II IBEMPA CONFERENCE

MICROORGANISMS FOR FUTURE AGRICULTURE

XIV National Meeting of the Spanish Society of Nitrogen Fixation (SEFIN)

XXVI Latin American Meeting on Rhizobiology (ALAR)

III Spanish-Portuguese Congress on Nitrogen Fixation

del 2 al 6 de SEPTIEMBRE 2013
Sevilla
II IBEROAMERICAN CONFERENCE ON BENEFICIAL PLANT - MICROORGANISM - ENVIRONMENT INTERACTIONS (IBEMPA)

XIV NATIONAL MEETING OF THE SPANISH SOCIETY OF NITROGEN FIXATION (SEFIN)

XXVI LATIN AMERICAN MEETING ON RHIZO BIOLOGY (ALAR)

III SPANISH-PORTUGUESE CONGRESS ON NITROGEN FIXATION

“Microorganisms for future agriculture”
Efficient soil microbial consortia: a new dimension for agriculture and environmental sustainability.

Cruz, C.1*, Delgado, M.1, Melo, J1, Meleiro, I.1., Gouveia, C.1, Eutrópio, F.1,2, Costa, R.1, Carolino, M.1, Carvalho, L.1, Correia, P.1
* ccruz@fc.ul.pt

ABSTRACT
Central to virtually all practices that contribute to sustainable agriculture are measures that cultivate and promote a diverse soil biota. The endogenous processes and potentials found within soil systems serve to sustain and enhance production in the long term, while promoting ecosystem health. Farming practices that increase soil biodiversity can create multiple benefits for farmers, farming communities and societies worldwide. We intend to stimulate soil biota activity by creating 1) catabolits resultant from in vitro microbial activity, and/or 2) microbial consortia able to interact with plant roots and improve soil functions in the perspective of the plant-microbial soil system in the biosphere.

INTRODUCTION
The striking increases in agricultural production during the last century have been achieved through massive inputs into farming systems. It was estimated that the doubling of world food production since 1950 was accompanied by seven- and 3.5-fold increases in the annual global fertilizer application of nitrogen and phosphorus. However, we are rapidly reaching the limits of resource availability and the capacity of agro-ecosystems to remain productive. The real challenge is to encourage agricultural practices that reduce the impact of farming practices on the environment while using existing ecosystem services to increase production. Researchers and farmers have to focus more on working with the soil biota and their functions to allow the sustainable use of soils, to the benefit of both agriculture and environment. In our lab we work on the hypothesis that soils are complex systems in which living organisms are fundamental to the preservation of their quality and capacity of production. In this context we aim at promoting practices that contribute to sustainable agriculture by promoting and cultivating a diverse soil biota. The endogenous processes and potentials found within soil systems serve to sustain and enhance production in the long term, while promoting ecosystem health.

MATERIAL AND METHODS
Most of our research is performed using tomato (Solanum lycopersicum) or maize (Zea mays) as host plants, since they are good hosts for rhizospheric microbial communities and respond to microbial improvements of the rhizosphere even in the presence of high concentrations of fertilizers. They are also cultivated using several and distinct agricultural practices, and represent two types of farmers, cereals and horticulture. All the experiments concerning the response of maize and tomato to microbial consortia started by assessing field microbial diversity, identifying microorganisms with the desired characteristics, and testing their efficiency and functionality in consortia associated with roots, and later in the presence of the total soil microbial community (field trials). The assessment of the pros and cons of using microbial consortia to stimulate productivity always included: soil biological quality assessment,
environmental impacts, productivity, and sustainability (including economical viability).

RESULTS AND DISCUSSION
It is known that soils have a real power to shape our planet, however, most people are unaware that the key drivers of soil ecosystems are the quantity and quality of living organisms, and the interactions between them. In our work using root consortia in association (or not) with catalobites resulting from microbial activity and taking in consideration the structure and function of the original rhizospheric community we were able to improve photosynthesis, plant defence, plant hormonal balance (auxin, cytokinins and ethylene), rhizodeposition, root biomass allocation and nutrient use efficiency (N and P), Figure 1.

When engineering the structure and function of the rhizosphere it is crucial to have in mind that “forced socialization is not socialization” meaning that before putting the microorganisms together based on their potential to perform certain functions, it is important to access their potential to work together and to form a working team.

In this context we performed a pot experiment to test the effects of the co-inoculation of arbuscular mycorrhiza fungi (AMF) and a commercial bacterial inoculant AMC2. Soil was collected from a field used to grow maize for more than 4 years. Results showed that the positive effects of the bacterial inoculant could be further improved (34–49%) with the co-inoculation of certain strains of AMF (Figure 2). These effects were visible at an early stage of the maize development, which is fundamental to assure a good start up of the culture. The improvements in biomass accumulation were due to a higher efficiency in taking up phosphorus, and nitrogen (Figure 2). From the analysis of the natural nitrogen isotopic signature of the maize leaves it was clear that AMF inoculants were interfering in the nitrogen sources used by the plant.
Figure 2. Shoot biomass, phosphorus and nitrogen content of maize plants grown in pots filled with soil from a maize field and not inoculated (control), inoculated with a consortium of benefit bacteria (AMC), or co-inoculated with the consortium of benefit bacteria and AMF fungi. Maize plants were grown under these conditions for 30 days. (n = 10).

The enrichment of the maize leaves, of the plants inoculated with AMF, in the heaviest nitrogen isotope ($^{15}$N) is (in the context of the experiment) a clear indication that the use of AMF inoculants (apart from those present in the soil) were facilitating the plant access to other forms of nitrogen, very possibly to organic nitrogen present in the soil organic matter.
Figure 3. Natural nitrogen isotopic signature of the maize leaves. All the treatments received the same amount and source of nitrogen. (n=3). For more details see legend of Figure 2.

From the applied point of view these results are very promising since they highlight the importance of taking advantage from the interactions of bacteria and fungi in soil and from theoretical point of view it also opens great challenges since it points out for the importance of AMF to mediate nitrogen acquisition by the plants, even in presence of high levels of fertilization.

ACKNOWLEDGEMENTS
The authors thank the FCT for the financial support of PTDC/AGR-PRO/115888/2009 and PTDC/BIA-ECS/122214/2010; and ADP fertilizantes and AMC chemicals for their collaboration in the realization of this work

REFERENCES