Infrastructure and Services for International Wheat Yield Partnership Hub (IWYP Hub) at CIMMYT

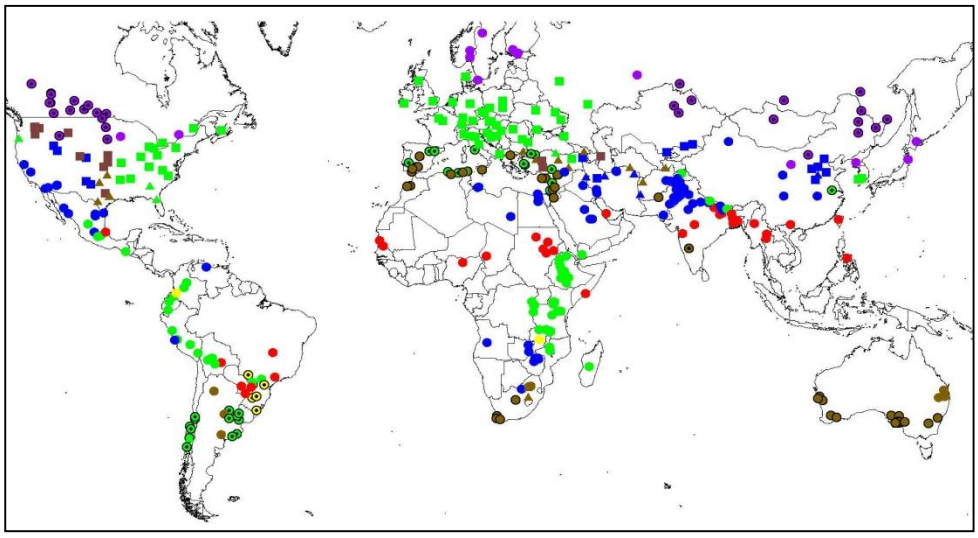
CIMMYT MR
International Maize and Wheat Improvement Center

Formation of an International Wheat Yield Partnership Hub at CIMMYT

Background

IWYP-funded research will require experiments to be conducted and/or validated in a genetic and environmental context such that outputs are representative of performance in major wheat growing areas worldwide, and can be applied directly to breeding. It is proposed to root this translation research effort at the heart of the International Wheat Improvement Network (IWIN). The IWIN, which involves hundreds of partners and testing sites worldwide (Figure 1), is coordinated by the Global Wheat Program of the International Maize and Wheat Improvement Centre (CIMMYT). The IWIN has underpinned increases in wheat productivity in the developing world ever since the Green Revolution (Braun et al., 2010), and currently develops and disseminates ~1,000 new wheat lines each year, with well documented up to date genetic gains (Manes et al., 2012; Sharma et al., 2012). In addition, IWIN germplasm is sought after by public and private entities in the developed world where its impacts are also well documented.

Fig 1. International Wheat Improvement Network, showing the 5 main spring wheat target mega-environments (blue = high yield potential irrigated, green=high rainfall, red=heat stressed, brown=drought stressed, purple = high latitude)



This would be achieved by establishing a dedicated Hub (IWYP Hub) at the main IWIN research and breeding station –CENEB[1] (located in Obregon, NW Mexico)-, for testing and translating novel traits into parents that will subsequently be made available and validated by both public and private breeders through the IWIN yield trial network (Fig 1). The IWYP Hub will be managed by CIMMYT's Global Wheat Program and linked to other WHEAT CRP activities, thus providing multiple avenues for leverage of IWYP and IWYP-aligned investments. It also enables the IWYP to be

launched with high levels of alignment with the vision and mission of the *Wheat Initiative*, which "…aims to encourage and support the development of a vibrant global wheat public-private research community sharing resources, capabilities, data and ideas to improve wheat land productivity, quality and sustainable production around the world."

The IWYP Hub at CIMMYT

As a result of the well documented global impacts of IWIN, as well as a number of pioneering research initiatives in phenotyping and genetic understanding of wheat, CIMMYT is a globally recognized hub of international collaboration. Considering just visitors to Mexico alone, the CIMMYT Global Wheat Program hosts over 120 scientists and policymakers from over 30 countries each year, in addition to ongoing collaborations worldwide. This global network enables cross-communication among all aspects of wheat genetics, physiology, and breeding, including the support areas of genomics, bio-informatics/statistics, and phenotyping.

CIMMYT's CENEB station in Obregon is already the key research and pre-breeding hub for the *MasAgro TRIGO* initiative, a Mexican Government funded collaboration focused on improving wheat production and research capacity in Mexico, which over the last 5 years has established crucial infrastructure, as well as sponsoring 8 doctoral research projects registered at world class universities. Deliverables to date include novel high yield potential germplasm whose genetic gains have been validated at over 25 international locations, new and standardized phenotyping protocols that have been published in user friendly manual formats, and the beginning of a stream of peer-reviewed journal articles documenting advances in the understanding of photosynthesis, phenology and partitioning of elite wheat lines in high yielding field environments.

It is therefore proposed that the IWYP Hub should capitalize and build on the CENEB facilities, as well as the operational capacity of the two generation-per-year breeding and research shuttle at the heart of the IWIN. The main site of the shuttle is the CENEB (in Ciudad Obregon, state of Sonora) while the secondary site is at CIMMYT's HQ at El Batan, Texcoco, State of Mexico. The El Batan shuttle station is necessary to ensure the fast advancement of generations.

The IWYP Hub will initially be configured to have five dedicated hectares at CENEB[1] for precision field phenotyping and pre-breeding, as needed. At El Batan, approximately one hectare will be dedicated to the IWYPHUB for fast multiplication of genetic resources and generation advance where a second cycle per year is required. These dedicated field areas will be serviced within CIMMYT's ongoing Mexican shuttle, thus ensuring that IWYP Hub collaborators benefit from the extensive facilities and highly experienced and competent Mexican field staff, who

[1] Formally known as the Centro Experimental Norman E. Borlaug (CENEB), Obregon, NW Mexico.

collectively possess hundreds of years of experience in high throughput and high quality seed, plot, and data management.

The CENEB station, located in the Sonora desert, is an ideal site for IWYP field work since it is predictive of performance for most of the high yielding spring wheat agro-ecosystems below 45° latitude, as confirmed by yield performance analyses of thousands of advanced breeding lines tested at hundreds of locations worldwide over several decades, through the IWIN (Braun et al., 2010). CIMMYT physiologists and breeders have also developed planting methods to simulate conditions that mimic major wheat growing environments in most of the major target regions.

The IWIN spring and durum wheat trial system –comprising of material generated by the Mexico shuttle- has up to 50 years of data reflecting the differential performance of a wide range of wheat cultivars in all major global wheat environments (e.g. Gourdji et al., 2012). CIMMYT scientists are well positioned to apply this knowledge as leverage to multiply the effect of IWYP outputs targeting new models of wheat physiology, development, and architecture for optimized yield performance in various environments. Important contributions coming from the IWYP Hub will include:

- Provision of the most appropriate germplasm panels for dedicated research objectives, including lines with high levels of expression and contrast for specific yield potential traits such as radiation use efficiency, phenological pattern, and distinct partitioning characteristics.
- Advice on the most appropriate growing conditions and treatments that best simulate realistic wheat target environments.
- Standardized field phenotyping protocols that have been developed and validated in partnership with collaborators worldwide.
- Pre-breeding for introgressing promising yield potential traits into elite, well adapted backgrounds; in fact pre-breeding serves three main purposes which are:
    - To quantify the effect of new traits and trait combinations in a range of appropriate genetic backgrounds; essentially an “acid test” for validating the outputs of IWYP research.
    - To determine genetic bases of successful trait combinations, opening new avenues for research in understanding the molecular basis of trait interactions.
    - As a vehicle for delivering new IWYP products to stakeholders worldwide via the IWIN.

Management

The IWYP Hub will have an IWYP Hub Manager who reports to CIMMYT for operational matters, while also reporting to IWYP leadership for science planning and clarification of priorities. The IWYP Hub Manager will actively liaise with and support IWYP-funded scientists using the platform as well as the small team of CIMMYT scientists responsible for scientific oversight who will work with IWYP leadership. This will in effect enable remote management of world-class field experimentation, complemented of course, with facilitated visits. Dedicated IWYP Hub funding will ensure the availability of a critical mass of research support from scientists in the areas of physiology, breeding, molecular genetics, and data management, backed by the necessary technical staff, to support the full range of activities required by IWYP collaborators.

Services

The IWYP Hub is designed to be a community resource that maintains world-class capability in field-focused science related to the IWYP objectives. The basic functions of the IWYP Hub will be funded directly by IWYP and will not detract from research project funding. The IWYP Hub will operate as a well-informed service and facilitation unit with substantial capacity.

The basic model for IWYP is that many of the competitively funded projects will require both germplasm and experimental facilities reflecting realistic wheat improvement objectives, and after initial discoveries have been achieved, require extensive breeding, evaluation and development work.

Basic services to be provided by the IWYP Hub are listed below. The 6 hectare figure for total, dedicated land area is a good faith estimate of the magnitude of IWYP-related research that CIMMYT could support but can be expanded relative to need and funding changes. It is important to note that the cost per unit of land varies dramatically in physiology phenotyping and research work depending on the traits measured and plot size, and that actual costs can readily exceed budgeted support. This issue will require the coordinated planning described above.

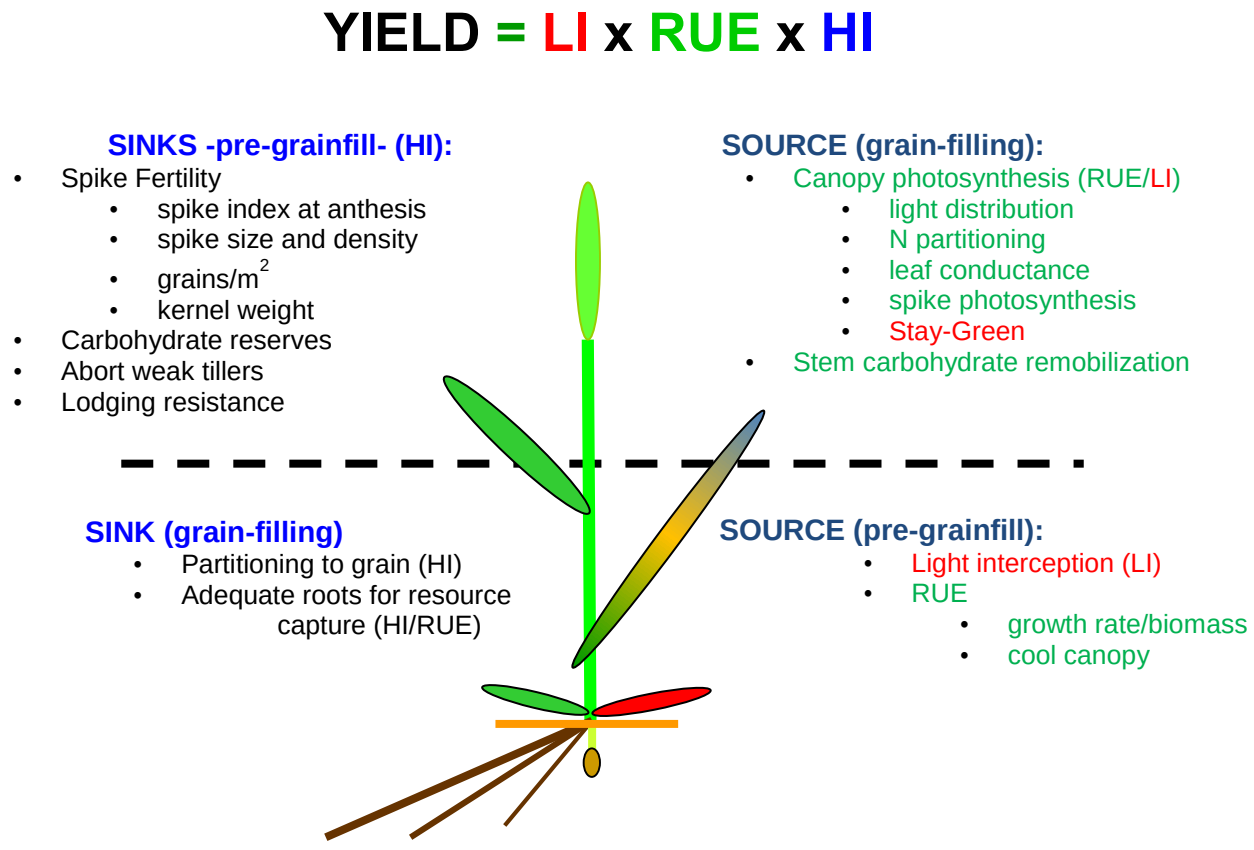
When the capacities at the current projected level of IWYP Hub funding are exceeded, funds from IWYP to IWYP Hub could be increased in line with the needs of projects. The IWYP Program Director and the IWYP Science Impact Executive Board (SIEB), will coordinate IWYP and IWYP Hub project funding to ensure that their needs and capabilities are aligned.

To maintain a deployment ready status, the IWYP Hub requires a critical mass of scientists and technicians. Should the working capacity of the Hub not be fully occupied by IWYP collaborators in any given season, it could be absorbed in the following activities which reflect opportunities for near-term gains in achieving

genetic yield potential, as well as identification of new germplasm sources for IWYP research:

- ***Screening*** of genetic resources in the World Wheat Collection and from IWIN (which produces 1,000 new elite lines each year), to identify new sources of promising traits such as high biomass/RUE, etc.
- ***Characterization*** of selected genetic resources and new elite lines, for a full range of yield potential traits as outlined in recently published conceptual models (Fig 2), to identify new strategies for combining complementary yield potential traits in pre-breeding, and to determine their genetic basis.
- ***Crossing*** based on 'best-bet' traits, building on the same approaches employed in recent crossing strategies that have achieved step changes in yield potential in national and international trials (i.e. 1st and 2nd WYCYT).

Figure 2. Ecophysiological Traits Associated with Yield Potential in Wheat (based on Reynolds et al., 2012)



Base services to be provided or made accessible by the IWYP:

- A full-time, dedicated IWYP Hub Manager to act as the point of contact for all logistics and communications with participating IWYP-supported or aligned scientists/projects (reporting to CIMMYT and to Program Director)
- Six hectares (5 in Obregon and 1 in El Batan) of dedicated land in the CIMMYT-Mexico breeding / phenotyping shuttle
- Office and lab facilities
- Critical mass of physiologists, geneticists, breeders, and support staff to enable seed-to-results field phenotyping, including:
  - Experimental germplasm encompassing panels of genetic resources selected for favourable expression of a range of yield potential traits (such as biomass, RUE, spike fertility, assimilate partitioning, etc.), as well as the most recent high yielding elite lines.
  - State-of-the-art high throughput phenotyping, including ground-based and aerial remote sensing platforms
  - Equipment for precision phenotyping of plant photosynthesis and respiration
  - Streamlined protocols for crop growth analysis
  - Fast-track introgression of new traits into elite spring wheat germplasm via either the two generation per year CIMMYT-Mexico
  - Field books, data collection, and genetic resource management including tissue, plants, and whole plots
  - Identity-preserved tissue sampling and DNA extraction (magnitude covered by core *funding contingent on sample numbers etc.)*
- Integration of IWYP with the International Wheat Improvement Network of over 200 collaborating institutions, thus enabling targeted phenotyping in non-Mexican environments, plus fast track distribution to private, public, national, and international actors for commercialization

Additional services available:

- Access to high throughput molecular marker facilities, including the new USAID-funded program on genomic selection in collaboration with Kansas State University, Cornell, Pakistan, and BISA-India
- Expertise in genetic analysis and biometrics
- Evaluation of new phenotyping apparatus and protocols
- Hosting and support services for visiting scientists for periods ranging from a few days up to a year;
- Development of purpose-designed physiological genetic stocks and mapping populations
- Access to MAS backcrossing or doubled haploid technology, depending on which approach is best suited for the trait under investigation;
- Facilities and capabilities for workshops and conferences for up to several hundred participants;

- Access to CIMMYT's extensive wheat and wheat relatives genetic resources in the gene bank, breeding programs (both bread and durum wheat), wide-cross program (including synthetic wheat), and other genetic stocks.

References

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