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Research Article: Invited Submission

Can Tomatosphere™ Tomato Seeds Germinate After Two Exposures to Space, in Mars-Like Conditions?

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Abstract

Tomatoes are commonly used throughout the world as a nutritious food source. Tomatoes are one of the only fruits to have had their seeds exposed to the harsh conditions of space travel. If humans are ever to colonize other planets then there will be a need for seeds to travel through space to those extraplanetary destinations. The objective of this study was to compare germination and growth of twice-space-exposed (TSE) tomato seeds with control-ground-truth (CGT) seeds. We found that the twice-space-exposed seeds had similar germination rates to the ground truth seeds but lower mortality. The TSE seeds were also taller from 18 to 56 days after planting than the CGT seeds. These results show that the frequency of space exposure is not a limiting factor for seed germination and growth.

Keywords: International Space Station, tomatoes, Tomatosphere, space research, germination

1 Introduction

Tomatoes grew in the wild before being cultivated from 700 A.D.[1] They were not cultivated earlier because they were thought to be poisonous.[1] They originated in South America in the Andes mountain range of Peru, Bolivia, Chile, and Ecuador.[1]

Tomatoes are rated the seventh most important crop in the world — the first six are maize, rice, wheat, potatoes, soybeans, and casava. Tomatoes are the most economically important vegetable globally (sold fresh and processed into many different forms and products).[2] While sold as a vegetable[3], tomatoes are botanically classified as a fruit. Tomatoes are used in many recipes and are highly nutritious with high amounts of vitamin A, vitamin C, carotenes, lycopene, and other vitamins and minerals.[2] While there are about 7,500 varieties of tomatoes grown globally [4], only one type of Canadian tomato seed has been to space. That is Tomatosphere™ seeds from 2016 (Heinz 9478 F1 Hybrid Tomato Seed) (these seeds were in space on the International Space Station (ISS) for five weeks April — May 2015). We chose the Tomatosphere™™™ seeds because we had previous experience (spring 2016) growing them. We also chose this experiment to expand our knowledge of deep space exploration and habitation on Mars or other planets.

Our proposal is to see if the Tomatosphere™ seeds, which have previously been exposed to microgravity and cosmic radiation environment along with entering and exiting Earth's atmosphere, will grow on Earth after being re-exposed to similar conditions on board the International Space Station (ISS). We will see if the growth rate and size of the tomato plant changes due to these environmental changes and compare control-ground-truth (CGT) tomato seeds, from Heinz tomato company not exposed to cosmic radiation, microgravity, and exiting and entering the Earth's atmosphere, with the Tomatosphere™ seeds that have been exposed to microgravity, cosmic radiation exiting, and entering the earth's atmosphere two times (twice-space-exposed; TSE seeds). We want to learn if a space flight can carry seeds without special handling and whether it can be used to start a food source after multiple exposures to cosmic radiation, microgravity, and the exiting and entering planets' atmospheres. This is important if humans are ever to perform interstellar travel and colonize other planets.

2 Methods

2.1 Experimental Materials

Tomatosphere™ seeds (tomatosphere.org; tomatosphere.letstalkscience.ca) were chosen was because we did the Tomatosphere™ project, during the spring of 2016, that was created by former Canadian Space Agency Astronaut Dr. Robert Thirsk, University of Guelph, Stokes Seeds, Let's Talk Science, and the Heinz tomato company. We also chose the Tomatosphere™ because we want to expand our knowledge base on the Tomatosphere™ seeds that we grew

in the spring. Our group is also very interested in deep space travel and space agriculture.

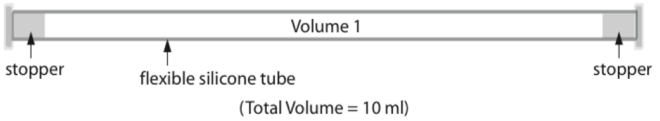

Figure 1: *Schematic of the type 1 fluids mixing enclosure (FME) mini-lab used to send the experiment to pack the seeds for space travel.*

2.2 Pre-Flight

We followed all safety procedures to ensure no contamination to the fluids mixing enclosure (FME). We cleaned and sterilized the FME according to Student Spaceflight Experiments Program (SSEP) directions, including the wearing of gloves, safety goggles, hospital face mask, and lab apron when handling the space FME and the ground truth FME.

Prior to flight, the space FME was filled with three cotton balls (Compliments Jumbo cotton puffs, Sobeys Ltd., Serial # 5574233979) and 15 Tomatosphere™ seeds from package D (Heinz 9478 F1 Hybrid Tomato Seed) were placed inside. The FME was then filled with the other two cotton balls to keep the seeds in place and prevent physical damage to them. The same procedure was followed with the ground truth FME with an additional 15 Tomatosphere™ seeds from package D.

The space FME was then be packaged in a container and shipped to Nano Racks, Houston, Texas, USA for flight. The ground truth FME was placed in the same type of container and stored in the dark at room temperature.

2.3 On-Board the International Space Station

There were no crew interactions with the space FME and no interactions with the ground truth FME, it remained in the science storage lab throughout.

2.4 Post-Flight Analysis

As soon as the seeds returned, we grew them in the Compact Three Tier Sunlight Grow garden (Veseys, www.veseys.com) to ensure all plants get an equal amount of replicated sunlight to ensure the same treatment for all plants. All seeds were planted individually into peat pellets with sterile soil at 12:05 p.m. on March 22, 2018. Each peat pot was watered with 25 mL water on days 7, 10, and 20. Each received 40 mL water on days 24 and 42.

Observations were made after 2, 10, 18, 20, 24, 32, 34, and 56 days for the 15 TSE seeds and the 15 CGT seeds not exposed to space. Results were graphed using MS Excel.

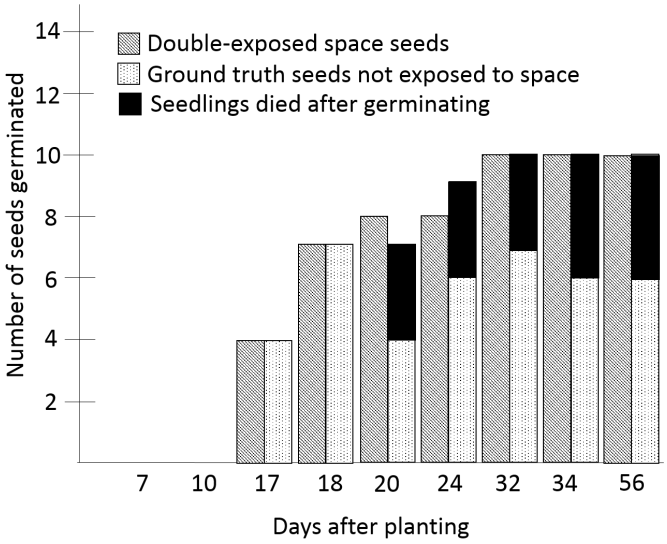

Figure 2: *Germination success of twice-space-exposed (TSE) and control-ground-truth (CGT) seeds at each observation.*

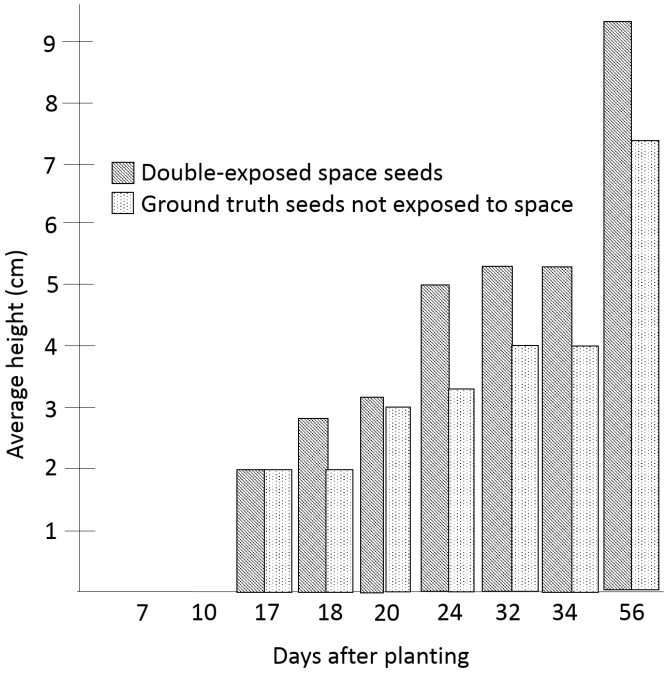

Figure 3: *Average height of germinated twice-space-exposed (TSE) and control-ground-truth (CGT) plants at each observation.*

3 Results & Discussion

The goal of our experiment was to compare growth between CGT that have not and TSE tomato seeds that have been to space two times and been exposed to all the accompanying environmental changes.

The first seeds germinated by day 17 (Fig. 2) and all germinated plants had two leaves that were light green in colour.

On day 18 all germinated plants had two light green leaves. By day 20, all plants had leaves that were noticeably larger and three of the CGT seedlings had died. Multiple leaves started growing on each plant by day 24. Leaves were larger and branches were noticed by day 32 on the TSE seeds. By day 56, thicker stalks and taller plants were seen for the TSE germinated seeds than those not exposed to space. Germination success at each observation day (Fig. 2) and plant height (Fig. 3) are presented.

Our results show that short-term, repeated space travel may be beneficial to the growth of the germinated plants. This in contrast to seeds in space for six years that showed a decrease in growth compared to the control [5]. However, our results are consistent with those of Martinez et al.[6] who found that early stages of tomato growth are accelerated following exposure to magnetic fields like those experience by our space FME during its exit and entry into Earth's atmosphere. From this literature and our results, duration of space flight appears to be more important than number of trips into space in reducing tomato plant growth. However, we have answered our question as to what effect the repeated entering and exiting of atmospheres has on tomato seeds and have found an improvement in growth.

4 Conclusions

We conducted this experiment is to see if astronauts can grow seeds in microgravity while on long-duration space flights as well to see if they can continue to regrow tomatoes as a food source on other planets such as Mars. This will help when we colonize multiple planets and travel back and forth from and to these planets.

We found that twice-space-exposed tomato seeds germinated faster and grew taller than the tomato seeds not exposed to space. Future work is needed to expand the number of seeds tested with space travel, the number of generations of seeds exposed to space, and whether there are any changes in nutritional content in the fruit from plants grown from those experiments.

5 Acknowledgements

Let's Talk Science Canada and Tomatosphere™ provided the seeds, SSEP granted the opportunity, and our teacher Mrs. Nickel made the experience happen!

References

1. Rick, C. M. 1978. *Scientific American*, 239: 76—89.
2. Bergougnoux, V. 2014. *Biotechnology Advances*, 32: 170—189.
3. Gray, H. 1893. *US Supreme Court*, 149: U.S. 304. URL `https://supreme.justia.com/cases/federal/us/149/304/`.
4. Zahedi, S. M. & Ansari, N. A. 2012. *International Research Journal of Applied and Basic Sciences*, 3: 1192—1197.
5. Nechitailo, G. S., Jinying, L., Huai, X., *et al.* 2005. *Advances in Space Research*, 36: 1329—1333.
6. Martinez, E., Carbonell, M. V., Flôrez, M., *et al.* 2009. *International Agrophysics*, 23: 45—49.