IWYP International Wheat Yield Partnership
Research to Deliver Wheat for the Future

IWYP SCIENCE BRIEF

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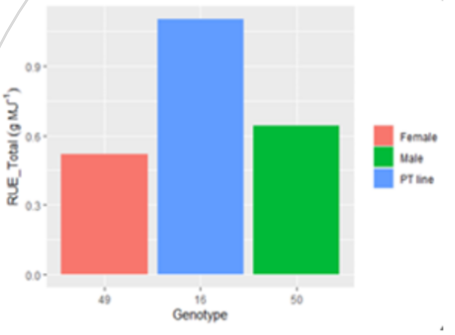
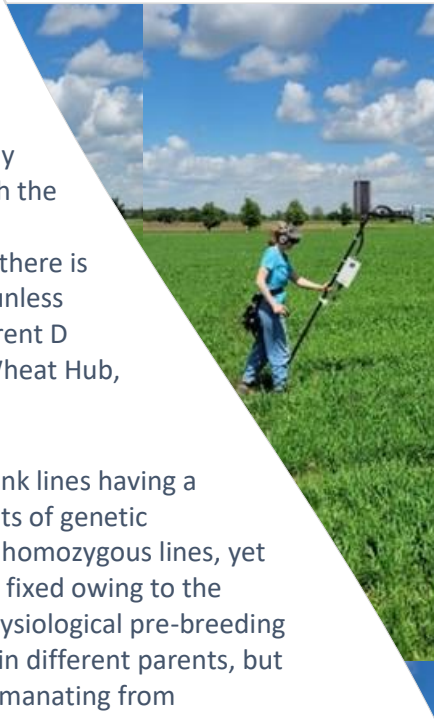
IWYP's Pre-Breeding Strategy, Polyploidy and Heterosis

Most breeders today keep elite germplasm in their breeding pools sufficiently homogeneous to maintain both high average progeny yields and the essential agronomic traits necessary to meet varietal development requirements. This enables the many traits to be managed concurrently and Genomic Selection schemes to function efficiently. However, it makes finding "breakthroughs" in yield and other traits less likely since the distribution of variation remains narrow.

The IWYP Spring Wheat Hub team at CIMMYT has adopted a contrasting approach in seeking optimizations for many physiological traits for yield potential. It has deliberately searched through "synthetic" lines and other exotic germplasm lines for enhanced expression of desired traits to increase the probability of finding breakthrough levels of yield. For example, from selections for high biomass and radiation use efficiency (RUE) within these populations, new lines have been obtained that do indeed show higher RUE than in other spring wheats known to date. Comparative data show that these lines display positive heterosis for RUE relative to elite parents (see figure at right).



IWYP lines with landrace and synthetic pedigrees expressing higher RUE than either parent



Intergenomic Heterosis

In hexaploid wheat there are many more opportunities for positive and negative heterotic effects to be manifested than in diploids due to combinatorial interactions and their downstream biochemical/physiological outcomes within and between the three sets of highly diverged homoeologous genomes. Furthermore, the extent of heterosis often correlates with the degree of genetic diversity between a line's parent genomes. Within the A and B genomes in hexaploid wheat germplasm there is much more diversity than within the D genome, where there is little. This means that new epistatic heterotic interactions involving D genomes are limited, unless driven by changes in the A and B genomes. However, when new genetic variation from different D genomes is introduced, as in the case of the "synthetic" lines screened by the IWYP Spring Wheat Hub, new options for interactions occur.

IWYP Pre-Breeding

The IWYP Spring Hub regularly crosses high yielding, high RUE (source) lines with elite high sink lines having a markedly different genetic background. The resulting F_1 plants therefore contain different sets of genetic interactions from those in either parent. When progeny are selected subsequently to obtain homozygous lines, yet more sets of interactions and therefore degrees of trait heterosis are inevitably selected and fixed owing to the various recombination and chromosomes reassortment events. Based on this hypothesis, physiological pre-breeding at the IWYP Spring Wheat Hub is not only combining genetically complex traits per se found in different parents, but also selecting amongst the many sources and degrees of trait heterosis (i.e., epistasis, etc.) emanating from interactions across the diversity within and between all three wheat genomes.

Inferences

It is hypothesized therefore that to build new/additional heterosis for yield and other traits in pure-line wheats, a good strategy is to introduce diverged novel genetic variation (e.g., from wild relatives, land races, etc.) capable of participating in novel within and between chromosomal interactions, but without compromising yield, instead of crossing existing elite lines in which many of the potentially favorable inter-genomic heterotic interactions have been fixed over the long history of pure-line improvement. Also, because F_1 hybrids often display even higher heterosis for some optimized traits, it is hypothesized that the approach at the IWYP Spring Wheat Hub for combining novel traits in high yielding but diverse genetic backgrounds could be a valuable contribution to F_1 hybrid wheat breeding.