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Hybrid wheat unlocking wheat's full potential

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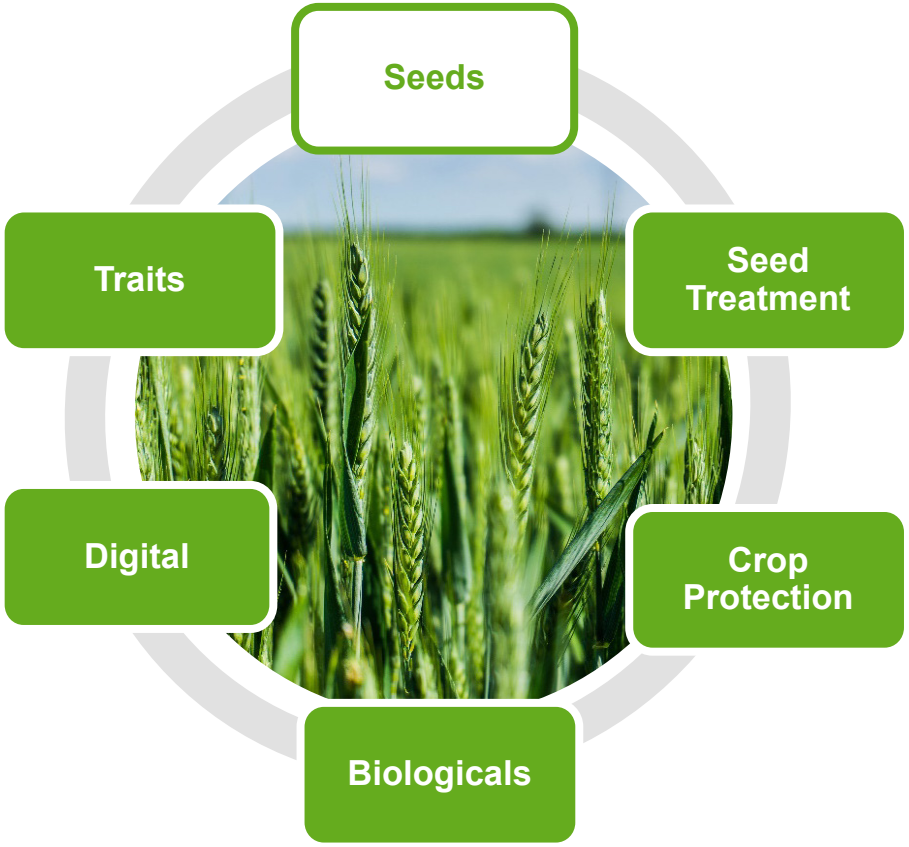
Global Head of Wheat Breeding

The right balance for better yield



Yield that is valued by society

More biodiversity protection

Higher yield with lower environmental impact

Less CO_2 per ton of protein produced

Help farmers make a living

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The demand for wheat will increase in the coming years

+2 billion
growth of world population by 2050

> +50%
wheat supply increase needed

Yield increases of ~3% annually during 1960s to 1980s, but this declined to less than half that rate in the last 30 years.

How to sustainably grow global wheat yields?

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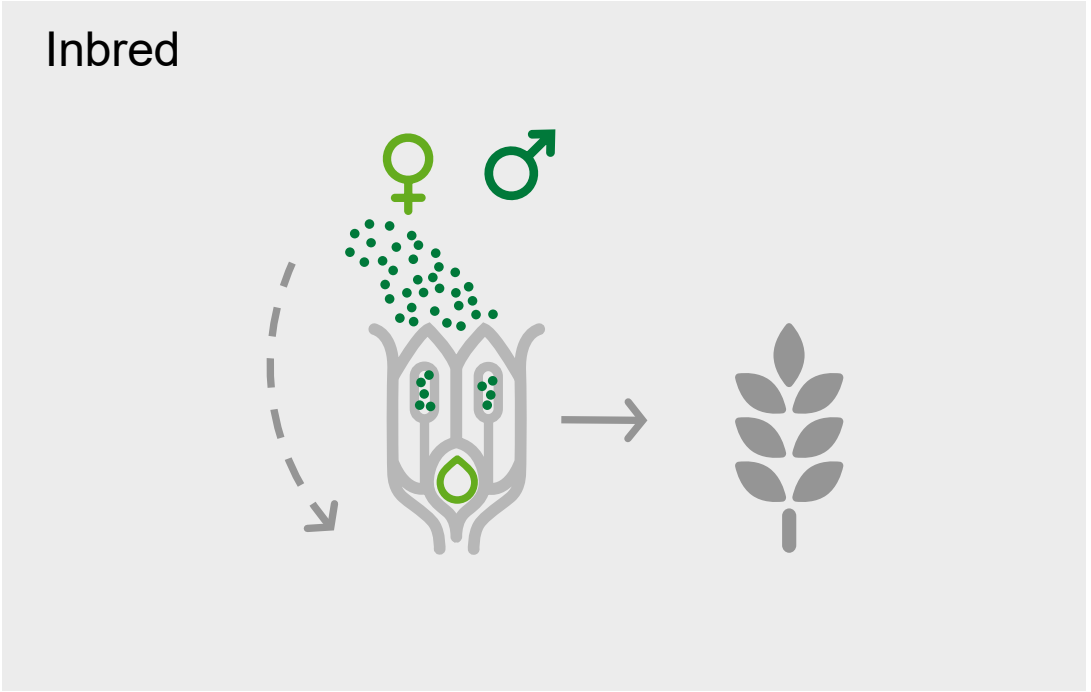
Until now, wheat seeds are cultivated through inbred varieties

- Wheat naturally self-pollinates, where the plants are fertilized by their own pollen
  - Often combine genes from a limited, local genetic pool
  - As a result, all wheat carry uniformity at each locus or position in the chromosomes
  - Lacks an increase of genetic diversity to meet demands of production and climate resilience
- Limitation of inbred varieties
  - More time, natural resources and inputs needed for inbred varieties to meet required yields



More options are needed to achieve higher wheat yield with greater sustainability

Unlocking the full potential of wheat with hybrid seeds

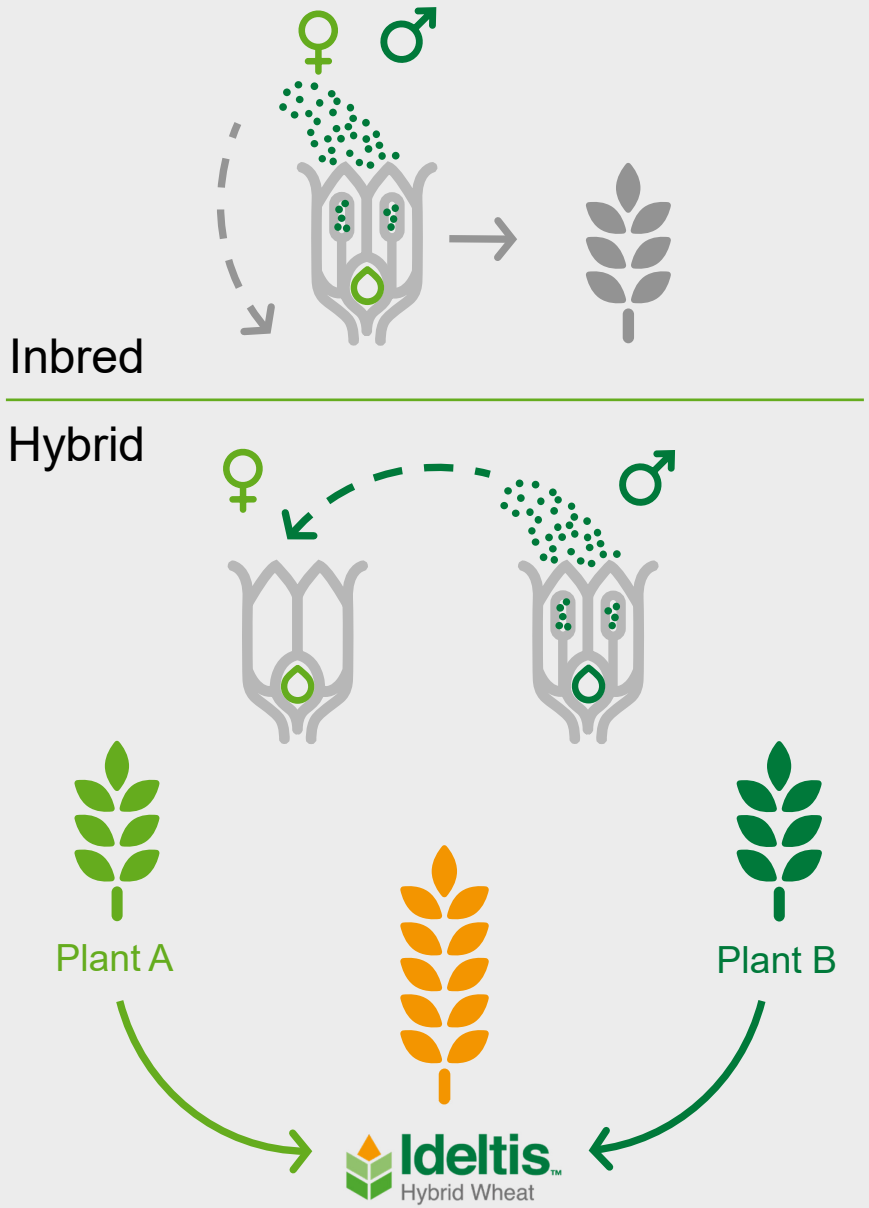
- Improved agricultural outcomes and land use result from hybridization of major market crops, such as corn (maize) and rice
- Why are commercial wheat hybrids not yet available for growers?
  - The wheat genome is 7 times larger than corn and 40 times larger than rice
  - More variability when combining genes
- Breakthrough technologies needed to manage complexity of wheat and stabilize desirable traits into hybrids

The advantage of hybridization is the improvement in genomic diversity

Hybrid breeding programs balance yield and genetic diversity

- Our wheat hybrids are the result of directed crosses between genetically distinct parents
  - Relies solely on the cross-pollination of pre-existing and naturally occurring genetic diversity
- Hybridization allows combination of the best traits from the parents in the offspring
  - For example, genes for disease and insect resistance and environmental stress tolerance
- Ideltis™ hybrid wheat
  - Yield increase over inbred varieties due to hybrid vigor

Hybridization improves yield and yield stability delivering climate resilience



Our wheat breeding program enables improved genetic selection through curated technology combinations

GPS-driven planters and combines

Genotyping by sequencing (GBS)

Near-infrared units measuring grain protein in field

Drone-based phenotyping

Automated data collection

Upload to databases

Field and genomic data are combined in AI models

Data interpreted by experienced breeders

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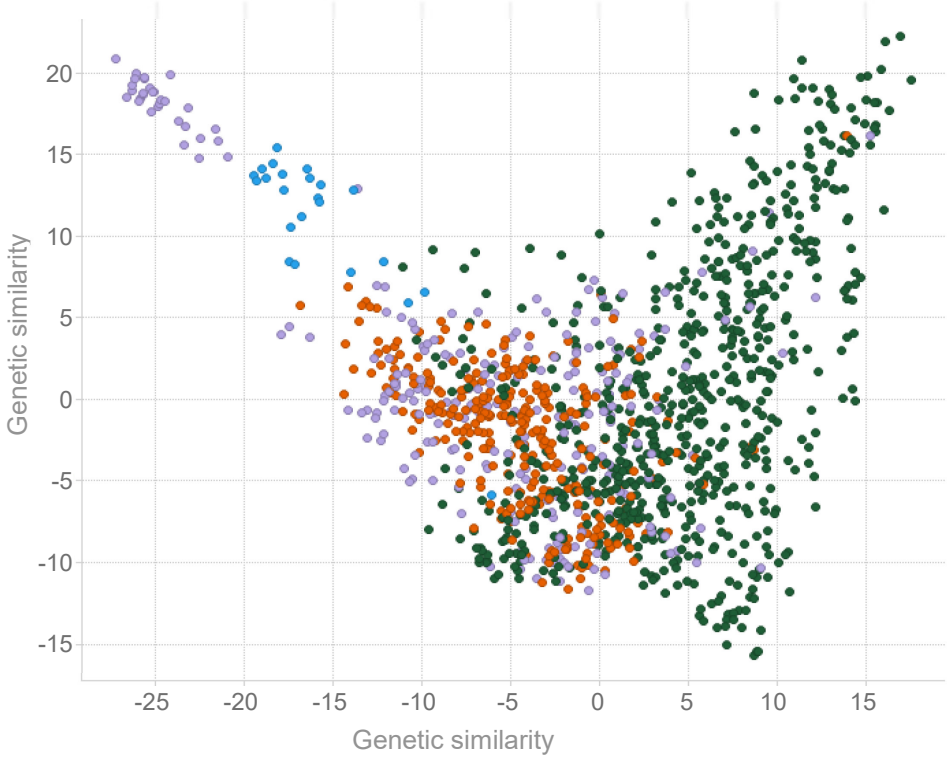
Harnessing the genetic diversity of elite germplasm

Map of genetic diversity of European germplasm[1]



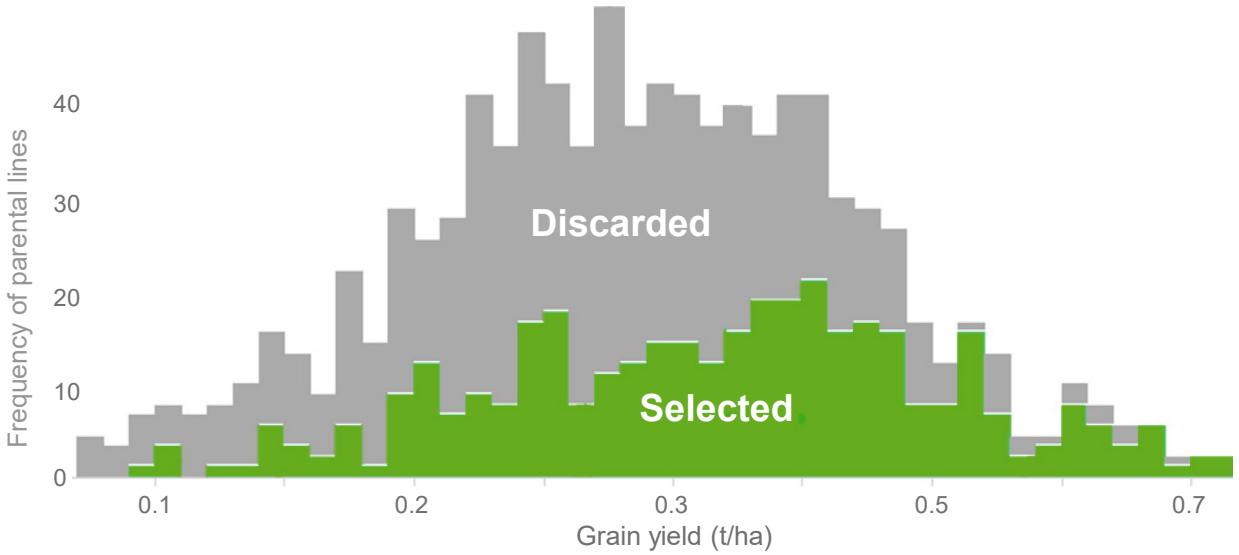
- Wheat varieties grown today trace back to many different lineages
  - Diversity of genes for adaptation, stress tolerance, baking quality, grain yield
  - Each lineage is a different evolutionary solution to the environmental stress in the region of origin
- Hybrids combine these solutions into stacks within a variety to manage seasonal unpredictability
  - Field testing all parental combinations would require replicated testing of millions of hybrid combinations across a farming region

Our breeding programs predict combinations of parents to create the best hybrids

[1]Hybrid parents color-coded by mating pools. Each point is a single type of wheat, when closer together represents more genetic similarity Measured by Multi-dimensional scaling (MDS)

Genomic selection enables delivery of hybrid wheat genetics

Selection via modeling[1]



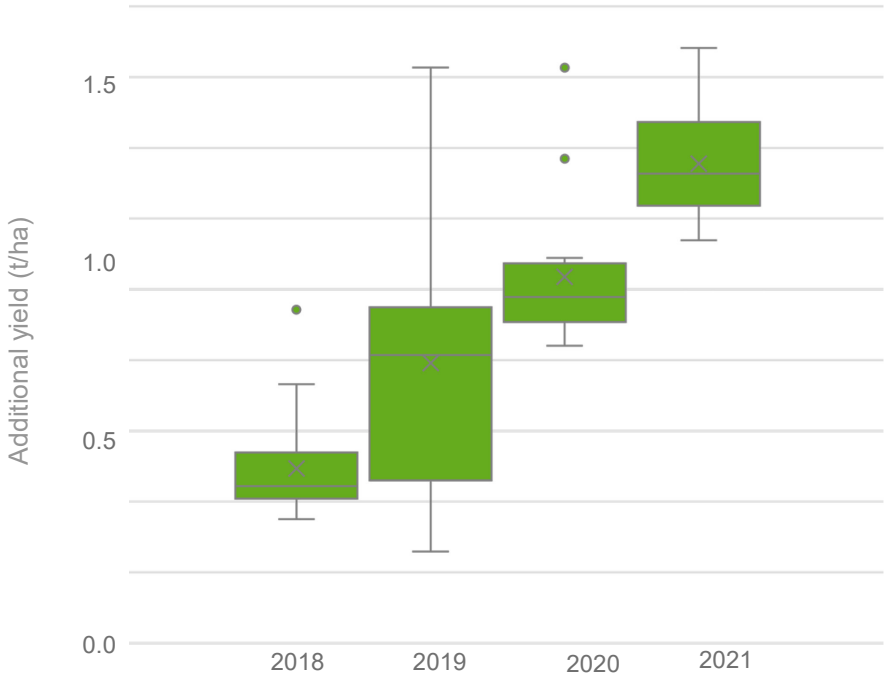
- New parents are
  - Discarded, if they do not meet minimum requirements for use by farmers, for example: plant height, maturity, and disease resistance
  - Genotyped by sequencing (GBS)
  - Selected from the remaining lines and modeled for their expected yield as hybrids
- Combination of expected performance models with breeder expertise of the germplasm to select candidate parents

Hybrid candidates are selected for farm and sustainable market goals

[1]Source: French hybrid wheat program

Success of predictive breeding program delivers improved regional varieties

Yearly improvement of hybrid performance[1]



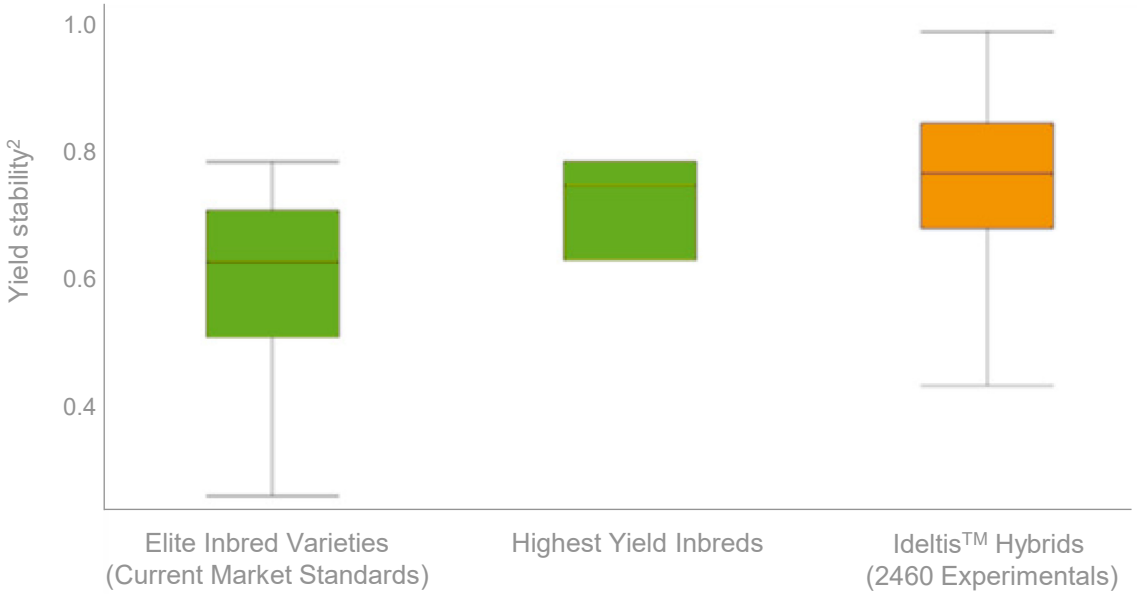
- Yield is increasing while selecting for background adaptions in agronomic traits such as resource efficiency as well as protein content and quality
- Models improve as years of data accumulate and added complexity of environments are included

Our research program selects traits and adapts new varieties to local climate conditions through targeted selection

[1]Source: Central & Southern French breeding program, comparing 20 highest yielding hybrids in each year, combining data across all trials in 2018 to 2021

Yield stability is key for improved regional land and resource use in changing conditions

Yield stability of experimental hybrids vs. inbreds[1]



Yield stability

- Measured as expected yield vs actual yield
- Stable varieties produce expected yields year over year – despite changing environmental variables, such as disease, water availability

Benefits from stability

- Better climate resilience
- Predictable and reliable use of resources
- Improved ability to synergize with other agricultural inputs like crop protection and prediction models

Yield stability in hybrids allows management of seasonal unpredictability for climate resilience

[1]Source: Northern France trials over 3 years
[2]Difference between yield predicted by the model and the actual yield (1- Root Mean Square Deviation)

Hybrid breeding is fundamental to the future of wheat innovation

Supporting food security

Enabling higher and stable yields

Locally adapted varieties

Predictable yield for climate resilience

Efficient resource utilization

- Ideltis™ hybrid wheat will help meet the nutritional needs of a growing population through **improved and stable yields**
- Contributes to our **sustainability commitments**
- Ideltis™ hybrid wheat employs genetic diversity for climate resilience, yield improvement, productive land use and resource efficiency
- Stability from hybrid wheat serves as basis to **integrate technologies** like precision, crop protection and digital farming tools **across wheat cultivation**

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