Use of new technologies (molecular markers and speed breeding) in the development of drought-tolerant wheat varieties in Morocco

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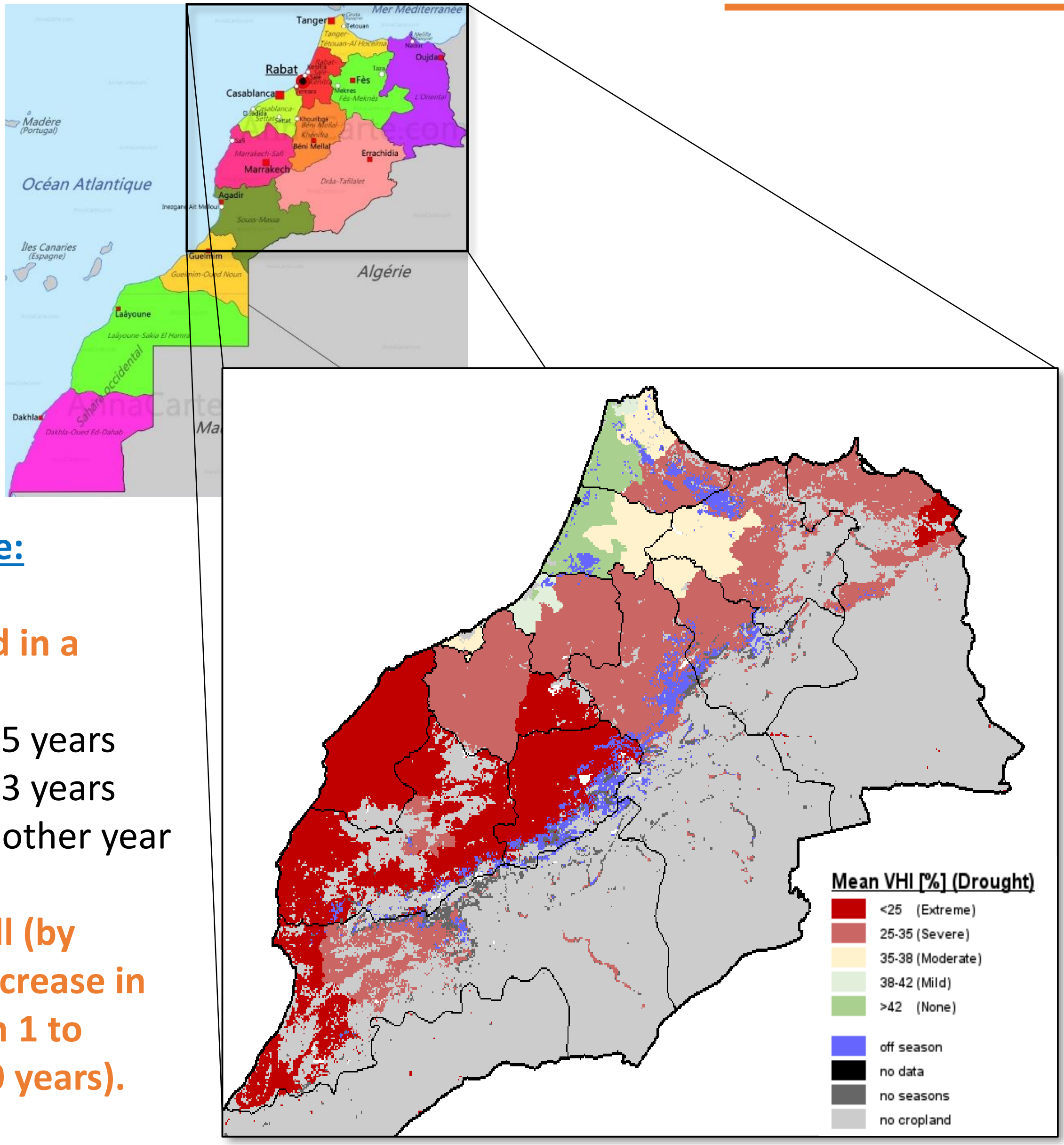
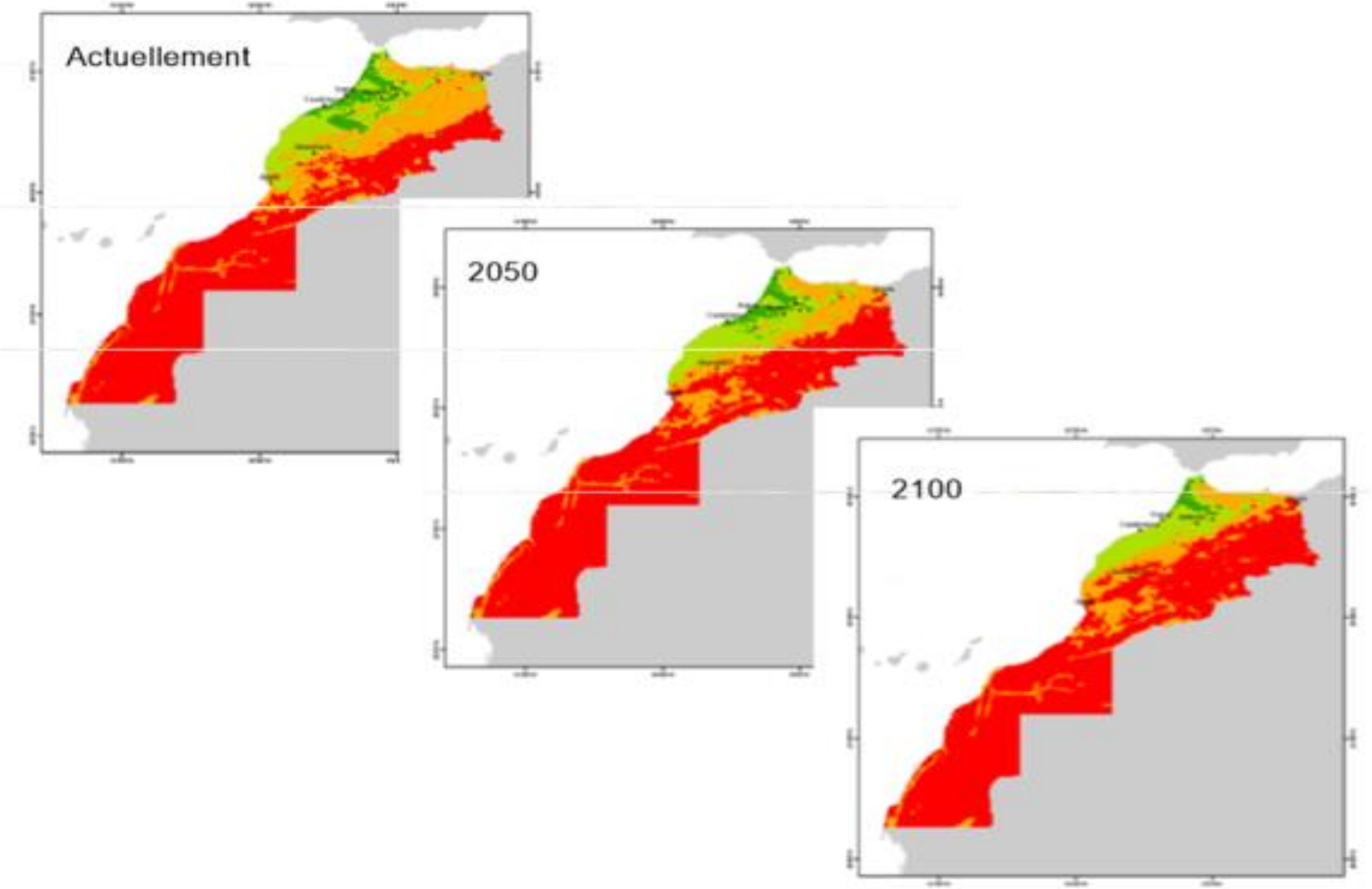
Drought and its consequences on crop establishment in Morocco

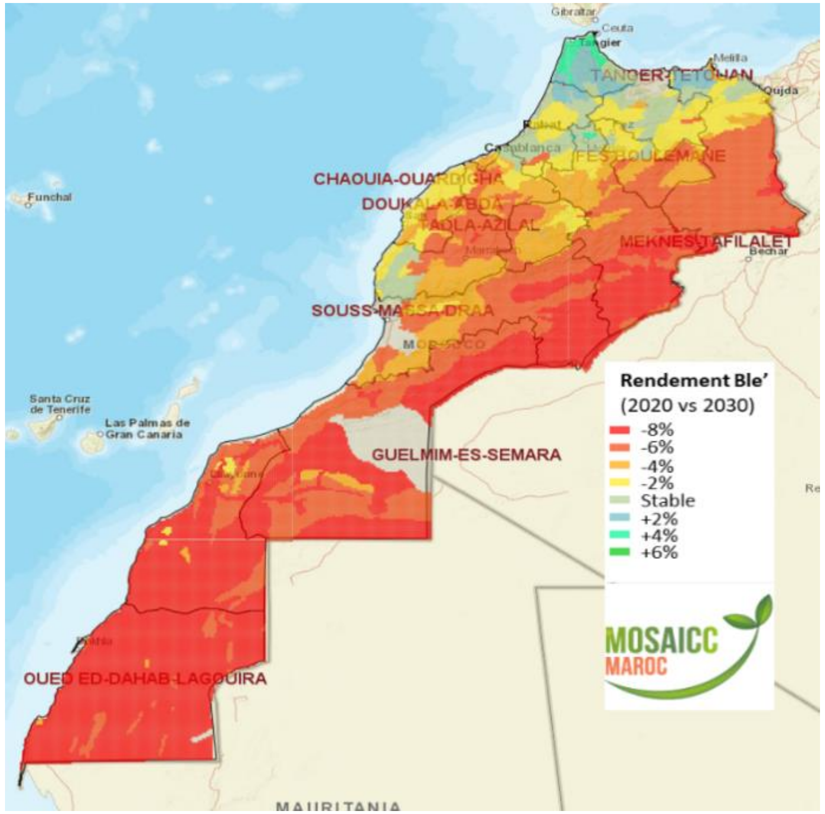


Climate change is here:

- **Morocco is located in a drought hot spot :**
  - -1980-2000: every 5 years
  - -2000-2020: every 3 years
  - -Since 2021: every other year
- **Decrease in rainfall (by about 40%) and increase in temperature (from 1 to 1,5°C in the last 40 years).**

Impact of Climate Change in Morocco

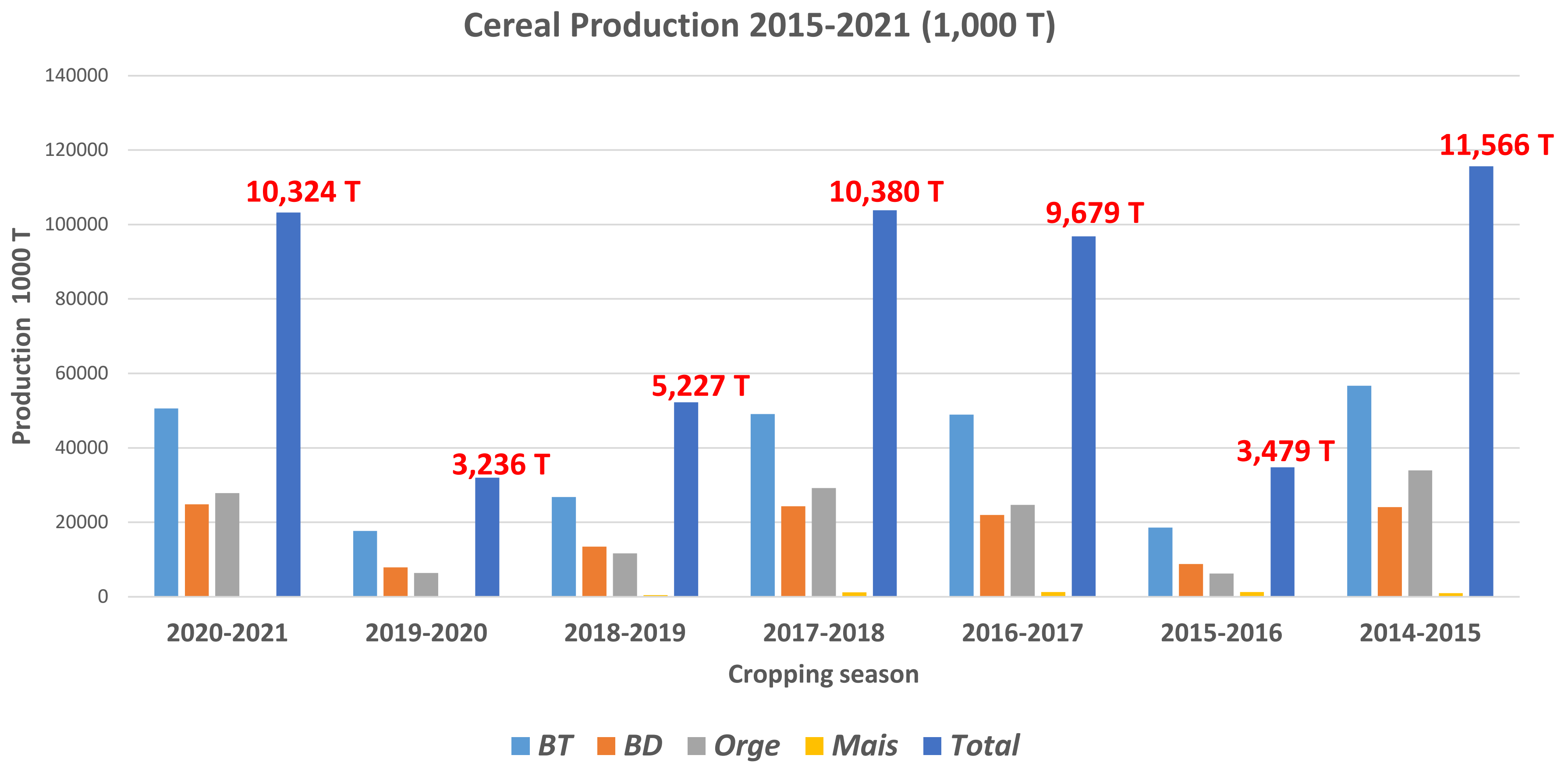




Projected reduction of 8% in wheat yields by in 2030

Impact of climate change: reduction of 30 % of cereal area in Morocco by 2050

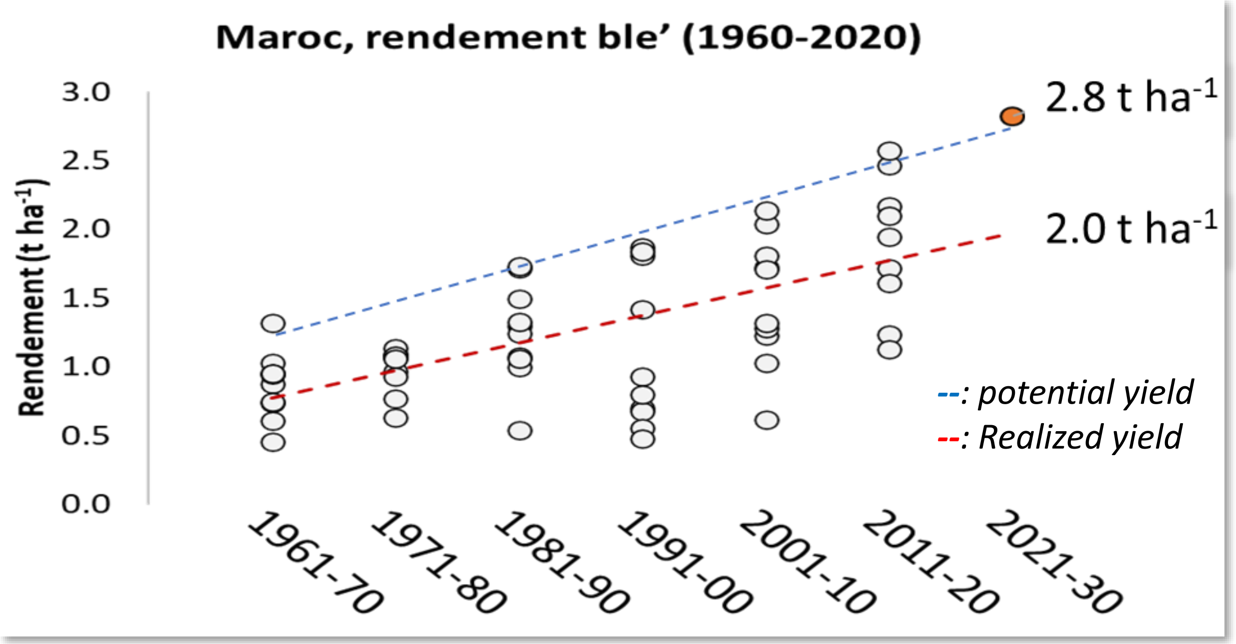
Cereal Production in Morocco



- Cereal Production is linked to rainfall, there is big fluctuation from year to year (last 3 years)
- In 2021-2022: similar to 2019-2020 with a production of 3,4 million T
- Area: 4,3 million ha (2020-2021)
- Average yield: 1,6 T/ha to 2,5 T/ha (2009-2021)
- Yield potential: 3-5 T/ha pilot farmers and in experimental station

More than a century in Cereal breeding in Morocco

Item	Value
Scientists involved	30
Support Staff	>70
Allocated area for trials each year	>200 ha
Released varieties since 1980	120
Market share of INRA varieties	15-58%



Average Annual Genetic Gain: 0.1 T/yr

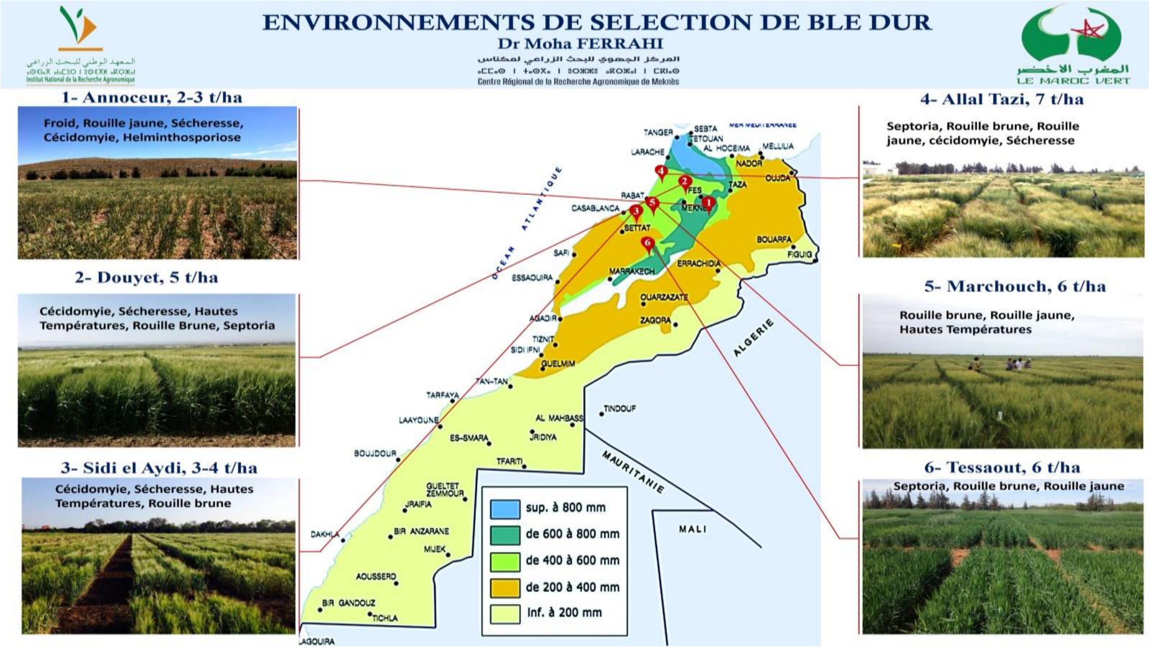
Cereal production: Environments and constraints in Morocco

- Fully irrigated or supplemented (**10% area**):
  - ✓ 3 Rusts and Septoria, tan spot and quality
- Humid and sub-humid (>450 mm, **40% area**):
  - ✓ Drought, heat, septoria, leaf and yellow rusts
- Semi-arid and arid (250 to 300 mm, **40% area**):
  - ✓ Drought, leaf rust and Hessian fly
- High altitude (350 - 600, **10% area**):
  - ✓ Drought, cold, frost, yellow rust, stem rust and TS

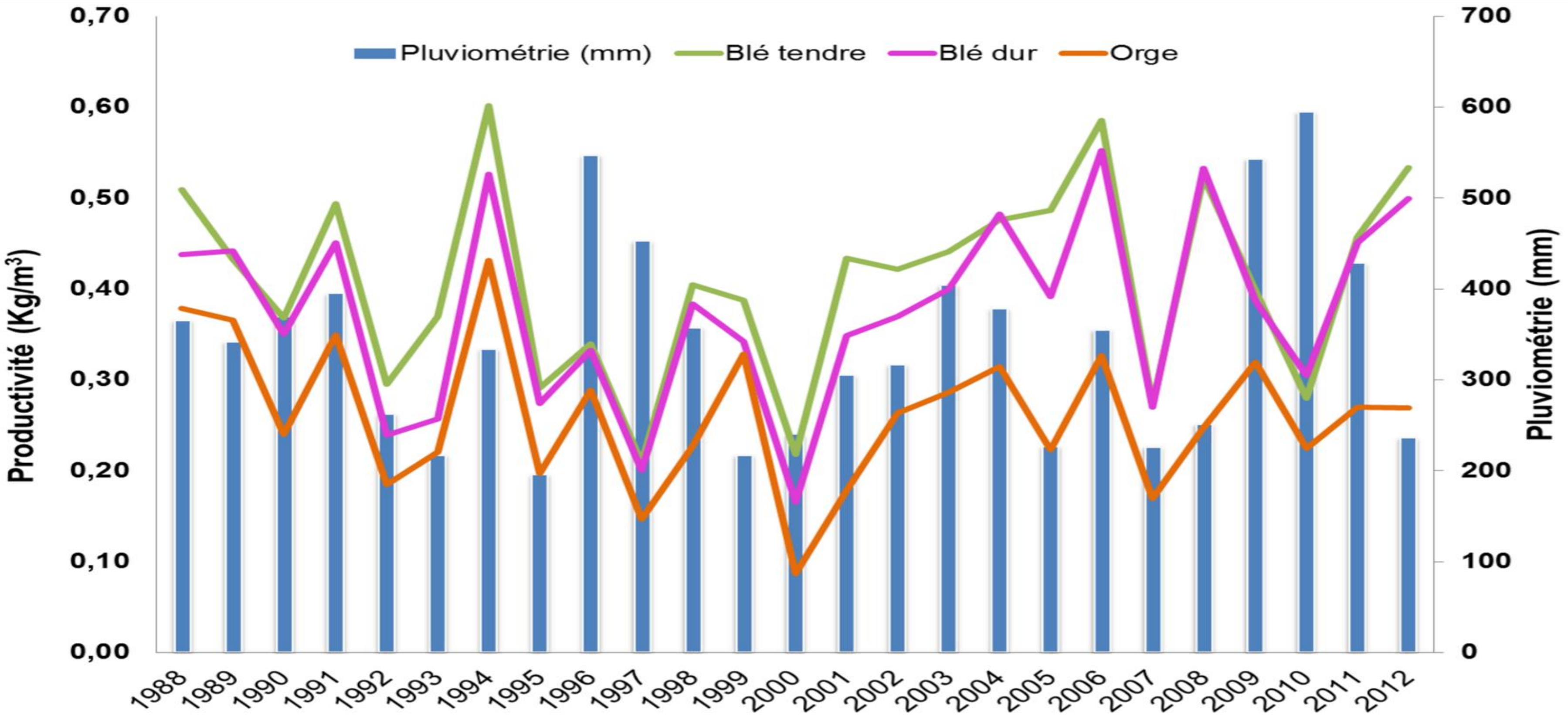
Cereal Germplasm Development at INRA

>10,000 Experimental plots for breeding each year

- Selection in different environments across the country
- Screening for major diseases and abiotic stresses
- More than 800 International lines evaluated each year
- Use of commercial varieties for comparison
- Use latest experimental analysis and genomics for MAS



Improving agronomic water productivity (WUE)

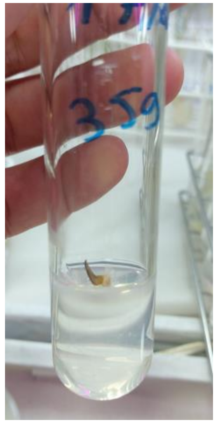


- ✓ The water productivity in the rainfed areas is very low (ranges from **0.506 Kg/m3** in good years to **0.149 g/m3** in dry season). Overall the water productivity varied between **1.15 Kg/m3** for Doukkala region and **3 Kg/m3** for Tadla region in Morocco (Balaghi et al., 2014);
- ✓ On the average, the varieties released by INRA have a water productivity of about **2.27 kg/m3** (Ferrahi, 2020), which is comparable to Australian varieties that are known to be drought tolerant.

Prebreeding effort for Drought tolerant germplasm development

- Interspecific hybridization for the transfer of Hessian fly resistance from wheat wild relatives to cultivated wheat

Crosses between durum wheat and *Triticum dicoccoides*




- New interspecific hybrids were obtained from cross between cultivated barley and tetraploid *Hordeum bulbosum*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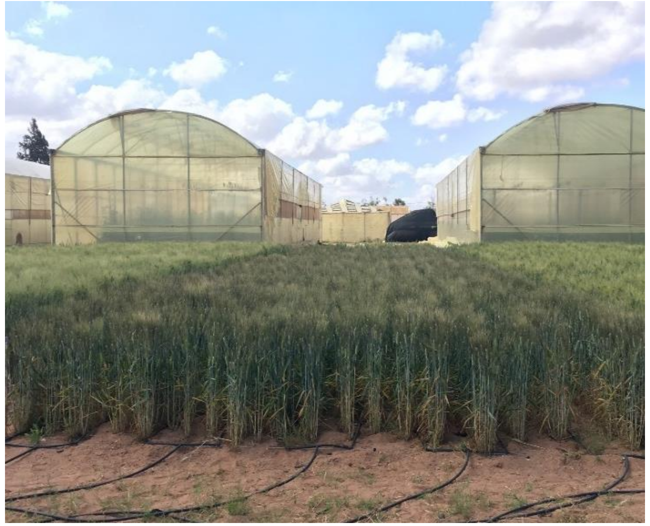
الجيل الأخضر
GÉNÉRATION GREEN
2020 – 2030

Use of Advanced technologies in cereal breeding

Use of innovative technologies such as

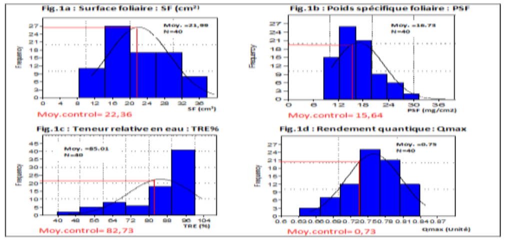
- Powerful tools in experimentation and data analysis;
- Use of speed breeding techniques/DH;
- Use of genomic as MAS;
- High throughput phenotyping to study abiotic stress;
- Use of drones to estimate yield;
- Taking into account the industry and end-use requirements;
- Farmers involvement for selection preferences ;
- Climatic changes;
- …

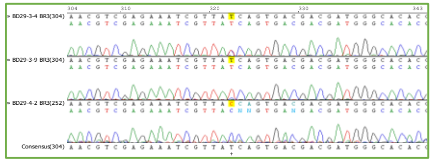


Application of Tilling and Irradiation to Create New Genetic Resources and Selection of Adapted Lines in Wheat

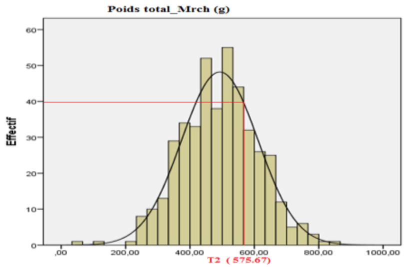
Creation of a mapping population from commercial durum and bread wheat varieties using nuclear irradiation (EMS) and selection of mutants with :

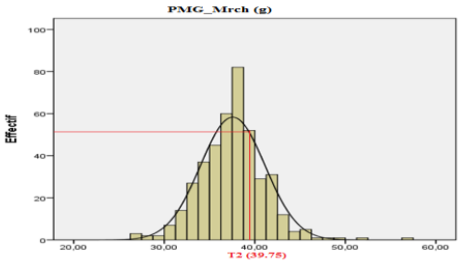
- ✓ Good Drought and Salt tolerance;



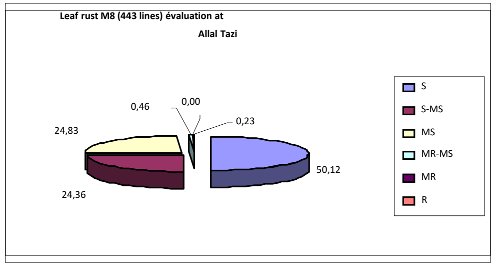


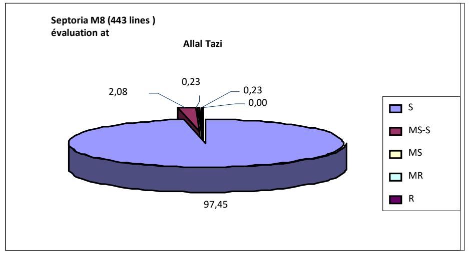
- ✓ High yield as compared to commercial varieties;





- ✓ Good tolerance to main wheat diseases.

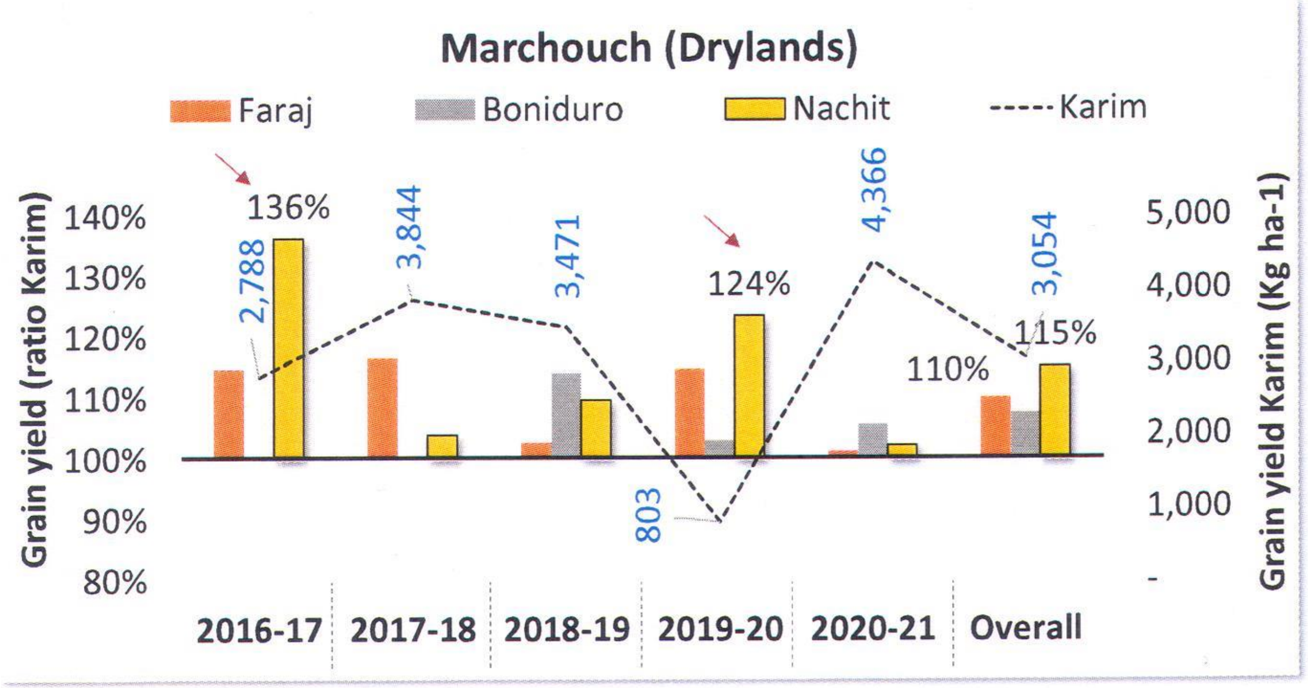




Case study: Durum wheat "Nachit" for drought tolerance

- ✓ Interspecific cross: Amedakul/*T. dicoccoides* Syr//Loukus
- ✓ Released in 2018 by INRA Morocco as 'Nachit'
- ✓ Released for its drought tolerance and large grains

Impact of the drought-resistant durum wheat variety Nachit



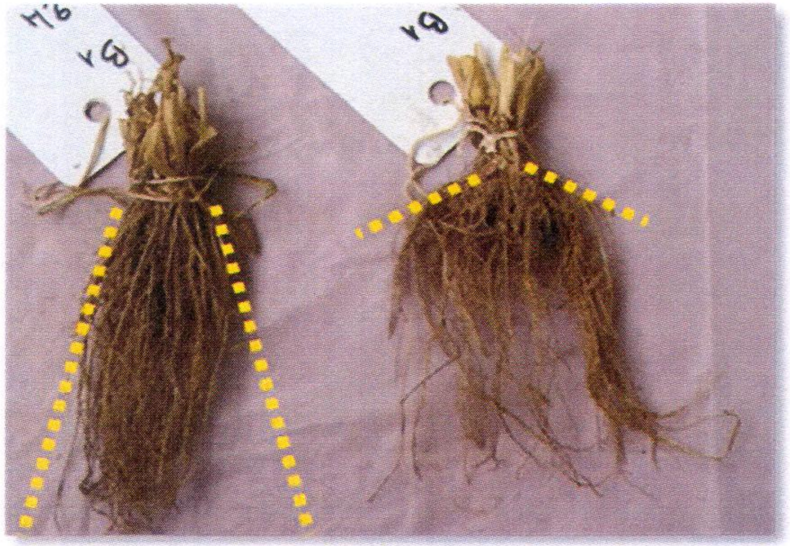
- Nachit produced *15% more yield* across five seasons
    - 24% and 36% in dry years
- It has *10% larger grains*
- Resistant to *RR, LR, SR, but not to HF*
- *Where does its drought tolerance come from?*

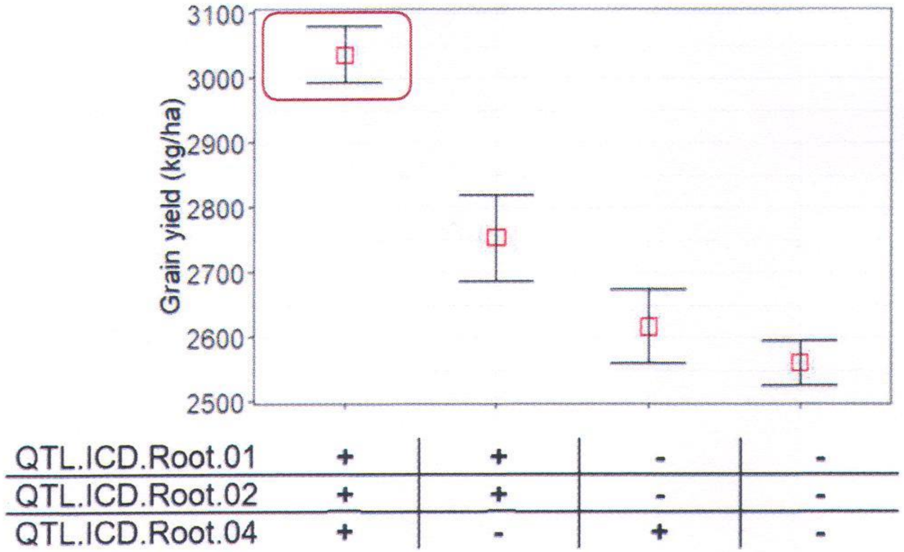
✓ The durum variety Nachit produced 15% more grain yield in 5 seasons and 24% and 36% more in two dry years.

✓ The drought resistance comes from a good root development with the identification of 3 QTLs that allow an increase of +300 kg/ha alone.

Where does come a drought-resistant durum wheat variety Nachit?

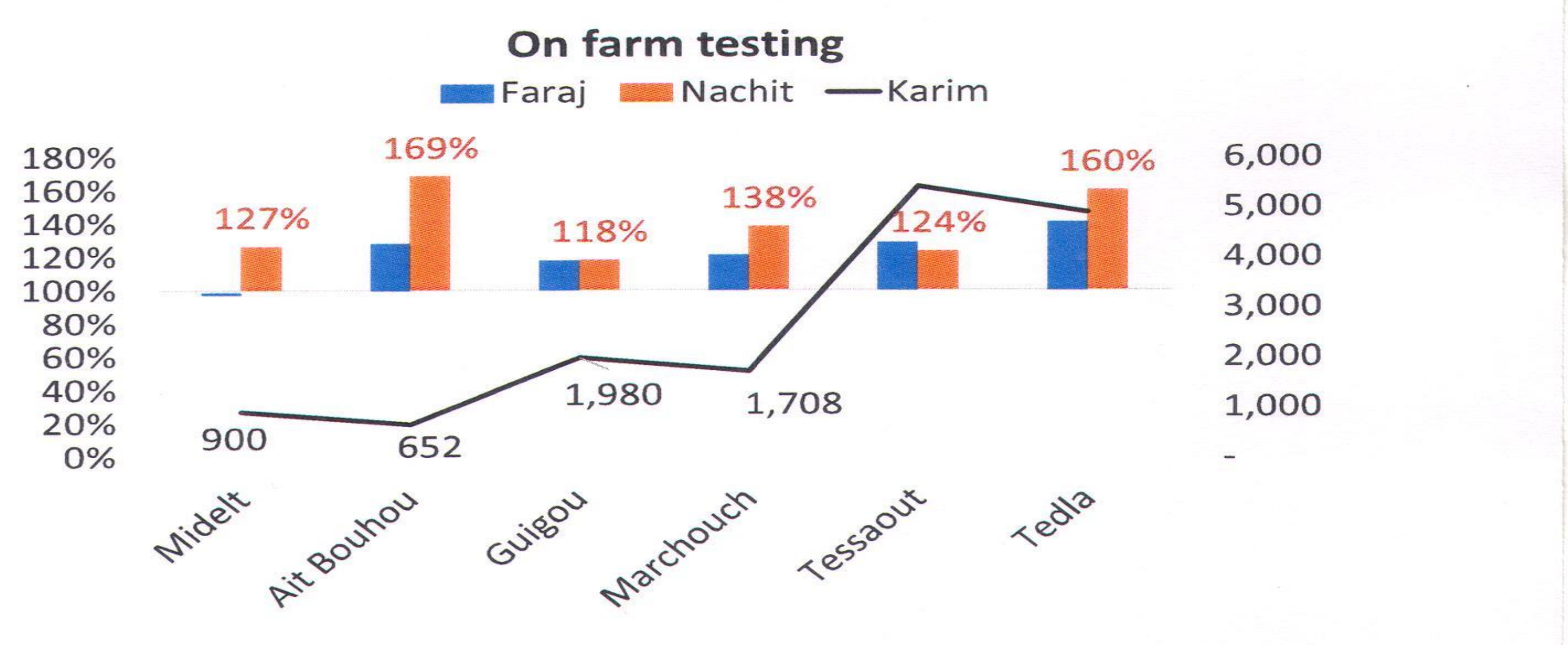
Nachit Karim





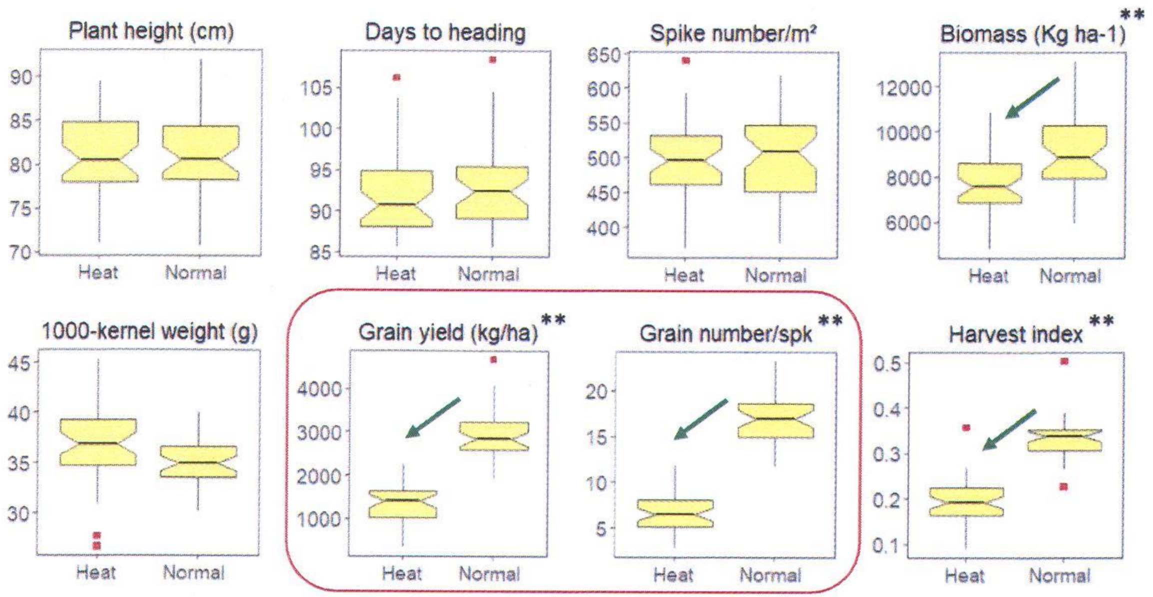
- Three QTLs controls root angel and together increase yield **+300 Kg ha^{-1}**

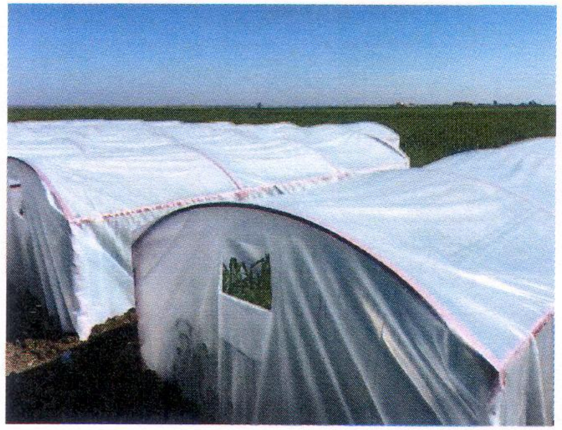
Durum wheat variety Nachit on farm drought tolerance



The deep roots of Nachit gave it **+38%** yield advantage under drought when tested across 19 farms in 2019-2020, and it has **+15%** larger grains.

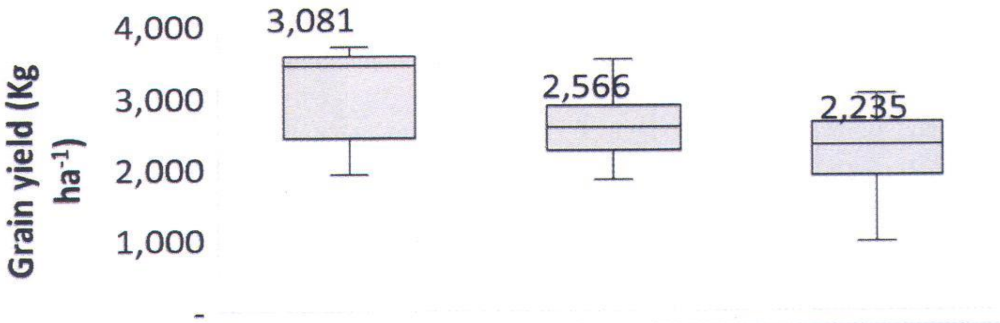
Heat tolerance: the secret of spike fertility





- Application of plastic tunnels at the time of flowering +**10 C**
- ***Grain number per spike*** (fertility) seems to be the most critical trait

KASP marker validated for heat tolerance



Q.icd.Heat.02	+	-	-
Q.icd.heat.12	+	+	-

El Hassouni et al. 2019 Doi: 10.3390/agronomy9080414

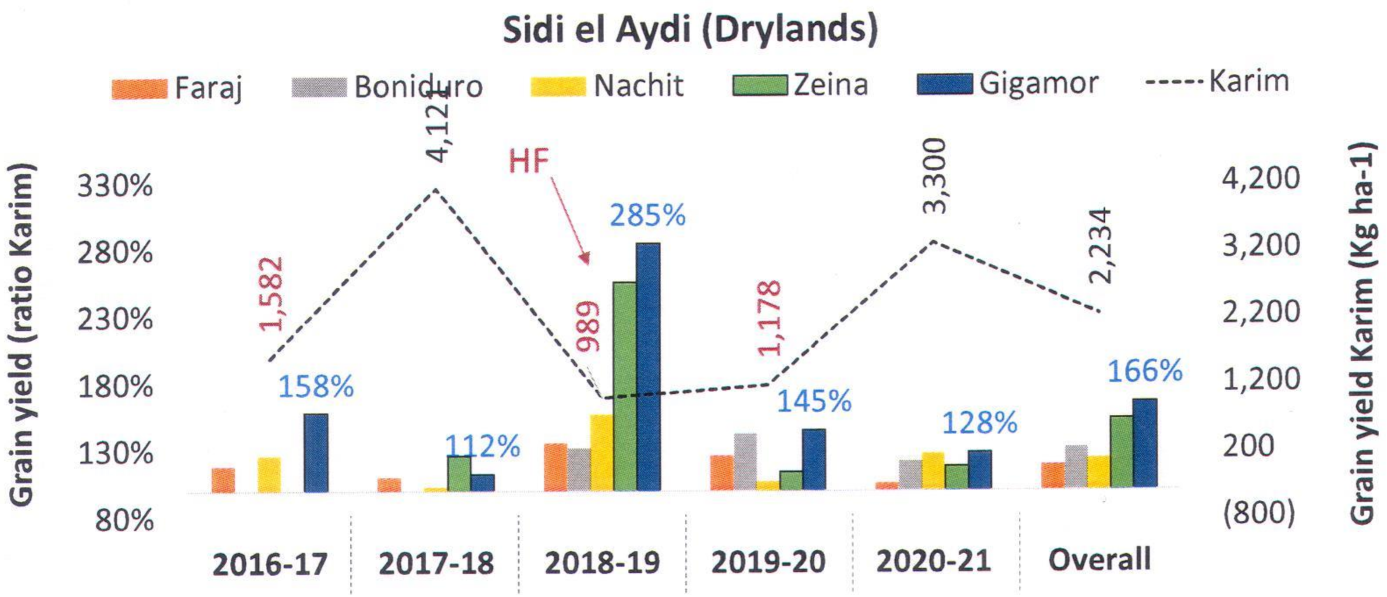
- 2 QTLs for spike fertility
- GY across 3 heat stressed env:
  - +500 Kg ha^{-1} (20%) on average

Two new HF resistant and drought tolerance varieties

Two new HF resistant candidates to the catalougue

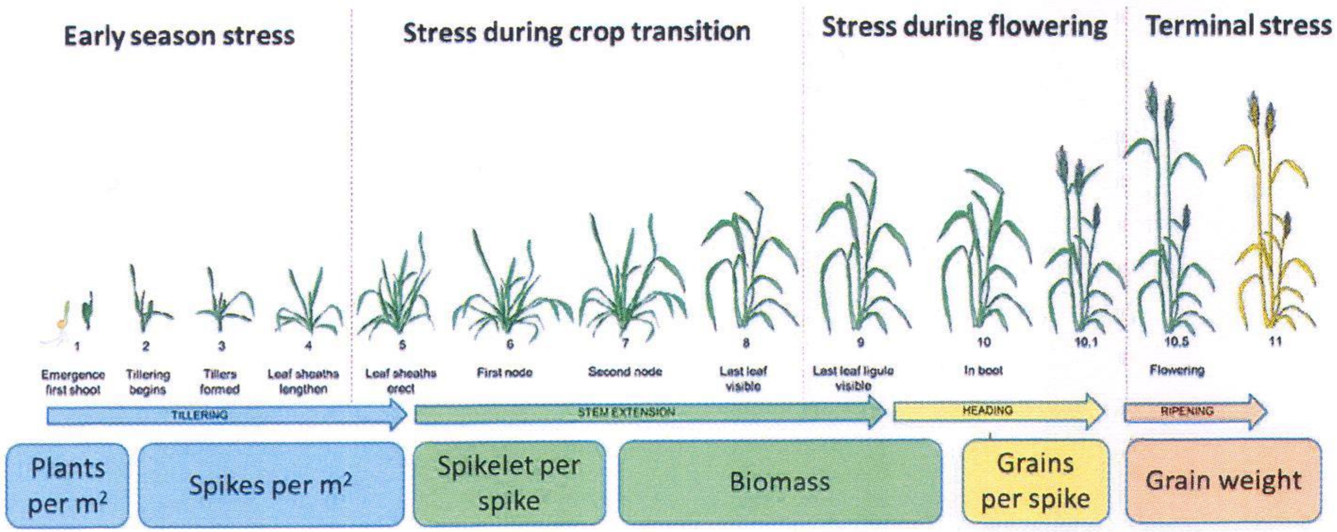
Two new entries superior to Nachit (*Gigamor and Zeina*) were presented by Dr Ferrahi

- These combine **3 roots QTL** for yield under drought, **1 QTL for HF** resistance, and top quality
- In HF years the yield advantage is ***almost double!!!***



Genetic strategy to climate proofing

1. More droughts:
   - ***Deeper roots + grain weight***
   - Spike per m^2
2. More heat waves:
   - ***Higher spike fertility***
3. Shorter growing seasons:
   - *Early flowering*
4. Damaging pests and disease:
   - *Rusts (stem and leaf)*
   - ***Hessian fly***
   - *Fusarium(s)*



Thank you