetitive cultural practices in Kisangani region may have caused the low diversity of the AMF families. The few present families have abundant members which could have adapted and survived from disturbances. In a study conducted in Turkey, Karaarslan *et al.* (2015) inventoried only three AMF species on bulb plants with a very variable abundance (61.54 % *Glomus mosseae*, 23.07 % *G. hoi* and 15.38 % *Scutellospora calospora*). The results observed by Brito *et al.* (2012) reveal that the abundance and the role of AMF are negatively influenced by ploughing and amendments.

The results of this research corroborate those obtained by Lakshmipathy *et al.* (2012) who observed a greater specific diversity of AMF in natural forest and fallow in India. These authors conducted their study in undisturbed ecosystems, explaining the high specific diversity they observed. These confirms the first hypothesis, but the diversity between agrosystems however did not vary.

The AMF abundance and diversity with regard to plantain vigour

The results revealed that vigorous plantain plants have a higher degree of mycorrhizal root colonization than non-vigorous plantain plants. In addition, fields with vigorous plants have more AMF spores for all mycorrhizal families than those with non-vigorous plants in the three agrosystems. The presence of vigorous plants is an indicator of the high fertility level of plantain fields due to presence and increased availability of major soil minerals (N, P and K) as well as other minerals essential for plantain growth.

Thus, the high AMF spores abundance attests to their action in improving the availability of nutrients in the soil. Through this action, plantain vigour is enhanced by nutrient-rich in agrosystems. However, these results deviate from observations made by previous studies under experimental conditions. For instance, Sieverding (1990) observed that when fertilization is intense, plants become independent from mycorrhization, this tends to drastically decrease the AMF diversity by selecting in the population, the AMF species capable of infecting the root system despite physiological changes in the host. Our study did not compare the initial nutrient level in the different systems.

It turns out that the use of mineral fertilization is not common in the peasant plantain fields of our study region. Mineral fertilizers have ability to make nutrients available to the plant instantly and can limit the extent of the root system. Thus, it is important to evaluate the separate effects of this mineral and organic fertilization, mainly made of compost and dung, used by local farmers. We can therefore think that the AMF action is crucial to extend root access to mineral elements and improve the plantain plant vigour. Given these results on the plantain vigour, the second hypothesis is confirmed, only the abundance and not diversity was varied.

Influence of soil characteristics of plantain fields on AMF

Because the precise effects of soil characteristics have not been measured on each mycorrhizal family in isolation, it cannot illustrate that each inventoried family has exclusive affinity for its assigned edaphic parameter. The edaphic factors mentioned above have a positive or negative influence, in very variable proportions, with all the AMF families.

Lakshmipathy *et al.* (2012) found under Niligiri conditions in India that sand content, porosity, total nitrogen content, organic carbon content and exchangeable bases were positively correlated with AMF activity. However, clay, silt, potassium, total phosphorus and exchangeable phosphorus were rather negatively correlated with their activity. Our study reveals a high level of total nitrogen in plantain fields located in fallow (8.21% N) and forest (4.3% N) were AMF activity is more intense than in homegarden (4.1% N). In addition, clay, silt and total phosphorus proportions which negatively affect AMF activity, are important in homegarden. However, Karaarslan *et al.* (2015) found under Turkish conditions that the number of AMF spores varied significantly with soil texture: clay soils had more AMF spores (124 spores per 10 g of soil) than sandy soils (78 spores per 10 g of soil). The same authors have discovered a negative effect of pH, $CaCO_3$ and K_2O on the AMF spores number in bulbous crops, a variable effect of the organic matter content on the AMF spores number depending on the plant species studied. The same authors noted a significant and positive effect of organic matter, total nitrogen, phosphorus, zinc and soil texture on mycorrhizal root colonization of all studied plant species. There could be the influence of plant species on these soil characteristics. In our study, the soil pH of fallow and forest fields is more acid than the homegarden soil pH. Sheikh *et al.* (1975) reported low spore abundance in soils rich in organic matter. Our study indicates that homegarden soil was richer in organic matter than fallow soil, but less than forest soil.

The soil phosphorus concentration negatively affects mycorrhizal root colonization in most plants (Declerck, 2011). Phosphorus levels are one of the most important factors affecting not only mycorrhizal root colonization but also the length of plant roots. Thus, Karaarslan *et al.* (2015) found that phosphorus positively affect both the rate of root infection and the root length of bulbous plants studied in Turkey. The importance of edaphic parameters for the AMF specific diversity is not very well known, however mycorrhizal production in the form of spores can increase with pH and organic carbon and decrease with increasing soil phosphorus content as mentioned by Menge *et al.* (1978). Kombele (2004) observed in Yangambi and Yakonde in the central Congolese basin, that the phosphorus content reaches its maximum in the superficial soil layers and horizons of the profiles and decreases towards depth, this decrease reveals that the phosphorus in this soil is almost entirely of organic origin. Nyssens (2012) mentioned that the Martinican soils have a great phosphorus fixing power, suitable for the development of the AMF. Thus, the relation between the phosphorus content and AMF activity needs to be more studied in the forest region of Kisangani. Our results attest to the influence of the soil physicochemical characteristics on the AMF families abundance in plantain agrosystems.

Conclusions

The purpose of this study was to assess the plantain AMF abundance and diversity in the Kisangani forest region with regard to plantain agrosystems, plantain vigour, and plantain fields soil characteristics. The mycorrhizal root colonization of plantain and the AMF spore number were higher in fallow and forest fields than in homegardens. In addition, the most vigorous plantain plants have a higher mycorrhizal root colonization and AMF spore number than non-vigorous plantain plants. This suggests that the vigour of plantain could be a result of mycorrhizal root colonization.

The family of Glomeraceae is the most abundant in all agrosystems than Gigasporaceae and Acaulosporaceae families. The edaphic factors have a positive or negative influence, in variable proportions, with the studied AMF families.

These results inform that forest and fallow agrosystems and vigorous plantains have the best mycorrhizal potential in the Kisangani forest region. This presents the possibility of isolating the most effective local mycorrhizal strains to be exploited for the biofertilization of plantain in the forest region of the Congo Basin in the Democratic Republic of Congo.

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