The power of flowers: Research sprouts a closer look at sunflower genetics

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A Kansas State University researcher's plant genetic work is rooted in the sunflower state.

Mark Ungerer, associate professor of biology, has two major research projects that involve evolutionary change in sunflowers, the state flower of Kansas.

"What we do in the lab is referred to as ecological or evolutionary genetics," Ungerer said. "We study naturally occurring species and try to understand the genetic basis or genetic underpinnings of natural variation."

There are more than 50 species of sunflowers. Some are annual plants -- meaning they germinate, flower and die in one year -- and some are perennial plants that grow and bloom every year and live longer.

Ungerer's first project focuses on five species of annual sunflowers: two parent species and three hybrid derivative species. All three hybrid species arose from ancient hybridization events between the same two parents -- an unusual way for new species to develop, Ungerer said.

"What also makes the system unique is that the hybrid species are recently derived in the last half a million years," Ungerer said. "It seems like a long time, but that is actually pretty recent in evolutionary terms."

But there is another interesting aspect of the three hybrid species: While they have the same number of chromosomes as the two parent species, the hybrid species' genomes are 50 to 75 percent larger in terms of the amount of DNA.

Ungerer's research team made an important discovery that explains this DNA difference. The researchers studied long terminal repeat, or LTR, retrotransposons, which are mobile genetic elements that can copy themselves and insert the copies into various chromosome locations. Ungerer's team discovered that the hybrid species and the parent species were different because of massive proliferation events, or rapid reproduction, of the LTR retrotransposons. Not only that, these transposable elements are still active and cause mutations in sunflowers.

"It's like a smoking gun," Ungerer said. "It helps us study the process."

The researchers now want to know the triggers of these proliferation events and how the species have reacted to this increase in genome size. Ungerer has received $610,000 from the National Science Foundation to study these rapid proliferation events and how they affect the evolution of the hybrid sunflowers.

"Although virtually all plants and animals have these types of sequences in their genomes, we still know very little about what phenomena cause them to amplify and make extra copies of themselves," Ungerer said.

Ungerer is studying two naturally occurring phenomena -- hybridization and stress -- that are hypothesized to cause proliferation of these mobile DNA sequences. The group of five annual sunflowers provides an excellent system to study the roles of hybridization and stress because not only have the three hybrid species arisen from ancient hybridization events, but they also are locally adapted to harsh and stressful environments, unlike their parental species. Two of the hybrid species grow in the desert and the third hybrid species grows in salt marshes, Ungerer said.

Ungerer's second project looks at clinal variation of a perennial sunflower species. This species has a wide geographic distribution across central North America and grows in areas from Texas north to Manitoba, Canada. Ungerer wants to understand population differences between sunflowers in

different parts of the region.

For this research, Ungerer's team is conducting common garden experiments, which involve gathering seeds from each of the populations across central North America. The Kansas seeds came from the Konza Prairie Biological Station. The seeds are then grown in the same common garden at Kansas State University.

"If you see differences among plants in a common garden experiment, you attribute that to genetic differences of populations at these different locations," Ungerer said. "We have found striking differences."

Some of these striking differences include germination and flowering time. For example, because the growing season in Manitoba is much shorter, sunflowers grow quickly and flower in about two months. In Texas, where the growing season is much longer, sunflowers grow much slower and the plants grow much larger before they flower in about seven months.

"Now we are trying to expand this research to look at some of the underlying genetics of these differences," Ungerer said.

His second project has been funded by the K-State Integrated Genomic Facility and the Division of Biology's Research Experiences for Undergraduates program.

Provided by Kansas State University