Summary & Recommendations
2nd National Workshop on Marker-Assisted Selection (MAS)
for Crop Improvement,
27-29 Oct, 2010, ICRISAT, Patnacheru, A.P., India

The “2nd National Workshop on Marker-Assisted Selection (MAS) for Crop Improvement” sponsored by the Department of Biotechnology in collaboration with International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the CGIAR Generation Challenge Programme was held during 27-29 October, at the ICRISAT-Patancheru campus. Although the workshop was termed a “national” workshop, as many as ~100 delegates from 19 different countries participated in the workshop. All presentations made in this workshop will be made available on a dedicated website <http://www.icrisat.org/bt-publicdomain-mas2.htm> being developed for this purpose.

The workshop had six technical sessions including an inaugural session, which was attended by DG, ICRISAT (Dr William Dar), DDG, ICRISAT (Dr Dave Hoisington) and DDG, Crop Science, ICAR (Dr Swapan Datta). Dr William Dar gave the inaugural address, and Professor Roberto Tuberosa of the University of Bologna (Italy) gave Keynote address, outlining the importance, progress and future possibilities in using marker-assisted selection in crop improvement. This laid down the stage for an excellent program that followed in this workshop.

The first two technical sessions (Session II and Session III) included presentations on recent developments in the following two areas: (i) methods of marker-assisted selection (MAS) including genome wide selection (GWS) and (ii) technologies of high throughput genotyping (including ‘genotyping by sequencing’) and ‘next generation sequencing’ (NGS). Jean-Luc Jannink from USDA and Cornell University gave an excellent lecture on research needs for genomic selection (GS), which we have yet to initiate in India. There were also presentations on the use of NGS technologies for development and use of SNPs for MAS. For example, Gengyun Zhang from Beijing Genomics Institute (BGI) made an impressive presentation on application of NGS technologies in crop breeding. Another excellent presentation by Rajinder Singh from Malaysia on development and use of molecular markers (including SNPs) in palm-oil demonstrated how one could start from scratch and deliver useful results within a period of five years. These presentations hopefully will develop awareness and inspire young scientists in India to improve their breeding programs by incorporating GWS and high throughput sequencing and genotyping approaches. A presentation on ISMAB programme for supporting MAS made by Trushar Shah from ICRISAT was also greatly appreciated. Many breeders involved in using MAS expressed their willingness to use ISMAB in their breeding programs.

Sessions IV and V were devoted to opportunities and challenges in using MAS in different groups of crops including cereals, millets, legumes, oilseeds, vegetable crops and cotton, the major fibre. Scientists from abroad, who participated and made presentations, included the following: Roberto Tuberosa, Jean Luc Jannink, Mike
Thompson, Rajinder Singh, Gengyun Zhang, Jacqueline Batley, Richard Hodgeson, Rattan Yadav and P. Kadirvel.

The concluding session in the afternoon of October 29 was chaired by Dr MV Rao and Professor PK Gupta. A summary of Brain Storming Session I was presented by Rajeev Varshney, and that of Brain Storming Session II was presented by PK Gupta (see the summaries below), who also presented a summary of the workshop and thanked Dr MV Rao for his participation. Professor Gupta also thanked Dr William Dar, the Director General, ICRISAT and Dr Dave Hoisington, the Deputy Director General, ICRISAT for their support and encouragement and thanked Rajeev Varshney and his team for making this excellent workshop possible on the beautiful campus of ICRISAT.

Rajeev Varshney thanked, DBT, Professor PK Gupta and Dr RR Sinha for choosing ICRISAT to convene this meeting, and expressed his special thanks to GCP for its help in making possible the participation of several scientists from abroad. He also acknowledged strong support received from DG, DDG, Management Group, GTL of ICRISAT and the help and cooperation received from his colleagues specially Mr KDV Prasad, Ms Manjula and Mr Y Muralikrishna, who made major contribution in the successful organization of the workshop.

**GENERAL RECOMMENDATIONS BASED ON THE WORKSHOP**

Majority of presentations and especially those that were made in the Sessions IV and V suggested new areas, where plant breeders in India can further extend molecular breeding activities. In particular, the need for developing MAS programs for enhancing yield and developing resistance against abiotic stresses was emphasized. Based on the presentations at this workshop, the Indian plant breeding community need to develop and use the following new technologies/approaches in their breeding programs: (i) association mapping approach in addition to linkage mapping for marker trait association, (ii) NGS technologies and high-throughput genotyping platform, preferably via outsourcing, (iii) MAS as integral component of conventional breeding programme, (iv) MARS and GS approaches in addition to MABC in their MAS programs; and (v) bioinformatics tools, databases in the breeding programme.

In addition to the above recommendations from the workshop, some other useful recommendations emerged from two brainstorming sessions (see below).
RECOMMENDATIONS FROM BRAIN-STORMING I
High-throughput sequencing and genotyping
(Facilitators: NK Singh, NRCPB & RK Varshney, ICRISAT)

About 100 participants - majority of them from India but some of them also from 18 other countries of Africa, Asia, Europe, North America and Australia - participated in the meeting. Following conclusions and recommendations emerged from the workshop:

(1) There is a need to have several marker genotyping centres in India, like the one already available at ICRISAT. Each of these centres should have SNP genotyping facilities including BeadXpress Vera Code (to be established at ICRISAT, if 2nd phase of CEG approved under COE programme of DBT), GoldenGate and Infinium assays of Illumina, KASPar assay facilities, etc. in coordinated manner.

(2) Breeders need to be well versed in developing and using the bioinformatic tools and databases such as ISMAB. (If approved, in the 2nd phase of CEG under COE of DBT, ICRISAT plans undertake training of some breeders for using ISMAB and other bioinformatics tools).

(3) Phenotyping facilities in the form of phenomics platforms also need to be established for precision in phenotyping. Some efforts in this direction have been initiated but these should be further intensified and extended.

(4) In all funded projects, provision in the budget for outsourcing the genotyping work should be allowed by all funding agencies. This would be necessary, if modern breeding methodologies like MARS and GS are to be used.

(5) ICAR needs to ensure inclusion of a session on molecular breeding in annual workshops of AICRPs for all crops.

RECOMMENDATIONS FROM BRAIN-STORMING II
Molecular Breeding
(Facilitators: PK Gupta, CCSU & O Riera-Lizarzu, ICRISAT)

After having extensive discussions, following conclusions and recommendations were made:

(1) Breeders should use MAS for only those traits for which phenotypic or visual selection is not feasible such as latent traits or drought-related traits.

(2) Priority needs to be given to new methodologies of MAS such as MARS and GWS (also called GS) in different breeding schemes especially for complex traits.
(3) Option for MARS or GWS should be exercised judiciously after due consultation with the experts and breeders, who have experience in deploying these methodologies for crop improvement. In case of GS or GWS, construction of ‘training population’ should also be done with due care and ‘phenotyping’ needs to be done with precision.

(4) There is a need for a shift from SSRs to DArTs, SNPs and ‘genotyping by sequencing’. While using SNP markers, choice of appropriate SNP genotyping platform is also important.

(5) Outsourcing the genotyping work and training for using bioinformatics tools needs to be encouraged as it is time and cost-effective.

(6) Clear-cut guidelines should be made by ICAR for release of MAS bred varieties. MABC bred varieties should need only one year trial data and should be treated as essentially derived varieties (EDV). All AICRPs should approve the guidelines already followed in rice for MAS-bred varieties. ICAR should ensure the implementation of these guidelines.

**DDG-ICAR (Dr Swapan Datta) assured the organizers of the workshop that he will arrange a joint meeting of ICAR and DBT with some leading scientists in order to implement the above recommendations and to discuss other issues raised in this workshop.**