The benefits of plants: a review of the literature and application to habitation systems for humans living in isolated or extreme environments

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Abstract

Humans rely on plants for their survival in a multitude of ways: plants provide nutritive value to organisms throughout the food-chain and also support a life-sustaining atmosphere. However, the idea that plants provide non-nutritive value will be evaluated for potential application as an ameliorative countermeasure for difficulties experienced by humans living in isolated or extreme environments. It is our purpose to connect the findings from these two bodies of research in order to provide empirical-supported justification for a suggested course of action for researchers.

Astronaut Jim Voss shows off an onion that he grew in a plastic bag during ISS Expedition 2.

Lada with fully grown Mizuna in the Zvezda module of the ISS. Cosmonaut Valery Korzun was our first space gardener.

Cosmonaut Nikolai Budarin works with dwarf pea crop in Lada vegetation module. The module to the right is from an earlier experiment and was used for "recreational gardening".

Physiological Consequences of Space Travel & Benefits of Plants

• ***Consequences***: A variety of physiological consequences of living in space have been considered and identified.

– *Health*: Davis (1999) outlined some of the health consequences of long-term microgravity exposure, including both cardiovascular and musculoskeletal consequences. Zulley (2000) reported that isolation can alter the circadian system (core temperature and sleep-wake patterns) causing difficulties with sleep, mood, and vigilance.

– *Stress*: Suedfeld (2005) summarized a variety of physiological consequences of living in space: most were related to physiological stressors.

• ***Benefits***: Ulrich (1986) as well as Ulrich and Parsons (1992) outlined a variety of physiological benefits to exposure to plants.

– *Health support & health recovery*: Ulrich (1984) found that surgical patients assigned to rooms with windows that faced nature had shorter hospital stays, used fewer analgesics and received fewer negative evaluative comments from staff than did patients assigned to rooms that overlooked a brick building. Fjeld (1999) found that office workers randomly assigned to plant, as opposed to no-plant, conditions had fewer health-related symptoms over time.

– *Stress recovery*: Ulrich, et al (1991) found that stress recovery was more rapid in conditions that included exposure to videotaped natural settings as opposed to urban settings. Lohr, Pearson-Mims, & Goodwin (1996) found that participants were less stressed and performed better in conditions that included plants. Shibata & Suzuki (2004) reported similar findings.

Psychological Consequences of Space Travel & Benefits of Plants

• ***Consequences***. The potential psychological consequences of long-term exposure to conditions common of long-term isolated environments have also been explored:

– *Boredom:* Boredom and lack of sensory stimulation was identified as a potentially problematic consequence by Manzey & Lorenz (1999), Gushin et al (1993), Harrison (2005) and Davis (1999).

– *Emotion, Mental Health, & Cognitive Function:* Gushin et al (1993) and Harrison (2005) noted that hypochondria, diminished motivation and performance, impaired cognitive ability, withdrawal, impulsive behavior, hallucinations, mood swings, helplessness, depression, and anger were potential outcomes of the stresses of space-travel. In studies of Arctic expeditions Palinkas (1986) and Palinkas et al. (2000) noted that depression, irritability, cognitive impairment (inability to concentrate), insomnia (or sleep disturbances), lonely, annoyed, nervous, tense were all problematic.

• ***Benefits.*** The psychological benefits of exposure to, or interaction with, plants has been examined within several disciplines:

– *Aesthetics/Environmental Preference*: Humans have a preference for nature scenery (Kaplan, 1987; Ulrich, 1986). This has been seen in controlled experiments (Ulrich, 1986) as well as studies of workplace environments (Larsen, Adams, & Deal, 1998; Randall, Shoemaker, Relf, & Geller, 1992).

– *Mood:* Korpela and colleagues studied the emotional significance of natural scenes and found that natural scene produced more positive emotions than did urban scenes (Hietanen & Korpela, 2004; Korpela, Klemettila, & Hietanen, 2002). Cackowski and Nasar (2003) found that roadside vegetation impacted automobile driver anger and frustration and Shoemaker, Relf, & Bryant (1992) outlined the role of flowers in the bereavement process where flowers provide both distraction and symbolism.

– *Mental Health:* Several researchers have examined the impact of plants on a variety of mental health constructs including mental fatigue (Larsen, Adams, & Deal, 1998). Shibata & Suzuki (2001), found that indoor foliage positive impacted recovery from mental fatigue. The impact that plants can have on sustained attention has also been studied (Fabor Taylor, Kuo & Sulivan, 2001; Kuo, 2001).

Social Consequences of Space Travel & Benefits of Plants

• ***Consequences***: A variety of researchers have identified potentially negative social consequences of living in space.

– *Isolation*: Loss of privacy (Manzey & Lorenz, 1999) and isolation (Manzey & Lorenz, 1999; Suefeld, 2001, 2005) have both been identified as problematic outcomes of long-term space travel. Ursin (1991) noted that isolation and removal from social support can lead to negative consequences and Davis (1999) identified confinement, separation from traditional social support, reduced sensory stimulation, loss of privacy potentially resulting in a variety of problematic outcomes. Finally, both crew social cohesion (Sandel, 2001) and alienation (Kozerenko, et al, 1999) have been identified as potential concerns.

– *Communication*: Harrison (2005) identified communication issues as likely. Kanas, et al. (2005) found that social tension resulting from external stress and factors related to crew heterogeneity (personality, crew demographics, culture, language, and goals), variability in crew mood and behavior over the course of the mission, effects related to the size of the crew, changes in cohesion as a function of leadership role, and communicative relationship between crew members in space and mission control personnel on the ground were common.

•**Benefits**: Researchers have reported the beneficial social outcomes related to the establishment and existence of community gardens.

– *Cohesion/Alienation*: Community gardens have been identified as a pro-social factor in community (Waliczek, Mattson & Zajicek, 1996), school, urban settings, and a variety of long-term detention settings (Sandel, 2004). Shinew, Glover, & Parry (2004) reported on the impact of a community garden on interracial relations and found that the shared experience of the community garden had a positive impact.

– *Communication*: Gillen, Rice, Talbott, and Stern (1980) found that incorporation of plants into a cafeteria setting influenced social interaction while Kuo and Sullivan (2001) studied the impact of the presence of vegetation on aggression and violence in the inner city (they suspected that mental fatigue was a mediating variable and that plants provided an effective countermeasure).

VPU P^{3}R: Approach

We have developed a program of research to explore these interconnections. There are four primary activities/tasks that will be used to explore these research questions for this portion of the VPU P3R project:

– *Ground Survey*. A ground-based survey of cosmonauts & astronauts will be designed, and data will be collected to assess the perceived benefits of tending plants while in space.

– *Seven-Day Chamber Study*. In collaboration with the Russian team at the institute for Biomedical Problems and consultants, a seven-day chamber study will be carried out in an effort to develop and field-test procedures and protocols for the assessment of the psychological value of having and/or tending plants in isolated environments.

VPU P^{3}R: Approach (continued)

– *Mars/500-Day Chamber Study*. In collaboration with the Russian team and consultants, methods and protocols to assess the psychological value of plant-tending for inclusion in the ESA/RSA funded Mars/500-Day Chamber Study will be developed, implemented and assessed.

– *Flight Study*. In collaboration with the Russian team and consultants, methods and protocols to assess the psychological value of plant-tending for inclusion in a flight study will be developed, implemented and assessed.

"Maintaining a healthy behavioral condition is…critical to the success of the mission and to return to Earth of normally functioning human beings"

-Committee of the Institute of Medicine (cited in Williams & Davis, 2005, p. B1)