the plant journal Features

FROM THE MIND OF A PLANT SCIENTIST

Prof. Yan Jianbing

In this article, Professor Yan Jianbing of the Huazhong Agricultural University in Wuhan, China, candidly speaks about his childhood, what brought him to plant sciences, his thriving career both in China and internationally and how the COVID-19 pandemic affected Chinese academia.

Childhood

I was born in central rural China in the 1970s, when the villages were still poor. Before I reached 10, the only household appliance in my home was electric light. Two years later, my family bought the first 14-inch black-and-white TV. This TV just received several channels using a long antenna.

But this did not prevent me from enjoying a happy childhood. For example, my friends and I would take natural materials from the bamboo forests in the mountains to craft bows and arrows for catching pheasants and hares and to weave bamboo baskets for fishing in the creeks; we would dig out wild bamboo shoots and picked wild fruits. One of the merriest memories in my childhood was to harvest a corn by the side of the road I took to and from the school and gnawed it as sugarcane. I could feel a mild sweetness in my mouth.

To be honest, it is hard to say what exactly inspired my interest in botany research. As I said, China's rural areas were rather economically disadvantaged at that time; most of the school teachers can only be part-time, after class who also need to go home to do farm work. They needed to attend to a heavy load of agricultural production while teaching; students were

 Author: Alon Cna'ani

desperate to read all the available precious printed materials. Whenever I was intrigued by something in the books and asked my parents, teachers, relatives, or friends “why?”, they seldom gave me satisfactory answers.

When I was in junior high school, only a small number of students had the opportunity to pursue further education. After I was enrolled in the best high school in the county with the highest score, I had the chance, for the first time, to visit the county (from today’s perspective, a county with a population of 30,000 may seem quite average, but I was truly overwhelmed during my first visit). After I entered high school, it was my first time to see a six-story building, to be exposed to the most basic physical and chemical experimental instruments, and to be able to do experiments to demonstrate and explicate some natural phenomena. I was enthralled by these inspiring encounters at the age of 16. For this reason, I was more determined to pursue university study in a larger city for more enlightening experiences.

Education

I entered college in 1995. At that time, only a small number of students could take higher education in China. The result of the last examination in high school was the decisive basis for college enrollment (the gross enrollment rate of higher education in China was only 7.2% in 1995; this figure reached 51.6% in 2020). The reason why I could be enrolled in a fairly good university was that I studied really hard in high school and achieved a presentable score in the college entrance examination.

Because my parents have only been studying for a few years, they have little idea of what university is, let alone what major to choose. I also know little about the university and major, and lack of corresponding channels to understand. It was my high school class advisor who proposed that I should choose Huazhong Agricultural University. His suggestion was based on a well-known saying at that time: the 21st century is the century of biology. Coincidentally, the university boasted a biology major and a biotechnology experimental class that was rare in China, which provides a holistic program covering undergraduate and graduate education.

I was fortunate to make that choice because Huazhong Agricultural University was then a pioneer in employing molecular biology to conduct agricultural research in China. Before and after my enrollment, two state-level key laboratories (the most advanced research institutions across China then) were established in the university, and some young professors were inspired to catch up with their world-class counterparts. They were following their cherished dream for excellence in a destitute China. I was deeply inspired by their endeavor, even at the present day.

Professor Yonglian Zheng was essential in my decision to pursue my Ph.D. study. He was a privileged professor at the university back then. The molecular biology he passionately delivered was so fascinating that it had led me into this world. After I had the opportunity to register for his course, I would arrive at classrooms very early to secure a seat in the first row and occasionally answered his questions in class. He finally took notice of me and invited me to carry on my graduate study in his lab when the semester was about to end. I was hesitant to give up graduate study since my family could not offer me enough financial support, and I was prepared to find a job instead and earn a salary as early as possible. But Professor Zheng's invitation made me think about whether this decision is appropriate. Finally, I decided to accept his invitation to continue my study and complete my Ph.D. study under his tutorship.

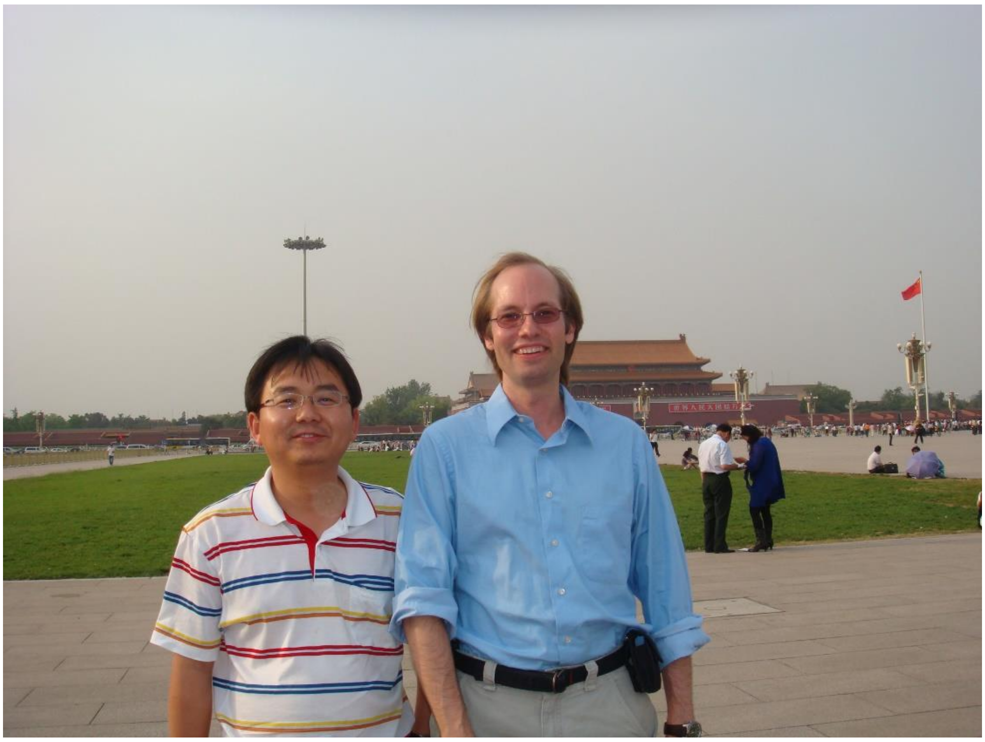
As Professor Zheng was engaged in maize-related research, naturally my doctoral dissertation focused on maize. Heterosis is a magic phenomenon. Why do the offspring of two seemingly common maize perform much better than their male and female parents? This has always fascinated me. In the past 100 years or so, the maize yield per unit area has increased eightfold around the world, in which heterosis has been playing a fundamental role. Following my tutor, I carried out maize heterosis research with molecular markers, a relatively advanced tool at that time, for my doctoral thesis.

After graduation, I had the opportunity to work as a teacher at China Agricultural University. Within only two years, I was promoted to associate professor. However, in the meantime, I have become increasingly aware of my limited knowledge and ability, so I decided to submit my application to leading universities in the world for post-doctoral studies. In this way, I can broaden my horizon and improve my academic performance. I was very fortunate to receive a post-doctoral position jointly recruited by Cornell University and the International Maize and Wheat Improvement Center (CIMMYT). After two years of post-doctoral training (the contract duration was three years, though), CIMMYT decided to hire me as an associate scientist ahead of schedule. 10 months later, they further promoted me to scientist. Usually, this promotion would take five to six years.

Cornell years, 2007 (Source: Prof. Yan Jianbing)

Outside of China

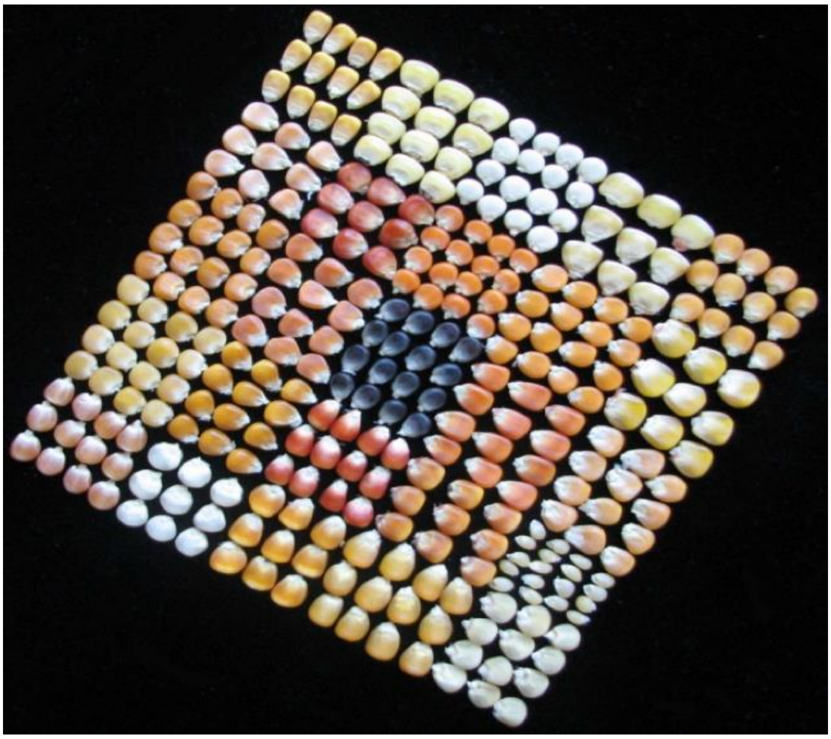
The research experience at Cornell University and the International Maize and Wheat Improvement Center broaden my horizons and brought me benefits. Dr. Edward S. Buckler's at Cornell is a world leader. The most valuable inspiration I received from him was his scientific vision, cooperative spirits, and his way of seeing problems. He told me, "learn to cooperate because you don't necessarily need to do everything on your own; you should plan well, invite the best scientists all over the world to work with you, and learn from each other". CIMMYT, as an international agricultural research institution, is built on a shared vision to provide solutions to eliminate poverty and malnutrition in underdeveloped countries through scientific and technological means, especially many African countries. My post doctoral advisor, Dr. Marilyn Warburton, is also a person with international vision. She has given me a lot of guidance. This is an important part of my life, which made a profound impact on how I reconsider my life plans and future career development.



With Professor Ed Buckler in Beijing, 2010 (Source: Prof. Yan Jianbing)

Benefiting from this experience, I gradually formed my own ideas and thoughts about maize functional genomics research. In 2011, I published my first review article in Crop Science in cooperation with Dr. Marilyn Warburton. In this article, I wrote a comprehensive review on the progress of maize association analysis. I often joked that I have put my life ideals into this article because it reflected the most comprehensive analysis of my future research directions at that moment. Indeed, the past decade has witnessed my research being carried out following my original ideas in that "blueprint" paper.

Another important impact of this experience on me was the discovery of a key gene: crtRB1 that affects the Pro-Vitamin A content in maize kernels through global scientific research cooperation. Maize Vitamin A deficiency (VAD) is a global challenge, especially in African countries. At that time, 127 million children were vitamin A deficient, and 500,000 children died of VAD annually. These numbers shocked me deeply. With the support of the harvest plus project, the CIMMYT has been committed to improve Pro-Vitamin A content in maize through genetic improvement for ten-odd years, but the progress remained slow. With this key gene discovered during my post-doctoral period, half of the goals of the Harvest Plus project could be achieved and thus the project proceeded quickly. Today, maize varieties with high Pro-Vitamin A source bred with this gene are still popularized in many African countries. I also won the Japanese International Agricultural Scientist Award for this contribution. The progress of this research has greatly boosted my self-confidence, and made me realize that scientific research can directly contribute to human poverty reduction and to promote human progress.



Maize kernels (Source: Prof. Yan Jianbing)

During the project, I had the opportunity to visit many poverty-stricken countries and regions, including Zimbabwe in Africa as well as Yunnan and Guizhou Provinces in China. On the streets of Zimbabwe, I saw shabby houses and groups of barefooted children, while many parts of China, including my hometown, have undergone profound changes. This made me realize that science and technology alone cannot achieve poverty elimination and human progress; the application of policies or systems matters more. I realized that China is witnessing a period of vigorous development. The Chinese government has attached great importance to agricultural research, which can provide me with more opportunities for practices and a bigger stage for life. So, I decided to return to China and work at Huazhong Agricultural University, my alma mater.

At CIMMYT, 2007 (Source: Prof. Yan Jianbing)

Research group

I began to work at Huazhong Agricultural University in April 2011. Before working, I only asked the University to recommend a few young college students to me so that I can establish my research group soon.

In China, there is a two-way selection process between supervisors and graduate students. If you favor a student, who happens to have passed the postgraduate entrance examination, and he/she is willing to join your laboratory, then you two can work together. But at the same time, there will be a "macro-control". The State and the university bear most of the postgraduate training costs, so the graduate enrollment quota of each university is determined by the state, and the graduate enrollment quota of each tutor is allocated by the school, which is usually dynamically adjusted according to the supervisor's talent training ability and research achievements. In addition, the quota will also be favored to the newly recruited professors. In Huazhong Agricultural University, the number of graduate students that a professor can recruit each year varies between two and four, but the University also encourages senior students to contact their prospective tutors and to join laboratories to start scientific research training as soon as possible.

When I had just arrived at the university and was still living in the guest house on campus, eight excellent junior students were recommended by the college for my research interviews. I shared my vision of a bright future for maize research with them. In the end, six became the first members to set up the laboratory with me.

I got 2 million RMB as start-up funding from the university to establish my research group. In China, almost all the salary of researchers and training cost of students are borne by the university, and the indirect cost is very small. At the same time, there was no specific restriction on the use of this fund, I can either buy instruments and equipment, pay the fees for students, or traveling for academic exchanges.

The team (Source: Prof. Yan Jianbing)

During my first year back in China, I recruited more research team members. Farhan Ali, a Ph.D. student from Pakistan, is now a researcher working at a university in Pakistan. Dr. Weiwei Wen was a postdoctoral researcher from the International Maize and Wheat Improvement Center, whom I convinced by emails that there were more opportunities available as a newly founded research group. Dr. Wen is now a professor and has built her own independent research group. I also recruited a research assistant, who was responsible for the daily management in the laboratory, such as finance, procurement, etc. I am very proud that the majority of my first crew college students have chosen to pursue doctoral degrees in scientific research. Some of them are currently continuing post-doctoral research in the United States and Europe. One of the members has established his own independent laboratory within the Institute of Genetics and Developmental Biology of the Chinese Academy of Sciences, one of the best scientific research institutions in China. To be honest, many innovative and diligent Chinese students of our times, having received an excellent basic education, could make outstanding achievements.

Research

I have built an independent research team for 10 years at Huazhong Agricultural University, during which we have achieved two stages:

In the first five years (2011-2015), we used the genomics tools to high-throughput mine the genes and the corresponding regulatory mechanism that affect the complex agronomic traits to accelerate the maize genetic improvement. One of the well-representative achievements is breeding the high-oil corn cultivar. A scientific story that inspired me to carry out the relevant research was that the scientists at Illinois State University in the United States spent almost 100 years to increase the oil content of maize kernel from 4% to 20% by the traditional breeding ways; while a professor from China Agricultural University only took 10-15 years to increase the oil content from 4% to about 20%. Two scientific questions were raised: first, what is the genetic basis for the long-term genetic improvement of maize kernel oil content? second, why is it largely different at the efficiency of breeding high-oil content maize among the labs all over the world? I thought it should be a great strategy to characterize the genetic architecture of oil biosynthesis in maize kernels by the means of a genome-wide association study. Through dense efforts, my collaborators and I have successfully identified 26 genes related to the total oil content of maize kernels, which can perfectly explain the phenotypic variation, and we also proposed that the accumulation of minor-effect genes was the genetic basis of high-oil corn long term selection. Finally, our findings were published in Nature Genetics. Inspired by the previous accomplishment, I collaborated with other groups and used the same approach to identify the causality for a series of complex quantitative traits. I also established a widely-used maize association mapping panel, including around 1,200 inbred lines worldwide. Based on the varied phenotypes and the diverse genotypes, we selected a total of 527 lines to form a representative association panel and analyzed the transcriptional regulatory network of genes expressed in maize kernels. Our panel is free to share with peers, and until now, more than 60 copies of seeds have been sent out to more than 50 research groups all over the world. Meanwhile, I have been thinking about how to take advantage of such findings to speed up the process of maize genetic improvement, which may be related to the poverty experienced in my youth. In practice, we used the molecular markers to select sweet corn varieties with high content of vitamin E, the growth area of which accounts for 20% of China's sweet corn growth area.

The team (Source: Prof. Yan Jianbing)

During the second five years (2016-2020), we first accomplished the single-cell sequence in maize. It was the first time to isolate the four microspores of the maize tetrad, extract the genomic DNA, and achieve the plant single-cell sequence. We constructed the maize recombination map at the nearly single base level and accurately calculated 19.3 crossovers occurred on average during one meiosis, which revealed the crossovers were unevenly distributed across the maize genome, enriched the maize genetics theory, and revised the classical views in the textbook. On such solid research basis, we continued to develop a series of plant single-cell seq-techs, including single nucleus separation and sequencing, single spore methylation sequencing, and single gametophyte isolation and sequencing. Via such well-developed technologies, we have answered a series of important scientific questions, for example, the recombination differences between male and female gametes, reprogramming of male gametes, and the induction mechanism of haploids. From my perspective, the plant single-cell biology harbors a bright future and enables us to answer the essential biological questions.

The future

As I age and become more experienced, I prefer to think about sustainable agriculture, which is the more important problem currently. The core issue is how to use limited arable land to feed the booming population of the world as well as to meet the increasingly diverse food needs. For example, the continued increasing demand for protein has occurred with the improvement of people's living standards around the world. But the current production model and efficiency are not enough to meet the global needs of protein, which requires agricultural scientists to innovate a new way to produce the proteins independent of the existing farmland. We proposed de novo domestication of “novel crop” to meet the future personalized demands. Human-guided domestication began approximately 12,000 years ago. Only around 100 species out of 400,000 plant species had been domesticated as modern crops. Nowadays, just 15 crop species provide 70% of the world’s food energy intake, among which corn, rice, and wheat make up as much as 50%. The continuously growing global population and the drastic consuming revolution have triggered more and more pressure on traditional agriculture. Can we provide an optimized solution to resolve the conflicts between the existing agricultural production and serious food demands by re-domesticate some new crops from wild or semi-domesticated plants satisfying humans’ emerging needs of nutrition, quality, and production? I and Professor Alisdair R. Fernie from the Max Planck Institute of Molecular Plant Physiology wrote a perspective paper in Molecular Plant to discuss it. We believe that recent developments in genome editing allow rapid and precise "de novo domestication".

Maize ears (Source: Prof. Yan Jianbing)

My second target in the future is to solve the basic scientific questions and core application issues by the means of plant single-cell technology and other emerging technologies in the agricultural field. For instance, I want to find the answer for the scientific basis and the applied technologies relevant to haploid induction and doubling via further research on developmental reproduction. The application of heterosis has contributed significantly towards increased crop production. In China, almost 100% of maize is hybrid varieties, and more than 50% of rice varieties are hybrid varieties. However, the utilization of heterosis has encountered a bottleneck at the current time, in which breeders and seed enterprises must pay for more labor and materials to produce hybrids. The increasing production cost has more and more offset the positive effects it brings. We believe that technological breakthroughs and novel research ideas will definitely help us to achieve the heterosis fixation, thereby providing new impetus for sustainable agriculture.

COVID-19

The epidemic has profoundly affected global scientific research and academic exchange activities. International academic exchanges, especially face-to-face collaborative exchanges, have been almost interrupted. During the pandemic, many of our field experiments were also delayed.

I am working in Wuhan, the municipality of Hubei Province, which was once the epicenter of the COVID-19 outbreak in China. In the first few weeks of the outbreak, we were also quite flustered. Because the school took strict pandemic prevention and control measures, our scientific research work almost ceased. Fortunately, the Chinese government quickly curb the spread of the pandemic, and thus the work of our University was back to normal. In late February, our University launched comprehensive online teaching according to the teaching plans. Almost all teachers, including myself, carried out online teaching activities. At the same time, my research group also carried out a group seminar through the internet on a weekly basis. Together, we studied literature, analyzed data, and wrote articles. In this way, the normal pace of scientific research was maintained. In late April, after graduate students of our university returned, the work of quickly returned to normal. In the past six months, all our members have been working at the front line, and we have reaped fruits with our hard work this year with a record-breaking publication of more than 10 articles.

The lab (Source: Prof. Yan Jianbing)

 Author: Alon Cna'ani

The pandemic has made us increasingly aware of the significance of solidarity and cooperation as the most powerful weapon for the international community to defeat the pandemic. The same principle applies to scientific research. We hope that in the future, we can continue to share wonderful research opportunities with academic scholars globally so that each country respects others' interests while pursuing its own and advance the common interests of all.

Author: Alon Cna’ani