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Growth media and mycorrhizal species effect on acclimatization and nutrient uptake of banana plantlets

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ABSTRACT

The objective of this study was to investigate the acclimatization and performance of banana (Dwarf Cavendish) in two substrates inoculated with different AM fungi (*Glomus. caledonium* and *G. macrocarpun*) and assess the plantlets dependency on inoculation for phosphorus (P) and zinc (Zn) uptake along with biomass development. In addition, to investigate the role of mycorrhizal fungi in supporting acclimatization phase, a plant growth promotion study was set-up in greenhouse using micropropagated plantlets. Two growth media, as GM-I and GM-II were used accompanied by *G. caledonium* and *G. macrocarpum*. In first phase, 9 weeks acclimatization study was conducted and in second phase, acclimatized plants were propagated for 16 weeks in both inoculated and non-inoculated conditions. Plantlets acclimatization and nutrient uptake were recorded along with other parameters. Mycorrhizal inoculation significantly increased banana plantlets growth, root infection and P uptake. Plantlets inoculated with *G. caledonium* exhibited increase in shoot and root dry mass, P and Zn concentration, and root infection in the GM-I. The shoot and root dry mass, P and Zn concentration, and root infection were higher in GM-I than Konaktas soil series. Banana plantlets are mycorrhizal dependent (MD) and soil-grown banana plantlets are more MD than plants grown in the GM-I. Mycorrhizal inoculation seems to be a significant factor in decreasing mortality and increasing production of high-quality banana plantlets under micropropagation conditions.

1. Introduction

Bananas are the second premier fruit crop, widely grown in developing countries and makes with production of 106 million tons followed by citrus (FAO, 2013; Madhulatha et al., 2004). Banana is a sensitive crop which faces a number of diseases on growing via vegetative propagation. To eliminate such risks, and develop disease-free planting material, bananas are micropropagated on a large scale, which has additional benefits of high multiplication rate, optimized use of resources (plant material) and the production of high-quality plant.

As the micropropogated plants are more sensitive to environmental changes (Vestberg et al., 2002), early inoculation with *G. intraradices* enhances the growth of bananas by improving nutrient uptake (Pinochet et al., 1997). Phosphorus makes 0.2% dry mass of banana plantlets and it's availability become more crucial for tissue-cultured plantlets in changing environment (Schachtman et al., 1998).

Arbuscular mycorrhizal (AM) fungi are widely recognized for plant growth improvement by nutrient uptake and assistance stress tolerance (Barea et al., 2005; Declerck et al., 2002; Johansson et al., 2004). Wide extension of mycorrhizal hyphae increase ability of roots to absorb nutrients by enhancing surface area mainly for depleted soils (Smith and Read, 2008). AM fungi facilitate in plant growth under nursery conditions (Douds et al., 1993; Jefwa et al., 2009; Kavoo-Mwangi et al., 2013) by colonizing 80% of the terrestrial plants (Brundrett, 2002). Banana roots are also colonized and increase plant vigour which enhances water absorption, mineral nutrient uptake, and mainly the phosphorus. Micropropagated plantlets are expected to be microbe free including pathogenic and non-pathogenic bacteria and AM fungi (Yano-Melo et al., 1999). Besides that, different species of *Glomus* are effective in promoting banana plantlets growth (Mwashasha et al., 2011; Yano-Melo et al., 1999).

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Fig. 1. Banana plantlets acclimatized up to 9 weeks and propagated further for 16 weeks in GM-I and GM-II.

Survival and development of mycorrhizal propagules depend on environmental factors such as soil types, fertility status, plant species and fungal strain which assist in establishment of symbiosis (Plenchette, 2000). In addition, survival of micropropagated banana plantlets is low on transplanting into sterile soil, therefore use of mycorrhizal fungi and other rhizospheric organisms is worthwhile to support plantlets survival and growth. At the beginning of weaning stage, growth response of micropropagated banana plantlets depends on plantlet variety and type of AM fungal inoculation (Declerck et al., 1995). The climate of Turkey is supportive for banana cultivation, however the banana production rely on nutrient management where, supply of P and Zn through AM fungi resides key role; therefore, the AM fungi application enabling sufficient nutrient supply could be a novel option along with chemical-P fertilizer for banana cultivation in Turkey. Deficiency of Zn is a worldwide problem among humans, where one-third of the human population suffers from Zn deficiency (Hotz and Brown, 2004).

The objective of this study was to investigate the performance of banana in two substrates inoculated with different AM fungi and assess the plantlets dependency on inoculation for nutrient uptake and biomass development. To the best of our knowledge, mycorrhizal species (*G. caledonium* and *G. macrocarpum*) and substrates have not been previously investigated to determine their role in nutrient uptake and biomass development of banana plantlets (*Dwarf Cavendish*). The present study could be baseline for use of specific mycorrhizal fungi in promoting banana plantlets growth under greenhouse conditions.

Table 1
Chemical properties of soil, compost and andesitic tuff.

Properties	Unit	Soil	Compost	Andesitic tuff
pH	(1:1 H_2O)	7.4	7.91	–
Clay	g kg^{-1}	330	–	–
Silt	g kg^{-1}	200	–	–
Sand	g kg^{-1}	470	–	–
CEC	cmol$^+$ kg^{-1}	16.57	–	–
C_{org}	%	2.47	54.2	–
N	%	–	1.13	–
P	kg ha^{-1}	32.6	0.18	0.03
K	%	0.006	0.98	4.3
Ca	%	0.21	2.5	–
Mg	%	0.22	0.27	–
Zn	mg kg^{-1}	0.64	40	0.1
Fe	mg kg^{-1}	3.76	1005	2
Cu	mg kg^{-1}	3.21	12	0.2
Mn	mg kg^{-1}	0.95	141	3.6

2. Materials and methods

2.1. Plant material and culture collection

Banana plantlets were produced via micropropagation technique by preparing the plant material and culture. The banana cultivar Dwarf Cavendish was obtained from a commercial banana grower and cultured according to the standard protocol (Kaçar et al., 2010).The MS basal salt mixture was supplemented with Morel vitamins 1 mg L^{-1} each (Ca pantothenate, Thiamine HCl, Pyridoxine HCL and Nicotinic acid), 0.01 mg L^{-1} Biotin and 100 mg L^{-1}