Acronym: Lada-VPU-P^3R

Title: Validating Vegetable Production Unit (VPU) Plants, Protocols, Procedures and Requirements (P^3R) Using Currently Existing Flight Resources

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Sponsoring Agency: NASA and Russian FSA

Increment(s) Assigned: 18, 19, 20

Brief Research Summary (PAO): Validating Vegetable Production Unit (VPU) Plants, Protocols, Procedures and Requirements (P^3R) Using Currently Existing Flight Resources (Lada-VPU-P^3R) is a study to advance the technology required for plant growth in microgravity and to research related food safety issues. Lada-VPU-P^3R also investigates the non-nutritional value to the flight crew of developing plants on-orbit. The Lada-VPU-P^3R uses the Lada hardware on the ISS and falls under a cooperative agreement between National Aeronautics and Space Administration (NASA) and the Russian Federal Space Association (FSA).

Research Summary:

- Validating Vegetable Production Unit (VPU) Plants, Protocols, Procedures and Requirements (P^3R) Using Currently Existing Flight Resources (Lada-VPU-P^3R) will optimize hardware and

plant growth techniques to allow maximum plant development to occur on the International Space Station (ISS).

- Lada-VPU-P^{3}R will develop procedures and protocols to allow US astronauts to safely eat space-grown vegetables

- Through surveys of previous and current space explorers, Lada-VPU-P^{3}R will measure the non-nutritional benefits (stress relief, etc.) crewmembers experience working with plants in space.

- Lada-VPU-P^{3}R uses the Lada hardware on the Zvezda module of the ISS

Detailed Research Description: Validating Vegetable Production Unit (VPU) Plants, Protocols, Procedures and Requirements (P^{3}R) Using Currently Existing Flight Resources (Lada-VPU-P^{3}R) identifies vegetable and flowering plant varieties that are most likely to be utilized to meet crewmember needs and that fit within the hardware resource limitations that exist on the International Space Station (ISS) and the ISS Crew Exploration Vehicle (CEV). Lada-VPU-P^{3}R also optimizes the support requirements for the Lada plant growth hardware and validates the technology readiness level of available cultural practices to provide reliable, low-cost, stimulating products for crewmember well being.

Lada-VPU-P^{3}R identifies the threat levels and validates the procedures and protocols required to allow crewmembers to eat space-grown vegetables. This study also determines how to implement these procedures to maximize crew mental health benefits with minimum mission costs by quantifying the mass value that should be assigned to the non-nutritional effects of plants in spaceflight.

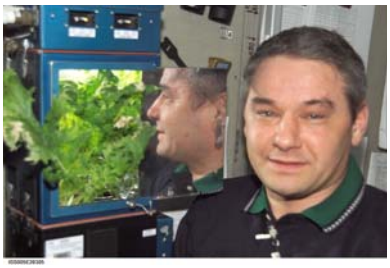
The Lada hardware design consists of a wall-mounted growth chamber that provides long-term, ready access for crewmember interaction. It provides light and root zone control but relies on the cabin environmental control systems for humidity, gas composition, and temperature control. Cabin air is pulled into the leaf chamber, flows over the plants and vents through the light bank to provide both plant gas exchange and light bank cooling. Lada was launched to the ISS in September 2002.

Lada-VPU-P^{3}R will answer the following questions:

- What plants can tolerate cabin ethylene levels without adding significant cost?
- How well do seeds need to be protected to survive and flourish during interplanetary travel?
- Will seed-producing plants be stable over the 500- to 600-day missions?
- What procedures and hardware need to be in place to assure crew health on a long flight?
- How much vegetable yield is required for a measurable boost to crew response under the isolation and stress of long-term space missions?
- How should this stress-relieving resource be presented (open or closed, single crew tended or multiple access) to maximize its value?
- Is this resource of value to all crew members, or is there a subset who value the experience much more highly? Should this be two separate questions or are they just asking if this resource is of equal value to all crew?

Project Type: Payload

Images and Captions:



NASA Image: ISS005E20305 - View of Cosmonaut Valery G. Korzun, Expedition Five mission commander, posing at the Rasteniya-2 with fully grown mizuna lettuce in the Service Module, *Zvezda* on the International Space Station.

NASA Image: ISS006E27426 - View of Lada Leaf Chamber and Light Module on panel 218 in the Service Module, Zvezda during ISS Expedition 6. The Lada Greenhouse is used for growing vegetables in the Zvezda module of the ISS.

NASA Image: ISS013E84325 - View of Spaceflight Participant (SFP), Anousheh Ansari, posing for a photo with barley, in a root tray from the Lada greenhouse, which is part of the Rasteniya experiment.

Operations Location: ISS Inflight

Brief Research Operations:

- The growing of the plant material in Lada and the collection of plant tissue will be carried out by Russian Federal Space Association (FSA) ISS crewmembers. No NASA support is required for the preflight, ascent, or on-orbit phases of the experiment; however, NASA support is critical for the freezing of the samples and for the return of the samples and root modules.

- Freezing the plant samples is necessary for the detailed chemical nutrition and microbiological material load analyses that are part of the Lada-VPU-P^{3}R experiment. The designated Russian crewmembers will collect the plant samples approximately two weeks before the designated Shuttle return. The plant samples will be packed in freezer bags before being transferred for

freezing. Each sample will be less than 200 ml and must be stored at a temperature colder than -68 degrees C in the Minus Eighty-degree Laboratory Freezer for ISS (MELFI). The frozen samples will be transferred to the Space Shuttle and maintained frozen for return to Earth.

- The Lada-VPU-P^{3}R experiment includes an analysis of the Lada root modules that have been on-orbit, specifically to characterize root growth patterns in microgravity and measure the growth of opportunistic organisms. The root modules do not require specific temperature control and may be stored at ambient conditions for return to Earth for analysis

Operational Requirements: On orbit, the Lada-VPU-P^{3}R needs to support the preservation of harvested plant matter at temperatures colder than -68 degrees C in the MELFI. There may be up to four frozen samples each with a 200-mL volume. The frozen plant matter must be returned from the ISS to Earth aboard the Space Shuttle. During return, the plant matter must be maintained at temperatures colder than -20 degrees C. Upon landing, the frozen samples should be delivered no later than return plus 6 hours (R+6 hours).

In addition to the frozen plant samples, four spent root modules must be returned. The root modules may be maintained at ambient atmospheric conditions. The root modules have a total mass of 6 kg like the frozen samples, the root modules need to be delivered no later than R+6 hours.

Operational Protocols: Root modules with seeds will be launched to the ISS on Russian Progress vehicles and transferred to the Zvezda module for the Lada-VPU-P^{3}R investigation. Crewmembers will imbibe the plant seeds and perform plant maintenance. Approximately two weeks prior to return, crewmembers will harvest plant material and transfer to the MELFI for freezing. Crewmembers will package and stow spent root modules. Frozen plant material will be transferred to a Space Shuttle freezer and the spent root modules will be transferred to an ambient middeck location. Post landing, frozen plant samples and ambient root modules will be delivered to the investigator for analysis.

Category: Physical and Biological Sciences in Microgravity

Subcategory: Plant biology in Microgravity

Space Applications: Plants not only provide food, but for many they provide comfort and relaxation, a diversion from the stress of required activities. For many people, plants provide significant non-nutritional benefits during long-duration spaceflight. These values are currently based only on anecdotal and untested observations that need verification. Part of the benefit may be a small fresh food source, which makes food safety issues important.

Earth Applications: As less fertile land is available to grow food, alternative agricultural systems that efficiently produce greater quantities of high-quality crops will be increasingly important. Data from the operation of this investigation will advance greenhouse and controlled-environment agricultural systems and will help farmers produce better, healthier crops in a small space using the optimum amount of water and nutrients.

Manifest Status: Planned

Category: Biological Sciences in Microgravity

Sub-Category: Plant Biology

Previous Missions: Several investigations have utilized the Lada hardware on the ISS, including Rasteniya and ORZS.

Related Publications:

Levinskikh, M.A., Sychev, V.N., Derendiaeva, T.A., Signalova, O.B., Podol'skii, I.G., Gostimskii, S.A., Bingham, G. Growth, development and genetic status of pea plants cultivated in space greenhouse "LADA". Aerospace and environmental medicine. 39(6):38-43, Nov - Dec 2005. [Russian]
Sychev, V.N., Levinskikh, M.A., Shepelev, E., Podol'skii, I.G. Biological processes of the human environment regeneration within the Martian crew life support systems. Aerospace and environmental medicine. 37(5):64-70, 2003. [Russian]

Levinskikh, M.A., Sychev, V.N., Derendiaeva, T.A., Signalova, O.B., Podol'skii, I.G., Avdeev. S.V., Bingheim, G.E. Growth and development of plants in a row of generations under the conditions of space flight (experiment Greenhouse-5). Aerospace and environmental medicine. 35(4):45-9, 2001. [Russian]

Web Sites:
Space Dynamics Laboratory - Programs
http://www.sdl.usu.edu/programs/lada/

Optimization of Root Zone Substrates for Reduced Gravity Experiments
http://www.sdl.usu.edu/programs/orzs

Related Payload(s): ORZS