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

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How IWYP is Building Higher Yielding Wheat Lines

IWYP and its associated scientists continually seek to define the traits that contribute to grain yield and the genes that control them. Candidate traits, often discovered in lower-moderate yielding lines, are studied to assess if they enhance yields when transferred to high yielding elite lines. For this, IWYP pursues two parallel strategies because of the different genetic complexities controlling yield-enhancing traits.

The first strategy takes a line containing the defined single gene/QTL with a larger effect on the target trait and transfers it into elite lines using marker-assisted back crossing (MABC), a methodology used for introgressing single traits via trait-linked markers or QTL. Multiple recipient elite lines are used as the magnitude of trait expression of any gene/QTL varies among genetic backgrounds. Evaluation of the new traits is made by comparing the original recipients to the recipient analogues with the new trait. This is the strategy that the IWYP Winter Wheat Hubs are following.

Back crossing in spring wheat pre-breeding generations in CIMMYT, Ciudad Obregón, Mexico

To move traits into breeding IWYP deploys two strategies. One for genetically simple traits and the other for genetically complex traits.

The second strategy transfers "physiological traits" determined by many genes, using trait-specific phenotypic assays and/or many genetic markers. This approach is based on the dissection of "genetically complex" or quantitative traits (e.g., harvest index, biomass) into subcomponent traits determined by fewer genes that are more tractable in breeding programs once an effective phenotypic assay or genetic markers have been developed to select them. This strategy is necessary because yield is the outcome of the interaction of many genetically complex traits and the potential to enhance yields by the simpler first strategy is therefore limited. Further, evaluation of trait effects by assessing new lines with introduced complex traits against their parent lines is one way to validate trait interactions and trade-offs. However, owing to the numerous genetic interactions associated with the introduction of the many and larger pieces of the donor genome determining the new trait expression, analyses should not seek qualitative or categorical effects, nor necessarily maximum expression of a given trait, but rather its optimal expression.

Selection of spring wheat pre-breeding materials in CIMMYT, Ciudad Obregón, Mexico

Traits identified and managed in both of these ways can then be combined in different ways to explore further yield enhancement. New lines with added simple traits can be used to transfer the trait per se into other elite lines. New lines enhanced with complex traits are best suited as parents in elite x elite crosses. Irrespective of the strategy, all resulting lines are evaluated in field trials to assess the effects of the trait changes. Resulting lines with enhanced yields are made available to breeding programs around the world, together with trait assays and markers, as novel trait sources, new high yielding parents or directly as varieties.

Breeders have long used the second strategy where a trait can be assessed by eye or simple measurement. To breed with physiological traits, well-established technical platforms and expertise are required. Few breeding programs are currently equipped to do this for the physiological traits targeted by IWYP, e.g., fruiting efficiency, internode mass, radiation use efficiency. Of the three IWYP Translational Hubs, only the Spring Wheat Hub at CIMMYT deploys the second strategy at scale for selected traits, sometimes referred to as "physiological breeding". It is this that makes the work of this Hub unique and successful in achieving yield potential gains as demonstrated by results from international field trials.