Boosting or balancing breeding: Yield, resilience and sustainability

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International Maize and Wheat Improvement Center

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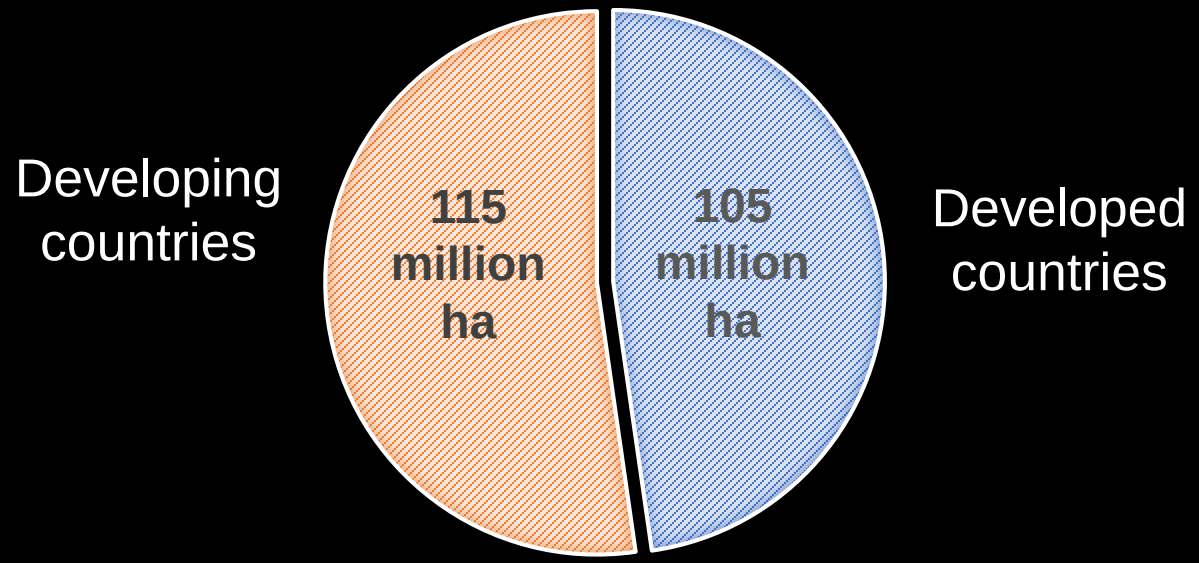
CIMMYT Global Wheat Program

CropBoosterP 11th June, 2021

Wheat is essential to global food security

Global wheat area ~220 million ha



Average farm size: 1-3 ha vs. 40-5000 ha

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CIMMYT's mission

Maize and wheat science for improved livelihoods.

CGIAR's vision

Transforming food systems for affordable, sufficient and healthy diets produced within planetary boundaries

CIMMYT Global Wheat Program aims:

- Delivering impacts to smallholder farmers.
- Innovations underpinning food & nutritional security.
- Building resilience to safeguard future production.

Today's talk:

Approaches & progress at scale.

Future perspective: accelerating breeding whilst achieving resilience.

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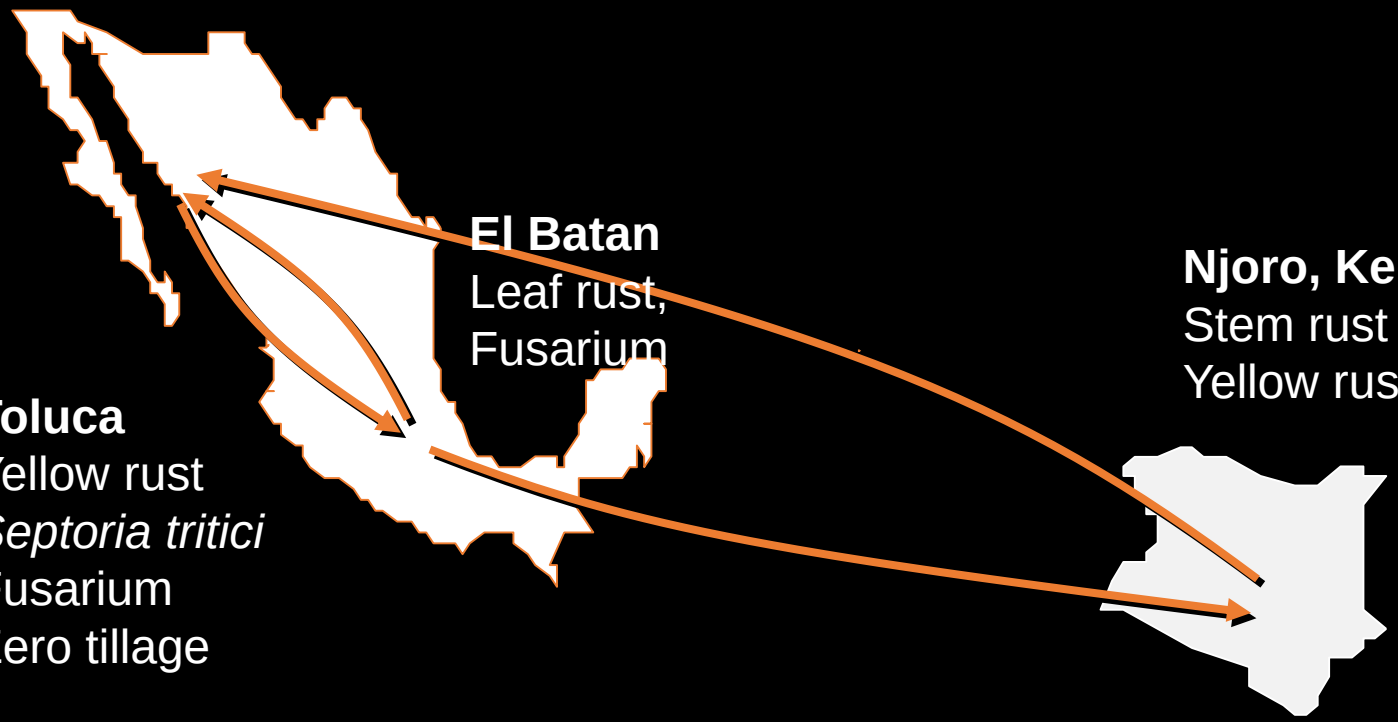
Shuttle breeding accelerates breeding progress

Cd Obregon
High yield (irrigated)
Water-use efficiency
Heat tolerance
Leaf rust
Stem rust (not Ug99)



El Batan
Leaf rust,
Fusarium

Toluca
Yellow rust
Septoria tritici
Fusarium
Zero tillage

Njoro, Kenya
Stem rust (Ug99 group)
Yellow rust

“Global selection” via simulated selection environments

Material for global partners selected in simulated environments in Cd. Obregón, Mexico



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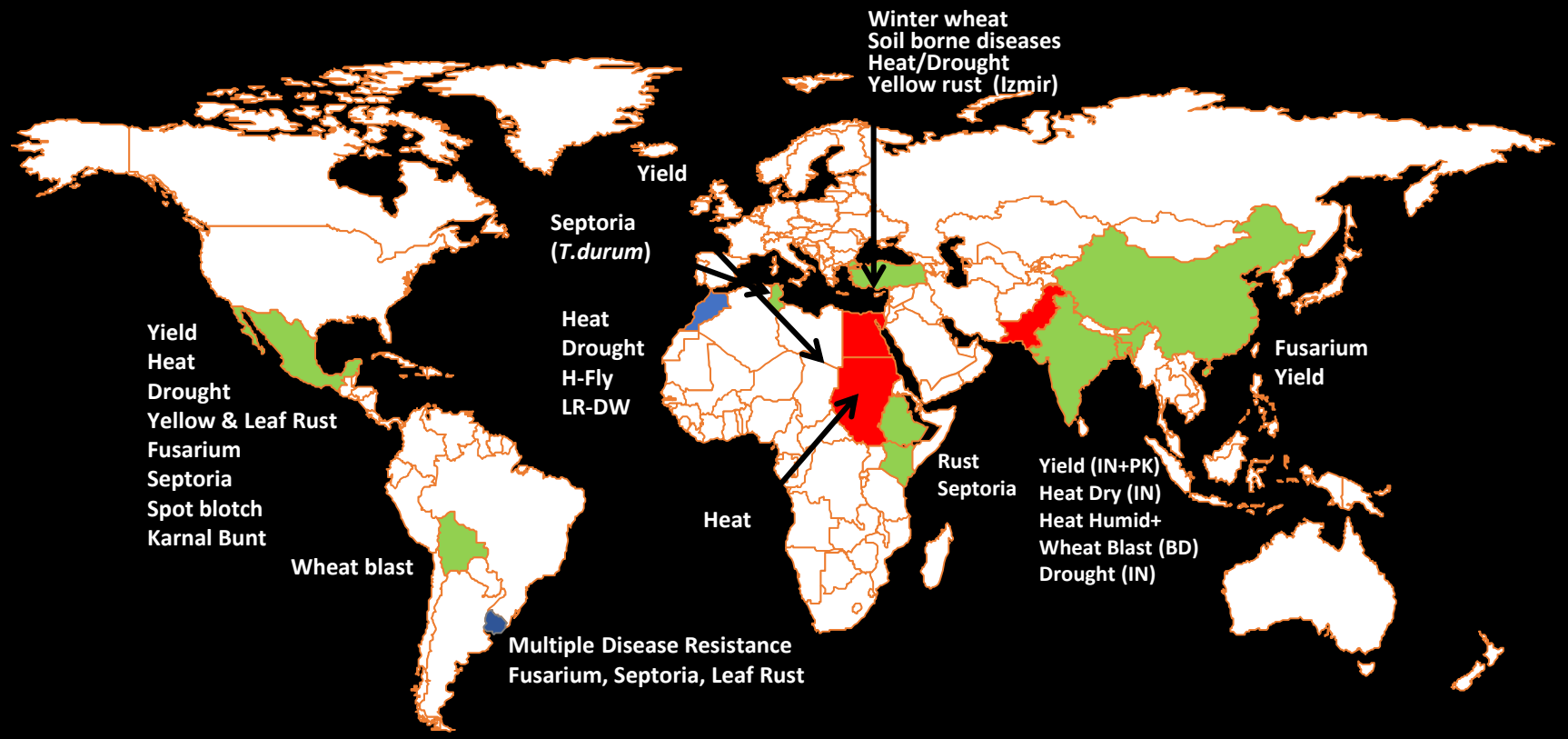
Supported by global phenotyping platforms

Aim: generating high quality phenotypic data under defined best practices and promoting training and sharing of knowledge. Some sites represent future climate analogues, others are hotspots for specific diseases.



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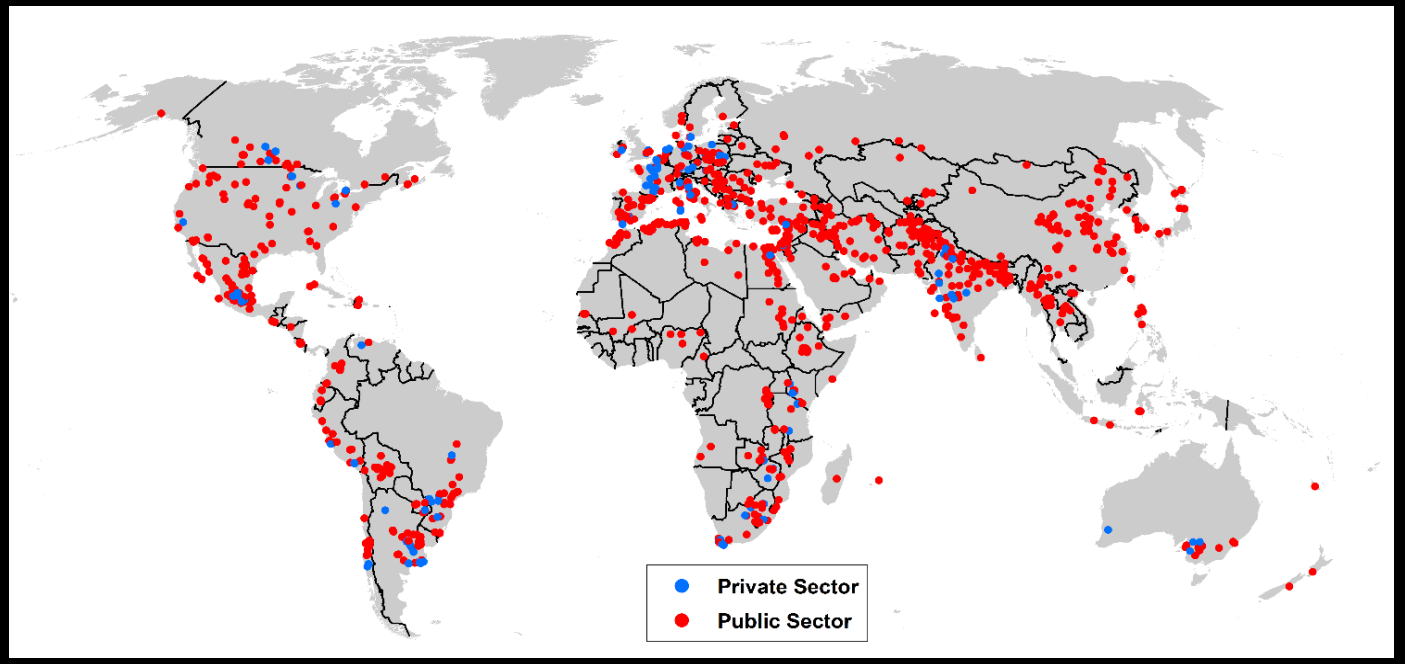
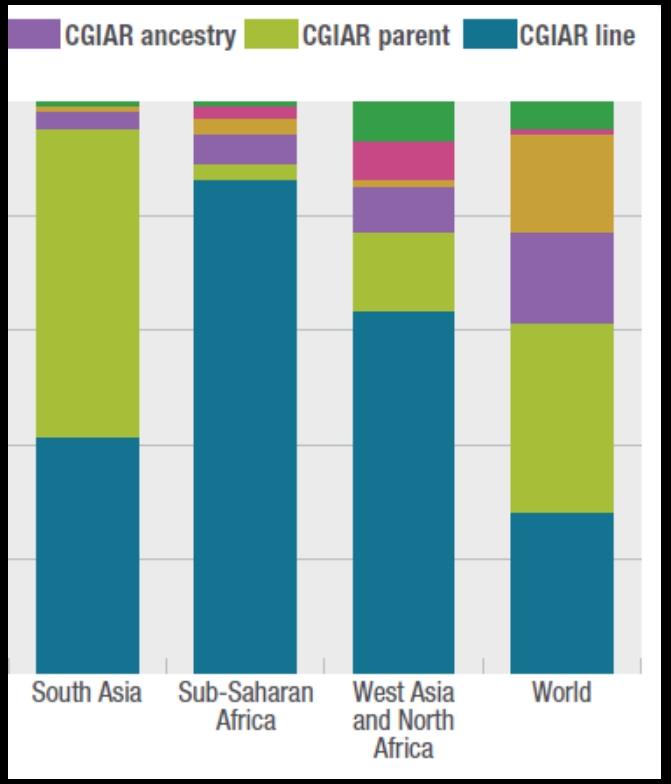
Outcomes & impacts

1. Centralized breeding has achieved large impact in target environments through provision of improved germplasm with wide adaptation (216 varieties released by partners between 2015-2020 in 24 countries).

Public and private breeding programs receiving germplasm through the International Wheat Improvement Network (IWIN)





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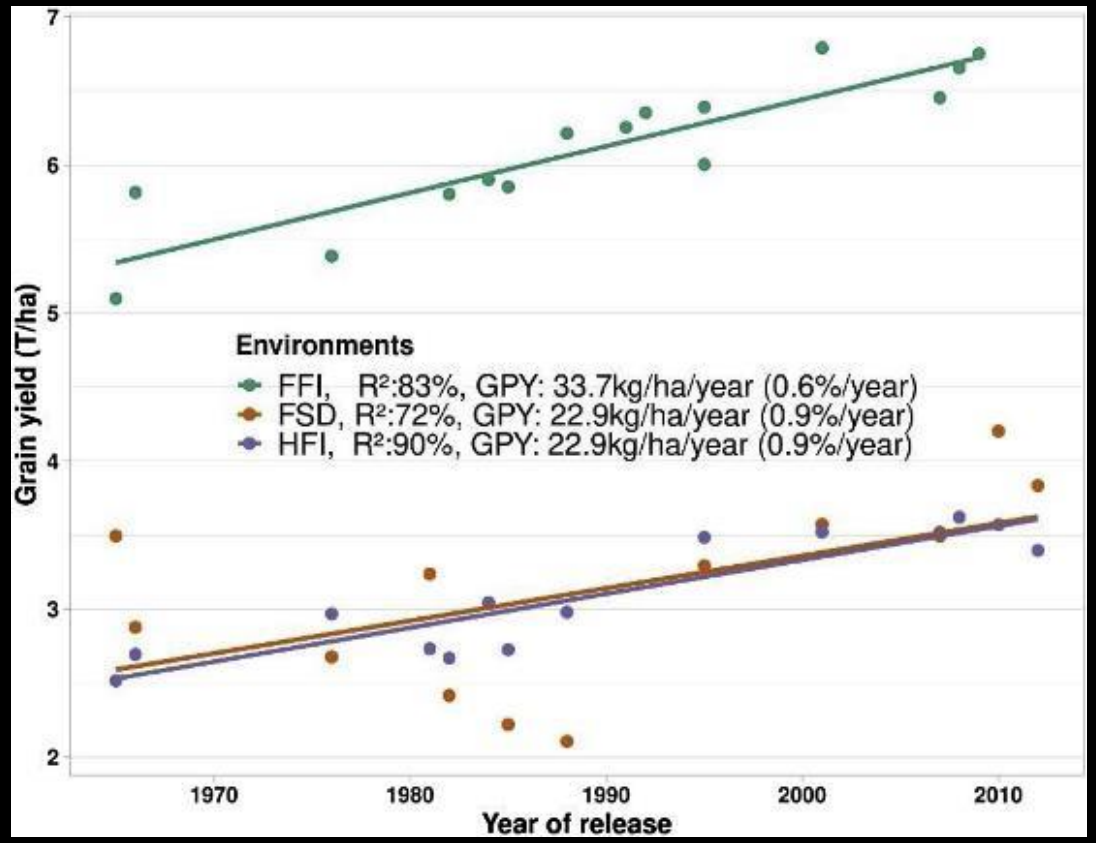
Outcomes & impacts

2. Centralized breeding and use of simulated selection environments has delivered upward genetic progress in yield both on-station, and in target regions, under a range of management conditions.

Continuous breeding progress in grain yield from 1965-2014 in simulated environments (Cd. Obregón)



FFI: flat sowing with flood irrigation (optimum)

FSD: flat sowing with severe drought stress (drought)
HFI: bed sowing with heat stress (heat)

Mondal *et al.* (2020) *Field Crops Research*
doi:10.1016/j.fcr.2020.107757.

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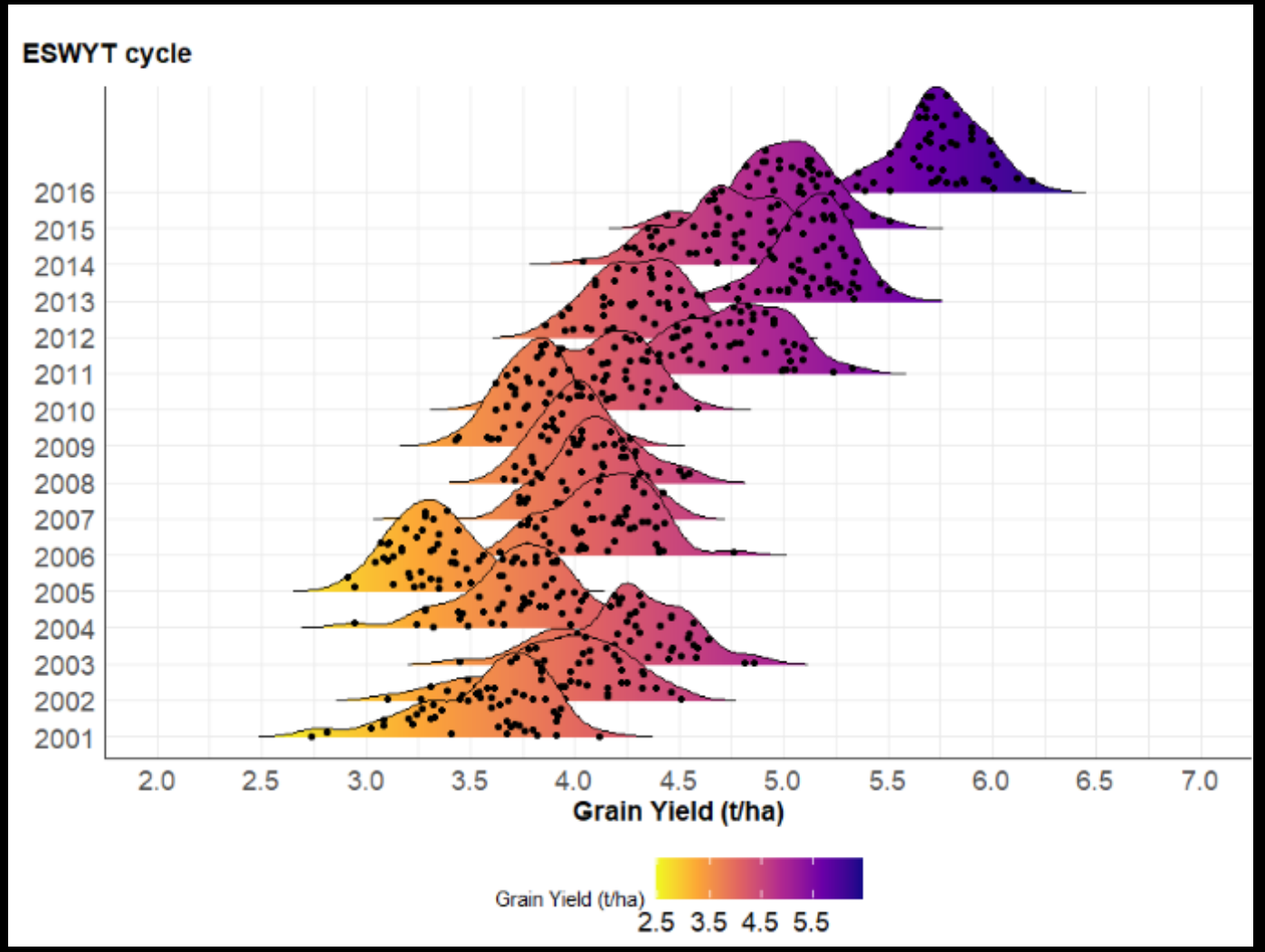
Continuous breeding progress in grain yield from 2001–2016 across Indian TPEs



Crespo-Herrera *et al.* (2021) *Frontiers in Plant Science* doi: 10.3389/fpls.2021.638520

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Outcomes & impacts

3. Diverse germplasm base, APR strategy and global phenotyping supports rapid response (e.g. Ug99, wheat blast), protecting against rapidly evolving pests and diseases. Smallholder farmers have limited access to plant protectives: improved varieties are the first line of the defence.

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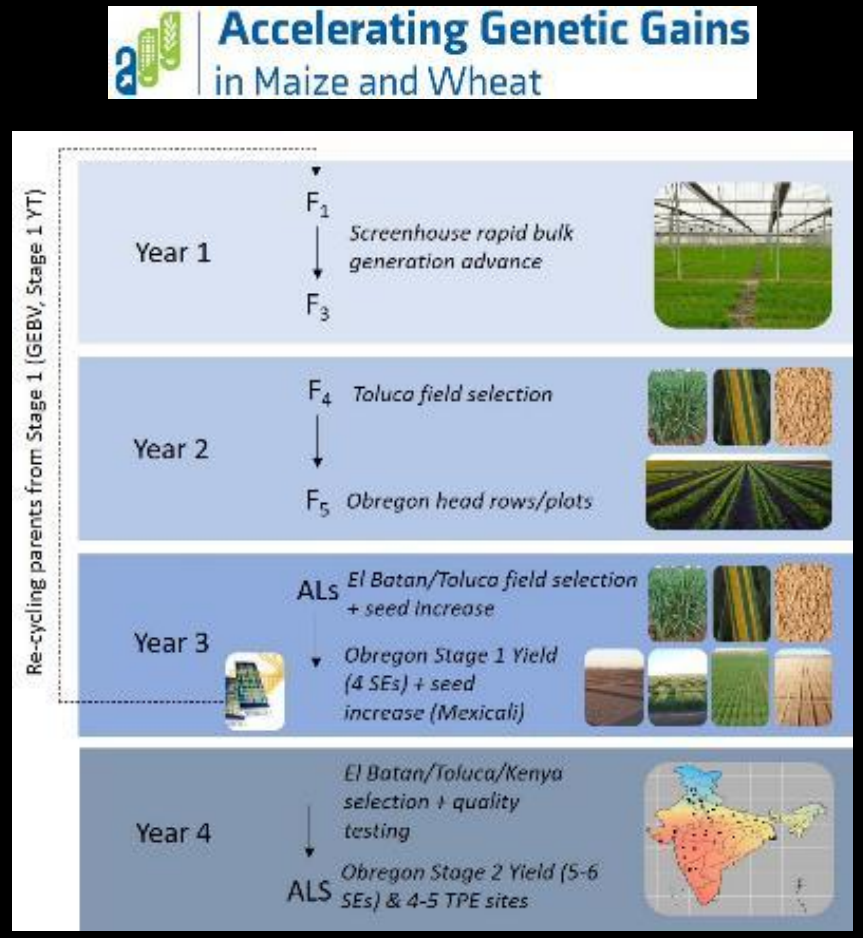
Accelerating genetic gains in CIMMYT wheat breeding

Adoption of rapid-generation breeding methods to reduce breeding cycle time

- **Faster breeding:** screenhouse infrastructure in Toluca is being used to reduce breeding cycle time from ~6 to 3 years per cycle.
- **Genotyping** of all Stage 1 material routinely implemented.
- **Genomic selection** is being implemented for rapid recycling of parents.
- **Novel trait introgression:** speed breeding has been initiated for rapid trait introgressions of race-specific genes and QTLs for disease resistance into elite lines.



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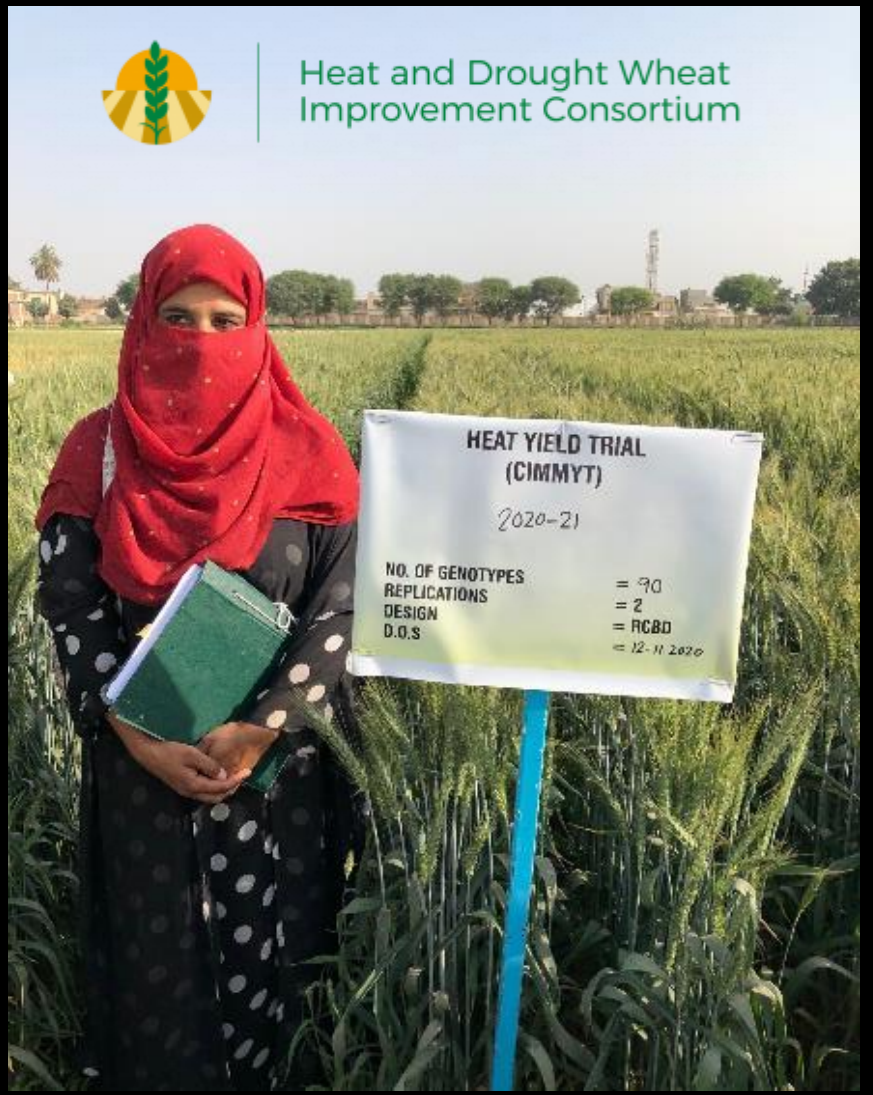
Future-proofing wheat to safeguard food security

Adaptation to future climate stresses: breeding for heat & drought resilience



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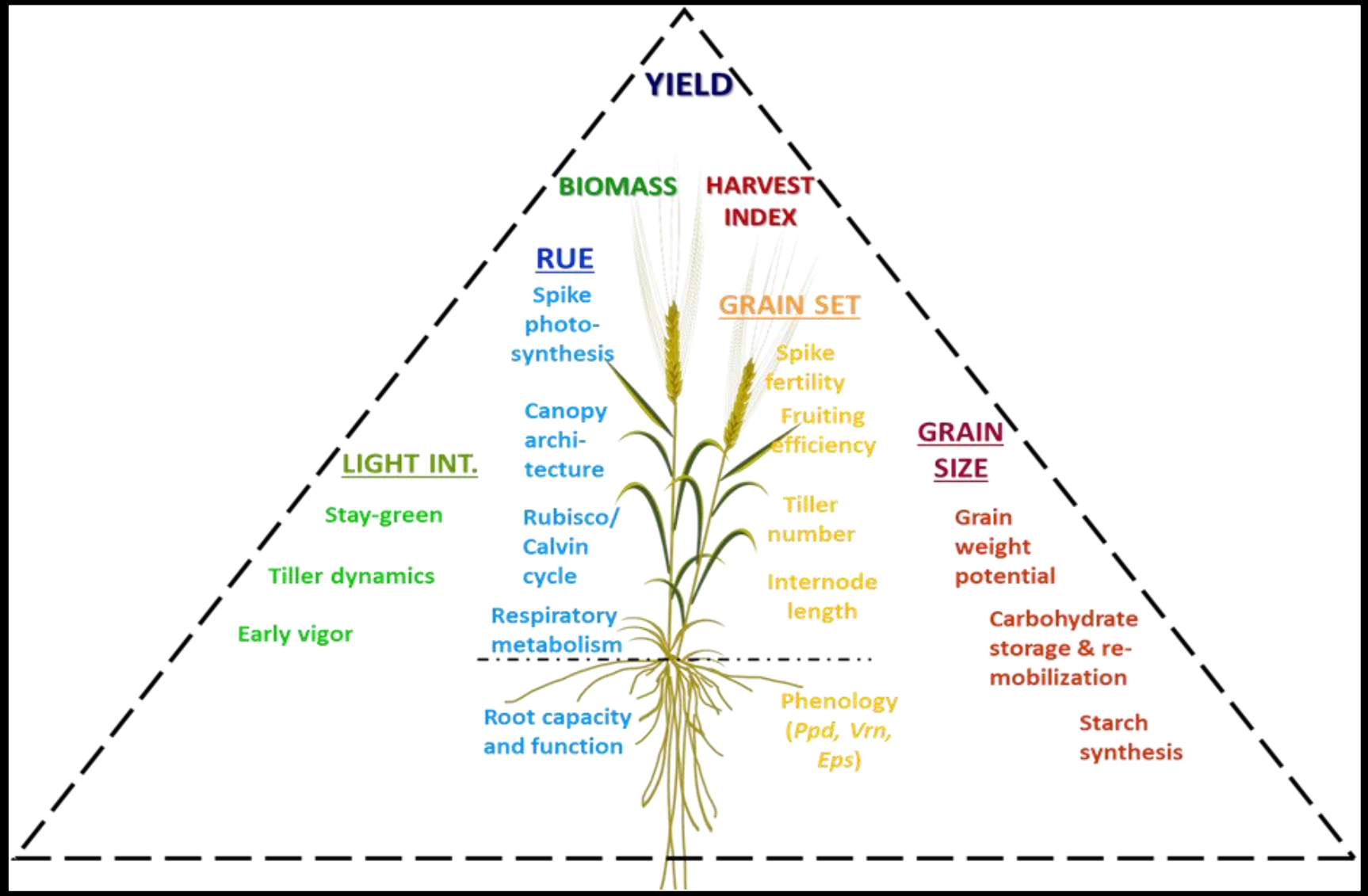
Pre-breeding using ‘source x sink’ strategic crossing



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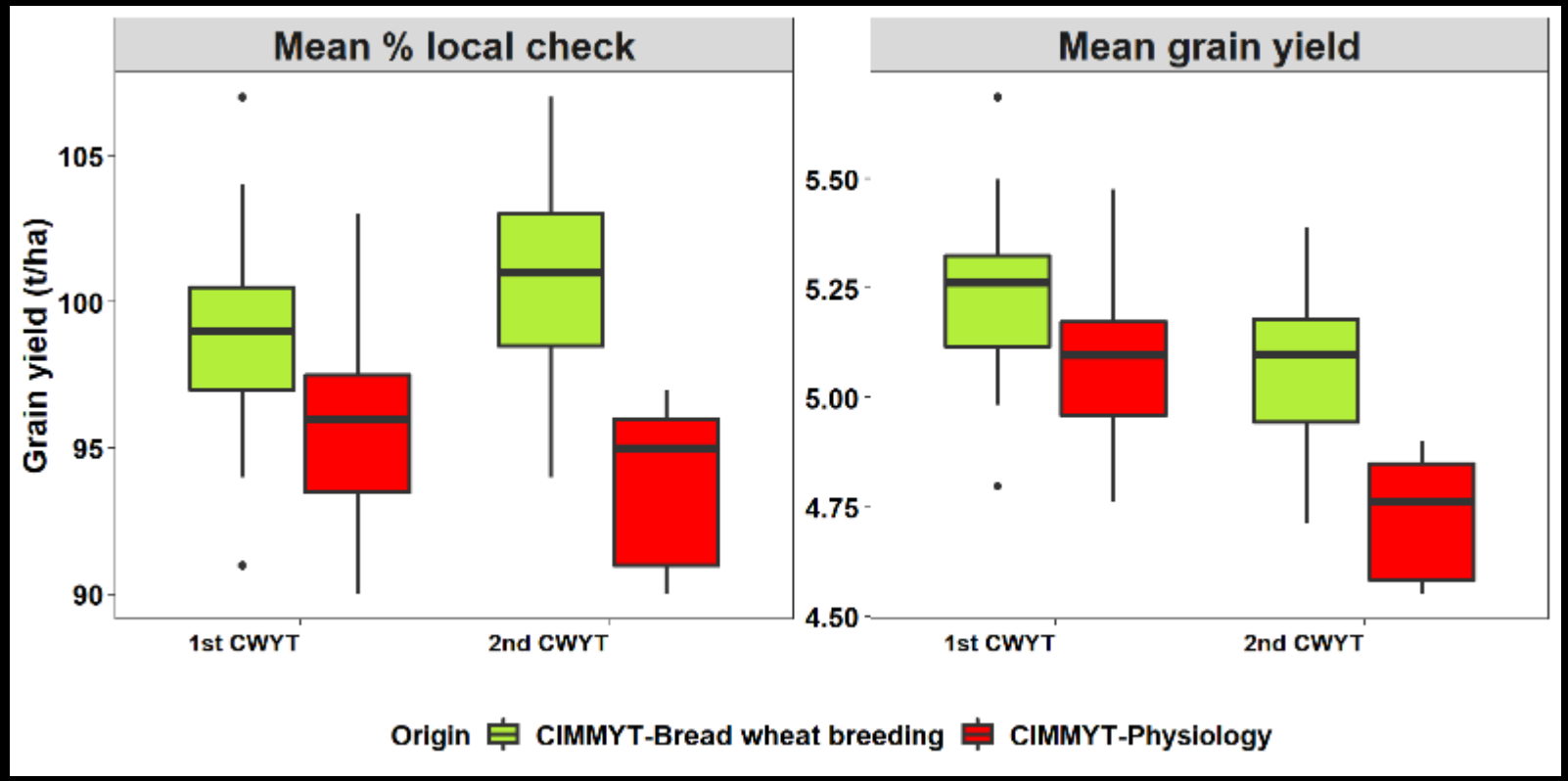
Benchmarking targeted pre-breeding

Collaborative Wheat Yield Trial (CWYT): benchmark breeding & pre-breeding material in multi-location trials



1st and 2nd CWYTs: comparison of mean % local check and mean grain yield for the CIMMYT bread wheat breeding and pre-breeding.

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What about nutrition?

Mainstreaming micronutrient biofortification: “fluoride in the water”

Selection for Zn in all CIMMYT wheat breeding pipelines to address malnutrition

https://www.reuters.com/business/healthcare-pharmaceuticals/exclusive-new-zinc-fortified-wheat-set-global-expansion-combat-malnutrition-2021-04-15/

HarvestPlus
Better Crops • Better Nutrition

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Addressing major production challenges

From varieties to systems

CSISA

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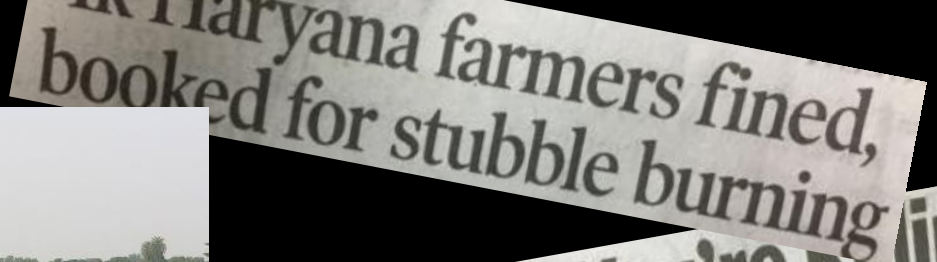
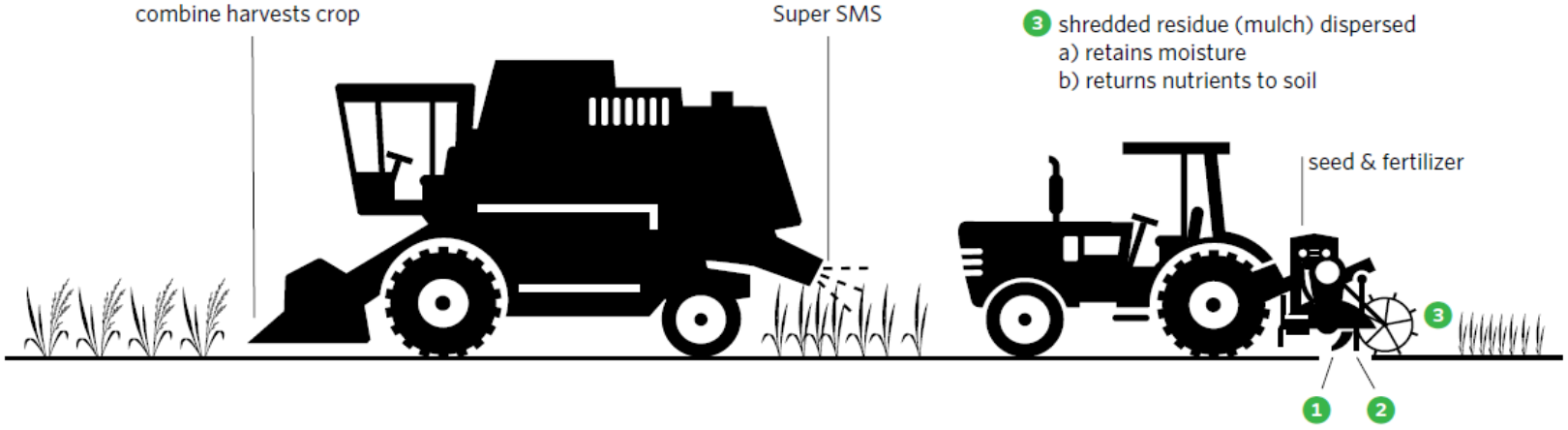


Happy Seeder rice residue management system.

A combine is fitted with a Super Straw Management System (SMS) so that rice residue is spread evenly across the field during harvest. A Happy Seeder follows, planting wheat seed directly into the rice crop residue, and applying fertilizer.



Wheat for the future

- > 50% of the world's wheat area is in the developing world.
- Wheat is a food source pivotal to alleviation of hunger, eaten by 2.5 billion people.
- Building resilience: important to safeguard future production.

- Innovations and discoveries are being rapidly made.
- Further investment/effort needed to rapidly and equitably accumulate & deploy them to farmers in the developing world.
- A "dynamic balance" needed to boost productivity, provide resilience & contribute to sustainable intensification.

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