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Unyielding

Megan Saunders
Kansas State University

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Researcher explores plant genomes to breed improved wheat varieties

The wheat that forms the basis of a tasty pasta dish today was domesticated nearly 10,000 years ago from wild grass. Eventually, these early cultivars, or breeding lines, spread to diverse regions around the world. These early wheat cultivars are helping researchers at Kansas State University develop new wheat varieties that are tolerant to changing climatic conditions.

Eduard Akhunov, associate professor of plant pathology at the university, has been investigating wheat genetic diversity for six years. Akhunov collaborates with a team of researchers from around the world in the search for specific wheat lines that are adapted to harsh environments.

"We analyze wheat lines that have been bred for many years around the world," Akhunov said. "People grew them in specific environments because they are very well adapted. This creates a unique opportunity to find new, useful genes that enable these wheat lines to grow in heat- or drought-prone conditions, or in the presence of pathogens."

For example, in 2013, Akhunov and his colleagues identified a gene that gives wheat resistance to a deadly race of Ug99, a wheat stem rust pathogen. Akhunov said that the goal is to find specific wheat lines that have these useful properties. Once they are pinpointed, researchers can begin crossing these lines with modern cultivars that currently grow in Kansas or in other regions.

Akhunov finds these genes by studying the sequences of multiple wheat genomes received from germplasm repositories around the world. This sequence-based approach leads to useful information without having to interbreed these wheat lines with local Kansas cultivars. For some traits — like drought and heat tolerance — it is impossible to simply bring in the wheat varieties from other parts of the world, plant them in Kansas, and deduce if these lines will be useful for breeding.

"If you bring wheat from the Middle East and try to grow it here, you would get a very poor product because it isn't adapted to the Kansas environment," Akhunov said. "Even if you plant a Kansas cultivar in Nebraska or Texas, it will develop completely differently. Instead, we study genetic diversity using technology that allows us to sequence all genes in the wheat genome."

The samples Akhunov studies all have a known geographic origin and are connected to the location's historic climate data. Researchers take isolated DNA from these samples and compare them against each other.

"When you compare genomic sequences, you're actually looking at genetic mutations in the genetic code that are enriched in the regions that show extreme climatic conditions," Akhunov said.

For example, if a group of lines grows successfully in a heat-stressed environment, the researchers can look at the mutations within that genome. If mutations are found frequently in these adapted lines, it could be deduced that these mutations make the wheat lines better adapted to this heat-stressed environment.

Akhunov said they create a catalog of mutations for a large number of wheat lines across the world. The project currently involves approximately hundreds of wheat lines from around the world and millions of mutations. To analyze these vast amounts of data, Akhunov uses the university's Beocat computer cluster.

"All our work is done on campus," he said. "In addition to computing resources, we're also lucky to have the Integrated Genome Facility just down the hall that has equipment for DNA sequencing. Just being able to process and analyze this data is a great success. The amount of DNA in a wheat genome is nearly six times greater than in the human genome. It takes a lot of time to analyze."

In spite of the seemingly never-ending job of data analysis, Akhunov and his team are continuing to expand their work. The next step is utilizing a technology that Akhunov, fellow Kansas State University researchers and industry developed that allows them to analyze genetic variations from grass species that are related to wheat. They collaborate on this project with the university's Wheat Genetic Resource Center.

"Species of certain grasses are related closely to wheat," he said. "We can crossbreed them with wheat and bring this exotic diversity into breeding programs. Many useful genes, including drought- and disease-resistance genes, are found in these grasses, so this could be an effective way of controlling wheat-killing diseases or yield losses."

Akhunov's wheat genetics projects are funded by the Kansas Wheat Commission, the U.S. Department of Agriculture, the National Science Foundation and the university. All support contributes to the project's overall goal of learning how plants adapt to their environments.

"When we understand the mechanisms, we can learn to predict if a wheat variety will be able to adapt or not," Akhunov said. "There will always be screening involved, but it will become a more precise science."

By Megan Saunders, Communications and Marketing