WHAT EARTHLY CARBON-BASED NANOMATERIALS CAN DO FOR INTERGALACTIC FARMING

By Mariya Khodakovskaya

For the next 50 years, the world's farmers will have to feed more people than who ever lived over the previous 100 years. Global population has risen to approximately 7 billion, leaving only 1.7 acres of agricultural land per person. With the population expanding and farmland shrinking, growers are compelled to become more productive. Few feel the weight of this responsibility more acutely than Arkansas farmers.

According to the Arkansas Farm Bureau, agriculture yields $16 billion in annual revenue for Arkansas – one of the few states where the average per capita farm income exceeds non-farm per capita income. Every square inch of the state's 14.5 million acres of farmland is essential to our nation's, and the planet's, food security.

As a professor of plant biology at UA Little Rock, Dr. Mariya Khodakovskaya leads a team of researchers focused on improving plant productivity and stress tolerance. Her approach leverages the unique properties of nanomaterials and applies them to plants.

"The discovery of carbon-based and biodegradable nanomaterials offers considerable potential for the enhancement of agricultural production," said Dr. Khodakovskaya, who also serves as director of the Applied Science Graduate Program at Donaghey College of Science, Technology, Engineering and Mathematics.

Khodakovskaya's breakthroughs in leveraging nanomaterials began in 2008, when she realized how specific properties of carbon-based nanomaterials (their small size, absorption ability, penetration ability and chemical stability) could affect plants. In particular, the amount of nanomaterial is linked to specific plant responses.

"I considered what might happen when tomato seeds were placed on a growth medium infused with carbon nanotubes," explained Dr. Knodakvskaya. "Would exposed seeds even germinate in a 'nano-environment?' Surprisingly, we found that tomato seeds exposed to low doses of carbon nanotubes germinated more quickly and at a higher rate. Carbon nanotubes also accelerated tomato growth and flower production. This discovery permanently altered the path of my research and raised many more intriguing questions."

Khodakovskaya was especially interested in seeing if the same positive effects would occur in other plant species. Ultimately, she needed to know the exact biological mechanisms driving the positive effects of nanomaterials on plant systems. The answers could have profound impacts: The creation of a new type of plant growth regulator that would boost plant productivity and enable us to address the increasingly critical global food demand.

To unearth the answers, Khodakovskaya's team is working to enhance the tolerance of agricultural plants to environmental (abiotic) stresses using biotechnology and nanotechnology. Environmental stresses, like high or low temperature, water deficit, flood, salinity and heavy metals limit crop productivity and quality. "These stresses drastically affect the growth, development and productivity of crops, and may reduce the performance of the crops and reduce yield by 50% to 70%," said Khodakovskaya.

Since discovering the unique ability of carbon-based nanomaterials to boost seed germination and plant growth, UA Little Rock has become the leading institution in the establishment of new applications of carbon nanomaterials in plant agriculture. The research not only stands to improve crop production on Earth, but one day may improve stress tolerance in plants developed for the exploration of Mars, where "environmental stress" takes on a whole new meaning.

"Our recent research with the Arkansas Space Grant Consortium and NASA holds the potential to solve the problem of how to feed astronauts during long-term space exploration missions," revealed Khodakovskaya, demonstrating yet another otherworldly benefit provided by Arkansas' extraordinary research community.

Dr. Mariya V. Khodakovskaya is a member of the Arkansas Research Alliance (ARA) Academy of Scholars and Fellows. She is known for her pioneering work in crop improvement by the application of a wide range of carbon-based nanomaterials. In 2014, she formed a startup company, Advanced Plant Technologies, LLC. Since 2008, she has been a principal investigator or co-principal investigator on grants totaling more than $10 million. Her research has been supported by grants from the USDA-NIFA, NSF-EPSCoR, NASA-EPSCoR, Arkansas Science and Technology Authority (ASTA), Arkansas Soybean Promotion Board, biotechnological industry, the Arkansas Space Grant Consortium, and ARA. To learn more about Arkansas research, please contact visit www.ARAlliance.org.