Yuan Longping (1930–2021)

When Mr Yuan Longping passed away on 22 May 2021 at the age of 91, in Changsha, Hunan Province, China, the field of agricultural science lost a true giant. Mr Yuan was one of the greatest agricultural scientists of our time, and a hero who will be forever remembered in China and around the world. He devoted his entire life to the research of hybrid rice and made great contributions to global food security and poverty alleviation.

Yuan Longping was born in Beijing in 1930 and received his agronomic degree from Southwest Agricultural College (now Southwest University) in 1953. Subsequently, he began his teaching career at Anjiang Agricultural School in Hunan Province, China. In the face of severe famine at that time, he was determined to use agricultural science and technology to defeat the threat of hunger. As rice was a staple crop and had great potential for yield improvement, he began to study rice breeding to solve the problem of food shortages in China and many developing countries.

In 1961, Yuan Longping unexpectedly found an 'outstanding' rice plant with excellent characteristics (large panicles and full grains). He carefully collected the seeds of this plant and planted more than 1,000 seeds the following year. Surprisingly, the traits of the offspring were segregated, and the elite phenotype was lost. Yuan was curious about the reason underlying the huge difference between the offspring and the parents. After careful analysis, he suggested that this 'outstanding' rice was a natural hybrid rice — therefore proposing that rice could be hybridized — which cast doubts on the popular authoritative theory that self-pollinated plants, such as rice, had no heterosis and were not suitable for hybridization. This interesting finding fuelled his enthusiasm in the study of hybrid rice, and thus determined his main research direction. Mr Yuan first proposed 'the three-line matching method' in the paper 'Male sterility in rice' published in 1966, laying the scientific foundation for breeding hybrid rice[1]. 'Three-line' refers to three lines of hybrid rice: male-sterile line, male-sterile maintainer line and male-sterile restorer line.

Because rice is a self-pollinating plant, it is extremely difficult to remove stamens manually for the production of hybrid seeds in large quantities. Moreover, heterosis is only obvious in the first generation of hybrids, which must be prepared for every planting cycle. This becomes the bottleneck in developing hybrid rice for agriculture, with the key solution being to breed with a male-sterile parent. Mr Yuan's discovery of natural hybrid rice inspired him to search for natural male-sterile rice with stamens that did not develop normally and pistils that could accept foreign pollen to reproduce hybridized offspring. The male-sterile plant, if it were to be found, would ideally be the female parent, which could then be crossed with other varieties to breed hybrid rice. With this in mind, Mr Yuan began to look for natural male-sterile rice plants. The search started in cultivated rice, where six male-sterile plants were found, but their male-sterile traits could not be maintained in the offspring. Mr Yuan and his team then expanded their search to wild rice and tried to perform distant hybridization. In 1970, they finally discovered a male-sterile wild rice plant called 'wild abortive' (WA). In 1973, the team harvested WA offspring which comprised tens of thousands of male-sterile rice plants — a milestone in the development of hybrid rice. WA has contributed ~95% of the male sterility source in the entire collection of hybrid rice developed worldwide so far. Although the process of discovering WA was long and challenging, Mr Yuan and his team remained confident. This confidence emerged from the clear research direction and their expertise on male-sterile phenotyping. Chance favours the prepared mind, and when encountering WA, they recognized the treasure at a glance.

Credit: Lu Boan / Xinhua / Alamy Live News

After establishing the sterile line and the maintainer line, the next step was to find a suitable restorer line, the last tie of the three-line matching to realize the utilization of heterosis. In 1973, Mr Yuan joined the Hybrid Rice Research Collaborative Group of the Hunan Academy of Agricultural Sciences and accelerated the progress of developing the three-line matching method. He found a suitable restorer line that closed the loop and led to breeding of the hybrid rice 'Nanyou 2'. By successfully developing the first hybrid rice varieties, Mr Yuan made tremendous contributions to the Green Revolution in agriculture, and he is recognized as the 'father of hybrid rice' in China.

The advent of high-yield hybrid rice greatly alleviated China's food problems, increasing the yield of conventional rice by about 20%. After making significant progress in the 1970s, Mr Yuan generously shared the results of the three-line method with domestic and international agronomists for no profit. In 1980, he volunteered to donate key rice varieties to the international community, and later trained farmers in Africa, Southeast Asia and South Asia to grow hybrid rice. The hybrid rice technology has been introduced and promoted in more than 40 countries around the world, and the cultivated area outside China has reached 9 million hectares.

After developing the three-line breeding method, Mr Yuan continued to seek breakthroughs to simplify the process of seed production. In the 1980s, Mr Yuan proposed to improve the hybrid rice breeding strategy from the three-line hybrid rice strain to a two-line variety, and finally to a one-line variety[2]. The two-line method uses temperature-sensitive or photosensitive sterile materials as the sterile line, omitting the propagation process of the maintainer line, whilst the one-line method refers to a

breeding technique that uses apomixis to fix the heterosis, and does not require annual seed production. This method could greatly reduce the cost of seed production and could maximize the application of heterosis. While the two-line method has been successfully developed and applied, the one-line method is not yet available. Mr Yuan's work had to stop here, but the search for the one-line method continues.

Mr Yuan Longping was credited with a long list of awards and prizes, including China's first special invention award in 1981, the UNESCO Prize for Science in 1987, the Nikkei Asia Award in 1996, the State Preeminent Science and Technology Award in 2000, the Wolf Prize in Agriculture and the Word Food Prize in 2004. He was elected as a member of the Chinese Academy of Engineering in 1995, and as the foreign associate of the United States National Academy of Sciences in 2006. Mr Yuan has won numerous titles and awards throughout his life, but these were not his pursuits. In a 2019 interview with China Central Television, he said that he had two dreams: one was "for super rice to grow taller than sorghum, with stems each ear as long as a broom, and each grain as big as a peanut", so he could "enjoy the cool underneath the rice crops"; the other was for "hybrid rice [to] be grown all over the world." For decades, Mr Yuan and countless researchers worked hard to realize these dreams. It is sad that Mr Yuan has left us, but his dreams are carried by many plant and agricultural researchers.

Mr Yuan Longping generated high-yield hybrid rice by proposing plant genetic theories and achieving practical field production. His breakthrough boosted the development and application of high-yield hybrid rice, and important contributions were also made by many other talented rice researchers. Mr Yuan's legacy is not only the progress of hybrid rice — his curiosity, devotion, courage, perseverance, diligence, cooperation and selflessness have left an indelible spiritual wealth to us all. ❐

Kejian Wang ✉

State Key Laboratory of Rice Biology, China National Rice Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China.
✉*e-mail: wangkejian@caas.cn*

Published online: 2 July 2021
https://doi.org/10.1038/s41477-021-00962-6

References

1. Longping, Y. *Chin. Sci. Bull.* **17**, 185–188 (1966).
2. Longping, Y. *Hybrid Rice* **1**, 1–3 (1987).