Final technical report for project R6667:

Marker-assisted selection, QTLs and contig lines for improving downy mildew resistance of pearl millet hybrids.

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Executive summary This project had as its primary purpose increasing the yield and yield stability of pearl millet hybrids by improving their resistance to downy mildew (DM) disease. It was intended to identify previously unidentified quantitative trait loci (QTLs) (equivalent to host plant resistance genes) for pearl millet DM resistance, and make these available to plant breeders in arid and semi-arid regions of India where hybrid pearl millets are grown. It was further intended to familiarize a wider range of breeders in these areas with the utility of marker-assisted selection (MAS) to improve disease resistance of economically important hybrid parental lines developed in their own breeding programmes.

Additional host plant resistances to downy mildew were identified by screening mapping populations against a diverse range of pathogen isolates from pearl millet producing regions of Africa and Asia - the resulting phenotypic data were combined with marker genotype data to map quantitative trait loci (QTLs) contributing to disease reaction against each pathogen isolate. Individually, or in combination with a few others, such QTLs accounted for as much as 70% of the observed phenotypic variation for disease reaction when a given pathogen isolate was used to screen a particular pearl millet mapping population. Transfer of several resistance QTLs from mapped donor parents P 7-3 and ICMP 85410 to the elite genetic background of early dwarf maintainer line 843B was completed, and evaluation of the hybrid performance of these (and their male-sterile line counterparts) was initiated. Based on these initial results it appears it will be possible, in some but not all cases, to introduce QTLs for improved disease resistance into such elite hybrid parental lines without adversely affecting the performance of their hybrids (as might occur if there were negative linkage drag effects due to linkage between genes controlling resistance and those controlling other characters of economic importance). Contiguous segmental substitution line set development of segments of ICMP85410 in the 843B approached completion. It has allowed identification of genomic regions associated with male fertility restoration ability for the A1 cytoplasmic-genetic male-sterility system, as well as those associated with panicle length and flowering time. Products of this research stream began to reach private- and public-sector

pearl millet breeders in India during the course of this project, and should make it to farmers' fields in India in a big way over the next five years, directly contributing to DFID's development goal of improving production of target crops on impoverished soils in semi-arid areas by selection and genetic enhancement of cultivars.

Background As detailed in the Grant Application and Project Memorandum Form ODA project number R6667 section 21.

Project purpose The main purpose of this project was to make a wider array of host plant resistances available in the genetic background of economically important single-cross hybrid pearl millet cultivars of economic importance in the Indian subcontinent. When used as parents of new hybrids (including, but not restricted to, backcross derivatives of currently important commercial hybrids), these will contribute substantially to increasing the genetic diversity for host plant resistance to pearl millet downy mildew that is deployed in farmers' fields in India, and substantially reduce the probability of another major pearl millet downy mildew epidemic there.

A secondary purpose was to familiarize a wider range of pearl millet breeders in this region with the utility of marker-assisted selection, and to actively involve them in application of this new tool in improving disease resistance of economically important hybrid parental lines developed in their own breeding programs.

Research activities Per Grant Application and Project Memorandum Form ODA project number R6667section 23c, with activities 1-10 approaching completion, activity 12 being initiated, and activities 11 and 13 being delayed until the next phase as time required for completion of prior activities was greater than anticipated. Reasons for this failure to achieve proposed targets included delays associated with transfer of the MAS technology to ICRISAT from Bangor, and departure of the ICRISAT support staff person mid-way through the project for personal reasons (she accompanied her husband when he was transferred to Australia).

Outputs Additional host plant resistances to downy mildew were identified by screening mapping populations against a diverse range of pathogen isolates from pearl millet producing regions of Africa and Asia, and combining the resulting phenotypic data with marker genotype data to map quantitative

trait loci (QTLs) contributing to disease reaction against each pathogen isolate. Individually, or in combination with a few others, such QTLs accounted for as much as 70% of the observed phenotypic variation for disease reaction when a given pathogen isolate was used to screen a particular pearl millet mapping population. Transfer of several resistance QTLs from mapped donor parents P 7-3 and ICMP 85410 to the elite genetic background of early dwarf maintainer line 843B was completed, and evaluation of the hybrid performance of these (and their male-sterile line counterparts) was initiated. Contiguous segmental substitution line set development approached completion, and has allowed identification of genomic regions associated with male fertility restoration ability for the A1 cytoplasmic-genetic male-sterility system, as well as panicle length and flowering time.

Contribution of outputs

Based on these initial results it appears it will be possible, in some but not all cases, to introduce QTLs for improved disease resistance into such elite hybrid parental lines without adversely affecting the performance of their hybrids (as might occur if there were negative linkage drag effects due to linkage between genes controlling resistance and poor alleles tightly linked loci controlling other characters of economic importance). Products of this research stream began to reach private- and public-sector pearl millet breeders in India during the course of this project, and should make it to farmers' fields in India in a big way over the next five years, directly contributing to DFID's development goal of improving production of target crops on impoverished soils in semi-arid areas by selection and genetic enhancement of cultivars. Results from this project are the subject of several conference papers (published and in preparation) and journal articles (again, both published and in preparation, as well as two Ph.D. thesis research projects). These are being followed up in a pair of new projects related to downy mildew resistance improvement and contig line sets development. No further marketing studies need to be done as the private and public sector pearl millet breeders in India—through which results of this project will be disseminated to farmers—are lining up for the genetic materials produced by the project as well as for training in the technologies involved in their development. A final stage of transferring a wider range of resistances into a broader array of elite genetic background will be required if the results of this research are to be sustainable in the long run. This is being covered by follow-on projects described above, and by substantial input by ICRISAT into this research area from its core funding. In addition, it will be necessary to develop breeder-friendly marker systems (read as cheap, co-dominant, SSR-based, PCR-compatible) in pearl millet. These are the subject of work funded by DFID, ICRISAT and Cornell University.

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