MOLECULAR BREEDING

Getting to the root of barley domestication

The remote plains of the Tibetan Plateau are one of the original sources of domestic barley, according to an international team of researchers, led by ZJU professor Zhang Guoping. They revealed that modern Chinese barley did not share a common ancestor with other cultivated barley species; but was closely related genetically to Tibetan wild barley.

Barley cultivation has been linked to the basis of human civilisation, being key to the transition of prehistoric man from a hunter-gathering lifestyle to agriculture and settlement. A region in the Middle East has been called 'the cradle of civilisation' because it was the primary centre of wild wheat and barley cultivation. However, there is increasing evidence of barley having multiple sites of origin.

Through comprehensive genome profiling of each species, Zhang's team mapped the relationship of Tibetan wild barley with barley strains around the world. The findings suggest that the extreme climate and altitude of Tibet created an evolutionary change and genetic split between the wild barley ancestors of the arid Near East and Tibet 2.76 million years ago, making Tibet the centre of barley domestication in Asia.

This highlights the potential for Tibetan wild barley to contribute to the cultivation and bio-engineering of more robust crops. The species has high nutritional value, while maintaining strong tolerance to cold, drought and poor soil fertility, all desirable traits to withstand climate change.

Close look at a staple gives hope for improvement

Genomic studies of *Brassica juncea*, or mustard greens, led by ZJU researcher, Zhang Mingfang, have shed light on new targets for crop improvement.

Zhang, with his collaborators, have created genome maps and sequences of the chromosome arrangement of *Brassica juncea* and revealed differential homoeolog gene expression influencing selection for the multiple sets of subgenomes within the plant. These homoeologous genes may contribute to novel features of mustard greens and play a key role in their evolution.

EARTH HEALTH

Digging deep into maths to tackle soil pollution

ZJU researchers have developed a mathematical model to predict the interfacial behaviours of organic pollutants in soil. Their work is helping with ways to tackle pollution globally.

China's already inadequate agricultural land is diminishing. Contaminants in soil, such as pesticides and polycyclic aromatic hydrocarbons, can last for generations and can evaporate into the atmosphere or leach into water supplies.

ZJU professor Zhu Lizhong and his team have now disclosed the molecular mechanisms of interfacial behaviours of organic pollutants, providing a clearer understanding of contaminant transport and its biological effects. The model's strength is mapping the life-cycle of pollutants as they move and transform in soil, water and air.

The result has already been successfully applied in the control and bioremediation of soil contaminated with organic pollutants.

Zhu's research also includes using chemistry to enhance bioremediation. This involves using surfactants or biochar to control the movement of organic pollutants between liquid and solid phases of soil. The team has employed plant and microbial processes for cleaning farmland contaminated with organic pollutants and developed systematic solutions to soil remediation based on the type of soil pollution.

The work by Zhu and colleagues provides technical support to the development of new materials for pollution control and helps to ensure the safety of agricultural products.

PLANT PROTECTION

Sexual prowess of an exotic crop raider

The sexual activity of the exotic silverleaf whitefly, a top invasive pest, has been the subject of scrutiny by ZJU researchers. Causing widespread damage to crops in tropical regions, the whitefly is a vector for new viruses that cause plant physiological disorders.

Through long-term field study, ZJU professor, Liu Shusheng, and his team found that the invader had higher sexual activity and produced more female offspring than the indigenous whitefly species. The asymmetric mating interactions between the two closely-related genetic groups of the whitefly are thought to be behind the rapid displacement of native whitefly by the invader.

Liu's team also found three-way interactions between insect vectors, viruses and plants and revealed, for the first time, the molecular and physiological mechanisms of their mutualistic relationships. They showed that viruses may suppress plant defence responses and enhance population growth of vector insects, which transport viruses to new hosts. The discovery contributes to better pest control and crop protection.

Controlling insect infestations and crop diseases

ZJU researchers have found what makes the migratory brown planthopper an efficient pest, offering hope for better crop protection.

Insulin, a hormone more commonly known to control blood sugar in humans, is also produced by insects. Zhang Chuanxi and his team at ZJU turned off the genes that code for two different insulin receptors — regions on the cell membrane that bind to the hormone. They found that silencing the first insulin receptor in young insects saw them grow into short-winged adults that could not fly, while the other produced adults with long wings built for long-distance travels and crop invasion. This discovery, published in *Nature*, sheds light on ways to control the insect's ability to infest rice fields.

Another ZJU faculty member, Zhou Xueping, led a team to systematically study a group of plant viruses known as geminiviruses and their relatives, which infect many crops across the world. By assessing 30 new viruses, they analysed the genetic structures and evolutionary paths of this family, and described the development of geminiviral infections.

FRUIT QUALITY

Why storage is not cool for tasty fruits

Putting fruit in cold storage to extend its shelf-life can kick-start a molecular sequence that greatly reduces flavour by the time it reaches the market, according to research at ZJU. This loss of taste can contribute to food waste.

Chen Kunsong and his team at ZJU studied tomato, a fruit vulnerable to chill damage, and found a molecular pathway that causes flavour loss. In the *Proceedings of the National Academy of Sciences*, they outlined how chilling 'turns off' many of the plant genes critical to generating flavour compounds. Even when temperature is restored to 20°C, the damage is irreversible.

In collaboration with Harry Klee, James Giovannoni, and Michael Thomashow from the United States, Mondher Bouzayen from France, Ian Ferguson from New Zealand and Donald Grierson from UK, Chen's team has conducted research on the genes controlling the production of important nutrients, such as carotenoids, anthocyanin pigments, volatiles, acids and sugars, and the softening or toughening of postharvest fruits.

Chen said this finding highlights the importance of the environment for gene regulation of fruit quality and lays the foundation for research to negate the drawbacks of cold storage and logistics, and eventually, reduce food waste.

Chinese bayberries were another subject for Chen Kunsong's team.

PROTECTED AGRICULTURE

Hormone gives a lazy grower a big push

Boosting levels of a naturally-occurring plant hormone may offer an environment-friendly way to improve greenhouse crop production, researchers at ZJU have shown.

First discovered in 1979 in rapeseed, brassinosteroids were later identified to control stages of plant growth and development, and more recently found to be responsible for frost resistance in plants. These qualities made the hormone highly attractive to researchers such as Yu Jingquan and his colleagues at ZJU.

Yu's team selected cucumbers as they are known to be hard to cultivate. They are extremely cold-sensitive under low light and even greenhouses cannot sufficiently stave off the chill.

Yu's team found that applying barrasinosteroids to cucumber plants made the plant more efficient at converting carbon dioxide to carbohydrates by activating crucial enzymes such as rubisco during the photosynthesis process. The discovery opens new opportunities to use barrasinosteroids for improving crop yields and protecting plants against environmental stress.

INFORMATION ENGINEERING

Intelligent systems that make the grade

Using computer vision technology, ZJU professor Ying Yibin and his colleagues have developed an intelligent system that automatically sorts and grades fruits to improve their market value. The system can simultaneously detect external fruit quality, such as size, shape, colour and bruising in real time.

Ying has also developed a new system for evaluation of internal quality that does not destroy the fruit, using visible/near-infrared spectroscopy technology and an integrated "data-model-decision support" approach.

Beyond determining quality, the team has developed nanotechnology-enabled bio-/chemical sensors and Terahertz technologies for safety evaluation of agri-products.

Fundamental methods and nanomaterials are incorporated to make the sensors simple, sensitive, low-cost and reliable.

Ying says he hopes that his research will lead to better and safer agri-products.

Making agriculture smarter

A team led by ZJU researcher, He Yong, is developing a software and computer network that collects data wirelessly and automatically controls precision farm equipment based on environmental information.

At the centre of He's team's research is the 'internet of things', information collection through machine-to-machine communication, cloud computing and networks of data-gathering sensors. He is developing a network that can gather information on plant growth, soil properties and environmental parameters simultaneously, which are integrated to create a system that would intuitively evaluate and adjust levels of fertiliser, water and pesticides to treat crop diseases.

The internet of things for agriculture developed by He provides an advanced tool to achieve standardized production and intelligent control throughout the production process.

ANIMAL FEED

Taking antibiotics off the stock menu

As the Chinese central government aims to cut down the use of antibiotics in stock, researchers are urgently trying to develop effective substitutes to keep animals safe and healthy.

Research by ZJU professor Wang Yizhen and colleagues have been looking for a natural solution. Through large-scale screening and molecular modification of natural compounds, Wang's team developed several novel antimicrobial peptides, which can stimulate protective anti-bacterial immune responses in animals, without the development of drug resistance, and have the side-benefit of promoting gut health.

Wang's team has also developed a bacterial protein-polysaccharide complex enriched with nanoscale selenium particles. They used it as a basis for developing a fermented feed containing probiotics, antimicrobial peptides and selenium nanoparticles. The feed avoids the use of antibiotics to boost animal meat production and quality.

Wang's work provides a technical foundation to fight a growing problem in China and across the world. ■

Safe and healthy agriculture

Food security is a prevailing issue for humans and animals. ZJU professor Liu Jianxin and colleagues have explored unconventional feed resources for ruminants and developed a good amino acid balance in an alternative feed. By harnessing the metabolic pathways of protein and lactose synthesis, they manipulated feed for efficient and safe dairy production. The team is also working on ways to reduce methane emissions from livestock.

Another ZJU researcher, Zhou Jiyong, leads a team focusing on virus detection and vaccine development for animals. Their recent findings include identifications of the H5N9 virus, a subtype of the avian flu virus and a viral protein of porcine circovirus (PCV). Based on the discovery of viral replication of PCV, they developed detection reagents and vaccines. Their study on the mechanisms of replication of infectious bursal disease virus (IBDV) in chickens has also led to the development of new vaccines and detection techniques.

PRODUCT SAFETY

Keeping it real from farm to table

Food safety causes serious concerns in China. Great steps have been made in tackling security issues within the dairy industry through technological innovation by ZJU professor Liu Donghong and colleagues.

They developed effective and fast methods to detect food-borne pathogens, psychrophilic bacteria, somatic cells, and antibiotics in raw milk.

In order to guarantee the safety and quality of infant formula in the food chain, Liu has developed a device to analyze milk composition in real-time and transmit data through wireless network communication technology. This monitoring system can detect adulteration in real time.

The team has also developed food traceability software for supply-chain management throughout production processes, offering a tool for guaranteeing milk quality and safety. They have applied the system to monitor the quality of vegetables and other farm products. ■

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