Year of CfP: 2009

Project No 0901-002 Completed

Project title: Agriculture sources of atmospheric biological ice nucleators in dryland cropping systems (DryLand BioIce)

Unit managing the project: AVI-PATHO (Plant Pathology) [INRA]

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Countries involved in the project: USA, Syria (ICARDA)

Research units from the Foundation's scientific network involved: EMMAH

Sub-thematic axes: IPB-2 (Integrative Plant Biology 2: *Plant pests and diseases, integrated crop protection, population ecology*)

Objectives:

With the growing awareness of climate changes on our planet, interest in atmospheric processes that define climate has heightened and diversified. Due to the abundance of micro-organisms in the atmosphere and the wide range of properties that could foster their direct involvement in atmospheric processes, numerous hypotheses have recently emerged about their roles.

One of the roles of micro-organisms in atmospheric processes that are receiving considerable interest concerns their potential to enhance rainfall. This role would be facilitated by their ability to act as cloud condensation nuclei and as ice nuclei. Several plant-associated bacteria are among the most highly active ice nuclei naturally present in the atmosphere. It is currently suspected that one of the limiting factors for rainfall can be the abundance of active ice nucleators in clouds.

The major source of biological ice nucleators are plants. Most of the microbial ice nucleators are inhabitants of leaf, stem and fruit surfaces. Hence, land use and management practices have an important effect on the abundance and variety of microbes in the atmosphere. Furthermore, the nature of the landscape (spatial organization of plants and other features) and deployment of management practices have marked impacts on the microclimate causing variations in temperature, relative humidity, wind speed and turbulence near the plant canopy. These variations could be sufficient to cause changes in microbial growth on plants and their flux into the atmosphere.

The objective of this project is to identify agricultural sources of biological ice nuclei in the atmosphere, as well as agro-climatic conditions that favor emission of aerosols containing these biological ice nucleators in dryland cropping systems of the Mediterranean region. Particular focus will be on regions covered by the ICARDA regional programs, especially those in North Africa, West Asia and other parts of the Mediterranean basin. The data obtained will then be used to establish a project proposal on the interaction of cropping systems and rainfall patterns.

Action carried-out and results obtained:

The main actions consisted of training a Master's level student, Mr. J. Samsatly from the American University of Beirut, at INRA-Avignon (Sept. 2009). Via this experience, Mr. Samsatly then organized a sampling campaign for April 2010 to screen dry land crops for biological ice nucleators, and for bacteria in particular. The crops to be screened consisted of a broad range of the different species and cultivars at the Tel Hadya field station in Aleppo, Syria and wheat cultivated between Aleppo and the northern border of Syria with Turkey. In collaboration with the head of the ICARDA Seed Pathology laboratory (Dr. Siham Asaad) in which the work was conducted, he also made sure that all of the necessary equipment for the research was available. The project coordinator (C.E. Morris, INRA) and the MSU partner (D.C. Sands) participated in the

April 2010 field campaign to further re-enforce the training of Mr. Samsatly and to effectively transfer the needed competence for this work to the Seed Pathology laboratory of ICARDA. During the field campaign we also identified the strategy to secure a scholarship for Mr. Samsatly's doctoral training.

The achievements of this project were as follows.

1) The screening work in Syria revealed that there was not any plant species that was particularly stronger than any other in harboring naturally-occurring biological ice nucleators. This led us to decide that the future orientation of this work should be to develop techniques to assure an increased and constant abundance of biological ice nucleators on one of the dominant cultivated plant species in the region, wheat.

2) The preliminary work realized in this project allowed the Seed Pathology Lab at ICARDA in Aleppo to acquire all of the necessary technology to conduct this work. In addition, we have determined that the principal technique to assure abundance of biological ice nucleators on wheat will be via seed inoculation. The ICARDA partner has significant competence to assure this work. Furthermore, a student entering into a Master's program at the University of Aleppo (Mr. A. Mukahhal) was among the laboratory assistants for the April 2010 experiments. He became enamored with the subject and will be conducting his research on developing seed inoculation techniques for ice nucleation active bacteria onto wheat.

3) This work has led to the development of a long-term research project with ICARDA's Seed Pathology lab, INRA and MSU. The initial objective of the 'Seed the Skies' project is to demonstrate the effective transfer of biological ice nucleators from seed-coatings to the atmosphere. For this project we will use non pathogenic ice nucleation strains of *P. syringae*. Current work in the greenhouse deploys strains from France. Sampling of wild plants from the mountains near Latakia, Syria has led to the isolation of Syrian strains that are non pathogenic and ice nucleation active that are currently being characterized by the INRA partner to validate the absence of pathogenicity before field trials will be conducted.

4) Preliminary field observations in Syria, conducted during a period of intense attack of wheat by stem rust, suggested that wheat plants with symptoms of bacterial blight (*P. syringae*) had markedly lower intensities of attack by rust. This suggested that, in addition to exploring how rust spores could be vectors of dissemination of *P. syringae* as ice nucleators, we should also consider how this bacterium might have biological control action against rust.

5) Mr. Samsatly has submitted applications for two sources of funding to conduct his graduate studies at MSU. His Fulbright fellowship application was refused for reasons of geographic choice for his studies. His application for a scholarship from the MSU Molecular Bioscience Program is currently being evaluated.

Prospects for the future:

There are 2 main prospects for this work. Firstly, we will continue collaboration with the ICARDA Seed Pathology lab to develop and validate a technique to assure that wheat harbors surface populations of ice nucleation active bacteria that can become aerosols. This will involve the training of a Master's student at the University of Aleppo. The second prospect will depend on success of Mr. Samsatly in obtaining funding for his studies. If he is successful, this will allow pursuit of further collaborative work between ICARDA, INRA and MSU on establishing plant sources of ice nucleation active bacteria, formation of aerosols, and their interaction with atmospheric processes.

Total Agropolis Fondation funding: €22,576 (running costs, living and travel expenses)

Funding category(ies): Agropolis Fondation small grants (support for small exploratory, risky and innovative projects, « proof of concept », new frontier research…, and support to pre-doctoral students)

Project duration: 20 July 2009 - 30 November 2010

Keywords: ice nucleators – rainfall – microorganisms