FY20 IRTD Final Report Summary

Alternative Plasma Sources for Space Agricultural Applications (20-1)

Kenneth Engeling / Co-PI / UB-E
Annie Meier / Co-PI / UB-E
Gioia Massa / UB-A
Nilab Azim / BA-A2
Ryan P. Gott / Universities Space Research Association, Kennedy Space Center, Florida
Christina M. Johnson / Universities Space Research Association, Kennedy Space Center, Florida
Haley Boles / University of Florida – NASA OSTEM Intern
Victoria Brown / Oakland University – NASA OSTEM Intern
Mary E. Hummerick / LASSO-Ammentum, Kennedy Space Center, Florida

Project Description:

Design an apparatus for plasma activated water in order to study it for seed surface sanitation purposes.

Executive Summary:

As human innovation continuously expands the knowledge base for life beyond Earth, the need for self-sufficient spacecraft is essential. With that, space crop production facilities are ever expanding for research and development. A current area of key interest is seed sanitation before transport from ground to the ISS. Sanitation practices are performed to mitigate any potential biohazard and to ensure the viability of the seed. Conventional methods involve fumigation of seeds or chemical processes but are not effective with all seed types. Therefore, plasma technology was implemented in this one year IRTD opportunity in order to explore low-temperature plasmas as an alternative means for seed sanitation without the need for chemicals. This project addressed the viability of plasma as a means for sanitation by incorporating three different plasma types within the study.

The team designed a test matrix and test apparatus for the plasma systems in order to plasma treat the seeds under varying conditions and study sanitation and seed viability.

The germination and microbial loads of seeds were monitored for 66 different treatments involving three power supplies at various powers, pressures, and gas mixtures. The goal of each experiment was to minimize microbial loads without losses in germination rates. A threshold of 70% germination was used to evaluate a successful test. The use of recirculated air performed better than the use of a single pass method. In the recirculated air setup, the same gas was repetitively exposed to plasma, while the single pass vented out the treated gas and continually introduced new, untreated air. This indicates that the reactive species being produced by the plasma system are the driving force for both the germination improvement and the microbial reduction. The dielectric barrier discharge had successful microbial reduction, but at the cost of germination rate. The high doses of reactive species were effective at reducing the microbes, but the high power required to generate these species caused damage to the seeds that reduced the germination rate.

The conclusion of this work resulted in a methodology and results for the treatment of radish seeds using various plasma systems. For our project purposes, the optimal system was the radiofrequency sub-atmospheric plasma chamber. The treatment using this system led to a trade off in operating conditions depending on the intended benefit. In general, treatments of 100 watts for times longer than 10 minutes were best for microbial reduction. However, in the cases of treatments reaching 18 and 20 minutes, the germination was negatively affected. Air was

shown to outperform argon, due to the production of reactive nitrogen and oxygen species. Overall, the plasma systems show promising potential, but require further exploration.