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In 2018, WHEALBI project is coming to the end, at least officially. A closing annual meeting was organized in Edinburg UK, 24-25 October. Partners draw a survey of what has been achieved and what remains to be worked out, particularly for valorizing our results through publications and dissemination to stakeholders. In WP1, 512 barley and 512 wheat varieties of the WHEALBI panels have been (most) made available through INRA and IPK gene banks, together with passport data. Evaluation data in the “garden experiment” from WP3 will also be available soon on

<https://wheat-urgi.versailles.inra.fr/Projects/Whealbi>.

Barley and wheat EXOME data from WP2 data have been exploited with the most recent approaches of population and quantitative genetics to infer the evolutionary history, domestication and selection effects on spatial and temporal structure of diversity and identify key genes for adaptive traits along the evolution of modern wheat and barley varieties. Two major manuscripts describing the results have been submitted in high standard scientific journals. Evaluation data in the field and in controlled conditions for disease, frost and drought tolerance, canopy development and adaptive phenology have also been analyzed together with polymorphisms in candidate genes to identify useful association. Particularly, a list of accessions with new resistance or tolerance to the main diseases will be delivered. A new software was developed in WP4 to achieve genome-wide association studies (GWAS) and genomic predictions with multi-environment data. Pending work in WP5 should identify new genes or haplotypes involved in resistance and other adaptive traits such as frost and drought tolerance, which would lead to new publications and disseminations in the coming years. Other deliverables are newly developed pre-breeding

materials in WP6, such as barley and wheat lines with introgression of alien (other species) or exotic (e.g. old landraces) genetic materials into modern lines, which are easier to use in applied breeding programs. These newly developed materials have been characterized for both agronomic traits and molecular markers, and a list of best adapted lines selected from phenotypic and molecular data is being delivered. Extensive results of management trials in WP7 have been delivered. These trials were conducted in UK, Hungary and Italy with a subset of diverse barley and wheat lines to identify ideotypes most adapted to conservation agriculture or organic farming. WP7 also delivered a list of candidate traits and ideotypes for improving wheat adaptation and stability identified using SirrusQuality2 model. Finally, 6 trainings plus numerous dissemination events have been organized, such as the college project. 15 videos explaining the aims, goals and intermediate achievements of the project are available (https://www.youtube.com/watch?v=fH_6cmtZ7wk).

A final conference was organized in Edinburgh 24-25th of October, attended by 70 persons all over Europe, and a final stakeholder meeting with members of the EU commission is organized in Brussels, December 4th, hosted by the European Seed Association.

Overall, we can say this project was successful in delivering a highly valuable corpus of data as a legacy for research and breeding. Particularly, exome data of 1000 accessions is the largest dataset produced to date worldwide, and we are proud that WHEALBI data have already been requested by numerous research consortium. It has been a pleasure, all along these five years, to be the coordinator of the WHEALBI project and to work with all the partners, and we wish to find other opportunities to keep working together.

Gilles Charmet, WHEALBI coordinator



Group picture at the Final Whealbi Conference, Edinburgh, 24th of October



Meeting Whealbi Consortium

We are now at the end of the WHEALBI project and each Work Package leader was interviewed to answer different questions about the main output obtained, the best and worst memories with the consortium, what they would two differently 5 years back and what drives their motivation...

"The main output of WP1 was selecting, collecting, and distributing the genetic resources used for all downstream activities of the project. The best memory is clearly the strong collaborative spirit, and as a bad point, I would say that the project wanted too much. If I was 5 years back? I would focus on one crop and thus use the resources of the project in a more focused manner. And probably implement a better tracking of the material. What next? We need to turn this work into profit for the crop innovation and have more systematic approaches for assessing the potential of genetic resources."



Nils Stein, WP1 leader, Group Leader at IPK Gatersleben

"The main output of WP2 was the identification of several million SNPs for both wheat and barley using gene capture sequencing. Discussions with the consortium during the different meetings were really rewarding. If I was 5 years back? I would realise that generating this much data takes longer than we think, and don't underestimate the time it takes to complete tasks in such a large and diverse group of colleagues. But I was worth the effort! Now, we should start using the data in meaningful ways by adding functionality and developing new cultivars tailored to different climatic zones."



Joanne Russell, WP2 leader, Barley geneticists at the James Hutton Institute in Dundee

"WHEALBI has achieved results far beyond the capacity of any single partner. WP3 has successfully managed to carry out a coordinated phenotyping of about 1000 accessions across 5-6 partners for about 20 different traits. The data produced have linked the genotypic information with a «real plant field behaviour» making genomics a tangible result. WHEALBI has developed a large legacy (germplasm + genotypic data + phenotypic data), and as a follow-up we need to promote the full exploitation of this legacy till final breeding results. If I had to redo it today, I will choose an extremely different germplasm panel as the one we have used, contains a lot of diversity but for some analysis/traits a less diverse material could have been better. My worst memory? The difficulties to transfer seeds to Israel (diseases analysis and quarantine) that have limited some phenotyping work for drought tolerance. My motivation? The discovery of novel genes/traits and see them in the fields 10 years later."



Luigi Cattivelli, WP3 leader, wheat and barley geneticists

"The main output obtained in my WP I am the most proud off? Data base with exome sequences and phenotypic data of 500 wheat and 500 barley genotypes. Statistical model to analyse multi-environment and multi-trait data using the exome sequences to identify the genetic basis of adaptation. My best memories with the consortium were the progress meetings. They were always highly scientific with touristic fun (Salsomaggiore, Haifa, Edinburgh)! More seriously creating such complementary multidisciplinary teams for collaboration allows everyone to benefit and learn from each other, which is highly motivating. If I was 5 years back, I would make stronger integration of exome sequencing and phenotyping activities to define clear a priori hypotheses about adaptation. One of my motivations: playing around with statistical models to add value to biological data that keep on increasing in complexity and size."



Fred van Eeuwijk, WP4 leader, Biometris, Wageningen

"WP5 main output is the identification of novel alleles of resistance genes by allele mining but also by GWAS (Genome-Wide Association Study). We can now do things in wheat which were possible only in model plants such as Arabidopsis until very recently. The consortium was composed of very dedicated people who were collaborating very well and determined to use the novel opportunities in genomics for improvement of wheat and barley breeding. If I was 5 years back? Hard to say... If we would start again now, the answer would be easier because there are many new technologies available which did not exist 5 years ago. Probably the one thing I would change is to focus the consortium and approaches a bit more and reduce the number of research questions.

My motivation? Scientific curiosity and the work on wheat as one of the most important crop plants. Whatever we discover has the potential to be useful in the short or long run to improve breeding and agriculture. Genomic approaches in wheat and barley have to be continued. With reference genome sequences available and the access to huge genetic diversity in gene banks, it is a fantastic time to determine the molecular basis of agronomically important traits in these crops and to apply the generated knowledge in breeding."



Beat Keller, WP5 leader, Head of plant and microbial biology at UZH



WHEAt and barley Legacy for Breeding Improvement

“On the pre-breeding work-package, all partners used different strategies for pre-breeding. Our aim was to showcase various options for utilizing the genetic resources characterised in other parts of the project. In the five years of the project we managed to start with unadapted genetic resources and produced a set of locally adapted lines with novel genetic diversity. These lines are currently being used as new parental lines in our elite winter wheat programme. This was achieved via classical pre-breeding combined with modern genomic characterisation to ensure that high performing lines also carried introgressed genetic diversity from the exotic parent.

Personally, my best memory is undoubtedly the trip to Israel where we witnessed genetic diversity in action. Seeing wild wheat and barley growing in their natural habitat was amazing. Professionally, my best memory will be the discussions with scientists from different organisations on topics such as data analysis and alternative strategies for utilization of plant genetic resources. At the opposite, the worst was getting the panel of wheat and barley accessions together in terms of permissions and paperwork. Free unrestricted access to plant genetic resources is a huge challenge facing the wheat community.

And finally, what drives you to be a breeder? Food security. As breeders and scientist we have taken on the challenge to address the issue of producing enough food for a rapidly growing population. This is something we have to take serious no matter what part of the sector we work in.”



Jacob Lage, WP6 Leader, Head of wheat pre-breeding at KWS, one of Europe's leading seed companies.

“The WHEALBI project has facilitated engagement within the wider research community across diverse disciplines. Future collaboration and integration of the research communities remains important and intra-work package engagement remains key to maximise the outputs from such projects. WP7 was identifying phenotypic traits that may be useful in future breeding programmes to facilitate grain yield and quality stability under organic and conservation practices.

WHEALBI has provided opportunities to engage with research groups that I would not normally engage with on a day-to-day level. Visiting research institutes across the project was a great opportunity to learn about specific analytical techniques and trial practices. The more difficult was to integrate the researcher work packages within the project with such a wide research remit from molecular genotyping to field agronomic performance. If I was 5 years back, I would learn how to improve the work package integration from the outset and work through how the outputs from individual work packages could be better used by others. In my work, what drives me is developing farming systems that are more resilient to edaphic challenges and to improve crop performance with lower resource requirements whilst maintaining economic and productive systems for global food security”.



Nathan Morris, Farming systems and soil specialist at NIAB, WP7 leader

“The outputs I am the most proud of in WP8? Certainly the organisation of the different WHEALBI trainings dedicated to young researchers and breeders, and the College project, sort of mini EU Research project with 5 participating universities originating from 5 different countries. It allowed to share with young generations the outputs of the project. My best memories? The annual meeting in Israel was amazing with the visit of the drought experiments and the natural genetic resources of wheat and barley. And all the exchanges we had with the consortium.

On communication, I would change some aspects to focus even more on videos and targeted social networks. As a follow-up, I will suggest to better link the work done on agronomy (including soil knowledge) with the work done on genetics and breeding. Indeed, a system approach is really needed to react fast to the different challenges agriculture has to face in the coming years.”



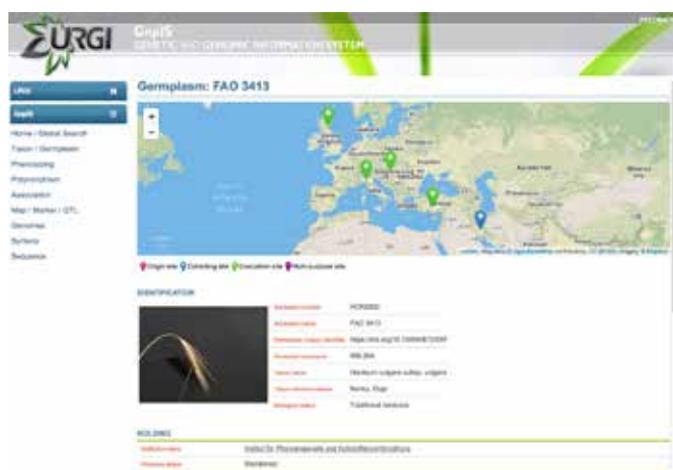
Sébastien Crépieux, WP8 leader, Arcadia International Consultant



News from the project

A database as a Legacy for the scientific community: <https://wheat-urgi.versailles.inra.fr/Projects/Whealbi>

The Wheat@URGI portal has been developed to provide the international community of researchers and breeders with access to the bread wheat reference genome sequence produced by the International Wheat Genome Sequencing Consortium. Genome browsers, BLAST, and InterMine tools have been established for in-depth exploration of the genome sequence together with additional linked datasets including physical maps, sequence variations, gene expression, and genetic and phenomic data from other international collaborative projects already stored in the GnpIS information system. The portal provides enhanced search and browser features that will facilitate the deployment of the latest genomics resources in wheat improvement (Alaux et al. 2018).



The WHEALBI project has been part in the development of the platform and data obtained for all the WHEALBI accessions (508 wheat accessions and 511 barley accessions, data in open access), SNPs and phenotyping experiments have been integrated as a legacy for the scientific community.

Example of a barley accession:

<https://urgi.versailles.inra.fr/siregal/siregal/card.do?id=63532&dbName=common&className=genres.accession.AccessionImpl>

Data are also available for student work upon request. Please contact: contact@whealbi.eu.

A study linking agronomy and breeding

A deliverable called “Socio-economic assessment of innovative crop management practices” linking agronomy, breeding, economics and CAP related issues, is under finalisation in the project WHEALBI.

The objective of this deliverable was first to investigate barriers toward adoption of Best Management Practices and particularly barriers to reduced/minimum tillage (RT) across Europe. A socio-economic analysis was realized to know the financial benefits for a farm to drop these barriers and apply reduced or no tillage on their fields. A review of recent research was done, and the main focus was put on three European countries: France, Italy and United Kingdom.

The performance under different tillage practices of wheat and barley varieties of the WHEALBI project (10 of each) were observed in three countries under different treatments (conventional, low nitrogen, organic) to know the best suited varieties and their economic performance under different management practices.

The second part of the deliverable report is dedicated to the study of CAP measures and public subsidies which could permit to develop at farm-scale conservation agriculture

and reduced tillage. The actual ‘Greening’ part of the CAP was dissected for the three countries France, Italy and UK, and prospection of the CAP 2020 reform and other agriculture and soil policies were reviewed to understand which policies could help providing adequate conservation measures. The Swiss BiodivSol project, which tries a new payment method based directly on the soil functionality, quality and organic matter, parameters highly correlated with the way farmers protect the soil through their management practices, is very inspiring. It helps farmers to take care of their soil and think about their practices on a long term approach, but also to think the soil structure and biodiversity as a capital and a legacy for future farmers and for the whole population.

Results have been presented at the Final Whealbi Conference and can be found here:

<https://www.whealbi.eu/wp-content/uploads/2018/10/Socio-economic-assessment-of-innovative-crop-management-practices-.pdf>

The deliverable will be available end of 2018 on www.whealbi.eu



WHEALBI Trainings

Training on Agronomy : “Crop management and development of innovative cropping systems”.

The “Crop management and development of innovative cropping systems” training was organized by the NIAB and the WHEALBI consortium the 29-30 May 2018 in Cambridge (England).

The training was attended by 20 persons from all over Europe with breeders, young researchers and students.



During the two days of the training, people had the opportunity to discover new cropping techniques, new measuring instruments and discuss around the different trials performed at NIAB Innovation Farm with WHEALBI accessions.

The organization of this training was excellent and the evaluation of the training by attendees was good.

The programme of this training could still be found here:

[https://www.whealbi.eu/trainings-crop-management-](https://www.whealbi.eu/trainings-crop-management-innovative-cropping-systems-practical-assisted-pre-breeding-may-2018-cambridge/)

[innovative-cropping-systems-practical-assisted-pre-breeding-may-2018-cambridge/](https://www.whealbi.eu/trainings-crop-management-innovative-cropping-systems-practical-assisted-pre-breeding-may-2018-cambridge/).

Videos of this training have been released on the Whealbi Youtube channel. Other videos of the WHEALBI projects are already shown on this page, don't hesitate to have a look!

Wheat and Barley pre-breeding training

The “Wheat and Barley Pre-breeding” training was organized by KWS and the WHEALBI consortium and hosted by NIAB in Cambridge the 30-31 May 2018.

This final WHEALBI training was a large success (38 people attended and more than 10 speakers from all over the world) and the evaluation of the training by participants was excellent.

Many results from improved pre-breeding techniques for wheat and barley were presented during the different talks (examples from different private breeders, programs in Australia, South Africa, etc). With the field visits at KWS, trainees had the opportunity to see how precisely pre-breeding is done in this company and how the WHEALBI varieties have been used to bring more diversity in European cultivars of wheat and barley.

The programme of this training could still be found here: <https://www.whealbi.eu/trainings-crop-management-innovative-cropping-systems-practical-assisted-pre-breeding-may-2018-cambridge/>.

At the end of the “Wheat and Barley Pre-breeding” training, interviews of attendees were performed to obtain their point of view on the interest of such practical trainings, the European pre-breeding state of art and the use of genetic diversity in breeding. Some of these interviews are briefly presented below and can be found on:

<https://www.youtube.com/watch?v=EJUCwClnDmk>.



DO YOU THINK TRAININGS ARE GOOD OPPORTUNITIES FOR EUROPEAN RESEARCHERS?



Jean-Noël Thauvin, Ph.D Student at John Hutton Institute: Yes, I think so because it puts together a lot of different institutes and the private sector.

So you have easily access to different ideas, tools and methodologies, so you learn a lot!

DO YOU THINK WE USE ENOUGH GENETIC DIVERSITY IN EUROPEAN BREEDING?



Sophie Buon, Limagrain UK, Barley Junior Breeder: Not really. I think, particularly in spring barley, that we always cross the best varieties with other best varieties, so we lose an important part of the genetic diversity. Like this, we miss something and I think we could improve breeding yet by introgressing more genes from genetic resources to better improve yield and disease resistances. Diversity is essential, and is the future of breeding. In ten years, we will need this genetic diversity. That is why we need pre-breeding.



Final conference Edinburgh

The Final WHEALBI conference was organized by the James Hutton Institute at the Royal Society of Edinburgh the 24 October 2018.



More than 70 participants attended this final meeting and the different results of the project were presented.

All the different work packages presented their results, and discussions around the sharing and the dissemination of these results were done, to best value the knowledge produced in the WHEALBI project. Lot of presentations shown in this meeting are available on the WHEALBI website, on the meeting page (<https://www.whealbi.eu/feedback-on-the-whealbi-final-conference-in-edinburgh-24-october-2018/>).

Final Stakeholder Forum

The EU-FP7 WHEALBI project is finishing end 2018 and the Final Stakeholder Forum was organised in Brussels, the 4th of December, where the results of the project were presented to the stakeholders. This meeting took place at the European Seed Association and was followed by twenty people from the European Commission, ESA, The Wheat Initiative, ETP Plant For the Future and by National Breeders' Associations.

More infos on : <https://www.whealbi.eu/final-stakeholders-forum-4th-december-2018-brussels/>



DISSEMINATION OF WHEALBI VIDEOS: YOUTUBE CHANNEL AND SOCIAL NETWORKS

A number of videos have been released in 2018 and published on different social networks with a short description explaining the WHEALBI project. Please find them on:

- › Youtube WHEALBI Project channel: <https://www.youtube.com/channel/UckwqKIC8tgGgB768ZprZtyw> and <https://www.youtube.com/channel/UCAkECSLfjZLEdLRXGKTe-UQ>
- › Twitter: <https://twitter.com/whealbi>

New videos recorded until the end of the project will be broadcasted in the different social networks – don't forget to register to get information!



One on one conversation with Daniela BUSTOS-KORTS, PHD Student during the Whealbi project



Who are you and what was your role in the WHEALBI project?

My name is Daniela Bustos-Korts, I come from Chile and I have a background in agricultural sciences and crop physiology (Universidad Austral de Chile). I joined the WHEALBI project in 2016, when I was in the third year of my PhD. I finished my PhD at Biometris (Wageningen University and Research) in November 2017. My role in WHEALBI was to develop and apply strategies to analyse the data of a number of wheat and barley data sets. I also had the opportunity to organize one of the workshops and provided support to the leader of WP4, Fred van Eeuwijk, in some of his tasks related to the WP organization.

You started as a WHEALBI Ph.D. and finished as a researcher in Wageningen University, was it your initial plan?

The funding for my thesis had recently stopped during the third year of my PhD. In this context, joining the WHEALBI project was great opportunity because it allowed me to fund the last part of my thesis work. It also provided unique data sets to investigate statistical methodologies and allowed me to interact with experienced researchers from very diverse disciplines. Since the beginning I knew that the project would end after my PhD graduation, and for that reason I was offered to stay at Biometris (Wageningen University) as a post-doc within the WHEALBI project until December 2019. That period allowed me to learn a lot and become increasingly interested in continuing to work on modelling. As Biometris was satisfied with my work, I was given the opportunity to stay for a longer period, after WHEALBI is finished. I'm very happy about this.

What is the main output obtained in WHEALBI you are the most proud off?

I'm very proud about the barley paper that we are about to publish. Initially, it was not easy to define the research questions to answer with this large data set. Working and communicating between researchers from different disciplines is also sometimes challenging. However, I think we succeeded to integrate a number of diverse approaches and look at the data from different perspectives. That makes it really nice.

What is your best memory with the consortium?

The annual meeting in Israel was certainly a wonderful experience. It was just fascinating to be at the Fertile Crescent looking at the diversity for barley, wheat, clover and other crops in the same place where they were originated. Visiting the centre of origin of many crops together with cereal specialists made it even a more unique experience.

And what is the worst?

I joined the project in 2016, in a period of uncertainty in the WHEALBI project because some activities were delayed. As a student with little project experience, I got a bit worried because it was not fully clear how things would work out in the end. I now realize that every project faces some period of uncertainty. In that sense, what I saw in 2016 is just a common part of the process. The positive news is that the WHEALBI team was able to deliver good results.

What are the lessons learned from such a European project?

As a young researcher, I think that participating a European project is a highly educational activity. My period in WHEALBI has been very interesting because it allowed me to learn a lot, not only from the scientific aspects, but also about how projects are managed. Most commonly, the process of a PhD is a rather individual activity, very focused on the scientific output. This is fine, but to become a good researcher it is also fundamental to learn how to acquire and manage projects. A researcher who wants to have impact on society should be good scientifically, but should also be very good at managing projects, bringing people from different disciplines together, leading a team and taking care that society can benefit from our research. WHEALBI was a very good school, it helped me to see research in a more integral way.



WHEAt and barley Legacy for Breeding Improvement

Are you ready to continue to collaborate in EU projects?

I think that EU projects are a great platform to strengthen the collaboration between people from different countries, exchange ideas and form multi-disciplinary teams that allow to achieve goals that none of us could achieve individually. For that reason, yes, I would be happy to join another EU project in the future.

You are at the beginning of your carrier, how would you convince young students to go to the field of research?

Research has the potential to transform people's lives. Research in agriculture is particularly powerful because it influences the quality of life of millions of people worldwide. I think we should help bringing this role more broadly to the public sphere. In this line, I fully support the role of scientific activities at school, as the WHEALBI-college project. It is possible to make a change and we, as the young generation, have a unique opportunity to access such a large variety of tools to make this change happen. Research was never so thrilling as before, but we just need to make this more visible to the young students, to raise their curiosity, and we also perhaps need to be more inviting so that young students don't see science as something completely detached from them.

And finally what drives you / motivates you to continue in research?

Plant breeding is a key activity to help agriculture becoming more sustainable, providing enough healthy food for everyone, with the least impact on the environment. Obtaining well-adapted varieties that can fulfil this role is a numbers game. The more genotypes breeders evaluate, the more likely it is that at least one will perform in the way we want. For that reason, we need modelling and statistics. I really enjoy this role of modelling of bringing different disciplines together and turning knowledge into a tool for decision making. I also think it is fun and interesting to interact and to exchange knowledge with breeders, physiologist, biologists, agronomists. These interactions with people from different disciplines give me energy and motivation to continue in research.

CONTACTS

Scientific contact

Gilles Charmet
gilles.charmet@inra.fr

Communication contact

Sébastien Crépieux
(WP Dissemination leader)
contact@whealbi.eu

www.whealbi.eu



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