

# Thirsty wheat needed new water management strategy in ancient China

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Research from Washington University in St. Louis shows that a practice of purposeful water management, or irrigation, was adopted in northern China about 4,000 years ago as part of an effort to grow new grains that had been introduced from southwest Asia.

But the story gets more complex from there. Wheat and barley arrived on the scene at about the same time, but early farmers only used [water management](#) techniques for [wheat](#). The results, reported Nov. 9 in the journal *Antiquity*, raise awareness that the dispersal of domesticated crops and the knowledge of best using them can be traced independently across time and space.

"Pioneering farmers who cultivated wheat in this region managed water to meet the higher demand of this newly introduced grain," said Xinyi Liu, an associate professor of archaeology in Arts & Sciences, who collaborated on this study with researchers from several prominent institutions in China and Australia, including Guanghui Dong from Lanzhou University, who led the field expedition on the Loess Plateau. "The water management may have been achieved either by deliberate watering or by strategic planting in soils with higher water retention."

On the other hand, [early farmers](#) were able to grow the other new grain, barley, in a rainfed system as if it were just another kind of millet—the locally domesticated and most commonly grown grain in northern China at the time—without using any form of irrigation.

Liu published the study with Washington University graduate student Yufeng Sun. Other co-authors include Haiming Li and Petra Vaiglova, former members of Liu's lab group.

## **Introducing irrigation**

Both wheat and barley were domesticated in an area known to archaeologists as the hilly flanks of the Fertile Crescent in southwest Asia, where they originally were grown as winter crops. Traditionally, farmers there sowed their seeds in autumn—to avoid the summer drought period—and harvested them in late spring or [early summer](#) before the next drought season.

When these Fertile Crescent crops, wheat and barley, were introduced to East Asia about 4,000 years ago, they would have encountered a markedly different climate compared with where they originated.

"Every summer, the East Asian monsoon brings rains from the Pacific Ocean to a region otherwise arid throughout the rest of the year. This environment is perfect for rainfed millet cultivation as these local grains are drought tolerant but need considerable water in the summer growing season," Liu said. "But it is a different story if you try to grow wheat there, not only because it is water demanding, but also the growing cycle doesn't match the rainy season."

Liu and his colleagues wanted to know: Did the farmers who sought to grow the new grains in northern China also introduce new systems of irrigation to support them?

"The introduction of a new irrigation system is something that scholars have speculated about, but now we have the technology to seek direct evidence," Liu said.

Using relatively new techniques, the actual growing conditions of past crops—including past water and soil conditions during [plant growth](#)—can be measured using the stable carbon and nitrogen isotope compositions of charred plant remains. These methods initially were established in plant science for research concerning environmental conditions of modern-day agriculture and have been subsequently applied to [archaeological research](#).

Previous studies using similar approaches have shed significant light on early crop management in Europe and the Middle East. This research is one of the first attempts to apply it to East Asian monsoon environments with innovative questions.

For this study, the scientists identified more than 35,000 charred seed remains of cereal plants, including wheat, barley and millet, from more than 50 [archaeological sites](#) excavated on the Loess Plateau of China spanning a timeframe over eight millennia. Selected plant remains from this collection were radiocarbon dated and isotopically measured.

The results showed major differences between wheat and barley.

Despite the arid local environment, the majority of the wheat samples from all time periods had isotopic values above an optimal watering threshold, indicating that their growth was not limited by water availability.

"We see this in the Qijia culture period, when wheat and barley were just introduced to this region," Liu said. "The isotopic data of wheat show a significant level of water manipulation unambiguously since 4,000 years ago, indicating the new crop was introduced with water management strategies to support it."

## **Simple ditches can be powerful**

This evidence alone does not necessarily imply large-scale irrigation, Liu is quick to point out; instead, wheat crops may have been strategically sown in areas with the best water availability, either close to local springs or in soils with high water retention.

"In those locations, small ditches to diffuse water is sufficient," Liu said. "This explains why there is no archaeological evidence of channels or other irrigation installations in the area until much later."

Barley, on the other hand, appears to have been grown on the dry hills of the Loess Plateau without a special water management approach—a landscape and cultivation strategy that had been familiar to the Neolithic

millet farmers since 8,000 years ago.

This and other evidence suggest to Liu and his collaborators that ancient farmers sought to optimize [land use](#) and crop yield by taking advantage of the different water demands of these two crops.

"Our results raise an awareness that the dispersal of domesticated crops and the knowledge of best using them can be traced independently across time and space," Liu said.

"Central to our inquiry is the tension between non-native crops and indigenous farming practices," he said. "When non-native innovations were adopted in another cultural and physical environment, they would have been transformed within the local context. How this happens is an enduring question that is relevant to globalization in the past and present."

This study resonates with other archaeological investigations led by Liu's research group, the Laboratory for the Analysis of Early Food-Webs at Washington University. For example, co-author Sun's previous work with Washington University graduate student Melissa Ritchey demonstrated a similar geographic decoupling of the dispersal of grains and cuisines, such that wheat and barley dispersed into ancient China 4,000 years ago, but the western grinding-and-baking cuisines did not. The eastern movement of these grains involved selections of phenotypic traits adapted to ancient China's cooking tradition of using steaming-and-boiling.

It has been a long time since some scholars assumed the association between the origin of bureaucracy and irrigation, and ancient China had been used as an example of "oriental despotism," according to Liu. The "hydraulic empire" hypothesis speculated that a centralized government structure that maintained power would have been derived from the need

for flood control and irrigation.

"Our results suggest otherwise, such that irrigation was a much more localized practice, which did not necessarily require central coordination and a specialized bureaucracy," Liu explained. "Simple ditches and strategic planting can be as powerful as monopoly empires."

**More information:** Haiming Li et al, Water and soil management strategies and the introduction of wheat and barley to northern China: an isotopic analysis of cultivation on the Loess Plateau, *Antiquity* (2022).  
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