



# Fertilizer

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# NASA's Technology Transfer Program fosters targeted fertilizer techniques

## ...in space and on Earth

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**As scientists at the National Aeronautics and Space Administration (NASA) experiment and test new ways to explore beyond Earth, the Technology Transfer Program works diligently in tow to transfer the knowledge and technology gained in these space travel efforts to the commercial sector. The NASA Technology Transfer Program was developed to disseminate NASA technology and information to the widest possible audience, to have the greatest effect on the economy and benefit society.**

At NASA's Kennedy Space Center (KSC), one of the best examples of this policy in practice is the successful collaboration between KSC's Veggie Space Plant Biology Program and Florikan, a Florida-based controlled-release fertilizer company.

In 2004 Florikan was recognized by the state of Florida and by the National Society of Professional Engineers (NSPE) for developing one of the year's most innovative new products. The award associated with this recognition

created the opportunity that initiated the relationship between NASA KSC and Florikan. The award came with 40 hours of free consulting with a Federal agency of the recipients choosing and Ed Rosenthal, Florikan's founder, chose NASA. "I knew NASA was working with some really sophisticated polymers that hadn't yet made it into the commercial market," Rosenthal said.

### Product redesign

By the end of the 40-hour collaboration, NASA's researchers recommended a holistic shift in the controlled release fertilizer approach. By using a specific combination of reactive polymers and coating the nutrients with a single polymer, the researchers were able to positively alter the performance of the fertilizer. This breakthrough prompted a total product redesign and two years of laboratory work to perfect the new formula. In 2008 Florikan had two new patents, the first for Staged Nutrient Release (SNR) fertilizer and the second

for the polymer coating the fertilizer used. The redesigned product is coated in semi-permeable polymers that control when, and how much, of each nutrient is released over 6-12 month periods.

Plant scientists at KSC are implementing similar techniques in their in-space plant growth efforts. The precise hands-off nature of controlled release fertilizer is perfect for the International Space Station (ISS), where minimal crew intervention is a necessity. "Having the ability to implement a controlled release fertilizer (CRF) - which adds the right amount of nutrients over time without any mixing or any measuring out of chemicals - makes it much simpler," explains Gioia Massa, science team lead for the NASA Veggie project at Kennedy Space Center.

The CRF solves the fertilizer industries biggest problem - absorption. Traditional fertilizers are administered frequently and in large quantities, because much of the fertilizer is not absorbed by the plant. The enhanced

efficiency' controlled release fertilizer mitigates, if not solves, this critical industry problem. One of the key benefits to CRF is its targeted nature, by keeping the nutrients in the 'root zone' of the plant, growers can maintain crop yield, while reducing nutrient inputs by up to 30%. This nutrient reduction has the potential to have a significant environmental impact, especially in Florida where sandy soils and high rainfall can be extremely detrimental to traditional nutritional programmes. This business model has definitely proven the concept and it appears to be an exceptionally successful one. Florikan has scaled up the controlled release technology and is now producing close to 40,000 tonnes of controlled release nutrients annually.

### Rigorous research

The future of every industry is trending toward specialization, optimization and innovation- agricultural engineering is no different. The technology that resulted from the NASA/Florikan collaboration is now being used to grow new crops aboard the ISS as well as to enable space plant biology' in NASA's new 'Advanced Plant Habitat' growth facility. With the knowledge gleaned from the experience, the Veggie team developed a way to incorporate the controlled-release fertilizers into the baked ceramic silica clay that holds the roots of NASA's Veggie plants - rather than the soil.

In 2013, NASA supported a rigorous research study, where the macro- and micro-nutrient release of three different controlled release fertilizers were tested, at five different temperatures between 5°C to 40°C. In 2015, for the first time, astronauts were eating romaine lettuce that was grown on the space station.

### Access to fresh food

Going forward, learning how to grow food in space will be hugely important as humans push forward in the effort to become a multi-planetary species. In the short term, the idea is to allow the astronauts on the ISS to have access to fresh vegetables and



US astronaut and Expedition 46 Commander Scott Kelly shared this photograph of a blooming zinnia flower in the Veggie plant growth system aboard the space station in early 2016. This experiment in flowering plants precedes planned tests of growing tomatoes and peppers in space. Credit: NASA

**We can use the same technologies to help create positive solutions here on Earth**



A NASA species selection of the Red Robin tomato is shown in vertical farming, grown with a blend of Florikan TM and Nutricote TM CRF 14-4-14 at Sweetgrass Farms, Sarasota, Florida. Credit Florikan





Lettuce being grown inside a control chamber at the space station processing facility at NASA's Kennedy Space Center in Florida. Credit: NASA

salad greens to supplement their diet and offer a little more of the natural comforts of home. The work that NASA and Florikan have done together has furthered both of these goals. "We worked very closely to develop a technology that would work for their hydroponic growing system in space," Rosenthal says.

The astronauts could not use the injectable liquid fertilizers that is typically used in hydroponic systems because water floats in microgravity and those systems typically require numerous applications, which is not practical for space, or efficient in general.

"We had to be able to deliver single-application nutrients without mixing them in water," Rosenthal says.

Dr. Luke Roberson, Sr. Principal Investigator, added: "Changing the way we fertilize our plants in space to optimize the nitrogen cycle on-board spacecraft and habitat structures will be critical to sustain and balance life in

remote areas of our solar system where we can't resupply critical elements."

In 2017, NASA KSC and Florikan, were inducted into the Space Technology Hall of Fame for previous fertilizer collaborations. Now NASA and Florikan are working to create new nitrogen release coatings and technologies.

### Advance knowledge

This story demonstrates the potential for meaningful collaboration between federal agencies and commercial industries.

"This is a good example of the way cycles of innovation can feed each other and advance knowledge. NASA's expertise in Polymer Chemistry from the Space Shuttle Program advanced Florikan's knowledge to perfect their fertilizer product and enable efficient fertilizer application and reduce environmental impacts to the Earth. Florikan's innovations with controlled

release fertilizer products have fuelled NASA's research to grow crop plants in space to supplement astronaut diets with fresh, nutritious food," said Trent Smith, Veggie Program Manager.

After the initial 40 hours of consultation, the KSC Technology Transfer Program facilitated the continued collaboration between Florikan and NASA KSC. The Technology Transfer Program works with a number of collaborative efforts like this. Moving forward, Florikan will continue to grow and improve their CRF product and the Veggie research will continue as NASA furthers its investigation into the complicated science of space agriculture in the hope that as researchers develop new technologies to push the boundaries of humanity's reach in space, they can use the same technologies to create positive solutions here on Earth. ■

*Note: Florikan® is a registered trademark*