Proposal number[1]: 1
Date of reception[1]: 12/03/14

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 Wheat Initiative 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. Each EWG will be established for an initial defined period. The minimum 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. EWGs will be set up after approval of the submitted proposals by the Research Committee or the Institutions' Coordination Committee, each in its area of expertise (science or research organisation/funding). An open call for members of the EWGs will be organised on the Wheat Initiative website. Research priorities established by EWGs and endorsed by the Research Committee will constitute a port-folio that will be available to the Institutions' Coordination Committee members to tackle priorities together or independently in each country.

Topic title		
Adaptation of Wheat to Abiotic Stress (AWAS)		
Proposer(s) [3]		
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[1] For Secretariat use only, do not fill

[2] Please send the completed form to Hélène Lucas, Wheat.Initiative@versailles.inra.fr, under a Word format.

[3] Add lines for other proposers if needed.

Summary

Abiotic stresses such as extreme temperatures, low water availability, high light intensity, high salt, and mineral deficiencies or toxicities can severely reduce productivity for wheat and other crops. In many cases, several types of abiotic stress challenge plants simultaneously. High temperatures, high irradiance, scarcity of water and nutrient deficiencies are commonly encountered in environments where wheat is grown but are not amenable to management through traditional farm practices. Drought and heat stress are now regarded at the most significant environmental stresses facing wheat production globally. Integration of genetic and phenotypic data, together with the availability of unique populations adapted to specific environments and end-uses will improve the understanding of traits determining yield in water limited environments. This will allow the creation of wheat varieties with improved performance. Several major international programs are already underway to address these challenges and there is a great opportunity to coordinate these efforts and build a global program targeted to enhancing yield under stress. This EWG will bring together the different programs and develop an international strategy to secure long term support, aiming to better coordinate or bring together national and international donors' current and future investment in addressing the challenge of increasing abiotic stress for wheat.

Detailed description (5 pages maximum)

Rationale

Population growth and a declining natural resource base threaten food security on a worldwide scale. However, the prerequisites to develop a globally coordinated effort to ensure long term food security are available. These include, recognition of a common scientific basis for many global agricultural problems, a large and expanding knowledge base from the many disciplines that impinge on agricultural productivity, networks of agricultural scientists working in almost every country in the word, and unprecedented opportunities for communication, data analysis, and financial investment. The Wheat Initiative was established to capitalize on such assets by bringing experts and other resources together.

Given that the Inter-governmental Panel on Climate Change has predicted that rising temperatures, drought, floods, desertification and weather extremes will severely affect agriculture and that the IAASTD Synthesis Report[4] (2009, see p.44, 48) expects that plant breeding plus MAS will make the most substantial contribution to addressing the challenge of increased abiotic stresses we propose an expert working group on the Adaptation of Wheat to Abiotic Stress (AWAS) under the WI umbrella. Wheat already provides reliable yields under a very wide range of growing conditions, and its large genome has responded beneficially to the introduction of genes from wild relatives. These factors, along with up-to-date genetic gains of spring wheat lines observed worldwide (0.6% p.a.), and especially under water stress (1% p.a. Yanes et al, 2012[5]) make investment in improving wheat's adaptation to abiotic stress an excellent opportunity. We propose a multidisciplinary effort, involving the expertise and resources from a large global partnership. There are a number of compelling reasons for investing in AWAS:

1) A major body of basic research on plant stress adaptation already exists and the recognition that climate change is a serious threat to food security has renewed interest and investment in this area.

[4] International Assessment of Agricultural Knowledge,
Science and Technology for Development Synthesis Report, 2009 :
http://www.unep.org/dewa/agassessment/reports/IAASTD/EN/Agriculture%20at%20a%20Crossroads_Synthesis%20Report%20(English).pdf

[5] Manes,Y.; Gomez, H.F.; Puhl, L.; Reynolds, M.; Braun, H.J.;Trethowan, R, 2012. Genetic yield gains of the CIMMYT international semi-arid wheat yield trials from 1994 to 2010. Crop Science 52(4):1543-1552.

2) To date, very little of such research has been applied in a translational context. With the right investment, this vast and relatively untapped knowledge base can be used to help increase the adaptation of crops to harsher climates.
3) The International Wheat Yield Partnership (IWYP) has already secured over $35m to raise the ceiling of wheat's genetic potential under favourable conditions; technologies coming from IWYP will underpin any effort to adapt wheat to harsher environments.

Therefore, AWAS could build on existing basic knowledge and expertise, while capitalizing on expected translational outputs of IWYP and other programs. The AWAS would tap into some of the best minds available worldwide in plant stress technology, while also linking to other initiatives that focus on wheat (SeeD, WiSP, BREEDWHEAT, T-CAP, ACPFG, etc.) in order to ensure that wheat yields continue to rise in the coming decades, even under much harsher climatic and environmental conditions.

Description of the EWG aims

Adapting wheat to abiotic stress will necessarily encompass a broad range of environments, mechanisms, and scientific approaches.

Two stresses that already predominate on a worldwide basis, and are expected to increase under climate change, are heat and drought. The response of crops to these stresses has a number of similarities, although the genetic basis is not necessarily the same. Growth rate is accelerated due to increased plant temperature which reduces the window of opportunity for photosynthesis while both heat and drought stress may also inhibit growth directly at the metabolic level. Furthermore, harvest index may be reduced if reproductive processes are impaired by stress that occurs at critical developmental stages. Conventional wheat breeding has made significant genetic gains under both stresses[6] (Gourdji et al., 2012) and the key aim of AWAS would be to complement this effort by deploying the most recent advances in biotechnology to accelerate current genetic gains, as well as tackle some of the most challenging aspects of climate change, such as tolerance to sudden extreme climatic events or combinations of stress factors. The focus of AWAS will be on drought and heat stress but it is important to remember that these stresses do not occur in isolation. They are frequently linked to other environmental factors that can limit wheat productivity. For example, cold and frost stress can restrict the suitable growth window, in appropriate nitrogen response can lead to excessive biomass production and increase susceptibility to drought stress and soil structure, including salinity, can limit access to moisture.

Key research approaches will encompass:

1. Developing conceptual models of new adaptive genotypes as a basis for hypothesis testing and strategic hybridization. This will be achieved using the following inputs; i) basic research on stress adaptive mechanisms across the entire plant kingdom, ii) genetic information coming from the various wheat genomics programs, including the IWGSC, iii) understanding of target breeding environments using GIS and other resources.
2. Exploration of the World Wheat Collection –including wheat landraces, wild species in the Triticeae tribe, re-synthesized hexaploids, and advanced lines to provide genetic panels for gene discovery, mechanistic studies, and breeding. In this context, proven transgenes would also be employed to embrace diversity across the widest possible range of taxonomic groups.

[6] Gourdji SM, Mathews KL, Reynolds MP, Crossa J, Lobell DB, 2012. An assessment of wheat breeding gains in hot environments Proceedings of Royal Society B: Biological Sciences 280: 1752-1760

3. Refinement and application of high through-put phenotyping (HTP) approaches to accelerate screening for potential genetic sources and identify the genetic basis of stress adaptive traits. A major focus will be application of spectral imaging approaches that estimate plant properties such as canopy temperature, water status, and pigment composition, as well as estimating a number of agronomic traits. Such approaches applied on large genetic panels, along with agronomic data, will also permit the identification of subsets of contrasting lines for more detailed physiological and molecular dissection.
4. Detailed precision phenotyping would be applied on the best lines to pinpoint key adaptive bottlenecks at a mechanistic level, using *in vitro* and controlled environments initially, and eventually scaling up to field level.
5. Gene discovery using prioritized traits and environments, appropriate genetic panels in combination with the latest marker systems and wheat sequence information, and statistical tools for genetic analysis. The development of various 'omics databases, such as metabolite and transcript profiles of different wheat accessions exposed to drought and heat stress, will provide a important resource for gene identification and allele mining.
6. Development of diagnostic molecular markers for application in MAS. The new genetic and genomic resources now make positional cloning of QTL feasible in wheat and several research programs are now close to isolating genes underlying drought responsive QTL. As genes associated with drought and heat stress are isolated, there will be an opportunity to screen for novel structural and expression alleles in the wheat germplasm collections
7. Strategic hybridization using all available information as outlined above to achieve favourable new combinations of alleles in agronomically acceptable backgrounds.
8. Deliver novel sources of germplasm encompassing specific combinations of stress adaptive traits to breeders worldwide, through the International Wheat Improvement Network.

Expected deliverables/outputs of the EWG

Through effective and efficient coordination of existing national and international R&D activities and proposals to WI members (ICC) to fund additional, complementary R&D activities, facilitate the following research results:

1. New genetic materials based on combining useful expression of physiological traits whose additive gene action results in 15–30% improved yield under heat and/or drought stress than that of current elite heat and drought-adapted materials, with no significant yield penalties in favorable years.
    a. Phenotyping methods useful to the WHEAT community
    b. Molecular markers useful to the WHEAT community
2. Shared resources (including populations) and databases on response of diverse wheat germplasm to abiotic stress.
3. Lines adapted to average temperatures approximately 2 °C above current temperatures in heat-susceptible environments.
4. Lines with roots that take up 95% of available moisture up to one meter below soil surface. In combination with improved partitioning of biomass to yield this will permit similar yields to be achieved with 15–20% less rainfall than currently experienced in drought-prone environments.

5. Wheat cultivars with enhanced stability of production despite unpredictable heat or drought stress.
6. Published information about yield limiting factors under heat and/or drought stress, and strategies for addressing these.

Timeline of Activities

Establishment Phase (2014/15)

- Solicit sponsorship from appropriate stakeholders internationally.
- Sponsors/stakeholders establish technical advisory committee(s)
- International call for ideas developed
- Series of conferences to help determine the most appropriate research areas and available expertise worldwide.
- Business plans developed around research topics (e.g. Heat-Drought, Problem Soils, etc)

First 5 year Research Phase (2015-2020)

- Establish research platform(s) at appropriate sites worldwide, by linking with existing national and international R&D activities and their sites
- Competitive call for research tenders published internationally and awards made, supported by a coordinated, or even joint funding effort by WI members (ICC; donors).
- Research and pre-breeding commence simultaneously to ensure applicability of one with the other, and to capitalize on near term wins.
- First new stress adapted lines available to breeding programs worldwide for testing and confirmation.

Second 5 year Phase:

- Second research and pre-breeding phase incorporating successful proofs-of-concept from Phase 1.

Alignment with the Wheat Initiative objectives

This EWG aligns with the item 4 of the strategic agenda - 4. Increase resource use efficiency and tolerance to abiotic stress. The EWG endeavours to coordinate global research efforts aimed at improve the abiotic stress tolerance of wheat which aligns fully with the objective of the Wheat Initiative.

Potential links with other Wheat Initiative activities

The AWAS would be aligned with the following EWGs: IWYP; Wheat Phenotyping EWG; Durum EWG; IWGSC; Wheat breeding methods and strategies EWG; AgMIP Wheat – crop model improvement EWG

Supporting countries/institutes

The CGIAR Research Program on Wheat (WHEAT) is already committed to supporting the strategic initiative (SI, now called Flagship Project, with Clusters of Activity) on Heat and Drought. The SI was designed by CGIAR centres CIMMYT (EWG Sponsor) and ICARDA. WHEAT is aiming to expand R&D efforts on heat and drought in WHEAT target regions (developing world, where wheat-dependent poor live) in its 2015-16 and 2017-24 proposals to CGIAR Consortium donors, some of whom are also donors to related national/bilateral R&D programs.

The Australian Centre for Plant Functional Genomics (EWG Sponsor) is one of the leading centres worldwide in wheat abiotic stress research. We are certain that a WI-backed EWG call for interest would attract attention of many of the best plant research in the world as well as funding bodies (see list below)

Potential participating countries[7]
Global (see above)
Resources (budget requirement, potential funders, etc.)
The research budget to enhance heat and drought tolerance in wheat is estimated at initially 10 million US$ and will increase to 15 million US$ per year, once all research activities are initiated. Key resource needs: 1. Screening of existing and planned relevant R&D activities at national/bilateral and international level, to 2. Identify research gaps, synergies (opportunities for light-to-heavy collaboration) and how they might be best addressed 3. Establish and maintain high level overview of R&D progress available to researchers (and donors) worldwide Potential funders are expected to be: • ACIAR • AAFC • BBSRC • BMGF • BMZ • CAAS • CIDA • CRP WHEAT - CGIAR • DFID • GRDC • ICAR • INRA • JIRCAS • USAID • USDA • Private Sector
Planned duration of EWG (in years)
20 years in approximately 5-year funding phases
Other comments
Date of submission to the International Scientific Coordinator
March 2014

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

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