Concept Study for Martian Seed Germination

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for
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Introduction

- Importance of showing plant growth potential
  - Support for biospheres
  - Extraterrestrial life
- Martian Environment
- Seed Options
- Creating the Environment
- Conclusion

Martian Environment

- Temp
  - Avg: -60° C
  - Range: -133° C to +27° C
- Average pressure: .1 psi (.6% of earth!)
- Atmosphere: 95% CO_2, 3% N_2, trace O_2/H_2O
- Natural light: Butterscotch color (yellow/brown)
  ≅ 600+ nm
- Humidity: ≅ 0% (100% precipitation would create ocean only .1 mm thick)
- Soil: rocky - exact contents uncertain

Seed Options

- Cactus Species
  - Pros
    - Needs less water
    - Can germinate in rocky soil
  - Cons
    - Long germination time
    - Requires higher average temperature
- Poppy Species (Icelandic or Arctic)
  - Pros
    - Germinates in colder environments
    - Germinates quickly (one week)
  - Cons
    - Requires more water
    - Requires higher grade soil

Environmental Control

Assumptions:

- Module (1/2m X 1/2m X 1/4m) should be on top of vehicle for unobstructed light
- Power and mechanical design used for soil acquisition not considered in power budget - not used during steady-state operation
- Photosynthesis/respiration is low enough to not require fresh O_2 supply more than twice/day
- Experiment should last no more than four weeks due to Surveyor's batteries

Environmental Control (Con't)

- Soil acquisition
  - Vacuum (could be difficult with low atmospheric pressure)
  - Corkscrew (dirt must be filtered)
  - Gathered in small increments for monitoring purposes
- Heat - estimated 60W required
  - Calculations for 1/2m X 1/2m X 1/4m module using avg outside temp (-60° C) and desired inside temp of 12° C
  - High-end estimate because other heat producing devices not included
  - Could be inaccurate because of convective heating coefficient estimate for martian atmosphere
  - Conductive coefficients similar to HW#2

Environmental Control (Con't)

- Atmosphere
  - CO_2 fairly abundant despite low pressure
    - ≅ .1 psi partial pressure (.15 psi partial pressure on earth)
  - Daytime - "louvres" stay open for fresh CO_2
  - Nighttime - must supply O_2 for respiration
    - CO_2 will be "flushed out" with O_2 through "louvres" then chamber sealed until next day
    - Minimal O_2 supply required for 28 days due to low atmospheric pressure
      - .005 m^3 O_2 tank at 3000 psi would purge volume 140 times (perfect gas law)
      - Extra O_2 for losses
    - Pressure inside module = Atmospheric Pressure
    - During respiration: only 3% earth's O_2 partial pressure
  - Pressurization allows greater O_2 partial pressure

Environmental Control (Con't)
Pressurization Options

Pressurized respiration

- Pros
  - Plant more survivable
  (3 psi differential allows same O_2 partial pressure on earth at 100% O_2)
- Cons
  - Hardware complexity required to seal/unseal module every day
  - Fire hazard

Unpressurized respiration

- Pros
  - Simpler/lighter
  - Less fire hazard
- Cons
  - O_2 partial pressure may be insufficient for germination
  - Requires more heat

Environmental Control (Con't)

- Humidity Control - Plants will dry out immediately
  - Propose semi-permeable water insoluble membrane
  - Humidity sensor coupled with dehumidifier
- Nutrients
  - 1/2 gallon of water for 28 days
  - Require 5W to keep 1/2 gal ≥ 0° C at -60° C OAT

Module Specifications

- Size: 1/2m X 1/2m X 1/4m
- Power
  - 60W power for radiative heater with temp sensor
  - 10W for humidity, fan, louvres, dehumidifier and camera
  - 5W for water heater, temp sensor, dispenser
- Semi-permeable membranes (water insoluble) for humidity control with low pressure fan (large diameter/ high speed)
- Clear lid, insulated walls
- Louvres to allow CO_2/O_2 exchange for photosynthesis/respiration
- Digital camera
- Water/nutrient dispenser with 1/2 gallon (for 28 days)
- Optional: pressurization allowing 3 psi differential (for respiration only)

Conclusion (The good news...)

- Acceptable factors:
  - Photosynthesis (maybe)
    - Lighting - wavelength longer than optimum/intensity dim, but maybe okay
    - High CO_2 concentrations make up for low atmospheric pressure
  - Soil (maybe)
    - Must be filtered to eliminate larger grains
    - Absence of previous life could result in low/ non-existent natural nutrients

Conclusion (The bad news...)

- Seed germination unlikely without large number of artificial controls
  - Pressure too low for respiration (although photo-synthesis maybe possible) O_2 required
  - Environment too cold. Requires artificially warm environments
  - Too Dry. Low vapor pressure means any plant moisture would immediately evaporate. Requires controlled humidity
- *The high number and extreme degree of controlled variables required for germination would cast doubt on the value of any positive results which may occur*

Questions?

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