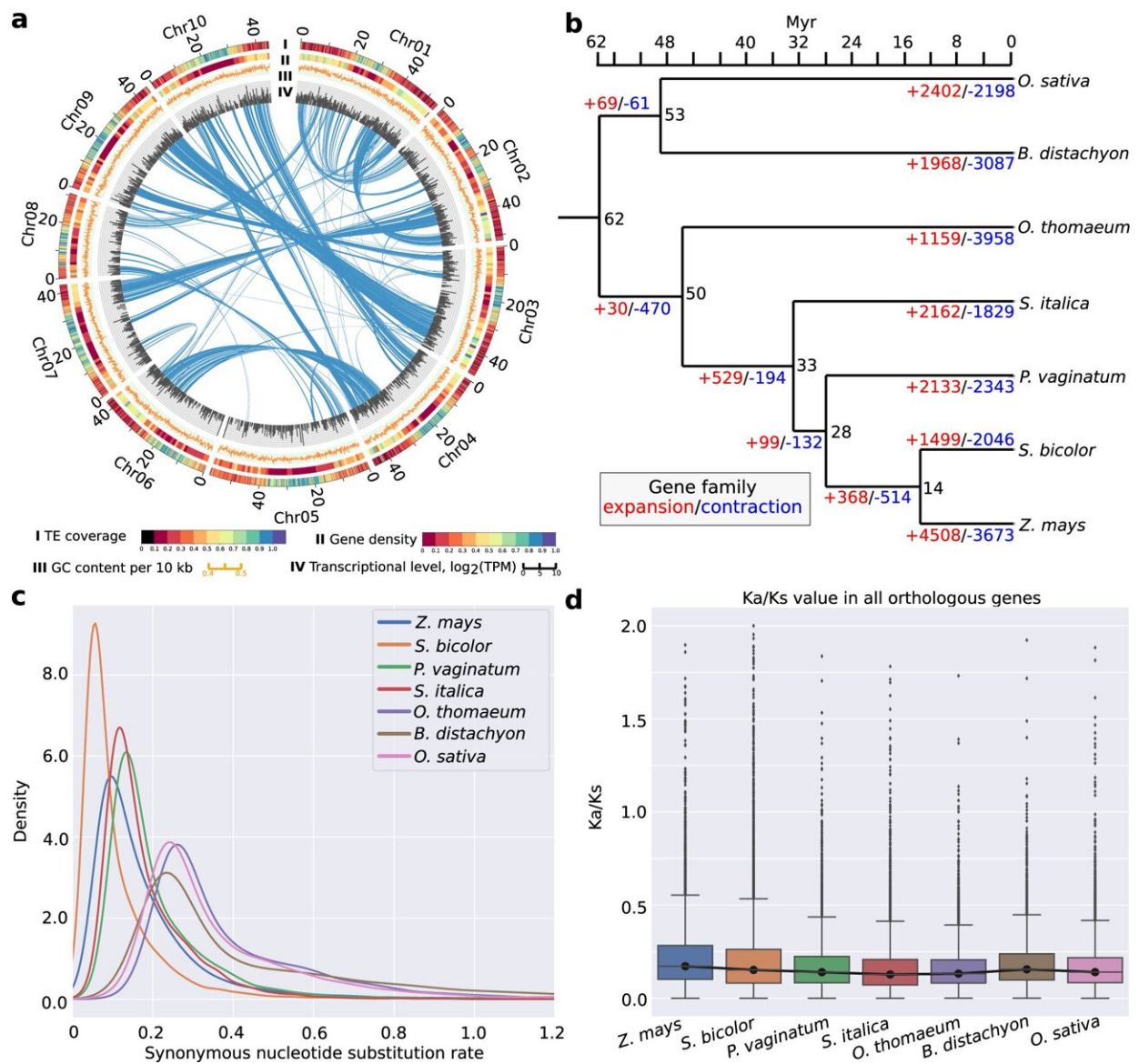


# Pitch-perfect: Study of World Cup's turfgrass may help crops yield more from less

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Paspalum (*Paspalum vaginatum*) genome and evolution. a Properties of the paspalum genome. Layers in circos plots are (I): TE (transposable element) coverage per 100 Kb, (II): gene density (proportion of sequence covered by annotated genes) per 1 Mb (megabase), (III): GC content per 10 kb (kilobase) region, (IV): transcription represented by  $\log_2(\text{TPM (transcripts per million)})$  per 100 kb. Green lines indicate inter- and intra- chromosomal synteny. b Phylogeny and estimated divergence times among maize (*Zea mays*), sorghum, paspalum, foxtail millet (*Setaria italica*), Oropetium (*Oropetium thomaeum*), Brachypodium (*Brachypodium distachyon*), and rice (*Oryza sativa*). Numbers in black indicate the estimated divergence time in millions of years before present (Myr) for each node. Numbers in blue and red indicate the number of gene families predicted to have experienced copy number expansion or contraction along each branch of the phylogeny, respectively. c Distribution of the estimated lineage-specific synonymous substitution rates for syntenically conserved genes in each of the seven species shown in panel a (see Methods). d Distribution of the estimated lineage-specific ratios of nonsynonymous substitution rates to synonymous substitution rates for syntenically conserved genes among each of the seven species shown in panel a.  $N = 16,633$  distinct genes. For box plots in this figure and all subsequent box plots shown in this paper center lines indicate medians, box limits indicate 25th and 75th percentiles if the data distribution and whiskers the closer to the median of the minimum and maximum values or 1.5x the interquartile range, with data points outside this range plotted as individual points. Colors correspond to the legend provided in panel c. Source data are provided as a Source Data file. Credit: *Nature Communications* (2022). DOI: 10.1038/s41467-022-35507-8

**Grass is famously resilient. But *Paspalum vaginatum*, a species better known as seashore paspalum, can tolerate stresses diverse and deadly enough to rival camels and cactuses.**

**Salinity? It's still worth its salt. Drought? Not thirsty. Heat? No sweat. Cold? It can chill.**

How about 22 soccer players sprinting, kicking and sliding their way across it at the 2022 World Cup, all amid the desert climate of the Middle East? Game on.

A commercial variety of seashore paspalum has padded every pitch in Qatar. There, it's withstood every steel-cleated footfall of Messi, Mbappé and Neymar, every sunbeaten day of temperatures creeping into the high 80s Fahrenheit.

Thanks to a new study led by the University of Nebraska-Lincoln and published in *Nature Communications*, seashore paspalum may soon assist another goal: growing crops that yield more food with less of the fertilizer that imposes costs on farmers, ecosystems and drinking water.

Global application of fertilizers, especially the nitrogen and phosphorous essential to plant growth, has skyrocketed since the mid-20th century, around the time a teenage Pelé was leading Brazil to its first World Cup title. As it turns out, seashore paspalum doesn't need much of those nutrients, either. That sets it apart from some of its surprisingly close relatives: corn and sorghum, among other grass crops.

After sequencing the full genetic blueprints of the hardy grass, a multi-institution research team has discovered the bag of tricks behind the plant's fasting technique. What's more, the researchers managed to recreate those tricks in corn seedlings, which responded by growing faster and larger than other unmodified seedlings deprived of the nutrients.

"We finally are starting to understand just what makes this plant so resilient," said James Schnable, one of the study's authors and Charles O. Gardner Professor of Agronomy at Nebraska.

The species really began intriguing Schnable and his colleagues after an

impressive showing at the Nebraska Innovation Greenhouse, where it seemed not to care that its caretakers were neglecting it.

"There was a period where no one remembered to water the paspalum plant for a couple of months," Schnable said. "But the plant was completely fine. In fact, it usually grows so fast that it'll try to invade the pots of neighboring plants, and the greenhouse manager has to yell at me or folks in my lab to come down and trim it."

Guangchao Sun, a doctoral alumnus and former postdoc at Nebraska, took notice, too. He decided to put seashore paspalum's resilience to the test with an experiment, growing it alongside corn and sorghum for several weeks under multiple conditions. When the corn and sorghum were denied nitrogen or phosphorous, their stunted development showed it. The seashore paspalum, meanwhile, continued "happily growing."

Fortunately, the Schnable lab was also working with the Department of Energy's Joint Genome Institute, the University of Georgia and the HudsonAlpha Institute for Biotechnology on mapping the species' genome. Those strides cleared the way to studying seashore paspalum's tolerance in greater detail.

Analyses of its genes and [gene expression](#) later revealed that the [grass](#) responds to a lack of nutrients by roughly doubling its production of a sugary molecule called trehalose. Though corn and sorghum naturally churn out some of that molecule, the team saw no change in its production among the two nutrient-starved crops.

While the finding suggested that trehalose was playing a central role in the plant's resilience, Sun and the team pressed on for evidence that could meet a higher burden of proof. "What if," they thought, "we could increase trehalose in corn, then observe the results?" But applying trehalose directly to the crop proved ineffective.

"So I thought about it in the opposite way," said Sun, who now works as a bioinformatician at the Mayo Clinic. "If I cannot supply trehalose to the plants, what if I stopped its degradation in those plants?"

He turned to an antibiotic that can inhibit the enzyme responsible for degrading trehalose. The plan worked: Curbing the enzyme cranked up the trehalose levels in the corn. Within days, he noticed the crop growing more—regardless of whether it was nutrient-deprived. The results were so startling to Sun that he soon repeated the experiment multiple times. Each time, the corn responded the same way.

But the team had reason to suspect that the tolerance also relied on [autophagy](#)—what Schnable called "a recycling program" in plant cells that takes apart old or damaged proteins, then reassembles them into fresh, functioning ones. Eventually, the researchers developed a mutant of corn that lacked the ability to engage the final stage of that recycling. Even with a surplus of trehalose, the mutant failed to thrive when deprived of nitrogen or phosphorous, marking autophagy as an equally essential facet of the resilience.

"There are still other things to do," Sun said, before the team resolves the complete picture of seashore paspalum's world-class tolerance. He considers it only a matter of time, though, before researchers identify the genes that code for higher [trehalose](#).

"And if you could (introduce) that genomic region into other elite [corn](#) varieties—say, some maize that has high yield but is really sensitive to nutrient stress—maybe now you get both a [high yield](#) and high resilience," he said.

For now, Sun said he's glad to bask in the team's accomplishment. In true World Cup fashion, learning that the team's study had been accepted for publication brought on a few tears, a few hugs. And why not?

Qualification for the 2022 World Cup may have kicked off in 2019, but the research team had embarked on its project a year earlier.

"This was a long, long journey," Sun said. "Honestly, it increased my resilience, too."

**More information:** Guangchao Sun et al, Genome of *Paspalum vaginatum* and the role of trehalose mediated autophagy in increasing maize biomass, *Nature Communications* (2022). [DOI: 10.1038/s41467-022-35507-8](https://doi.org/10.1038/s41467-022-35507-8)

Provided by University of Nebraska-Lincoln

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