International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(4): 2936-2938

Received: 24-05-2020
Accepted: 26-06-2020

Janhavi V
Teaching Faculty, Department of Physics, Bengaluru North University, Tamaka, Kolar, Karnataka, India

Manjunathagowda DC
Scientist, ICAR-Directorate of Onion and Garlic Research, Rajgurunagar, Pune, Maharashtra, India

Corresponding Author:
Janhavi V
Teaching Faculty, Department of Physics, Bengaluru North University, Tamaka, Kolar, Karnataka, India

Plants culture in space environment for feeding food to the space travelers

Janhavi V and Manjunathagowda DC

DOI: https://doi.org/10.22271/chemi.2020.v8.i4ai.10097

Abstract
Differential growth responses of plants to gravity know as gravitropism, the geotropic plants were familiar to humans by the nature of their use. However, the plants can grow successfully in low gravitational force, microgravity and no gravity too. This is the most important aspect of science in this era to focus on the supply of dietary food as live healthy greens to the space-travelling astronauts during prolonged spaceflight. Hence, the space culture aided to provide food in spacecraft. The effort to grow the agricultural or horticultural plants in space has limited success so far. In this view, the devising of technology has worth pursuing to prepare of space activities, with potential low, microgravity or no gravity aspects in the closed space plant growth system with the nutrient release arrangement. However, the plant-like lettuce, cabbage, cauliflower, amaranths, radish, turnip, endive, Swiss chard, dandelion, New Zealand spinach and other vegetables were underway evaluation for their suitability to the space culture.

Keywords: Agriculture, gravity, horticulture, space

Introduction
Cultivation of plants in space environment and their responses to differential units of gravity, and their studies were revealed as space culture. Space culture suited for long-duration on boarding Space Station (SS). It was focused on improving human habitability, by the supply of continuous source of fresh food for relaxation and recreation of the crews. With this, basic research on plant growth and development under differential gravity has an important implication for improving plant production. A simple, stowed with low resource facility Veggie- a vegetable production system was developed for the International-Space-Station (ISS) to the flight crew members for food supply and also for the scientists to conduct different experiments to grow plants in space at differential gravity and microgravity. Veggie was designed, and built by Orbital Technologies Corporation it is now part of Sierra Nevada Corporation for NASA. At present, two Veggie services exist in the ISS. The initial Veggie was delivered to the ISS on board SpaceX CRS-3, which was launched on 18/4/14. The second Veggie was launched to the ISS on board Orbital ATK-7 (OA-7) on 18/4//17. Veggie has a growing vicinity of 1.7 square feet through 18 inches of maximum growing height. The Veggie is cooled through ExPRESS Rack Avionics-Air-Assembly (AAA) air and it also provides green, red and blue spectra for plant growth and development. A new plant growth container for space culture called Passive-Orbital-Nutrient-Delivery-System (PONDS) is currently underway of development and testing by NASA, it will offer researchers by a substitute of plant growth competence. As plants grows the Veggie requires least crew maintenance, the edible parts of plants could be consumed by the crew, while inedible waste biomass has to be discarded or returned to Earth, harvesting of plants, returning with samples to the earth for further analyses [1]. Indeed, investigation of plant cultivation practice in space for bio-regenerative living life supporting systems is a foresight avenue of research, innovations advanced controlled environment agriculture technologies of closed-loop systems an objective for future missions are the critical component of future, human exploration to worlds unknown.

Methodology
The Veggie is a plant growth unit set up, used to produce the salad vegetables to the crew, and

astronauts for edibility with dietary nutrition as protective fresh food for palatability and relaxation. The Veggies were grown by utilization of light and the mineral nutrients delivered system in cabin environment of space station, with better management of temperature, carbon dioxide, and relative humidity to encourage the plant growth [1]. The choice of plants for extended space missions is initially determined by the physical constraints of the facility in which they are to be grown. The precincts on crop culture in terms of cultivation area within the spaceship and the limited campaign duration require a critical selection of crops for space life support systems [2]. Crop selection methodology was developed by Wageningen University and Research experts in terrestrial greenhouse cultivation [3]. The crops were grown in climate rooms to define the optimal light recipes (spectral quality, light intensity, and photoperiod), to optimize the nutrients and water use to check the cultivation and management of crops [4] and top-level suitable crops were listed in Table 1 [3, 4]. Choosing crops for cultivation in space, Space missions require bio-regenerative life-support systems. Eating of fresh food as salad is not only a fundamental requirement for survival but also influences the psychological well being of astronauts operating on long-duration space missions, Human quality aspects, such as taste, appearance, and texture were associated with well-being of astronauts. Yield aspects combined crop yield and growth efficiency in time and space, Production aspects growth modules and the technical aspects of cultivation [4].

Table 1: Crop and suitable cultivar for space culture

Crop	Cultivar	Crop	Cultivar
Lettuce	Crispy green 'Expertise' Batavia 'Othilie' Field lettuce 'Pulsar' Iceberg 'Morinas' Lettuce 'Outredgeous'	Strawberry	Delizz
		Spinach	Gazelle, Mandril, Red Kitten
		Swiss chard	Ruby red
Dwarf tomato	2011-281M, F1 1202, F12414	Red mustard	Frizzy Lizzy, Mizuna
Cucumber	Quatro, Picowell, Northern Pickling	Chives	Staro, Purly
Bell pepper	Cupid, 1601-M	Coriander	HI 13475 HEC
Radish	Raxe, Lennox	Parsley	Moskrul, Frise Vert Fonce-rina
Basil	Dolly, Genovese	Mint	-

Table 2: Pioneer space culture researcher and their organization

Area of research	Researchers	Organization
Horticulture for Mars	Raymond M. Wheeler	NASA Biological Sciences Office, Kennedy Space Center, FL, USA 32899
The preliminary design of the EDEN ISS Mobile Test Facility - An Antarctic greenhouse	Paul Zabel, Matthew Bamsey, Conrad Zeidler, Vincent Vrakking, Daniel Schubert and Oliver Romberg	German Aerospace Center (DLR), 28359 Bremen, Germany
	Giorgio Boscheri	Thales Alenia Space Italia, 10146 Torino, Italy
	Tom Dueck	Wageningen University and Research, Wageningen, The Netherlands
Choosing crops for cultivation in space	Tom Dueck, Frank Kempkes, Esther Meinen, Cecilia Stanghellini	Wageningen University and Research, Wageningen, The Netherlands
Living in Space: An Astronaut Perspective	Robert Thirsk, P.	Canadian Space Agency 6767 Route de l'Aéroport Longueuil, Québec J3Y 8Y9 Canada
Plant growth strategies are remodelled by spaceflight	Anna-Lisa Paul, Claire E Amalfitano, Robert J Ferl	Department of Horticultural Sciences, University of Florida, Gainesville, FL 32611, USA.

Results and discussion

Horticultural crops are more responsive to environmental parameters and light characteristics, the vegetables have mostly of short growth duration. Thus, make a good precursor of vegetables with short growth durations to grow. Humans have endeavored beyond Earth orbit, and in soon agriculture or horticulture will surely venture. However when the mission durations increases, in case the role of space culture would have greater insight, where plants would provide fresh food, oxygen, and help in the removal of carbon dioxide. In order efficient implementation an innovative Horti-, Agricultural technologies and approaches with efficient electric lighting, and/or solar collectors, innovative design and concepts for greenhouses growing modules, capabilities to manage temperature, humidity, and atmospheric composition like oxygen, carbon dioxide, ethylene, and total pressure use of technologies to recycle and conserve the water and nutrients. As well, a successful intervention of agriculture or horticulture on Mars would require suitable crops and cultivars would well acclimatize under the constraints of Martian gardening. The flexibility of plants to the external environment is challenging, but it could benefit the terrestrial space culture [2]. The astronauts in International-Space-Station had grown Zinnias the first time; they had focused on the growth of plants and vegetables in space. The high-tech variation on soil-less, hydroponics had favored with a craft with a truly self-contained environment for the space travelers inside the orbiting space station. Gioia Massa revealed little grow bags called plant pillows were used to raise red Romaine lettuce inside the space station, systems that yielded lettuce, radishes and green onions at the Kennedy Space Center. These space veggies had other benefits on both atmospheric and psychological. Plants remove harmful carbon dioxide from the air and replace oxygen. Plants have well-known stress-reducing effects, something particularly desirable for those circling the globe in confined spaces. The

relaxation and peace that comes while they are working, critical things to those confined in a delicate, tiny space with a handful of others [5]. The selection of suitable crops for space culture is based on human edibility, ready to eat and no alternative form possible, with soft criteria as appearance, taste, pungency, and texture. Cultivation aspect as it is commercially availability, plant height, Spread harvesting, handling time and the possibility of harvest within mission time, shelf life, suitable for artificial production system under 600 µmol m^{-2} s^{-1} of light and disease resistance and yield aspects production efficiency in time and space (kg $m^{-3}d^{-1}$), Light and energy use efficiency (g μmol^{-1}) and Harvest index were need to prioritized und the selection of crop for space culture [3]. The human scientific explorations of the planets to determining supported life in the biosphere soon. Humans are planning to land on Mars, but in performance with other life forms of the Earth. The plants will be a key resource for human explorers to establish the plant-based ecosystems on Mars robotically before humans arrive. It is an essential near-term step to test the plant growth module on Mars-Lander-Mission. Further, it may lead to the long-term, plant-based ecosystems that may form on the basis for global eco-synthesis on Mars [6]. Scott Kelly an astronaut ate space salad and the taste was good that is Kinda like Arugula on board the International-Space-Station. Fresh Red-Romaine-Lettuce grown in orbit, it is the startling new vision for farming. It is a gift to starved headline writers. The space agency has attempted to do grow stuff in zero gravity since 1999, and challenged perceived wisdom about the behavior of plants. Charles Darwin concluded that plants use gravity to draw roots downwards 130 years ago, NASA also found that plants do the same in space. Dr. Kelly and his crew chomp on lettuce 300km up [7]. Training and delivery are important life sciences; the microgravity experiments were described and illustrated with the use of Life and Microgravity Spacelab mission (STS-78) on-orbit for 17 days in 1996. The forty-three (43) experiments involved co-operating scientists across 13 countries. Two experiments were assigned to estimate the extent of long-term space travel, as like a Mission to Mars, influence on muscle performance and respiratory function. Another arena of life sciences experiments involved growing pine seedlings and transportation of Canola (*Brassica napus*) seeds to space. The latter seeds were used post-Mission to engage the Canadian school children in the excitement of space research [8]. Arabidopsis plants were cultivated on the International-Space-Station within specialized hardware that included the plant growth habitat maintained in the Orbital-Environment-Simulator at Kennedy Space Center. Arabidopsis seeds were germinated on orbit on nutrient gel Petri plates. Under no gravity with directional light, spaceflight roots remained strongly negatively phototropic and growth of shoot growth was in opposite direction. The Space-flight environment was influenced on the growth of Arabidopsis plants. The plant size in flight was uniformly smaller than the ground grown control plants. This could reveal that Skewing and waving were assumed to be the gravity-dependent phenomena of space-flight plants. In the presence of oriented light source the phenotypic growth of plants tends be in skewing and are gravity independent; the overall growth patterns of plants on the orbit was less uniform. Skewing appears to be the independent of axial orientation of ISS, it suggested that the tropisms were not influenced by oxygen and temperature [9].

Conclusion

Although in India, Several organizations are working on space agriculture, and horticulture, crops were cultivated under controlled environmental conditions like greenhouses. No work has been reported under crop cultivation with no gravity, low gravity, or micro-gravity given spacecraft for feeding food for space travelers so far, nonetheless lots of avenues are opened for Indian researchers to take up the task of space culture.

Reference

1. NASA, Vegetable Production System (Veggie), https://techport.nasa.gov/view/10498, https://www.nasa.gov/mission_pages/station/research/experiments/explorer/Investigation.html?#id=374, Assessed on 28th September 2019.
2. Wheeler RM. Horticulture for Mars, Acta Hort. 2004; 642:201-215. DOI: 10.17660/ActaHortic.2004.642.22
3. Dueck T, Kempkes F, Meinen E, Stanghellini C. Choosing crops for cultivation in space, 46th International Conference on Environmental Systems July 10th–14th, Vienna, Austria, 2016. https://zenodo.org/record/60430 Paper ICES-2016-206.
4. Zabel P, Bamsey M, Zeidler C, Vrakking V, Schubert D, Romberg O *et al*. The preliminary design of the EDEN ISS mobile test facility–an Antarctic greenhouse; Plant cultivation technologies and operations, ICES-2016-198. 46th International Conference on Environmental Systems, Vienna, Austria, 2016.
5. Vinje E. Vegetable gardening in space. https://www.planetnatural.com/growing-in-space/
6. Christopher PM. The Case for Plants on Mars, Acta Hort. 2004; 642:187-192. DOI: 10.17660/ActaHortic.2004.642.20
7. Simon U. Sprigs in space: Exploring how to grow vegetables in zero gravity. 2015; 18:06. https://www.independent.co.uk/news/science/sprigs-in-space-exploring-how-to-grow-vegetables-in-zero-gravity-10450677.html
8. Robert TP. Living in Space: An Astronaut Perspective, Acta Hort. 2004; 642:193-199. DOI: 10.17660/ActaHortic.2004.642.21
9. Paul A, Claire EA, Robert JF. Plant growth strategies are remodeled by spaceflight, BMC Plant Biology. 2012; 12:232(2-14). http://www.biomedcentral.com/1471-2229/12/2327.