IWYP

International Wheat Yield Partnership

Research to Deliver Wheat for the Future

INTERNATIONAL WHEAT YIELD PARTNERSHIP ANNUAL REPORT 2018-2019

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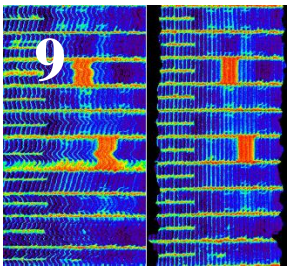
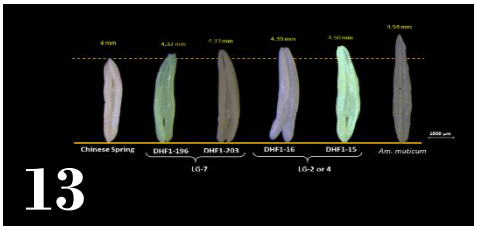




IWYP – The International Wheat Yield Partnership (IWYP) will stimulate research and its application through a combined approach that coordinates some of the best scientists in the world to work towards the common goal of raising the genetic wheat yield potential by 50% by 2035. IWYP is committed to working in partnership with other programs across the globe such as CGIAR WHEAT, Designing Future Wheat (DFW), Canadian Wheat Alliance, Breedwheat and the Wheat Initiative (WI).

Executive Summary

IWYP is pleased to present the 2018/19 International Wheat Yield Partnership (IWYP) Annual Report, detailing the progress that has been made over the last 12 months. IWYP has continued to strengthen its abilities to fulfil its mission of providing the means to make major gains in wheat yield potential through discoveries and the provision of enhanced germplasm to both public and private breeding organizations around the world. The IWYP Science Program has expanded with additional research projects that strengthen our current research areas and bring in valuable new expertise from other geographies where wheat is an important commodity and where significant investments are made in the academic research arena. IWYP is currently comprised of over 50 scientific research institutions carrying out 38 research projects spread over 14 countries. Further, IWYP has also begun the expansion of its translational capabilities with two new pre-breeding Hubs, one in the US and one in the UK, planned to be operational in the first half of 2020. They will be supported and managed as public-private partnerships by 13 public sector and 9 private company investor/partners to accelerate the delivery of IWYP discoveries in elite winter wheat germplasm. These new Hubs will both complement and feed off the outputs of the main IWYP Hub for spring wheat at CIMMYT.

As IWYP comes to the end of its first 5-year Program of Work, we have focused this past year on raising the financial resources for a second 5-year phase that puts more emphasis on creating "trait packages" in elite lines with higher yield potential for delivery to breeders around the world. At the time of writing, a significant proportion of the required funds has been pledged.

IWYP's research strategy is based on finding new genetics that leads to optimized and more efficient photosynthesis through the production of higher biomass and increased radiation use efficiency ("source") coupled with discovering genetic variation that produces increased numbers and sizes of grains ("sink"). Many processes underpinning these yield traits have been screened, in many cases for the first time, in large numbers of cultivated wheats, landraces and wild relatives. Many of our cutting-edge discoveries have been published in leading scientific journals. These illustrate new opportunities for the global wheat breeding community and the means of generating higher yield potential.

Significant new genetic variation has been found for almost all of the physiological and phenotypic traits assayed, and many examples are given in this Annual Report. For example, over two-fold variation in rates of photosynthesis at maximum light levels has been detected across various germplasm panels. Similarly, over two-fold variation in rates of respiration has been found. Respiration leads to a loss of carbon previously fixed by photosynthesis and is negatively correlated with grain yield. Genetic variation has also been shown for the rapidity of response of photosynthesis to light/shade transitions both in canopies and cloud movement. Mutations in genes that control grain size have been found. The stacking of such alleles has led to larger grains that also have higher levels of protein. Genes important in determining the numbers of grains on

a spike have also been identified. We have learned that grain "sink" levels are correlated with radiation use efficiency in field studies, for which we have positive genetic variation. Many other ground-breaking discoveries will continue to emerge as the research projects mature and the outputs move through translational stages. Defining the best combinations of the traits and gene variants should lead to significantly higher yield potential. Thus, IWYP believes its strategy remains sound and worthy of continued exploitation.

The IWYP Hub for spring wheat at CIMMYT continues to carry out pre-breeding activities and develop unique new germplasm with higher yield potential. It has started to import lines from various IWYP research projects around the world to assess the novel genetic variation in field studies under relevant environments. Hub scientists have been selecting lines with specific traits enhanced and using them as parents to make crosses between high biomass, high grain sink and high harvest index plants and sifting the progeny to select higher yielding lines. Some of the latter are performing extremely well in international field trials.

IWYP has held its Annual Conference again, this year in CIMMYT. This enabled progress to be presented and assessed and new potential plans to be discussed. Conclusions are being evaluated.

IWYP has enhanced its website as a major vehicle for communicating progress and especially its deliverable outputs for others. The foundation of IWYP's strategy is to make its germplasm enhancements, marker-trait association knowledge, and tools and protocols available to all. It has this year created an "Asset catalog" on its website, to enable others to browse its inventory and request to receive and use its outputs. The current catalog highlights over 200 wheat lines that are being made available as well as information on 60 marker-trait associations and 16 descriptions of novel tools and protocols. IWYP also now provides a list of publications that showcases the technical progress being made.

It is important to remember that IWYP is "product driven", with the goal of creating significant increases in global wheat yields for impact. The novelty of the technical and entrepreneurial approaches behind and within IWYP are extremely important facets of IWYP because it can enable IWYP to make breakthroughs in yield gain over and above those typically realized today. We hope this Annual Report clearly illustrates the new approaches being adopted and the commitment and passion within IWYP to work along the whole pipeline of discovery to product to ensure that smart science leads to impact and benefits for the farmers, agricultural systems and environments of the world.

Message from the

Board Chair

As Chair of the IWYP Science and Impact Executive Board (SIEB), I am very pleased to report that this past year IWYP has achieved substantial progress towards its goal of delivering innovations into wheat breeding, to aid future yield increases. Nearly all our Projects being developed in different institutions around the world, supported by different funding agencies, are being successful. The projects are focused on traits highly likely to underpin yield increases including the regulation of photosynthesis, plant architecture, plant biomass distribution, and grain number and size. As the results emerge it is becoming possible to envisage how to combine them and therefore remove multiple constraints affecting yields in farmers' fields. The future looks both exciting and promising. However, to make these trait combinations and validate them on the road to new variety production, we must continue to build and finance the downstream translation pipelines. We have therefore this year paid special attention to the downstream translation Hub in CIMMYT in Mexico, for spring wheat types, and to the establishment of two more Hubs for the improvement of winter wheat germplasm, one in the USA and the UK. Our private sector members of the Partnership are particularly active in working to establish the winter wheat Hubs. IWYP continues to be an exemplary model for stimulating crop improvement where current progress is too slow, investments are too low, and/or the links between discovery and translation into variety production are too weak to meet future global needs. This Annual Report is one vehicle for telling the IWYP story. It relates new scientific ideas, new discoveries and the commitment of IWYP to generate a difference via its product-driven goals. I thank all members of the IWYP family for their commitment to the enhancement of wheat production, worldwide, for the benefit of future generations.

Richard Flavell
Chair, IWYP Science and Impact Executive Board

Message from the

Program Director

After another exciting and productive year, I am extremely pleased to present the 4th IWYP Annual Report. In it, IWYP Management seeks to provide a summary of the exciting activities that have occurred across the IWYP Program over the last year and what we have planned moving forward. What marks this year as special is that IWYP is ramping up a new phase in its endeavors to make breakthrough discoveries for wheat yield improvement by further developing those now in hand for delivery via the IWYP Hub pipeline. New strategies for pre-breeding and trait stacking are being implemented as we seek to quickly discover the means to push wheat yields higher. Many potentially valuable outputs from our research are being validated at CIMMYT and the best are entering our pre-breeding program. Trait stacking is now taking center stage in the pre-breeding program combining different "source" traits and different "sink" traits, and most importantly, making combinations of the two to create novel trait packages that will ultimately be tested in dozens of field trials across the globe over the next few years. These trial results from relevant environments will further substantiate that our trait targets are resulting in the level of grain yield enhancements sought, and most importantly provide new higher yielding germplasm for breeders and seed companies to capitalize on when creating new products for farmers. This last year we further expanded our research capacity with a new set of IWYP research projects and Aligned Projects bringing our total to 38 projects within the IWYP Science Program! The IWYP Hub at CIMMYT continues to make strides in the improvement of the elite germplasm base and we are also in the midst of expanding the IWYP Hub Network by adding two Hubs for winter wheat types in the US and UK. As always, none of the progress reported this year would be possible without the dedication and passion of all of those involved in the IWYP initiative, especially the research scientists of the IWYP international science team.

Jefferson Gwyn
IWYP Program Director

IWYP at a Glance

The urgent needs for improving global wheat yields at a faster rate than current trends are well established and understood due to the rapidly growing world population that is projected by the FAO to reach nearly 10 billion by 2050. The benefits that raised yields can make toward reducing land use, preserving and enhancing rural life and sustainability are also well documented. While many public funding agencies are investing in discovery science to facilitate general crop improvement, including that of wheat, much of the potential value remains academically terminal and is not being realized because the discovery efforts are most often not connected with downstream or translational activities such as validation, trait stacking and the field-based performance assessments required to quantify and scale the value of the discoveries into significantly improved pre-products and products.

IWYP was deliberately set up over 4 years ago in part to provide these missing pieces. It was purposely founded on international cooperation and coordination in order to maximize the value of research investments in different countries for the benefit of global agriculture and the world's rapidly growing population. Since then, IWYP has developed a massive interconnected network of public and private partners that include public funding agencies, private companies and numerous public research institutions and their scientists. Further, significant scientific advances that were never envisaged in the original research proposals have been achieved over this period, especially those driven by genomics, bringing new opportunities and generating added value. This Annual Report deliberately focuses on the current status of IWYP, the valuable outputs being produced by the international team of scientists and the hard work being done at the IWYP Hub at CIMMYT to translate these outputs into tangible products that can be handed off to wheat breeders and farmers globally.

IWYP Network

IWYP Members and Contributors

IWYP developed a collaborative approach to bring together public and private research organizations from a large number of countries. Organizationally, IWYP is managed at the highest level by the Science and Impact Executive Board (SIEB) composed of representatives from our funding, research and private organization partners. The SIEB is led by an independent Chair. The operations and administration of IWYP are managed by an independent Program Director who is assisted by a Program Manager and Secretariat. Innovative discoveries from IWYP Research Projects and IWYP Aligned Projects are being made by a global network of leading wheat scientists whose outputs are funneled into translational development pipelines for validation and stacking into elite germplasm for use by breeders directly, as varieties or as parents for further breeding purposes.

60 Scientific Institutions

3 IWYP Hubs

14 Countries

9 Private Partners

13 Public Partners

>150 Researchers

38 Research Projects

Delivering Global Outcomes & Impacts

Early highlights of outputs from IWYP

IWYP seeks to create diverse kinds of impact that are beneficial to many. Of overriding importance in the longer term is the provision of germplasm, tools and systems that can be used by many to sustain major improvements in wheat yields, globally. To achieve this IWYP will make available to all its germplasm with significant increases in genetic yield potential above what is currently available. The expectation is that this germplasm will help replace current, or older varieties grown by farmers, either as varieties directly or as parents for the improvement of locally adapted material in breeding programs. This improved IWYP germplasm will likely be created by stacking beneficial alleles for several target IWYP traits. It may be accompanied by information on the molecular genetic markers that enable the favorable alleles to be selected in a breeding program or to be used to screen for these alleles in different plant materials. Tools and methodologies developed during the course of IWYP's research are also made available to screen more efficiently for traits that increase genetic yield potential.

- Pakistan-13 released as a variety in the rain-fed region of the Punjab and has been widely adopted with over 90,000 farmers currently growing this variety (https://bit.ly/2OHnxsf). It was developed in-part by selecting for many physiological traits that are IWYP targets.
- Wheat lines (Spring and Winter) with larger grains and improved quality (and associated molecular genetic marker information) shared with public and private wheat breeding programs
- Early generation pre-breeding and experimental lines made widely available on request
- Over 70 publications made in scientific journals
- More than 50 graduate students being trained in modern wheat genetics and breeding

>200 Wheat lines made available on request

>60 Marker Trait Associations

3 Wheat varieties released in Pakistan

70 Peer reviewed articles

16 Tools & protocols

>240 New crosses made at the IWYP Hub at CIMMYT

IWYP's Research Strategy for Higher Yields

Given that many of the IWYP research projects have been active for several years, it is important to periodically assess the validity of our strategy for achieving the IWYP goal of a 50% increase in genetic yield potential in 20 years. This strategy is based on achieving higher rates of photosynthesis to increase source strength via a number of traits, e.g. increased total plant biomass, in combination with greater grain sink strength, e.g. more and larger grains, to effectively use the additional carbon and available nitrogen resources.

Thus, the focus of many of the IWYP research projects has been to discover genetic variation that drives better photosynthesis and radiation use efficiency, as well as optimizes the processes that lead to loss of fixed carbon through respiration. Our scientists have been screening large, genetically diverse populations of germplasm using state-of-the-art methodologies, many new, to identify preferred genetic variation in photosynthetic capacity/efficiency. This includes Rubisco functionality, enzymatic activity and production of metabolites by the Calvin-Benson cycle and chloroplast electron transport processes at several scales (individual leaves, plant canopies and light intensities) together with improvements in the speed of responses to light-shade transitions. In parallel, other projects are focused on sink attributes, such as making improvements in grain size, grain number and modifying the development of the wheat spike.

Results from the first four years demonstrate that genetic variation can be found in all or most of our target physiological processes and traits in wheat and its wild relatives. We have also shown that yield gains can be generated when selected genes identified in other species are introduced as highly expressed transgenes into wheat, supporting the hypothesis that yield gains in agriculture have slowed primarily because of limited useful novel variation in elite breeding pools. Many of the lines selected by IWYP for high biomass contain genetic segments introduced from wild relatives of wheat, again emphasizing the importance of novel genetic variation. Given the large number of physiological processes targeted directly for the first time and the large germplasm collections surveyed it is highly likely that some of the new variation will enhance the target traits better than variation available in most breeding programs today. Furthermore, there is an expectation that these many new but small effects will be additive and will lead to the large step change we are seeking. Thus, we consider our strategy remains relevant to our goals.

Our discoveries of new usable genetic variation affecting key yield determining traits, including grain size and number, ideally position IWYP to move forward into a second five year IWYP program where the strategy is to fully exploit this new genetic variation and build enhanced genetic trait packages, along with the supporting genetic markers, that should enable plants with significantly higher yields to be created and selected for in breeding programs.

Selected Outputs of

IWYP's Research

The first sets of IWYP Research Projects, NIFA-IWYP Research Projects and IWYP Aligned Projects have been delivering outputs and many of these have now been transferred into the IWYP Hub at CIMMYT for validation and pre-breeding, as well as to leading private wheat breeding companies. Key accomplishments include 1) identification of germplasm containing novel and more optimal alleles for IWYP target traits, 2) identification of molecular genetic markers to better dissect the genetic determination of these traits and for use in marker assisted selection and 3) development of new tools and protocols to more efficiently identify better genotypes, genes and markers correlated with IWYP target traits. The following is a selection from the many research highlights which have the potential to contribute to the development of high genetic yield potential germplasm, to be released with the molecular genetic markers and other tools for use globally by wheat breeding programs.

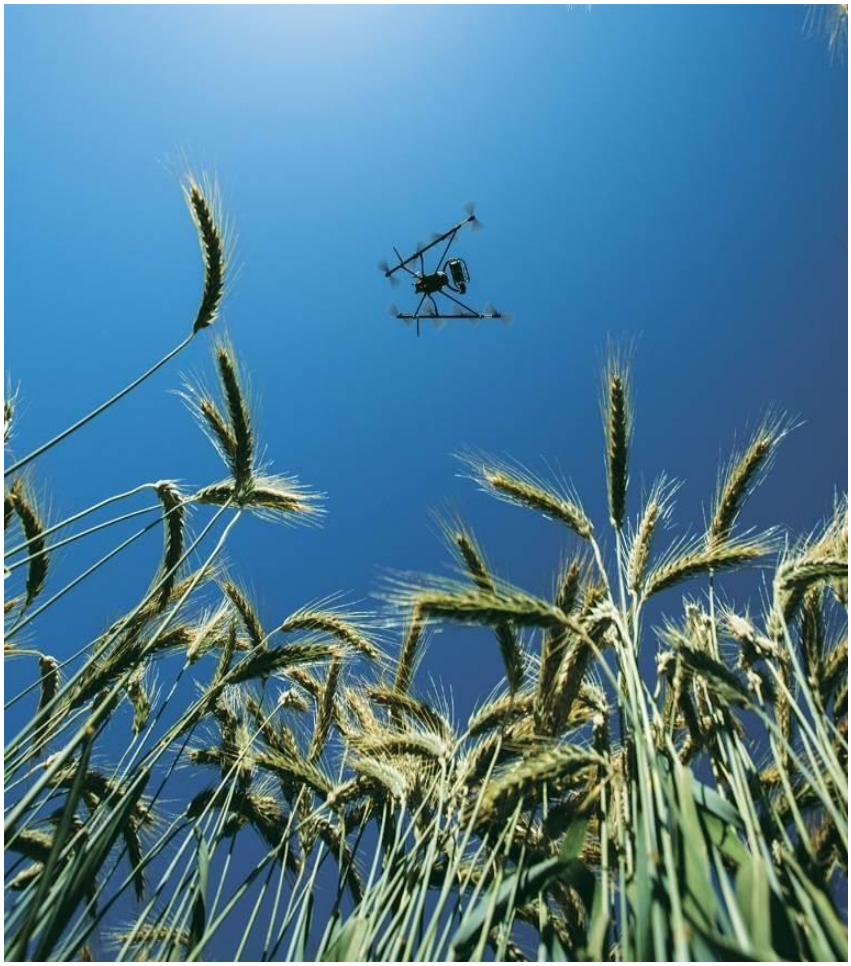
Germplasm

- New wheat germplasm with higher final biomass, radiation use efficiency (RUE), light incidence (LI) and a better distribution of chlorophyll content throughout the wheat canopy
- Wheat lines containing chromosome segments introgressed from wild wheat relatives showing increased photosynthetic efficiency relative to their wheat parents
- Wild wheat relatives and wheat landraces with increased levels of photosynthetic efficiency potentially useful in trait introgression
- Wheat lines with more optimal energy use efficiency traits that are linked to improved yield in field trials
- Wheat lines with a more optimal canopy scale light use efficiency which have been transferred to private and public breeding programs
- Wheat lines with high dry matter partitioning to the grain (increased harvest index) and lodging resistance which are useful as parental lines

- Germplasm and the associated selectable molecular markers, containing combinations of alleles conferring increased grain weight and spikelet number and transferred to private and public breeding programs
- Potentially high yielding wheat lines selected by molecular markers for yield component traits initially targeting South African environments and shared with public and private breeding programs
- Introduction of a more erect canopy phenotype into target CIMMYT wheat lines with high biomass, radiation use efficiency, harvest index and larger grains following research suggesting that wheats with erect leaves are higher yielding than those with floppy leaves

Tools and Protocols

- Development of high throughput phenotyping tools based on infra-red, hyper and multispectral imaging methods together with systems to analyze the outputs and more rapidly screen and identify favorable wheat lines
- Technologies developed for high throughput screening of wheat plants to discover novel photosynthetic traits
- High throughput hyperspectral screening methods developed for dark respiration (*Rd*) and energy use efficiency (EUE) traits to screen and select for more energy efficient wheat lines
- Custom made genotyping tools developed to more accurately identify the genomic regions and potential genes determining target traits and to screen for more optimal alleles of the target genes
- New validated tools to measure canopy-scale light use efficiency. The novel tools in use by other public and private breeding programs



- Techniques for identifying mutations in any gene and assessing the phenotypic effects of these mutations

Trait-Linked Markers

- Molecular markers correlated with several improved photosynthetic traits, biomass production, harvest index and yield component traits - many of the markers have been delivered to the IWYP Hub
- Biochemical and molecular genetic markers for traits associated with improved energy use efficiency (EUE) that can be used to select more energy efficient wheat lines
- Characterized alleles for known and novel phenology genes that have been assembled in different combinations and are being tested in the field for their impact on final yield, to enable breeders to "tune" phenology for specific environments
- Genetic markers for improved harvest index, fruiting efficiency, spike partitioning index, internode 2 and 3 biomass partitioning, glume and lemma partitioning and for spike hormones that can be converted into breeding friendly markers to screen for these traits
- Genes responsive to trehalose 6 phosphate that could be developed into markers associated with improvements in grain number, grain size and photosynthetic potential
- New candidate genes affecting grain characters identified by the latest molecular genetic techniques and development of novel bioinformatics tools to identify them
- New candidate genes contributing to spikelet number per spike thus offering the possibility to select for increased number
- New genetic markers for tolerance to ammonium thus maintaining grain and protein yields under future predicted climate scenarios of increased carbon dioxide when assimilation of nitrate by wheat is inhibited

Expanding the

IWYP Science Program

IWYP Research & Aligned Projects

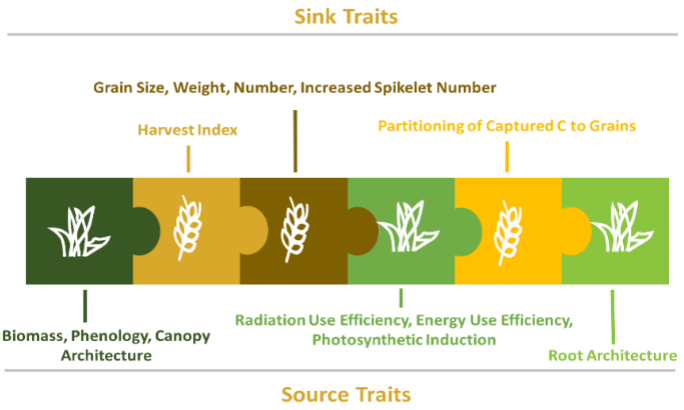
Towards the end of 2018 an IWYP Aligned Call in Canada was launched by Agriculture and Agri-Food Canada (AAFC) (https://bit.ly/32iel00). BBSRC and GRDC also committed funds to participate in this Call and support activities conducted by UK and Australian Scientists. Three projects were selected for funding. More information on the research scope of these projects and all the other funded IWYP projects can found at https://bit.ly/31sdoSy.

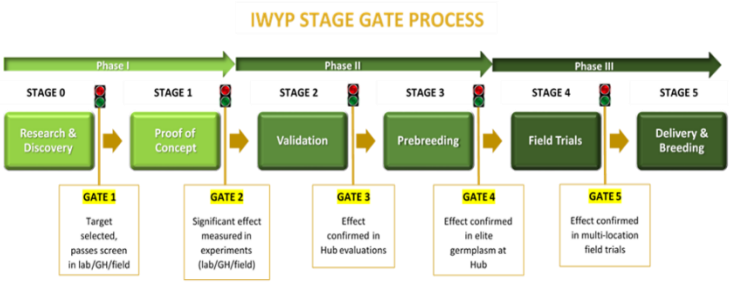
AAFC – IWYP RESEARCH PROJECTS

We also continue to identify and partner with relevant research funded outside of IWYP to expand our **Aligned Projects** initiative. This year has seen the addition to the IWYP Science Program of 5 new and exciting projects supported by NSF-USDA-BBSRC Joint Funding Opportunity - Early Concept Grants for Exploratory Research (EAGERs) (https://bit.ly/2JE3zZM). More information on the research scope of these projects can be found at https://bit.ly/2JCDQAz.

What's new at the
IWYP Hub at CIMMYT?

The role of the IWYP Hub at CIMMYT is to conduct pre-breeding and development of elite lines with enhanced yield traits for dissemination to breeding programs worldwide. The largest yield gains are expected to come from combining, or "stacking", the best validated "source" (biomass, photosynthetic efficiency, etc.) and "sink" (grain and grain component) traits.





The activities at the Hub are rapidly increasing as the research projects feed the pipeline with more outputs. These then move through the Stage Gate Process as progress in trait improvement occurs.

Current trait stacking activities

- High biomass + increased harvest index + high yield components (from elite varieties). Progeny lines are being tested in field trials
- High biomass + high harvest index + high Radiation Use Efficiency (RUE) at grain filling
- A balanced source:sink + RUE + high biomass + high yield components (from elite varieties)
- Fruiting efficiency + source:sink balance + high biomass + high yield components (from elite varieties)
- High biomass + increased harvest index + high yield components (from elite varieties) + erect canopy types
- Increased grain size/weight alleles + best physiological trait lines coming from Wheat Yield Consortium Yield Trials (WYCYT)

IWYP Hubs in the UK & USA

Expanding our delivery capabilities with Public Private Partnerships

Arguably the most important and unique feature of the IWYP initiative which distinguishes it from other international programs is the IWYP Hub Network. The main Hub at CIMMYT functions to convert elite spring wheat lines with validated outputs from the research projects into near finished lines (pre-products) that are disseminated to breeding programs globally for direct use as standalone varieties or as parents in crossing programs for varietal development.

Recognizing there are significant numbers of geographies and breeding programs where winter wheat markets are more significant, IWYP took a decision to establish Winter Wheat Hubs in the US and UK to accelerate the development of IWYP innovations in the distinct germplasm groups found in the US and Europe, and thus the wheat markets in these geographies. These new IWYP Hubs will be developed as public-private partnerships involving most of our Private Members. Outputs from the research projects may feed directly into these new Hubs or may be transferred directly from the CIMMYT Hub following validation and pre-breeding into an elite spring wheat "chassis". The establishment of these new IWYP Winter Wheat Hubs is still in development with our respective partners (Kansas State University in the US, NIAB and the John Innes Centre in the UK), but it is expected that these will be operational in the next few months, once plans are finalized and the financial support is in place.

Coordinating the

IWYP Science Program

IWYP Program Conference



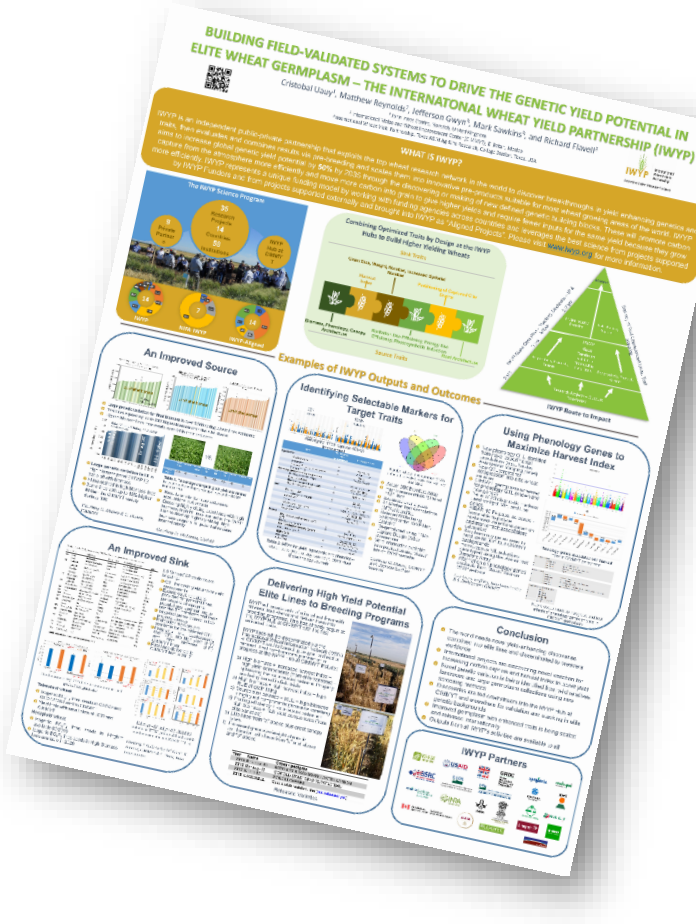


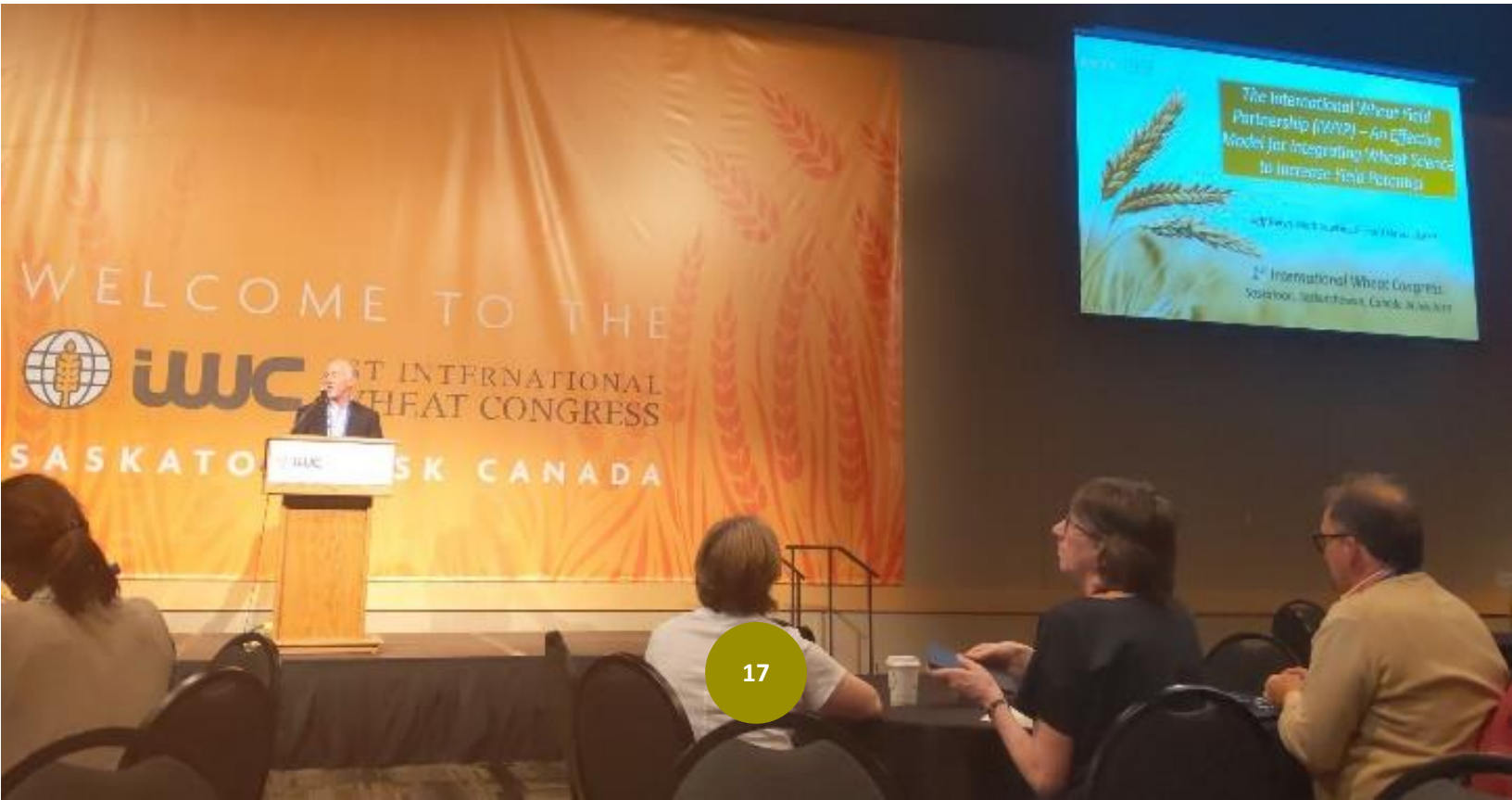


The 4th IWYP Program Conference was held during the first week of April at the CIMMYT Field Station in Obregon, Mexico. Over 60 attendees participated in the Conference and included research scientists, IWYP Management, Private Member representatives, IWYP Board members and IWYP Hub staff. The event featured research project updates, breakout sessions addressing key questions pertinent to the IWYP Program and a day in the field to view and examine the pre-breeding activities being conducted at the IWYP Hub. Over the years, this event has become a great forum to give all those involved in IWYP an opportunity to interact, exchange ideas and launch new research. This year was especially important as more discoveries are being delivered and the theme of this Conference focused on how to rapidly use these discoveries to generate higher yielding, elite wheat germplasm. Project PIs listed concisely what research outputs had been generated, timelines for delivery to the translational pipeline at the IWYP Hub at CIMMYT and strategies for best combining traits to deliver impact. Further, breakout sessions identified the current set of research outputs ready for testing and strategies for individually validating and combining them in the most efficient manner to maximize potential impact. A post-event survey of all participants revealed that participants valued meeting at the IWYP Hub where they could see material in the field. Being the fourth Program Conference participants considered themselves better placed to understand the complete portfolio of the IWYP research projects and the role that the IWYP Hub serves. Several new research linkages between existing projects were suggested and gaps in the IWYP research portfolio identified which should be addressed. The suggestions and recommendations are being considered by IWYP Management and the SIEB.

1st International Wheat Congress, Saskatoon, Canada

The 1st International Wheat Congress was held in Saskatoon, Canada 20-26 July. With over 900 wheat scientists and industry representatives registered, this was an opportunity for IWYP to promote and showcase the valuable work being conducted by the IWYP research projects and also promote the Partnership among the wheat community. The IWYP Program Director gave an oral plenary presentation on the background and goals of IWYP, including selected outputs from the IWYP research projects and IWYP Hub to exemplify progress. IWYP also presented a poster providing more detailed information on the scientific discoveries being generated by the IWYP Research Projects. Both types of presentation helped promote the work of IWYP and new contacts were made with wheat researchers and representatives from funding organizations.





Promoting IWYP Outputs

Germplasm, Genes, Tools

A variety of means are used by IWYP to advertise and promote our output assets and encourage uptake of the innovations that our researchers discover. It is critical in the IWYP strategy that public and private breeding programs integrate the IWYP innovations and pre-products into their breeding pipelines to help create products that deliver greater impact in farmers' fields. The main vehicle for informing funders, researchers and the broader community of plant breeders and interested parties has been our regularly updated IWYP Website. Social media platforms and development of targeted promotional material (Annual Reports, brochures and other documentation) are increasingly playing an important additional role. IWYP also features prominently on many of our Partners' websites.

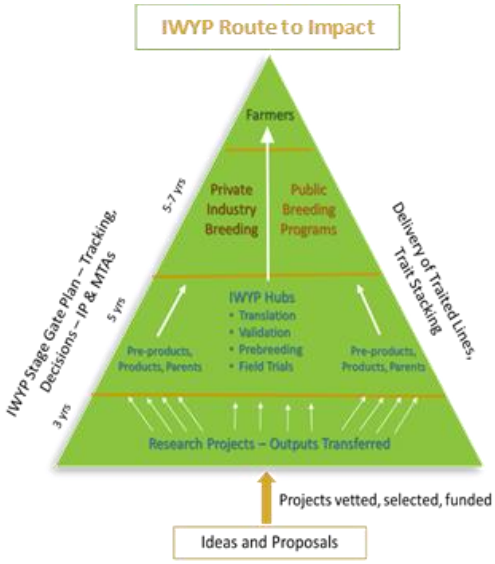
IWYP is publishing this Annual Report to highlight the exciting and novel scientific discoveries that have been made over the course of the previous year and to communicate the validation and pre-breeding activities at the IWYP Hub at CIMMYT where new research outputs are evaluated, tested and incorporated into elite germplasm in the pre-breeding pipeline. Research outputs and those being developed in the Hub Network are available to all for further research and breeding.

This year we have begun to more actively promote outputs coming from the research projects and the IWYP Hubs by advertising our "Asset Catalogues". These are informative lists that are grouped into different categories: 1)Trait-Linked Markers, 2) Tools and Protocols, and 3) Germplasm. Lists are now publicly available from the main page of the IWYP website (https://iwyp.org) and will be regularly updated (twice per year) as new discoveries and germplasm become available.

Further, we have also compiled a list of scientific articles published from the IWYP research projects to showcase the exciting research being conducted and to make it easier to find them. This list is available from the IWYP Website, (https://bit.ly/2woXhab) and illustrates the volume and quality of the science being produced by the Partnership.

Looking Forward

In the coming months, a top priority for IWYP will be to secure the funding needed for the next 5 years. Turning discoveries into “plant breeding ready opportunities” are dependent on this.



IWYP will collaborate with the host institutions of the new IWYP US and UK Hubs to make sure the Hubs are well-founded, well-funded and begin to evaluate efficiently promising genetic leads in winter wheat elite germplasm. All Hubs, including the spring wheat Hub at CIMMYT, will be firmly interconnected.

Given the large number of genetic variants emerging from the IWYP Program that correlate with or are predicted to generate yield gains, there will be an expanded emphasis on evaluating them as rapidly as possible, in elite germplasm and in high yielding environments, using state-of-the-art tools and processes. Many have already been evaluated in field conditions, while others require field assessment as soon as possible. This means IWYP will be optimizing the efficiency of its Hubs as a holistic network to accelerate delivery to others through its highly managed pipelines.

IWYP can generate much additional value by communicating its outputs and ensuring that others have the opportunity to capitalize on them. Therefore, additional efforts will be made on communication, in all its forms.

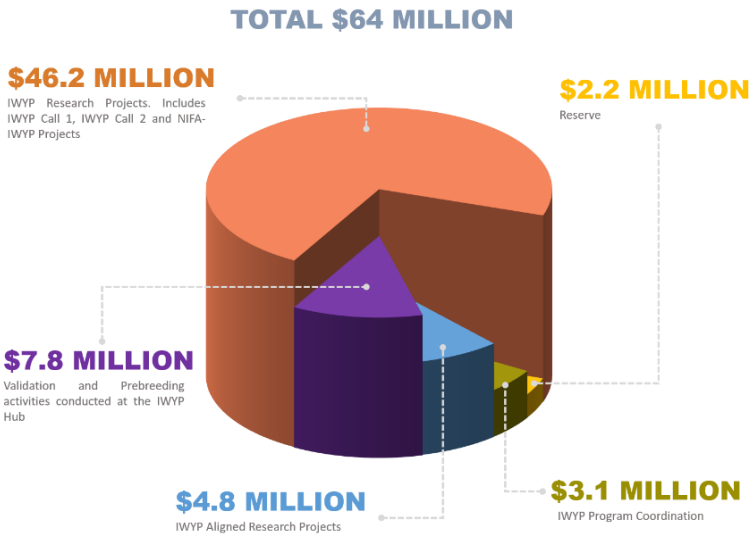
Finally, IWYP recognizes that wheat breeding is now undergoing a transition as wheat genetics and phenotyping are becoming highly tractable, compared with past efforts. IWYP will therefore endeavor to keep abreast of these developments and play its part in ensuring that they are implemented into varietal breeding programs for the benefit of peoples wherever they are in the world.

- **Secure total funding necessary for next 5 years of operations**
- **Continue to drive research discoveries through the development pipeline to create new higher yielding germplasm**
- **Optimize IWYP Hub technical processes to increase efficiency and speed to delivery**
- **Enhance communications capabilities**
- **Launch IWYP Hubs in USA and UK**

Financial Overview

2015-2019

IWYP was originally funded as a 5-year initiative, with the view that if success was in sight then subsequent 5-year phases requiring additional and different types of downstream activities and expertise would be necessary to develop the outputs of the discovery science into pre-products and products for farmers' fields.



Over the first 4 years, significant advances never anticipated in the original research proposals have been achieved offering IWYP new opportunities, especially those driven by genomics. The discovery opportunities have accelerated significantly in the past two years because of global developments in wheat science so there is even more than planned on which to capitalize.

2020-2024

IWYP is currently funded by IWYP Partners (BBSRC, USAID, GRDC, USDA-NIFA, and AAFC). New investments are required from 2020 for the second 5-year phase to generate pre-products and products from current investments and the outputs that continue to emerge from the IWYP international scientific network. These innovations are arising from state-of-the-art plant physiological and developmental trait discoveries, coupled with rapidly advancing wheat genomics platforms developed by leading global teams in wheat research.

We currently seek a total of ~US$15M over 2020-2024 to transform and scale these innovative discoveries, into significantly higher yielding validated elite wheat lines and breeder-friendly tool kits for direct transfer to commercially oriented public and private breeding programs that serve both developed and lesser developed nations. The costings include the platform activities and the necessary associated coordination, scientific management and communication activities.

IWYP envisions that a consortium of funders/investors that contributes and shares costs will be suitable to resource the downstream activities and drive the innovations to impact. At the time of writing, over half of this sum has been pledged by current investors.

IWYP | International Wheat Yield Partnership

Research to Deliver Wheat for the Future

The Australian Plant Phenomics Facility (APPF) PhenoLite, a self-propelled system used to screen field plots with LiDAR and Greenseeker NDVI to produce digital biomass

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