SpaceOps meets Science: WAICO

Columbus BIOLAB

WAICO - the first Scientific Experiment in the Columbus Laboratory

On February 29th, 2008 ESA astronaut Léopold Eyhards activated the WAICO (Wave and Coiling of Arabidopsis Roots) experiment in the BIOLAB double-rack multipurpose experiment facility inside the Columbus module. The experiment investigates the root growth and patterns of root movement originating from root growth of wild and mutant samples of the thale cress (Arabidopsis thaliana).

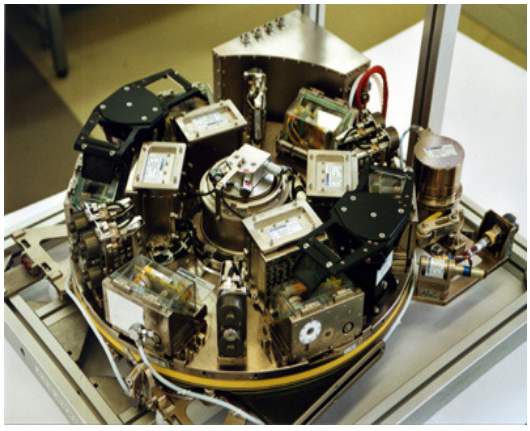
Since plants normally use light and the gravitational force of the Earth to orient themselves the effects of gravitational forces on the roots is of interest. When a plant germinates its roots grow towards the center of the Earth. This growth movement is known as gravitropism. In addition there are other plant specific phenomena which play a role in the orientation of the root tip depending on whether the root can grow unobstructed or encounters obstacles (e.g., a stone or an in-penetrable layer in the soil).

In addition the Arabidopsis roots when growing undisturbed on Earth show a spiral coiling of the root tip, thus "drilling" the root into the ground, however the mutant type roots show a behavior distinctly different from the wild type.

When obstructed slightly by growing on a 45 deg. angle tilted surface the wild type sample plant shows "waving" of the roots (i.e. circumnavigating the obstacle) while the mutants often make a "coil", the coiling could be a complete circle or a spiral. This means that roots have a tendency to grow asymetrical. The question is: do they grow like this in space or not?

The first experimental run was started by placing wild and mutant Arabidopsis seedlings into 16 experiment containers containing the smaller agar boxes filled with plant nourishing media. The 16 containers were placed on the a centrifuge of the BIOLAB incubator to be observed over a period of approx. 14 days via camera and telemetry measurements. The permanently recorded parameters were humidity, gas contents (oxygen, carbon dioxide and nitrogen) and illumination. During the observation period the centrifuge was operated at a speed simulating 1g and the other stood still to provide zero-gravity in the environment identical to the other centrifuge.

Samples in identical experiment containers were raised at the Facility Responsible Center (FRC) at the Microgravity User Support Center (MUSC) at DLR Cologne for reference purposes.



BIOLAB Incubator Centrifuge

After the 14 days growth period in space the experiment was stopped via ground command and the conserved samples were returned to the experimenter with the STS-123 return flight from the ISS. Unfortunately the chemical "fixation" of the samples did not work.

After the preliminary evaluation of the samples and to the surprise of the prime investigator, **Prof. Dr. Guenther Scherer** from the Gottfried Wilhelm Leibnitz University Hannover the Arabidopsis samples behaved different than expected: also under zero-gravity conditions the roots coiled and stabilized themselves in the nourishing media however most of the distinct differences between the wild type and mutant samples vanished. Further evaluation is under way and a second run of the experiment is planned in May 2010 to confirm the assumption that the observed spiraling mechanism is an internal mechanism in the plant, rather independent of the influence of gravity and roots have an in-built tendency to grow asymetrically.

These findings are of importance for the general understanding of how plants grow, thus enabling the production of more efficient agricultural plants on Earth and as a long term goal to gain insight on how to cultivate plants on space vehicles for long lasting human space missions.

SpaceOps News (**SoN**) had the opportunity to talk with the prime investigator Prof. **Scherer** about the WAICO experiment results and his operational experience with the very complex international ISS infrastructure supporting the experiment activities on board.

SoN: In your field of expertise many research and experimentation activities took place already during the past years of space research (Spacelab and MIR missions). What is the particular new capability of the Columbus/ISS research facility for your discipline?
Scherer: Of course many biological growth experiments took place on Russian and US missions. The published results are well known, however no experiment had the goal to investigate the root growths of two types of Arabidopsis samples under the proposed set of variables. Fortunately I could take advantage of the results of the Spacelab D-2 mission (STS-55, 1993) Biolab experiments

since I was a member of one the Biolab investigation teams. Of course the technical capabilities with respect to monitoring and recording the experiment results were more direct at that than during the Spacelab mission.

SoN: What would be the "breakthrough" if your research expectations would be fulfilled completely, i.e., what kind of unresolved knowledge would be gained?
Scherer: The goal of the WAICO experiment was to understand the interaction of circumnavigation and gravitropism by observing the two types of Arabidopsis (wild and mutant types) and specifically verify and confirm that the circumnavigation of the Arabidopsis roots is driven by an endogenous mechanism, i.e., independent of the gravitational field.

SoN: What could be the follow-up steps?
Scherer: As is true for every scientific experiment, investigating the influence of various parameters and as is in our case we would continue with a series of experiments by varying the parameters (gravity, light, air contents) taking the previous results into account in order to enlarge the science data base. There were also positive surprises: we obtained long after the end of the experiment the sample plants from the second centrifuge with dry and dead plants. However they showed strong differences between wild type and mutants which we can evaluate even from those dry and dead plants. The benefit is that they experienced no gravity for a long time during their development which is impossible to be observed on the ground.

SoN: Are you getting the appropriate institutional/commercial funding for your experiment program?
Scherer: First of all let me point out that the WAICO experiment was proposed and accepted by ESA in 1987, over ten years ago. Because of well known reasons the Columbus laboratory got delayed several times and was finally launched in Feb. 2008. The development of the experiment and it's operation was funded by the German Space Agency throughout. Following the general budgetary regulations and appropriations the funding was adapted to the needs over the years and was sufficient.

SoN: Was the support by the operations infrastructure (FRC, USOC, Col-CC) satisfactorily or would you have suggestions for improvements?
Scherer: Since with my Spacelab D-2 experience I could compare the differences in the organizational structures. While D-2 was operationally centralized, i.e., the experimenters were co-located at the control centers in the USA and Germany while Columbus operations adopted a local, decentralized system with a hierarchical science support structure. Although the decision processes are much more complicated in the ISS case the decentralized structure for turned out to work to my full satisfaction.

SoN: Is the available experimentation time sufficient to reach the expected goals during the planned time horizon?
Scherer: Since a plant growing experiment doesn't require fast reactions, the originally 14 days of experimentation time was granted and the experiment could be executed and observed as planned. Unfortunately the chemical fixation did not work at the end of the experimentation time but we still received useful samples back for further investigation.

A second experiment run can be conducted in early 2010 which will take the "lessons learned" of the first run into account and will substantiate our findings.

WAICO on board Plant Container after 14 days of growth time

SoN: Is the planning cycle flexible enough to react to unexpected changes?
Scherer: Since the experiment could be conducted as planned I have no experience with re-planning and turn-around times.

SoN: Could the experiment facilities onboard of the ISS be maintained at the expected technical state-of-the-art over the next 5 years?
Scherer: From a technical point of view and with reference to the Biolab facility I would say yes. However there is a general uneasiness with respect to the possible up-and downloads and the involved logistics capabilities. The shuttle will be retired in 2010 leaving the Russian Soyuz system as the only means to service the ISS with up- and downloads including astronauts.

SoN: Would you expect a continuation of microgravitiy experimentation in your filed of expertise 5 years from now?
Scherer: Definitely yes, I would have enough ideas to continue my investigations, however it boils down to the long term concept of operating and utilizing ISS/Columbus for scientific experiments, the turn-around times and the budgets involved.

SoN: If so, what are the long term science goals in your field of expertise?
Scherer: My preference clearly would be to continue the scientific experimentation on board of the space station rather than go to te Moon or attempt sending astronauts on a Mars mission.

Prof. Dr. Scherer we thank you for sharing your scientific and operational experience as the first Columbus prime investigator and hope for a positive development in using the space station for uninterrupted experimentation during the next 5 years.

Note: The text of the above article was changed according to the Experimenter's inputs on 18. January 2010. The previously published text differs slightly.