

WHEAT  
INITIATIVE



# ANNUAL REPORT 2022

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## ORGANISATION OF WHEAT INITIATIVE

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# INTRO LETTER 2022



## THANK YOU VERY MUCH FOR YOUR INTEREST IN OUR WORK

2022 was a very exciting year for the Wheat Initiative (WI) community. We were able to put travel restrictions behind us and start meetings in person again. The year included many highlights and provided us with some new challenges. We would like to thank our community for showing resilience during the last couple of years and for their enthusiasm in welcoming back face-to-face meetings and events.

2022 marked a new chapter in the history of the WI. As you may know, the WI moved from INRAE Paris to the Julius Kühn Institut in Berlin, in 2018, for a period of five years. The five-year term was due to end in December 2022, but thanks to the support of the Federal Ministry of Food and Agriculture (Bundesministerium für Ernährung und Landwirtschaft, BMEL) and the Julius Kühn Institut, the WI will remain in Germany for five more years, until the end of 2027. Thank you, Germany, for the support and being such a great host!

In July 2022, and thanks to the support and work of the WI community, an updated version of the WI Strategic Research Agenda (SRA) was launched. Through the process of updating our SRA, we evaluated our progress, reassessed the international research priorities, and identified major technological advances. This analysis has highlighted the large impact of the WI on the community, and we look forward to continuing this role in the years to come. The SRA was published on November 7, 2022, in the open access journal *Agronomy*, titled 'Meeting the Challenges Facing Wheat Production: The Strategic Research Agenda of the Global Wheat Initiative'. The SRA can be accessed either through the WI website: <https://www.wheatinitiative.org/2022-strategic-research-agenda> or <https://doi.org/10.3390/agronomy12112767>.

Also, during July 2022, the meeting of G20 Agricultural Chief Scientists, titled "Sustainable intensification to meet food security and environmental objectives" was hosted in Bali, Indonesia. The Chair of our Scientific Board attended virtually and presented the "Importance of science and collaboration in addressing food security: Role of the Wheat Initiative".

In October 2022, the Teagasc (Agriculture and Food Development Authority) hosted our Jamboree meeting at the Oak Park Crops Research Centre in Carlow, Ireland. Members of our three committees, and Expert Working Group Chairs and Co-Chairs participated in this hybrid meeting that had been postponed since 2021. It was great to have so many members of our community together and being able to meet and have discussions in person.

During 2022, we prepared for the launch of the new associated program "Wheat Initiative Crop Health Alliance – WATCH-A", with the aim to achieve global monitoring of disease outbreaks.

There have been several leadership and organisational changes in our Expert Working groups (EWGs) and they have continued to be critical for supporting the research community. Two new EWGs were born out of a split of the old Pest and Pathogens EWG and the new chairs and co-chairs have exciting plans for 2023 and beyond. We thank all leaders and members of the EWGs for their work and dedication in helping support global research collaboration.

**Mr John Spink, Chair, Institutions' Coordination Committee**

**Prof Dr Frank Ordon, Chair, Research Committee**

**Prof Dr Peter Langridge, International Science Coordinator & Chair, Scientific Board**

**Ms Teresa Saavedra Bravo, Programme Manager, Wheat Initiative**

# 1. INTRODUCTION



# WHAT TO EXPECT IN THE 2022 ANNUAL REPORT



## THANK YOU FOR YOUR INTEREST IN OUR 2022 ANNUAL REPORT

This report aims to show how the wheat research community have embraced the easing of restrictions from the last couple of years. Even though adapting to the new times and moving activities to a virtual world did prove to be efficient, we cannot deny that meeting in person gives more opportunities to interact and network that the virtual world cannot provide. Our members have taken advantage of both, and we are very proud of the inventiveness they have shown to keep the community together.

Our 2022 annual report contains information on developments in global wheat research, advances of our community and updates on our associated programs. We would like to thank our members, including representatives from member countries, organisations and private companies, and EWGs for providing us with an overview of their activities, that we share with you in this report.

We rely on the support of our followers and members to help 'spread the news' of the work we do. Our WI communication section outlines the media channels that are being used and the changes that have been made in our strategy for communications. The updated strategy has enabled us to gain almost 900 Twitter followers in one year, reaching 4,074 followers in total by the end of the year.

The annual report concludes with a financial overview of 2022, as well as the new and exciting in-person events that happened during the second half of the year.

The return of face-to-face events has been particularly valuable, as our community has faced many different challenges imposed not only by COVID-19, but also by geopolitical events. The development and evolution of our community in adapting to challenges have shown how strong the community is. Every member of the WI is valuable and does their part to help overcome difficulties and achieve success in wheat related research.

If you would like to help us on our mission to assure food security through wheat improvement, please contact us on [wheat.initiative@julius-kuehn.de](mailto:wheat.initiative@julius-kuehn.de) or click below.

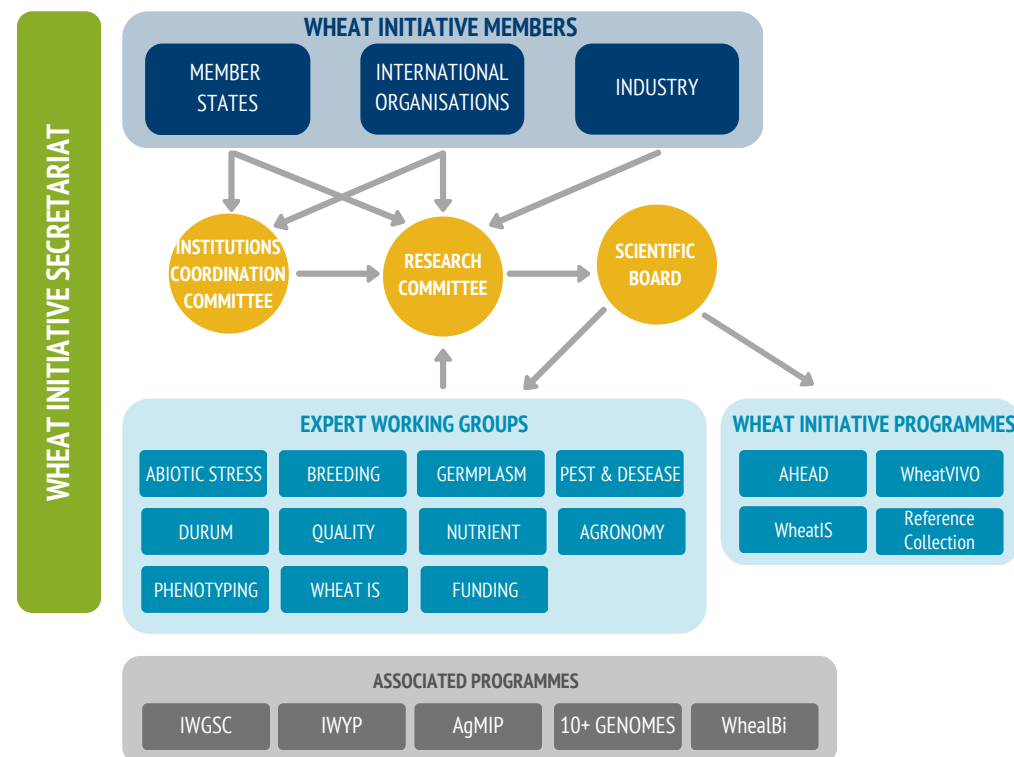
### Stay informed and get involved in wheat research by:

- **Becoming a member:** <https://www.wheatinitiative.org/member>
- **Becoming an Expert Working Group member:** <https://www.wheatinitiative.org/expert-working-groups-2>
- **Signing up for the quarterly newsletter:** <https://www.wheatinitiative.org/newsletter>
- **Signing up for the weekly "Wheat In The Media":** <https://www.wheatinitiative.org/wheat-in-the-media>

# WHEAT INITIATIVE BACKGROUND



The WI is an international organisation endorsed by the G20 Agriculture Ministers in 2011. It draws together multiple countries, organisations and industries to address global challenges facing wheat production. From its creation in 2011, and until 2018, the WI Secretariat was hosted in France at the former National Institute for Agricultural Research, now National Research Institute for Agriculture, Food and Environment (INRAE). In 2018, the WI moved to its new host institution and country, the Julius Kühn Institute (JKI) in Berlin, Germany, where it has been well supported by the Ministry of Food and Agriculture (Bundesministerium für Ernährung und Landwirtschaft, BMEL). The WI mission is to increase food security, wheat nutritional value and safety while taking into account societal demands for sustainable and resilient agricultural production systems; and maximising opportunities for gaining added value internationally. The aim is to encourage and support the development of a vibrant global wheat public-private research community that shares resources, capabilities, data, knowledge and game changing ideas to improve wheat productivity, quality and sustainable production around the world. The WI provides a framework to initiate, establish and advance strategic wheat research and priorities. Its network consists of more than 500 wheat scientists from more than 55 countries. They contribute through the 11 Expert Working Groups that make up the WI task force. Its Institutions' Coordination Committee, Scientific Board and Research Committee provide oversight of the activities and priorities. The WI currently has 14 member countries, 6 observer countries, 3 international research centres and 3 private companies.



# HISTORY



Launched September 15, endorsed by G20 countries, based at INRAE in France

Vision paper published; first EWGs established

German Federal Ministry of Food and Agriculture agrees to host WI

1st International Wheat Congress (IWC)

10 year anniversary, G20 stocktaking exercise

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Establishing Committees

Publication of the 1st Strategic Research Agenda

Transfer of WI office to Berlin, Germany

Alliance for wheat adaptation to heat & drought (AHEAD)

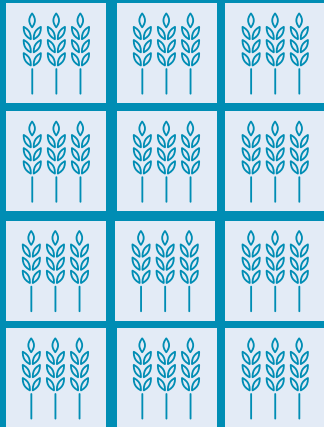
Publication of the 2nd Strategic Research Agenda



# NUMBERS



12 Expert Working Groups



From 55 countries

500+ EWG members

100 100  
100 100  
100 +

14 member countries (public)



3 industry members (private)



6 observer countries



3 research organisations



# PURPOSE



## VISION

Encourage and support the development of a vibrant global wheat public - private research community sharing resources, capabilities, data, knowledge and ideas to improve wheat productivity, quality and sustainable production around the world.

## MISSION

Increase food security, wheat nutritional value and safety while taking into account societal demands for sustainable and resilient agricultural production systems; and maximising opportunities for gaining added value internationally.

# 2. HIGHLIGHTS



# HIGHLIGHTS OF 2022



## STRATEGIC RESEARCH AGENDA

The Wheat Initiative Strategic Research Agenda (SRA) was originally released in 2015 after a meeting was held in Paris in 2014 where all EWG Chairs, the Research Committee and the Scientific Board brainstormed about the future of wheat research.

This document proved influential and was used by several agencies to influence their research priorities and focus investments in areas of international importance. It was considered important to review the SRA, to evaluate what progress we had made so far achieving the objectives, and to reassess and update the international research priorities ensuring their relevance and identify major technological advances. The revised SRA is aimed to provide direction and support future investment in wheat research.

There were 2 workshops held in January and February 2022 to work on updating the SRA. They involved the EWG Chairs, Co-Chairs and Research Committee members and included much brainstorming, feedback and discussions. After the workshops, a draft version of the SRA was prepared and submitted to the Scientific Board for review. A final version was prepared and launched on July 5, 2022, in the Botanic Garden in Berlin.

Details on the launch can be found in the following press release:  
<https://www.wheatinitiative.org/press-releases/science-to-tackle-global-wheat-productivity-challenges-jmkns>

**To access the updated version of the SRA go to**  
<https://www.wheatinitiative.org/2022-strategic-research-agenda>

The original SRA listed three “game changers” that were predicted to have a large impact on wheat research. All have come to pass, although all proved to represent only a first phase; the wheat genome sequence led to the development of the pan-genome, data access through WheatIS continues to grow and the deployment of new allelic combinations is a work in progress. For wheat research a series of short (1- 5 years) medium (5-10 years) and long term (over 10 years) objectives were identified across the diverse areas of research important for wheat production. We are now at the end of the time for the short-term objectives and it was very encouraging to note that virtually all had been met. In some areas, such as lifting the wheat yield potential, we were well into the medium-term objectives, in this case thanks to the efforts of the International Wheat Yield Partnership. Continued support and investment in the existing activities is clearly important if we are to continue with the excellent progress.

In the new SRA, three areas are identified as requiring increased investment and coordination. These are:

- Recognising that major benefits can be derived from considering wheat production within the broad cropping system and there are several examples where integration across agronomic, genetic approaches and the cropping system have resulted in significant increases in yield and yield stability.
- Despite considerable effort by several genebanks and research programs, much remains to be done to better characterise and facilitate the use of novel germplasm. Similarly, tetraploid collections will play an important role in identifying and selecting novel haplotypes not yet exploited in bread wheat.
- Clearly, soil and root health are critical for sustainable wheat production. Soil research has had a significant impact in understanding limitations to production, but direct studies of root development and their interactions with the soil have been difficult due to problems in accessing and phenotyping root systems.

# HIGHLIGHTS OF 2022



In developing the updated SRA, the group also recognised that changes should be made in the way the Wheat Initiative operates, with an increased role in advocacy in encouraging science based decision making and increased investment and collaboration in wheat research, in particular through the development of multinational research partnerships. Although the membership of the Expert Working groups has continued to grow, there are still many regions of the world that are underrepresented. A further objective over the next few years will be to extend the membership base to support wheat researchers working in poorly resourced programs, and young researchers.



## JAMBOREE 2022

From the 16th to the 19th of October, the Wheat Initiative held a Jamboree in Carlow, Ireland. This was a fantastic chance to have a hybrid meeting with members of our three committees (Institutions' Coordination Committee, Research Committee and Scientific Board) and with the chairs of our Expert Working Groups (EWGs). Teagasc, the Irish Agriculture and Food Development Authority, hosted the conference kindly on their premises where John Spink, Institutions' Coordination Committee (ICC) Chair is located.

This was the first opportunity for all WI three committees to meet since the 1st IWC in Saskatoon, Canada in 2019.

During the three-day event, EWGs and associated programs were given the opportunity to talk about their updates. As well, lively discussion rounds were held on the major topics outlined in our Strategic Research Agenda. Along with the main meeting, individual ICC meeting as well as Research Committee and Scientific Board meeting took place within these days.

Members from our committees attended in person from places as far as Japan and Canada, while others attended via video conference, with Australia being the furthest away attendee.

# HIGHLIGHTS OF 2022



## G20 AGRICULTURE DEPUTIES MEETING AND MACS-G20 MEETING - INDONESIA 2022

The Presidency of the G20 in 2022 was held by Indonesia. The G20 meeting of Agricultural Working Groups and the Agricultural Chief Scientists meetings (MACS-G20) were held in Bali 5-7 July 2022, on a face-to-face only model. Due to travel restrictions still being in place, the WI could not attend in person, but we did take part in the Technical workshops.

In July 2022, we participated in a workshop on “Sustainable intensification to meet food security and environmental objectives”. In our presentation, we advocated for the following three practical steps to capture the benefits provided by research and collaboration:



## WHEAT INITIATIVE

- Boost research and technology delivery capabilities by investing in staff and student training, encouraging, and supporting exchange of personnel between research organisations and building research infrastructure. This can be achieved if national research programmes place priority on activities with strong international linkages. Financial or organisational support from national agencies to research groups seeking participation in international partnerships would be beneficial.
- Providing support, both financial and organisational, to international activities targeted to facilitating exchange of resources, particularly germplasm, and supporting the evaluation and delivery of research outcomes. Examples of the efficient evaluation and delivery of technologies from diverse sources is provided through the germplasm evaluation and distribution capabilities, or hubs, developed by CIMMYT, ICARDA and the International Wheat Yield Partnership.
- Actively participate in Wheat Initiative research alliances that bring together capabilities and resources targeted to global research challenges. These include the three current alliances: The International Wheat Yield Partnership (boosting wheat yield potential), Alliance for Wheat Adaptation to Heat and Drought (producing heat and drought tolerant germplasm) and the Wheat Initiative Crop Health Alliance (diagnosis and monitoring of wheat diseases).

A second workshop was held in August 2022 on Climate Change. Peter Langridge, Chair of the Scientific Board, had the opportunity to present the WI during the meeting where the issues around research collaboration raised in the earlier workshop (see above) were emphasised. Peter’s presentation is available at: [https://www.macs-g20.org/fileadmin/macs/Annual\\_Meetings/2022\\_Indonesia/Presentations/Wheat\\_Initiative\\_Lesson\\_Learned\\_on\\_Climate\\_Resilient\\_Agriculture.pdf](https://www.macs-g20.org/fileadmin/macs/Annual_Meetings/2022_Indonesia/Presentations/Wheat_Initiative_Lesson_Learned_on_Climate_Resilient_Agriculture.pdf)

# HIGHLIGHTS OF 2022



## 2ND INTERNATIONAL WHEAT CONGRESS (IWC) 2022

The 2nd IWC was held from September 11 to 15, 2022 with the theme “Future Wheat: Resilience and Sustainability”. The congress was transmitted through the IWC 2022 website at no cost. The website is still available and can be accessed through: <http://www.2022iwc.cn/>

We would like to thank the hosts of the IWC 2022, Chinese Academy of Agricultural Sciences (CAAS) and Consultative Group on International Agricultural Research, for all the hard work and intense preparations to make IWC 2022 a successful event, while facing the restrictions due to COVID19.

At the conclusion of the meeting, it was announced that the 3rd IWC, to be held in 2024, has been granted to Perth, Australia. The call for a new host was organised by the Wheat Initiative Secretariat on behalf of the International Organizing Committee (IOC). The winning bid to host the conference, led by Professor Rajeev Varshney, is expected to provide an excellent opportunity for the wheat research community to share the latest progress and to develop recommendations for future wheat research and innovation programs.

We look forward to this great event!



# HIGHLIGHTS OF 2022



## MEETINGS, SEMINARS AND WORKSHOPS

The WI EWGs kept activities running despite the travel restrictions that were still in place in early 2022.

Our Durum EWG hosted its 4th Virtual Durum Meeting (VDM), on 21 and 22 April 2022. The VDM were created in 2020 to keep the Durum EWG community active and to provide them with updates, while promoting discussion on the latest scientific advancements on wheat genetic diversity. This series have been well attended.

The Durum EWG also organised the fourth “From Seed to Pasta” (FSTP4) congress, held 26 to 28 October 2022. This event took place in Bologna, Italy, giving the first opportunity for all the durum community to meet in person and it was very successful. Early Career Researchers and experienced researchers had the opportunity to interact. The event was successful.

The Chair of the WI Scientific Board, announced during his presentation the launch of the WI’s Early Career Researcher programme.

The Wheat Initiative sponsored the Carlotta Award, held during the FSTP4 event. We are proud to see so many ECRs as winners: Ilaria Marcotuli, Caixa Lan, Jyoti Saini Sharma and Valentyna Klymiuk.

Thanks to a collaboration with Dr Simon Griffiths and Dr Luzie Wingen at John Innes Centre (JIC) and “Designing Future Wheat” (DFW), the Wheat initiative granted G Mahendra Singh, PhD Scholar at the Dept. of Genetics and Plant Breeding, I.Ag.Sc., Banaras Hindu University, a grant to attend the DFW course at JIC, Norwich, UK, held in November 14-18, 2022. The course’s main workshop was how to utilise diverse wheat germplasm (including wild relatives) to improve bread wheat for future climates, especially for abiotic and biotic stresses.

## NEW EXPERT WORKING GROUPS PESTS AND PATHOGENS

The Control of Wheat Pathogens and Pests (P&D) Expert Working Group under the leadership of Richard Oliver, Robert Park and Steve Goodwin, has been working for several years to determine major priorities and opportunities for international collaboration. A key outcome of the discussion was to focus work around developing a global disease diagnosis and monitoring system. To further this aim, it was decided to establish an associated program (WATCH-A) and survey the research community to see if greater impact could be achieved by developing two EWGs; one focussed on pathogens and the other on pests. The survey was held in late 2021, and the clear outcome was to support two EWGs.

The new Chairs and Co-Chairs were elected for the two EWGs:

Control of Wheat Pathogens:

- Chair Kar-Chun Tan (KC) from the Centre for Crop And Disease Management at Curtin University, Perth, Australia.
- Co-Chairs, Reem Aboukhaddour from Agriculture and Agri-Food, Canada, and Caixia Lan from Huazhong Agricultural University, China.

Control of Wheat Pests EWG’s Co-Chairs:

- Leonardo Crespo (CIMMYT, Mexico) and
- Gia Aradottir (Mamoré Research and Innovation Limited, UK) chair and co-chair respectively.

They started working with their respective community on finding ways in which to move forward with each of their EWGs.



# HIGHLIGHTS OF 2022



## EARLY CAREER RESEARCHER PROGRAMME

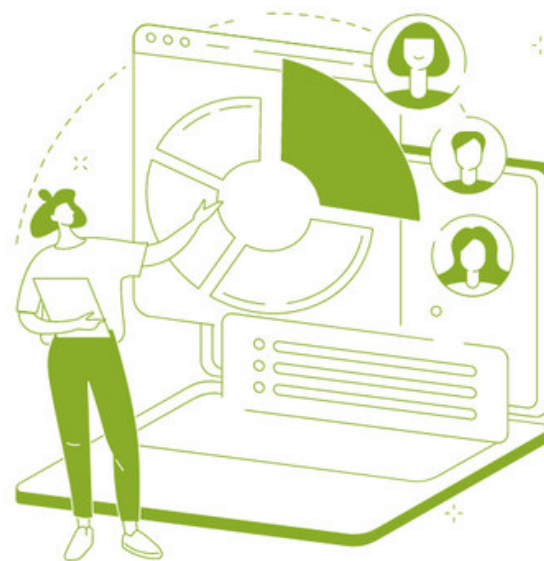
During the FSTP4 event, in October 2022, the Wheat Initiative announced the launch of the Early Career Researcher Programme (ECR). It is targeted to postgraduate students or researchers with five years or less in a scientific position since completing their PhD in a scientific area related to wheat.

Our aim is to encourage participation of the next generation of wheat scientists into our network. This programme emphasizes the role of networking in building research careers by supporting the engagement of future wheat research leaders in our EWGs activities.

By participating in the programme, Early Career Researcher members will gain access to a vast research network and will help shape the priorities of the Wheat Initiative EWGs to ensure food security. ECR members will have the opportunity to apply for support to attend Wheat Initiative and EWGs workshops and meetings; while contributing to the development of creative, effective research and education plans to support the goals of the EWGs and the Wheat Initiative. Members will be accepted for one year, with the opportunity to extend their membership registration at the end of this period. More info on the Early Career Researchers membership here: <https://www.wheatinitiative.org/early-career-researchers>



## Early Career Researcher

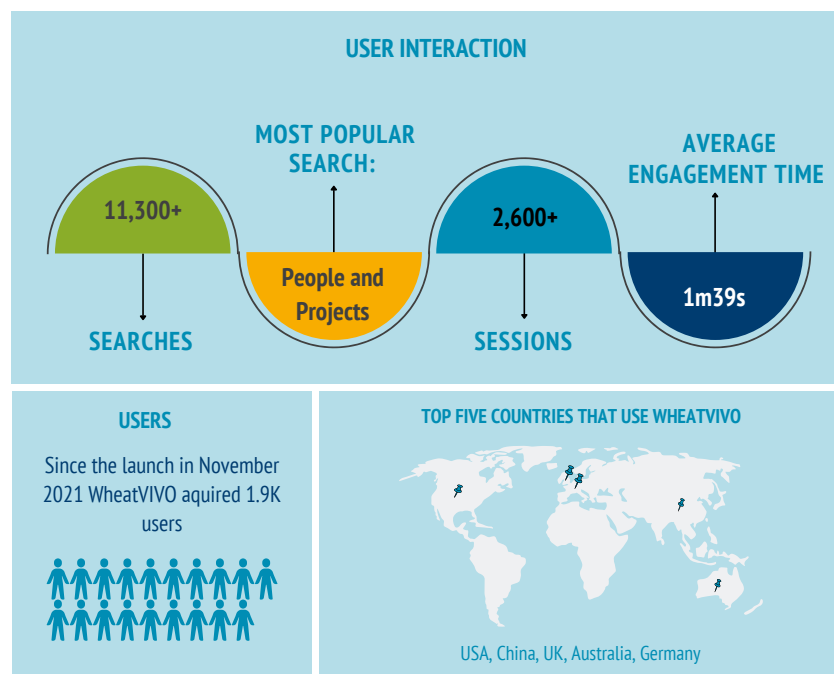


# HIGHLIGHTS OF 2022



## WheatVIVO

WheatVIVO is an open access database which enables users to search for researcher's profiles, organisations, publications and projects. Since [www.WheatVIVO.org](http://www.WheatVIVO.org) was launched in November 2021, there have been:



In November 2022, the 1-year anniversary of the launch of WheatVIVO was celebrated, with various Twitter announcements, a frontpage item on the WI webpage and a WheatVIVO cake.



During the year, several new features were implemented, including:

- Satisfaction survey which pops up at the bottom of the screen during the user's session whereby users can rate their satisfaction from 1-10.
- A What's New tab, highlighting the new content for the current month.
- The ability to search by 'newest' content within a certain category eg publications.
- The ability to differentiate between current and completed projects in the projects category.

Any queries or feedback regarding WheatVIVO is welcome at [wheatvivo@julius-kuehn.de](mailto:wheatvivo@julius-kuehn.de).

# 3. REPORTS



# REPORTS AND HIGHLIGHTS 2022



## THE EXPERT WORKING GROUPS (EWGS)

On the following pages, our scientific working force, the EWGs - our essential backbone, present a summary of their 2022 year. They bring together international experts from various fields, which benefits research efforts by sharing ideas, knowledge, information, and data with a focus on a topic of relevance to WI's aims and objectives. The numerous EWGs reflect all important research fields for yield improvement and include experts from the public and private sectors.

ADAPTATION OF WHEAT TO ABIOTIC STRESS

CONTROL OF WHEAT PATHOGENS

CONTROL OF WHEAT PESTS

DURUM WHEAT GENOMICS AND BREEDING

GLOBAL WHEAT GERMPLASM CONSERVATION AND USE COMMUNITY

IMPROVING WHEAT QUALITY FOR PROCESSING AND HEALTH

NUTRIENT USE EFFICIENCY IN WHEAT

WHEAT AGRONOMY

WHEAT BREEDING METHODS AND STRATEGIES

WHEAT INFORMATION SYSTEM

WHEAT PHENOTYPING TO SUPPORT WHEAT IMPROVEMENT

# ADAPTATION OF WHEAT TO ABIOTIC STRESS (AWAS EWG)



**87 members from 21 countries**

**Co-Chairs: Fernanda Dreccer (Australia),  
Krishna Jagadish (USA) and Tadesse Wuletaw Degu (Morocco)  
SB Liaisons: Wolfgang Friedt and Roberto Tuberosa**

## AIMS

The AWAS EWG aims to accelerate current genetic gains in wheat under abiotic stress by deploying the most recent advances in phenotyping and physiology, biotechnology, complementing breeding efforts. The EWG provides a platform for members to discuss research priorities on abiotic stress, connect across organisations and act as experts in education/extension activities concerning abiotic stress impact for capability building purposes.

## 2022 MEETINGS

A training course was held in Morocco (seat of the new Global Drought Phenotyping platform from the CGIAR system) for 4 Early Career Researchers (ECRs) to learn new techniques in the screening and evaluation of drought tolerant germplasm.

## ACTIVITIES/ACHIEVEMENTS IN 2022

In partnership with the Phenotyping EWG, a video competition was launched in 2021 and evaluated during 2022. Nine videos/webinars were received from eight different countries. The titles of the videos:

1. Screening barley lines for resistance to devastating Barley yellow rust in Toluca, Mexico.
2. Agar gel phenotyping of roots as rapid and sensitive assay of wheat seedlings response to edaphic factors (Ukraine).
3. Stem carbohydrate dynamics in diverse wheat genotypes under drought and high temperature stress (India).

4. High-throughput field phenotyping to study the physiology of plants (Switzerland). Fourth Prize to Lukas Roth.
5. A low-cost method for phenotyping wilting and recovery of wheat leaves under heat stress using semi-automated image analysis (Italy).
6. Single kernel moisture reader (Canada). Third Prize to Jatinder Sangha.
7. Development of a robotic platform for in-field wheat phenotyping (Belgium). First Prize to Sebastien Dandrifosse.
8. Developing wheat that can beat the heat! (Australia). Second Prize to Rebecca Thistlewaite.
9. Into the unknown - predicting unmeasured traits in unobserved or future climates with any abiotic stress (Australia).

Members of the AWAS EWG took part in several meetings and workshops organised by the Wheat Initiative. These included: 2nd International Wheat Congress in China; From Seed to Pasta IV, Bologna, Italy; International Plant Phenotyping Symposium, Wageningen, The Netherlands; the Australian Plant Breeding Conference, Surfers Paradise, Australia.

## MAJOR SCIENTIFIC DEVELOPMENTS IN 2022

Abiotic stress continues to be a major area of wheat research. A literature search identified 794 publications in 2022 for drought in wheat, 534 for heat, 307 for salinity and 215 for cold and frost. The chairs and co-chairs of the AWAS EWG published over 10 papers on the genetic analysis of abiotic stress tolerance in wheat.

## 2023 PLAN

The chairs and co-chairs of AWAS have decided to transfer responsibility for this EWG to a new leadership group. Appointments of a new chair and co-chair will take place in early 2023 and the new leadership team will develop the activity plan for 2023 and beyond.

# BREEDING METHODS AND STRATEGIES (BREEDING EWG)



**43 Members from 14 countries**  
**Chair: Sanjay Kumar Singh (India)**  
**Co-Chair: Suchismita Mondal (Mexico)**  
**SB Liaisons: Roberto Tuberosa, Chris Burt**

## AIMS

The EWG aims to:

- Coordinate ongoing wheat breeding methods research.
- Identify support for public wheat breeding programmes.
- Develop a trans-national training programme in state-of-the-art breeding methods.

Research areas are:

1. Genomic selection.
2. Hybrid wheat.
3. Mutation breeding (including genome editing).
4. Utilization of cultivated and wild genetic resources (to cross with GR-EWG).

## 2022 MEETINGS

There were no meetings held this year due to the COVID-19 pandemic.

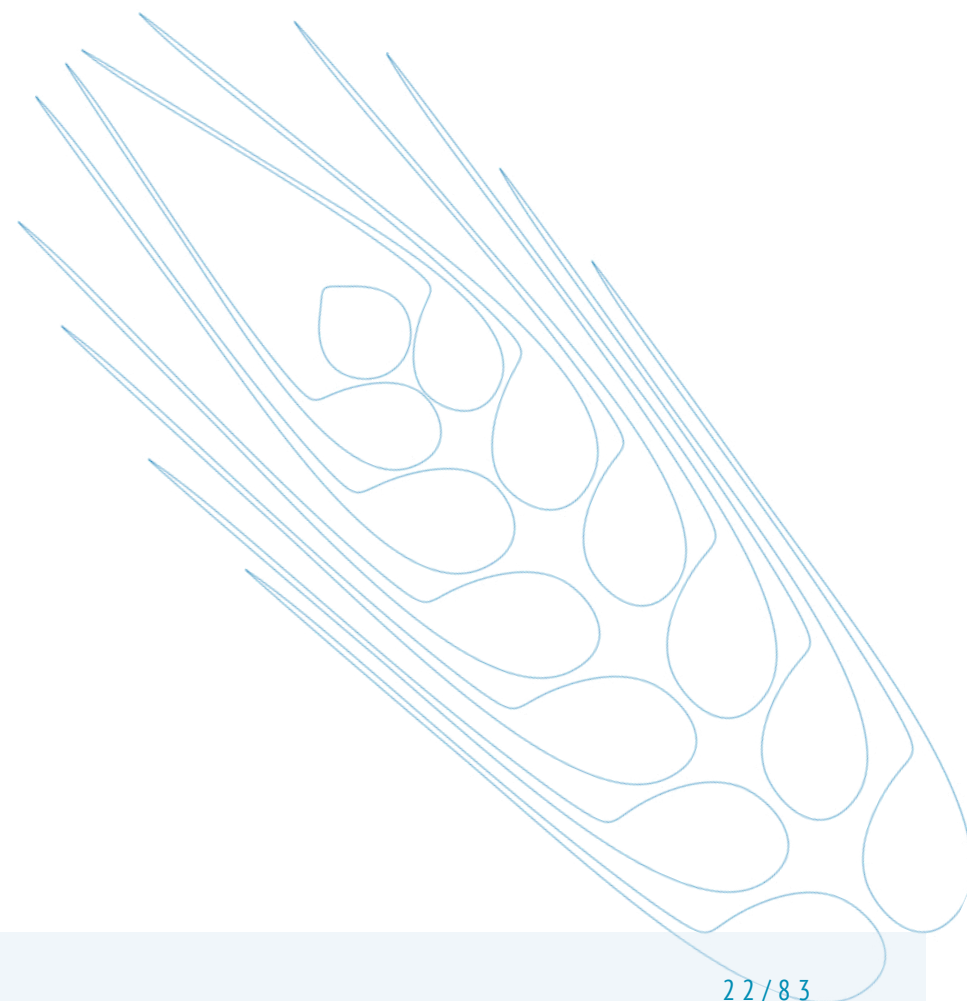
## EWG ACTIONS AND PROGRESS IN 2022

There was no progress made towards objectives due to the COVID-19 pandemic.

## 2023 PLAN

The Breeding EWG plans to have a face-to-face meeting in Germany.

It is also planned to hold an online conference on advanced breeding strategies for higher wheat productivity in collaboration with CIMMYT/ICARDA and other EWGs.



# CONTROL OF WHEAT PESTS (PESTS EWG)



**21 members from 14 countries**  
**Chair: Leonardo Crespo (Mexico)**  
**Co-Chair: Gia Aradottir (UK)**  
**SB Liaisons: Alison Bentley, Chris Burt**

## AIMS

The Pests EWG focuses on the following topics:

- Biological control of pests.
- Development and/or application of chemical control substances/strategies.
- Diagnosis and monitoring of pest outbreaks.
- Diagnosis and monitoring of resultant disease spread for diseases spread by pests.
- Genetics and breeding of host resistance to wheat pests and the diseases they transmit.
- Integrated strategies to manage crop losses due to pests and the diseases they spread.
- Wheat-pests interactions, including arthropods, virus and nematodes and higher order trophic interactions.
- Other aspects of pest management and associated disease control.

## BACKGROUND

Pests can cause devastating effects on wheat grain yield and quality. The assessment presented by Oerke in 2005 indicates that the global grain yield loss due to pests is about 9%. The study from Deutsch et al. (2018), indicates that the loss caused by insect pests can change substantially with climate change, eg the current loss can increase up to 25% under a 2°C warmer climate.

The sustainable protection of wheat yields from the damage caused by pests and diseases is paramount to increase productivity within planetary boundaries and improve food security. The current and future scenario for the control of wheat pests requires the integration of knowledge from different disciplines. Hence, wheat science must generate and integrate knowledge that contribute to the development of adequate tools to manage pests in the farmers' field. To this end, the Pests EWG brings together experts in the field from across the globe to gather knowledge, share experiences and foster international collaborations.

## 2022 MEETINGS

In November, the Pests EWG started with a presentation from Dr Beant Singh from Punjab Agricultural University. A second meeting of the Pests EWG was held on December 2022.

## ACTIVITIES/ACHIEVEMENTS IN 2022

The Pests EWG is a new EWG formed from the division of the former Pathogens and Pests EWG. A major achievement for the newly formed EWG was the appointment of a Chair and Co-Chair.

# CONTROL OF WHEAT PATHOGENS (PATHOGENS EWG)



**53 members from 23 countries**

**Chair: Kar-Chun Tan (Australia)**

**Co-Chairs: Reem Aboukhaddour (Canada); Caixia Lan (China)**

**SB Liaisons: Fiona Doohan, Silvia German**

## AIMS

Our goal is to bring together experts from the field of wheat research with an interest in minimising yield loss caused by microbial pathogens through open collaboration by focusing on the following goals:

- Improving microbial isolates and resource accessibility.
- Effective disease diagnosis and monitoring.
- Improving wheat disease control.

## 2022 MEETINGS

- Meeting 1: 24 May, online, EWG chair meeting.
- Meeting 2: 28 June, online, EWG meeting, ~20 participants.
- Meeting 3: 3 October, online, EWG chair/co-chairs and SB meeting, 4 participants.
- Meeting 4: 17 October, face-to-face, the WI Jamboree, >22 participants.
- Meeting 5: 17 November, online, EWG chair and co-chairs update and 2023 planning, 4 participants.

## ACTIVITIES/ACHIEVEMENTS IN 2022

The Pathogens EWG is a new EWG formed from the division of the former Pathogens and Pests EWG. A major achievement for the newly formed EWG is the appointment of 3 chair/co-chairs with broad expertise in molecular plant pathology, wheat breeding and field-based disease resistance research. There were 11 new members recruited in 2022.

## MAJOR SCIENTIFIC DEVELOPMENTS IN 2022

- The Keller lab identified ancient variants of the AvrPm17 gene in *Blumeria graminis* f. sp. *tritici* that renders Pm17, an R gene introgressed into wheat from rye, less effective against wheat powdery mildew, Müller et al. (2022) doi.org/10.1073/pnas.2108808119.
- For stem rust, The Wulff lab cloned Sr62 from wild wheat and demonstrated that transgenic bread wheat carrying Sr62 possesses showing a high level of resistance against diverse stem rust isolates, Yu et al. (2022) doi.org/10.1038/s41467-022-29132-8.
- For necrotrophic fungal pathogens, the Aboukhaddour Lab has generated extensive pan-genome data for the Tan Spot of wheat fungus. In addition, new transposons involved in ToxA and B mobilisation have been identified, Gourlie et al. (2022) doi.org/10.1186/s12915-022-01433-w.
- The Friesen lab identified two new fungal effectors critical for *Septoria nodorum* blotch (SNB) of wheat, Kariyawasam et al. (2021) doi.org/10.1111/nph.17602 and Richards et al. (2021) doi.org/10.1111/nph.17601.
- The Tan Lab identified a mechanism of effector epistasis that undermine breeding for SNB resistance in wheat, John et al. (2022) doi.org/10.1371/journal.ppat.1010149.
- Knowledge of effectors and their matching receptors in wheat can be further exploited to improve resistance to diseases.



# CONTROL OF WHEAT PATHOGENS (PATHOGENS EWG)



## 2023 PLAN

- Meeting 1: August, face-to-face, annual EWG meeting.
- Meeting 2: February, April, and July online, WATCH-A steering committee meeting.
- Other meetings: monthly, online, Control of Pathogens EWG webinar series and discussions.

The EWG aims to establish a monthly Pathogens EWG webinar series in 2023. The webinars will have a specific focus on WATCH-A topics (see <https://www.wheatinitiative.org/ewg-pathogens>), knowledge of the presenter's lab activities and areas for collaboration. At this stage, EWG presenters will focus on (but not be restricted to) priorities. There have been 2 webinars so far in 2023, featuring Tom Fetch, AAFC in January and Tofazzal Islam, Bangabandhu Sheikh Mujibur Rahman Agricultural University in February. The webinars were well received with the format being a 40 min. talk, plus time for discussion afterwards. Through the webinars, it is anticipated that the EWG members will get to know each other's speciality, be able to explore opportunities for collaboration and identify resource availability.

The Pathogens EWG encourage and support members to contribute to the development of a vibrant global wheat public-private research community sharing resources, capabilities, data, knowledge and ideas to improve wheat productivity, quality and sustainable production around the world. Therefore, they will aim to establish a WI-hosted database of pathogen isolates/resources and pan-genome rather than have a central repository for logistic reasons, as a part of the WATCH-A plan. It is realised that not all isolates can be shared similarly due to IP, third-party ownership, biosecurity, pending publication etc. Therefore, it is proposed to use a traffic light system to highlight resource availability ie Green = freely available; Yellow = requires MTA; Red = not available/not available until xxx.

In addition, the possibility will be explored with EWG members of exchanging wheat lines with differential disease phenotypes in different wheat planting regions. In addition, the EWG will ask members if they are interested in offering a disease screening nursery which they are focusing on. For example, Lan's group (China) is working on FHB and stripe rust. Interested members can contact the host to phenotype both diseases or one of them, no matter whether they are from China or other countries. This will facilitate closer cooperation between EWG members through resource exchanges and access to international disease nurseries.

Further planned activities for 2023 include:

- Recruit new EWG and ECR members.
- Organise WI funded travel grants for ECRs and EWG members from developing countries to attend conferences or receive training for projects that are relevant to the EWG.
- Hold a manuscript competition of articles published between July 2022 and June 2023. Suggested categories include best manuscript overall and best front cover.

# DURUM WHEAT GENOMICS AND BREEDING (DURUM EWG)



**86 members from 23 countries**

**Chairs: Luigi Cattivelli (Italy) and Roberto Tuberosa (Italy)**

**Co-Chairs: Jason Able (Australia) and Karim Ammar (Mexico)**

**SB Liaisons: Peter Langridge and Sylvie Cloutier**

## AIMS

- Promote synergy between durum wheat research groups.
- Identify research priorities to enhance opportunities for genetic progress in durum wheat breeding globally.
- Promote the utilization of the durum wheat genetic resources through collaborative initiatives.
- Promote the development of molecular tools/platforms open to the global durum wheat community.
- Enhance the capacity of breeders to access and use 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 to major scientific goals.

## 2022 MEETINGS

Meeting 1: 4th Virtual Durum Meeting (VDM), 21-22 April 2022, online.

Title: "Contribution of Tetraploid Wheat Genetic Resources to Enhance Wheat Sustainability". 90-100 participants. Some of the videos are available at VDM-Videos – Wheat initiative website. The presentations given were:

- Zvi Peleg (Hebrew University of Jerusalem, Israel): Stress-induced deeper rooting introgression enhances wheat yield under terminal drought.

- Elisabetta Mazzucotelli (CREA Research Centre for Genomics and Bioinformatics, Italy), Filippo Bassi (ICARDA, Morocco), Marco Maccaferri (University of Bologna, Italy) The international effort for GDP phenotyping: current situation and perspective.
- Matteo Dell'Acqua (Scuola Superiore Sant'Anna, Italy) Genomics-driven breeding for Ethiopian durum wheat is supported by local agrobiodiversity and farmers' traditional knowledge.
- Angelica Giancaspro (University of Bari, Italy) Tetraploid wheat genetic resources to enhance resistance against Fusarium head blight.
- Brande Wulff (KAUST, Saudi Arabia) Harnessing wild wheats for their disease resistance.
- Miguel Soriano (IRTA, Spain) Across the Mediterranean basin, a trip of 3000 years.
- Sarrah Ben M'Barek (Regional Field Crops Research Center of Beja, Tunisia) Exploiting Diversity to Achieve Sustainable Wheat Disease Management - case study of the durum wheat – Zymoseptoria tritici pathosystem.
- Pablo Roncallo (Centro de Recursos Naturales Renovables de la Zona Semiárida, Argentina) Allelic variability in a durum wheat collection for glutenin loci (Glu-1, Glu-2 and Glu-3) and its effect on quality attributes.
- Cristian Forestan, Marco Maccaferri (University of Bologna, Italy) Characterization of the Global durum and wild relative resources for root system architecture traits and transcriptome analysis to support candidate genes for Root Growth Angle.
- Valentyna Klymiuk (University of Saskatchewan, Canada) Discovery and identification of a partially dominant stripe rust resistance gene derived from tetraploid wheat wild relative.

# DURUM WHEAT GENOMICS AND BREEDING (DURUM EWG)



Meeting 2: 4th edition "From Seed to Pasta" conference (FSTP4) and EWG meeting. 26-29 October, 2022. A face-to-face meeting held in Bologna, Italy (<https://www.fromseedtopasta.com>).

The FSTP4 has reviewed the most recent advances in research-based innovations to release climate-proof, high-quality cultivars for a more sustainable durum grain production. More than 220 participants and more than 80 speakers (invited or selected from abstract) discussed the latest progress in genomics, breeding, sustainable production and milling of durum wheat and health issues related to the consumption of pasta and other durum-derived food. The congress was followed by an EWG meeting with 27 EWG members present.

## ACTIVITIES/ACHIEVEMENTS IN 2022

The EWG has been and still is instrumental in promoting an international network of expertise and resources capable to focus on large sequencing actions for durum wheat improvement. The first step has been the re-sequencing of the Svevo genome at "platinum quality level".

- The platinum quality assembly of the durum wheat reference cultivar Svevo has been completed through an approach based on PacBio HiFi and Optical map, thanks to the in-kind contribution of CORTEVA.
- In 2022, transcriptomic data derived from Illumina reads and ISOseq data based on ONT have been produced for more than 30 tissue/treatment combinations with the financial support of about 15 research groups.
- The assembly has been validated and detailed annotation based on transcriptomic data is in progress.
- Some partners of the EWG have a specific budget for sequencing of the wheat pangenome. The Italian (University of Bologna and CREA) and Canadian (University of Saskatchewan) research groups will sign an initial international agreement that can then be signed by others.

In Italy and in Canada, coordination is in progress to finalize the resources toward a single worldwide initiative for a high-quality sequence of the tetraploid wheat pangenome.

The Global Durum Panel (GDP), Mazzucotelli et al. (2020) and the Tetraploid wheat Global Collection (TGC), Maccaferri et al. (2019) represent two complementary global platforms for durum wheat diversity and their implementation represents one of the Hub Pilots of DivSeek. While the TGC is an effort of few labs, GDP is an internationally open initiative carried out in the frame of the EWG. The GDP is maintained at the ICARDA genebank and has been distributed worldwide.

- In 2021 and 2022, several research groups have phenotyped this panel, all using their own funding, for major phenological traits and disease resistances.
- In 2022, through the EWG network, a coordinated analysis of the data was carried out and the first manuscripts are ready for submission. Additional work on global data analysis is in progress.

Five members of the EWG (R Tuberosa, L Cattivelli, A Ceriotti, A Distelfeld, C Pozniak) are acting as co-editors of a book titled 'The Durum Wheat Genome' to be published by Springer. The book will include a series of chapters focusing on durum wheat sequencing and genomics and their applications to wheat breeding and will be mainly authored by members of the EWG. The publication of the book, initially setup for 2022, will, most likely be in 2023.

During the FSTP4 meeting in Bologna, several EWG members discussed with Martin Ganal (SGS SGS - Institut Fresenius, formerly Trait Genetics) the opportunity to include additional durum wheat specific SNPs in the new edition of the breeding SNP wheat array commercialized by SGS-Trait Genetics. During the EWG meeting, it was decided to select about 2,000 durum wheat SNPs to optimize the use of the 25k chip for durum wheat. Thanks to the collaboration of several EWG members, a list of about 2,000 durum wheat SNPs has been generated and submitted to SGS-Trait Genetics in January 2023.

# DURUM WHEAT GENOMICS AND BREEDING (DURUM EWG)



## 2023 PLAN

### Meetings:

- April 2023 (2 days), online, 5th Virtual Durum Meeting dedicated to “Durum wheat sustainability”. This meeting will be organized by the ECRs that have joined the Durum EWG.
- October 2023 face-to-face EWG meeting. The meeting will focus on “Fusarium head blight in durum wheat, status, challenges and possible ways forward”. The meeting should result on a position paper on FHB and durum wheat. During the event, the mentees selected during the mentorship program of the EWG will have the opportunity to meet their mentors.

## ACTIVITIES

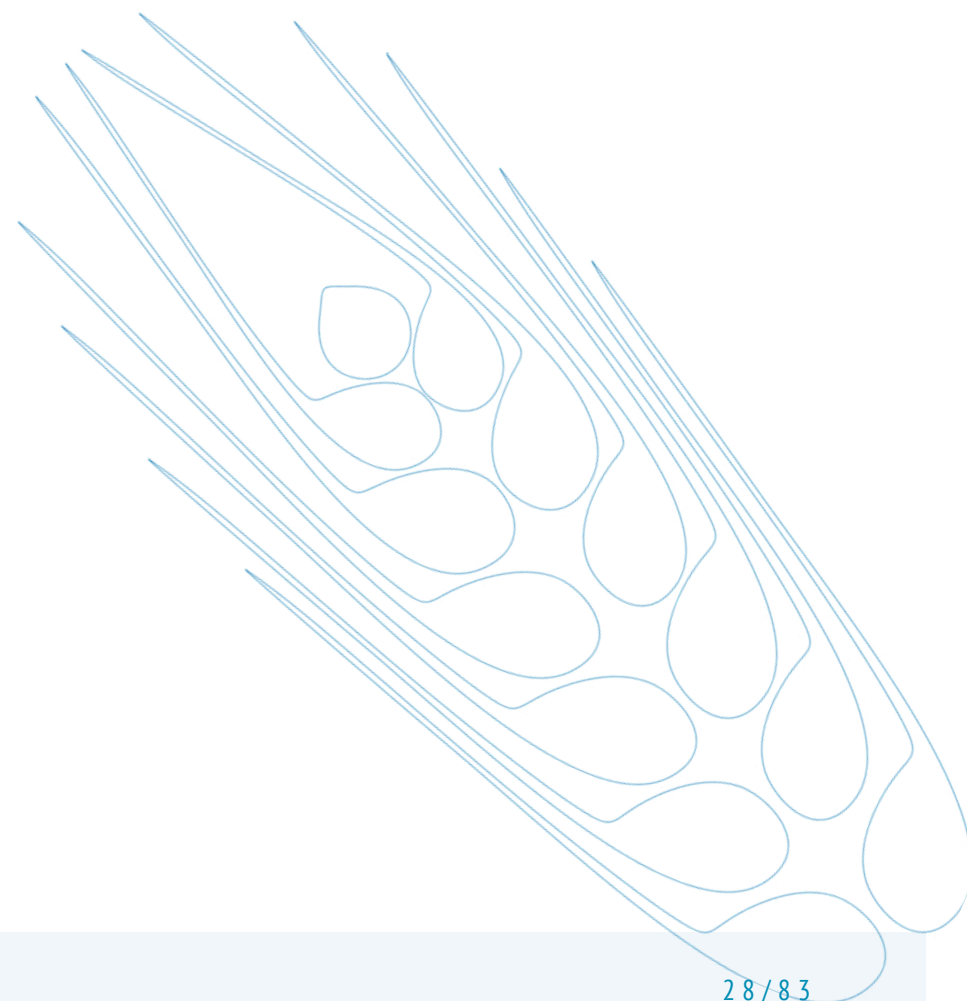
### In 2023, the following actions will be carried out:

- Complete annotation of the platinum quality sequence of the durum wheat reference cultivar Svevo with the collaboration of many EWG members.
- Expansion of the current partnership to implement the sequencing of the tetraploid wheat pangenome.

The fully annotated Platinum quality sequence of the durum wheat reference cultivar Svevo is expected to be released in 2023.

The EWG will further promote the GDP as a reference panel for durum wheat genomics and breeding. A specific action will be implemented to monitor and compile results of the ongoing GDP phenotyping activities and promote coordination/analyses of the data. The meeting planned for October 2023 will provide an opportunity to discuss the status of coordinated data analysis.

In 2023, the book ‘The Durum Wheat Genome’ should be published by Springer. The EWG will develop a Mentorship program dedicated to 4-6 young scientists (PhDs or early post docs) from poorly resourced research programs, offering them the possibility of having a mentor in an advanced research group.



# GLOBAL WHEAT GERMPLASM CONSERVATION AND USE COMMUNITY (GERMPLASM EWG)



**53 members from 25 countries**

**Chair: Benjamin Kilian (Germany)**

**Co-Chairs: Shivali Sharma (India), Peter Civaň (France), Hakan Özkan (Türkiye)**

**SB Liaisons: Hans Braun and Hisashi Tsujimoto**

## AIMS

- Our mission is to serve the wheat genetic resources community and act as a discussion platform and information hub. In this central role, we aim to connect genebanks, breeders, researchers, farmers and all other stakeholders interested in wheat improvement.
- The Germplasm EWG fosters connections among stakeholders through shared learning with the goal of advancing the conservation and use of wheat genetic resources.
- It facilitates communication between holders and users of wheat germplasm collections, identifies current challenges, supports the development and implementation of solutions, and provides direction to the wheat community.
- A major goal of the Germplasm EWG is to provide guidance on a use-based conservation strategy that serves the needs of all Expert Working Groups of the Wheat Initiative and is based on the latest research and regulatory policies.

## 2022 MEETINGS

15 June 2022, online, EWG Germplasm Group Meeting, 19 participants.

## ACTIVITIES/ACHIEVEMENTS IN 2022

The Germplasm EWG chair and co-chairs held monthly meetings where all activities of the EWG were planned and discussed. These discussions linked to the EWG members' meeting in June 2022 and identified several action points that are either currently in the process of planning and/or implementation.

Building on earlier discussions between Tom Paine, Ahmed Amri and the WI, we resumed discussions with EWG Germplasm members, key stakeholders and experts, and the Wheat Initiative Secretariat to develop a proposal to update the Global Wheat Conservation Strategy. The proposal, including workplan and budget, was submitted to the Wheat Initiative Secretariat in August, and after receiving positive feedback, a revised proposal was submitted. The proposal was discussed at the Jamboree meeting in Carlow, Ireland, and at several virtual and in-person meetings. At the end of 2022, the proposal was under consideration by the WI Scientific Board and funding has been allocated for 2023.

The EWG co-chair Shivali Sharma participated in a series of meetings on incorporating Global Crop Conservation Strategies into the support mechanisms of the International Treaty on Plant Genetic Resources for Food and Agriculture. This led to an opinion paper by Ehsan Dullo and Colin K. Khoury on this subject: <https://zenodo.org/record/7610356#.ZCvONnZByUl>

# GLOBAL WHEAT GERMPLASM CONSERVATION AND USE COMMUNITY (GERMPLASM EWG)



Listed below are some selected wheat papers/chapters by the Germplasm EWG members:

- Shaw PD, Wiese S, Obreza M, et al. (2022) Database solutions for Genebanks and Germplasm Collections, Book Chapter, Plant Genetic Resources for the 21st Century, Apple Academic Press, Chapter 16, pp 285-309  
<https://doi.org/10.1201/9781003302957-19>
- Neumann K, Schulthess AW, Bassi FM, et al. (2022) Genomic approaches to using diversity for the adaptation of modern varieties of wheat and barley to climate change, Book Chapter, Plant Genetic Resources for the 21st Century, Apple Academic Press, pp 47-78 <https://doi.org/10.1201/9781003302957-7>
- Langridge P, Alaux M, Almeida NF, et al (2022) Meeting the challenges facing wheat production: the Strategic Research Agenda of the global Wheat Initiative, *Agronomy* 12 (11:2767)  
<https://doi.org/10.3390/agronomy12112767>
- Lehnert H, Berner T, Lang D, et al (2022) Insight into breeding history, hotspot regions of selection and untapped allelic diversity for bread wheat breeding, *Plant J. Vol 112 Issue 4* pp 897-918  
<https://doi.org/10.1111/tbj.15952>
- Eastwood R, Tumbam B, Aboagye LM, et al (2022) Adapting Agriculture to Climate Change: A Synopsis of Coordinated National Crop Wild Relative Seed Collecting Programs across Five Continents (2022), *Plants*. 11 (14) 1840  
<https://doi.org/10.3390/plants11141840>
- Hussan B, Akpınar B, Alaux M, et al (2022) Capturing Wheat Phenotypes at the Genome Level, *Front. Plant Sc.*2022 Vol 13-2022  
<https://doi.org/10.3389/fpls.2022.851079>
- Keilwagen J, Lehnert H, Berner T et al (2022) Detecting major introgressions in wheat and their putative origins using coverage analysis, *Sci. Rep* 12, 1908  
<https://doi.org/10.1038/s41598-022-05865-w>

## 2023 PLAN

There is an online EWG meeting planned for March.

As described previously, several action points are either currently in the process of planning and/or implementation to:

- Actively seek membership of farmers, who potentially can provide useful information on wheat genetic resources.
- Conduct a mini-survey among the EWG members on the current views on the problem of germplasm duplicates. Current trends in collection-wide genomic and phenotypic characterization have the potential to revive calls for the optimization of germplasm collections through the identification and removal of duplicated samples via genotyping, which offers a growing number of technological options at decreasing costs. The EWG is studying this issue and considering opening an expert debate by co-editing a special issue in an appropriate journal.
- Have uniform guidelines for the in situ conservation of crop wild relatives.
- Increase the visibility of the WI and the Germplasm EWG through interactions with the International Wheat Sequencing Consortium community.

In December 2022, during discussions between the Germplasm EWG co-chairs, the Wheat Initiative Secretariat and Scientific Advisory Board liaisons and other experts, it was agreed that instead of updating the Global Wheat Conservation Strategy, published in 2007 (and adding a use component), the goal is to develop a use-based conservation strategy/opinion paper that meets the needs of all the EWGs and is based on the latest research and regulatory framework.

# IMPROVING WHEAT QUALITY FOR PROCESSING AND HEALTH (QUALITY EWG)



**65 members from 26 countries**

**Chair: Tatsuya Ikeda (Japan)**

**Co-Chair: Carlos Guzman (Spain)**

**SB Liaisons: Hisashi Tsujimoto and John Snape**

## AIMS

The Quality EWG aims to maintain and improve wheat quality under varying environmental conditions. The group focuses on wheat quality in the broad sense, including seed proteins, allergens, carbohydrates, nutrition quality including micronutrients, grain processing, food safety, genetic resources and gene nomenclature. The group shares genetic resources and unifies gene nomenclature related to grain quality.

The Quality EWG plays a vital role to advance the research area of grain quality and apply scientific knowledge to develop improved varieties of wheat with desirable grain quality attributes. The EWG builds on existing basic and applied knowledge and expertise, while utilising outputs of other international initiatives, wheat research organizations and other EWGs. The EWG also includes some of the leading experts available worldwide in different aspects of wheat quality, and also links to other international groups that focus on a wide range of grain end-use requirements, adaptability and sustainable wheat production.

## ACTIVITIES/ACHIEVEMENTS IN 2022

The Quality EWG has been working on a new survey on how wheat quality testing and classification is done around the world. Almost every country has a different official system to classify wheat grain in different grades/classes/groups. These systems are based on analyzing different grain/flour characteristics with different devices or methods. The aim is to compile all those rules and develop a document (maybe a book chapter or review paper) that could be useful for all the community

to understand better the wheat value chains from other countries. Classification methods have already been collected from eight countries. Our members collaborated with the WheatIS EWG to update guidelines for gene nomenclature in wheat. The outcome has recently been published in Theoretical and Applied Genetics (<https://doi.org/10.1007/s00122-023-04253-w>).

## 2023 PLAN

Meeting 1: June, face-to-face, Annual EWG meeting

In 2023, the Quality EWG plans to continue working on the survey to compare wheat quality testing and classification around the world.

Various factors are involved in wheat end-use quality. Besides protein contents, genotypes related to gluten viscoelasticity (Glu-1/Glu-3), starch viscosity (Wx-1), damaged starch content (grain hardness, Pina-D1/Pinb-D1) and dough discoloration (PPO activity, Ppo-1) are critical attributes determining various end-use quality. Our aim is to clarify breeding targets for end-uses that could be useful for all the community to accelerate the development of high-quality wheat cultivars. Ideotypes for each end-use will be discussed among members.

There will be discussions about whole wheat in view of flour/end-use quality and safety among the EWG members, with a view to summarizing the EWG strategies for whole wheat quality and safety. Possibilities for collaboration with the Health Grain Forum and the Whole Grain Initiative will also be discussed.

The methods to examine grain quality traits have differed between laboratories. We will share our methods and standardize them to facilitate the comparison of quality data among laboratories.

The EWG will re-connect the network of grain quality scientists by organizing the XIV International Gluten Workshop in Spain, which will cover various topics related to wheat quality and safety.

# NUTRIENT USE EFFICIENCY (NUE EWG)



**33 members from 13 countries**

**Chair: Jean-Pierre Cohan (France)**

**Co-Chairs: Jairo Palta-Paz (Australia), Ivan Ortiz-Monasterio (Mexico)**

**SB Liaisons: Alison Bentley and John Snape**

## AIMS

The main aim of the NUE EWG is to contribute to the improvement of the Nutrient Use Efficiency of wheat (bread and durum wheat):

- For grain yield and grain quality (grain protein concentration, but also other nutritional parameters, such as baking parameters).
- By understanding more precisely the physiological pathways determining NUE.
- By understanding and exploiting the genetics of processes that result in improved NUE.
- By addressing the interactions with agronomic practices (including crop management).

To achieve these goals, the NUE EWG plans to produce the following deliverables:

- Provide an international space for experts to exchange information leading to improve wheat NUE.
- Initiate new collaborative research projects.
- Publish original scientific papers.
- Build and share datasets in support of ideas for new projects and scientific papers.

## 2022 MEETINGS

- Meeting 1: 16 March, online, new chairs team meeting, 6 participants.
- Meeting 2: 29 April, online, chairs team transfer of information, 6 participants.

## MAJOR SCIENTIFIC DEVELOPMENTS IN 2022

In Europe, 2022 has seen the emergence of major concerns about the economic and environmental sustainability of crop fertilisation and, consequently, the continuous need to improve the NUE of all crops, including wheat. Announced in 2020, the “Farm to fork” strategy of the EC “Green deal” has an ambitious objective of reducing the use of fertiliser by 20%. Also, the consequence of this plan on European production is still being discussed, Beckman et al. (2020), Barreiro-Hurle et al. (2021). The “Farm to fork” strategy will be manageable only if serious progress is made on improving NUE. In parallel, the acceleration of the impact of climate change quoted by the last IPCC report (IPCC AR6 SYR) must push research programmes to formulate a fertiliser strategy with less greenhouse gas emissions (GES). Finally, multiple factors due to the international situation, have provoked a rise in fertiliser prices as well as in crop prices. That could jeopardise the long-term economic sustainability of farms if the crop prices drop before the fertiliser prices.

In Australia, recent increases in payments for grain protein in wheat have made decisions on the use of nitrogen fertiliser more critical to profits. In some regions, the protein benefits from nitrogen fertiliser does not fully compensate for the cost of the fertiliser inputs. An alternative option is to improve the utilisation by the wheat crop of the nitrogen fertiliser applied by using genotypes with higher uptake and greater remobilisation of stored nitrogen to the grain. Wheat growers are seeking information on the management of grain protein and are keen to adopt genotypes with the ability to utilise the nitrogen fertiliser more efficiently.



# NUTRIENT USE EFFICIENCY (NUE EWG)



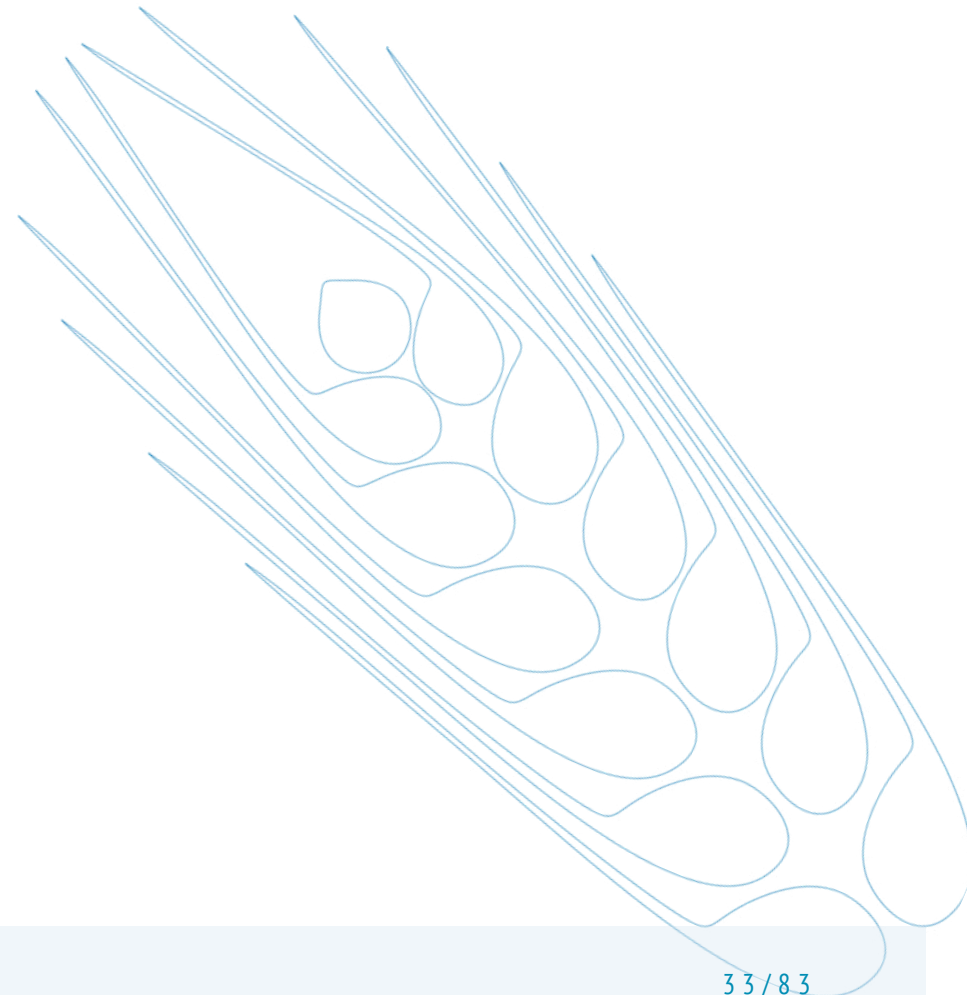
## 2023 PLAN

- May/June or September/October, face-to-face, annual EWG meeting
- November/December, remote EWG meeting

The spring/autumn annual meeting will be set up as a workshop dedicated to 2 main issues:

- Defining the work plan of the NUE group for the next 2 years
- Sharing one or two arising scientific issues that could be addressed by the group

Depending on the content of the annual meeting, an opinion paper on the main challenges of wheat NUE could be proposed before the end of the year.



# WHEAT AGRONOMY (AGRONOMY EWG)



**25 members from 9 countries**

**Chair: Brian Beres (Canada)**

**Co-Chair: John Kirkegaard (Australia)**

**SB Liaisons: Hans Braun and Peter Langridge**

## AIMS

The main aim of the Agronomy EWG is to consolidate the global expertise for agronomy with a focus on wheat production systems. The overarching approach is to develop and adopt a 'systems agronomy framework' relevant to any wheat production system. Such an approach first establishes the scale of current yield gaps identifying physiologically defensible benchmarks, and then takes a holistic approach to understand and overcome exploitable yield gaps.

Finally, new opportunities to drive increased productivity will be sought by capturing future Genotype X Environment X Management (GxE<sub>M</sub>) synergies identified in different systems. The Agronomy EWG will then be able to influence priorities for wheat agronomy research in member countries that would facilitate collaborations, minimise duplication and maximise the likely global impact on wheat production systems.

## 2022 MEETINGS

Meeting: 6-9 November 2022, face-to-face, ASA-Wheat Initiative Agronomists Community Symposia, Baltimore, USA.

The meeting included a symposium and a student competition, which included posters and 5 minute oral presentations. The incoming community leader (chair) for 2023 is Alison Bentley, an EWG and SB member.

## ACTIVITIES/ACHIEVEMENTS IN 2022

In 2022, the Agronomy EWG liaised with the WI Secretariat to develop updates and revisions as needed to Core Theme 3 (Protect the environment and increase the sustainability of wheat production systems) and supported the re-launch of the Strategic Research Agenda. There remains strong interest from regional and national stakeholders in member countries to align wheat research priorities to the SRA. The re-launch of the SRA was presented at the 3rd International Wheat Congress in Beijing, China in November and published in *Agronomy: Langridge P, Alaux M, Aldmeida NF, et al. (2022) Meeting the Challenges Facing Wheat Production: the Strategic Research Agenda of the Global Wheat Initiative. Agronomy 12(11), 2767; <https://doi.org/10.3390/agronomy12112767>*. The EWG worked with the WI Secretariat and Scientific Board to discuss the role of the Agronomy EWG aims within the framework of the SRA. This activity will be revisited in 2023.

## 2023 PLAN

Meeting: 29 October – 4 November, ASA Wheat Initiative Agronomists Community Symposia.

In 2023, the EWG plans to explore synergies with CGIAR Excellence in Agronomy as a pathway toward enhancement of developing regions where wheat is an important staple crop. Currently, Agronomy membership lacks participation from these regions, yet smallholder farming systems would greatly benefit from the expertise of the Agronomy EWG.

The EWG plans to liaise with the WI Secretariat to discuss the future of the Agronomy EWG. An output or deliverable should centre on an agreement for a roadmap that reinvigorates the Agronomy EWG and engages with both membership and the ASA Wheat Agronomists Community.

# WHEAT INFORMATION SYSTEM (WHEATIS EWG)



**12 members from 6 countries**

**Chair: Taner Sen (USA)**

**Co-Chairs: Hadi Quesneville (France), Mario Caccamo (UK) and Dave Edwards (Australia)**

**SB Liaisons: Alison Bentley and Sylvie Cloutier**

## **AIMS**

Build an International Wheat Information System to support the wheat research community. The main objective is to provide a single-access web-based system to access the available data resources and bioinformatics tools.

## **2022 MEETINGS**

- Meeting 1: 13 October 2022, online, interim EWG meeting, 6 participants.
- Meeting 2: 13 January 2023, hybrid, annual EWG meeting at PAG, 27 participants.

## **ACTIVITIES/ACHIEVEMENTS IN 2022**

Development of a new version of the WheatIS Data Discovery tool

<https://urgi.versailles.inrae.fr/wheatis/>:

The new version includes:

- Same URL and functionalities.
- Interface update using WheatIS logo and colours.
- Codebase unified between WheatIS Data Discovery and FAIDARE (developed in the frame of ELIXIR).
- Ease management of data sources, development and maintenance.
- Automatic addition of BrAPI sources.
- Perspectives: some FAIDARE functionalities should be easily implemented in WheatIS Data Discovery.

## **2023 PLAN**

- Meeting 1: June, interim EWG meeting, online.
- Meeting 2: January 2024, annual EWG meeting, hybrid at PAG.

In 2023, the WheatIS EWG plans to update the metadata indexed by the WheatIS Data Discovery tool, update the WheatIS website, be more active on Twitter and advertise the new version of the WheatIS Data Discovery tool. It is also planned to find new members for the EWG, rotate a co-chair and hold a workshop on adopting the gene nomenclature as a follow-up of the upcoming publication.

# WHEAT PHENOTYPING TO SUPPORT WHEAT IMPROVEMENT (PHENOTYPING EWG)



**55 members from 20 countries**

**Chair: Bettina Berger (Australia) (until September)**

**Kerstin Neumann (Germany), Nicola Pecchioni (Italy) (since October)**

**Co-Chairs: José-Luis Araus (Spain), Ulrich Schurr (Germany) (until September)**

**SB Liaisons: Silvia German and Fiona Doohan**

## AIMS

The Phenotyping EWG aims to strengthen and support wheat phenomics research, promote international collaborations and the exchange of expertise in wheat phenotyping, enhance the integration of wheat phenotyping into breeding and genomics programs and engage experts from non-plant disciplines in wheat phenotyping (eg computer vision, software engineering, bioinformatics).

## 2022 MEETINGS

- Meeting 1: 27 September, online, hand-over to new EWG chairs.
- Meeting 2: 17 October, the WI Jamboree, Carlow, Ireland and online.
- Meeting 3: 25 November, online, organizational meeting between chairs and SB liaisons.
- Meeting 4: 9 and 14 December, online, organizational meeting between chairs.

## ACTIVITIES/ACHIEVEMENTS IN 2022

A 10-day plant phenotyping workshop for scientists and assistant professors organised by Jagadish Rane (EWG member) was held at ICAR-NIASM, Pune, India for approximately 25 participants. The presenters included other EWG members. There was an IPPN organised Webinar series with video recordings online (<https://www.plant-phenotyping.org/index.php?index=877>). The webinars had about 25 people attend live and some had over 1000 views on YouTube after being published online.

The Phenotyping EWG had interactions with other EWGs, eg during the Jamboree, and the wider phenotyping community through IPPN and the 7th IPPS in Wageningen, Netherlands.

There has also been the recruitment of new ECR (Early Career Researcher) members and the publication of high-impact research papers by EWG members (see below).

## MAJOR SCIENTIFIC DEVELOPMENTS IN 2022

Both controlled environment and field phenotyping is becoming more widely used in wheat research and several examples show the application of novel phenotyping approaches in forward genetics screens to identify the genetic basis of complex traits, such as photosynthesis, Sales et al. (2022); Robles-Zazueta et al. (2022), drought tolerance, Lauterberg et al. (2022) or lodging, Dreccer et al. (2022).

In addition, the 7th IPPS in Wageningen highlighted a trend towards field phenotyping and the focus on trait measurements, instead of simple correlation between phenotypic measurements and traditionally measured traits. The increasing trend of machine learning and the use of AI has become apparent and promises novel approaches to data analysis, provided high-quality data is available to train algorithms.

Articles:

- Sales CRG, Molero G, Evans JR, et al. (2022) Phenotypic variation in photosynthetic traits in wheat grown under field versus glasshouse conditions. *J. Exp. Bot.* Vol 73 (10) 3221–3237, <https://doi.org/10.1093/jxb/erac096>.
- Robles-Zazueta CAM, Pinto F, Molero G, et al. (2022) Prediction of Photosynthetic, Biophysical, and Biochemical Traits in Wheat Canopies to Reduce the Phenotyping Bottleneck. *Front. Plant Sc. Sec. Plant Physiology.* Vol 13: 2022 <https://doi.org/10.3389/fpls.2022.828451>.

# WHEAT PHENOTYPING TO SUPPORT WHEAT IMPROVEMENT (PHENOTYPING EWG)

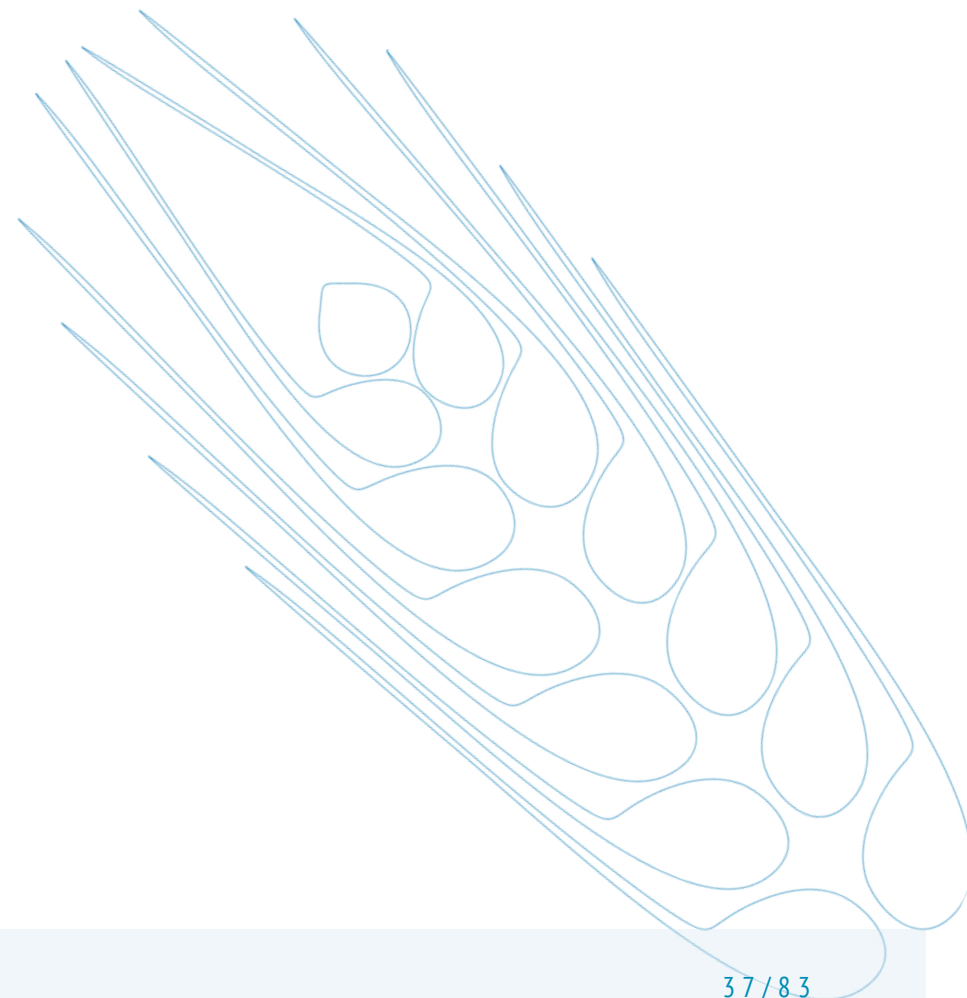


- Lauterberg M, Saranga Y, Deblieck M, et al. (2022) Precision phenotyping across the life cycle to validate and decipher drought-adaptive QTLs of wild emmer wheat (*Triticum turgidum* ssp. *dicoccoides*) introduced into elite wheat varieties. *Front. Plant Sc. Sec. Plant Systems and synthetic biology*. Vol 13: 2022 <https://doi.org/10.3389/fpls.2022.965287>.
- Silva P, Evers B, Kieffaber A, et al. (2022) Applied phenomics and genomics for improving barley yellow dwarf resistance in winter wheat. *G3-Genes, Genom Genet*. Vol 12: Issue 7. Jkac064. <https://doi.org/10.1093/g3journal/jkac064>.
- Dreccer F, Macdonald B, Farnsworth CA, et al. (2022) Multi-donor × elite-based populations reveal QTL for low-lodging wheat. *Theor. Appl. Genet.* 135, 1685–1703. <https://doi.org/10.1007/s00122-022-04063-6>.

## 2023 PLAN

- Meeting 1: May, CREA Foggia, Italy, Training workshop for Italian, European, and MENA/Türkiye breeders (but open to all countries) on digital field phenotyping for breeding. There will be a combination of theory and hands-on-training field phenotyping.
- Meeting 2: November 6-9, Wernigerode, Germany, at the CBB7, Seventh International Conference of Cereal Biotechnology and Breeding, half day face-to-face annual EWG Meeting.
- Meeting 3: Monthly, online meetings of the co-chairs, together with Liaisons, for organizational purposes.

The Phenotyping EWG plans to have a small number of seminar days, with a couple of seminars each day, where an early career researcher together with a senior scientist shares their experiences of plant phenotyping, with the possibility of discussion and sharing of problems/solutions/advancements. There will be an open access publication grant awarded to one of the EWG members, the manuscript applications will be reviewed by the co-chairs and winner will be communicated to the community at the EWG annual meeting.



# FUNDING EXPERT WORKING GROUP (FEWG)



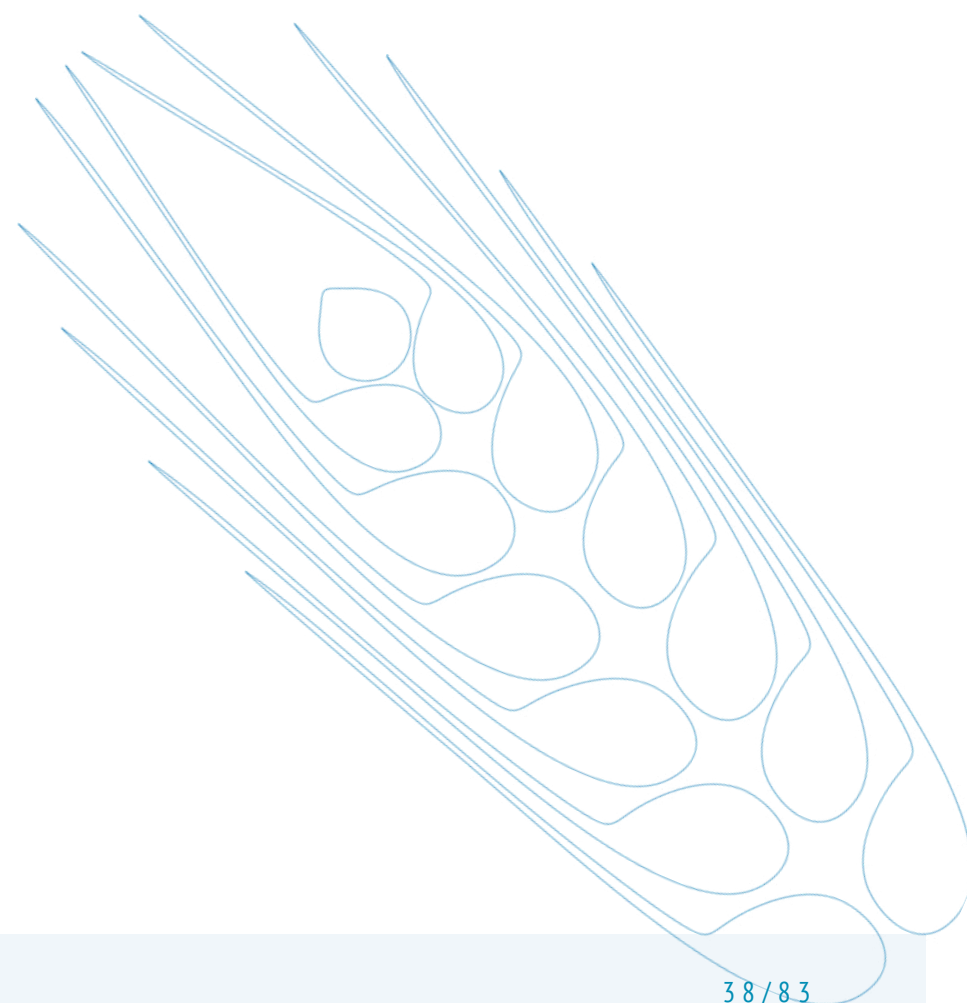
**9 Members from 7 countries**  
**Chair: Tim Willis (UK)**

## **AIMS**

The FEWG aims to identify and disseminate information on funding mechanisms and tools available to support multi and bilateral international collaboration in wheat research, for the benefit of the WI's EWGs. The EWG aims to enable dialogue and coordination at a funder-to-funder level with an aim to explore priorities and opportunities for alignment of funding under broad wheat research themes.

## **EWG COMMENTS FOR 2022**

Funders of research are continuing to re-establish their connections and to strengthen their links now that COVID-19 restrictions have eased in many countries. For example, the FEWG held a hybrid meeting during the Wheat Initiative Jamboree in October 2022 which welcomed the new Institutions Coordination Committee (ICC) representative from the Republic of Korea. The group continues to support research programmes which had been delayed or were in need for further funding due to the pandemic. In addition, an immediate priority for the group is assessing the impact of the conflict in Ukraine on research programmes. Going forward, the group will continue to work in alignment with the Wheat Initiative Strategic Research Agenda launched in July 2022, with particular attention to the knowledge exchange and inclusion of Early Career Researchers into the programmes.

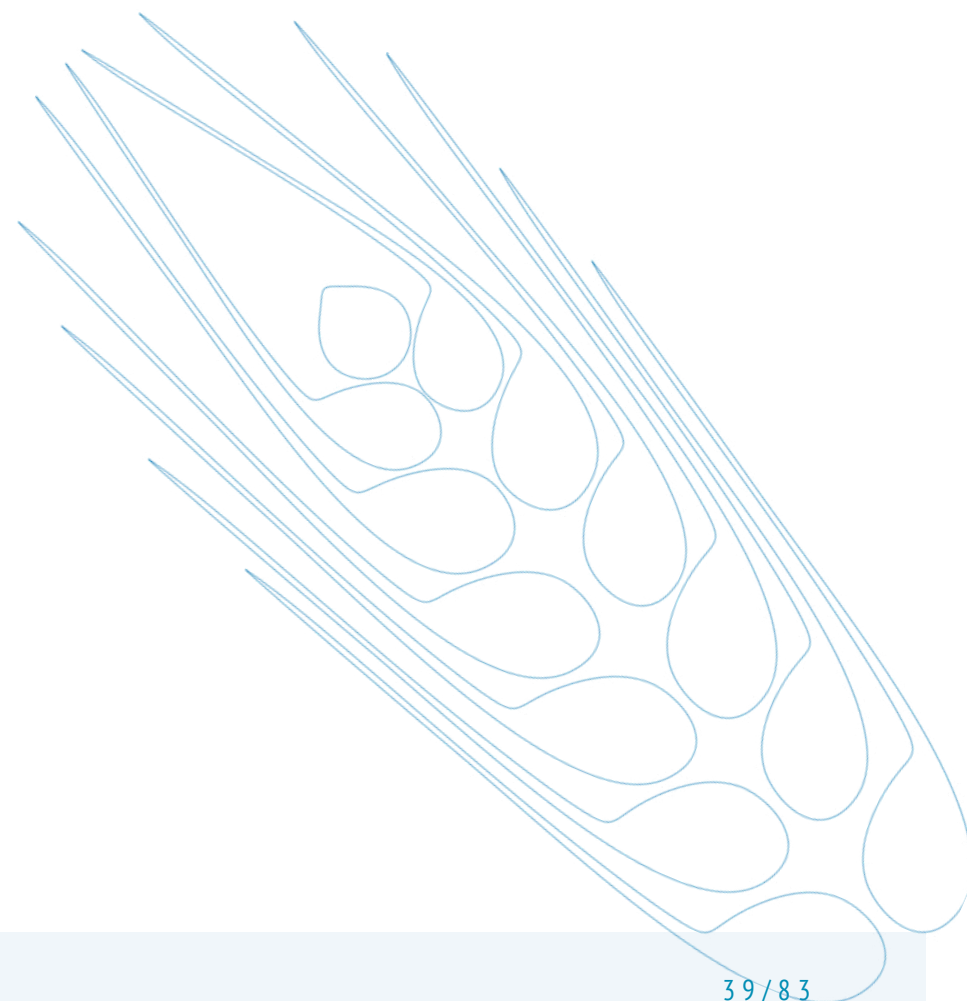


# REPORTS AND HIGHLIGHTS 2022



## OUR MEMBER COUNTRIES

<u>AUSTRALIA</u>	<u>CANADA</u>	<u>CHINA</u>	<u>FRANCE</u>
<u>GERMANY</u>	<u>IRELAND</u>	<u>ITALY</u>	<u>JAPAN</u>
<u>MOROCCO</u>	<u>REPUBLIC OF KOREA</u>	<u>TÜRKIYE</u>	<u>UNITED KINGDOM</u>
<u>URUGUAY</u>	<u>UNITED STATES OF AMERICA</u>		



# AUSTRALIA (GRDC)



## 1. WHEAT PRODUCTION (AREA, AMOUNT, AND AVERAGE YIELD) AND MAJOR PRODUCTIONS ISSUES (DROUGHTS, FLOODS, HEATWAVES, ETC.)

Australia's wheat production reached another new record production in the 2022 season, with an estimated 39.2 Mt produced. Average yields were 3.0 tonnes per hectare (t/ha). This was despite widespread spring flooding on the east coast with an estimated 8.1% and 2.9% of cropping land affected in NSW and Victoria, respectively. The record high yields in the south and west did result in a dilution of grain protein, but generally quality was better than expected given the wet conditions.

## 2. SIGNIFICANT NEW NATIONAL/INTERNATIONAL ENGAGEMENT OR PARTNERSHIPS

Australian wheat breeding company, AGT, has partnered with Arista Cereal Technologies to release a new high amylose wheat variety for Australian production, called HAW1. This variety, developed through traditional breeding, has higher levels of resistant starch, resulting in better gut health for consumers. The technology behind this trait was developed in a partnership between CSIRO, Limagrain and GRDC. A new classification has been developed by Grains Australia Ltd, the Australian Innovation Wheat (AIW) class to support the release of varieties with unique end use properties such as the high amylose wheat.

The University of Queensland has entered a \$15 million partnership with the German Research Foundation to accelerate genetic improvement in cereal and pulse crops. The International Research Training Group will involve researchers and students from the Justus Liebig University, Julius Kühn Institute and Geisenheim University.

## 3. RESEARCH HIGHLIGHTS

Dr Zhigan Zhao and colleagues at CSIRO found that long coleoptile wheats were expected to increase national Australian wheat yields by 18-20% when combined with deep sowings, based on field validated crop simulations, Zhao et al. (2022). Novel sources of genetic resistance to tan spot were identified using one step GWAS and genomic prediction models which account for additive and non-additive genetic variation. This work was undertaken by Dr Julian Taylor at the University of Adelaide in collaboration with Manisha Shankar at DPIRD and others, Taylor et al. (2023).

## 4. WHEAT RESEARCH FUNDING AND NEW RESEARCH PROGRAMMES

The Australian Research Council has awarded a Centre of Excellence in Plants for Space, led by Prof. Matthew Gilliham at the University of Adelaide. The \$90 million 7-year centre aims to create on-demand, zero-waste, high-efficiency plants and plant products to address sustainability for Space and on Earth. The international collaborative includes 15 academic space agencies and enablers, five controlled environment agricultural companies and seven government and technology partners.

GRDC is investing in taking the development of long coleoptile wheats to the next stage of integration in the farming system. Long coleoptile wheat allows growers to sow into deep sub-soil moisture to ensure timely establishment of the crop in an increasingly variable climate. This \$12.7 million national research project will be led by Dr Greg Rebetzke at CSIRO and involve the development of regionally specific agronomic practices to maximise the benefit of long coleoptile wheats for growers. GRDC and CSIRO have co-invested in the development of long coleoptile wheats for over 10 years, using a range of international sources of genetic diversity.



## AUSTRALIA (GRDC)



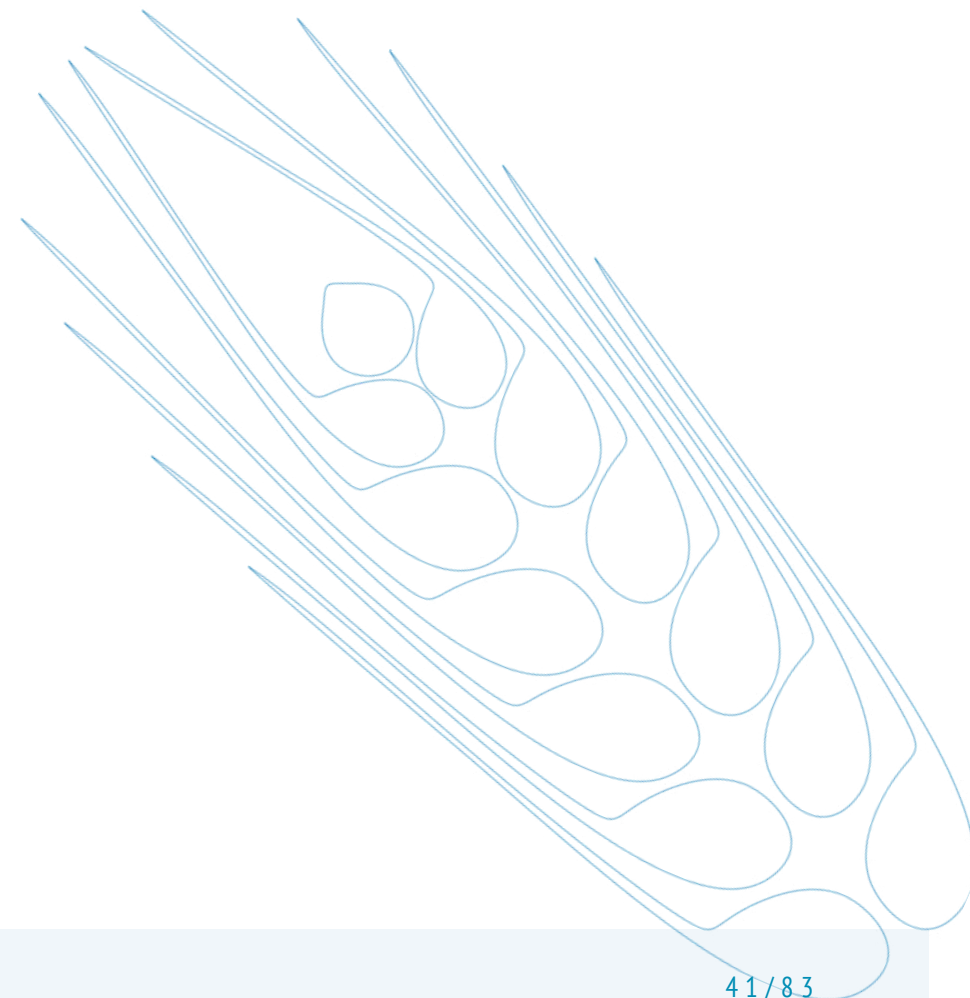
GRDC has also partnered with University of Sydney and Intergrain in a \$10.2 million co-investment to improve the heat tolerance of wheat during grain filling. Under Australian conditions, heat stress has been modelled to result in an average 14% yield loss. The collaboration, which also involves Agriculture Victoria and DPIRD, will use wide diversity and genomic selection to improve the tolerance of Australian wheats to high temperature.

The Australian Centre for International Agricultural Research (ACIAR) has funded a proof-of-concept project to accelerate genetic gain through hybrid breeding in Bangladesh, Ethiopia and Pakistan. The \$1.9 million project will be led by Prof Richard Trethowan at University of Sydney. The project aims to validate the use of a novel, cost effective system for rapidly producing large numbers of wheat hybrid combinations, as well as undertake a feasibility study of introducing hybrid wheat industries in the collaborating countries.

### References

Taylor J, Jorgensen D, Moffat CS et al. (2023) An international wheat diversity panel reveals novel sources of genetic resistance to tan spot in Australia. *Theor Appl Genet.* 136: 61. doi.org/10.1007/s00122-023-04332-y.

Zhao Z, Wang E, Kirkegaard JA et al. (2022) Novel wheat varieties facilitate deep sowing to beat the heat of changing climates. *Nat. Clim. Chang.* 12: 291–296. doi.org/10.1038/s41558-022-01305-9.



# CANADA (AAFC)



## 1. WHEAT PRODUCTION (AREA, AMOUNT, AND AVERAGE YIELD) AND MAJOR PRODUCTIONS ISSUES (DROUGHTS, FLOODS, HEATWAVES, ETC.)

Canadian farmers reported both higher yield and growth area of wheat in 2022 compared with 2021, as better growing conditions across much of western Canada positively impacted all major wheat classes for the crop year.

In 2022, total wheat production in Canada rose up to 33.8 Mt, the highest production since 2020 and the third highest production on record, largely attributable to higher production on the Prairies.

The largest impacts on wheat yields of Canada in 2022 were drought, gophers, grasshoppers, wind and spring flooding across the major wheat growing area. In western Canada, the largest contributors to downgrading were light kernel weights due to drought, insect damage, grain bleaching or discolouring from rain, and an increase in diseases such as ergot in cereal crops and spring wheat and durum.

## 2. SIGNIFICANT NEW NATIONAL/INTERNATIONAL ENGAGEMENT OR PARTNERSHIPS

Every year, Canada exports wheat to more than 70 countries. In 2022, Agriculture and Agri-Food Canada (AAFC) established multiple research collaborations with research facilities from UK, Australia, US, Mexico, Brazil, Germany and China; and new collaborations with various universities and research providers nationally. The New Wheat Crop Report from Cereal Canada was shared with researchers and producers from over 15 countries in Asia, Latin America, Europe, Africa, and the Middle East.

## 3. RESEARCH HIGHLIGHTS

AAFC has registered new wheat varieties in 2022 including “AAC Antler” which is remarkable for its improved resistance to fusarium head blight (FHB).

The following awards were presented:

- Dr Ron Knox of Swift Current Research & Development Centre (RDC) received the 2023 Plant Breeding and Genetics Award co-sponsored by Seeds Canada and Germination magazine for his outstanding contribution to wheat research.
- AAFC’s spring wheat variety, AC Foremost, was the recipient of the 2023 Seed of the Year Award, which is part of the Canadian Plant Breeding Innovation (CPBI) Awards.
- A team of AAFC researchers was awarded the Borlaug Global Rust Initiative (BGRI) Gene Stewardship Award for their outstanding innovations and strategies to combat wheat rust in Canada and around the world.
- Dr Jatinder Sangha of the Swift Current RDC, won third prize for the best abiotic stress/phenotyping video competition held by the International Wheat Initiative Expert Working Groups.

## 4. WHEAT RESEARCH FUNDING AND NEW RESEARCH PROGRAMMES

The Sustainable Canadian Agricultural Partnership is a new five-year agreement between federal and regional governments to better position Canada as a world leader in sustainable agriculture. It will provide strong support for science to address challenges and seize opportunities for Canadian agriculture.

Genome Canada announced the Interdisciplinary Challenge Teams funding call to provide genomic solutions for agriculture and food production systems. Wheat research has been proposed under these programs.

Western producer wheat commissions continue to fund wheat research individually and through the Canadian Wheat Research Coalition, in addition to provincial government programs such as the Saskatchewan Agriculture Development Fund (ADF).

# CHINA (CAAS)



## 1. WHEAT PRODUCTION (AREA, AMOUNT, AND AVERAGE YIELD) AND MAJOR PRODUCTIONS ISSUES (DROUGHTS, FLOODS, HEATWAVES, ETC.)

China experienced an unexpectedly good harvest in the 2022 season, with a wheat area of 23.5 Mha, production of 137.7 Mt, and an average yield of 5.856 t/ha. The sowing date was delayed around one month in 2021 in major wheat areas largely due to waterlogging. Factors which attributed to the high productivity, in particular high yield, were good rain, limited occurrence of diseases and positive government policy. Very high-test weight and little sprouting were recorded, accompanied by average processing quality. Around 10 Mt of wheat was imported from the international market including Australia, Canada, France, and the USA.

## 2. SIGNIFICANT NEW NATIONAL/INTERNATIONAL ENGAGEMENT OR PARTNERSHIPS

The China-Pakistan Joint Wheat Molecular Breeding Laboratory was funded to strengthen the collaboration between the Chinese Academy of Agricultural Science, Quaid-i-Azam University and National Agricultural Research Centre of Pakistan and CIMMYT. It will focus on joint research on molecular marker development, application in breeding and testing Chinese germplasm for yellow rust resistance, and training Pakistani scientists.

## 3. RESEARCH HIGHLIGHTS

The pathogen-sensitive genes, PsIPK1 and Mlo1 were knocked-out by gene editing, wheat lines with wide resistance to yellow rust and powdery mildew races without penalty on yield were obtained by two teams (Cell, 185:2961 doi.org/10.1007/s44154-022-00060-3 and Nature 602:455, doi.org/10.1038/s41586-022-04395-9) in 2022. Knocking out MLO-B1 usually lead to a yield penalty, but a 304Kb deletion upstream of MLO-B1 changed the chromatin structure and led to expression increase, balancing the negative effect. The Rht8 gene was isolated by two teams independently (Mol Plant, 2022, doi.org/10.1016/j.molp.2022.01.013). Chinese scientists also found HST1-like gene controlling tiller angle by regulating endogenous auxin in wheat (PBJ, 2022, doi.org/10.1111/pbi.13930). A chromosome-scale assembly of the Dasypyrum villosum genome was released in 2022 (Mol Plant, 2022, doi.org/10.1016/j.molp.2022.12.021), providing insights into its broad-spectrum disease resistance. An EMS mutant library of KN9204 with 98.79% of coding genes mutated was constructed (Plant Com., 2023, doi.org/10.1016/j.xplc.2023.100593). AB-NAMIC, a new strategy fully merging functional gene discovery and selective breeding into one population, was proved operable by GWAS and identification of crucial genes (Plant Com., 2023, doi.org/10.1016/j.xplc.2023.100593).

## 4. WHEAT RESEARCH FUNDING AND NEW RESEARCH PROGRAMMES

In 2022, two R&D projects were launched, one focusing on wheat drought and salt tolerance, the other focusing on germplasm pre-breeding in the north winter wheat region. They were financially supported by the Ministry of Science and Technology China. The NSFC also supported a set of proposals on wheat germplasm and gene discovery.

# FRANCE (INRAE)



## 1. WHEAT PRODUCTION (AREA, AMOUNT, AND AVERAGE YIELD) AND MAJOR PRODUCTIONS ISSUES (DROUGHTS, FLOODS, HEATWAVES, ETC.)

In 2022, 34.61 Mt wheat and spelt (Eurostat) were harvested (average 2017-2021: 36.19 Mt) on 4.95 Mha (average 2017-2021: 5.12 Mha). The national grain yield is also quite normal (7.01 t/ha) compared to the last five seasons (7.12 t/ha). Grain quality is generally good with average grain proteins concentrations of 11.4% (Arvalis-FranceAgrimer).

## 2. SIGNIFICANT NEW NATIONAL/INTERNATIONAL ENGAGEMENT OR PARTNERSHIPS

In November 2021, the French Ministry for Agriculture, Research and Industry announced several Priority Programs for Research and Equipment (PEPR). The PEPR "agroecology and digital" is co-led by INRAE and INRIA (National Institute for Research in Digital Science and Technology). It particularly concerns data, agri-equipment, but also genetic resources for the agro-ecological transition and adaptation to climate change. Several of the 13 flagship projects funded in 2022 for 25M€ involve cereals, for example CoBreeding (Co-design of animal and plant breeding schemes to improve multi-performance), and AgroDiv (Genomic and functional characterisation of plant and animal diversity).

## 3. RESEARCH HIGHLIGHTS

Paux et al. (2022) published a review of the results obtained within the BreedWheat project, [doi.org/10.3390/biology11010149](https://doi.org/10.3390/biology11010149). Perronne et al. (2021) analyzed the spatio-temporal changes in varietal resistance to yellow rust in France, highlighting an increase in field resistance level since 1985 despite the rapid breakdown of several major race-specific resistances during the last decades, [doi.org/10.1094/PHYTO-05-20-0187-R](https://doi.org/10.1094/PHYTO-05-20-0187-R).

Furthermore, Vidal et al. (2022) identified some of the potential causes of the success or failure of two yellow rust pathotypes (PstS7 and PstS2), among them temperature adaptation and virulence spectrum, [doi.org/10.1111/ppa.13581](https://doi.org/10.1111/ppa.13581). Gluten proteins digestibility figure among the traits that are potential triggers of non-celiac wheat sensitivity. Lavoignat et al. (2022) showed that protein digestibility was similar for bread made from old wheat cultivars registered before 1960 and modern cultivars registered after 1960, [doi.org/10.1016/j.jcs.2022.103533](https://doi.org/10.1016/j.jcs.2022.103533). Aury et al. (2022) report on an optimized procedure based on long reads of the Oxford Nanopore Technology PromethION to assemble the genome of the French bread wheat cultivar Renan that provides a highly contiguous chromosome-scale assembly, [doi.org/10.1093/gigascience/giac034](https://doi.org/10.1093/gigascience/giac034).

## 4. WHEAT RESEARCH FUNDING AND NEW RESEARCH PROGRAMMES

WheatSecurity: Identification and sustainable deployment of wheat genetic diversity to enhance the resilience and security of the European food supply (JPI-FACCE and l'ERANET Suscrop, coordinator: Fiona Doohan)  
DeFI-Wheat: Decipher the Fate of Introgressions from wild relatives in the wheat genome (French National Research Agency, ANR, coordinator: Pierre Sourdille)  
WITT: Unravelling CRK mechanisms in Wheat resistance To zymoseptoria Triticum (French National Research Agency, ANR, coordinator Cyrille Saintenac).

# GERMANY (BMEL)



## 1. WHEAT PRODUCTION (AREA, AMOUNT, AND AVERAGE YIELD) AND MAJOR PRODUCTIONS ISSUES (DROUGHTS, FLOODS, HEATWAVES, ETC.)

Wheat is the most widely cultivated crop in Germany. Based on preliminary representative results, wheat was grown on an acreage of 2.89 Mha in 2022, which corresponds to a share of 47% of total cereal cultivation. The average yield for wheat is estimated at 7.62 t/ha, which increased by 4.6% compared to last year. The decline in total wheat yield was caused by hot and dry weather conditions in summer resulting in yield depression and also local-scale above-average precipitation, often with severe weather character leading to lodging. In 2022, 17 new wheat varieties (10 winter type, 5 spring type, 2 durum wheat), were registered in Germany. They combine high yield with a high level of resistance and different qualities (E, A, B, C).

References: BMEL Erntebericht 2022, BSA Beschreibende Sortenliste 2022-Getreide, Mais, Öl- und Faserpflanzen, Leguminosen, Rüben, Zwischenfrüchte

## 2. SIGNIFICANT NEW NATIONAL/INTERNATIONAL ENGAGEMENT OR PARTNERSHIPS

TERTIUS, a project resulting from the call promoting innovative ideas for breeding efficient wheat varieties in the face of climate change, started. The overall objective of TERTIUS is to develop wheat prototypes with optimized root system, improved water-use efficiency and good baking quality. TERTIUS is one of the flagship projects in the area of plant breeding in the 2035 arable farming strategy discussion paper of the BMEL and is integrated into the global network Alliance for Wheat Adaption to Heat and Drought (AHEAD).

The private PILTON research project was launched involving nearly 60 German plant breeding companies with the aim of developing wheat with improved fungal tolerance through new breeding methods. Currently, the tolerance of the genome-edited plants is being tested.

Within WDV-MAS, a project resulting from the call promoting innovative ideas for breeding higher-performing wheat varieties from 2013, quantitative trait loci for partial wheat dwarf virus (WDV) resistance were identified. The results were published in 'Frontiers in Plant Science' in 2022.

## 3. RESEARCH HIGHLIGHTS

By genome wide association studies, quantitative trait loci for wheat dwarf virus resistance causing severe yield losses in Central Europe have been identified for the first time and in a cooperative project with Ethiopia, QTL for drought tolerance in durum wheat have been identified. In addition to this, good progress has been made in analysing of the IPK wheat gene bank for resistance and identifying QTL and major genes by GWAS has made good progress.

## 4. WHEAT RESEARCH FUNDING AND NEW RESEARCH PROGRAMMES

All 11 collaborative projects resulting from the call promoting innovative ideas for the breeding of efficient wheat varieties in the face of climate change within the Innovation Program are running successfully. After three years, an interim evaluation was conducted from the first quarter of 2022 onwards. After a positive evaluation of the specified success criteria, ten projects are continued for a maximum of two more years.

There were 93 project outlines submitted for call, promoting innovative ideas for the breeding of climate-adapted varieties and crops within the Innovation Program by the deadline in July 2021, nine of which deal with wheat as a crop. More details on the newly funded projects will be given in the next report as they will mostly start in 2023.

# IRELAND (TEAGASC)



## 1. WHEAT PRODUCTION (AREA, AMOUNT, AND AVERAGE YIELD) AND MAJOR PRODUCTIONS ISSUES (DROUGHTS, FLOODS, HEATWAVES, ETC.)

### Winter Wheat

The area of winter wheat was 60,300 hectares which was an increase of 4,300 hectares or a 7% increase on 2021 and 7,000 hectares over the 5-year average of 53,200 hectares.

Average yield was 11.0t/ha which equals the previous wheat record set in 2015. This year's yield is 1.1 t/ha over the five-year average yield for winter wheat of 9.9 t/ha. Some exceptional individual yields were recorded with reports of individual fields producing in excess of 14.0 t/ha.

Excellent sowing conditions last autumn and a good growing season contributed to the excellent wheat yields this year. Disease levels were below average this year which was helped by a reduced area of varieties susceptible to yellow rust, and good spraying conditions at critical spray timings.

Harvest conditions were excellent and crop losses were minimal. Grain moisture was below average at 16.4% and hectolitre weight was 75.4 kg/hl with individual crops exceeding 80 kph.

### Spring Wheat

The area of spring wheat was similar to 2021 at 6,700 hectares which is close to the 5-year average of 6,340 ha.

Almost all spring wheat was planted in March and benefited from an excellent growing season where disease levels were low. Excellent harvest conditions resulted in an earlier than normal harvest where many crops were harvested in late August/early September. Average yield was 8.1 t/ha which is above the 5-year average of 7.74 t/ha.

Grain quality was excellent with average grain moisture recorded at 17.4%.

## 2. SIGNIFICANT NEW NATIONAL/INTERNATIONAL ENGAGEMENT OR PARTNERSHIPS

At the end of 2021, John Spink, Head of Crops Environment and Land Use Programme at Teagasc, became the new Chair of the Institutions' Coordination Committee of the Wheat Initiative.

## 3. RESEARCH HIGHLIGHTS

- Baseline sensitivities have been established for Irish and European *Zymoseptoria tritici* populations to the novel Qil fungicide fenpicoxamid and azole mefentrifluconazole.
- Virulence profiles of the Irish 2022 *Z. tritici* population have been established to key wheat STB resistances currently deployed in Ireland.
- Establishment of an extensive *Z. tritici* isolate collection representative of the wider Irish *Z. tritici* population in 2022.
- Initial varietal mixture trials aiming to assess the potential role of mixtures in suppressing STB under high disease pressure conditions.

# ITALY (CREA)



## 1. WHEAT PRODUCTION (AREA, AMOUNT, AND AVERAGE YIELD) AND MAJOR PRODUCTIONS ISSUES (DROUGHTS, FLOODS, HEATWAVES, ETC.)

### Summer 2022

Durum wheat planting intentions released by the National Institute of Statistics (Istat) would indicate a national decline of areas by 1.4%. The qualitative survey conducted by the Institute of Agricultural Food Market Services (Ismea) focused on yields, estimates a reduction in yields that would fall to about 3.4 Mt. That is 16% less than the previous year (2021) and 15% less than the average of the last five years (2017-2021). With respect to common wheat, data recently released by Istat indicate a growth in areas (+9.3%) and a decline in yields (-6.8% to 2.8 Mt) due to the sharp decline in unit yields per hectare. However, these are provisional figures and subject to further revisions.

### Winter 2022

An increasing trend in total winter investments was foreseen, between soft and durum wheat, of between 8-10%. This increase was due not only to market expectations, with prices close to all-time highs despite the volatility and decline of the past, but also made possible by the extension to the sector of exemptions to the new Common Agricultural Policy on the use of set-aside land. For both the categories of wheat, drought has become the most significant calamity with damage to the quantity and quality of crops.

## 2. SIGNIFICANT NEW NATIONAL/INTERNATIONAL ENGAGEMENT OR PARTNERSHIPS

The 4th From Seed to Pasta congress (<https://www.fromseedtopasta.com>) was held in Bologna on 26-29 October 2022. This has been the major scientific event for durum wheat worldwide and the first scientific congress dedicated to wheat carried out in person after the pandemic.

The congress, organized by the University of Bologna, CREA (Council of Agriculture Research and Economics, Italy), CNR (National Research Council, Italy), CIMMYT, ICARDA, University of Saskatchewan and the Wheat Initiative, has provided a timely update on durum wheat multidisciplinary research towards a more sustainable and resilient durum wheat chain capable of enhancing food security and provide a healthier diet. State-of-the-art presentations reported how the recent advances on genomic characterization of wheat genetic resources have contributed to reduce the environmental footprint of durum wheat production while contrasting the impact of climate changes on durum yield. More than 220 participants were registered with about 80 oral presentations. During the congress, the Carlotta awards were presented, an international prize dedicated to young women active in wheat science.

At the European level, MASAF (Ministry of Agriculture, Food Sovereignty and Forestry) is working on the process of building of new Horizon EU partnerships (e.g. Agridata, Agroecology, Food systems) focused on agri-food sectors including wheat, and is also still involved in the European initiatives as JPIs and Eranets in the agri-food sector. At the national level, MASAF is continuing to implement the Sector and District Contracts, developed in the different segments of the agro-food supply chain (primary production, processing, marketing and distribution phases), wheat sector included, to boost investments in the agri-food sector to realize integrated investment programs of interprofessional nature and with national relevance.

# ITALY (CREA)



## 3. RESEARCH HIGHLIGHTS

Italy played a major role in the assembly of a global platform for leveraging the genetic diversity of tetraploid wheat. The University of Bologna and CREA (Council of Agriculture Research and Economics), in collaboration with other members of the EWG on durum wheat genomics and breeding, have assembled two major diversity panels: (1) the Tetraploid wheat Global Collection (TGC), particularly versed for evolutionary studies and gene/QTL discovery and cloning that includes wild relatives and tetraploid subspecies (1,852 accessions in total) and (2) the Global Durum Panel (GDP), a breeding-dedicated tool suitable for GWAS, mainly focused on landraces and modern varieties (1,056 accessions in total). Both collections have been genotyped and are available as reference panels for durum genetics. From the panel illustrated above, a set of 24 representing the genetic diversity of the tetraploid wheat germplasm accessions have been selected as a reference panel for the tetraploid pangenome analysis.

## 4. WHEAT RESEARCH FUNDING AND NEW RESEARCH PROGRAMMES

Within the PRIMA program (Partnership for Research and Innovation in the Mediterranean Area), one of the main funding opportunities for Mediterranean countries, three projects dedicated to durum wheat and coordinated by Italian scientists are currently ongoing:

- 1.CEREALMED: “Enhancing diversity in Mediterranean cereal farming systems”.
- 2.EXPLOWHEAT: “Exploring durum wheat genotypes to minimize drought stress impact on grain yield and nutritional quality”.
- 3.IMPRESA: “IMProving RESilience to Abiotic stresses in durum wheat: enhancing knowledge by genetic, physiological and “omics”.

Also, Horizon 2020 allowed the start of projects on wheat (DiverIMPACTS, with an Italian study case on durum wheat; MED-GOLD).

A major research opportunity for was launched in 2022 in Italy with a National program for recovery and resilience (PNRR), part of the Next Generation EU program that funded a large research project (AGRITECH) including a strong action on plant genetic resources. In 2022, through PRIN calls (Research Projects of Significant National Interest) a smaller research project (PanWheatGrain) was funded with the aim to sequence the durum wheat pangenome. Recently a new project part of the FACCE JPI-SUSCROP call dedicated to wheat genetic resources and participated by 2 Italian teams, has been approved through the Italian Ministry of Agriculture. Also, at the regional level, projects on wheat have been funded through regional development programs (eg Graditi project, New Grain project). Regarding the new future research programs, MASAF is involved in the process for building new partnerships of the new Horizon Europe and within the Pillar 2 - Cluster 6 - Food, bio-economy, natural resources, agriculture, and environment. Among the partnerships, Agridata and Agroecology could be the ones with opportunities for cereal and wheat sector.



# JAPAN (AFFRC-JIRCAS)



## 1. WHEAT PRODUCTION (AREA, AMOUNT, AND AVERAGE YIELD) AND MAJOR PRODUCTIONS ISSUES (DROUGHTS, FLOODS, HEATWAVES, ETC.)

Japan consumes 5.6 Mt of wheat but the self-sufficiency rate is merely 17%. The national average yield is 4.3 t/ha, rising in recent years with the introduction of new varieties. However, yield in 2021/2022 season was a bit lower because of less sunlight in the ripening stage. The primary constraints in wheat production are preharvest sprouting, Fusarium head blight, moisture damage, and soil-borne virus diseases. Domestic wheat is used mainly for Japanese noodles (udon). However, new wheat cultivars for bread-making are getting popular and increasing their brand value.

## 2. SIGNIFICANT NEW NATIONAL/INTERNATIONAL ENGAGEMENT OR PARTNERSHIPS

In breeding programs, engagement with international organizations is not extensive. However, researchers are intensively involved in global networks, and the results appeared in many publications. Japanese wheat researchers have contributed significantly to wheat genetics, such as the discovery of chromosome numbers, polyploid evolution, and cytoplasmic inheritance, and have actively participated in the international wheat genome sequence project. The semi-dwarf genes which originated from Japanese wheat cultivars have played a crucial role in the Green Revolution. Recent efforts in gene mining have revealed heat-tolerant QTLs in *Aegilops tauschii* and biological nitrification inhibition (BNI) in *Leymus racemosus*. These genes are also expected to become indispensable in the second Green Revolution for wheat production under climate change.

## 3. RESEARCH HIGHLIGHTS

Japan has very strict quality standards. Thus, many studies focus on improvement of seed quality including seed-storage proteins and starch. Researchers are positively introducing advanced technologies such as genome editing and in vitro fertilization. Conservation of valuable genetic stocks is also a major priority and basic research using these stocks are active. An example of applying such basic study to breeding is the creation of wheat with enhanced biological nitrification inhibition (BNI) using *Leymus racemosus* chromosome addition lines. The BNI-enabled wheat varieties can reduce environmental burden due to excessive nitrogen input which leads to soil emission of nitrous oxide, a strong greenhouse gas, and therefore contribute to climate change mitigation. The paper on the development of BNI-enabled wheat has been published in PNAS and won the Cozzarelli Prize in 2022.

## 4. WHEAT RESEARCH FUNDING AND NEW RESEARCH PROGRAMMES

The Ministry of Agriculture, Forestry and Fisheries (MAFF) and local public sectors as well as semi-governmental bodies, such as the National Wheat and Barley Improvement Association, provide funding for wheat breeding research. The private-sector contribution to wheat research is limited to milling and baking companies. The Ministry of Education, Culture, Sports, Science and Technology (MEXT) also provides funding for basic research in wheat science, and has promoted overseas joint research and implemented a large project on plant research. Several wheat researchers are participating in this project, which is expected to promote international joint wheat research.

# REPUBLIC OF KOREA



## 1. WHEAT PRODUCTION (AREA, AMOUNT, AND AVERAGE YIELD) AND MAJOR PRODUCTIONS ISSUES (DROUGHTS, FLOODS, HEATWAVES, ETC.)

### Production of wheat in 2021/2022:

The cultivation area is 6,224ha, total production is 26,327 t and productivity is 4.23 t/ha. In 2022, wheat yield increased by 8.7% compared to the 5-year average production (3.89 t/ha) due to favourable weather conditions such as solar radiation and rainfall during the ripening stage.

### Wheat policy:

Except for wheat for grain feed, the annual consumption of wheat is around 2.5 Mt and the self-sufficiency rate is 1.1%.

To foster wheat industry of the Republic of Korea, the wheat public stockpiling and a policy of scaling up production has been implemented since 2021. The wheat quality management system will be implemented in 2023.

## 2. SIGNIFICANT NEW NATIONAL/INTERNATIONAL ENGAGEMENT OR PARTNERSHIPS

None to report.

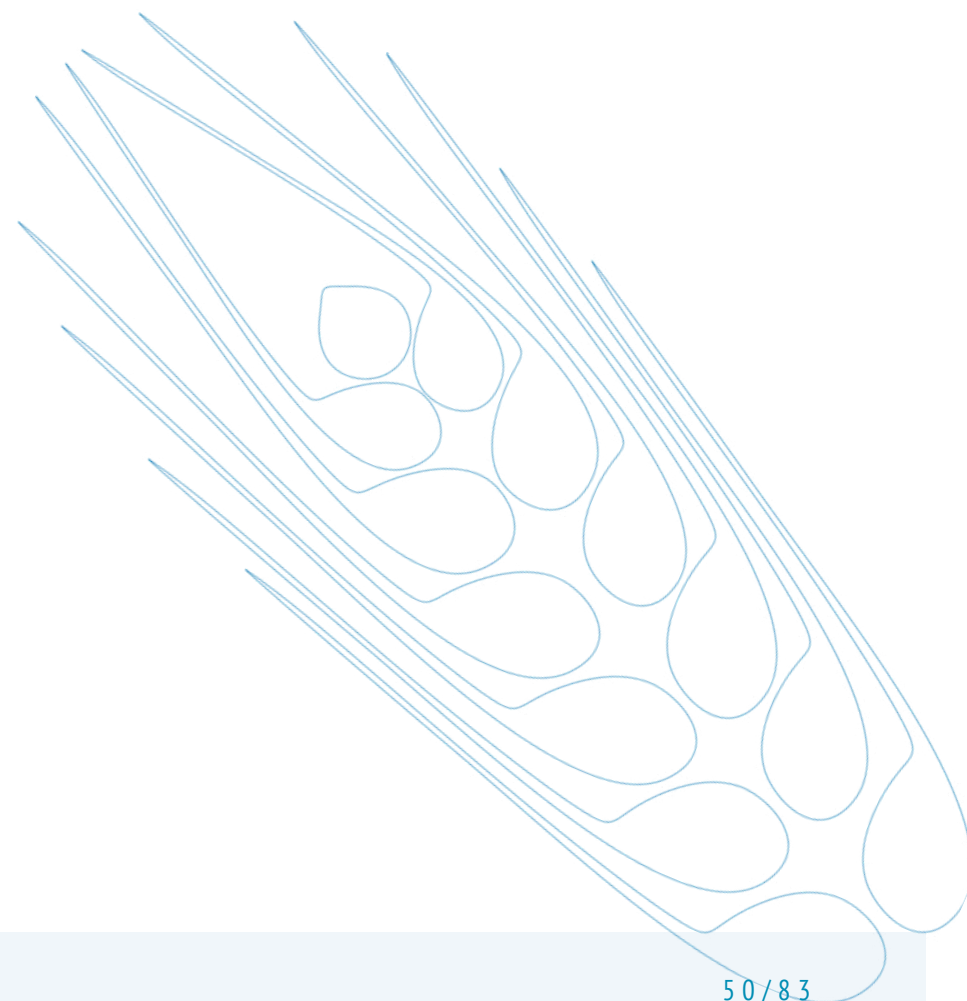
## 3. RESEARCH HIGHLIGHTS

### Key R&D areas

- Development of high-quality varieties for noodles and bread wheat.
- Research on production technology of sowing, fertilization, and water management on wheat.
- For development of quality control technology, seed purity control using molecular marker, Non-destructive kernel quality evaluation technologies, method of distinction kernel vitreousness, and production traceability management system.
- Development of health functional wheat varieties such as high antioxidant and low allergic wheat.

## 4. WHEAT RESEARCH FUNDING AND NEW RESEARCH PROGRAMMES

None to report.



# MOROCCO (INRA)



## 1. WHEAT PRODUCTION (AREA, AMOUNT, AND AVERAGE YIELD) AND MAJOR PRODUCTIONS ISSUES (DROUGHTS, FLOODS, HEATWAVES, ETC.)

Cereal production 2021-2022:

- Final assessment of the harvest was 3.4 Mt of cereals, down 67% from the 2020/2021 season.
- The forecasted agricultural value added is expected to decline by 14% in 2022.

The cereal area sown this season was 3.6 Mha compared to 4.35 Mha in the previous season of 20/21, which recorded an exceptional performance of 10.3 Mt.

By species, cereal production in 2021/22 was as follows:

- 1.89 Mt of bread wheat;
- 0.81 Mt of durum wheat;
- 0.70 Mt of barley.

There was 58% of production from the favorable regions of Fez-Meknes and Rabat-Kenitra. Irrigated cereals have contributed only 20.7% of total production, this is due to the decrease in the irrigated area of cereals and irrigation restrictions in the large hydraulic perimeters.

As a reminder, the 2021/2022 crop year recorded a rainfall to end of May 2022, 199 mm down, 44% compared to the average of 30 years (355 mm) and a drop of 34% compared to the previous season (303 mm) at the same date.

This season was also characterized by a poor temporal distribution of rainfall, with nearly one-third of the rainfall occurring in the months of November and December and 53% of the cumulative rainfall occurring in March and April. The very low rainfall, or even its absence in several regions of the Kingdom during January and February, caused a delay in the growth of cereals and a more or less significant drop in yields depending on the region. Cereals in favorable areas performed relatively better following the rains of the last decade of February, March and early April.

Given the final production of cereals, the performance of fruit trees, market gardening, and spring crops, as well as the positive effects of the rainfall mitigation program and the impact of the rainfall deficit, particularly on livestock, the forecast value added is expected to decline by 14%. This decline would translate into a drop in GDP growth points of 1.8.

## 2. SIGNIFICANT NEW NATIONAL/INTERNATIONAL ENGAGEMENT OR PARTNERSHIPS

During this year, INRA Morocco has strengthened its engagements through new national and international partnerships. At the international level, several new MoU were established to enhance wheat research and develop more resilient varieties that are drought and heat tolerant. At the national level, INRA is working on the national strategy Generation Green 2020-2030 to improve wheat yields and enhance the adoption of new released wheat varieties and promote national durum wheat varieties with good quality (high protein content and high yellow pigment). Work is also being done on seed multiplication to provide enough Breeder and Foundation seeds to seed companies that are in contract with INRA.



## 3. RESEARCH HIGHLIGHTS

### Released Varieties in 2022

#### 1. The Bread wheat: Ibtissam

Agronomic characteristic: Number of days to heading (d): 95 +/-2, Number of days to maturity (d): 150 +/-3 and eight (cm): 70- 80.

Resistance to diseases: Leaf rust, Yellow rust and Septoria.

Quality parameters: Protein content: 15%, TKW (g): 40-44, Moisture content: 12.5, Gluten strength (ml): 15,8 and Seed color: Vitreous

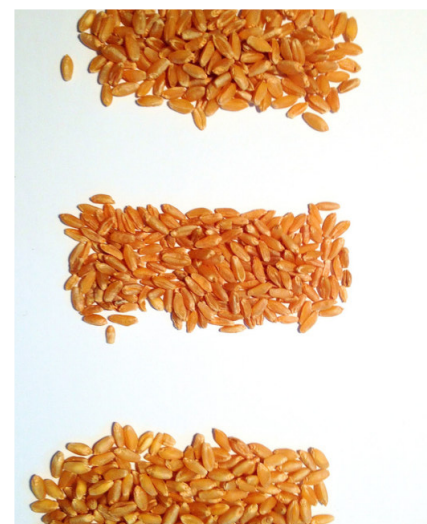


#### 2. Durum wheat variety: Jawahir

Brief description: Hessian fly resistant variety, early flowering, medium height, large seeded, high yellow pigment, good gluten strength, excellent drought tolerance.

Agro-ecology: ideal for dryland conditions with 150-350 mm of season moisture. Acceptable performances also for highland drylands (Atlas Mountains).

Diseases: Resistant to Hessian fly, leaf and yellow rust. Good resistance against Septoria tritici. Moderate tolerance to crown or foot rot. Yield performances: This entry was tested for three seasons (2017-18, 2018-19, 2019-20) across Moroccan environments (Marchouch, Sidi el Aydi, Annoceur, Tassaout). It achieved an overall yield advantage over Karim of 33%, mostly via outstanding performances in Sidi el Aydi (+96% average over three seasons), Annoceur (+24%), and Marchouch (+17%), while it proved not ideal for high fertility conditions in Tassaout (-7%).





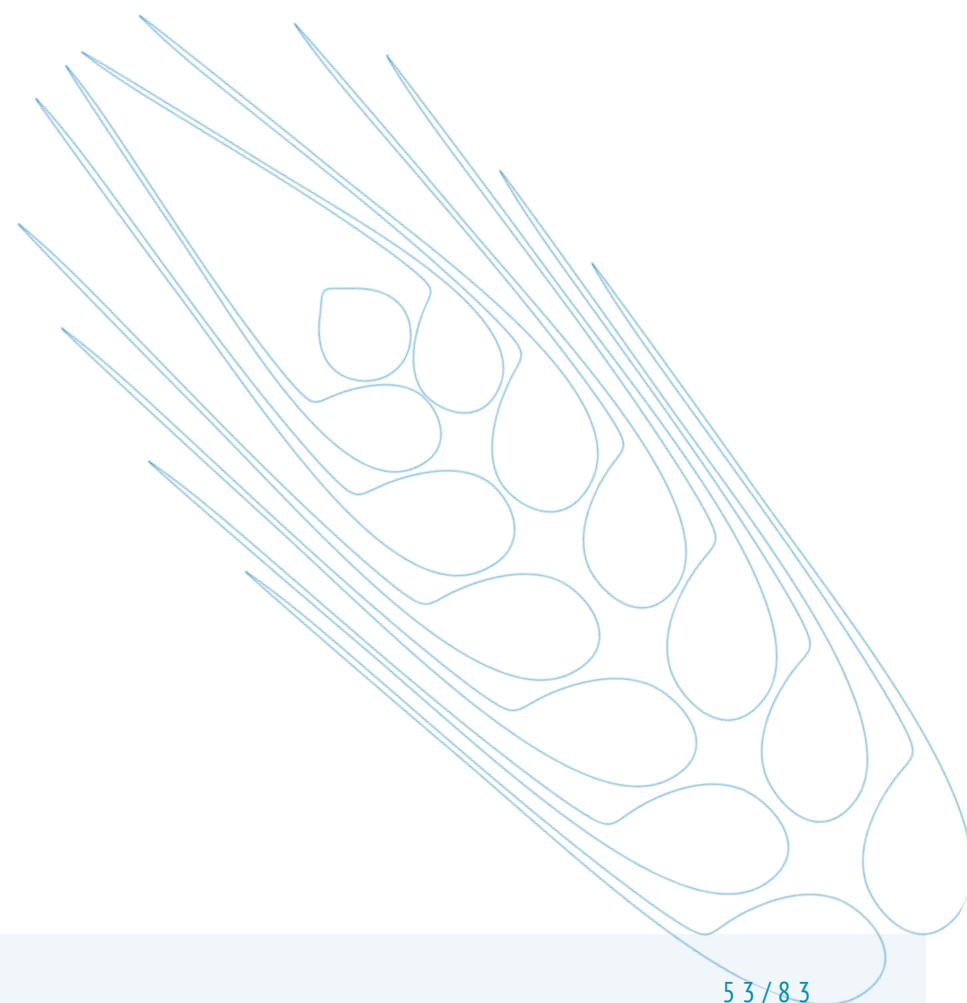
## 4. WHEAT RESEARCH FUNDING AND NEW RESEARCH PROGRAMMES

Regarding wheat research funding, there are mainly two research programs dealing with wheat:

1. Morocco Collaborative Grants Program Phase IV (MCGP IV) between INRA Morocco and ICARDA (Period: 2020-2024). Component 1. Enhancing genetic gains of cereals and legumes to adapt to climate variability and user requirements (200.000 dollars/year). Component 2. Unlocking the yield gap of wheat-based cropping systems in different rainfed agro-ecological zones of Morocco (300.000 dollars/year).
2. National midterm wheat research program (PRMT2021-2024): the expected funding for the 4-year term is around 40 million MAD (approx. 1M dollars/year). The main components of this research program are:
  - Wheat Genetic improvement and biotechnology (speed breeding and new technologies);
  - Wheat crop management (Production, Protection);
  - Agro-industrial valorization, technological and nutritional improvement of wheat and its derivatives;
  - Value chain, governance mechanisms and coordination of the actors of the wheat sector.

### **INRA partners in the area of wheat research are:**

International Wheat Research Centers (ICARDA and CIMMYT), Public Institutions (ADA, DDFP, DSS, DEFR, DRA and ONCA), National Wheat Organizations (FIAC, FNIS, AMMS, SONACOS, COMADER), National Universities (IAV Hassan II, ENA and others).



# TÜRKIYE (TAGEM)



## 1. WHEAT PRODUCTION (AREA, AMOUNT, AND AVERAGE YIELD) AND MAJOR PRODUCTIONS ISSUES (DROUGHTS, FLOODS, HEATWAVES, ETC.)

Bread and durum wheat production in 2022 was 19.7 Mt and the total production area was 6.62 Mha. The average yield of bread and durum wheat was 3.05 t/ha. Total production decreased almost by 3 Mt due to drought and heat stress conditions. Bread wheat and durum wheat production areas were affected mainly by drought stress conditions in Central Anatolia and drought and heat stress in the South-eastern Anatolia region in Türkiye. Major production issues are decreasing yield, due to various environmental conditions such as lower rainfall and higher temperature during shooting and grain filling periods in the Central and South-eastern Anatolia region. There was no drought stress in coastal areas in 2022.

## 2. SIGNIFICANT NEW NATIONAL/INTERNATIONAL ENGAGEMENT OR PARTNERSHIPS

Although there are no new international joint studies on wheat, the International Winter Wheat Improvement Program (IWWIP) continues with CIMMYT and ICARDA. In this program (IWWIP), studies continue with the research institutes of TAGEM to develop genotypes resistant to biotic and abiotic stress conditions, especially in winter and alternative bread wheat. In recent years, there has also been an increase in joint project studies between public and private sector research institutions. It is possible for the registered varieties to take part in the production in a short time in the studies carried out with the private sector. Cooperation with the private sector is essential in this regard.

## 3. RESEARCH HIGHLIGHTS

Some research projects related to bread and durum wheat breeding and agronomic studies, supported by mostly TAGEM were completed in 2022. Official agricultural research institutes and private sector seed companies, have registered 37 new bread wheat varieties and nine durum wheat varieties in Türkiye. The majority of registered cultivars were developed for arid and semi-arid regions. In these research projects, adaptation to different environmental conditions and high yield potential are aimed. Certified seed production of registered varieties with private sector organizations represent a significant research output.

## 4. WHEAT RESEARCH FUNDING AND NEW RESEARCH PROGRAMMES

For bread and durum wheat researchers, the main funding institution in Türkiye is TAGEM. Some notable projects are continuing in the private sector. Research institutes also provide budget support for projects carried out by the private sector. Drought is the most important abiotic stress factor in Central Anatolia, which is the main wheat production region in Türkiye. Due to climate change, drought continues to increase in this region. Another important region for wheat production in Türkiye is Southeast Anatolia, where both drought and heat stress limit wheat production. Therefore, resistance to drought and heat stress is the main goal of new research programmes. A large number of ongoing and newly started projects are carried out by the research institutes affiliated with TAGEM in 2022. Drought resistance is the main goal in new research projects, and studies on fertilization and macro and micronutrients are carried out. Some biotic stress factors, primarily leaf and yellow rust, are effective in some years in the coastal belt. Projects are also carried out on rust diseases.

# UNITED KINGDOM (BBSRC)



## 1. WHEAT PRODUCTION (AREA, AMOUNT, AND AVERAGE YIELD) AND MAJOR PRODUCTIONS ISSUES (DROUGHTS, FLOODS, HEATWAVES, ETC.)

UK 2022 wheat production was 15.5Mt, an 11% increase from 2021. The wheat area in England (where most UK wheat is grown) in 2022 was 1.8 Mha, a 1.0% increase from 2021. This is a return to expected levels, following the large reduction in 2020 due to wet weather during winter planting.

## 2. SIGNIFICANT NEW NATIONAL/INTERNATIONAL ENGAGEMENT OR PARTNERSHIPS

BBSRC 2021-2022 expenditure on international collaborative wheat research through international schemes totalled £30.5K.

BBSRC is a member of the Alliance for Wheat Adaptation to Heat and Drought (AHEAD) Steering Committee. UK's contribution is led by Prof Graham Moore, Designing Future Wheat's (DFW) programme leader. DFW is a £24 million UKRI-BBSRC strategic investment established in 2017, spanning eight research institutes and universities, aiming to develop new wheat germplasm containing the next generation of key traits.

BBSRC continues to lead and support coordination of the International Wheat Yield Partnership (IWYP), collaborating with the private sector and major funding agencies in research-intensive and developing countries. IWYP outputs are translated by CIMMYT and two established Winter Wheat Hubs in USA (Kansas State University) and Europe (NIAB, UK), breeding into elite lines and making seeds available.

BBSRC annual responsive mode continues to fund wheat research.

## 3. RESEARCH HIGHLIGHTS

Wheat is a vital source of calories but is typically low in bioavailable micronutrients such as iron and zinc, contributing to conditions associated with deficiencies in these nutrients. In wheat grains, iron and zinc are concentrated in the aleurone (and outer layer) and embryo (the "germ"), removed as bran during milling to form white flour. BBSRC funded researchers at the John Innes Centre and Rothamsted Research are working to understand processes by which micronutrients are concentrated in different parts of the wheat grain, in order to underpin future approaches to create mineral-rich wheat products (<https://onlinelibrary.wiley.com/doi/full/10.1111/nbu.12361>).

The circadian clock (CC) influences gene expression affecting plant development and responses to the environment. In an AAFC-IWYP project, researchers from Agriculture and Agri-Food Canada in collaboration with the University of Cambridge, are using transcriptomics to identify core CC genes, and gene editing techniques to develop lines carrying core CC regulatory genes ([https://iwyp.org/wp-content/uploads/sites/34/2022/07/A-IWYP103-Science-Brief\\_FINAL.pdf](https://iwyp.org/wp-content/uploads/sites/34/2022/07/A-IWYP103-Science-Brief_FINAL.pdf)). It is expected that mutations in core CC regulators will create variability in clock output for generating potential yield increases and improved stress tolerance under warmer and drier growth conditions.

## 4. WHEAT RESEARCH FUNDING AND NEW RESEARCH PROGRAMMES

UKRI-BBSRC 2021-2022 expenditure on wheat totalled £17M supporting 79 projects in areas including wheat genetics and epigenetics, immunity against infectious diseases, and digital platforms for farming and research uses.

# URUGUAY (INIA)



## 1. WHEAT PRODUCTION (AREA, AMOUNT, AND AVERAGE YIELD) AND MAJOR PRODUCTIONS ISSUES (DROUGHTS, FLOODS, HEATWAVES, ETC.)

In 2022, a total production of 1.283 Mt was estimated from an area of 0.302 Mha, with an average grain yield of 4.25 T/ha (the highest on record). The production was 31% higher than 2021, with a 23% increase in the planted area and a 7% rise in yield as compared to the previous growing season.

For the third consecutive year, the growing season was influenced by a strong La Niña event. Climatic conditions were characterized by normal temperatures in general across the growing area, and lower than average rainfall, particularly in the southern region. However, in the northern region, close to normal rainfall occurred during most of the crop cycle. The rainfall pattern had high spatial variation, associated with variable distribution during the growing season.

## 2. SIGNIFICANT NEW NATIONAL/INTERNATIONAL ENGAGEMENT OR PARTNERSHIPS

The Precision field-based Wheat Phenotyping Platform (PWPP) for Wheat Diseases at INIA-La Estanzuela, Uruguay, as part of the Wheat Global Field-based Precision Phenotyping Network, continued to deliver high quality data for regional and international, public and private research institutions and breeding companies in collaboration with CIMMYT. In 2022, 990 lines from seven institutions were phenotyped for Septoria tritici blotch, leaf rust and Fusarium head blight.

INIA made the first shipment of national seeds for conservation to the Svalbard Global Seed Vault (Norway). The collection consisted of 1.572 samples of *T. aestivum* and 8 *T. durum* accessions selected from INIA's breeding and research programs. This process will continue with shipments in the coming years to back up the highest possible percentage of the 7.000+ wheat samples housed in the INIA La Estanzuela Germplasm Bank.

## 3. RESEARCH HIGHLIGHTS

Five new varieties were registered for planting in 2022. Three were introductions from the region, one introduction from Europe, whereas one was a cultivar developed by the National Wheat Breeding Program from INIA, based at La Estanzuela. Additionally, a new and promising new cultivar developed by INIA's Breeding Program was registered at the beginning of 2023 and will be present in commercial fields in the coming season.

Inter-institutional projects with INIA leadership related to FHB, stripe rust and Bacterial leaf streak, advanced knowledge on the pathogens population and FHB associated mycotoxins changes in the last two decades and sensitivity to the main fungicides used for fungal diseases control. Results from these projects assisted in the optimization of integrated diseases management, including the deployment and use of genetic resistance in cultivars, rational and efficient use of fungicides and alternatives.

## 4. WHEAT RESEARCH FUNDING AND NEW RESEARCH PROGRAMMES

None to report.



# UNITED STATES OF AMERICA (USDA)



## 1. WHEAT PRODUCTION (AREA, AMOUNT, AND AVERAGE YIELD) AND MAJOR PRODUCTIONS ISSUES (DROUGHTS, FLOODS, HEATWAVES, ETC.)

Winter wheat production for 2022 totalled 1.10 billion bushels (30 Mt), down 14% from the 2021 total of 1.28 billion bushels (34 Mt). The United States yield, at 47.0 bushels per acre (3.16 t/ha), was down 3.2 bushels from 2021. Area harvested for grain was estimated at 23.5 million acres (9.5 Mha), down 8% from the previous year. Record low planted acres were estimated in Utah in 2022. Record low harvested acres were estimated in California and Utah in 2022. Record high yields were estimated in Illinois, New Jersey, North Dakota, and Tennessee for 2022. Compared with 2021, harvested acreage was down 11% in the major Hard Red Winter (HRW) growing States, the primary winter wheat-producing area. HRW production totalled 531 million bushels (14.5 Mt), down 29% from 2021. In the Soft Red Winter (SRW) growing area, planted and harvested acreage decreased from 2021. SRW production totalled 337 million bushels (9.2 Mt), down 7% from 2021. White winter wheat production totalled 226 million bushels (6 Mt), up 41% from the previous year. Harvested acreage was up 3% from 2021.

Production of spring wheat for 2022 was estimated at 482 million bushels (13.1 Mt), up 46% from the 2021 total of 331 million bushels (9 Mt). Harvested area totalled 10.4 million acres (4.2 Mha), up 3% from 2021. The United States yield was estimated at 46.2 bushels per acre (3.1 t/ha), up 13.6 bushels from 32.6 bushels per acre in 2021. A record high yield was estimated in North Dakota. Of the total production, 446 million bushels (12.1 Mt) were Hard Red Spring wheat, up 50% from the 2021 total.

Durum wheat production for 2022 was estimated at 64.0 million bushels (1.7 Mt), up 70% from the 2021 total of 37.6 million bushels (1.0 Mt).

Area harvested for grain totalled 1.58 million acres (0.64 Mha), up 4% from the previous year. The United States yield was estimated at 40.5 bushels per acre (2.72 t/ha), up 15.8 bushels from the 2021 yield. Production in North Dakota, the largest Durum wheat-producing State, was up 59% from 2021. The increase in production is a result of dry conditions last year in the major Durum wheat growing States.

Source: Small Grains 2022 Summary (September 2022). USDA, National Agricultural Statistics Service. ISSN: 1949-162X.

## 2. SIGNIFICANT NEW NATIONAL/INTERNATIONAL ENGAGEMENT OR PARTNERSHIPS

None to report.

## 3. RESEARCH HIGHLIGHTS

WheatCAP 2022-2026: Leveraging high-throughput genotyping and phenotyping technologies to accelerate wheat improvement and mitigate the impacts of climate change.

During the first year of the project, WheatCAP breeders have released 33 commercial varieties and 7 improved germplasm. The WheatCAP team published 47 peer-reviewed papers (not reported before). Data was collected from 173 UAS flights over 23.8 acres and a total of 25,400 samples were sent for genotyping (mostly with medium throughput genotyping platforms). Approximately 55,000 plots from 175 trials were entered by breeders into T3, with data already incorporated for 167 trials, based on currently available information. This information was used to advance the implementation of genomic selection in public wheat breeding programs.

## UNITED STATES OF AMERICA (USDA)



In addition, the combined genotypic and phenotypic datasets represent an invaluable resource to investigate the effects of different alleles and their epistatic interactions across environments and germplasm. This year, 7 students completed their PhD and 42 participated in multiple educational activities organized by the project.

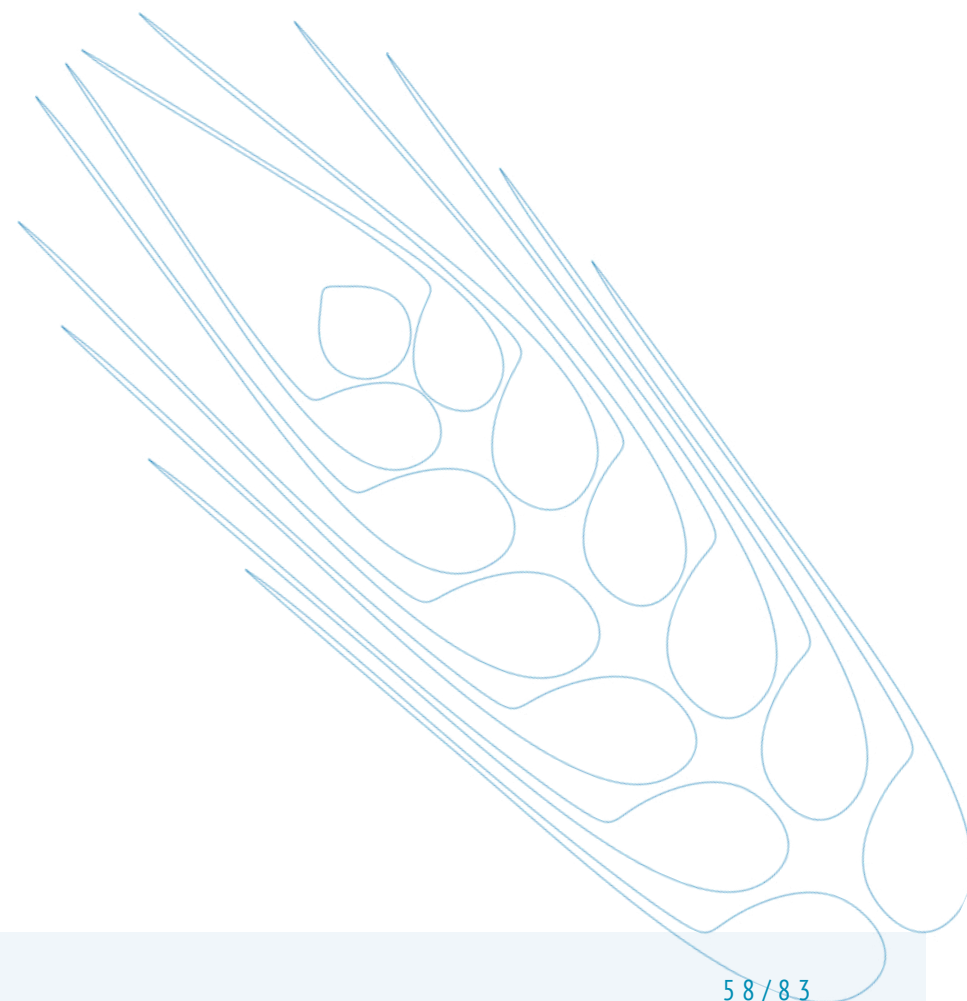
Source: Wheat Coordinated Agricultural Project. J. Dubcovsky.  
[www.triticeaecap.org/publications-and-germplasm/](http://www.triticeaecap.org/publications-and-germplasm/).

#### 4. WHEAT RESEARCH FUNDING AND NEW RESEARCH PROGRAMMES

The US Wheat & Barley Scab Initiative continues to be the single largest public investment in wheat research and was again fully funded at the authorized amount of \$15 million this past fiscal year. Details about the progress in the fight against this pathogen can be found at <https://scabusa.org/home-page>.

In the president's current budget proposal, both the US Wheat & Barley Scab Initiative and the US Small Grains Genomics Initiative have been zeroed out. The likelihood that both initiatives will not be funded by Congress at the authorized amounts of \$15 and \$3.4 million, respectively, is unlikely.

The National Wheat Improvement Committee recently presented a new task to the US Congress in support of public research to address emerging disease and pest issues in wheat across the US. This 'Wheat Resiliency Initiative' asks for a \$6.5 million annual public investment to address the emerging and/or changing dynamics of wheat stem sawfly in the central plains, Hessian fly in the southeast and northwest, bacterial leaf streak in the northern plains, and stripe rust in all wheat production areas.



# REPORTS AND HIGHLIGHTS 2022



## PUBLIC RESEARCH ORGANISATIONS AND PRIVATE COMPANIES

[FLORIMOND DESPREZ](#)  
[VEUVE & FILS](#)

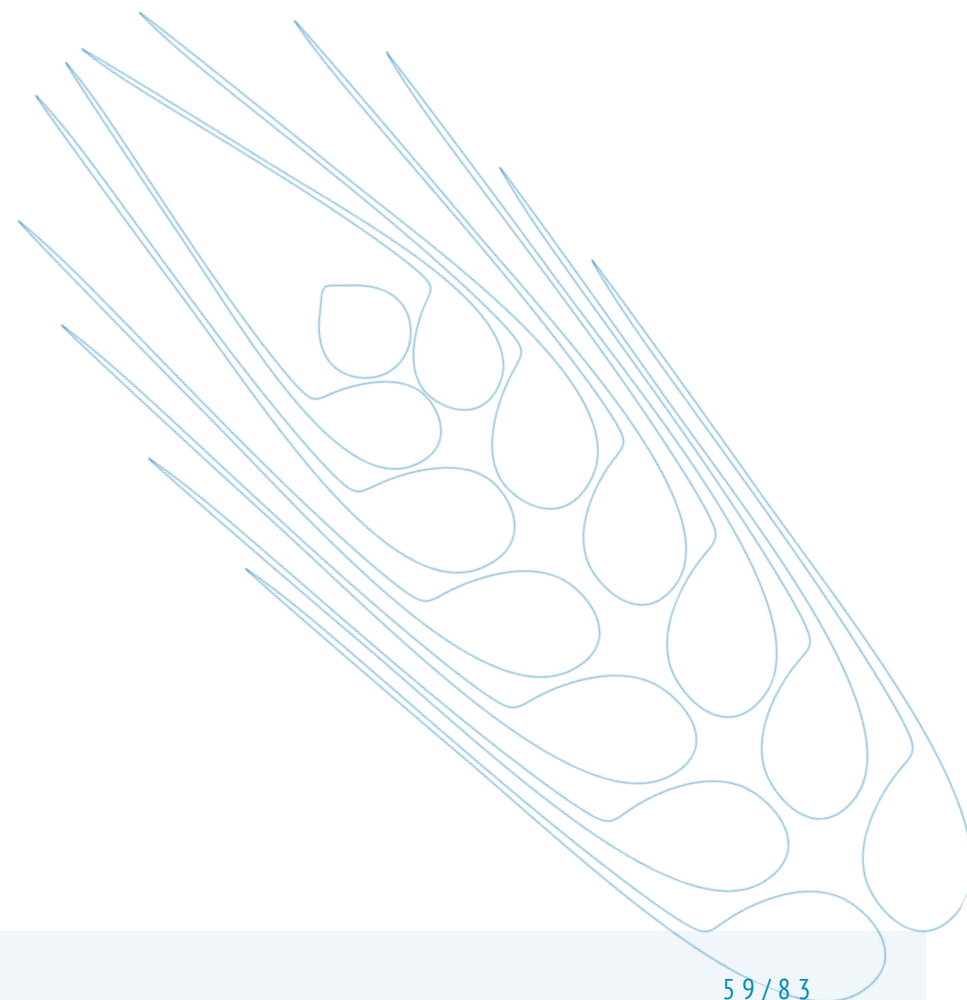
[ASUR](#)

[RAGT 2N SAS](#)

[CIMMYT](#)

[ICARDA](#)

[ARVALIS](#)





### 1. WHEAT PRODUCTION (AREA, AMOUNT, AND AVERAGE YIELD) AND MAJOR PRODUCTIONS ISSUES (DROUGHTS, FLOODS, HEATWAVES, ETC.)

In 2022, French bread wheat production was around 33.6 Mt, approximately 5% less than in 2021. This drop is mainly related to a decreasing in area because mean yield reached 7.2 t/ha in 2022 (7.1 t/ha in 2021). Concerning durum wheat, the production reached 1.35 t/ha in 2020, approximately 16% less than in 2021. Once again, this drop is mainly related to a decreasing area, while mean yield showed only a slight decrease (5.3 t/ha in 2022 and 5.4 t/ha in 2021). Mean grain protein concentration was 11.4% for bread wheat and 14.0% for durum wheat. The main agronomic fact of the season 2021-2022 was the early and intense water stress during spring, which has impacted many regions. The consequences were more problematic in shallow soils, and in the earliest production areas where the returns of rain in June were too late to compensate for the stress that occurred during stem elongation.

### 2. SIGNIFICANT NEW NATIONAL/INTERNATIONAL ENGAGEMENT OR PARTNERSHIPS

In 2022, ARVALIS joined AHEAD, the Alliance for Wheat Adaptation to Heat and Drought.

### 3. RESEARCH HIGHLIGHTS

Among all research objectives of ARVALIS, it's interesting to highlight two connected topics:

- As it is well known that root traits are of major interest to address performance of wheat against various abiotic stresses, there is an increase of interest in field root phenotyping methods. In this context, ARVALIS continued to develop the Minirhizotron method, Postic et al. (2019). In particular, it has been used to characterize the water stress tolerance of wheat cultivars in the EU H2020 INVITE research project and will also be one of the tools used in the Horizon EU project Root2Res (see below).
- As water stress during spring was one of the major agronomic facts in France during the 2022 season, the field trial network for post-registration evaluation of wheat cultivars (managed by ARVALIS) has been specifically characterized against this stress. This 'envirotyping' effort was very useful to start considering water stress tolerance in cultivar recommendations and genetic progress assessment.

### 4. WHEAT RESEARCH FUNDING AND NEW RESEARCH PROGRAMMES

Root2Res project started in September 2022. It is funded by the EU's Horizon Europe research and innovation program, Innovate UK, and Swiss State SERI. It includes 22 partners and will run for five years. It is coordinated by ARVALIS and scientifically led by ARVALIS and The James Hutton Institute. The main goal of the project is to address root phenotyping and genetic improvement for rotational crops resilient to environmental change. It will deliver a complete set of tools (phenotyping, genetics, modelling) to help breeders and agronomists to develop and evaluate cultivars (including wheat) with improved root traits against abiotic stresses.

# ONE CGIAR WHEAT (PRE)BREEDING RESEARCH (CIMMYT AND ICARDA)



## 1. WHEAT PRODUCTION (AREA, AMOUNT, AND AVERAGE YIELD) AND MAJOR PRODUCTIONS ISSUES (DROUGHTS, FLOODS, HEATWAVES, ETC.)

The Ukraine–Russia war will impact global food security over months if not years, Bentley et al. (2022). In the wake of COVID-19 and in the face of increasing climate change, responses to a multi-layered global food crisis that mitigate near-term food security risks, stabilize wheat supplies and transition towards long-term agri-food system resilience were proposed.

[doi.org/10.1038/s43016-022-00559-y](https://doi.org/10.1038/s43016-022-00559-y).

Following the Ukraine-Russia crisis, many countries in the CWANA and SSA regions were looking for seed to start and strengthen local level wheat production to ensure their national food security. AfDB has allocated emergency seed funding for countries in SSA, and ICARDA has assisted technically the purchase of improved seed from countries where there is enough certified seed of commercial wheat cultivars.

The wheat production in Ethiopia has increased both horizontally and vertically. According to government and published reports, Ethiopia produced more than 13 Mt in 2022/23 season and is set to export at least 3 Mt.

[doi.org/10.20900/cbagg20220003](https://doi.org/10.20900/cbagg20220003).

CIMMYT was unable to send seed to Ukraine in 2022, for obvious reasons, but was just a small example of the huge impact on wheat supply and trade globally that was caused by the conflict in that country. Bentley (2022) highlighted the need for greater geographic spread of wheat production areas, while also maximising production in existing areas. Further interventions in flour blending, monitoring and feedback, genomics and social inclusion were also identified as needed. [doi.org/10.1038/d41586-022-00789-x](https://doi.org/10.1038/d41586-022-00789-x).

Heavy summer rains led to severe floods in Pakistan, affecting over 800,000 hectares of land. Rural areas in the southern coastal provinces were hardest hit with water levels remaining high throughout the Indus River system.

Due to flood damage, the estimated direct crop loss by economists stands at around \$2.3 billion. Reports indicated that over 32 million people were displaced by the flooding. [www.cimmyt.org/news/after-the-flood/](http://www.cimmyt.org/news/after-the-flood/).

## 2. SIGNIFICANT NEW NATIONAL/INTERNATIONAL ENGAGEMENT OR PARTNERSHIPS

The theme of the 2nd IWC was “Future Wheat: Resilience and Sustainability” and provided excellent opportunities for participants from around the world to share the latest progress and to develop recommendations for future wheat in terms of research, technology, and transfer. CIMMYT played a key role in coordination and execution of the conference. [www.2022iwc.cn/](http://www.2022iwc.cn/).

## 3. RESEARCH HIGHLIGHTS

Under the Accelerating Genetic Gains in Wheat (AGG), CIMMYT implemented and utilised accelerated breeding infrastructure (rapid generation advancement and screenhouse facilities) at the Toluca Research Station. New breeding schemes incorporating these facilities are now operational. [www.cimmyt.org/projects/agg/](http://www.cimmyt.org/projects/agg/); [www.cimmyt.org/news/plant-breeding-innovations/](http://www.cimmyt.org/news/plant-breeding-innovations/).

CIMMYT has successfully transferred alleles for high zinc and iron from diverse genetic backgrounds into elite wheat lines, and more recently have now integrated this material into the mainstream breeding pipeline, Govindan et al. (2022). [doi.org/10.1016/j.jcs.2022.103473](https://doi.org/10.1016/j.jcs.2022.103473).

Under the IWYP project (<https://iwyp.org/>), CIMMYT scientists and collaborators developed a high throughput method for radiation use efficiency demonstrating a 30-fold capacity increase over existing methods. [doi.org/10.3389/fpls.2022.828451](https://doi.org/10.3389/fpls.2022.828451).

# ONE CGIAR WHEAT (PRE)BREEDING RESEARCH (CIMMYT AND ICARDA)



The modified shuttle breeding scheme at ICARDA involving two cycles in the plastic-house and two seasons in the field (winter and summer seasons) enabled to complete the breeding cycle from crossing to shipment of elite lines to national programs through international nursery in only 4 years. This method enables to test large set of populations under the prevailing biotic and abiotic stresses while shortening the breeding cycle to increase genetic gain. Tadesse et al. (2022).

## 4. WHEAT RESEARCH FUNDING AND NEW RESEARCH PROGRAMMES

In 2022, the new One-CGIAR initiatives commenced. For wheat, CIMMYT and ICARDA participated in:

- Accelerated Breeding Initiative (ABI) [www.cgiar.org/initiative/01-accelerated-breeding/#:~:text=This%20Initiative%20aims%20to%20develop,evolving%20markets%20and%20production%20systems](http://www.cgiar.org/initiative/01-accelerated-breeding/#:~:text=This%20Initiative%20aims%20to%20develop,evolving%20markets%20and%20production%20systems).
- Seed Equal [www.cgiar.org/initiative/06-seedqual-delivering-genetic-gains-in-farmers-fields/](http://www.cgiar.org/initiative/06-seedqual-delivering-genetic-gains-in-farmers-fields/).
- Breeding Resources [www.cgiar.org/initiative/breeding-resources/](http://www.cgiar.org/initiative/breeding-resources/).
- Plant Health Initiative (PHI) <https://www.cgiar.org/initiative/13-plant-health-and-rapid-response-to-protect-food-and-livelihood-security/>.
- CWANA regional Integrated initiative [www.cgiar.org/initiative/fragility-to-resilience-in-cwana/](http://www.cgiar.org/initiative/fragility-to-resilience-in-cwana/).

A hybrid wheat development project using the blue aleurone system has been launched by the University of Sydney involving wheat breeders from Australia, Pakistan, Bangladesh, Ethiopia and ICARDA.

The TAAT II project funded by AfDB and led by ICARDA to out-scale wheat technologies in SSA has been approved.

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# FLORIMOND DESPREZ

## RAGT

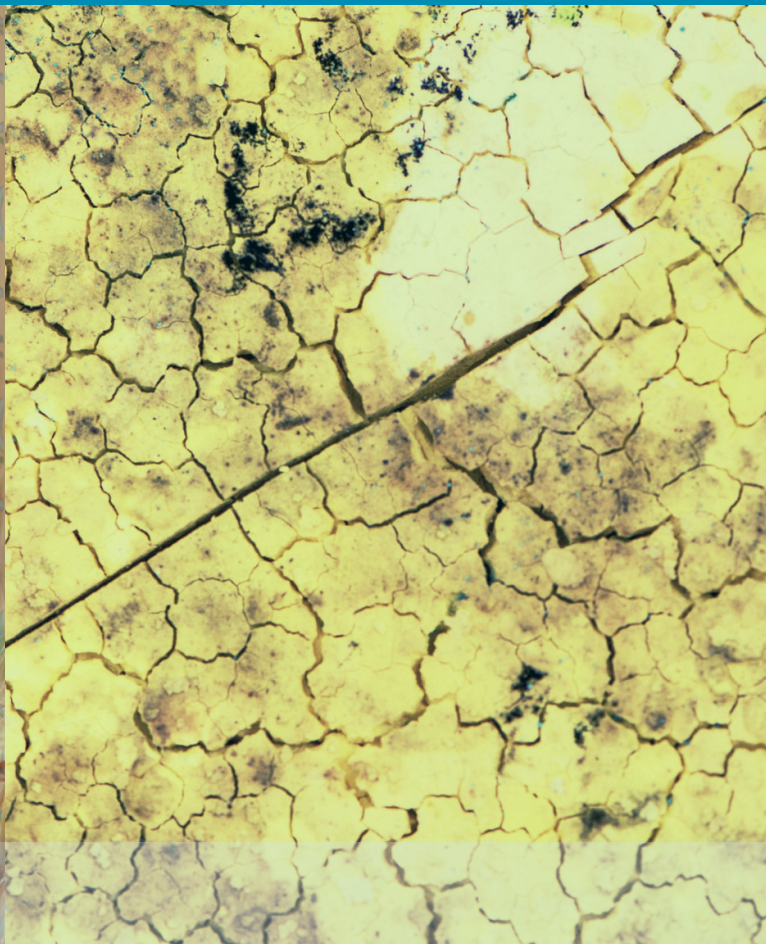


Florimond Desprez is an independent breeding and seed company headquartered in France and has had a long commitment to wheat breeding. Wheat varieties bred by Florimond Desprez are successfully cropped in many European countries as well as in South America and North Africa. Florimond Desprez has a long tradition of teaming up with colleagues from both public and private research and has joined in 2021 the French private-public research consortium PlantAlliance. The current collaborations include works aiming at breeding innovative wheat varieties with sustainable resistances to pests and diseases and also meeting the various market expectations in terms of quality. Florimond Desprez devotes more than 15% of its yearly turnover to Research and Development.



Founded in 1919 and established in all major European agricultural regions, RAGT researches, breeds, produces and sells seeds including wheat, corn, barley, oilseed crops, oats, pulses, forage grass and soil health crops. Innovation is vital to us, and we spend over 15% of our turnover in research, supporting 17 subsidiaries, 17 research stations, 300 scientists and technicians, and 4 multi-species laboratories. RAGT is a leader, with a strong market share for wheat in European markets including France, Germany and the UK. As part of our efforts in wheat research we are involved with international partnerships such as the Wheat Initiative, the International Wheat Yield Partnership (IWYP) and the International Wheat Genome Sequencing Consortium (IWGSC). We believe in collaborative research and are involved in many PhD and post-doctoral research projects with Universities and research institutes, all of which share the aim of providing insight into wheat genetics.

# 4. ASSOCIATED PROGRAMMES

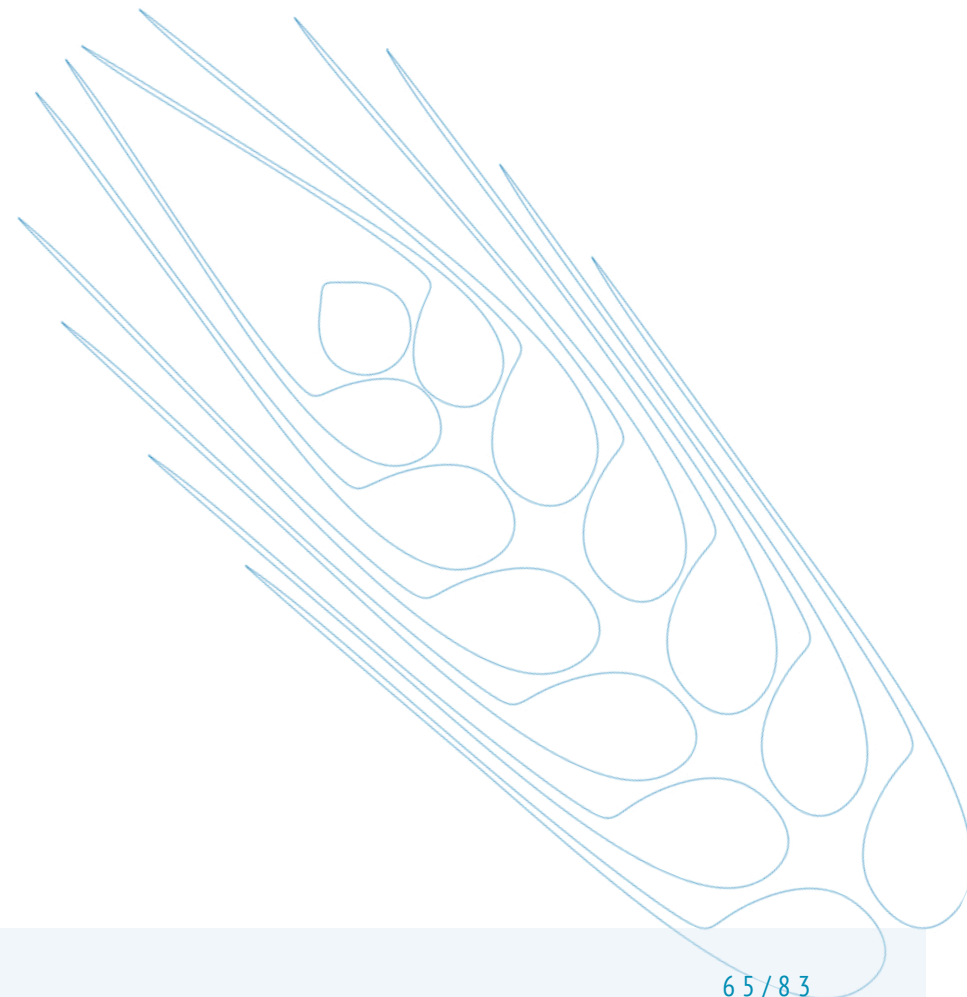




# 10+ WHEAT GENOMES PROJECT



The 10+ Wheat Genomes Project is a global partnership that leverages collaborative expertise and funding with the aim to characterize the wheat 'pan genome'. The 10+Wheat Genomes Project assembled 15 wheat cultivars to improve our understanding of genetic diversity and selection within the pan-genome of wheat (<https://doi.org/10.1038/s41586-020-2961-x>). The Project has now completed its work to develop a wheat functional pan-transcriptome with full de novo gene predictions and differential expression analysis. Analysis of de novo gene annotations are now available in Ensembl Plants (Release 52) and facilitated the discovery of novel genes unique to particular cultivars, including genes absent from Chinese Spring, and copy number variations. The completed de novo annotations improve the definition of the core and shell genome of bread wheat, highlights tissue-specific genes, and reveal changes in sub-genome expression bias between cultivars. This dataset provides a novel resource for the wider wheat community and reveals several important findings about the core and dispensable genome and transcriptional diversity in wheat beyond a single reference genome.



# AHEAD - ALLIANCE FOR WHEAT ADAPTATION TO HEAT AND DROUGHT



Next to other factors, Heat and Drought play a crucial role for food security and stable yields. The development of resilient lines is one way to avert future yield losses and stabilise food chains. However, many questions about useful methods, techniques, and strategies to address this issue globally, remain unanswered. The Alliance for Wheat Adaptation to Heat and Drought (AHEAD) offers a forum for discussion about this topic, to identify synergies and work out strategies to secure future wheat supply under the conditions of a changing climate.

As described in the previous annual reports of the WI, AHEAD has undergone several phases of development. Founded in August 2020 the basic framework was established, and the mission and vision of the network were defined by the Steering Committee and by experts at a workshop in March 2021. The experts identified gaps in research actions on wheat under heat and drought. This was followed by actions to build the network by attracting new members with expert knowledge from many countries. Considerable effort was expended into informing researchers and stakeholders about the AHEAD network, its vision and mission. The AHEAD Global coordinator, Stefanie Hagemann, presented the Alliance at the launch of the Strategic Research Agenda in Berlin in July 2022, as well as at the RC and ICC meetings of the WI and at the Jamboree of the WI in October in Ireland. In addition, the process of writing an Action plan for AHEAD was started. This process began at the AHEAD workshop “Moving AHEAD” in March 2022, where topics were identified to be addressed by researchers, breeders and other stakeholders for the future development of climate resilient wheat lines.

There was discussion about inclusion of climate models into wheat research, phenotyping methods, parameters to identify heat and drought resilient germplasm, and strategies to support young researchers. For these topics, bottlenecks and drawbacks were identified and strategies developed to overcome these issues. Next to defining the topics and content of the action plan highlighted the need for more input from international wheat researchers and experts and it was decided to involve the chairs and members of the Expert Working Groups (EWGs) of the WI into this process. The outline of the Action plan was presented by the Global Coordinator, Stefanie Hagemann at the Jamboree of the WI in October 2022 in Ireland and was discussed with the chairs of the EWGs. Based on the positive feedback from the audience, a survey was designed including questions focussing on wheat germplasm, breeding and the support of young researchers. The survey was distributed by the WI Secretariat to the members of the EWGs in December 2022. Feedback was obtained from researchers from 22 countries and work is currently underway to include this information into the draft Action plan. In addition to receiving useful information for the Action plan, the survey increased interest from several Expert Working Group members to participate in the AHEAD network. AHEAD is happy to welcome several new members. The AHEAD Twitter account (@AHEAD\_wheat) and Website ([www.ahead-wheat.org](http://www.ahead-wheat.org)) are useful tools for informing researchers globally about AHEAD actions.



## Wheat plant and crop modelling

### Collaboration and partnerships

The activities of the Crop Modelling Programme in 2022 have focused on AgMIP-Wheat and aligned with the IWYP Project Modelling Traits for Increasing Wheat Grain Yield. The IWYP partners in this project include: Pierre Martre and Sybille Dueri (INRAE, France), Frank Ewert, Heidi Webber and Tommaso Stella (ZALF), Senthold Asseng (TUM, Germany), Jose Guarin and MD Ali Babar, University of Florida, USA, Matthew Reynolds, Gemma Molero (now KWS) and Diego Pequeno (CIMMYT), Mexico, Benjamin Dumont, ULG, Belgium Hamish E. Brown, Plant and Food Research, New Zealand, Jeremy Derory, Limagrain Europe, France, Roger Sylvester-Bradley and Daniel Kindred, Crop Performance, UK and Jean-Pierre Cohan, ARVALIS, France. In addition, we have been collaborating closely with Daniel Calderini, University of Valdivia, Chile and Daniel Mirrales, University of Buenos Aires, Argentina on field data exchange. About 50 crop modellers from across the world contributed with about 25 wheat crop models and simulations.

### Key research activities

Detailed simulation protocols have been carried out by crop modelling teams with instructions to simulate field experiments in France, NZ and CIMMYT (includes Chile, Argentina and Mexico). In an initial task, 26 groups have participated with process-based crop simulation models. The aim of the simulation exercise was to confront wheat crop models with observed, very high yield and growth data, compare their response to inter-annual variability, sowing date, density,

seasons, Dueri et al. (2022), and varying geographic conditions and crop characteristics, including measured high-yielding traits, Guarin et al. (2022), to understand crop model performance under favourable but varying growing environments. A second task included the simulation of the highest yielding DH lines resulting from a cross between cv. Bacanora and cv. Weebil with improved RUE, light extinction coefficient, grain filling rate, and potential grain size and slightly decreased fruiting efficiency and grain filling duration. In addition, protocols were developed and distributed to the modelling teams to expand the simulations to 34 representative locations across the world for high-rainfall and irrigated wheat environments with daily climate data from the past and for future climate change scenarios to up-scale simulated impacts to the globe. A smaller number of the modellers also simulated additional N supply treatments to explore the interactions of new traits and possible additional crop N demand, Guarin et al. (2022).

In a third task, a crop model was used to explore the potential to close any existing genetic yield gap by genetic improvement and how this could increase crop yield potential and global production. Here we estimated present global wheat, covering all wheat-growing environments and major producers, by optimizing local wheat cultivars using a wheat model. The estimated mean global genetic yield gap was 51%, implying that global wheat production could benefit greatly from exploiting the untapped global gap through the use of optimal cultivar designs, utilization of the vast variation available in wheat genetic resources, application of modern advanced breeding tools, and continuous improvements of crop and soil management, Senapati et al. (2022).

# CROP MODELLING



## Overall project output

The best performing doubled haploid (DH) crosses with an increased canopy photosynthesis from wheat field experiments were extrapolated to the global scale with a multi-model ensemble of process-based wheat crop models to estimate global wheat production. The DH field experiments were also used to determine a quantitative relationship between wheat production and solar radiation to estimate genetic yield potential.

The multi-model ensemble projected a global annual wheat production of  $1050 \pm 145$  Mt due to an improved canopy photosynthesis (761 Mt produced globally in 2020), a 37% increase, without expanding cropping area. Achieving this genetic yield potential would meet the lower estimate of the projected grain demand in 2050.

A closure of any existing genetic yield gap by genetic improvement showed a further yield increase is possible and implied that global wheat production could benefit greatly from exploiting the untapped global gap through the use of optimal cultivar designs, Senapati et al. (2022).

A wiring diagram was proposed by Reynolds et al. (2022) as a platform to illustrate the interrelationships of the physiological traits that impact wheat yield potential to integrate knowledge of the interrelationships of physiological traits impacting wheat yield potentials and their interactions with the crop developmental stages that can be used to accelerate genetic gains through breeding.

These findings suggest that if wheat with improved physiological traits is grown across all high-rainfall and irrigated wheat-producing regions in the world, a potential increase of at least 37% of global wheat production and yield is feasible, as already achieved at sites in Argentina and Chile. There is also basis for doubling global wheat production and yield when only limited by solar radiation, although this is an elusive and immense challenge at the global scale. The 37% increase of global wheat production would meet the lower estimate of the projected future grain demand in 2050, without expanding the current agricultural cropping area.

To achieve this, breeding strategies would need to optimize physiological traits with minimal trade-offs, while additional crop management inputs may be required to maintain such high yields. A newly developed efficiency of incoming radiation capture and use (ERCU) relationship, see Guarin et al. (2022) can be applied as a simplistic upper benchmark, rather like the yield-water use function is routinely used in low yielding rainfed agriculture, but with readily accessible, near real-time global incoming solar radiation data anywhere in the world (<https://power.larc.nasa.gov>).

Farmers, scientists, and policymakers can use the ERCU relationship to benchmark local and regional yield improvements against observed high yields, provide a yardstick for sustainable intensification and potential yield gap analysis, and develop breeding adaptation strategies.

We also have proposed a rationale for crop-model-driven, trait-focused collaborative research for yield improvement. A collaboration of crop modellers, physiologists, geneticists, plant breeders, and system agronomists is proposed to efficiently create genetic improvements that, when taken to the field, will have regional and global yield impacts. The effort will require a large, internationally integrated science project and related infrastructure. The proposed integrated research is applicable to explore traits and trait combinations and could become a model for yield improvements for major food crops, Asseng et al. (2019).

# CROP MODELLING

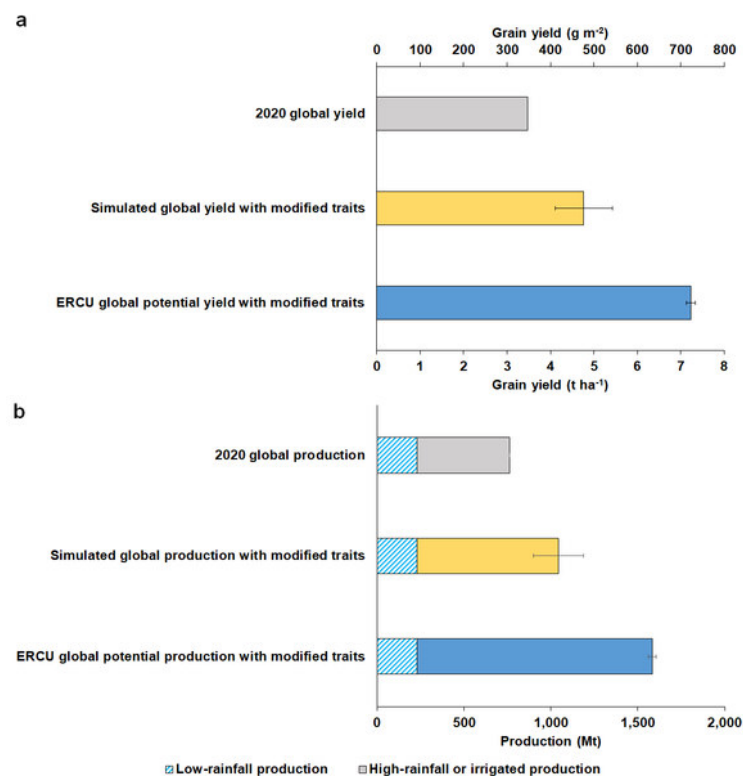


Figure: Potential global yield and production under different high-yielding scenarios. Bar plots show global wheat (a) average yield and (b) production based on the latest reported FAO statistics for 2020 and the results of simulations aggregated from a multi-model ensemble median of 26 wheat crop models for 34 high-rainfall or irrigated AgMIP locations around the globe using modified cultivar traits, and the potential based on yield gaps determined from the efficiency of incoming radiation capture and use (ERCU) relationship.

Total global production is the sum of global low-rainfall production and global high-rainfall or irrigated production. Global yields were calculated by dividing the total global production (including the unimproved yields in all low-rainfall regions, approximately 30% of the global wheat area) by the total global wheat area harvested. Error bars for the simulated production with modified traits scenario indicate standard deviation from annual and model variation. Error bars for ERCU potential production with modified traits scenario indicate standard deviation from yield gaps between the ERCU upper limit and baseline simulated scenario. All production and yields shown are with a commercial moisture content of 13%. After Guarin et al. (2022).

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# GENOME SEQUENCING CONSORTIUM (IWGSC)



Founded in 2005, the IWGSC is dedicated to delivering high quality, platinum standard reference genome sequences of bread wheat and sequence-based resources for the accelerated development of improved varieties. Through an enhanced understanding of the molecular basis of key agronomic traits and the deployment of molecular breeding technologies, wheat producers and the wheat industry will be able to meet the demands for sustainable and profitable wheat production. The IWGSC is a 501(c)(3) non-profit organization registered in the United States.

## Board of Directors in 2022

- Kellye Eversole (IWGSC Executive Director and chair of the Board of Directors)
- Rudi Appels (University of Melbourne, Murdoch University & AgriBio, Australia)
- Ute Baumann (University of Adelaide, Australia)
- Hikmet Budak (Montana BioAg Inc, USA)
- Chris Burt (RAGT Seeds, United Kingdom)
- Pierre Devaux (Florimond Desprez, France)
- John Jacobs (BASF, Belgium)
- Yann Manès (Syngenta, France)
- Pierre Sourdille (INRAE, France)

## Coordinating Committee:

59 members from academia and industry who develop the strategic objectives of the consortium and requirements for IWGSC projects.

Number of members: 3,400 in 72 countries, representing 929 institutions/companies.

## 2022 activities and progress

- IWGSC RefSeq Assembly and Annotation v2.1  
The latest versions of the Chinese Spring reference sequence (IWGSC RefSeq v2.1) and IWGSC RefSeq annotation v2.1 are publicly available at the IWGSC data repository at URGI-INRAE Versailles, France, at <https://wheat-urgi.versailles.inra.fr>.
- Genomics Tools  
As part of the IWGSC ongoing collaboration with Daicel Arbor Biosciences, a new improved and expanded regulatory capture panel for promoters and other regulatory elements in wheat was developed. The panel was designed by Jorge Dubcovsky and Junli Zhang at UC Davis (USA) in collaboration with Jacob Enk at Daicel Arbor Biosciences and researchers from INRAE (France). An article describing the panel was published in The Plant Genome <http://doi.org/10.1002/tpg2.20296>.
- Wheat Diversity project  
In this project, the IWGSC plans to produce platinum quality sequences of 12 landraces and a new version of IWGSC Chinese Spring RefSeq (v3.0).
- Webinar series  
The IWGSC organized eight webinars, with a record attendance from all over the world. The webinars showcase research results, tools, and resources. They are free to attend, and the recordings are posted on the IWGSC YouTube channel to allow access for people who cannot attend the live event. <https://www.youtube.com/c/internationalwheatgenomesequencingconsortium>
- Early Career Award  
Each year, the IWGSC recognizes promising early career scientists working on wheat. The award is now called the “IWGSC and Catherine Feuillet Early Career Award” and was awarded in 2022 to Daniela Miller, PhD Candidate in Crop Science at North Carolina State University (USA).

For more information on the IWGSC, visit <https://www.wheatgenome.org/>

# IWYP (INTERNATIONAL WHEAT YIELD PARTNERSHIP)



Research to Deliver Wheat for the Future

## Background and Strategy

Recent geopolitical events have reinforced the importance of maintaining robust global wheat supply chains. Climate change and its impacts have also dominated the news. Funders now emphasize the need for higher yielding, climate resilient wheat varieties. These factors underpin the value and need of IWYP as a leading public-private-academic integrator of wheat research leading to yield enhancement. IWYP has completed its 8th year. Over this period an enormous number of scientific discoveries have been made that may potentially positively impact wheat yield improvement. Many are described in the list of over 170 IWYP-linked publications (<https://bit.ly/3YCHsYj>). IWYP outputs include new knowledge and tools for wheat breeding and novel higher yielding trait-improved lines, useful as parents in breeding programs globally.

While IWYP continues to learn about the genetics and expression of novel source and sink traits, their interactions and their impact on wheat yield, it continues to improve our understanding of which traits, singly or combined, are important candidates to achieve significant yield improvement. Therefore, IWYP pursues two parallel germplasm improvement strategies, in both spring and winter wheats. The first takes genes/QTL with known effects and moves these traits into elite lines using marker-assisted back crossing (MABC). The second combines genetically complex physiological traits in new high yielding IWYP genetic backgrounds using trait-specific phenotypic assays and/or markers rather than converting these traits into genetically simpler subcomponent traits before combining them.

All lines are evaluated in field trials and distributed to breeding programs around the world as novel sources of parents. The genetic basis of preferred, yield-enhancing complex traits can then be dissected from application of marker technologies to the populations of phenotyped lines if desired.

Selected progress and activities that IWYP has made over the past year is found in the IWYP Annual Report <https://iwyp.org/annual-report/>.

## Recent Discovery Research/Application Highlights

- 3 marker-trait associations for novel favourable alleles introduced into wheat from a wild wheat relative increase yield under heat stress by up to 50%, with no yield penalty under optimal conditions. This provides new genetic tools to maintain or improve yields in seasons with excessive heat.
- Different combinations of alleles of newly discovered phenology genes are being used to tailor crop development in different environments to improve yield.
- Wheat lines containing favourable introgressed alleles for floral characters, targeted for more efficient hybrid seed production systems, are being evaluated in elite backgrounds.
- Novel robust methods to integrate phenomics and genomics data are being applied in the field to better evaluate single plants in plots in the early generations of a breeding program.
- Results suggest at midday plants reach photosynthetic saturation, and a transient up-regulation of thousands of genes occurs, transiently activating photorespiration. Exploiting novel variation in these genes may help optimize photosynthetic efficiency.

# IWYP (INTERNATIONAL WHEAT YIELD PARTNERSHIP)



## Update on Progress at the IWYP Translation and Development Hubs Bringing New Trait Variation into Elite Breeding Lines

North American Winter Wheat Breeding Innovation Hub at KSU (USA)

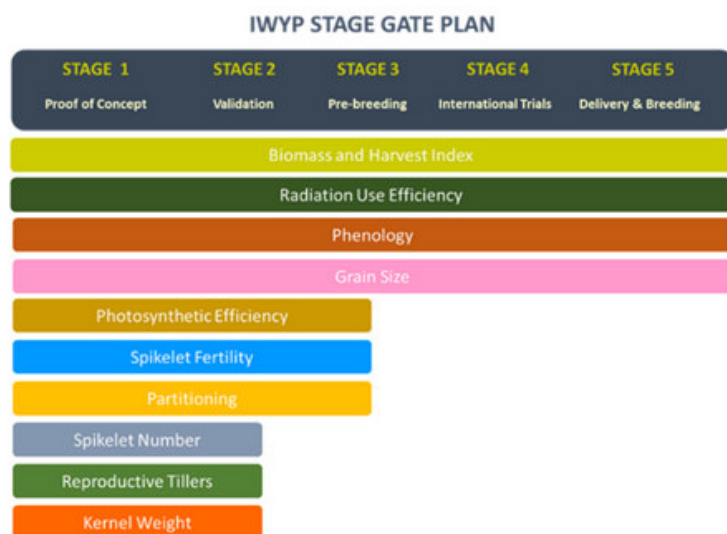
- Marker-assisted backcrossing (MABC) of 10 yield enhancement traits to 11 recipient elite parents has progressed. For non-gene edited crosses, several rounds of backcrossing have already been achieved. These new populations will be evaluated in field trials in the next 2 years.

European Winter Wheat Hub at NIAB (UK)

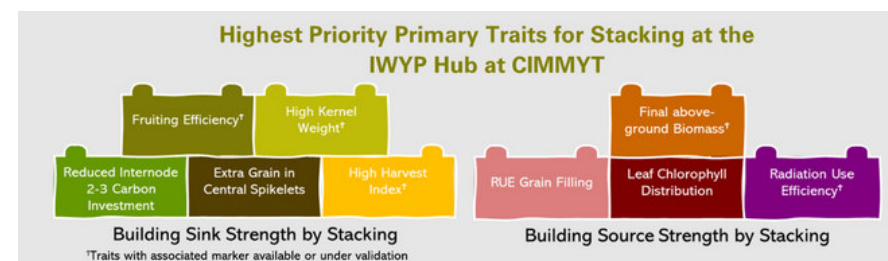
- Seed of lines converted using MABC for traits suitable for hybrid wheat breeding will be offered to wheat breeders for evaluation and validation in 2023-24. A second cycle of MABC has been initiated with three new IWYP yield traits (photosynthetic efficiency, fruiting efficiency, harvest index).

Spring Wheat Hub at CIMMYT

- Over 2 dozen new trait variants are progressing through the pipeline, including source traits (eg radiation use efficiency, biomass, canopy temperature, roots), sink traits (eg fruiting efficiency, various grain characters, spikelet number) and traits linked to crop development in specific environments (see illustration of the IWYP Stage Gate Plan).
- The Hub continued to stack different complex traits for source and sink to maximize source strength linked to optimal sink strength (see illustration) in lines for use as potential parents.
- Many new lines selected for international field trials in 2022/23 contain introgressed QTL for improved grain characters discovered in IWYP Research Projects.
- Lines containing improved IWYP yield-enhancing traits were delivered to the CIMMYT bread wheat breeding program including traits previously absent from CIMMYT elite breeding material.



Some IWYP traits currently represented in the IWYP Stage Gate Plan used by the IWYP Hub at CIMMYT





# IWYP (INTERNATIONAL WHEAT YIELD PARTNERSHIP)



## Deliveries to Date

- A large public-private-academic partnership including ~150 scientists from 60 research institutions in 14 countries.
- More than 170 scientific peer-reviewed articles.
- ~ 3 dozen new trait variants transferred to the IWYP Hubs from discovery programs for validation and translation into high yielding genetic backgrounds.
- ~300 new higher yielding lines with novel traits delivered for yield testing around the world.
- More than 100 new molecular genetic markers useful for breeding.
- 25 new breeding tools and protocols.
- 5 new high yielding wheat varieties released in resource-poor countries, with more in the product development programs of these countries.
- 3 important scientific articles presenting the latest understanding of the processes determining grain yield in the form of “Wiring Diagrams” (see references).

## Progress Towards Enabling Breeding Programs to Achieve Greater Yield Gains

- IWYP evaluates its trait-combined selections and genetic backgrounds in which they are selected by yield trials conducted in environments globally, along with detailed phenotypic measurements at the CIMMYT Hub.
- These results indicate that combining yield subcomponents is a valid strategy to provide breeders with novel high yielding parents. Breeders need to consider many additional market-specific traits so we do not expect them to immediately realize this level of additional gain, therefore IWYP must continue pushing gains higher through additional trait improvements.
- The results also indicate that yield improvements occurred across a range of environments. Under optimal/high yielding environments, the rates of yield improvement exceeded the average over all sites with a year-on-year improvement of 2.8%. Under low yielding environments, an increase of 1.4% yield year-on-year improvement was observed.

The latter results suggest that IWYP outputs have a positive impact on yield in environments with greater variation in abiotic stresses and/or where fewer agricultural inputs are applied.



## IWYP Impacts

- Added technical value and insight being disseminated into the wheat breeding communities, from multidisciplinary international research teams.
- New tools and techniques starting to be adopted by wheat breeders.
- The education and training of the next generation of crop scientists and breeders in many countries
- Communication of research progress through Science Briefs, Annual Reports and other Publications.
- Better understanding of the role of specific traits in determining grain yield.

## Important New Publications

Reynolds MP, Slafer GA, Foulkes MJ et al. (2022) A wiring diagram to integrate physiological traits of wheat yield potential. *Nat. Food*, doi.org/10.1038/s43016-022-00512-z

Murchie EH, Reynolds MP, Slafer GA, et al. (2023) A ‘wiring diagram’ for source strength traits impacting wheat yield potential, *J. Exp. Bot.*, doi.org/10.1093/jxb/erac415

Slafer GA, Foulkes MJ, Reynolds MP et al. (2023) A ‘wiring diagram’ for sink strength traits impacting wheat yield potential, *J. Exp. Bot.*, doi.org/10.1093/jxb/erac410

# 5. WI SECRETARIAT INSIGHTS



# WHEAT INITIATIVE COMMUNICATION



In 2022, the communications area of the Wheat Initiative supported online events as in previous years, but now that Covid-19 restrictions have eased, support was focused on major face-to-face events. The major events for the year were the launch of the updated WI Strategic Research Agenda and the Jamboree in Ireland, where all the WI committees met. The WI had a presence at the From Seed to Pasta 4 Congress in Bologna, Italy, with a WI booth, where the wheat community could meet with the WI Secretariat.

The communications strategy used the tools of the Newsletter, the Media Brief, and the Twitter account to promote and report on the activities of the WI. The usage of these tools continues to evolve, and the numbers are constantly improving.

## NEWSLETTER

The WI newsletter continued to be sent out quarterly in January, April, July and October. A special “End of the Year” edition, sent in December, gave a review of 2022. The opening rate in 2022 stayed well above average with 35% (according to MailChimp, our newsletter tool, the average newsletter opening rate lies at 23%). The Wheat Initiative’s newsletter performed very well in 2022.

The December edition presented 918 successful deliveries that is 97.1% of the audience at that time. Our average campaign performance is 42.8% (our peers’ average performance 42.1%). The newsletter gained more than a 100 new subscribers in 2022, making 935 subscribers by 31 December 2022.

## MEDIA DIGEST – WHEAT IN THE MEDIA

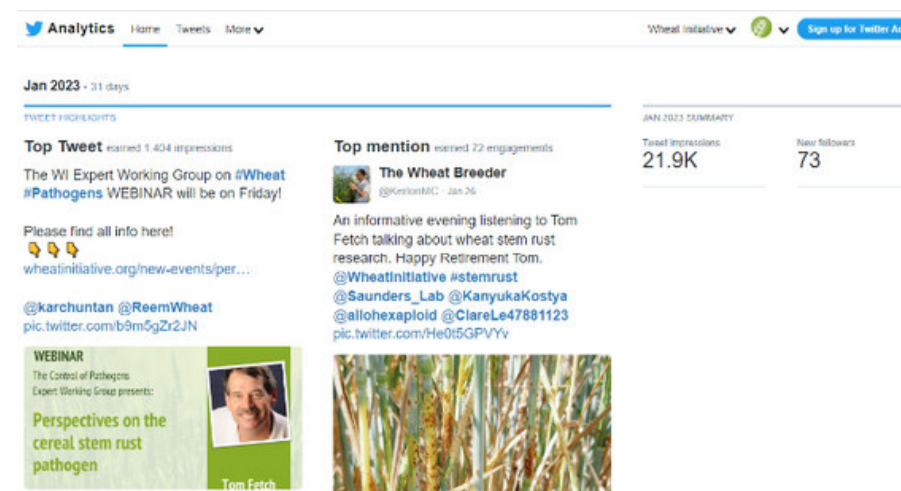
The weekly media digest continued being sent out on Fridays by the Genome Canada Programme 4D: Diversity, Discovery, Design and Delivery, with the great support of Raelene Regier.

Wheat in the Media presents a collection of the latest news articles and publications in wheat. The Wheat Initiative uses a specialized media-monitoring tool to scan diverse media sources for information. In December 2022, a transition and optimisation process was kicked off to enhance the quality of the media brief. Total number of subscribers in December 2022: 392.

## TWITTER

The Wheat Initiative’s Twitter account is used every weekday to highlight research or industry related topics such as wheat news, relevant job opportunities, and research projects, funds, sharing publications of interest and of our members. The platform is also used to promote the Wheat Initiatives own events, newsletter, videos, projects and virtual workshops.

The Wheat Initiative has had great success in 2022 by reaching the 4000 followers mark. Total numbers of followers on December 31, 2022: 4074.



# WHEAT INITIATIVE COMMUNICATION



## WEBSITE

Dynamic changes to the website kept pace with events, grants and video meetings and workshops. <https://www.wheatinitiative.org/>  
Our website main page has been used to make important announcements, including:

### Video Competition:

Announcement and publication of the winners of the 2021 Video Competition was completed early in 2022.  
<https://www.wheatinitiative.org/videowinner>

### Statement

The Wheat Initiative will continue to support wheat researchers, breeders, and producers around the world to build a better future for all.



### The Virtual Durum Meeting (VDM):

The VDM VIDEO GALLERY was organised to publish the recordings of the meetings of our EWG on durum wheat, it has been updated:  
[www.wheatinitiative.org/virtual-durum-meeting-videos](http://www.wheatinitiative.org/virtual-durum-meeting-videos)

### Strategic Research Agenda:



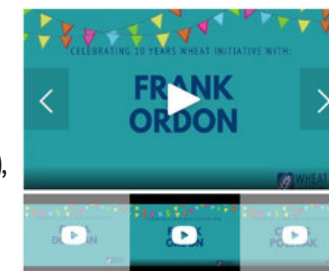
**THE STRATEGIC RESEARCH AGENDA 2022**  
The Wheat Initiative has published its Strategic Research Agenda and launched it on July 5th 2022. The Wheat Initiative is presenting the Strategic Research Agenda that highlights the current global wheat research challenges and provides a strategic roadmap. The agenda includes the current wheat research priorities, the wheat research goals, needs and industry recommendations to identify the key actions to advance wheat security and productivity and to improve wheat.  
In addition to providing a vision for the future, the agenda also looks at what has been achieved since the previous agenda was launched in 2012. Wheat production across the world has increased, but it faces numerous challenges, in particular through the impact of an increasing number of climate and political conflicts. Addressing these challenges requires that wheat research focuses on the most important wheat research challenges of the future. It is clear that wheat is one of the most important crops in the world and that it is essential to ensure that it is produced in a sustainable and secure way. The agenda provides a clear vision for the future of wheat research and a roadmap for the industry and researchers to follow.

The online publication of the SRA was part of the official launch on 5 July 2022. The 2022 SRA is available since then in our website.  
<https://www.wheatinitiative.org/2022-strategic-research-agenda>

## 10 YEAR Celebrations

The celebrations of the 10th anniversary of the Wheat Initiative started in September 2021 and ended in September 2022, during the 2nd International Wheat Congress with the production and publication of four inspiring and supportive videos from members of our committees: Jean François Susanna (INRAe, France), Fiona Doohan (University College Dublin, Ireland), Curtis Pozniak (University of Saskatchewan, Canada) and Frank Ordon (Julius Kühn Institut, Germany), as well as with a collection of memories from the past 10 years.  
[www.wheatinitiative.org/anniversary](http://www.wheatinitiative.org/anniversary)

CELEBRATING 10 YEARS WITH ...



## WheatVIVO - <https://wheatvivo.org>

WheatVIVO is an open access database that was officially launched in November 2021. It enables users to search for researcher's profiles, organisations, publications and projects. WheatVIVO celebrated its 1st anniversary in November 2022 and feedback is welcome from users via a satisfaction survey on the website or by emailing: [wheatvivo@julius-kuehn.de](mailto:wheatvivo@julius-kuehn.de)

WHEATVIVO CELEBRATES ITS 1-YEAR ANNIVERSARY! CONGRATULATIONS WHEATVIVO!!!



# WHEAT INITIATIVE COMMUNICATION



## LIVE EVENTS

### The launch of the SRA

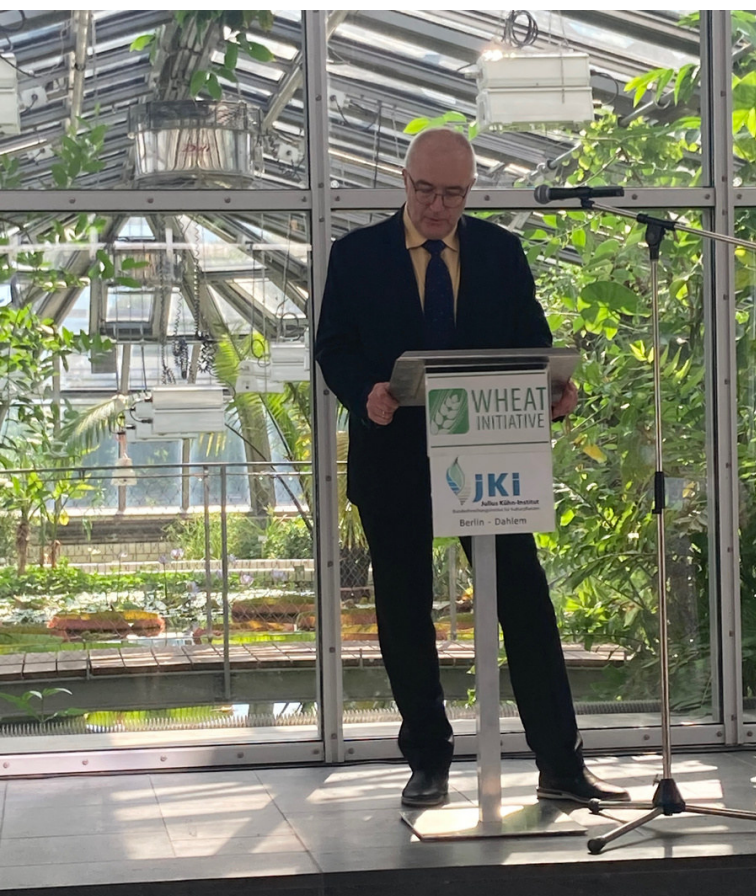
The SRA launch was the first live event in over two years. The event took place in Berlin at the Botanical Gardens with members and representatives of member countries, agricultural attachés and representatives of embassies in Berlin and members of the WI Scientific Board. Remarks were given by Dr Burkhard Schmied, Head of the Agricultural Production, Horticulture, Agricultural Policy Department of the German Federal Ministry of Food and Agriculture.

### The WI Jamboree

The meeting in Carlow, Ireland, was a great success and a great opportunity to meet committee members in person.

### From Seed to Pasta IV

The WI participation at the From Seed to Pasta Congress was well received, as well as the launch of the Early Career Researchers Programme during it. It was a great success!



# FINANCIAL STATEMENT 2022



## Financial Report 2022

The budget of the Wheat Initiative relies on the annual membership fees of its members, and exceptional contributions. This revenue is used to cover the activities of the Wheat Initiative.

The Wheat Initiative is administratively embedded in the JKI as Managing Institution. Consequently, all funds are managed by the JKI finances section according to the JKI rules, and therefore, under the German Ministry of Agriculture guidelines.

Since 2019, the budget has been managed on a cash basis.

This section is a condensed version of the 2022 Annual Financial Report which includes a summarisation of the financial activities from 1 January to 31 December 2022.

## Financial Key Points

- The Wheat Initiative Secretariat posted a budgetary deficit of -17,783 Euros for 2022, compared to an estimated deficit of -381,392 Euros, due to underspending of the budget in many areas.
- When the 2021 Carry forward of 838,012 Euros is included, the Wheat Initiative had a positive balance on 31 December 2022 of 820,229 Euros.

Table 1: Wheat Initiative Income and Expenditure Summary 2022 (Cash Basis-Euros) | 1 January 2022-31 December 2022

1. The income received is less than the budgeted amount, due to the Korean membership fee being paid in 2021 (showing in 2021 income) and the USA membership fee not received, due to administration issues.
2. Exceptional contributions include BMEL support to Wheat Initiative salaries of 150,000€ and JKI Support for the AHEAD Coordinator (.3).
3. Personnel expenditure includes: 1.0 Program Manager (January - December 2022); 1.0 Foreign Language Secretary (March - December 2022); 0.5 Communications Manager (February - December 2022); 0.5 Chair of Scientific Board, International Science Coordinator (January - December 2022); 0.3 AHEAD Coordinator (January-December 2022)
4. WheatVIVO Support includes technical support and cloud services for the WheatVIVO database. Some invoices for 2022 services will be paid in 2023.

Table 1:

Revenue	Budget 2022	Closing 2022
Membership fees 2022	179,000	158,982
Exceptional contributions (2)	174,750	171,891
<b>Total Revenue 2021</b>	<b>353,750</b>	<b>330,873</b>
<b>Expenditure</b>		
<b>Secretariat</b>		
Personnel (3)	256,442	238,124
Travel Reimbursements (WI Staff)	40,000	5,815
Communication	13,000	12,587
Consumables	1,700	650
Equipment	1,000	277
WheatVIVO support (4)	6,000	3,948
AHEAD – Consumables	25,000	916
WATCH-A	25,000	-
WI support (5)	50,000	54,935
Staff Training	5,000	284
Contingency (6)	20,000	3,995
<b>Expert Working Groups Expenses</b>		
Expenses for 2021 activities (7)		17,021
Expenses for 2022 Activities (8)	150,000	3,500
	122,000	3,604
<b>Meetings &amp; Workshops (9)</b>	20,000	3,000
<b>Education &amp; Training (10)</b>		
<b>Total Expenditure 2022</b>	<b>735,142</b>	<b>348,656</b>
<b>Balance 2022</b>	<b>-381,392</b>	<b>-17,783</b>

5. WI Support is for 0.6 Finance, IT and Research Coordination Officer (January – December 2022). Actual is higher than the budgeted amount due to exchange rate fluctuations.
6. Expenses related to hosting the Strategic Research Agenda launch in Berlin in July 2022.
7. Expenses related to 2021 Durum EWG budget for Open access publications and Sponsorship of Seed to Pasta conference.
8. Expenses for 2022 EWG activities related to AWAS/Phenotyping awards.
9. Expenses related to Scientific Board meeting in July in Berlin and Jamboree in October in Ireland.
10. Expenses related to 4x Carlotta awards presented at the FSTP4 Congress.



## ABBREVIATIONS

<b>AAFC</b>	Agriculture and Agri-Food Canada	<b>GRDC</b>	Grains Research and Development Corporation
<b>AFBI</b>	Agri-food & Biosciences Institute	<b>GWHD</b>	Global Wheat Head Detection
<b>AGG</b>	Advances in Genetic Gains (for Maize and Wheat)	<b>GxExM</b>	Genotype X Environment X Management
<b>AHEAD</b>	Alliance for Adaptation of Wheat to Heat and Drought	<b>HeDWIC</b>	Heat and Drought Wheat Improvement Consortium
<b>ANR</b>	The French National Research Agency	<b>HMW-GSs</b>	high molecular weight glutenin subunits
<b>APR</b>	Adult Plant Resistance	<b>ICARDA</b>	International Centre for Agricultural Research in the Dry Areas
<b>AVR</b>	Agriculture Victoria Research	<b>ICC</b>	Institutions' Coordination Committee
<b>AWAS</b>	Adaption of Wheat to Abiotic Stress	<b>ICRISAT</b>	International Crops Research Institute for the Semi-Arid Tropics
<b>BBSRC</b>	Biotechnology and Biological Sciences Research Council.	<b>INRAE</b>	Institut National de la Recherche Agronomique
<b>BMEL</b>	Bundesministerium für Ernährung und Landwirtschaft	<b>INVITA</b>	INnovations in plant Variety Testing in Australia
<b>CIMMYT</b>	Centro Internacional de Mejoramiento de Maíz y Trigo	<b>IPPN</b>	International Plant Phenotyping Network
<b>conacyt</b>	Consejo Nacional de Ciencia y Tecnología	<b>IPPS</b>	International Plant Phenotyping Symposium
<b>CSIRO</b>	Commonwealth Scientific and Industrial Research Organisation	<b>ITPRFA</b>	International Treaty on Plant Genetic Resources for Food and Agriculture
<b>CWANA</b>	Central and West Asia and North Africa	<b>IWC</b>	International Wheat Congress
<b>DFW</b>	Designing Future Wheat	<b>IWGSC</b>	International Wheat Genome Sequencing Consortium
<b>ECR</b>	Early Career Researcher	<b>IWWIP</b>	International Winter Wheat Improvement Programme
<b>EWG</b>	Expert Working Group	<b>IWYP</b>	International Wheat Yield Partnership
<b>FEWG</b>	Funding Expert Working Group	<b>JIC</b>	John Innes Centre
<b>FFAR</b>	Foundation for Food and Agriculture Research	<b>JKI</b>	Julius Kühn Institute
<b>FHB</b>	Fusarium head blight	<b>LMA</b>	Late maturity alpha-amylase
<b>FSOV</b>	French Funds to support Plant Breeding	<b>LR</b>	Leaf rust
<b>FSTP</b>	From Seed to Pasta	<b>MARPLE</b>	Mobile and Real-time PLant disEase
<b>GDP</b>	The Global Durum Wheat Panel	<b>MCGP</b>	Morocco Collaborative Grants Programme
<b>GM</b>	Genetic modification		



## ABBREVIATIONS

<b>MoBiDiv</b>	Mobilising and selecting intra- and inter-specific crop diversity for systemic change towards pesticide-free agriculture	<b>STB</b>	Septoria tritici blotch
<b>NAPPN</b>	North American Plant Phenotyping Network	<b>TERTIUS</b>	Genome-based strategies to use the tertiary gene-pool for breeding of climate-smart wheat
<b>NARO</b>	National Agriculture and Food Research Organisation	<b>TGC</b>	Tetraploid wheat Global Collection
<b>NIASM</b>	National Institute of Abiotic Stress Management	<b>TGW</b>	Thousand grain weight
<b>NSFC</b>	Natural Science Foundation of China	<b>TS</b>	Tan spot
<b>NUE</b>	Nutrient use efficiency	<b>UBC</b>	University of British Columbia
<b>OECD</b>	Organisation for Economic Co-operation and Development	<b>VDM</b>	Virtual Durum Meeting
<b>OG</b>	Operational Groups	<b>WB</b>	Wheat blast
<b>PM</b>	powdery mildew	<b>WheatIS</b>	Wheat Information System
<b>PUE</b>	phosphorus use efficiency	<b>WI</b>	Wheat Initiative
<b>QTL</b>	Quantitative trait locus	<b>WUE</b>	Water Use Efficiency
<b>RAGT</b>	Rouergue, Auvergne, Gévaudan, Tarnais	<b>YDV</b>	Cereal aphids/yellow dwarf viruses
<b>RC</b>	Research Committee	<b>YR</b>	Stripe/yellow rust
<b>ReVaViLoVGra</b>	Recovery and valorisation of old local Venetian varieties of soft wheat		
<b>SAB</b>	Strategic advisory board		
<b>SB</b>	Scientific Board		
<b>SB</b>	Spot blotch		
<b>SMTA</b>	Standard Material Transfer Agreement		
<b>SNB</b>	Septoria nodorum blotch		
<b>SNP</b>	Single nucleotide polymorphisms		
<b>SONACOS</b>	National Seed Marketing Company		
<b>SR</b>	Stem rust		

## NOTE OF THANKS

### THANK YOU!

2022 was a challenging year with big changes across the world as we adapted to shifting health, environmental and political issues. The importance of wheat and alternative food sources for food security was evident and shone the spotlight on the role of the wheat community in supporting global food security.

We are very proud and thankful that the wheat community came together to address these challenges. A big thanks for the effort and resilience you have shown and demonstrating the importance of wheat research.

We would like to thank particularly our Expert Working Group Chairs, Co-Chairs and all Expert Working Group members for their dedication and commitment to wheat research and for their hard work in 2022.

Our community provides a model for others to follow, and bringing the new generation of researchers into the community is a task that our EWGs have embraced. We are pleased that our Early Career Researcher Programme will help support the new generation.

We cannot forget to thank our invaluable WI member countries, organization, and industry members for their support to the WI and the wheat community. Thank you for belief in our work.

Special thanks are owed to our host: the Julius Kuehn Institute, the Federal Research Centre for Cultivated Plants (Bundesforschungsanstalt für Kulturpflanzen) and the German Federal Ministry of Food and Agriculture.

In this note, Scientific Board members cannot be forgotten. Your time and the expertise you provide has been critical. We appreciate your commitment and continued support. Thanks!

A note of thanks also to our Research Committee members and Associated Programmes. Thanks for helping support global research collaboration.

Finally and importantly, we would like to thank you, our readers, for your interest in the Wheat Initiative and in reading our Annual Report 2022.





THANK YOU FOR READING OUR ANNUAL REPORT

