SOIL MICROBIOLOGY AND SUSTAINABLE AGRICULTURAL SYSTEMS: APPLICATION OF BENEFICIAL MICROORGANISMS IN AGROECOSYSTEMS IN THE CANARY ISLANDS

M.C. Jaizme-Vega y A.S. Rodríguez-Romero
Instituto Canario de Investigaciones Agrarias
Apdo. 60-38200 La Laguna, Tenerife, Islas Canarias
e-mail: mcjaizme@icia.es

Introduction

Soil microbiology can be defined as the study of organisms inhabiting in soil, their metabolic activity and their functions within energy flows and nutrient cycling [1]. The biological fraction of soils is now considered to play a fundamental role in soils fertility, i.e. biology fertility, which involves organic reserve, as well as abundance and activity of soil biomass. Plant-associated microbiota has demonstrated their crucial role in maintaining soil ecological balance and therefore the sustainability of either natural ecosystems or agroecosystems [2]. Among others, soil microorganisms are involved in nitrogen fixing or humus synthesis. They can also promote vegetal development through the production of phytohormones, protect plants against root pathogens or ease soil pollution by degrading toxic substances [2]. Therefore, the knowledge of the soil microbiology is essential to understand agronomy.

In the same way, soil microorganisms can influence agroecosystems activity; they can be affected by environment. Environmental conditions (temperature, humidity, solar radiation...) and crop management (crop type and variety, fertilisation, pesticides...) may drastically affect soil microbial populations. Therefore, crops sustainable management should include practises that contribute to preserve soil microbial activity and health, which in turn, assures soil health and fertility.

Microbial activity is mainly concentrated around the roots, within the zone of soil directly surrounding and influenced by them, which is called the rhizosphere, as a result of the organic compounds constantly released by roots. This process known as the rhizodeposition involves a large portion of the matter photosynthesized by the plant and provides a substantial amount of nutrients to soil microbes [3]. Plant-microbe interactions that take place within the rhizosphere area are among the major factor to regulate plant health and growth [2]. Two main groups of microorganisms can be distinguished: saprophytes and symbionts. Both of them comprise detrimental, neutral and beneficial bacteria and fungi. Among these beneficial rhizosphere microbes, arbuscular mycorrhizal fungi (AMF) and plant growth-promoting rhizobacteria (PGPR) can be considered.

Arbuscular mycorrhizal fungi are obligate symbionts that colonise the roots of most cultivated plant species. Mycorrhizal symbiosis can be found in nearly all types of ecological situations and most plant species are able to form this symbiosis naturally. Mycorrhiza establishment involves benefits for both partners, plant and fungus. These associations occur naturally when plantlets are transplanted into the field, favouring plant development by increasing nutrient uptake, growth rates and hormonal activities [2].
Mycorrhizae may also increase plant tolerance to stress conditions such as salinity, drought, heavy metals, root soilborne pathogens and the improvement of soil structure [2]. An increasingly interest in their application as biofertiliser to ease plant stress situations, as well as the significant presence of high quality commercial products based on mycorrhizal inoculants is favouring the integration of these symbionts within vegetal production systems.

Plant growth-promoting rhizobacteria are able to colonise the root surface, survive and multiply in microhabitats associated with the root surface, in competition with native microbiota; at least to express their plant promotion activities. Certain strains of *Pseudomonas, Bacillus, Azospirillum, Azotobacter, Enterobacter* or *Serratia*, have been frequently described as PGPR. Their positive effect on plant development has been described for different crops; both herbaceous such as potato and soybean or woody ones such as apple and citrus [4]. Several mechanisms, which involve phytohormone production, mineral solubilisation and availability or biological control of soilborne pathogens, have been proposed to explain bacterial activity. Certain crucial environmental processes such as nutrient cycling or seed establishment are also attributed to rhizobacteria [5, 6].

**Isolation and multiplication of rhizosphere microorganisms**

Both mycorrhizal fungi and rhizobacteria can be isolated from their natural environment (soil and/or roots) and later multiplied in the laboratory or in the greenhouse. This feature has contributed to the establishment of mycorrhiza and rhizobacteria isolates collections for further studies. The study process involves multiplication and selection through specific bioassays where isolates are evaluated on different plant species, having different propagation systems and different management conditions. These bioassays allow determining the biofertiliser and biocontrol ability of the isolates. The optimisation of large-scale multiplication techniques by certain enterprises has contributed to develop high quality commercial inoculants for agricultural proposes.

**Application of rhizosphere microorganisms on some crops with agronomic importance in the Canary Islands**

In the recent years, numerous studies have been conducted in order to determine, the effect of these microorganisms as biofertilisers and biocontrol agents against certain root pathogens. Those studies have been conducted on different plant species of agronomic interest and under closer commercial conditions. Summarized results from some of these works are presented herein.

**AMF-fodder crops**

Several tedera or psoralea species (*Bituminaria bituminosa* L. var. albomarginata), are well distributed in the Canary Islands. This autochthon leguminous specie traditionally used as fodder has been also considered for reforestation of degraded soils. A previous work conducted under nursery conditions confirmed the positive effect of several mycorrhizal isolates on different ecotypes of this plant specie [7]. Benefits of *Glomus mosseae* inoculation on Famara ecotype (one of the most difficult agronomic management) are shown on Figure 1 [8]. Aerial biomass of mycorrhizal plants was two folds higher while root biomass was five folds higher as compared to non-inoculated plants.
AMF-tomato

Tomato culture (*Solanum lycopersicum* L.) is one of the most important crops in our region both economically and socially. Despite it is described to be able to establish mycorrhizal symbiosis; practical application is not always easy, due to the high degree of sophistication of recent commercial seeds. Thus, several works have been conducted to determine under organic management whether commercial varieties can be benefited of mycorrhization on harvest [9, 10] (Figure 2).

AMF-rhizobacteria-tropical crops

Rhizosphere microorganisms’ inoculation (AMF), during the early phases, can contribute to improve plant development and nutritional status as well as tolerance to stress conditions. In order to gather up more data, in the last decade, several works on the combined effect of both types of microorganisms on plant development or against root pathogens have been performed [11, 12]. Results have confirmed beneficial effects of rhizobacteria on banana plants: plants inoculated with any of both microorganisms had a significant higher development as compared to non-inoculated plants (Figure 3). In addition, combined effect of both types of rhizosphere microbes was higher to individual effect of any of them.
Concerning to papaya, another tropical crop economically important in our region, our results showed protection provided by mycorrhization against nematodes from *Meloidogyne* genus, while no effective protection was detected due to rhizobacteria presence (Figure 4).

**Conclusions**

According to our results as well as results from other authors, the inoculation of these rhizosphere microbes during early phases have demonstrated consistent improvements in plant development and nutritional status and may contribute to reduce plant stress.

Research advances in the recent years have worked out some basic biology aspects from those microorganisms which led to a more complete outlook of these plant-microbe interactions. Consequently, increasing high quality production inocula, either *in vivo* or *in vitro*, may facilitate their application under certain circumstances. AM fungi and rhizobacteria early inoculation may be included in intensive production systems or in poor soil systems which have a minimal microbial population level unable to assure soil fertility. Otherwise, organic agrosystems should contain their own microbial population richness from selected native strains as a consequence of their adaptation to the environment. In
this case, cultural practises should be conducted to preserve and enhance natural sustainability of the systems.

References


