

FY21 IRTD Final Report Summary

Project Title: Microgreens Root Zone/Shoot Zone Partitioned Planting Box

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Project Description: To enable sustainable food production in future human exploration missions, plant growth is being studied by the Space Crop Production Team at KSC. Microgreens are good candidates for food supplements and contain specific nutrients that are lacking in the prepackaged diet, including vitamin C and vitamin K. Because they are densely sown, typical growth methods do not allow the ability to distinguish between the levels of evaporation from the rooting substrate and transpiration from the leaves. With larger plants, the root and shoot zone can be separated to distinguish these fluxes and accurate transpiration measurements of plant canopies are feasible. Furthermore, separation of the root and shoot zone may also be beneficial when harvesting microgreens in microgravity as it may reduce microbial contamination of the edible biomass by the roots, which have high microbial loads. Using a root and shoot separator box when harvesting may help with microbial contamination, but these tiny plants are challenging to handle in microgravity, so harvest management remains an open question.

The innovation proposed here is a microgreen root/shoot partitioned planting box, which offers a solution to these challenges with accurate gas exchange measurements and a safe microgreen harvest in low gravity environments. Being able to measure transpiration of a microgreen canopy will be important for modeling plant growth in reduced gravity environments, so the first objective was to develop a planting unit with a seal between the root zone and the shoot zone. With an unsuitable harvesting technique, freshly harvested microgreens may add debris to the cabin, so the second objective was to test different harvesting techniques and management approaches associated with this innovation. These two objectives were pursued in parallel since many goals were the same: develop a planting unit that 1) separates the shoots from the roots, 2) allows acceptable germination rate, and 3) allows for seedlings to emerge and develop. What differed was the need to have a seal, which was only applicable for our gas exchange goal, and the need to have an embedded harvesting mechanism and bagging method which only applied to our harvesting goal.

Testing of the various harvesting mechanisms and bagging methods was performed during a series of parabolic flights. All parabolic flight procedures took place inside a rented secondary containment chamber (e.g., glovebox) that was developed by the University of Louisville specifically for experiments involving fluids and other materials that may become airborne during reduced gravity flight. Three different harvesting methods and two different bagging collection methods were tested for microgreens. A third bagging method was initially tested but found to be unsuitable. Human factors were also taken into consideration, to identify which harvest and bagging collection methods would be easiest to use with favorable results in microgravity. Three parabolic flight tests were performed in total, one in November 2021 and two in December 2021.

Closeout Summary: In future human exploration missions, plant growth will help reduce resupply, storage, and launch costs, as well as provide astronauts with necessary nutrients, which tend to degrade over time in pre-packaged meals. Microgreens are a category of crops that are rich in nutrients and easy to grow, but they have not yet been tested in spaceflight. The Space Crop Production Team at KSC has developed a microgreens root/shoot partitioned planting box to 1) enable accurate gas exchange measurements of microgreens canopies, and 2) improve microgreens harvest techniques both in 1g (Earth's gravity) and in microgravity, without concern for contamination by roots, which generally have high microbial loads. Growth chambers on the ISS (Veggie and the Advanced Plant Habitat), designed for larger, less-densely-sown plants, allow for a full separation between plant roots and shoots, but microgreens are densely sown, making this separation challenging. Harvesting microgreens in microgravity could allow for contamination by roots, and this could present food safety concerns. Microgreens may also become loose debris within the cabin under unsuitable harvesting techniques, so different harvesting techniques associated with these planting boxes in microgravity and reduced gravity were tested during three parabolic flights to determine the best approach(es). A validated microgreens planting box has enabled easier microgreens harvests and may improve food safety for sustainable and safe nutrient production in future missions, as well as provide data for gas exchange of these small plants.