Coordinating global research for wheat

Durum Wheat Genomics and Breeding EWG Annual report and action plan

NAME OF EXPERT WORKING GROUP
EWG on DURUM WHEAT GENOMICS AND BREEDING

LEADERSHIP & AUTHORSHIP	
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AIMS OF THE EWG

The EWG acts to reach the following aims:

- Provide synergy among durum wheat research groups.
- Identify research priorities relevant to most groups in order to enhance opportunities for genetic progress in durum wheat breeding globally.
- Promote the development of molecular tools/platforms open to the global durum wheat community via (i) a high-density SNP-based consensus map and (ii) a sequence of the durum genome, (iii) public reverse genetic tools (e.g. sequenced TILLING populations, radiation hybrid (RH) collection), and (iv) characterization of the durum wheat pangenome through *de novo* sequencing and exome resequencing of specific tetraploid durum accessions.
- Promote the utilization of the durum wheat genetic resources through collaborative genotyping and phenotypic characterization of a reference collection including most of the main germplasm groups worldwide.
- Enhance the capacity of breeders to access and use markers suitable for high-throughput marker-assisted selection.
- Enhance awareness and familiarity with genomics approaches applied to durum breeding through the organization of workshops and training courses.
- Facilitate the formation of consortia aiming at raising funds for research projects nationally and/or internationally.

STRATEGIC RESEARCH AGENDA CORE-THEME(S) /TOPIC(S) COVERED BY THE EWG

The EWG facilitates and coordinates research activities in genomics and breeding of durum wheat and, when possible, links some of the findings/materials in/of durum wheat to those of the bread wheat community. Additionally, the EWG aims at facilitating and offering additional opportunities for networking among the different stakeholders in order to advance knowledge/understanding of durum genomics and gene functions as well as to enhance the effectiveness of breeding programs. More in details, the EWG is contributing to the Wheat Initiative SRA with two specific activities:

i) the sequencing of the durum wheat genome indicated as priority action in the SRA Subtopic 5.1 Enabling technologies and methods;

ii) the exploitation of the tetraploid wheat genetic resources designed according to the priority actions indicated in the SRA Subtopic 5.3 Genetic resources.

Furthermore, the co-chairs of the EWG during the Jamboree meeting in Frankfurt (Dec, 2016) have suggested the organization of a workshop on "Bioinformatics to advance wheat breeding after the publication of the wheat genomes" open to durum and bread wheat breeders/scientists, this activity is part of the Cross-cutting theme 6 (Knowledge exchange and education).

2016 ACTIVITY REPORT

MEETINGS HELD				
Face-to-Face Meetings	Location	Date	Duration	# EWG members attending
	EWG informal meeting (San Diego, CA, c/o XXIV PAG congress)	11 Jan 2016	2 hrs	About 20
	EWG meeting dedicated to the discussion of the project on the durum wheat reference collection (Rabat, Morocco)	1-2 Oct 2016	2 days	34
Other Meetings	Type (online, etc)	Date	Duration	# EWG members attending

PROGRESS AGAINST AIMS				
Objectives identified for 2016 in the global EWG Action Plan (with objective #)	**Tasks/actions undertaken by the EWG (with task #)**	**Achievements**	**Outputs/Deliverables**	**Comments**
Sequencing of the durum wheat genome.	Sequencing of the durum wheat genome	See description below	The reference sequence of the durum genome (cv. Svevo) has been completed through an international cooperation.	
Durum Wheat Reference collection (DWRC)	Identification of a panel of accessions representing the durum wheat germplasm investigated worldwide	See description below	The DWRC has been organized starting from 2,503 accessions contributed by EWG members. All accessions have been preliminary field-phenotyped and genotyped with 96 SNPs to assess the structure of the germplasm and multiplied. A discussion within the EWG has identified a subset of 960 accessions that will represent the core DWRC, these accessions are currently under multiplication	
	An international research programme for the implementation of the DWRC	See description below	The international research project for the implementation and exploitation of the DWRC has been submitted to WI and endorsed by ICC.	

Additional objectives	**Tasks/actions undertaken by the EWG**	**Achievements**	**Outputs/Deliverables**	**Comments**

Additional comments/information

Sequencing of the durum wheat genome. In 2016, a number of groups have been involved in a community effort for the sequencing of the durum wheat genome. Six main partners (CREA, CNR, University of Bologna, University of Saskatchewan, University of Tel Aviv and Montana State University) have pooled sufficient resources to complete the reference quality genome sequence of the durum wheat cv. Svevo. The sequencing work has been carried out using whole genome shotgun sequences made with Illumina technology (275x) assembled by NRGene with the DeNovo magic software. Assembled reads were anchored to the durum wheat genome using the information of the POPSEQ map Zavitan x Svevo and of the 3D conformation capture (Hi-C) analysis provided by IPK-Gatersleben. Genome annotation has been carried out at the Helmholtz Centrum of Munich in collaboration with many research groups worldwide. The assembled genome sequence is characterized by high-quality standards with N50 = 6 Mb and N90 = 1.1 Mb. The same strategy has been recently used for the sequencing of wild emmer, *T. tauschii* and bread wheat. Once the durum sequence is available, a direct comparison of the genomes of wild and durum wheat will be possible. It is expected that the durum reference genome will be published in 2017.

Durum Wheat Reference collection (DWRC). On May 31, 2015, the EWG members met in Bologna for a workshop to discuss the priorities and strategies to optimize the utilization of the durum wheat genetic resources. As main output of the meeting, the EWG decided to assemble the DWRC. In September 2015, a call for germplasm contribution to build the DWRC has been launched at the EWG level and about 2,500 durum wheat accessions have been collected and assembled by Filippo Bassi, durum breeder at ICARDA. The accessions represent a worldwide collection of elite durum cvs., advanced lines, durum landraces, tetraploid durum subspecies (*T. dicoccum* and *T. dicoccoides*) and other materials (e.g. INRA evolution population) currently used by breeders ad geneticists. All accessions are regulated by a MTA (Material Transfer Agreement) that allows their free distribution worldwide. In November 2015, all the accessions were sown at the ICARDA research station in Terbol-Lebanon and during the 2015-16 growing season all accessions have been phenotyped for basic phenological traits. In the first semester of 2016, the whole collection has been genotyped with a core set of 96 SNP markers selected for their high level of polymorphism in the durum wheat germplasm. Twelve SNPs that tag specific genes often considered in MAS (*Vrn*, *Rht*, *Ppd*, *Lpx*, *Psy*, etc.) and 84 (about 6 per chromosome) additional SNPs were selected to scan the genome diversity. Marker information is available in Cereals DataBase at http://www.cerealsdb.uk.net/cerealgenomics/CerealsDB/wheat_durum_ref.php and the corresponding KASP assays can be purchased at LGC. In total, 2,503 tetraploid accessions were genotyped with 96 KASP markers. An inspection of accession name/pedigree/molecular similarities has identified about 400 duplications and 2,095 non-redundant accessions were retained. The EWG met on October 1 and 2, 2016 in Rabat (Morocco, c/o ICARDA) to discuss collaborative opportunities for the exploitation of the DWRC. A stratified collection of 960 accessions (the final DWRC panel) has been organized in four main subpanels (elite, landraces, durum relatives and INRA evolution population) to provide genetic materials suitable for both GWAS for the identification of loci controlling the variability of target traits and for the identification of novel halotypes/alleles (allele mining) at known loci of agronomic interest.

ELITE DURUM FOR MEDITERRANEAN-LIKE CLIMATE (semi-dwarf, vernalization insensitive)	288 (3 plates)	1 plate CIMMYT MATERIALS
		1 plate ICARDA MATERIALS
		1 plate MEDITERRANEAN materials (Italy + Spain + north Africa + desert durum + others)
ELITE SEMI-DWARF DURUM PHOTOPERIOD SENSITIVE/VRN-SENSITIVE	96 samples (1 plate)	PPD/VRN (French + central Europe + mixed origins)
DURUM VARIETIES NON-SEMIDWARF (TALL)	96 samples (1 plate)	1 plate of tall accessions (Canadian + mixed origins)
DURUM LANDRACES (TALL, GENETICALLY DIVERSE)	192 samples (2 plates)	Selected to maximize diversity
T. DICOCCUM	96 samples (1 plate)	Selected to maximize diversity
T DICOCCOIDES + TETRAPLOID RELATIVES	96 samples (1 plate)	Selected to maximize diversity
INRA EVOLUTION_COMPOSITE_CROSS	96 samples (1 plate)	Selected to maximize diversity

In each group the accessions were chosen according to the following criteria:

- inclusion of important founders/parents of mapping populations and sampling most of the origins and pedigrees within each sub-group
- considering the information available on heading date, plant height and seed production (heterogeneous accessions in the field were discarded)
- genetic distance; accessions with a low genetic similarity were selected.

A single plant from each selected accession will be used to generate a single plant descendant that will undergo a first round of multiplication in 2017 c/o ICARDA.

The DWRC should in time become the main global durum panel to be used by the whole durum community in all activities during the next decade. It aims at becoming the 'one-stop' durum wheat platform for enhancing cooperation and breeding progress. It will facilitate the exchange of genetic information in terms of markers, phenotypic data (traits) and alleles. The EWG meeting in Rabat, dedicated to the discussion of collaborative opportunities for the exploitation of the DWRC, was attended by Ahmed Amri, responsible for the organization of the EWG on Global Wheat Germplasm Conservation and Use Community and by Gilberto Igrejas from the EWG for Improving Wheat Quality for Processing and Health. Their participation was intended to assure a coordination of the activities of the two EWGs.

An international research programme for the implementation of the DWRC. In 2016, the EWG has internally discussed and submitted to WI an international research programme for the implementation of the DWRC (germplasm multiplication, exome sequence based genotyping, phenotyping and data analysis). The proposal was officially endorsed by the ICC of WI during the meeting in Budapest (July 2016).

2017 PLAN

MEETINGS PLANNED			
Face-to-Face Meetings	Location	Date	Duration
	Informal meeting of the EWG at the XXV PAG congress	15 January 2017	Two hours
	Meeting of the EWG before/after the International Wheat Genetic Symposium	2017	One day
	Workshop on: Bioinformatics to advance wheat breeding after the publication of the wheat genomes	Between Oct. and Dec 2017, after the publication of the wheat genomes	Two days
Other Meetings	Type (online, etc)	Date	Duration

PLANNED ACTIVITIES			
Objectives identified for 2017 in the global EWG Action Plan (with objectives #)	**Tasks/actions to be undertaken by the EWG (with tasks #)**	**Timeline (e.g. February-March)**	**Expected Outputs/Deliverables**
Advancement in the international initiative for the characterization of the DWRC.		January.-July	• Multiplication of the 960 selected accessions of the DWRC core set. Seed of all accessions will be made available for phenotypic analysis.
Organization of the EWG meeting to discuss: i) the follow up on genotyping and phenotyping activities of the DWRC, and ii) the durum pangenome initiative. The meeting will be held on 29 April 2017, immediately after the International Wheat Genetics Symposium.		April	• Identification of funding opportunities for the exploitation of the DWRC and pangenome sequencing.
Completion of sequence annotation of the durum genome through the extant international collaborations and submission of the durum genome paper for publication.		June-September	• Durum wheat genome annotation and manuscript submission.

Organization of a training workshop dedicated to wheat breeders on "Bioinformatics to advance wheat breeding after the publication of the wheat genomes". The next release of the wheat, durum wheat and wild emmer genomes offer an unprecedented opportunity for wheat breeding. This notwithstanding, the access to the sequence information requires some basic bioinformatics skills that are not part of the knowledge of typical wheat breeders. To improve this situation, this EWG has suggested during the Jamboree meeting the organization of a training workshop on wheat bioinformatics. The workshop will be organized together with other EWGs with an interest in breeding and bioinformatics.		October-December	• Training workshop on wheat bioinformatics for breeders.