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EDITORIAL

Highlights of special issue on "Wheat Genetics and Breeding"

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Wheat is one of the world's most important food crops and a major constituent of daily calorie and protein intake in humans, thus maintaining sustainable development of wheat production is a globally important issue, particularly for less developed countries. Producing more wheat with better nutrition using less inputs, has become a common objective both for producers and consumers. However, wheat production is facing great challenges such as increasing climate variation and occurrence of various diseases and pests, as well as shortage of water and other resources. For example, Chinese wheat production is limited by four factors, including extreme weather events such as the cold temperature on 5 April 2018 resulting over 10% yield reduction in major wheat-growing regions, spread of *Fusarium* head blight or scab from Yangtze region to the Yellow and Huai Valleys, shortage of irrigated water in northern China and strong demand for better quality products. Therefore, development and integration of new technology with existing technology, as well as international collaboration, are expected to contribute significantly to wheat improvement. This special issue on wheat genetics and breeding presents global progress in wheat genomics, breeding for disease resistance, as well as quality improvement, with an excellent collection of nine review articles and one research article. It shows the significance of utilizing new technology including both genotyping and phenotyping in developing new cultivars, as well as the importance of global collaboration which is the basis for CIMMYT's daily operation.

Advances in genomics of wheat has been behind rice and maize for over 10 years, however, the International Wheat Genome Sequencing Consortium (IWGSC) released IWGSC RefSeq ver1.0 wheat genome in August 2018, marking a milestone progress of wheat genomics. Wheat research and breeding in the new era of a high-quality reference genome authored by Appels (https://doi.org/10.15302/J-FASE-2019265), highlights the potential use of IWGSC RefSeq ver1.0 in research, such as developing new markers for choosing parents and tracking progeny, understanding the variation in the number of genes in a family, fine-scale modification of gene structures and predicting new targets for complex traits. However, it will need tremendous effort and much longer time to transfer scientific progress into practically useful new technology such as gene-specific molecular markers and improved genomic selection approach. Experience and lessons from the rice genome and its application in breeding programs should be a particularly useful reference for the international wheat community.

Integration of new technology into established breeding schemes can accelerate the breeding of new cultivars with better disease resistance. The contribution of Bhavani et al. (https://doi.org/10.15302/J-FASE-2019268) on progress in breeding for resistance to Ug99 and other races of stem rust fungus in CIMMYT wheat germplasm presents an excellent example of combining multiple adult plant resistance (APR) genes in high yielding backgrounds and discovery of new quantitative trait loci conferring stem rust resistance, enhancing the durability of resistance. Actually, APR is not an new approach, but only a few breeding programs including CIMMYT wheat breeding program in Mexico have used APR as a routine approach for developing new cultivars over the last 40 years. Three pleiotropic APR genes in addition to *Sr2* (= *Yr30*) locus, viz. *Sr55* (= *Lr67*/*Yr46*/*Pm46*), *Sr57* (= *Lr34*/*Yr18*/Pm38/*Sb1*/*Bdv1*) and *Sr58* (= *Lr46*/*Yr29*/*Pm39*), conferring multi-pathogen resistance were identified in

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CIMMYT wheat germplasm and used in marker assisted selection. Progress in gene cloning over the last decade has confirmed pleiotropic resistance to several diseases. Importantly, the phenotyping platforms in Kenya and Ethiopia have greatly facilitated disease screening and breeding for stem rust resistance. The successful development of cultivars with stem rust resistance also indicates the crucial importance of a multidisciplinary approach and international collaboration in generating benefits in the field through scientific innovation. The contribution of He et al. (https://doi.org/10.15302/J-FASE-2019254) on China-CIMMYT collaboration enhancing wheat improvement in China also shows that resistance to yellow rust, leaf rust and powdery mildew can be achieved through pyramiding several pleiotropic APR genes. The contribution of Morgounov (https://doi.org/10.15302/J-FASE-2019261) on the International Winter Wheat Improvement Program covering its history, activities, impact and future reviews the progress in developing winter and facultative wheat germplasm in Central and Western Asia through international collaboration. The contribution of Liu et al. (https://doi.org/10.15302/J-FASE-2019269) on spectral reflectance indices used as proxies for yield potential and heat stress tolerance in spring wheat considering their heritability estimates and marker-trait associations indicates the potential use of high throughput phenotyping technology in improving yield potential and stress resistance.

The contribution of Ma et al. (https://doi.org/10.15302/J-FASE-2019262) on breeding wheat for resistance to *Fusarium* head blight in China gives an excellent review on the progress made by Chinese breeders over the last 50 years. Yangmai 5 and Yangmai 158 were the leading cultivars in 1980s and 1990s in Yangtze region, although *Fhb1* gene was not employed since other parents with excellent agronomic performance and acceptable disease resistance were used in breeding program. Shortage of gene specific markers for *Fhb1* and its linkage with poor agronomic traits have been the major limiting factors in deploying this gene in breeding programs. However, the development and validation of gene specific makers based on the progress in gene cloning over the last 2 years has made it possible to better use this gene in the Yellow and Huai Valleys of China and other parts of the world. The combination of a large population size in segregation generations, speeding breeding through several generations per year, excellent phenotype screening and molecular marker confirmation is likely to allow significant progress in the development of cultivars with acceptable level of scab resistance.

Both nutritional and processing qualities have become important objectives in breeding programs. The contribution of Guzmán et al. (https://doi.org/10.15302/J-FASE-2019260) on genetic improvement of wheat grain quality at CIMMYT describes CIMMYT's efficient phenotyping platform for quality testing and the approach of combining processing quality and nutritional traits into elite high yielding germplasm. The valuable review article of Morris (https://doi.org/10.15302/J-FASE-2019259) on development of soft kernel durum wheat is another key contribution to this issue. The new soft durum wheats provide several advantages in processing quality, and were developed by the author over many years of research on grain hardness and puroindoline genes. It shows that focused long-term basic research can change our modes of thinking and develop novel products for improving human livelihoods. The contribution of He et al. (https://doi.org/10.15302/J-FASE-2019254) on the enhancement of wheat improvement in China through the China-CIMMYT collaboration also presents the development and validation of molecular markers for improving noodle quality. Also, the contribution of Ma et al. (https://doi.org/10.15302/J-FASE-2019267) on wheat gluten protein and its impacts on wheat processing quality recommends that in the post-wheat genomic era, new high molecular weight glutenins identified from wheat relatives and landraces with long central repetitive domains that contain high number of consensus hexapeptide and nonapeptide motifs as well as high content of cysteine and glutamine residues should be targeted.

The history of the origin and utilization of wheat in China is not fully known. The brief history for wheat utilization in China prepared by Lu et al. (https://doi.org/10.15302/J-FASE-2019266) provides an excellent review on this subject. Based on the most recent results of taxonomic, genetic, archaeological and textual studies on the wheat in prehistory, wheat was introduced into China about 5000 years ago. In the subsequent centuries, this exotic crop was soon utilized as staple food in northwest China. In contrast, it was adopted as a staple in central north China only in the Han Dynasty (202 BCE–220 CE), which was mainly as a consequence of living environments, population and the innovation of stone milling and flour fermentation technology.

Finally, as the guest editors, we would like to thank the authors and reviewers who have given their time, energy and expertise to this special issue, as well as the *FASE* editorial team for their valuable inputs and support.

Dr. Zhonghu He, Director of China National Wheat Improvement Center, and Country Liaison Officer in China for CIMMYT, serves as Research Professor of Chinese Academy of Agricultural Science. His major contributions include establishment of standardized quality testing protocols for Chinese noodles and steamed bread, development and validation of 50 functional markers, release of five cultivars with an accumulated area of 6 Mha, author/coauthor of 125 publications in international journals. He received the First Class Award in Science and Technology Progress from State Council in 2008 and prestigious award in 2015, selected as Fellow of Crop Science Society of America in 2009 and Fellow of American Society of Agronomy in 2013, the Guanghua Award from Chinese Academy of Engineering in 2010, and the China Agriculture Elite Award in 2012.

Prof. Zhendong Zhao, Academician of Chinese Academy of Engineering (CAE), very well-known wheat breeder, serves as Chief Scientist and Research Professor of Crop Research Institute, Shandong Academy of Agricultural Sciences. His major contributions include release of five leading wheat cultivars with an accumulated area of 32 Mha, and Jimai 22 with high yield potential and broad adaptation, has been the first leading cultivar in China from 2008 to present. He has published over 80 papers in refereed journals. He received prestigious award in Science and Technology Progress from State Council four times. He received the Highest Award of Science and Technology in Shandong Province in 2012, National Labor Medal in 2006, and the Science and Technology Prize of the Ho Leung Ho Lee Foundation in 2008, the China Agriculture Elite Award in 2009, National Outstanding Workers in 2010, and the Top Ten Outstanding Figures in China Seed Industry.

Prof. Shunhe Cheng, Academician of Chinese Academy of Engineering (CAE), very well-known wheat breeder, serves as Chief Scientist and Research Professor of Lixiahe Agricultural Research Institute, Jiangsu Academy of Agricultural Sciences. His major contributions include release of 30 wheat cultivars with an accumulated area of more than 40 Mha. Yangmai 5 and Yangmai 158 with high yield potential, broad adaptation and resistance to head scab, used to be the first leading cultivars in the Yangtze region in 1980s and 1990s, respectively. He has published over 40 papers in refereed journals and edited two books, i.e., *Wheat in South China* and *A Study on Wheat Scab*. He received the First Class Award in Science and Technology Progress from State Council in both 1991 and 1998. He also received the Highest Award in Jiangsu Province in 1997, and Award for Outstanding Contribution to Science and Technology in Jiangsu Province in 2012, and elected as the Top Ten Outstanding Scientific and Technological Figures in Jiangsu Province in 2009 on the 60th anniversary of the founding of PRC, and the Top Ten Greatest Figures in China Seed Industry.