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EXPERT WORKING GROUP TOPIC SUBMISSION[2]

Expert Working Groups (EWG) are established where a particular topic of direct relevance to the Wheat Initiative would benefit from bringing together experts in that specific field. The EWG would provide them with a platform for discussion, information sharing, consideration of specific problems, identification of research priorities and gaps. The EWG should have clear objectives and these could include (but are not limited to) specific activities such as contributing to the development of the Wheat Initiative Strategic Research Agenda, producing a position paper for publication or addressing a particular challenge through a research programme. An output should be annual reports to the Scientific Board for dissemination to the Research Committee, the Institutions' Coordination Committee and the wheat research community through the Wheat Initiative website.

Expert Working groups are established following the attached flow diagram. Organised consortia addressing wheat research challenges can be endorsed by the Wheat Initiative as EWGs following the same process.

Topic title		
WHEAT BREEDING METHODS AND STRATEGIES		
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[3] Add lines for other proposers if needed.

Summary

The EWG for breeding methods has the goals of capacity building, support for improved breeding methods research, and international exchange of information and germplasm. Anticipated deliverables include more efficient wheat breeding programs that use advanced breeding methods and a larger pool of wheat breeders trained in state-of-the-art breeding methods. Underpinning wheat breeding methods research will be increased exchange of wheat germplasm and information and training workshops. The Wheat Initiative will serve as an integrative force linking complex environmental issues with wheat genetics/genomics and advanced phenotyping methods to understand how to recombine and deploy optimal combinations of genes in new wheat varieties across space and time to meet future production needs.

Detailed description (5 pages maximum)

Rationale

The sudden increase in commodity food prices since 2008 triggered international protests, suspension of international grain sales from some countries and global concern over food security resulting in renewed attention to the importance of agriculture and agricultural research. Wheat improvement has lagged behind other major food crops for several reasons. Until recently most of the wheat breeding programs in many countries (excepting Europe) have been in the public sector and this has limited investment in wheat improvement. In recent years, private entities have made major investments in wheat breeding, especially in Australia and the U.S. Consequently, breeding companies are expanding their operations, generating the need for hundreds of plant breeders, and triggering a renewed interest of students in breeding careers. However, even with recent private investments, support for wheat breeding still lags far behind other major crops. Transgenics have benefited other major crops, however to date, no transgenic wheat varieties have been commercialized. Because in many countries farmers can freely replant seed from their own production, seed sales and profits have suffered. Wheat is the only major crop that does not have a complete genome sequence. The complexity of the polyploid wheat genome with 80% repetitive DNA also limits advances in wheat genomics. Germplasm exchange is becoming increasingly difficult with most entities now imposing restrictions or simply prohibiting exchange. These restrictions will limit wheat improvement over the long term.

Traditional breeding methods include pedigree, bulk, single seed descent, and backcross. Less commonly used wheat breeding methods include recurrent selection, hybrid development, doubled haploids, genomic selection, mutation, transformation and multilines. Single and three-way or top-crossing is a common hybridization approach for generating segregating populations. Most wheat breeding programs use traditional breeding methods with some marker-assisted selection (MAS) for major genes controlling disease and insect resistance and quality. Pedigree, bulk and modifications of these methods are the most common methods used for wheat breeding. Molecular markers are publicly available for many traits (e.g. http://maswheat.ucdavis.edu). Recently, there is growing interest in using genomic selection for improving quantitative traits; however, there is limited information in the literature using this approach for wheat improvement. Using current technologies, additional investment can be used to expand the number and size of breeding populations and evaluate more selections in more environments. Additional investment in wheat breeding methods research is needed to increase the rate of wheat improvement and avoid falling further behind other major crops in productivity.

A technological revolution is changing the landscape of plant breeding. High-throughput sequencing technologies are generating molecular markers at densities and costs that revolutionize their applications to breeding, new high throughput phenotyping platforms are providing novel and deeper ways to “see” plant traits, and genomic selection approaches are being developed to integrate this information and accelerate breeding cycles. Predictive science can dramatically improve the efficiency of breeding programs by focusing the phenotyping (most expensive phase) on those genotypes with the greatest potential for variety release.

The wheat breeding community will need to develop some of the resources already available to other crops such as completion of a genome sequence, hapmaps for cultivated wheat and related species, and inexpensive marker platforms. Although phenotyping will continue to be limiting, more efficient, high throughput methods need to be developed. Crops including wheat are prone to huge genotype x environment (GxE) effects. Merging crop modeling methods with genomic prediction could bring new levels of efficiency to the identification of genotypes suited to particular climatic conditions or regions. Transgenic and hybrid wheat varieties will also likely contribute to wheat productivity in the foreseeable future. These tools will facilitate the development of widely-adapted, elite genotypes.

Description of the EWG aims

Overall Objectives:

1. Coordinate ongoing wheat breeding methods research and identify support for public wheat breeding programs researching and developing new plant breeding strategies.
2. Develop a transnational training program in state-of-the-art breeding methods for students, post docs and professional breeders.

1) Wheat breeding methods Research Areas:
For each of the research areas, activities can include workshops, training courses, communications, and sharing of germplasm and information. The expert working group will establish specific priorities within each of these research areas. The expert working group will meet by the end of 2013 to map out the existing resources, elaborate the research priorities and develop a publication reviewing current and future breeding methods.

A) Genomic Selection
Tool Development needed:

- Recurrent selection
- New algorithms and predictive models
- Improved marker platforms and reference consensus sequence map
- Reference genotypes for marker referencing
- Link to standard phenotypes and trait ontologies
- Methods for distribution and sharing of germplasm and data on related phenotypes and genotypes
- Methods for utilizing information in genome wide association studies

New Knowledge needed:

- Data processing pipeline needed that will link to bioinformatics Wheat Information System EWG and the Integrated Breeding Platform
- Training population design (especially composition and size)
- New methods for including GxE and highly dimensional environmental covariates and marker matrices in predictive models
- Methods for maintaining and/or expanding genetic diversity in selection populations

B) Hybrid Wheat
Tool Development needed

- Recurrent selection methods
- Apomixis
- Effective male sterility systems
- Efficient hybrid seed production systems

New Knowledge needed

- Understanding of heterosis in wheat

- Effective methods of collaboration
- Methods for combining the dominance characteristics for various traits in hybrids
- Methods for predicting hybrid performance
- Methods for gene pool development

C) Mutation Breeding

Tool Development needed

- TILLING populations and sequencing mutated lines
- Site-directed mutagenesis methods
- Transgenic methods for validation

New Knowledge needed

- Assessing and utilizing epigenetic variation
- Communication and information sharing

D) Utilization of Cultivated and Wild Genetic Diversity

Tool Development needed

- Improved methods of introgression of exotic germplasm
- Methods for reducing the size of introgressed chromosome segments

New Knowledge needed

- Methods for prioritizing utilization accessions of exotic germplasm
- Manipulation of meiosis and recombination
- Allele mining
- Develop methods for communication and sharing of information and germplasm

2) Develop a Transnational training program in state-of-the-art breeding methods for students and post-docs.

1. Survey existing training programs and provide a description of each.
2. Complement existing student training programs with training (internships) in breeding programs in different public and private institutions.
3. Develop hands-on workshops for new breeding methods that would include analyzing their own datasets.
4. Establish a Wheat Initiative Ph.D. Fellowship program named for the sponsor that would link private and public institutions through projects that require experience in multiple countries and address one or more of the priority research areas.

Expected deliverables/outputs of the EWG

1. New enhanced breeding methods that utilize predictive science to improve the efficiency of variety development
2. Increased numbers of plant breeders trained in state-of-the-art plant breeding methods.
3. Increased international exchange of tools, methods and germplasm.

Timeline of Activities

Initially, activities consisted of an organizational workshop in May 2013 where an interim committee met to establish research priorities. Subsequent to that meeting a revised proposal will be submitted to the Research Committee for approval. A call for volunteers to serve on the EWG will go out to the wheat community so that a representative EWG committee can be established. That committee will be charged with developing a global inventory of research on

breeding methods and identify gaps in breeding methods knowledge. Reports from the committee will be used to set research priorities and produce a position paper by the end of 2013. A grant proposal consisting of objectives (listed above), methods, and budget will be prepared and funding agencies contacted by December 2013.

Alignment with the Wheat Initiative objectives

The development of new, more efficient breeding methods is consistent with the G20 report in 2011 stating the need for more agricultural research. The Wheat Initiative can be a one-stop portal for external donors, grant organizations and industry to establish collaborations with various institutions in the area of plant breeding. The Wheat Initiative can serve as an integrative force linking broad environmental issues with deep genetics/genomics and biological inquiry as we begin to understand how to recombine and deploy optimal combinations of genes in new wheat varieties and across space and time in ways that will help meet future production needs.

Potential links with other Wheat Initiative activities

This EWG will establish links to other entities in the Wheat Information System to store, share, and access information. Breeding methods research requires databases containing large volumes of genotypic and phenotypic data. Consequently, links to those working groups would be desirable.

Supporting countries/institutes

Potential participating countries[4]

Plant breeding is a global science that is important for all food producing countries. As such, any country is a potential participant. A survey will be developed to determine where breeding methods research is being conducted. International centers are logical participants as well as multinational corporations. An open call for participants to the EWG will be posted on the Wheat Initiative website.

Resources (budget requirement, potential funders, etc.)

The first meeting of the EWG will be held in conjunction with the International Wheat Genetics Symposium in September 2013. A budget of 40,000 € is requested from the Wheat Initiative to cover it and make sure that travel and accommodation expenses do not prevent participation of experts.
Additional budget requirements for research will be established during the 1st year of the EWG. Potential funding sources include international agencies, government agencies, industry, and foundations.

Other comments

Wheat breeding methods span the entire spectrum of approaches to crop improvement. In this concept note, a plant breeding method is defined as a process for producing new plant genotypes by hybridization and/or inbreeding. Specifically excluded are topics relating to testing strategies, intellectual property issues, and governmental regulations.

Date of submission to the International Scientific Coordinator

16 May 2013

[4] Not limited to current members of the Wheat Initiative

NB: relevant accompanying papers (concept note, articles, research project,…) could be joined to the pro-forma.