Science Societies

Pearl Millet: The Cereal of the Future?

A New Book and Crop Science Special Section Highlights the Grain

By Tess Joosse

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Photo courtesy of Wikimedia Commons/sarangib.

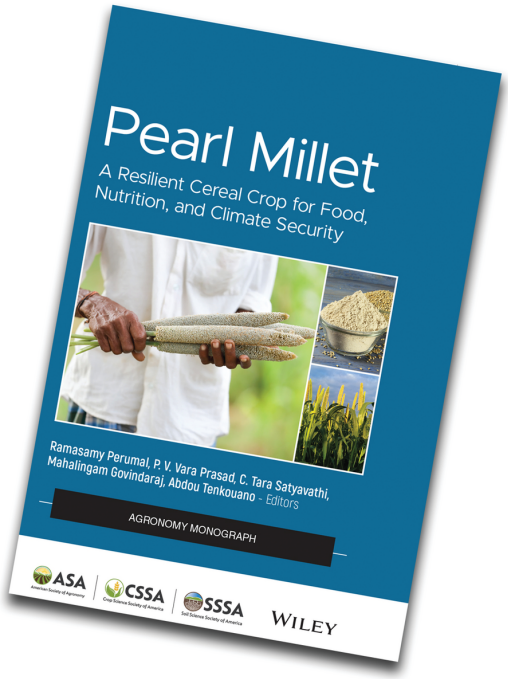
Video Summary

Of the 8.2 billion people in the world, most of them get their daily calories from three crops: wheat, rice, and maize. And at least half of them face water shortages for a month out of the year at minimum. In this scenario, climate change and population growth hand in hand present existential threats to food security.

“Climate change is going to be a big challenge to growers,” says Ramasamy Perumal, a sorghum and millet breeder at Kansas State University and ASA and CSSA member. In the future, “we cannot depend on all these water‐loving crops like wheat, corn, and rice,” Perumal says.

But there are alternative crops out there that could address these challenges. Millets are nutritious cereal grains that can grow in water‐stressed, arid and semi‐arid environments and have a wide range of end‐uses. To elevate and promote millets’ international profile, the United Nations declared 2023 the International Year of Millets. “It is very important for global food security, nutrition security, and climate security,” says Vara Prasad, a crop physiologist also at Kansas State and ASA, CSSA, and SSSA member, of millet.

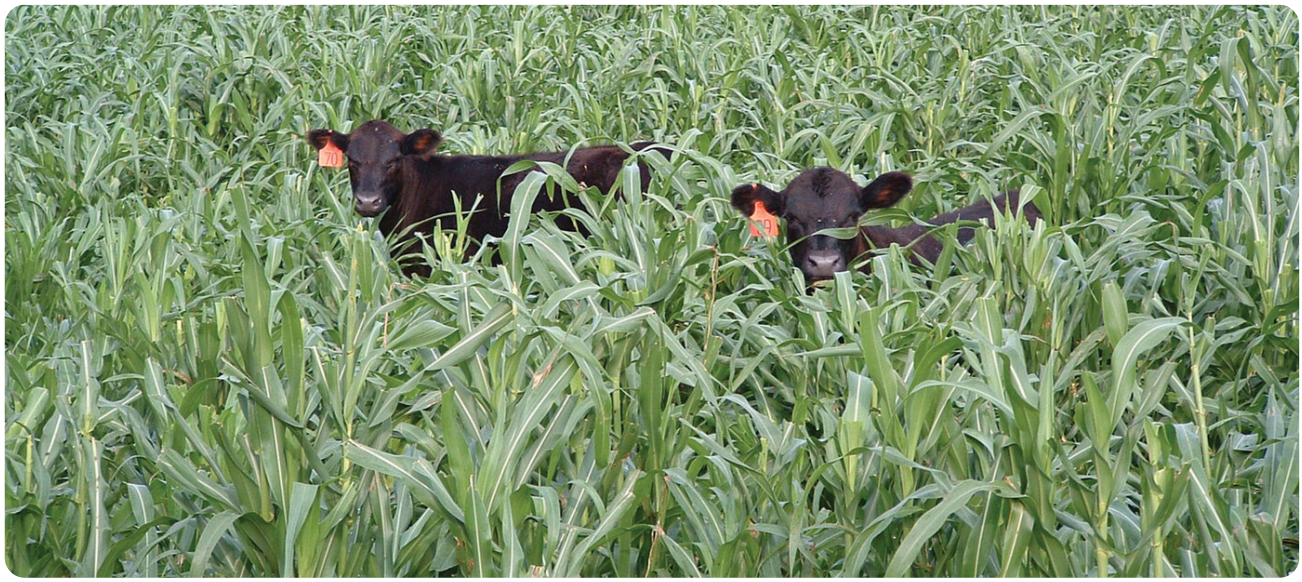
The upcoming ASA, CSSA, SSSA book *Pearl Millet: A Resilient Cereal Crop for Food, Nutrition, and Climate Security* and a recent *Crop Science* special section commemorate the International Year of Millets and highlight the opportunities these cereals offer. As editors of the book, Prasad and Perumal hope to introduce millet to a diverse audience of students, teachers, researchers, industry professionals, and growers, particularly in North American markets. “In the United States, this crop is totally underutilized,” Perumal says.



An Ancient Grain with Global Impact

Millets may not be star players on breakfast, lunch, or dinner plates in the U.S. But this expansive grass family of small-grained cereal is a staple for a huge chunk of the global population.

Archaeologists have traced the origins of millets back 10,000 years to northern China where excavations in the 1970s uncovered fossilized foxtail millet (*Setaria italica*) and common millet (*Panicum miliaceum*) remains in ancient storage pits. Today, millets are cultivated on more than 30 million ha across arid and semi-arid climes of the world with Africa hosting 60% of global cultivation and Asia 35%. On both continents the grain is used as fodder for livestock, in a variety of industrial applications, and, of course, as food for humans. “Close to 90 million people are using this cereal crop as a food crop, particularly in African countries and in the northern part of India,” Perumal says of millet’s global prominence.



A cow and calf grazing on a summer cover crop of pearl millet. Pearl millet's growing season is short, making it an attractive option to incorporate into cropping and livestock systems. Photo by Steven Knapp, USDA-ARS.

Pearl millet (*Pennisetum glaucum* [L.] R. Br.) is the most popular type of millet and makes up half of the world's millet production. In Africa and Asia, pearl millet is used in breakfast porridges like ogi, in unleavened breads like roti, in other baked items like biscuits, cookies, and cakes, and even in beers and noodles.

The small amount of pearl millet grown in the U.S. (approximately 1.5 million estimated acres according to numbers from 2002 compared with the yearly average of 90 million acres of corn) is almost wholly used for forage or in poultry feed and birdseed—an underutilization, as Perumal puts it. In particular, many U.S. growers are totally unaware of the value of millet in terms of drought tolerance, he says.

Drought Tolerance and Climate Resilience

Pearl millet has many benefits and qualities to explore. But one of its most bedrock qualities is its drought and high temperature tolerance. “Pearl millet is one of the most climate-resilient crops we have,” Prasad says.

It can survive, and indeed thrive, in parched conditions. “The water requirement from sowing to maturity is very low, approximately 300–400 mm of water,” says Prasad, “which is very low compared to that of rice, which probably needs more than 1,000 mm.”

What’s more, pearl millet can handle high heat: between 25 and 35°C (77 to 95°F). In studies, Prasad and Perumal have compared temperature tolerance of grain crops and have found pearl millet to be more heat tolerant than rice and wheat. The latter two use C3 photosynthesis, like most other crops, while pearl millet uses C4 photosynthesis, a process that enables plants to concentrate CO_2 around the Rubisco enzyme in respiration, improving efficiency and water use.

But pearl millet even wins the heat tolerance contest against sorghum and maize, which also use C4 photosynthesis. “Among these all having the same type of physiology and photosynthetic mechanism, still pearl millet is the most heat tolerant compared to maize and sorghum,” explains Prasad. Even when comparing apples to apples, pearl millet comes out on top.

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compared with maize and sorghum."



Pearl millet has a lot of genetic diversity that could be exploited by breeding for things like drought tolerance, yield, and nutrition. Photo by Michael Major/Crop Trust.

Genetics and Gluten

In a new study published as part of the *Crop Science* special section, Perumal and Prasad also compared drought tolerance across dozens of pearl millet parental lines, identifying several possible lines for further hybrid development (https://doi.org/10.1002/csc2.21271). "Another beauty of this crop is that there's a lot of genetic diversity," Prasad says. According to the ITPGRFA, there are 73,578 accessions of pearl millet germplasm available globally. These genetic resources are waiting to be exploited for hybrid development, the researchers say.

This includes breeding for drought tolerance and of course yield, but also nutrition. "When we look at the global population, we have serious issues with malnutrition… micronutrient deficiencies in particular are very critical," Prasad says, spotlighting iron

and zinc deficiency as specific global public health concerns.

A 100 g portion of raw pear millet grain contains about 366 calories, 9.9 g of protein, and 9.5 g of fiber. It also supplies high quantities of iron, zinc, phosphorus, magnesium, and copper. Pearl millet provides such a comprehensive portfolio of nutrients that it's sometimes dubbed a "nutri cereal."

It's also gluten free, a benefit for consumers with celiac disease or gluten intolerance. Pearl millet also has a low glycemic index, due to its high resistance starch and slowly digestible starch content. "It's slow in releasing sugar, so it's very good for diabetics," Prasad says.

And its nutritional bonuses don't just apply to humans. "For forage also, it has tremendous nutritional value for feeding animals," says Perumal, and has high palatability, with a high leaf to stem ratio, more tillers, and a thin stem when compared with sorghum. A recent study in the *Journal of Entomological Science* even found that the crop can be a good source of pollen for honey bees. And pearl millet's growing season is short, making it an attractive option to incorporate into cropping and livestock systems.

Digestibility and Other Disadvantages

Though there are still improvements that can be made to pearl millet through breeding, its benefits are well established. "It's very clear that pearl millet is a nutritious, healthy option," Prasad emphasizes.

Still, pearl millet is not a panacea without its disadvantages. It can be difficult to digest, especially when compared with other cereal crops like rice. However, Perumal notes that pearl millet has high protein and fat content, and when it is mixed with other

cereals in a multi-grain context, “that kind of issue can be easily compensated.” Some breeding efforts are focused on enhancing digestibility, he adds.

Other breeding efforts are aimed at improving pearl millet grain production to increase its harvest index. “The grain productivity is relatively low when you compare it with maize or sorghum,” Prasad says. Weed control is also an issue; there are not many herbicide options available for this crop.

Another problem is storage and shelf life. “When it comes to post-harvest, once you process the flour, the flour goes bad very rapidly,” Prasad says, due to rancidity, oxidative and hydrolytic changes that occur in lipids in the grain after grinding. And, of course, the lack of gluten affects what end products you can make with pearl millet flour—namely, you can’t make leavened breads. “Gluten has some of its advantages,” Prasad says. “You are able to make a nice loaf of raised fluffy bread.”



Millet flour—freshly ground and for hand?processing to form it into rolled pellets for millet couscous or millet porridge recipes. Photo courtesy of Wikimedia Commons/ T.K. Naliaka.

A One-Stop Shop

These barriers aside, millet's value has been known around the world for decades and even centuries. So why has it not caught on for consumers in the U.S.? "I would say it's communication and marketing," Prasad says. "I would compare it to the story of quinoa" he continues. "Fifteen, 20 years ago, I didn't know what quinoa was," he says of *Chenopodium quinoa*, which originated in South America and started becoming popular in North America in the early 2000s. By the time the crop got its own public relations boost when the UN General Assembly declared 2013 the International Year of Quinoa, it was cultivated in 70 countries and could be found in multiple forms across grocery store shelves in the U.S. Case in point: a search for "quinoa" on the *New York Times*' popular *Cooking* vertical returns 124 recipes while "millet" only returns 31 ("rice" yields a whopping 2,581 hits).

Prasad hopes to see a similar trajectory for pearl millet and millets broadly. "It's a matter of awareness," he says. "Now it's up to the communities, including all stakeholders: private sector, government sector, consumers, to put in proper investments." Private sector engagement with pearl millet unsurprisingly pales in comparison to maize, rice, and wheat, Perumal notes. "A lot more research investment dollars are needed."

In all, Prasad and Perumal say *Pearl Millet: A Resilient Cereal Crop for Food, Nutrition, and Climate Security* is for this wide and diverse audience of stakeholders. But they especially hope to see it used by young researchers and in educational contexts, both in the U.S. and internationally.

"I really want the young generation, the new set of scholars, new set of extension folks, new set of farmers, the people who are getting into the donor and the private sector to know about this particular crop moving forward," Prasad says. "I would also see this as a good resource for teaching, because … there is not a dedicated book at this point of

time which covers all the components of pearl millet available in the developing nations." The book is designed to be a comprehensive guide to the biology, uses, benefits, drawbacks, and future of the crop, he says. "This is a one-stop shop for everything."

DIG DEEPER

The book *Pearl Millet: A Resilient Cereal Crop for Food, Nutrition, and Climate Security* will soon be available for purchase through the Wiley website at https://bit.ly/3ZpRkse.

Read the *Crop Science* special section commemorating the International Year of Millets here: https://bit.ly/3ZUk7Fr.

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