Arbuscular Mycorrhizal Fungi Association with Some Selected Medicinal Plants

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Authors’ contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Arbuscular mycorrhizal fungi (AMF) are group of fungi of the order Glomales that form symbiotic association with plant roots and enhance the uptake of nutrients, and improve plant growth and yield. This study was conducted to investigate the occurrence of arbuscular mycorrhizal fungi in the rhizospheres of some commonly grown medicinal plants in Maiduguri viz; Aloe vera, Mentha, Cymbopogon citrates and Ocimum gratissimum. The results revealed all the plants have formed mycorrhiza symbiosis. Arbuscular mycorrhizal fungi spores from five genera (Glomus, Acaulospora, Dentiscutata, Scutellispora and Gigaspora were isolated and identified. Cymbopogon citrates significantly recorded the highest total AMF spore counts (90±4.17) while Aloe vera recorded the least (54±2.28). Amongst the five mycorrhiza genus Glomus species were comparatively higher under all plant species, while, Dentiscutata and Gigaspora had the lowest spore counts. Highest percent root colonization (72±4.23%) was recorded under Cymbopogon citrates and Aloe vera recorded the least (55.5 ±2.41%). The study confirmed mycorrhiza association with all the plants, however, AMF spore counts diversity varies with plant species. Arbuscular mycorrhizal fungi could be inoculated to soils with scanty or ineffective spores for enhanced plant nutrition and growth of medicinal plants.

Keywords: Arbuscular mycorrhizal fungi; medicinal plants; aloe vera; menthe; cymbopogon citrates and ocimum gratissimum.

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1. INTRODUCTION

The world health organization (WHO) estimated 80 % of worldwide population used medicinal and aromatic plants (MAP) for their medicinal therapy [1]. An estimation of 50,000 to 80,000 People around the planet had been revealed to use flowering plants for as medicines [2]. Many medicinal herbs possess some dietary supplements that are good sources of antioxidants and anti-inflammatory compounds [3]. Public interests in using herbs are increasing due to concern about side effects of synthetic drugs. In this regard, the cultivation of MAP is receiving attention, at commercial level. The pressing demand for medicinal plants and their products has created ground for their any-how cultivation. In order to sustain increasing demand different soil management practices are employed, thus making the product unstable and affect products quality. With the discovery of research in medicine, it was found that the plant contained abundant of principal active metabolites which can be used to treat and cure numerous diseases. As a result, researchers are focused on how to increase production of medicinal plants with no chemicals. Many soil microbes form symbiotic association with plants, among them AMF stand out because of their enhanced plant nutrition, stress tolerance, production of growth promoting substances and protection from root pathogen [4,5]. AMF symbiosis attributed to favorable characteristics of medicinal plants, by improving the production and accumulation of important active ingredients such as terpenes, phenols, and alkaloids. The association also optimized the composition of different active ingredients in medicinal plants and ultimately improved the quality of herbal materials and total yields. A large number of medicinal plants have been reported by different researchers to harbor AMF [6,7]. On the contrary such study has not been conducted in this study area. Furthermore, there have been reports that AMF symbiosis plays a positive role in the accumulation of alkaloids in some important medicinal plants, such as camptothecin in Camptotheca acuminata and vinca alkaloids in vinca (C. roseus) which have important anticancer functions [8,9]. Considering the benefits accrued from AMF symbiosis with medicinal plants it is paramount to utilize these fungi as bio-fertilizer for their cultivation. The present study was conducted to investigate spore population and colonization percentage of AM fungi in the rhizospheres of some commonly grown medicinal plants in Maiduguri viz; Aloe vera, Mentha (mint), Cymbopogon citrates (lemongrass), Ocimum gratissimum (African basil).

2. MATERIALS AND METHODS

2.1 Collection of Soil Samples

Four medicinal plants; Aloe vera, Mentha, Cymbopogon citrates, Ocimum gratissimum were selected from a commercial garden in Maiduguri for the present study. Rhizospheres soils (0-20 cm depth) and feeder roots of each plant species were collected from plants immediately after digging the plant from the ground for soil physico-chemical properties and mycorrhiza investigation (AMF spores and percent colonization). Sampled soils were transported to the laboratory in a polythene bag. Stone debris, root fragments >2 mm and any visible animal materials were handpicked. The soil samples were spread for air-drying in the laboratory and later passed through 2 mm sieve for subsequent analysis.

2.2 Soil Physico-Chemical Properties

Air dried soil samples was analyzed for soil texture, soil reaction (pH), organic carbon (OC), available P, NO$_3$-N, and K. Soil pH was measured using pH meter in 1:5 (soil: water) ratio suspension, EC was calibrated with EC meter, % OC was determined by loss-on-ignition method as described by [10]. Available P was analyzed using Bray 1 method [11] and the absorbance measured at 882 nm in a spectrophotometer. Extractable K was assessed using flame photometer as outlined by [12], NO$_3$-N, using UV-VIS spectrophotometer at420 nm [13].

2.3 Isolation and Identification of AMF Spores from Soil Samples

Arbuscular mycorrhiza spores were isolated using wet sieving-and-decanting techniques [14]. To 50 g of the air dried soil, substantial amount of water was added and stirred vigorously. The suspension was left to settle for 2-3 minutes. Supernatant was decanted over stack of sieves (750, 500, 250, 180, 100 and 38 μm) arranged from top to bottom in decreasing order of mesh size. The spores were examined and sorted according to morphological characteristics (spore size, colour, shape and sub-tending hypha) spores collected were mounted onto slides for
identification according to [15] manual and counted under a compound microscope (4X). Spore density was expressed in 50 g soil.

2.4 Percentage Root Colonization

Roots were investigated for root colonization after clearing root by heating at 90˚C with 10% potassium hydroxide (KOH), acidified with 2% (v/v) hydrochloric acid (HCl) and stained in 0.05% trypan blue following the method described by [16]. Percent root colonization was calculated using the formula below;

\[
\text{% Root colonization} = \left( \frac{\text{No. of colonized root}}{\text{Total root No}} \right) \times 100
\]

2.5 Statistical Analysis

All data collected were subjected to analysis of variance (ANOVA). Differences between treatments were separated using Fisher’s least significant difference (LSD) at 5%.

3. RESULTS AND DISCUSSION

The basic physico-chemical properties of the studied soil was characterized as sandy loam soil (56% sand, 25.1% silt and 18.9% clay), neutral pH (6.7), with EC (1.3 dS m\(^{-1}\)). The soil had nitrogen (0.17%), organic carbon (0.96%), available soil P (5.8 mg kg\(^{-1}\)), and exchangeable K (0.32 meq/100 g soil). Mycorrhiza association of the four medicinal plant species under investigation is depicted in Figs 1-3. Results revealed that Aloe vera, Mentha, Cymbopogon citrates and Ocimum gratissimum formed mycorrhiza symbiosis. Arbuscular mycorrhizal fungi spores from five genera (Glomus, Acaulospora, Dentiscutata, Scutellispora and Gigaspora) were isolated and identified. Cymbopogon citrates significantly recorded the highest total AMF spore counts (90±4.17) while Aloe vera recorded the least (54±2.28) as shown in Fig. 1.

Amongst the five mycorrhiza genus Glomus species were comparatively higher under all plant species, while, Dentiscutata and Gigaspora had the lowest spore counts (Fig. 2).

There was no statistical difference in % root colonization of Cymbopogon citrates, Mentha and Ocimum gratissimum. Highest percent root colonization (72±4.23%) was recorded under Cymbopogon citrates and Aloe vera recorded the least (55.5 ±2.41% ). It is important to count AMF spores because the greater the presence of spores, the greater the positive effects that these fungi will have on plants, especially on species of economic interest [17]. Research shows that the presence of spores in soil can minimize the cost of agricultural inputs, such as mineral fertilizers, irrigation and pesticides, especially in the tropics where traditionally soils have low levels of phosphorus [18]. As observed in this study arbuscular mycorrhizal fungi was not host specific because AMF diversity and % root colonization were recorded under all plant species. However, variation in spore counts and percent root colonization could be attributed to different root architecture and exudates produced by different plants. Plant preference by AMF could be ascribe to plant physiology [19] among

![Fig. 1. Total spore population counts of arbuscular mycorrhizal fungi under different plant species](image-url)
plant species and susceptibility to symbiosis could vary due to root architecture providing suitable condition for sporulation. Competitive ability of AM fungus to form symbiosis with plant roots varies between host plants. Differences in rate of spore germination and hyphal growth vigour are governed by root exudates [20, 21] which might influence AM fungi to undergo physiological changes enabling higher root colonization.

Evidence indicating *Glomus* as the most dominant arbuscular mycorrhizal fungi as reported in our studies have been referenced [22,23]. They concluded that *Glomus* and *Acaulospora* could favorably dominate tropical soils compared to other mycorrhiza genus due to their broad host range [24].

4. CONCLUSION

The study confirmed mycorrhizal association with all the plants species. AMF spore counts and diversity varies with plant species. *Cymbopogon citrates* recorded the highest total spore counts and percent root colonization. Arbuscular mycorrhizal fungi could be inoculated to soils with scanty or ineffective spores for enhanced plant nutrition and growth of medicinal plants.
COMPETING INTERESTS

Authors have declared that no competing interests exist.

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