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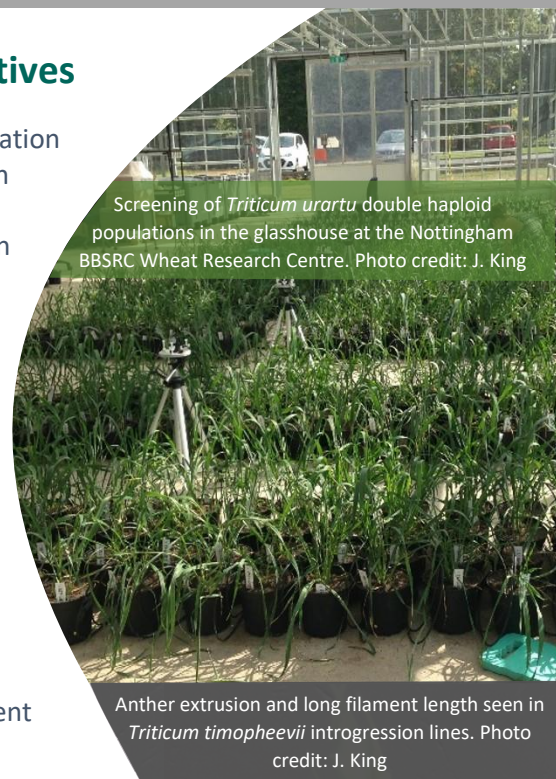
Mining for Yield Determinants Left Behind in Wheat Relatives

In the evolution of wheat and subsequent selection by breeders much genetic variation was left behind in the populations of its ancestors. Capturing this “exotic” variation today requires dedicated investment and few commercial breeding programs can afford an internal pipeline to bring these lost genes into elite wheat lines. This then becomes the responsibility of publicly supported efforts. The potential value of such exotic introductions is well documented ([Sansaloni et al., 2020](#); [Aberkane et al., 2020](#); [Leigh et al., 2022](#)). For example, introgressions from various *Aegilops* species conferring resistance to several wheat diseases are widespread in wheat varieties and as sources of modifications to plant architecture and physiological characters (see [King et al., \(2022\)](#) for an excellent review). The yield enhancement introduced by the 1BL.1RS translocation from rye is still present in many modern wheat varieties due to continued selection. An introgression from wild emmer wheat (*Triticum dicoccoides*), introduced in a key historical wheat variety Robigus, has been reselected into many UK and European wheat varieties and a large proportion of UK wheat varieties since 2000 contain key landrace lines ([Fradgley et al., 2019](#)). CIMMYT established a “wide crossing” program in 1986 to make Synthetic Hexaploid Wheats (SHWs) that carry novel D genomes from different *Aegilops* diploids. As a consequence, ~20% of wheat lines from CIMMYT contain synthetic genome segments from *Aegilops tauschii* ([Rosyara et al., 2019](#)).

Building on this, IWYP saw the value of mining exotic germplasm to find better yield traits, in ways not being done by other breeding programs. Experimental populations (i.e., HiBAP I) were developed at the IWYP Hub at CIMMYT that contained rich genetic diversity in the D genomes together with introductions from Mexican landraces, other synthetics and 1BL.1RS translocations. Lines with enhanced traits such as high biomass, radiation use efficiency and thousand grain weight for example, have been selected and identified from within this large program ([Joynson et al., 2021](#); [Molero et al., 2023](#)). Sources selected from populations containing genes from Mexican landraces have also revealed improved physiological traits, e.g., canopy temperature, high stem carbohydrate, flag leaf chlorophyll content and biomass. One third of new IWYP lines developed from this program and distributed to breeding programs worldwide in the last 5 years have chromosomal segments from one of 8 different SHWs and about 38% of all selected elite lines have a landrace in their ancestry. The challenge is now to define which of these outstanding trait enhancements are dependent on exotic chromosomal segments and genes so that they can be selected rapidly in breeding programs around the world using molecular markers linked to the exotic segments.

IWYP is also mining a public collection of introgression lines (ILs) created by an IWYP partner ([Nottingham BBSRC Wheat Research Centre, Nottingham University, UK](#)) which carry segments of exotic chromosomes from wild wheat relatives. ILs displaying a positive impact on photosynthetic efficiency, biomass, or floral morphology are being evaluated in different elite genetic backgrounds at the IWYP Hubs in Mexico, USA and the UK.

To determine the size, distribution and genic content of these exotic selected segments, as well as their origins, new genomic tools, some developed in IWYP Research Projects, are being employed ([Coombes et al., 2022](#)). The plan is to continue offering these new highly selected genetic elements to breeding programs around the world, together with their genetic markers, to boost yields in ways that the breeding programs have not been able to previously because there have not been discovery programs tied to advanced trait selection and distribution that are the basis of the IWYP program.



Screening of *Triticum urartu* double haploid populations in the glasshouse at the Nottingham BBSRC Wheat Research Centre. Photo credit: J. King

Anther extrusion and long filament length seen in *Triticum timopheevii* introgression lines. Photo credit: J. King

