IWYP | International Wheat Yield Partnership

Research to Deliver Wheat for the Future

2018 ANNUAL REPORT

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EXECUTIVE SUMMARY

Welcome to the International Wheat Yield Partnership (IWYP) 2017/18 Annual Report, describing the key activities and achievements that have been made during the last year by the entrepreneurial teams progressing the 30 Projects being carried out in over 50 laboratories in 12 countries. IWYP has continued to grow and progress its discoveries towards the delivery phases of its Program with increasing emphasis this year. We have conducted a 2nd Competitive Call for Research Proposals that resulted in grants being awarded to 6 new IWYP Research Projects. These new Projects bring in expertise that expands our Research Portfolio into new areas and/or bolsters existing areas of IWYP research that need additional attention. We also continue to attract world-renowned scientists to IWYP as part of the Aligned Projects initiative.

IWYP is "product driven" with the goal of creating significant increases in global wheat yields. The need for a consistent year-on-year increase in wheat yields to provide sufficient grain for global consumption is best exemplified by the situation faced in the 2018 growing season where less than optimal environmental conditions, such as the droughts experienced in Europe and North America, significantly reduced wheat yields in several regions across the globe. This situation, if experienced over a relatively few seasons, would have a dramatic and negative impact on global grain stocks causing prices to spike upward and likely lead to social unrest in many countries as has occurred in the past. Indeed, stocks of wheat have fallen this year (down 5% from 2017), and while countries like China have huge stockpiles of wheat, these are unlikely to be made accessible internationally.

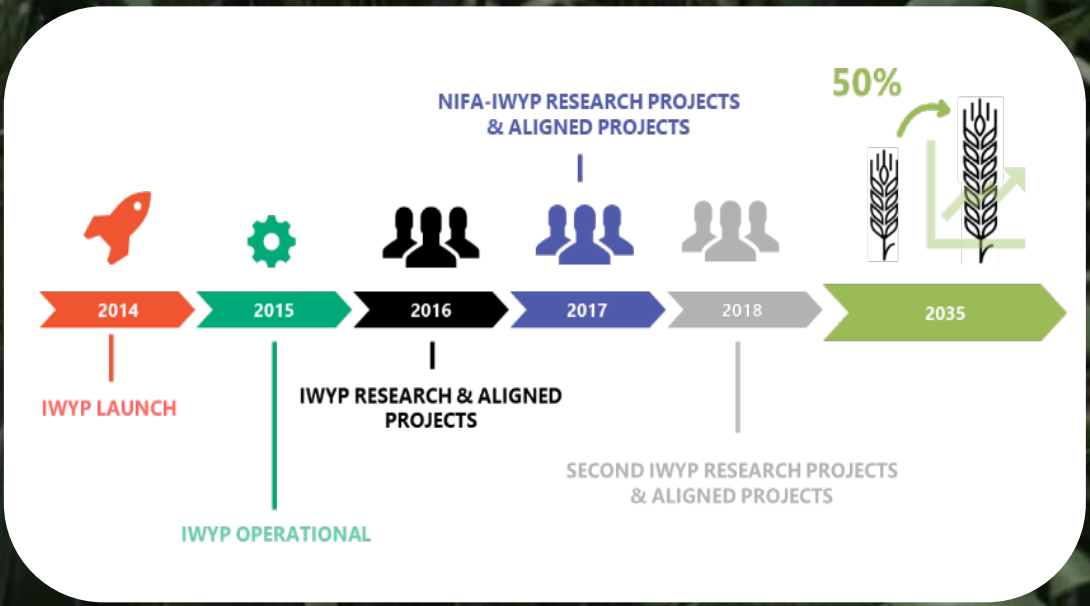
IWYP's strategy comprises entrepreneurial discovery research through to the release of advanced, characterized germplasm to all wheat breeding enterprises in the world. Examples of significant progress have been generated at all stages of this broad and complex pipeline, which importantly illustrates the role of IWYP in not only making discoveries but also bringing innovations into wheat breeding. These examples include:

- Validation of the hypothesis that biomass at flowering time is correlated with grain yield in spring wheats and that combining parents with high biomass (source traits) with parents possessing good harvest index and other good sink traits can boost genetic yield gains
- Two lines selected based on this hypothesis have been chosen for varietal release in Pakistan
- Radiation Use Efficiency is highly correlated with grain yield, supporting the hypothesis that increasing the amount of carbon captured is a sound approach for increasing yield potential
- Significant genetic variation exists in many facets of the complex photosynthesis process in wheat and between different parts of wheat plants implying that there is considerable scope for improving the efficiencies of carbon capture by optimizing the photosynthetic processes throughout the plant and the canopies

- Significant genetic variation exists for the amounts of fixed carbon that are lost by respiration and other processes, implying that optimizing this trait should promote yield gains
- Specific canopy architecture characters that increase light capture and penetration into the canopy correlate with higher grain yields
- Optimizing the complement of alleles for a set of genes known to influence flowering time and plant development in defined environments leads to higher grain yields
- Introducing genetic variation from wild relatives is a sound way of finding novel variation to increase yields in modern breeding programs
- Using state-of -the-art molecular marker mapping technologies, combined with novel phenotyping technologies of traits, has led to new opportunities to incorporate novel traits into wheat breeding programs by marker assisted breeding and genomic selection

Many other examples are noted in this Annual Report and many others are in the pipeline to be combined and developed in future years. 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 over and above those in wheat breeding programs today. We hope this Annual Report 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 smart science leads to impact and benefits for the farmers, agricultural systems and environments of the world.

The model that has been adopted by IWYP where funding and research is combined between countries, flexibly managed and coordinated, and where a delivery pipeline has been deliberately integrated as part of the partnership, is now being adopted by other crop/commodity communities to ensure long term impact is made from these initiatives.



Message from the IWYP 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 retained its focus on the goal of delivering innovations into wheat breeding to aid significant future yield increases. The discoveries include elucidation of new traits, the means of measuring them and genetic variation controlling them. There has also been state-of-the-art discovery of molecular markers that are co-inherited with these and many other traits to enable the traits to be utilized more easily in breeding programs. The chosen traits are highly likely to underpin yield increases because they include features of photosynthesis, plant architecture, plant biomass distribution, and grain number and size. While we are witnessing many new scientific discoveries, there remains much to do to validate their relevance to elite germplasm and to the many breeding programs around the world. It is important to note that IWYP is "product driven". Therefore, while IWYP champions the development of entrepreneurial innovations not previously found in wheat breeding, it also remains focused on building and financing the downstream pipelines that will define their utility for wheat breeding, farmer economic enhancement and sustainable agriculture worldwide. IWYP as a new model for tackling a global agricultural problem has much to offer others seeking innovations to meet global challenges. This Annual Report is one vehicle for telling the IWYP story. Creative thinking and commitments by many are behind the progress reported here. These members of the IWYP family deserve our thanks and perpetual encouragement.

Richard Flavell – Chair, IWYP Science and Impact Executive Board

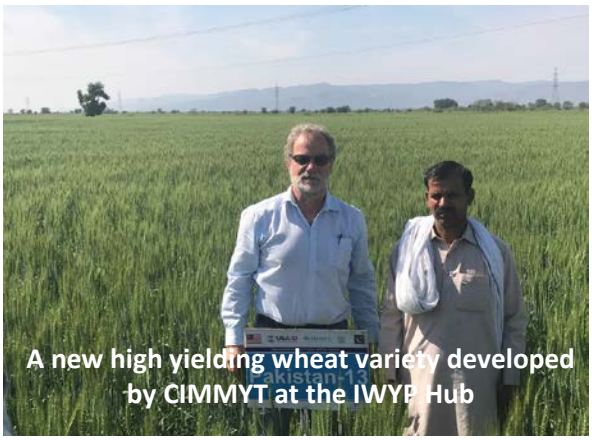
Message from the IWYP Program Director

I am happy to present the 3rd IWYP Annual Report to provide a summary of the exciting activities that have occurred across the IWYP Program over the last year. What marks this year as special is that IWYP is entering 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. As our first research projects are in their 3rd year, many of the outputs from research are being validated in relevant field environments at CIMMYT and the best are entering our prebreeding program. New traits and new genetics are being assembled in elite wheat lines to ultimately be tested in dozens of field trials across the globe over the next few years. These results will further substantiate that our trait targets are resulting in the level of grain yield enhancements sought, and most importantly providing 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-funded research projects and we continue to seek out the best and most relevant outside research to join IWYP. The IWYP Hub continues to make strides in the improvement of the elite germplasm base with which validated research outputs are being combined. Several selected lines with higher biomass and higher grain yields, traits that are key IWYP targets, have been made available to the global wheat community. 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

The Challenges Facing Agriculture and IWYP

IWYP is paying much attention to the prevailing challenges faced by farmers, and the crop industry in general, to produce sustainable high yields. A multitude of issues are becoming more critical, from the effects of a changing climate on crop yields and quality, soil loss and degradation, fertilizer and agrochemical run off, and more limited access to improved seed varieties and agricultural technologies. This is particularly true for rural farmers in less developed countries. There is a requirement to grow more food on less land with fewer inputs, in a more sustainable way and there is no one "silver bullet" that can achieve this. There is an urgent need to find solutions to these problems, both at the national and international level, to support the rising demands for nutritious food from the increasing global population.


A new high yielding wheat variety developed by CIMMYT at the IWYP Hub

Enhancing the genetic yield potential of important crop species such as wheat is one way to help mitigate many of these issues, as well as aid in stabilizing food supplies at a global level. Yields on-farm in some geographies have remained stagnant or even fallen over the last few decades. Whilst breeders have continued to increase the genetic potential for wheat yield, the rate of genetic gain is insufficient to achieve the necessary increase in yield required to ensure food security. IWYP aims to assist in reversing this trend by developing new germplasm and traits that will feed existing breeding pipelines and aid to raise the rate of genetic gain for yield potential over and above the current annual rate, with an overall goal of increasing the genetic yield potential by 50% by 2035. IWYP is "demand led" in that the outputs delivered by our research are rigorously tested and then developed into pre-products and/or products by public and private systems to serve the requirements of wheat markets worldwide. IWYP seeks breakthroughs that go beyond the "business as usual" model to make a significant and lasting impact to global wheat productivity. We aim to lead the way and provide a model to deliver solutions to alleviate food insecurity. The impacts of IWYP achieving its goals and objectives are many, and include:

- Increased profitability/incomes for famers globally
- Enhanced rural economies in developed and less developed countries
- Assistance in alleviating hunger and poor nutrition habitually present in many parts of the world
- Help to mitigate the impact of climate change and the associated issue with crop yield losses
- Improvements in overall soil heath by sequestering more carbon in root systems by improvements in the efficiency of photosynthesis
- Stable and increased food production on less land and with fewer environment affecting inputs such as fertilizers and agrochemicals
- Use of scientific discoveries to improve and produce new wheat varieties to achieve higher yields
- Deployment of pre-products to major wheat growing regions of the world using the existing and well established CGIAR infrastructure and network of NARS partners
- Capacity building and education opportunities for the next generation of plant scientists and breeders
- Development of private-public partnerships to deliver on all the above that can be extended to other initiatives and needs

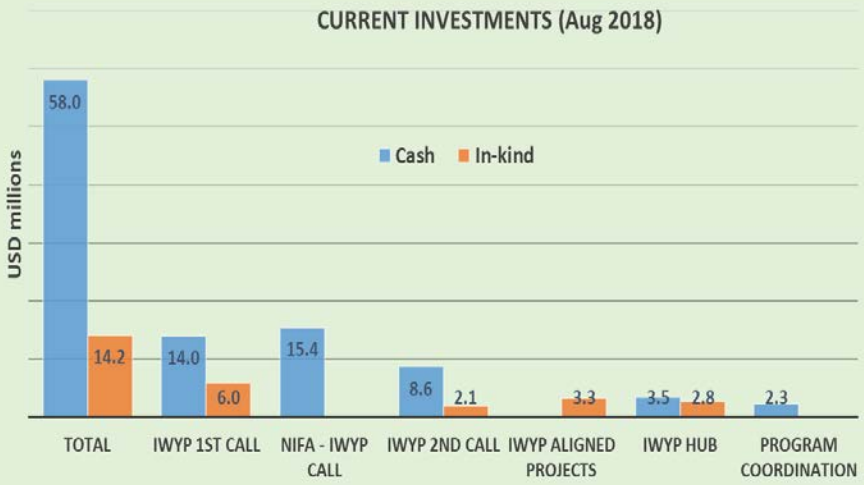
Financial Overview

IWYP is over halfway towards its overall goal to invest US$100 million to realize its goals and objectives

The IWYP financial plan is built upon investments from its many IWYP Partners, each of which funds or underwrites specific components of the total IWYP operational and research activities. Government agency partners that support scientific discoveries (currently in the UK, USA, Australia, Canada, France, India, and Mexico) are responsible for the activities where investments are research based and made in multi-year assignments (grant awards). USAID, BBSRC and SFSA currently also invest in the development pipeline downstream of discovery (IWYP Hub) through a commission to CIMMYT in Mexico.

Through its partners, approximately US$58 million has been committed to IWYP research and operations to date.

However, additional sustained funding is critical to support the essential IWYP Hub technical development platforms(s) in Program phases downstream of discovery research, the central operations and research coordination. The overall resource requirements associated with the execution of the "IWYP Strategic Plan" will continue to inform future needs and adjustments will be made as necessary (See iwyp.org).



The IWYP Science Program

In **IWYP's Strategy**, the IWYP Science Program is structured into 3 overlapping operational phases:

Phase I Discovery Research

- **Focused coordinated research in the best wheat laboratories and field plots of the world to develop breakthroughs for crop improvement**

Phase II Validation & Development

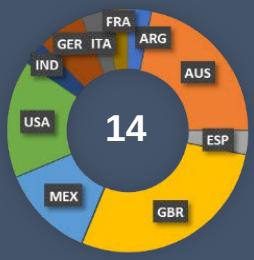
- **Collation of the results and their translation into prebreeding in commercially relevant environments in Mexico, USA and Europe**

Phase III Delivery

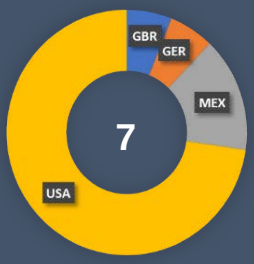
- **Deployment of improved products to NARS organizations and public or private seed companies for them to select the most locally adapted high yielding lines to breed with or submit directly for commercialization**

At the heart of the IWYP Science Program is the working hypothesis that a wheat plant has the potential to convert more atmospheric CO_2 into carbohydrates and translate this into a greater number of harvested grains. To do so requires radical improvements in the way the wheat plant can capture and utilize solar radiation, from increasing photosynthetic efficiency per unit area to ensuring that light penetration is more evenly distributed throughout the plant canopy. These changes lead to an increase in the production of more and/or larger grains without compromising vital protein levels in the grain, as well as enabling more efficient use of critical inputs such as nitrogen. This hypothesis has been tested by the team at CIMMYT where they have shown that selecting lines with higher biomass and radiation use efficiency can result in plants with significantly higher yields. IWYP aims to builds on these advances by adopting and applying new approaches and technologies to create breakthroughs in these areas and bring resulting improved products to farmers' fields faster.

The wheat plant being sought by IWYP has all the following attributes in relevant environments and optimal growing conditions, over and above those common in commercial agriculture today. Such plants would have substantially higher inherent yield potential. Significant improvements in any of these traits would equate to breakthroughs and combining multiple



IWYP RESEARCH PROJECTS



NIFA - IWYP RESEARCH PROJECTS

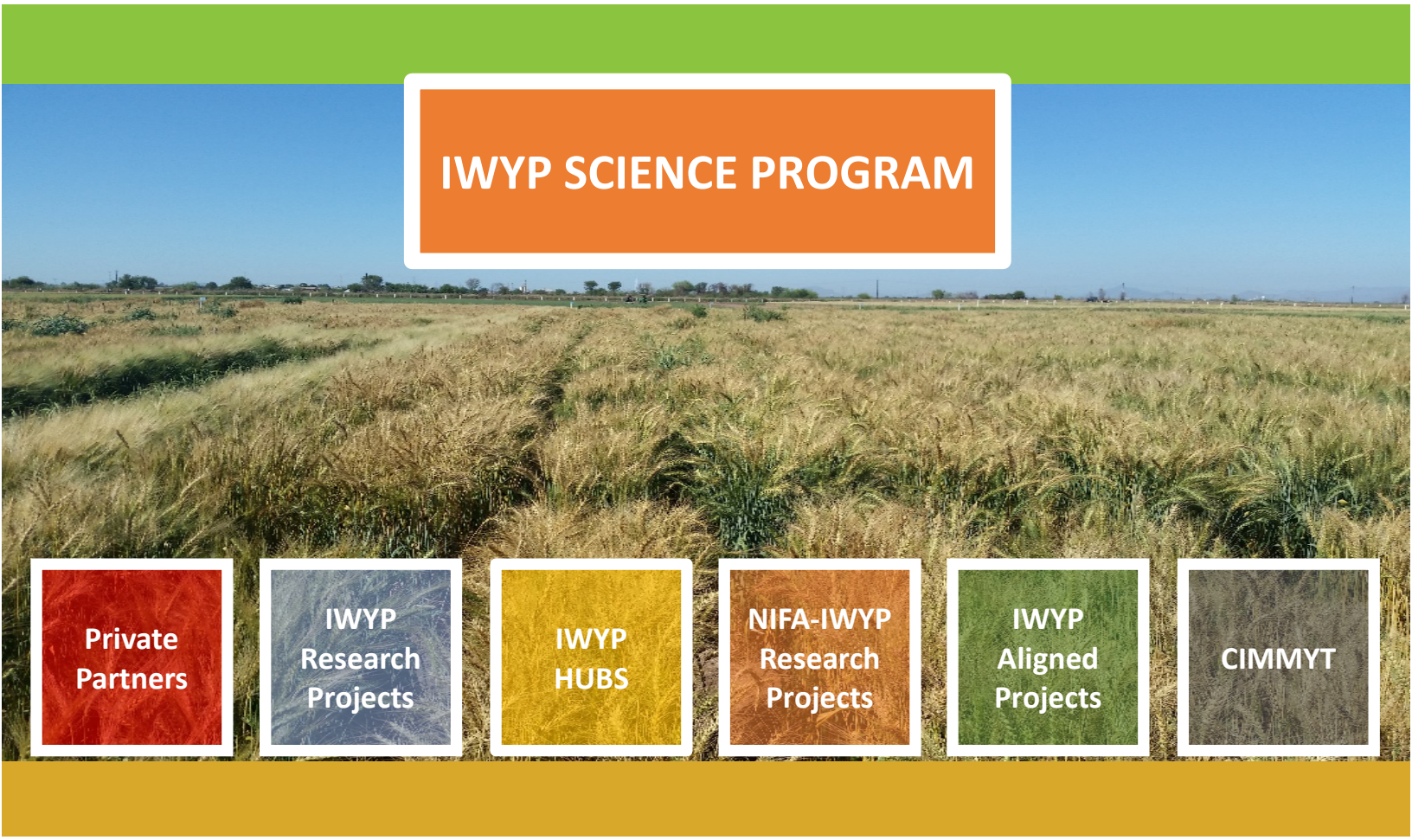
IWYP ALIGNED RESEARCH PROJECTS

12 COUNTRIES

58 INSTITUIONS

attributes would lead to the highly improved wheat plants we are seeking. Some of the attributes we envision an optimized wheat plant to have include:

- Rapid growth from germination to flowering owing to more efficient photosynthesis and reduced loss of carbon due to respiration
- Greater efficiency of photosynthesis during transitions from shade to high light, and vice versa
- Strong stems that do not store carbon unnecessarily but rather make it available for grain formation
- Tillers that develop synchronously and therefore are not shaded by being late to develop or a waste of stored nitrogen
- Larger spikes with more highly filled grains, containing adequate N to make protein and other high nutrition compounds
- High harvest index owing to high photosynthesis, optimized carbon distribution, and optimally timed flowering and senescence
- Root structures that support the above attributes and provide the right balance of carbon in above ground growth versus below ground growth
- An optimal architecture that permits the maximal amount of sunlight to reach all parts of the canopy



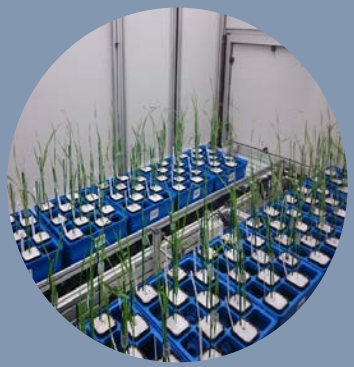
Progress Towards IWYP Science Goals and Objectives

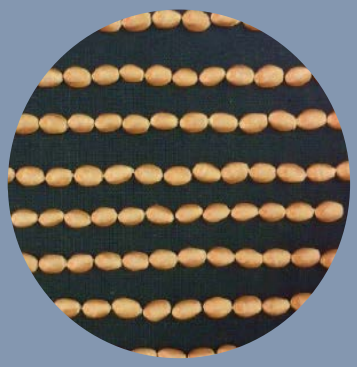
Research Success in 2017/18 - Highlights from the Science Team

Many new research discoveries have been recorded over the last year. These take the form of germplasm that has been found to have the target trait(s) to improve genetic yield potential; molecular genetic markers that have been associated with an IWYP target trait; mutations in a gene that impart a change in the expression of a trait; new methods or technologies that help IWYP better screen individuals; and the optimization of methods for rapid screening for or the manipulation of traits at the genetic level. While some are still at the early stages of discovery, others are now ready for transfer to the IWYP Hub to begin the process of validation. IWYP is cataloguing all relevant discoveries and working with the researchers and the IWYP Hub staff to prioritize and plan which should enter the validation and prebreeding pipeline. The next few pages highlight some of the key research successes over this past year.

Evaluating Effects of Known Genes on Yield and Components of Yield

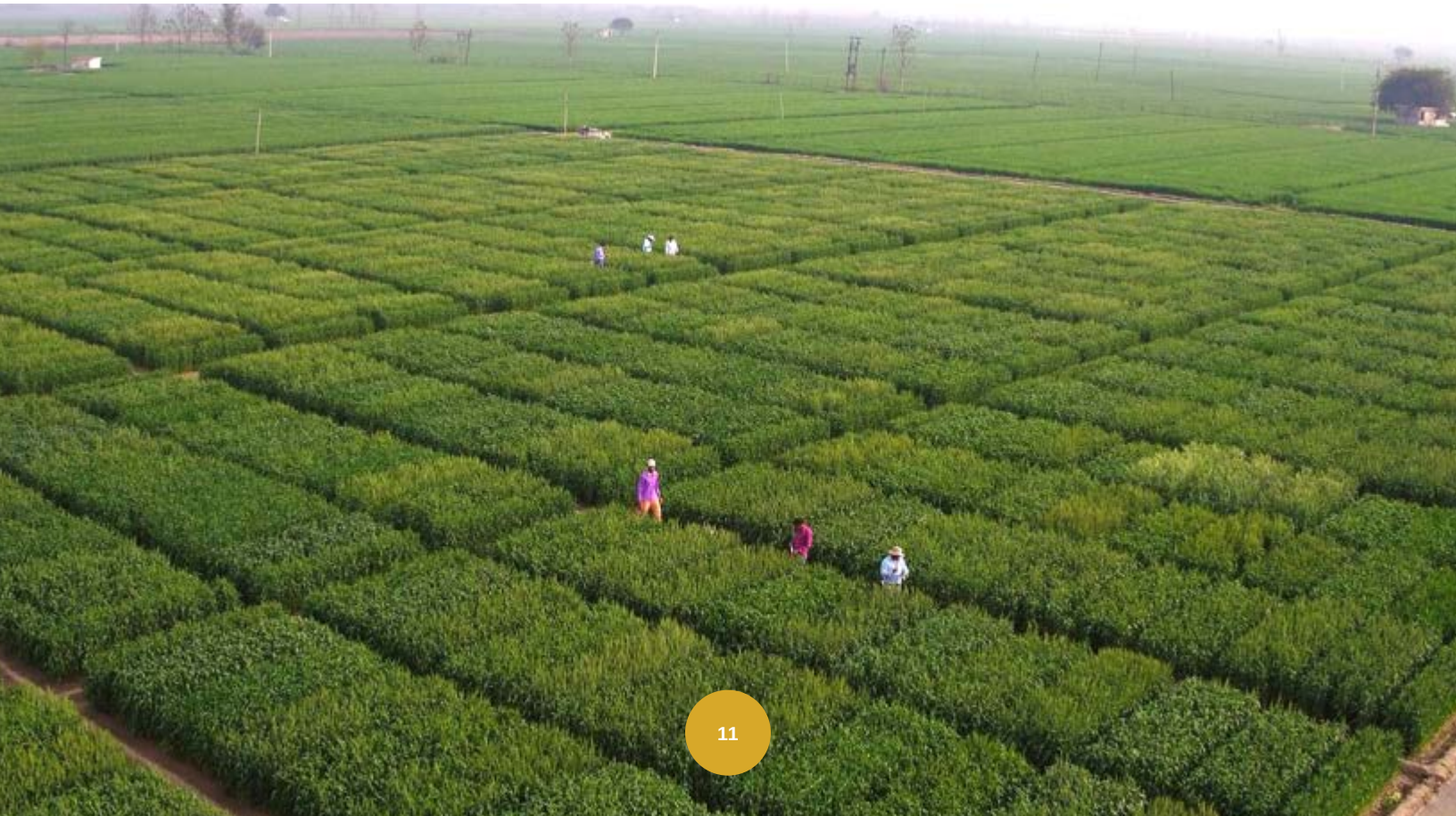
- Known genes that determine grain size and number have been gene edited in several winter and spring wheat lines from US and CIMMYT breeding programs to explore their effects on yield in different genetic backgrounds.
- Lines with mutations in genes affecting grain size (width and/or length) and spike morphology are being introgressed into different bread and pasta wheat varieties to evaluate their effect under field conditions. Several introgressions have been advanced to a stage where they are publicly available for order and have been supplied to breeding companies in the UK, Europe and Brazil.
- Greenhouse evaluations of transformed wheat lines containing multiple events of genes influencing biomass, grain or root development have led to the identification of individuals with significant yield increases.
- Known genes linked to yield components and secondary target traits have been screened in germplasm suitable for several Southern African production regions and the favorable haplotypes were identified. These are now being validated in various combinations for their ability to enhance yields.





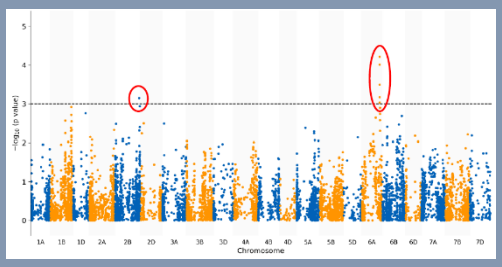
Discovering Optimized Traits in Wheat and Wild Relatives

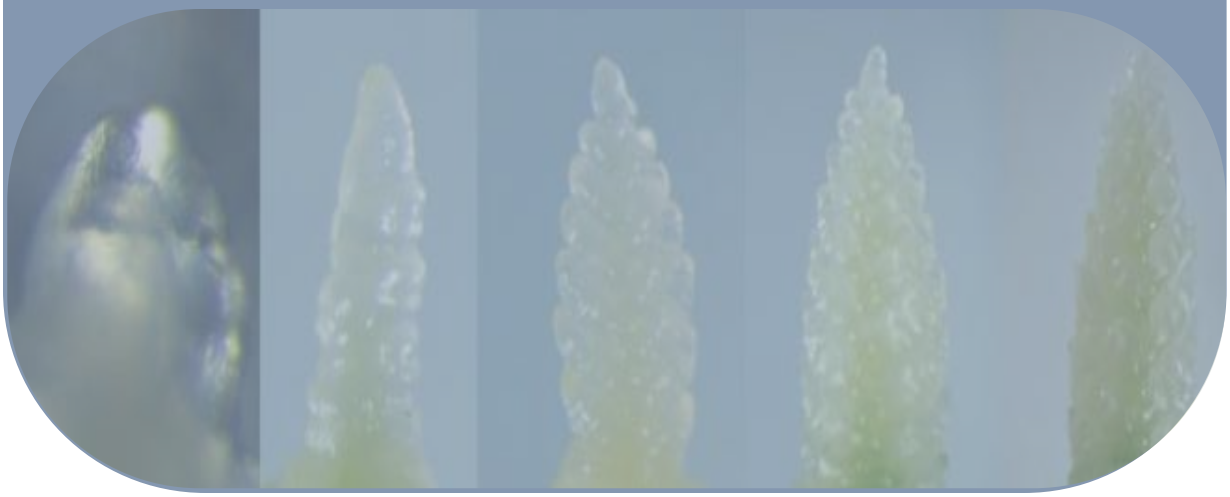
- Higher photosynthetic efficiency has been found in wheat landraces and wheat wild relatives that may boost productivity if introduced into cultivated bread wheat. Several lines are now being evaluated in the field at CIMMYT.
- Over 30 lines expressing specific source:sink balance traits have been combined to test the effect on genetic yield potential.
- Significant genetic diversity was observed for radiation use efficiency (RUE) at different phenological stages suggesting that photosynthetic capacity improvements can come from increasing RUE at all growth stages.
- Numerous advanced breeding lines with good anther extrusion have been identified and selected. These should make better pollinators for hybrid production.
- 100's of wheat hybrid combinations have been tested in multiple environments to identify levels of heterosis and useful parental lines for constructing heterotic pools in hybrid wheat breeding programs.
- Considerable variation for the efficiencies of photosynthetic ratios between flag leaf and lower leaves has been found between wheats. This provides a new trait for wheat breeding.
- Variation in leaf photosynthetic responses in leaves experiencing transitions from shade to light has also been found which also provides a new trait for wheat breeding.



Detecting New Genes and Markers for Breeding

- At least 50 molecular genetic markers have been associated with key photosynthetic, biomass and other phenotypic traits in field studies and they are currently being tested to confirm the associations.
- Several genes that determine phenological development have been associated with grain yield and harvest index in CIMMYT germplasm. These are in addition to the well-known genes for controlling photoperiod (*Ppd*) and vernalization (*Vrn1*).
- Catalogs of the combinations of alleles controlling phenology that have been indirectly selected by wheat breeders at CIMMYT have been produced enabling their associations with other yield traits to be made.
- A catalog of all potentially useful variation for phenology genes, but not widely used by CIMMYT breeding programs, has also been compiled.
- New crosses to introduce and validate the effect of different combinations of phenology alleles in spring wheat are continuing.
- 100's of wheat lines and wheat relatives have been genotyped to define genetic variation and identify the location/size of introgressions from wild wheat relatives.
- Protein analyses have identified 17 candidate genes linked to respiration and yield.
- New candidate genes for early spike and grain development have been identified and are being tested for effects.
- A population developed by crossing a fertility restorer source with an advanced line has been phenotyped for fertility restoration to map the nuclear genetic control of the CMS system currently used to make hybrids.





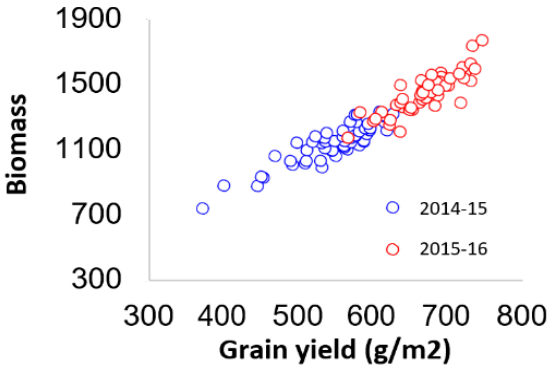
Developing Tools and Protocols

- An Unmanned Aerial Vehicle (UAV) platform was developed that can be deployed across large-scale breeding nurseries to measure more phenotypic traits with increased precision and throughput.
- Standardized protocols describing the routine collection of field-based High Throughput Phenotyping (HTP) measurements using UAVs have been developed.
- A new imaging technique has been developed to assess the dynamic response of stomata in diverse wheat germplasm.
- Hyperspectral signatures were found to be a useful proxy to predict leaf respiration and could be used as a parameter for plant selection by breeders.
- A hybridization-based genotyping wheat community platform was built including full sequencing of 200 candidate genes identified by other IWYP researchers.
- Data on a million Single Nucleotide Polymorphisms (SNPs) from wheat parental lines of the wheat Coordinated Agricultural Project (CAP) was compiled and uploaded to the T3 Project Database (https://triticeaetoolbox.org/wheat/) and made freely available to all researchers.
- An assay designed to target regulatory elements covering approximately 84% of the wheat genes with corresponding data on 200 lines (including Wheat CAP parents) was completed.
- A genetic recombination map was constructed to help positionally clone or fine map traits of interest.
- Custom made tools that measure photosynthetic capacity in the field were developed that enable more than 2X the number of genotypes to be measured for this trait.

Delivering Wheat with Greater Genetic Yield Potential

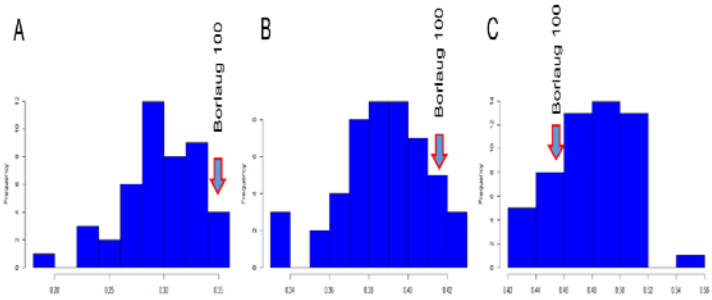
The IWYP Spring Wheat Hub at CIMMYT

The IWYP Hub platform for spring wheat types is managed by CIMMYT under the direction of IWYP. Located in Mexico at the CIMMYT field station near Ciudad Obregon, it serves both as a validation and a prebreeding pipeline for IWYP research discoveries. CIMMYT has a long-established successful record in developing elite wheat germplasm with demonstrated impact, has world-class infrastructure and a critical mass of expert physiologists, geneticists, breeders and support staff. As their breeding and evaluation processes are devised to mimic the largest spring wheat growing areas in the world, significant improvements in spring wheat yields demonstrated in Mexico can have a significant impact on global livelihoods and food security.



At the IWYP Hub, IWYP discoveries are first tested to ensure that the effects observed in labs and field by researchers in other countries are maintained in relevant environments, and if so, are then entered into a prebreeding pipeline to integrate them into elite germplasm. Valuable genes and new traits are combined in different combinations to further drive yields.

Over the course of 2017/18, research discoveries made in many of the IWYP Projects have started to flow to the CIMMYT Hub for testing. At the same time, the Hub staff continue to make progress in increasing genetic yield potential by developing improved germplasm by combining physiological traits where evidence indicates a positive correlation with final grain yield. For example, a significant and positive correlation has now been confirmed between plant biomass and grain yield in the field, thus validating the breeding strategy for making plant selections or selecting those with high final biomass. This has resulted in higher performing lines being sent to the CIMMYT International Nurseries and made available to breeding programs worldwide. Many of the lines that outperform the best check varieties contain synthetic or landrace material also validating the importance of introducing novel variation into breeding programs.



Harvest Index range in (A) 1st WYCYT (B) 2nd WYCYT and (C) 3rd WYCYT

Optimizing Harvest Index (HI) is another trait that is a target for breeding at the IWYP Hub. The sets of new wheat lines that have entered the Wheat Yield Consortium Yield Trial (WYCYT) International Nurseries have, over successive years, been improved for this trait with the check variety Borlaug 100 being overtaken.

Selected Highlights from the IWYP Hub at CIMMYT

- Validation of the hypothesis that combining parents with high biomass (source traits) with parents expressing good harvest index and other yield components (sink traits) can boost genetic gains. Some of the new improved lines have been proposed as candidates for varietal release in national programs with two selected in the last two years in Pakistan (Borlaug-16 and Kohat-17).
- Genomic selection models based on screening over 1000 genotyped lines have been used to optimize the prediction of performance and selection for international nurseries.
- Marker Assisted Selection (MAS) for improved harvest index is being conducted on populations combining high biomass with high harvest index to drive yields higher.
- Lines from historic crossing blocks have been genotyped for major phenology genes and grain size genes to determine what alleles have been indirectly selected in the breeding program and to guide further selection schemes.
- Several physiological trait lines from the 4th WYCYT (Wheat Yield Consortium Yield Trials) germplasm set have outperformed the best local and CIMMYT check varieties in over 27 environments in the 2016/2017 Spring Wheat Cycle, with many having landrace or synthetic hexaploid wheat in their pedigree, again highlighting the value of introducing novel genetic variation into breeding programs.
- Lines from the 5th WYCYT germplasm set were grown by >100 collaborators in >35 countries and results are being compiled.
- New candidates for the 6th WYCYT germplasm set were readied for distribution in the summer of 2018 to enter into the international trialing system.

Expanding the Science Program

Second IWYP Competitive Call for Proposals

The 2nd IWYP Competitive Call for Proposals was launched in late December 2016. As before, the Call followed a two-stage process whereby in the first stage, applicants submitted Pre-Proposals. Following peer review, the best fit-for-purpose Pre-Proposals were selected in late May, and these applicants were invited to submit Full Proposals in June. The Full Proposals were received in late August and then critically assessed based on a set of criteria related to scientific quality and fit to IWYP goals and objectives by a peer review panel consisting of 18 international experts. The results of the peer reviews were compiled and analyzed, and recommendations were made to the IWYP SIEB based on scientific quality and potential impact rankings. Following extensive evaluation by the SIEB in December, a subset of the Full Proposals was selected and recommended to funding agencies for support. As a result, funding for 6 new IWYP Research Projects has been secured and these Projects have been added to the IWYP Science Portfolio. The new Projects were selected to complement the existing Projects in, as well as expand, the IWYP Research Portfolio and are expected to further push forward our understanding of genetic yield potential in wheat and aid to deliver solutions within a breeding context. More details of the research scope of these new Projects can be found at iwyp.org/funded-projects/

IWYP Aligned Projects

New Research led by Dr. Scott Boden at the John Innes Centre in the UK has been recently adopted as an IWYP Aligned Project. This brings the total number of IWYP Aligned Projects to 9. Dr. Boden is investigating the potential impact of different alleles of key inflorescence development genes in contributing to an increase in grain number and thus the genetic yield potential of wheat. More details of this Project and indeed all current IWYP Aligned Projects can be found at iwyp.org/aligned-projects-2/.

ERIC OBER
NIAB
Rooty: A Root Ideotype Toolbox to Support Improved Wheat Yields

JULIE KING
University of Nottingham
Isolation of Genetic Variation for Flowering Morphology for Hybrid Wheat Production

MATTHEW PAUL
Rothamsted Research
Transforming Yield through Source-Sink Synchronization

ELIZABETE CARMO-SILVA
Lancaster University
Speeding the Adjustment of Photosynthesis to Shade-Sun Transitions to Increase Yield Potential in the Field

SENTHOLD ASSENG
University of Florida
Traits for increasing wheat grain yield

TRACY LAWSON
University of Essex
Manipulating Stomatal Blue Light Response in Wheat to Improve Productivity

NEW IWYP RESEARCH PROJECTS

Coordinating the Science Program

IWYP Hub Tour 2018

On 20 March 2018, a tour was organized for IWYP researchers and other IWYP members to the IWYP Hub at CIMMYT in Obregon, Mexico. This provided an opportunity, in an organized setting, for researchers to closely observe the IWYP trials and experiments in the field, discuss and engage with other IWYP researchers and IWYP Hub scientists, and overall obtain a first-hand perspective of the activities at the IWYP Hub. Further, the processes of how individual research outputs are validated and applied in the IWYP prebreeding pipeline were showcased. The agenda included a mix of presentations by IWYP Hub scientists followed by in depth inspections of IWYP experiments and trials in the field. The day concluded with a discussion around preferred strategies to rapidly test research outputs and integrate them into germplasm for wide distribution.

IWYP Program Conference 2018

The 3rd Annual IWYP Program Conference was held at the John Innes Centre, Norwich, UK, from 11-14 June 2018. As for previous IWYP conferences, the main purpose of the Conference was to give IWYP researchers the opportunity to update fellow IWYP research team members on scientific progress made over the last year, gain feedback on their work and form new research linkages. Several breakout sessions were organized for researchers to provide their collective advice regarding critical issues related to the IWYP Science Program and its operations. Importantly, various field tours were conducted, including the IWYP research at the John Innes Centre and Earlham Institute, and the National Institute of Agricultural Botany (NIAB). The Conference group also visited the local site of KWS where they learned how private industry commercially focused breeding is scaled and structured, and how IWYP research outputs fit into their product development strategy.

Training and Capacity Building

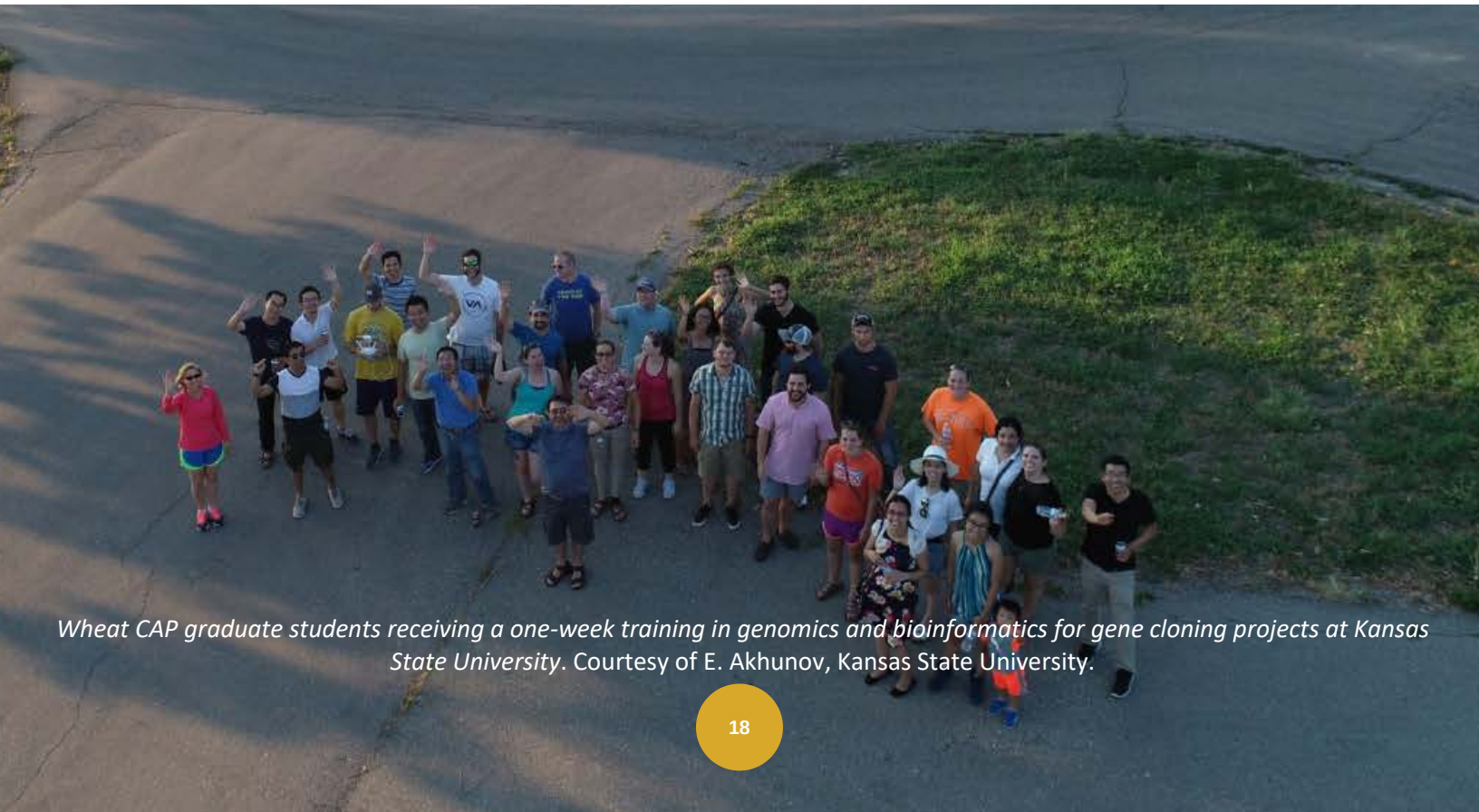
BBSRC in the UK provides funds to IWYP to facilitate exchange and training among scientists between UK and Mexican institutions. Since the funds were made available, 5 IWYP Researchers have applied and have received such support.

> *"This trip cemented an already strong relationship and opened new opportunities. I understand better than ever the complementarity of what is done at JIC with the achievements of CIMMYT."*
> … Simon Griffiths, John Innes Centre, Norwich, UK

PhD Student Bethany Love at the IWYP Hub at CIMMYT

Overall, the IWYP researchers who have taken the opportunity to apply for the Scientific Exchange Program have considered these opportunities for scientific exchange extremely valuable, either in helping to develop new working relationships or enhancing existing working relationships. IWYP plans to be able to continue this initiative in the future and expand it to scientists in more countries.

From the beginning, the IWYP Hub at CIMMTY in Mexico has provided training and support to IWYP Projects. In 2017-18 training was provided to 11 scientists from several IWYP Research Projects and Aligned Projects. Many were early career scientists (PhD students and Post-Doctoral Researchers). Individual IWYP Research Projects have also conducted their own training over the course of this year, most notably the NIFA-IWYP Project led by Dr. Jorge Dubkovsky at UC Davis where training is a significant component of this large Coordinated Agricultural Project.



Wheat CAP graduate students receiving a one-week training in genomics and bioinformatics for gene cloning projects at Kansas State University. Courtesy of E. Akhunov, Kansas State University.

Expanding the IWYP External Profile

The IWYP communications strategy focuses on the development of messaging of the features of the improved wheats to both anticipate and accompany their release into the advanced trialing systems and commercialization. This strategy emphasizes the role of wheats with improved photosynthesis and other traits for sustainable yield increases, thus enabling more to be gained on less land. Where possible, it will be tailored to farmers and consumers in the diverse societies of the world.

Events

NIFA-IWYP Project Director meeting, San Diego

IWYP Management co-hosted with the National Institute of Food and Agriculture (NIFA) a NIFA-IWYP Project Director meeting during the Plant and Animal Genome Conference in San Diego, CA, in January 2018. IWYP's presentation focused on how well the NIFA-IWYP Projects have become integrated in the overall IWYP Science Program in their first year. Several exciting examples of collaboration and generation of added value already occurring across Projects and other IWYP research groups were shared with the audience.

At the same conference, KeyGene organized a Workshop entitled "Crop Innovation and the Impact on Food, Nutrition and Health" and invited the IWYP Program Director to present an overview of IWYP. The presentation focused on the importance of the IWYP model and the value of partnerships in solving important issues with science.

IWYP Research Workshop in Adelaide, Australia

At an IWYP Research Workshop in Adelaide, Australia, the IWYP Program Director provided a general overview of the partnership for interested parties. For the first day, researchers involved in IWYP Projects came together to discuss research progress and experimental approaches, and the beneficial linkages made with other IWYP Projects across the globe.

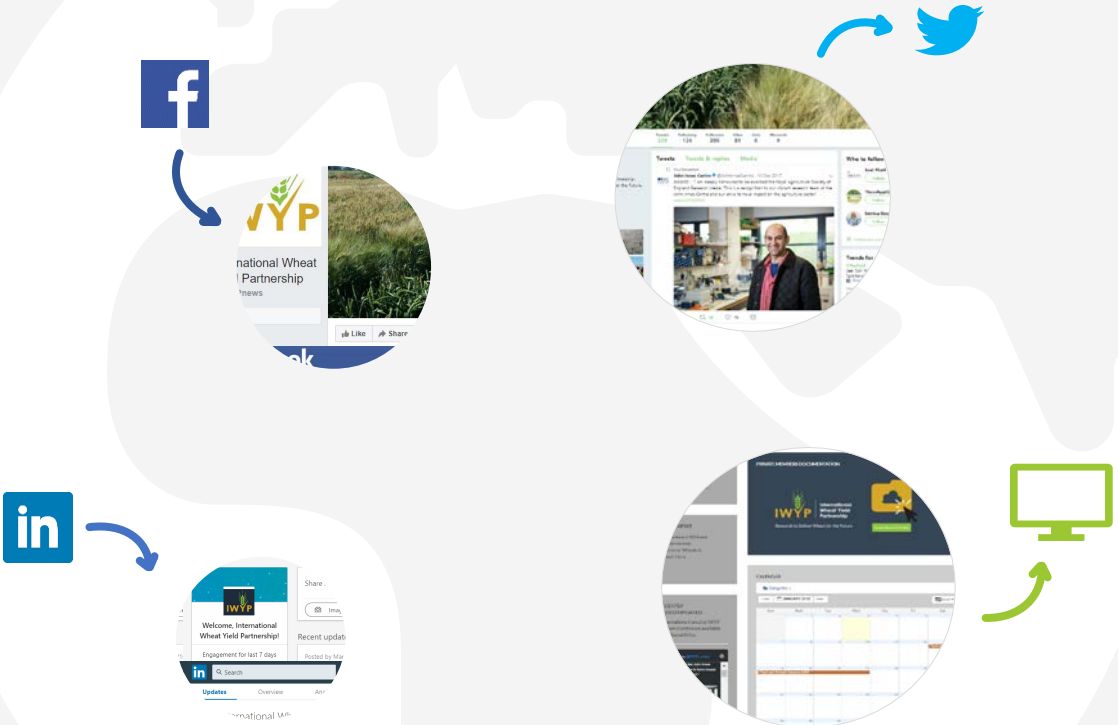
On the second day, representatives of the Grains Research and Development Corporation (GRDC) and commercial breeding companies in Australia joined the group. Research progress summaries were presented with a follow up discussion on how these Projects and others in IWYP were progressing, and the extent to which the research was providing important new information, tools, traits and germplasm that will ultimately benefit the Australian wheat industry. The commercial breeders were especially excited to see the new technologies, tools and traits being developed that could be immediately applied in their breeding programs to create new higher yielding products.

The IWYP Website and Social Media

IWYP continues to update our partners and the public with the latest news on the Partnership. While the IWYP website has been our main vehicle for achieving this, social media applications including Twitter are becoming more important for sharing the latest news on our research with our followers, including scientists, funding organizations and other initiatives operating in the cereals research space.

The IWYP Twitter account continues to attract new followers reaching a total of approximately 700 to date, an increase of almost 50% since December 2017. In addition, many of our IWYP colleagues are adept and active with sharing updates about their IWYP research. IWYP Management actively ensures that these updates are more widely disseminated among our followers, some of whom are IWYP Members.

We will continue to evolve the way IWYP communicates our science and successes with the outside world, working more closely with communications colleagues at CIMMYT (www.cimmyt.org) and The Wheat Initiative (www.wheatinitiative.org) to develop a more targeted and cohesive communications strategy.



Looking Forward

IWYP now has a pipeline of research projects feeding outputs in successive waves to the IWYP Hub at CIMMYT for development into pre-products. As the first Projects are nearing completion, others are in mid-stream while others are just starting. This continuous pipeline that covers numerous aspects of wheat improvement is necessary to ensure we have the best "toolbox" of new traits, genetics and technology at our disposal to enable us to reach our goals.

Over the coming months, IWYP will be ramping up activities in the IWYP Hub in CIMMYT. New strategies are being formulated to plan how best to combine the research outputs, in the quickest way, and in the best germplasm to drive grain yields higher. The roles and responsibilities of the additional IWYP Hubs for winter wheat germplasm will be finalized soon as we build a more complete pipeline. The multiple Hub mechanism should speed and expand the dissemination of our research outputs more quickly into other wheat germplasm types and geographies. Work will also be done to integrate the newly commissioned IWYP Research Projects into the Science Program to form new research linkages and generate further added value. We will also be making a more concentrated effort over the coming year to make the mission of IWYP more visible to the outside world, including to recruit new funding organizations and researchers.

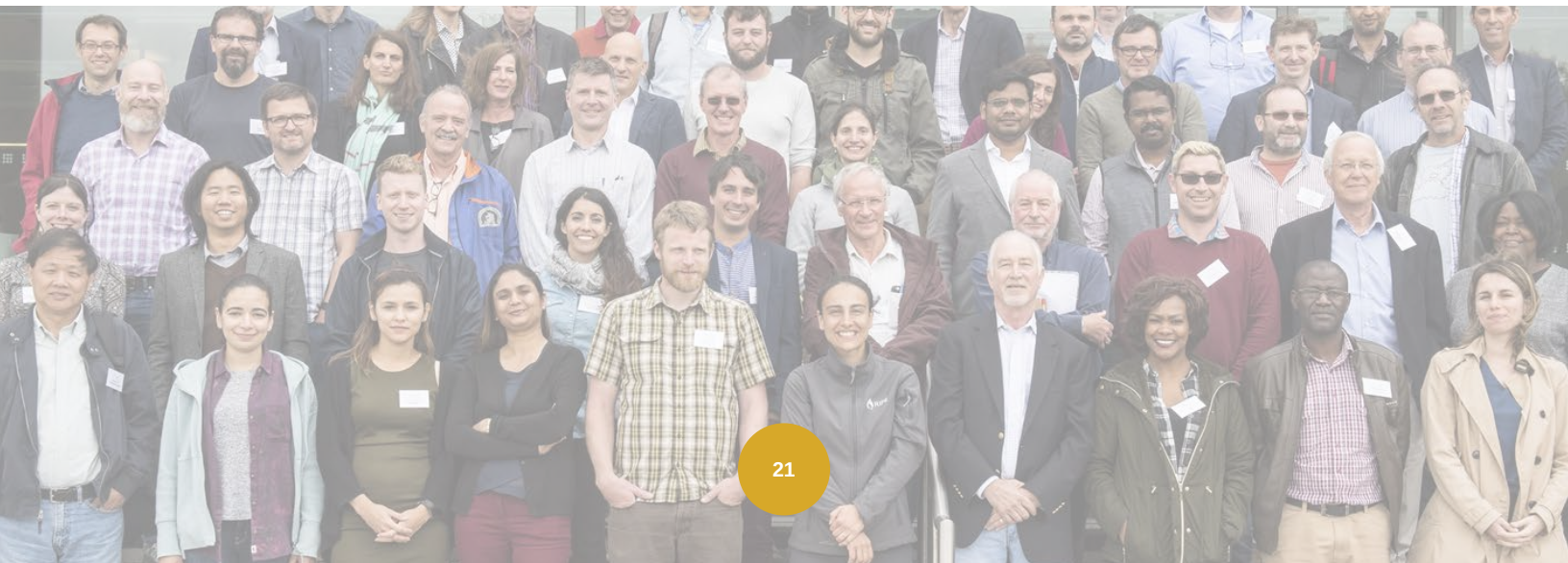
It is apparent that the level of excitement, interaction and collaboration of the researchers in the IWYP team continues to be very high. This has created a "stakeholder's mentality", a sense of ownership if you will, in the IWYP Program that drives them to succeed. All remain committed to the IWYP goals and objectives and are pushing their research to ensure that their innovations reach farmers' fields. All involved in IWYP, from Funders to lab technicians, are aware of the critical challenge to raise genetic wheat yield potential by 50% by 2035. IWYP remains optimistic that by choosing the right research targets, delivering the best validated science by some of the best labs and scientists in the world and to the breeding organizations of the world, we will meet the urgent challenge set out to assist in global food and nutritional security.

In closing, we at IWYP hope this Annual Report is useful to inform you about our strategy and progress toward meeting a critical global need.

For further information on IWYP, please visit www.iwyp.org

IWYP International Wheat Yield Partnership

Research to Deliver Wheat for the Future



IWYP

International Wheat Yield Partnership

Research to Deliver Wheat for the Future

IWYP represents a long-term collaborative effort with the goal to increase the genetic yield potential of wheat by up to 50% in 20 years. IWYP will do this via a unique partnership of public sector agencies with private industry by supporting research that is innovative and high risk, but when successful will substantially boost global wheat productivity and contribute to meeting rising global demand.