First look at complete sorghum genome may usher in new uses for food and fuel

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Although sorghum lines underwent adaptation to be grown in temperate climates decades ago, a University of Illinois researcher said he and his team have completed the first comprehensive genomic analysis of the molecular changes behind that adaptation.

Patrick Brown, an assistant professor in plant breeding and genetics, said having a complete characterization of the locations (loci) affecting specific traits will speed up the adaptation of sorghum and other related grasses to new production systems for both food and fuel.

Brown is working on the project through the Energy Biosciences Institute at the U of I, hoping to use the sorghum findings as a launching pad for working with complex genomes of other feedstocks. The EBI provided the startup funding for the study.

To adapt the drought-resistant, tropical sorghum to temperate climates, Brown explained that sorghum lines were converted over the years by selecting and crossing exotic lines with temperate-adapted lines to create lines that were photoperiod-insensitive for early maturity, as well as shorter plants that could be machine-harvested.

"Surprisingly no one had ever really genotyped these lines to figure out what had happened when they were adapted," Brown said. "Now that genotyping is cheap, you can get a lot of data for a modest investment."

Previous studies had looked at a specific genomic region or a smaller subset of these lines. "This is the first study to look at all of them. A previous paper had come out looking at a specific region of chromosome 6. What we did was not much more expensive, and we got a bigger picture that was completely technology enabled," he said.

The researchers used a new technique called genotyping-by-sequencing (GBS) to map genetic differences in 1160 sorghum lines. Brown said GBS is a new technology developed in the last two years. Brown and his team, along with other researchers, have made refinements to the process. "Using GBS, we're now able to cover the whole genome with some gaps in individual lines," he said.

While much improvement has been done for grain sorghum, Brown said little improvement has been done for sweet or bioenergy types.

"Part of the reason for caring about all of that now is that up to this point sorghum has mostly been grown for grain. It's pretty short stuff, doesn't blow over on the windy high plains, and is really hardy. But now there is a lot of interest in using sorghum for other things, such as growing sweet sorghum in areas where they grow sugarcane, and growing biomass sorghum for bioenergy through combustion or cellulosic technology."

Getting a complete map of the traits researchers are most interested in—plant height and maturity—will help researchers unlock the diversity in the exotic lines and bring it into grain sorghum, Brown said.

"We'll be able to start moving forward. We'll basically be able to breed all these sorghum types more easily and use the genes that we bred for in grain sorghum over the last hundred years and move them into sweet sorghum and biomass sorghum. We think that finding those genes is going to be critical," he said.

Even with this complete genetic map, Brown said the research is still not at the end point.

"The case I always make is that over here we have grain sorghum, where we've done almost all the plant breeding, and where we've stacked the good genes. Over here we've got exotic sorghum, which hasn't been improved at all, yet it's where most of the genetic diversity is. For that genetic diversity to be useful to grain sorghum, we need to know where the genes are for height and maturity so we can bring in good diversity while keeping our grain sorghum short and early like we need it," he said.

On the other hand, Brown added that if improvements are to be made for sweet, forage, or biomass sorghum, researchers will need to bring in some of the genes from grain sorghum, for traits like seed quality or early-season vigor.

"This is the general agronomic stuff we've been breeding for, not the genes for dwarfing and earliness. Most of this sorghum now goes to chicken feed or ethanol in the United States."

"We do have a collaboration with Markus Pauly, an EBI researcher at Berkeley who is looking at the composition of sorghum. But the bigger problem with biomass sorghum right now is the moisture content of the biomass. Unlike miscanthus or switchgrass, where you can go in and harvest in February when it's pretty much bone dry, and all the nitrogen has already been moved back down underground, sorghum doesn't work that way," Brown said.

Because biomass sorghum is grown annually, growing until frost comes, when it is harvested it has a high moisture content. "When we cut it down, there's tons of biomass. I don't know that there's anything else that can match it in the area, but the biomass is really high moisture. For the existing cellulosic idea as it stands now, that is not very useful," he said.

"That's one of the roadblocks to biomass sorghum right now," he said. "Sweet sorghum, where you squeeze the sugary juice out like sugarcane, may be closer on the horizon. There is an ethanol plant starting up in southern Illinois that plans to use 25 percent sweet sorghum. "Right now, we're using sorghum as a model —maybe we can find sorghum genes that we can also tinker with in miscanthus or sugarcane," he said.

Brown added that with genetic studies and improvements there are other value-added opportunities for sorghum grain. "It's not quite as nutritious as corn, but researchers are looking at it as a way to combat obesity. They are looking at compounds that will prevent you from absorbing all the nutrition in your food in the small intestine," he said.

Another gene found shows that sorghum produces a huge amount of antioxidant in the outer layer of the grain. "It produces 10 times more antioxidant than blueberries. The yield of sorghum hybrids with those traits aren't quite what they need to be yet. There is stuff to work out with all of this," he said.

More information: "Retrospective genomic analysis of sorghum adaptation to temperate-zone grain production," was published in *Genome Biology* (*Genome Biology* 2013 14:R68) and can be accessed online at genomebiology.com/2013/14/6/R68. Co-authors of the study were Carrie S. Thurber, Justin M. Ma, Race H. Higgins, and Patrick J. Brown.

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