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Quantitative genetics and plant genomics: an overview

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The last fifty years have witnessed a significant improvement in global food production. However, the required growth rate for food production in the coming years is projected to be higher than ever, in view of the fact that the world's population, growing at a rate of six million people per month, is likely to plateau at no less than nine billion people by 2050 (Godfray et al. 2010, Science 327: 812–818). This population growth, mainly in Asia, accompanied by the accelerated pace of economic growth in certain Asian countries and sub-Saharan Africa, has already driven the demand for additional food, feed and fuel. Consequently, the first decade of the present century witnessed a deficiency of food grains and unprecedented price rises, such that a significant proportion of the world's population, particularly those living in Asia and Africa, do not have access to an optimum diet (3000 kilocalories/day), causing malnutrition and its associated problems. Since the land area suitable for agricultural practices is shrinking, the water table is falling (Rodell et al. 2009, Nature 460: 999–1002) and some food crops are now also being grown for production of biofuel (MW Rosegrant, International Food Policy Research Institute), the problem of food security has now become more serious than ever before. In view of this alarming situation, special issues of *Science* (February 12, 2010), *Current Opinion in Plant Biology* (April 2010) and *Crop Science* (March–April 2010) have been devoted to this subject. The problem has also been discussed in a recent critical review (Beddington 2010, Phil Trans R Soc B 365:61–71). In addition, agricultural researchers held the first ever Global Conference on Agricultural Research for Development (GCARD) on March 28–31, 2010 at Montpellier, France to address these issues.

Genetic improvement of crop productivity has been suggested as one of the several solutions for food security in several of the above articles/meetings. According to some estimates, even in the past at least 50% of the gain in grain yield was due to genetic improvement, the rest being due to improved agricultural practices. However genetic improvement itself is limited by several factors, including susceptibility of crop plants to a number of biotic and abiotic stresses such as diseases, pests, drought,

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salinity and heat. The anticipated change in climate and accumulation of toxic substances in food grains due to soil and water pollution and contamination are other major concerns which crop scientists worldwide need to address.

The desired further improvement in genetic potential of crop plants may be achieved through a better understanding of the genetic architecture of complex quantitative traits and their manipulation through plant breeding, although development of transgenic crops will play its own role. Recently, statistical tools have been developed for analysis of quantitative genetic variation for traits of economic importance. These tools are being regularly upgraded, and supplemented by new ones. These developments, along with the concurrent development of a variety of DNA-based molecular markers, have facilitated not only the detection of the genomic regions (quantitative trait loci, QTL) controlling the traits of interest, but also allowed the study of QTL–QTL and QTL–environment interactions. The recent genomics revolution has also greatly contributed to our understanding of the genetics of both model and economically important plant species. The available DNA/protein sequences and the developing bioinformatics tools have played their own part in a better understanding of the relationship between genes, proteins and phenotypes. They have also contributed to the development of a variety of molecular markers e.g. SSR (simple sequence repeat), SNP (single nucleotide polymorphism), SFP (single feature polymorphism) and DArT (diversity array technology) markers, which have been extensively used for genetic mapping, germplasm evaluation and marker-assisted selection (MAS). The challenge before us now is to integrate the recent developments in the areas of genomics, bioinformatics and quantitative genetics in order to develop cost-effective protocols and high-throughput technologies and apply them to molecular breeding. These developments will certainly help bridge the gap between demand and supply of food, thus eventually providing food security through the required doubling of the world's food production to feed its nine billion people by 2050.

In order to review and deliberate upon the developments in the areas of quantitative genetics and molecular breeding as described above, an international symposium on "Plant Genomics and Quantitative Genetics" was held during February 14–16, 2009 in the Department of Genetics & Plant Breeding, Ch. Charan Singh University, Meerut, India. Nearly 50 scientists from India, USA, Germany and China participated in the symposium.

This Special Issue of *Molecular Breeding* includes 15 articles which are either based on the presentations made at the symposium or solicited from scientists who could not attend. These articles highlight the role of various approaches of quantitative genetics and genomics in crop improvement involving enhanced productivity and improved grain quality. The introductory article gives an overview of the methods of analysis of quantitative genetic variation in plants and argues for the application of a "systems quantitative genetics" approach to unravel genotype–phenotype relationships. The remaining articles are arranged crop-wise such that four articles are devoted to wheat, two to barley, five to rice and one article each to maize, peanut and pigeonpea. These articles discuss some of the recent developments related to MAS (marker-assisted selection), advanced backcross QTL analysis, mapping-as-you-go, MARS (marker-assisted recurrent selection) and GWS (genome-wide selection). There are other articles, which discuss the use of markers for QTL analysis (including association mapping), genetic diversity, hybrid purity assessment and breeding for disease resistant, arsenic resistant and aromatic rice. Two other articles also discuss the application of genomics research and the role of alien introgression in crop improvement.

We hope that the collection of articles published in this Special Issue highlighting the role of quantitative genetics and genomics will prove useful for those involved in the improvement of productivity and quality of food crops, and will also serve as useful reference material to geneticists, plant breeders and research scholars engaged in teaching and research in the field of quantitative genetics and plant genomics.

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