



Fast and Focused: *novel strategies of the Global Barley Breeding Program to accelerate genetic gains under Climate Change*

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ICARDA Global Barley Breeding Program

40 years of impact

- ICARDA has the **Global Mandate** of the CGIAR to breed barley for the Developing World
- Breeding for **20Mha** in the Developing World, **>5Mha in Africa**
- **Extremely drought tolerant and adapted to poor soils**
- **Ultimate multi-purpose crop: Food-Malt-Feed-Forage**

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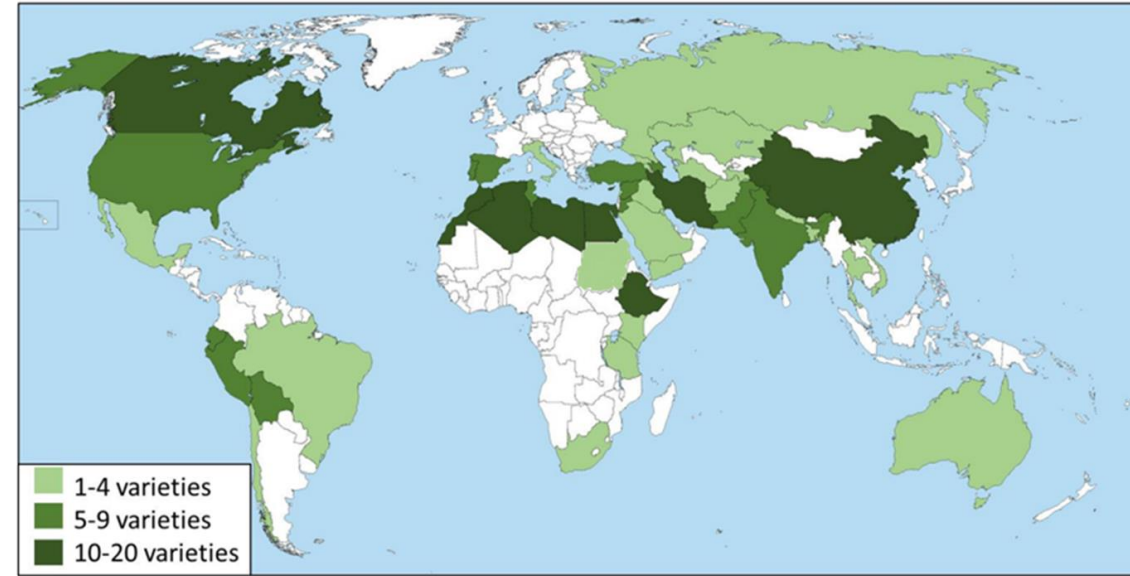


Figure 1 Number of barley varieties of ICARDA origin released per country.



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Product profiles

- **Product Lines co-designed with NARS and grouped in:**

- Feed Barley for Arid and Semi-Arid Environments
- Feed and Forage Barley for Favorable Environments
- Food and Fodder Barley
- Malt and Fodder Barley

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Feed and Forage Barley for Favorable Environments



Feed Barley for Arid and Semi-Arid Environments



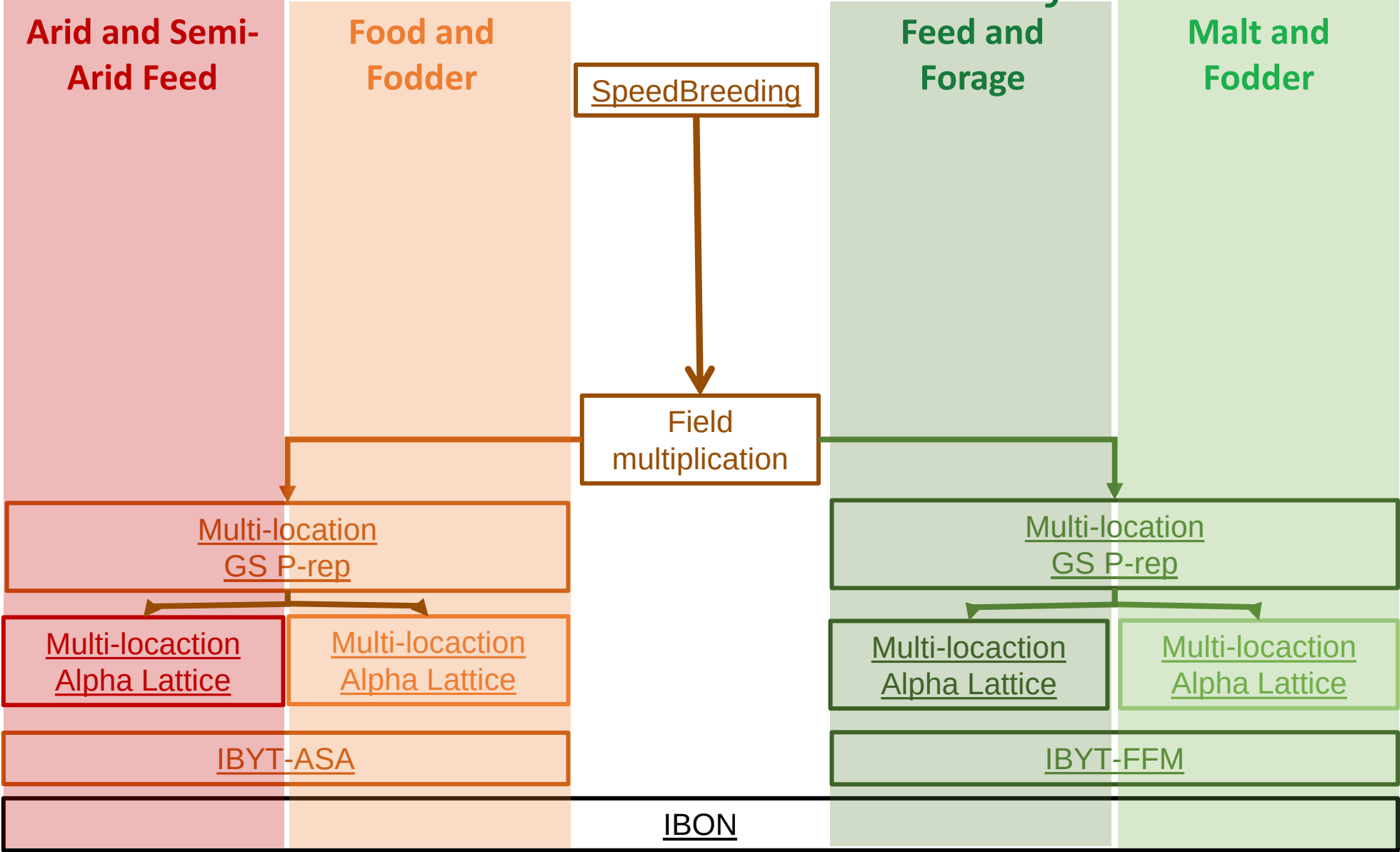
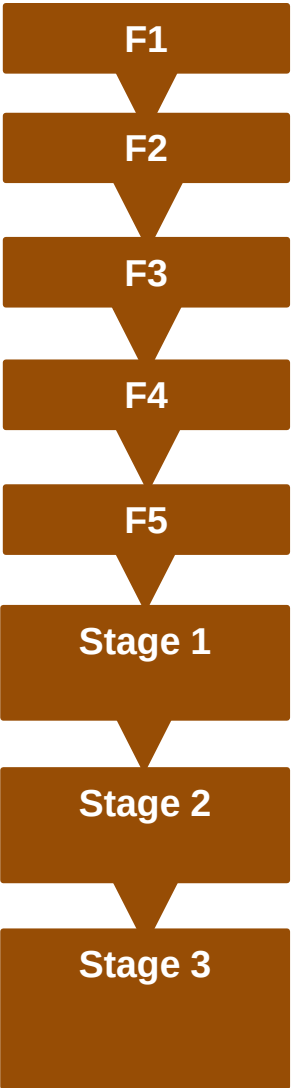
Malt and Fodder Barley



Food and Fodder Barley

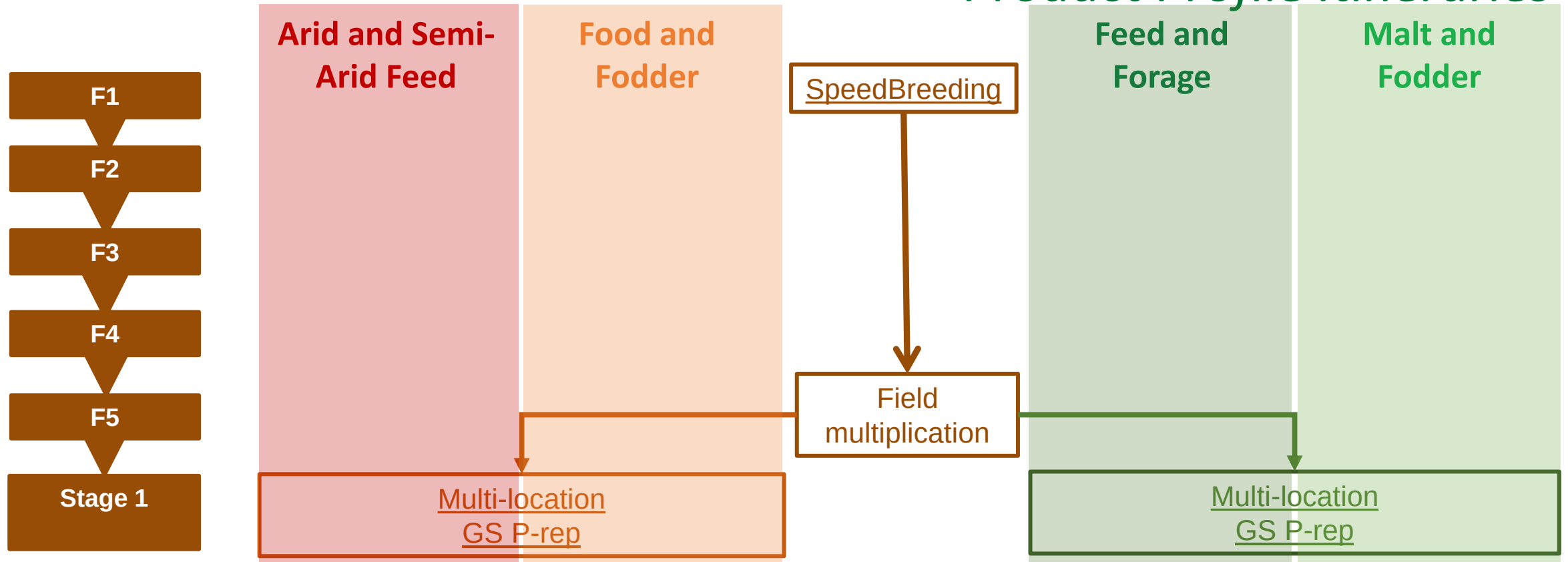
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Product Profile Itineraries



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Feed and Forage Barley for Favorable Environments



Feed Barley for Arid and Semi-Arid Environments



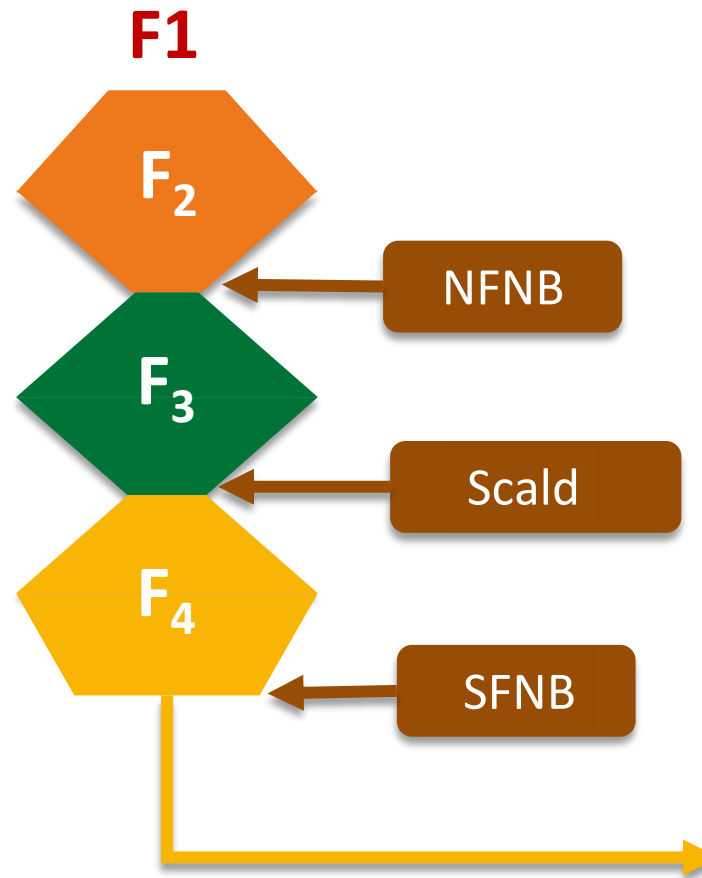
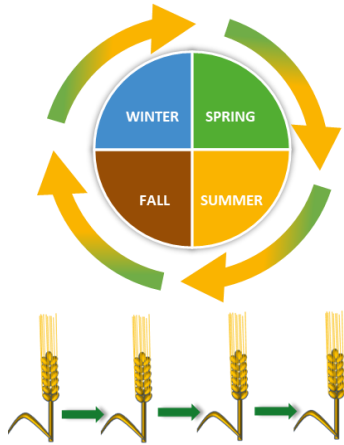
Malt and Fodder Barley



Food and Fodder Barley

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Disease Assisted Speed Breeding



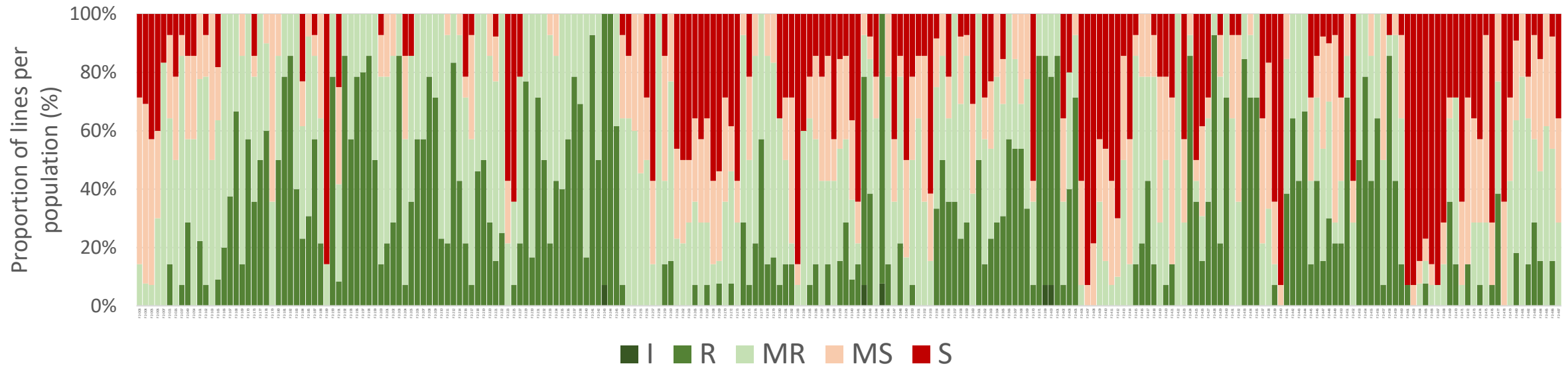
Speed Breeding

4 Generations per year instead of 1 or 2
Capacity for >100,000 entries
Currently 12,000 entries per generation

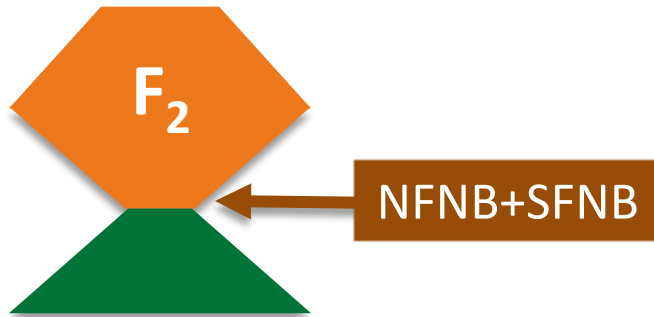


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Disease-assisted Speed Breeding

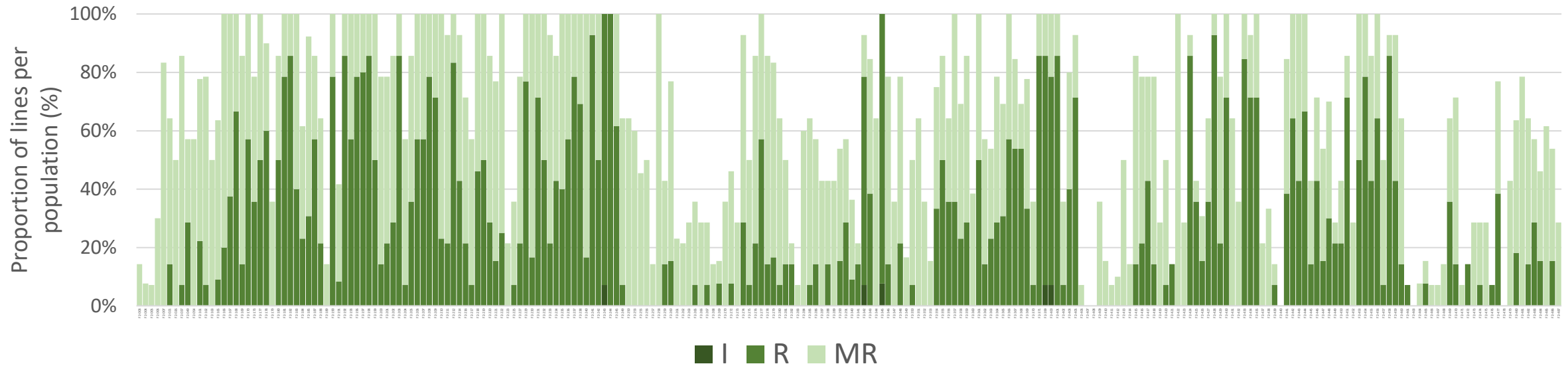


Muamar El-Jaboobi
ICARDA Pathologist

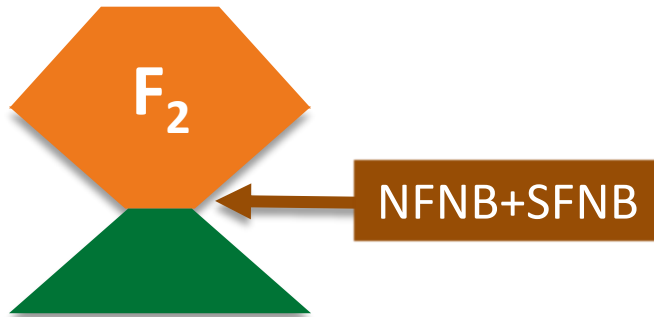


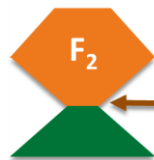
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Disease-assisted Speed Breeding



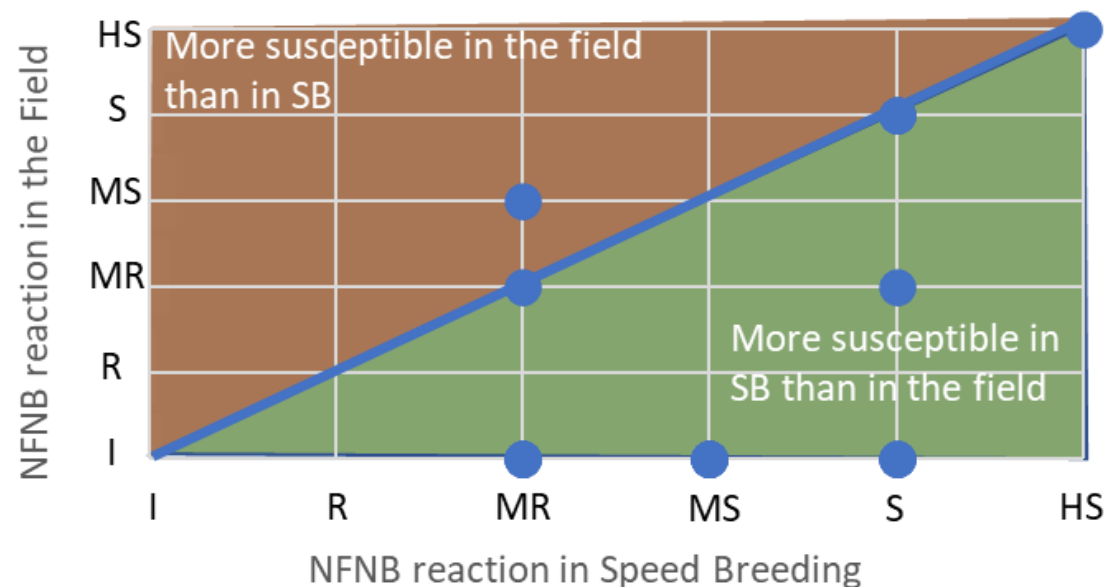
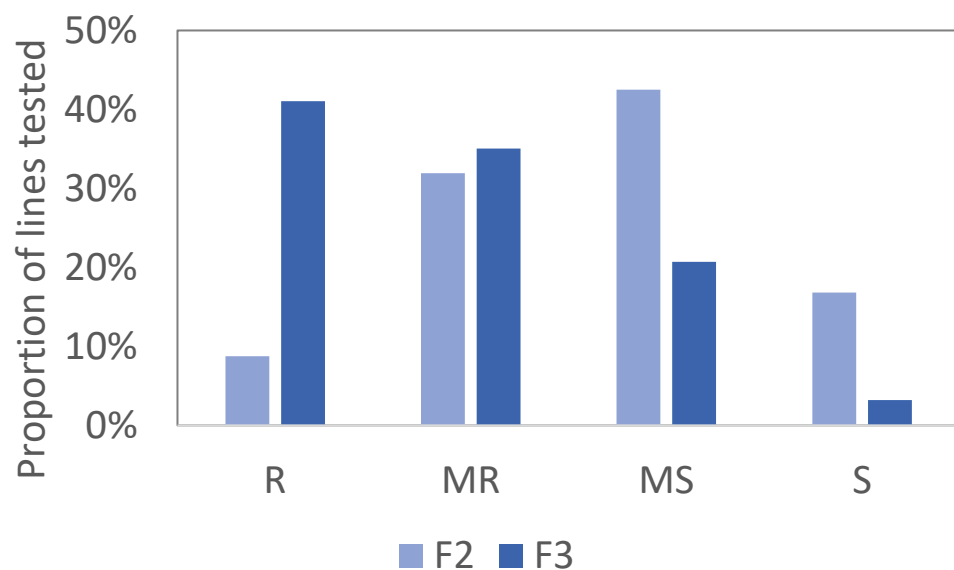
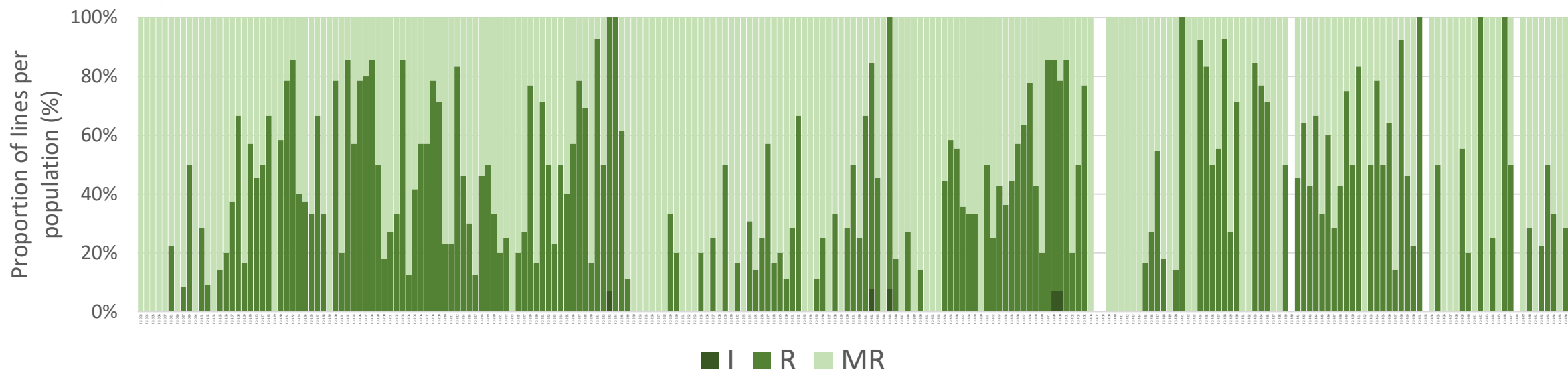
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Disease-assisted Speed Breeding



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Response to Speed Breeding in the field

- Many important traits like **plant height, phenology or lodging resistance** have **lower heritability** than disease resistance
- Growing and selection conditions in Speed Breeding (SB) (0.16L cones and long photoperiod) different to **Field**

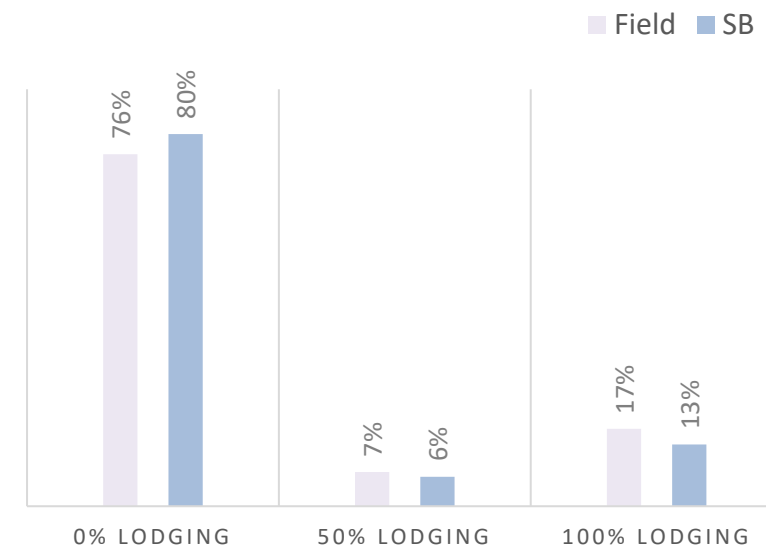
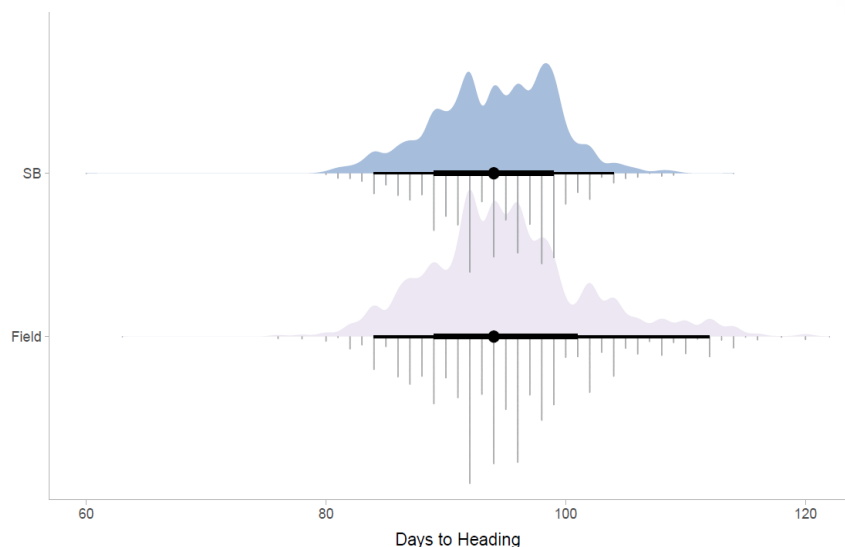
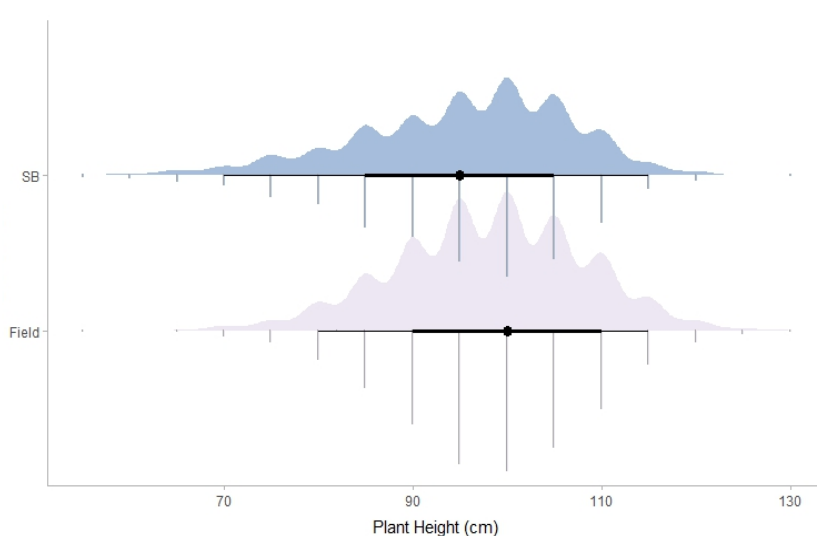


- **2 sets of ca. 5,000 F₅** – One advanced under Speed Breeding (SB) and one in the **Field** planted side-by-side

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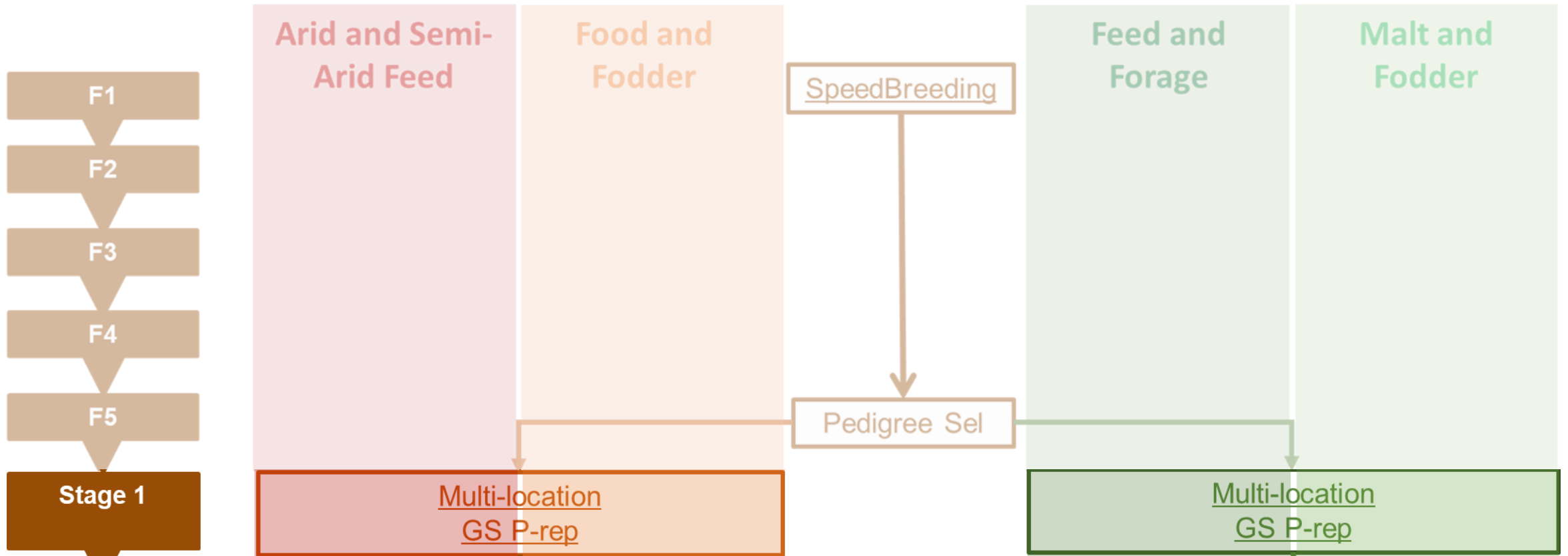
Response to Speed Breeding in the field

- **No significant difference** in phenology, plant height or lodging tolerance at main location between **SpeedBreeding** and **Field** generation advancement
- SOP for SpeedBreeding available online



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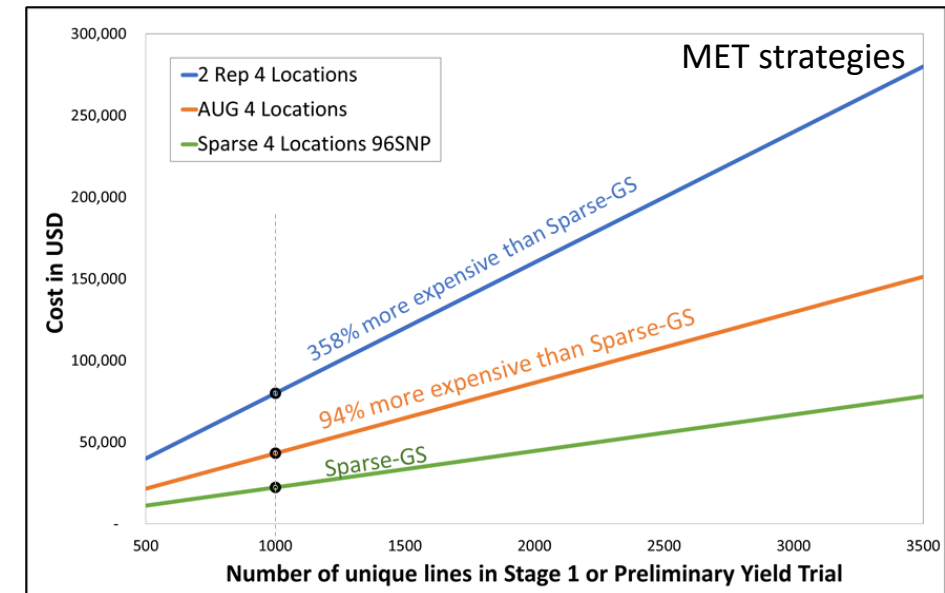
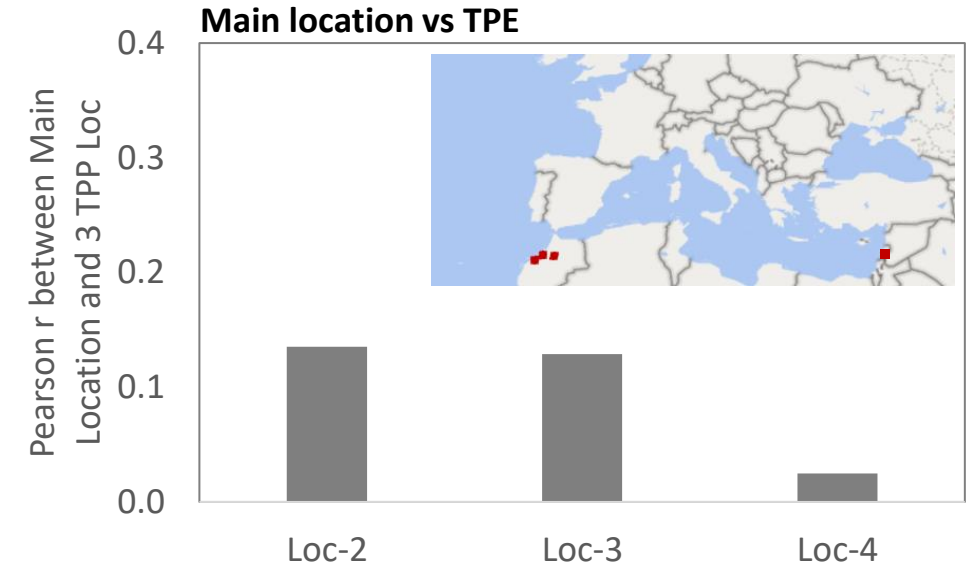
Stage 1



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Genomic-assisted Sparse MET

- Breeding for >**20Mha** in the developing World
- **Traditionally** initial yield trials (**Stage1**) were done in **1 loc**
- Multilocation testing is needed when **1 location does not represent all target envir.**
- Identify locations that **represent TPE**
- Very large **GxY** variability
- *Genomic-assisted Sparse MET*
 - **Testing at TPE**
 - Higher accuracies than **year by year variation**
 - Allows to **recover failed trials**

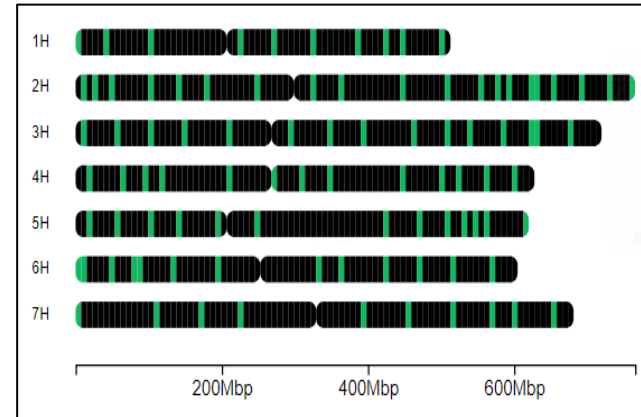


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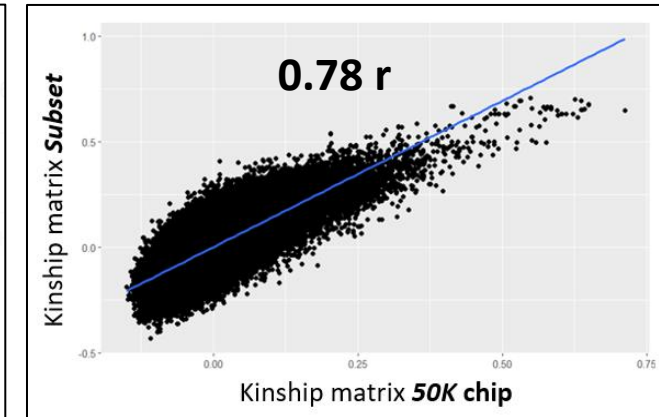
Genomic-assisted Sparse MET: Marker Selection

- **192 markers** distributed along the genome, selected from the **50K SNP chip** used in CB
- **Unlinked markers** and situated beyond the expected recombination distance per chromosome region
- Markers selected based on **>0.4MAF** in CB
- Includes several **QTL** identified in CB
- Represent **0.78 off-diagonal correlation** of kinship matrix of full 50K SNP in CB
- **The KASP markers** were also **unlinked** and with a **ca. 0.4 MAF** in the progeny (Boxplots)

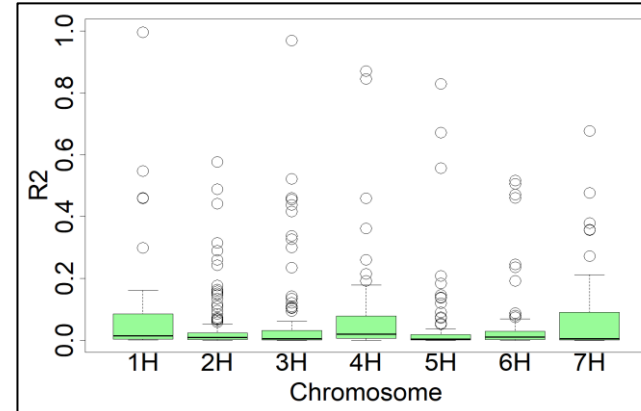
Marker Distribution



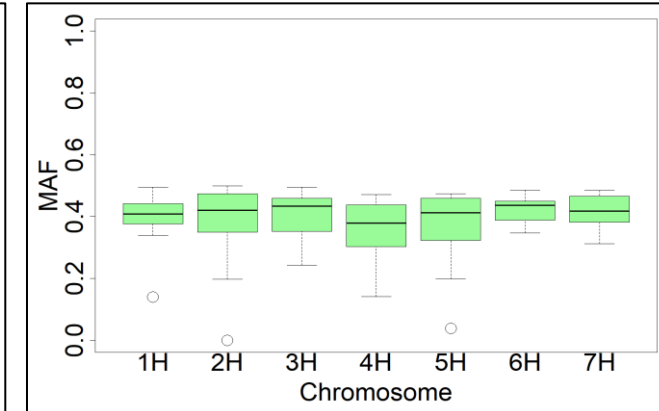
Subset Representativity



LD within chromosome (KASP)



MAF per chromosome (KASP)



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Genomic-assisted Sparse MET: Field Design

- 1000-2000 Stage1 entries and 8 commercial checks
- 400 plots and 360 genotypes per location
- 4 locations representing TPE for arid and semi-arid
- Proportion Overlapping-Non-Overlapping: 27%-73%
- Genotypes allocated across envir. based on Pedigree

Matrix

Sub-optimal rainfed (Marchouche, Morocco)

Average Temp: 15.6°C
Precipitations: **323 mm**
Max.Temp: 47.2°C
Min. emp: -1.6°C

Loc 1

North African Highland (Annoeur, Morocco)

Average Temp: 12.8°C
Precipitations: **337 mm**
Max.Temp: 39.3°C
Min. Temp: -8.3°C

Loc 2

Arid envir (Sidi el Aidi, Morocco)

Average Temp: 16.4°C
Precipitations: **163 mm**
Max.Temp: 47.9°C
Min. Temp: -1.6°C

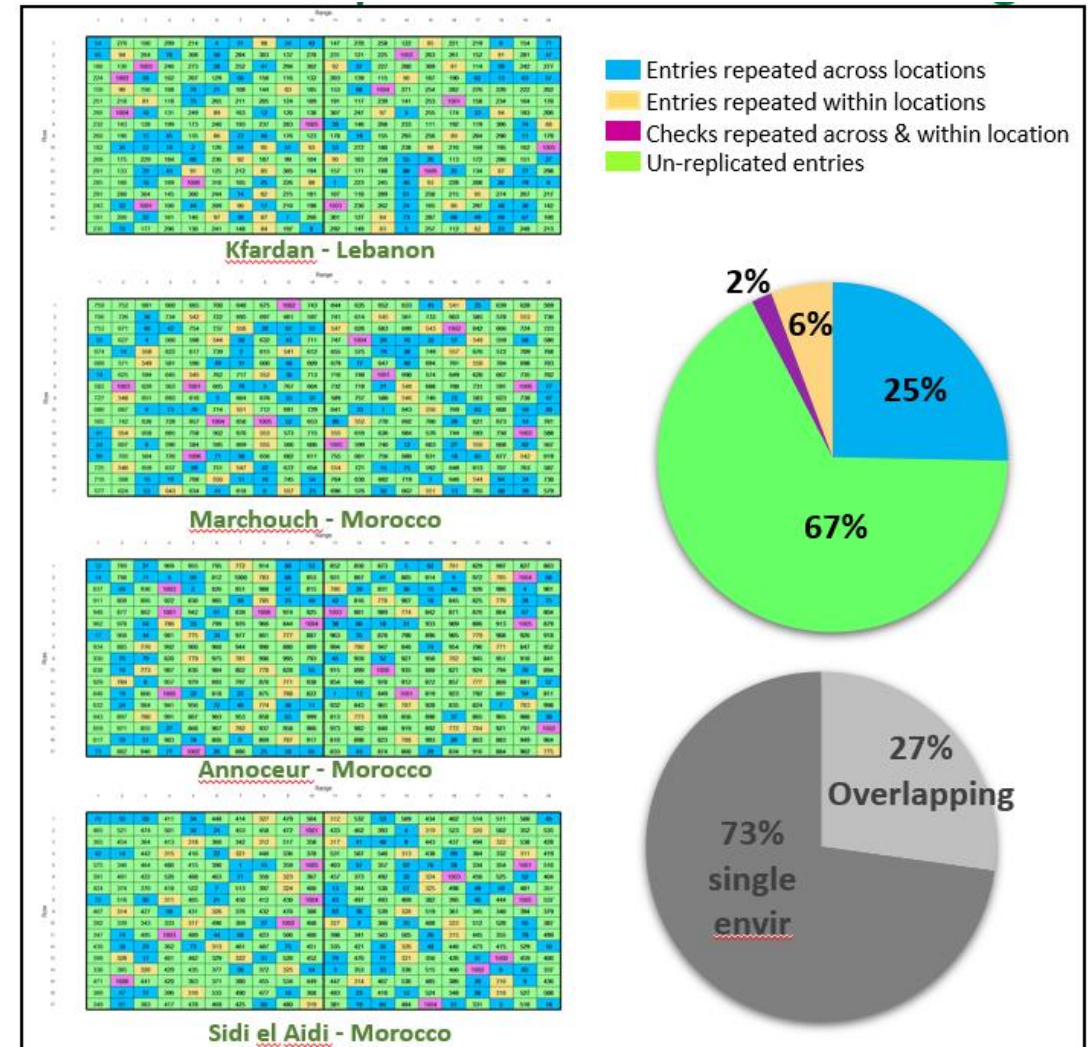
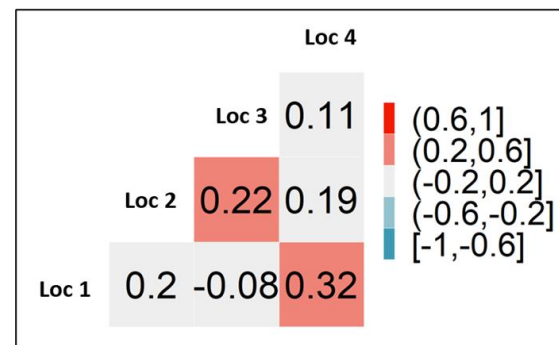
Loc 3

West Asian Highlands Kafardan, Lebanon

Average T^a: 16.9°C
Precipitations: **436 mm**
Max.Temp: 46.3°C
Min. Temp: -7.6°C

Loc 4

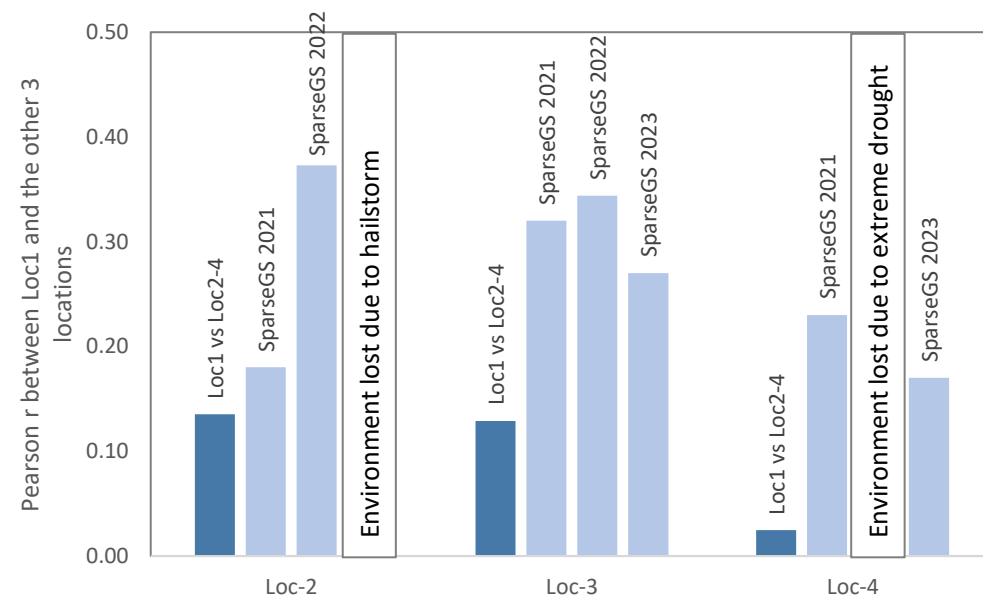
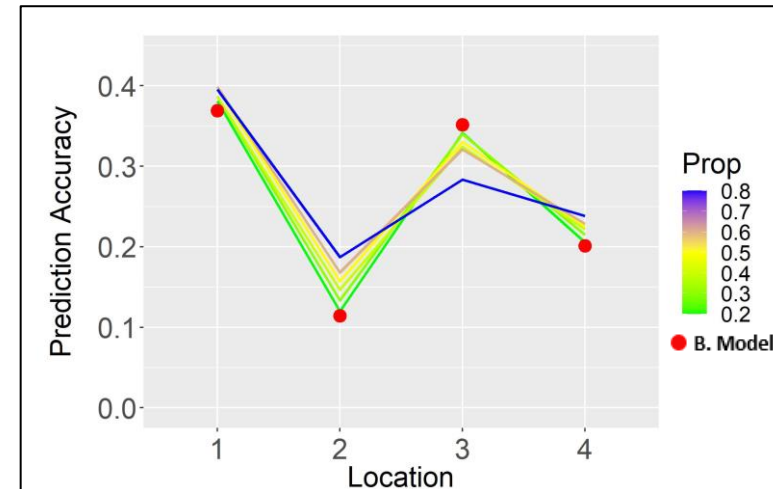
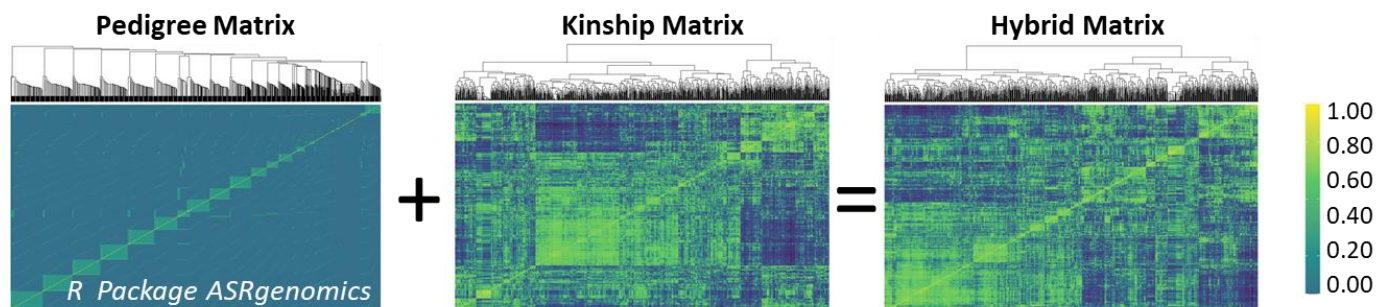
Genetic correlation



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Genomic-assisted Sparse MET: Predicting Grain Yield

- **Hybrid matrix:** Pedigree Matrix + Kinship Matrix
- **G + GxE** modelling with asreml
- The accuracy of the GP: correlation (r) between the BLUEs values and the GEBVs.
- The **MET** results **increased selection accuracy (r)** as **compared to single location** selection by up to **28% to 8-fold**
- **Recovery of failed trials**

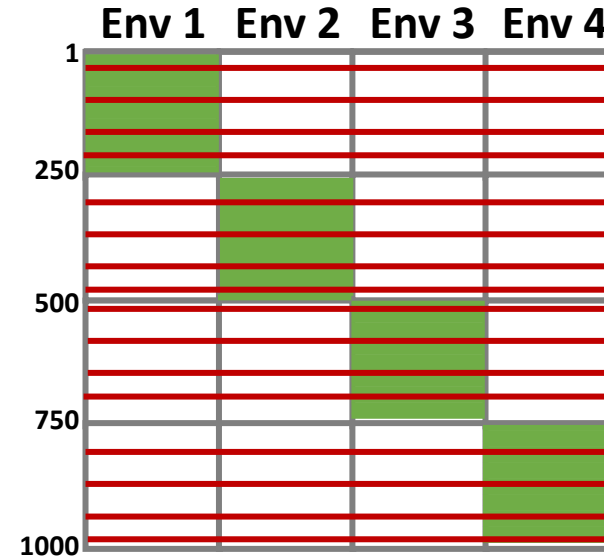


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New steps for the use of Sparse-GS in Stage 1

- Increasing marker number
- Not only grain yield
- Potential of the strategy to **easily up-scale**

Trials in 2021

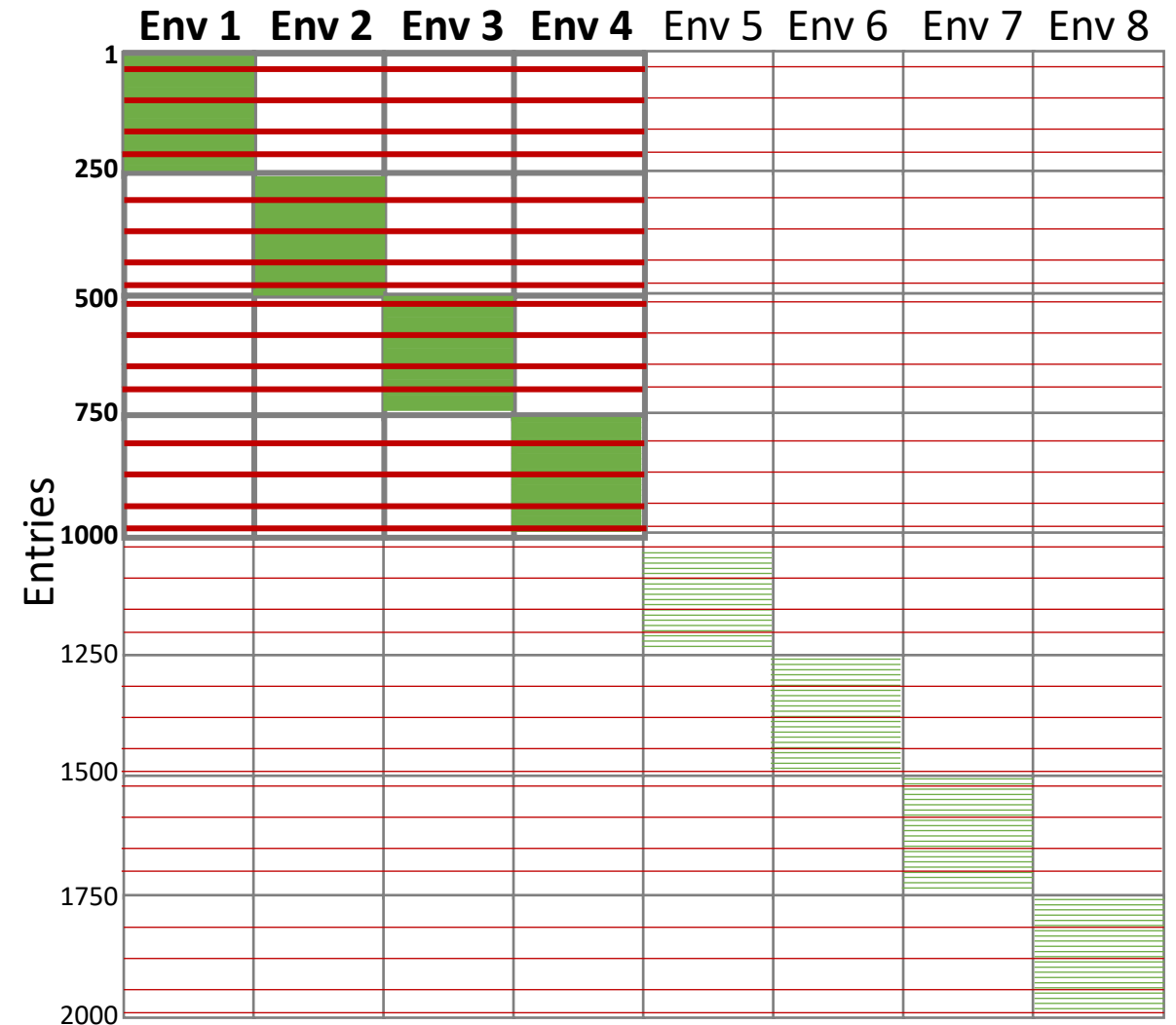


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New steps for the use of Sparse-GS in Stage 1

- **National programs and CGIAR can create joint Stage1** in key locations and maximize selection accuracy
- In **2023/24**, collaborators in **Egypt, India, Spain and Tunisia** will plant Stage 1. In addition, 2 locations in Lebanon and 5 in Morocco used.

Collaborators in the World. In **green** Stage 1 trials in 2023/24



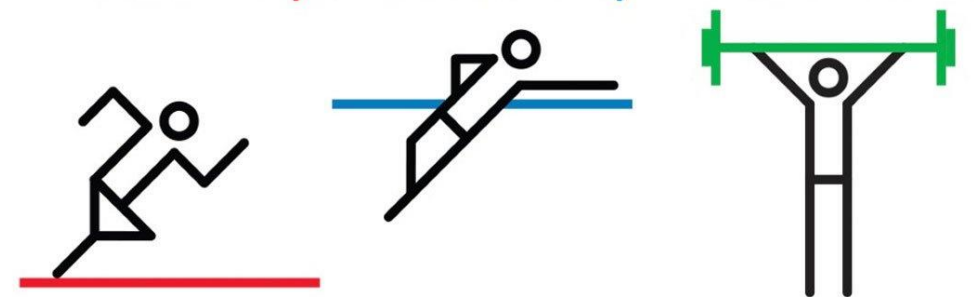
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Take home message

- The new technologies strategies presented have the potential to **increase Genetic Gain**
- We can and **MUST** be faster
- We can and **MUST** be more efficient
- We can and **MUST** be more effective

 Rio 2016

CITIUS, ALTIUS, FORTIUS



Global Barley Breeding Program



Global Barley Breeding Team

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Jamal El Haddouri
Athanasios Tsivelikas



Quality Team

Hasnae Choukri

Precision Phenotyping Team

Andrea Vioni
Bouaza M.



Special thanks:



Thank you

85 collaborators

in **46 countries** in Africa, Asia, America and Europe request the barley International Nurseries

More than **20Mha** in the **Developing World**

25 new varieties

released by NARS partners in 7 countries in the last 6 years

Over **3Mha** of **Food Barley**, a staple crop among poor farmers

Livestock in Africa is increasing by **2.7% year**

Over **460,000** households in **Ethiopia** adopted malt/food & Feed ICARDA barley varieties.



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