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How the Space Environment Affects Seed Germination and Growth

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Understanding space environment effects on biological organisms like seeds will help plan for long duration space missions, such as those planned to Mars. Evaluation of the effects of real and simulated space environments on seed coats, germination, and growth is the focus of this research. Measurements were compared for the control group (ground based), space-exposed, vibration-exposed and radiation-exposed seeds by LHS and USU students to determine physical and biological changes resulting from space flight.

Methods

Changes to radish seed performance were hypothesized to result from radiation exposure during flight or vibrations during launch and reentry. A paint shaker was initially used to simulate launch vibrations; a smaller vial shaker and satellite shaker table will be used for future tests. To simulate low-earth and geosynchronous orbital radiation environments, the USU Materials Physics Group Space Survivability Test (SST) chamber was used. A custom biological exposure test chamber designed by Tsukuba students, was placed inside the SST chamber for testing; this ensured the SST vacuum would not harm the seeds and that incident radiation and temperature were uniform and controlled.

Results

Examination of seed coats showed enhanced production of surface proteins in space-exposed and shaken seeds. Images (Fig. 3) show space seeds have the most proteins and ground seeds have the least. These proteins are presumably related to defense of the embryo from soil pathogens during seed germination. Production of such proteins through cell walls may weaken the seed surface, allowing for faster water uptake and subsequent emergence of the plant embryo.

Preliminary tests of seed germination rates identified statistically significant differences in both “space” and “shaken” seeds coats (Fig. 4).

Conclusions

- Continued disruption of the protective seed coat during the production of proteins likely leads to micro-fissures in the seed surface. These fissures could hasten water loss and/or degrade the embryo’s food source, leading to seed death.
- Germination is different from viability. Not all embryos that germinate are viable. Physiological or genetic damage to embryos during dormancy or seed formation may not manifest until plant growth. This study looked at germination, not viability, for evaluating effects of space travel on long-term storage/use of crop seeds.
- Faster germination does not always produce robust seedlings. Associated changes to enzymatic function and seedling growth should be studied if the seed crop is intended to provide food in locations far from Earth.
- Collaboration has been an amazing experience in international and multigenerational learning.