

Molecular breeding in plants: moving into the mainstream

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Received: 14 February 2012 / Accepted: 14 February 2012 / Published online: 13 March 2012
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Molecular breeding, including both marker-assisted breeding and genetic engineering, has experienced significant innovations and advances during the past three decades. Starting with Mendelian genetics, plant breeders have progressed from using morphological markers to protein isozymes and then ultimately to DNA-based markers, which have enabled routine genome-wide analysis. As a result, thousands of genes and quantitative trait loci (QTL) have been mapped across the major crop species, laying the foundation for marker-assisted selection (MAS) techniques, such as precise marker-assisted backcrossing, to transfer desirable loci into breeding lines. With the subsequent development of advanced MAS strategies, including QTL pyramiding, marker-assisted recurrent selection and genomic selection, marker-assisted approaches have led to rapid gains in selection for plant breeding programs. Breeding by design and genetic modeling

have received great attention as designing a desirable plant based on marker and associated gene information becomes increasingly possible. Following rice as the first crop species sequenced, whole genome sequences have been increasingly available for more and more crop species, enabling genotyping by sequencing and sequence-based marker technology and molecular breeding strategies to become a viable option, one widely used in large multinational seed companies. With significant reduction of genotyping cost and increased throughput, next-generation sequencing and SNP genotyping technologies are increasingly making MAS a choice of public-sector plant breeding as well. Now crop genomic diversity can be characterized at the sequence level based on haplotype maps, and molecular breeding can be further accelerated through allele mining and haplotype-based design and selection. With all the developments and significant advances in various fields of molecular biology and their integration with platforms and tools, molecular breeding is rapidly moving into the vanguard of mainstream breeding programs.

To review and evaluate new theories and technologies recently developed in relation to plant breeding, the 3rd International Conference on Plant Molecular Breeding (ICPMB) was held in Beijing, China, Sept. 5–9, 2010. The conference was organized by an International Organization Committee represented by Zhi-Kang Li (Chinese Academy of Agricultural Sciences/International Rice Research Institute), Jean-Marcel Ribaut (the Generation Challenge Program), Aimin Zhang (Chinese

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Academy of Sciences), Jianming Wan (Chinese Academy of Agricultural Sciences), Masahiro Yano (National Institute of Agrobiological Sciences, Japan), Andrew H. Paterson (University of Georgia, USA), Peter Langridge (Australia Center for Plant Functional Genomics), Roberto Tuberosa (University of Bologna, Italy), Yunbi Xu (International Maize and Wheat Improvement Center/Chinese Academy of Agricultural Sciences), Michael J. Thomson (International Rice Research Institute) and 12 others from different institutions worldwide. The conference brought together over 700 scientists and entrepreneurs from 33 countries. The main track of the conference was represented by 16 plenary talks addressing important issues in molecular breeding, including MAS, genomics-assisted germplasm enhancement, genetic engineering, functional genomics, epigenetics, molecular bases of heterosis, polyploidy, breeding by design, and whole-genome strategies for molecular breeding. The conference also featured 12 concurrent sessions/workshops with a total of 99 talks, which covered various topics including applied plant genomics, gene discovery and function, new transgenic technologies, products, and markets, germplasm and genetic diversity, applied molecular breeding in several major and minor crops, molecular breeding platforms and new technologies, and molecular breeding for abiotic and biotic stresses.

This special issue of *Molecular Breeding* includes papers covering key topics from the plenary and session speakers. The first four papers included in the special issue are focused on molecular breeding strategies, platforms, and tools, including genome-wide selection, fostering molecular breeding in developing countries, and new platforms for SNP genotyping (Xu et al. 2012, Delannay et al. 2012, Thomson et al. 2012, Kwon et al. 2012). The rest of the papers included in this special issue provide case studies on applied molecular breeding, with examples from several crops on yield, quality, and abiotic and biotic stress tolerance.

Although we have seen significant progress in various fields of molecular breeding, we are still

facing many challenges, particularly for the public sector. As genotyping becomes increasingly cheaper and easier, our future challenges will be precision and high-throughput phenotyping under managed environments and e-typing (environmental assaying) and using genotypic and environmental information to predict the phenotypic performance of a plant. As a major avenue for academic exchange of progress in molecular breeding and related fields, the Fourth International Conference of Plant Molecular Breeding will be held in the first half of 2014, in China.

Acknowledgments We hope that readers and research workers in the field of molecular breeding will find this special issue useful as a resource both for teaching and research. We would like to thank the reviewers and the Advisory Committee of the *Molecular Breeding* Special Issue who helped us in reviewing and evaluating the articles submitted for this special issue. We also would like to thank the Editor-in-Chief Dr. Paul Christou from Universidad de Lleida, Spain, and other editorial staff and the publisher of *Molecular Breeding* who provided us with their support and assistance at all stages in the production of this special issue.

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