المعهد الوطني للبحث الزراعي

Institut National de la Recherche Agronomique

الجيل الأخضر

GÉNÉRATION GREEN

2020 - 2030

# Seminar on the role of plant breeding and plant variety protection in enabling agriculture to mitigate and adapt to climate change

**Thematic Session 4: Plant breeding for climate change adaptation and mitigation in agriculture: Breeding strategies and techniques**

## Genetic improvement by mutagenesis of oilseed crops to cope with climate change: case of rapeseed and sesame

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UPOV/SEM/GE/22/1

Geneva, October 11 and 12, 2022 (virtual meeting)

# Introduction

- Morocco is suffering a food security problem in edible oils : Overall national production, including olive and oilseed crops, covers just 20% of the country needs.

- Edible oils from oilseeds (only sunflower 25,000 ha, and rapeseed 10,000 ha) represent only 2%.

- The gap is covered by importation: Negative repercussions on the national economy and food security.

  Annual Cost > 4 billions MAD (400 million USD)

- World bank study: Oilseed production will decrease as a result of climate change effect on agricultural production in Morocco. Rising trend in:
  - Drought;
  - Heat;
  - Flooding

# Introduction (Cont.)

- Increasing reduction in oilseed crops yield: -10% in 2030 and -30% in 2050 (Gommes et al., 2009).

- Abandoning/reducing oilseed crops, as a result of climate change, affects negatively the global cropping system since those crops play an important role in rotation with cereals.

- Political will in Morocco to develop oilseed sector to improve the farmers' income and ensure edible oil food security by increasing national oilseed production.

- Challenging and facing the increasing abiotic stresses:
  - Developing and cultivating tolerant varieties;
  - Diversifying oilseed crops (Resilient and alternative).

# Objective

- Overview on the main and recent achievements in oilseed crops breeding to face the most important abiotic stresses increasingly observed in Morocco:

  - ✓ Focusing on mutagenesis breeding
  - ✓ Talking about rapeseed and sesame

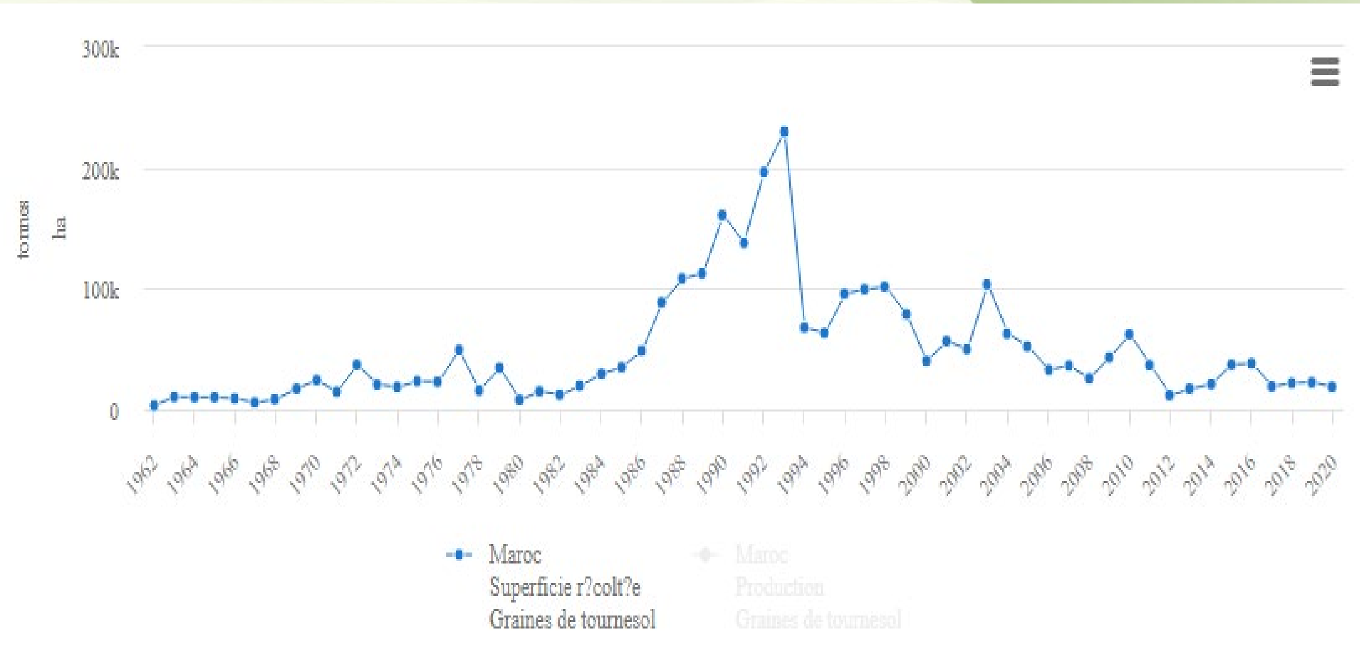
# Oilseed crops and climate change in Morocco

## Oilseed crops cultivated

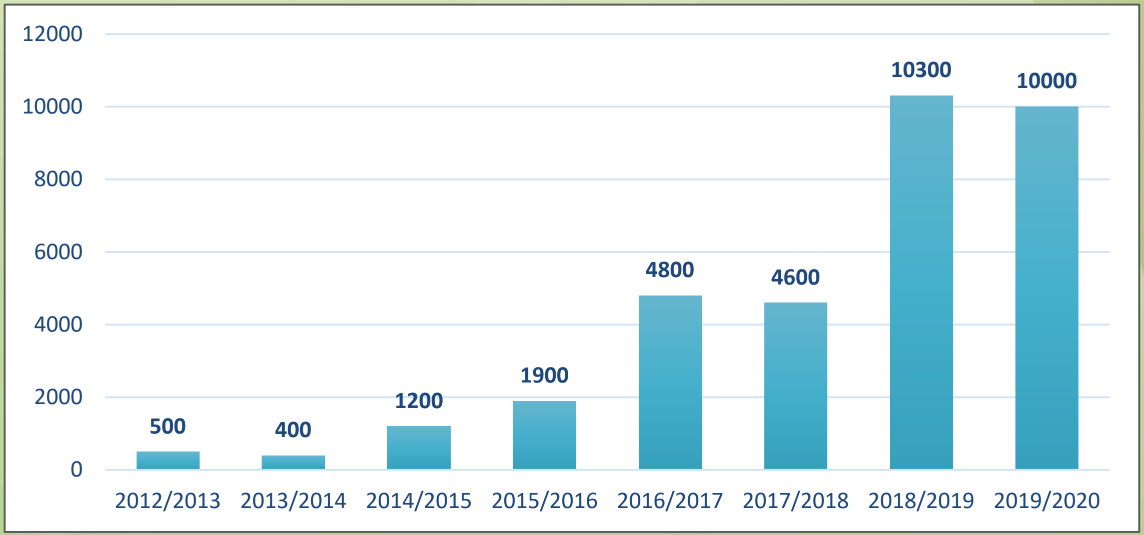
- Before 2000: Sunflower, rapeseed, safflower, soybean (sesame)
- From 2000 – 2012: Sunflower, (sesame)
- From 2013 – Today: Sunflower, rapeseed, (sesame)
  - 2013: Year of the agreement between the government and oilseed sector's Interprofession (FOLEA)

## Climate change

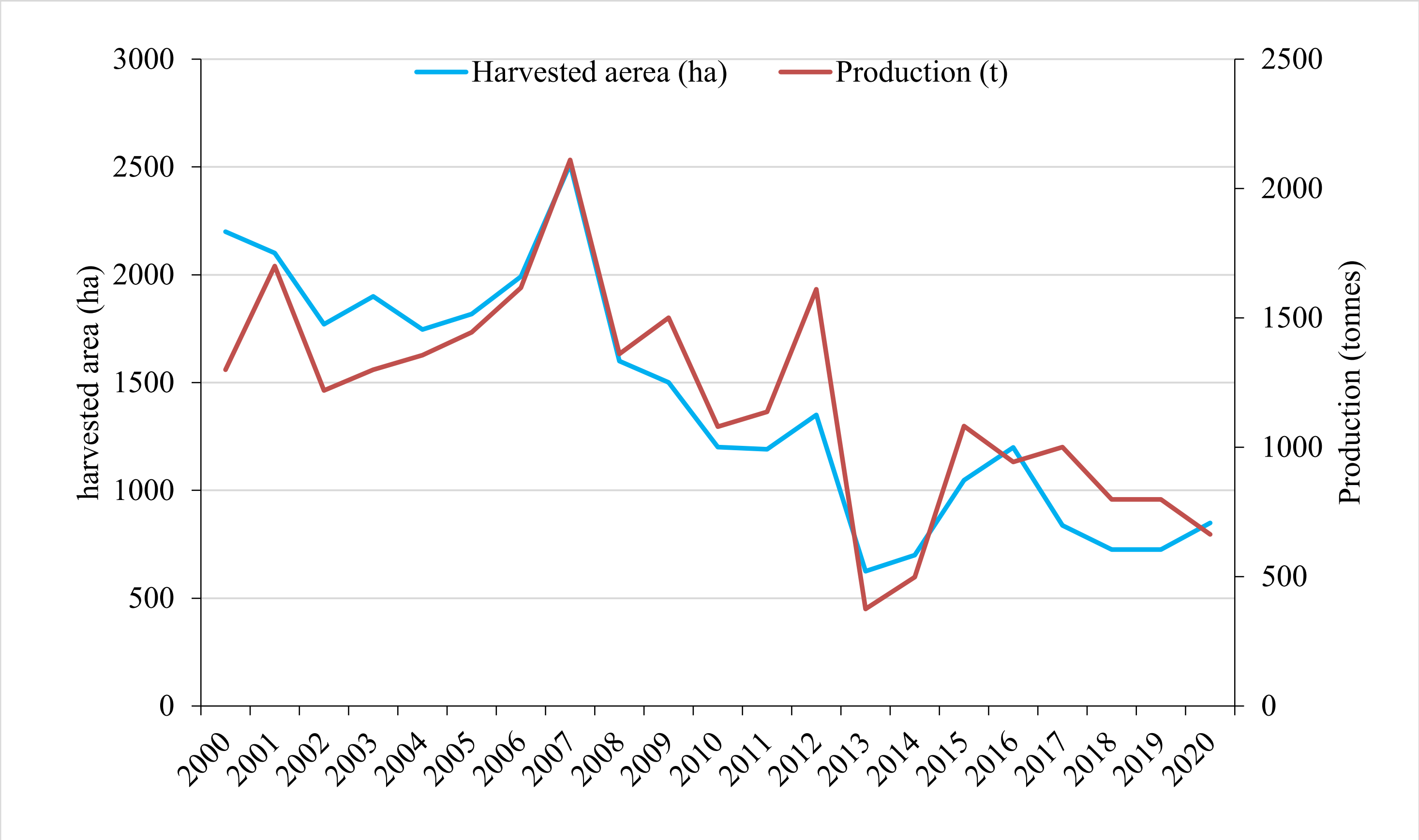
- Importance of drought, as a structural element of the country's climate
- Net reduction in the overall rainfall.
- Increasing heat trend.
- large fluctuation in the amount and frequency of rainfall from year to year and among locations within year.
- Increasing flood trend in some regions.
- Appearance of new pests and diseases.




Evolution of harvested sunflower area during 1962-2020 (FAOSTAT, 2022)




Evolution of harvested rapeseed area after 2013-CP agreement (FAOSTAT, 2022)




Evolution of sesame harvested area and production during 2000-2020 (FAOSTAT, 2022)

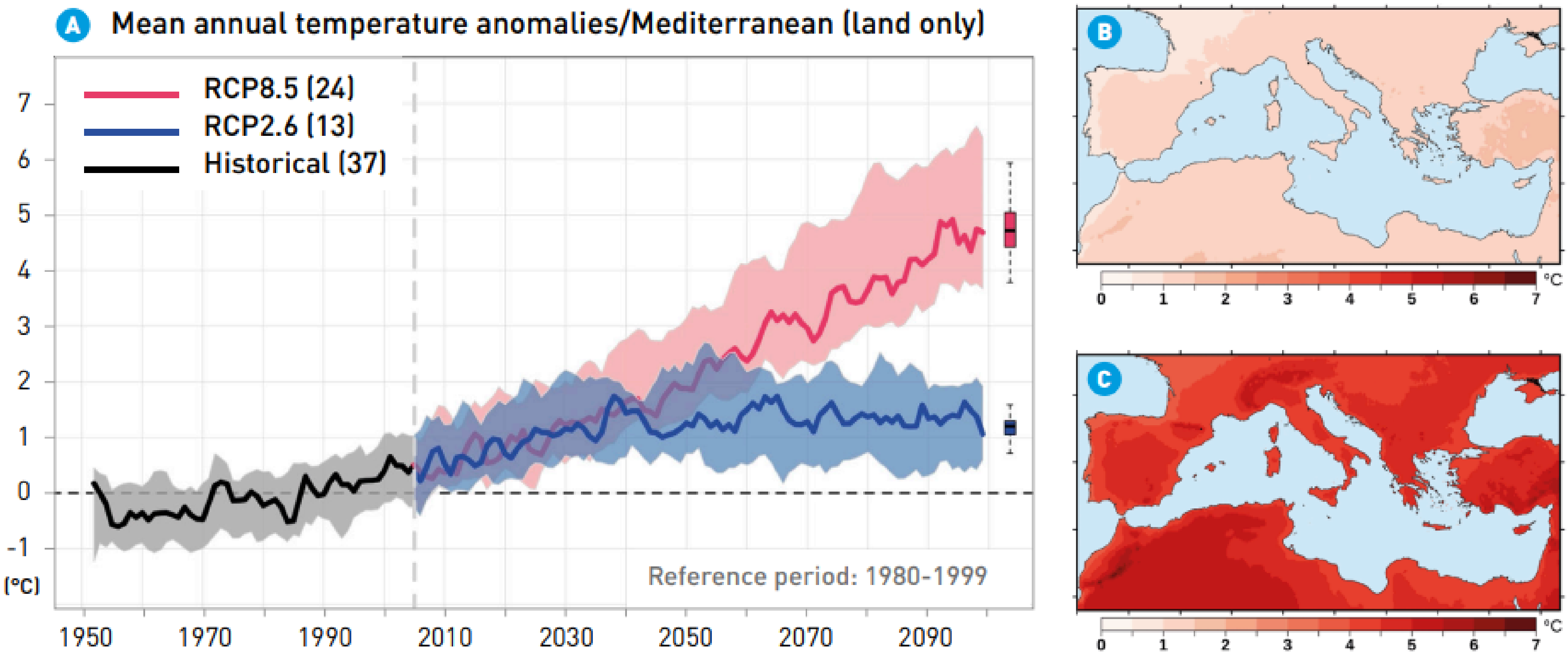



**Figure SPM.2 | Projected warming in the Mediterranean Basin over land.** Projected changes in annual temperature relative to the recent past reference period (1980-1999), based on the EURO-CORDEX 0.11° ensemble mean, A: simulations for pathways RCP2.6 and RCP8.5, B: warming at the end of the 21st century (2080-2099) for RCP2.6, C: idem for RCP8.5.

MedECC 2020 Summary for Policymakers. In: Climate and Environmental Change in the Mediterranean Basin – Current Situation and Risks for the Future. First Mediterranean Assessment Report [Cramer W, Guiot J, Marini K (eds.)] Union for the Mediterranean, Plan Bleu, UNEP/MAP, Marseille, France, pp 11-40.

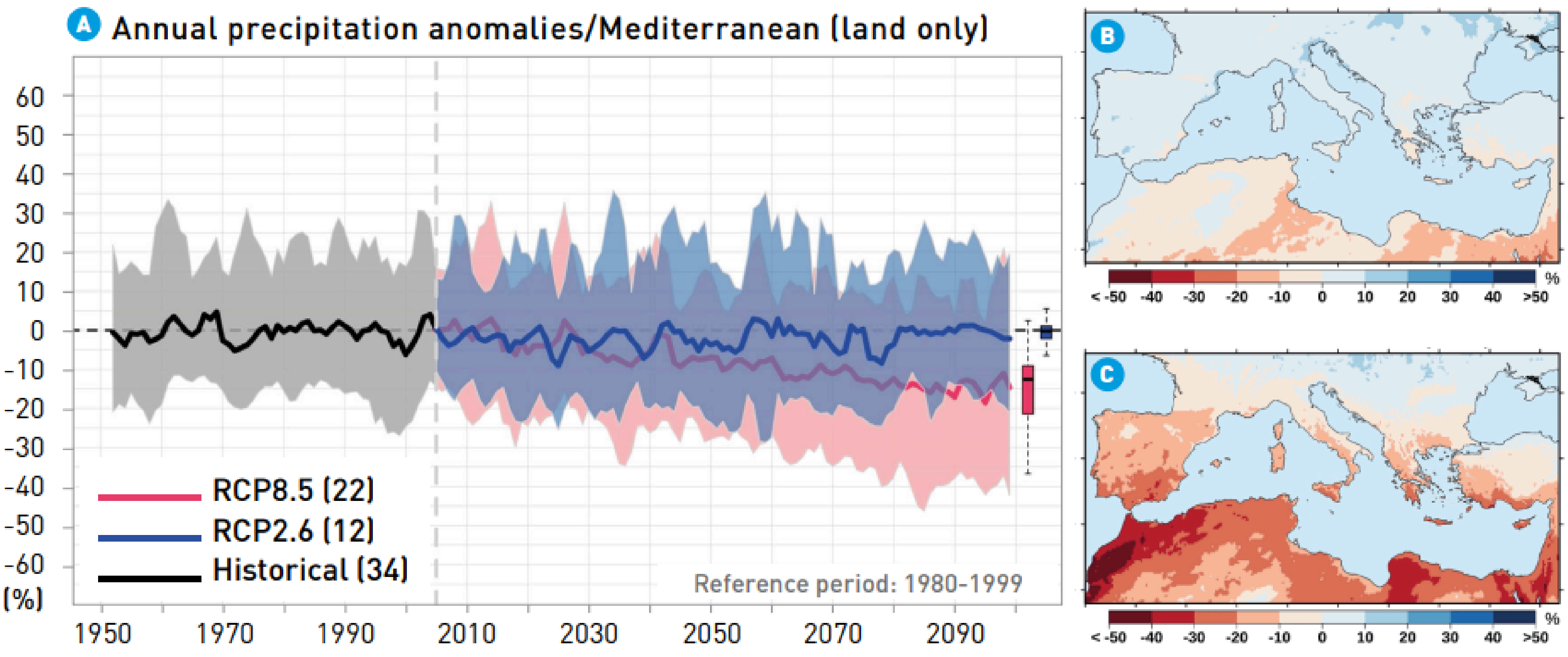



**Figure SPM.3 | Projected rainfall change in the Mediterranean Basin.** Projected changes in annual rainfall relative to the recent past reference period (1980-1999), based on the EURO-CORDEX 0.11° ensemble mean, A: simulations for pathways RCP2.6 and RCP8.5, B: rainfall anomalies at the end of the 21st century (2080-2099) for RCP2.6, C: idem for RCP8.5.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# Breeding strategy to face changing climatic conditions

## Germplasm enhancement

- Introductions
- Intra & interspecific hybridizations
- Mutagenesis

## Characterization and evaluation under stressed conditions

- Different growth/development stages
- Multi-traits phenotyping
- Selection indices definition

## Selection of productive and adapted lines

- Tolerance to stresses (Selection indices)
- Stability
- High yielding

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# Oilseed crops and mutagenesis breeding

# RAPESEED (*Brassica napus* L.)

## Use of Rapeseed

Rapeseed

**Seed**

- Oil and Meal

**Entire plant**

- Animal feeding

**Oil**

- Human food
- Biodiesel
- Industrial uses

**Meal**

- Livestock feed

# PROBLEMATIC

**Rapeseed germplasm has a fairly narrow genetic variability.**

Need to sustainably expand the existing genetic variability for breeding and variety release.

**Conventional cross breeding was restrictedly used due to the limited genetic variability in nature (Sestili et *al*., 2010).**

Induced mutation is an effective alternative to increase genetic variability that could rarely be found in germplasm collections (Szarejko and Forster, 2007).

# ACHIEVEMENTS

Check-DYT

EMS1-7-DYT

EMS1-7-ATZ

Check-ATZ

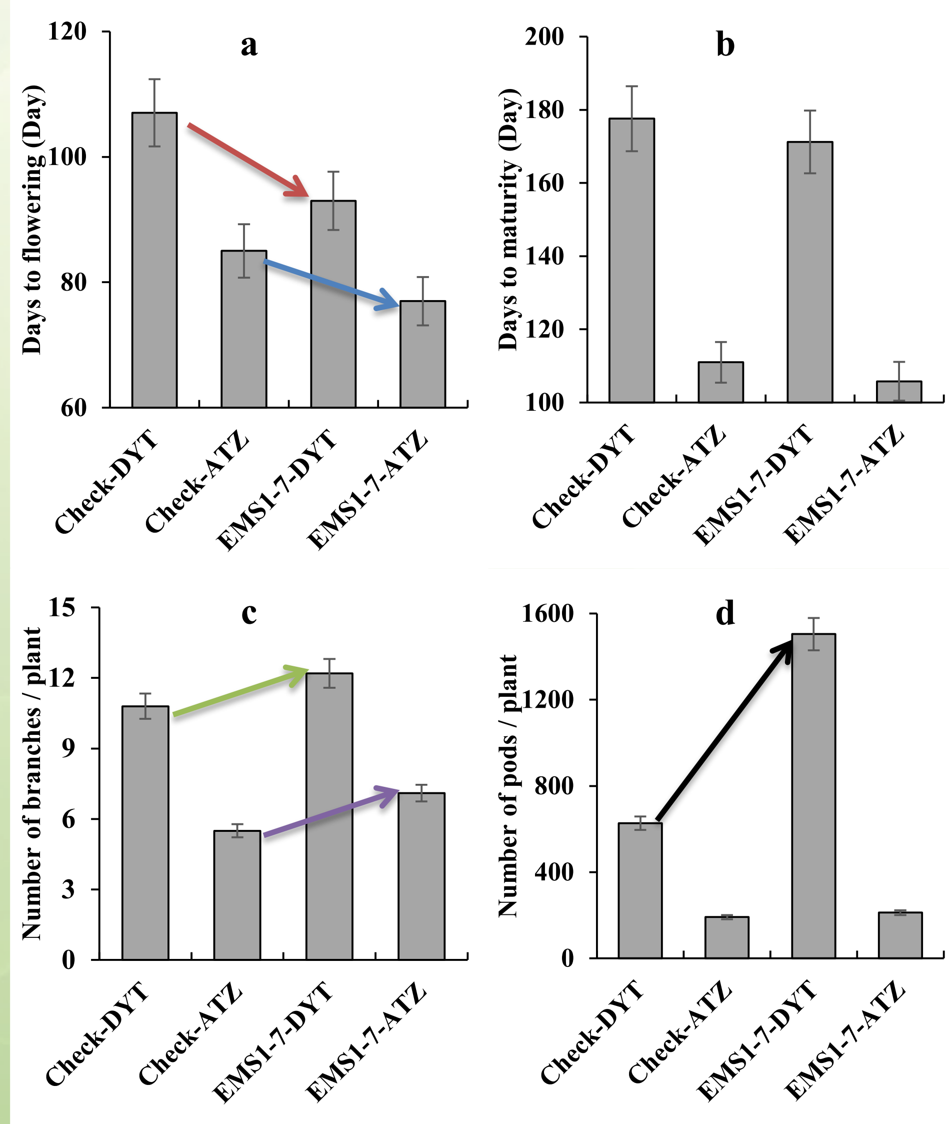


Fig. Genetic gain in earliness to flowering, branching and pods/plant in a M2 mutant derived from 1% EMS during 7 hours (EMS1-7), compared to the check variety 'INRA-CZH2', evaluated in two different environments, Douyet (DYT) and Sidi Allal Tazi (ATZ).

# ACHIEVEMENTS

Compared to the check or wild-type material (INRA-CZH2), the mutant H2M-5:

- flowered and matured earlier,
- had higher number of pods per plant in different environments,
- showed higher level of adaptation to stressful conditions associated with low rainfall, high temperature and late planting.

Channaoui et al., 2019a, Pak. J. Botany.

# ACHIEVEMENTS

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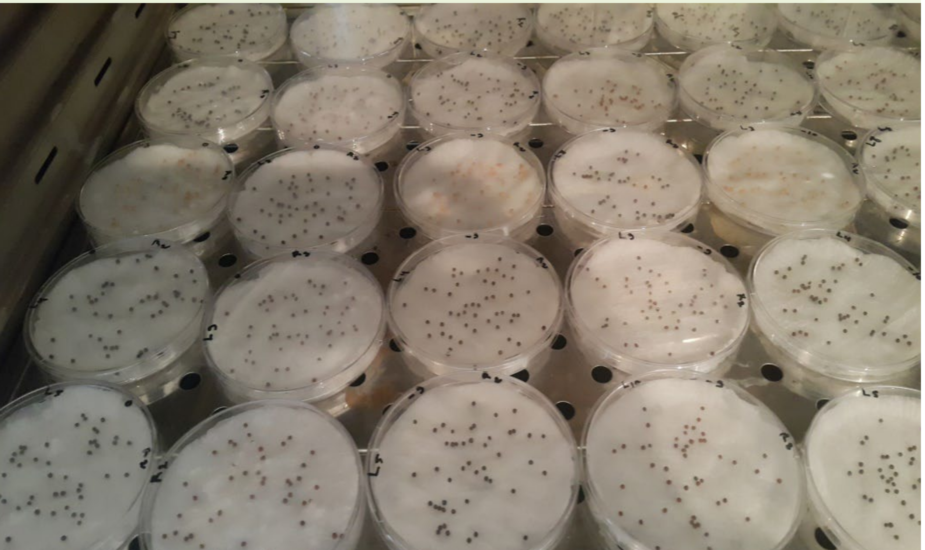
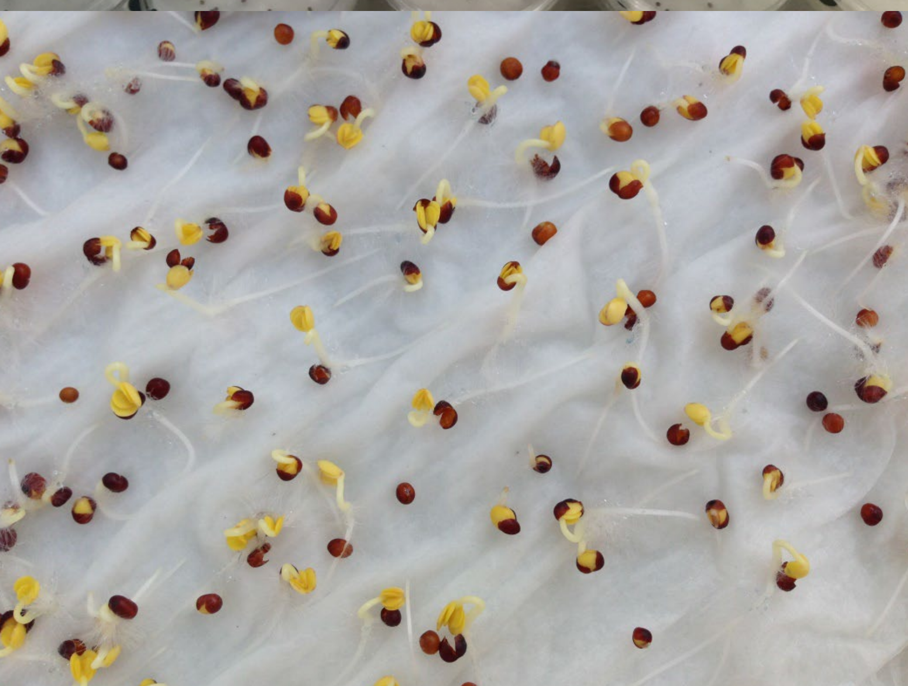
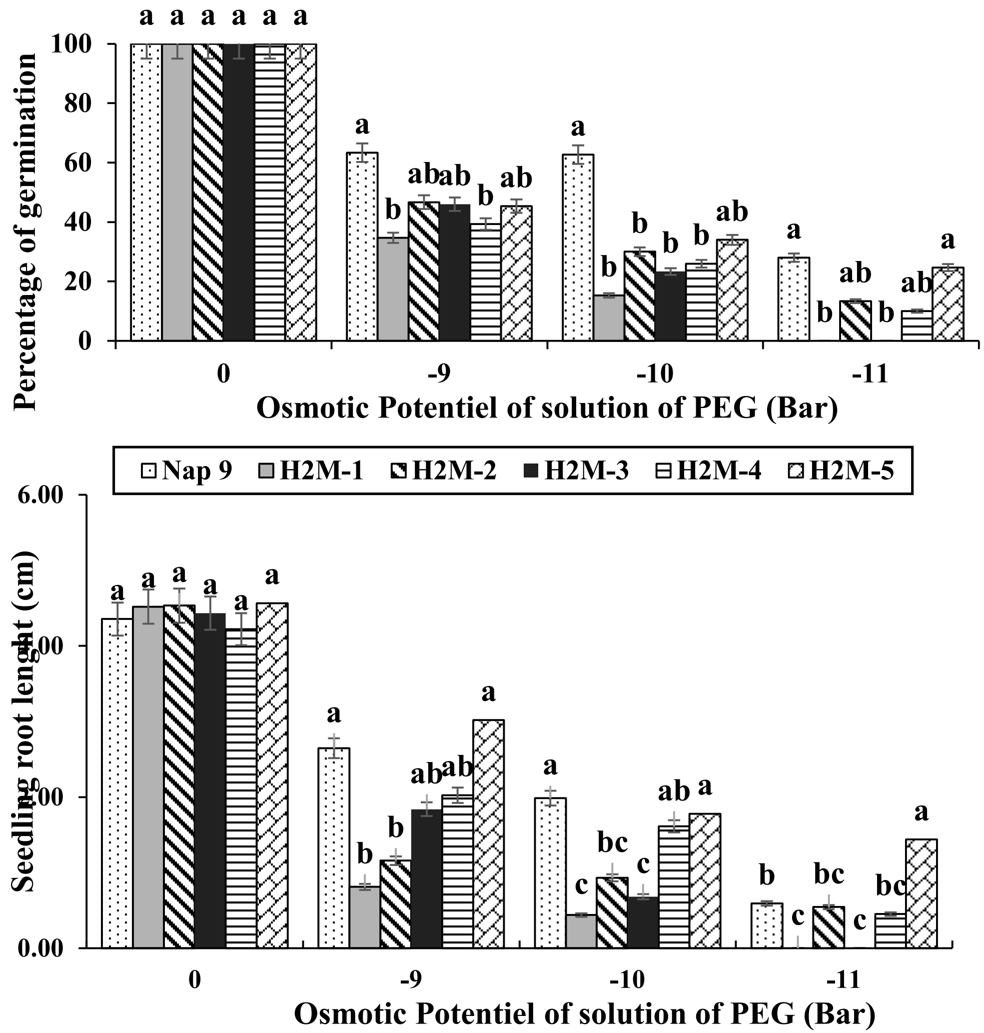


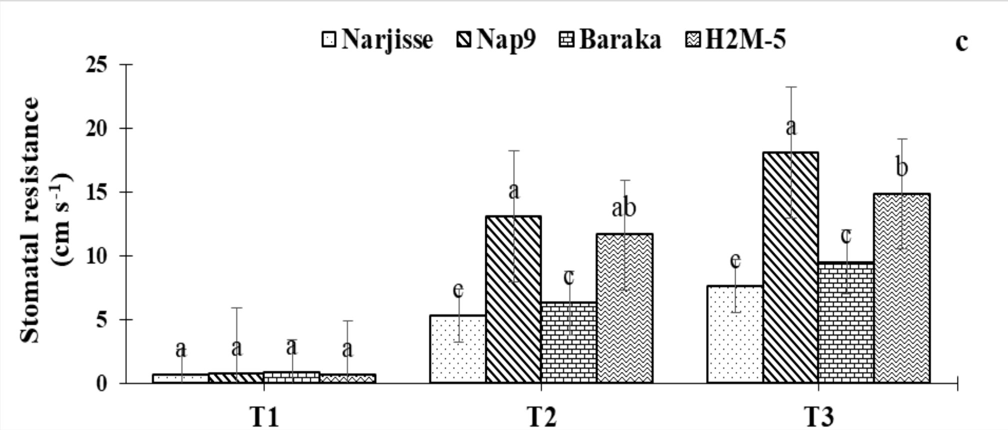


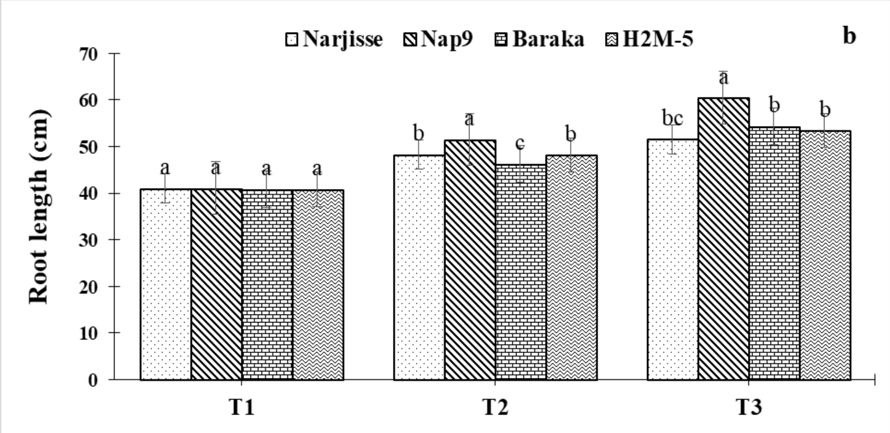



Reaction of rapeseed genotypes (mutants) to various levels of drought during germination and early seedling growth

Channaoui et al., 2019b, OCL.

# ACHIEVEMENTS




| T | G | NBP | NPP | AB (g) | NSP | TSW (g) | SY (g) | HI | OC |
|---|---|---|---|---|---|---|---|---|---|
| T1 | Narjisse | 9 b | 431 b | 162.64 ab | 14 bc | 2.30 b | 12.37 b | 0.33 b | 40.80 a |
| | Nap9 | 10 a | 486 a | 151.65 b | 18 a | 3.88 a | 20.86 a | 0.64 a | 40.48 a |
| | Baraka | 8 b | 411 b | 179.31 a | 16 b | 2.60 b | 13.90 b | 0.39 b | 41.74 a |
| | H2M-5 | 7 c | 404 b | 129.51 b | 15 b | 2.74 b | 12.58 b | 0.34 b | 39.10 a |
| T2 | Narjisse | 7 b | 324 b | 107.45 b | 12 bc | 1.70 c | 11.43 b | 0.55 b | 37.54 b |
| | Nap9 | 8 a | 355 a | 106.27 b | 16 a | 3.17 a | 15.86 a | 0.78 a | 40.31 a |
| | Baraka | 6 c | 277 b | 125.29 a | 14 b | 2.50 ab | 11.51 b | 0.32 c | 40.07 a |
| | H2M-5 | 6 c | 344 b | 105.88 b | 13 b | 2.20 b | 11.65 b | 0.43 bc | 38.36 b |
| T3 | Narjisse | 6 a | 198 b | 83.47 ab | 11 bc | 1.36 b | 7.20 c | 0.54 a | 36.28 b |
| | Nap9 | 6 a | 190 a | 74.90 b | 16 a | 2.02 a | 12.45 a | 0.79 a | 40.26 a |
| | Baraka | 5 b | 207 a | 99.49 a | 13 b | 1.81 ab | 8.63 b | 0.24 b | 39.14 a |
| | H2M-5 | 5 b | 215 a | 79.76 ab | 12 b | 1.78 ab | 8.48 b | 0.47 a | 36.44 b |

Saghouri Idrissi et al., 2022, J. Crop Improv. (Under review)

# ACHIEVEMENTS

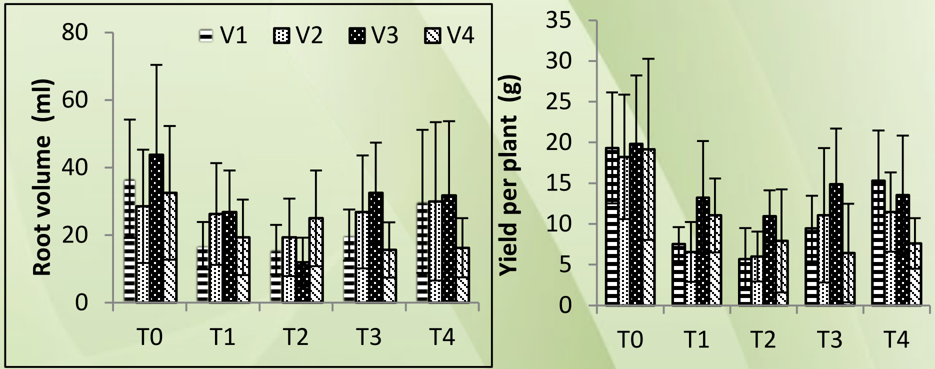



**Fig. Average treatment performance for each variety for root volume and seed yield per plant. (V1=Narjisse, V2=INRA-CZH2, V3=INRA-CZH3, V4=Lila), (T0=Absence of waterlogging, T1=Waterlogging during germination, T2=Waterlogging during post-emergence seedling stage, T3=Waterlogging during rosette stage, T4=Waterlogging during floral bud stage)**

Nabloussi et al., 2019, OCL

# SESAME (*Sesamum indicum* L.)

## Use of sesame

Sesame

### Seed

- Food additive
- Therapeutic
- Aromatic

### Oil

- Human food
- Biodiesel
- Industrial uses

# PROBLEMATIC

The available genetic diversity in Morocco is too limited

- El Harfi et al., 2018, J. Agric. Sci. Technol. A
- El Harfi et al., 2021, OCL

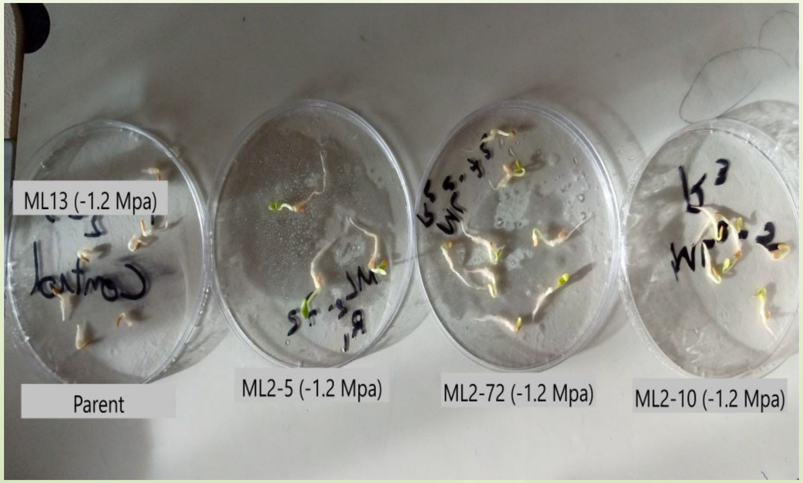
The Moroccan cultivar requires a lot of water (too much irrigations); however it has just an average yield

- Kouighat et al., 2022, OCL

# ACHIEVEMENTS

Drought during germination

M2 & M3 generations




US06

ML13

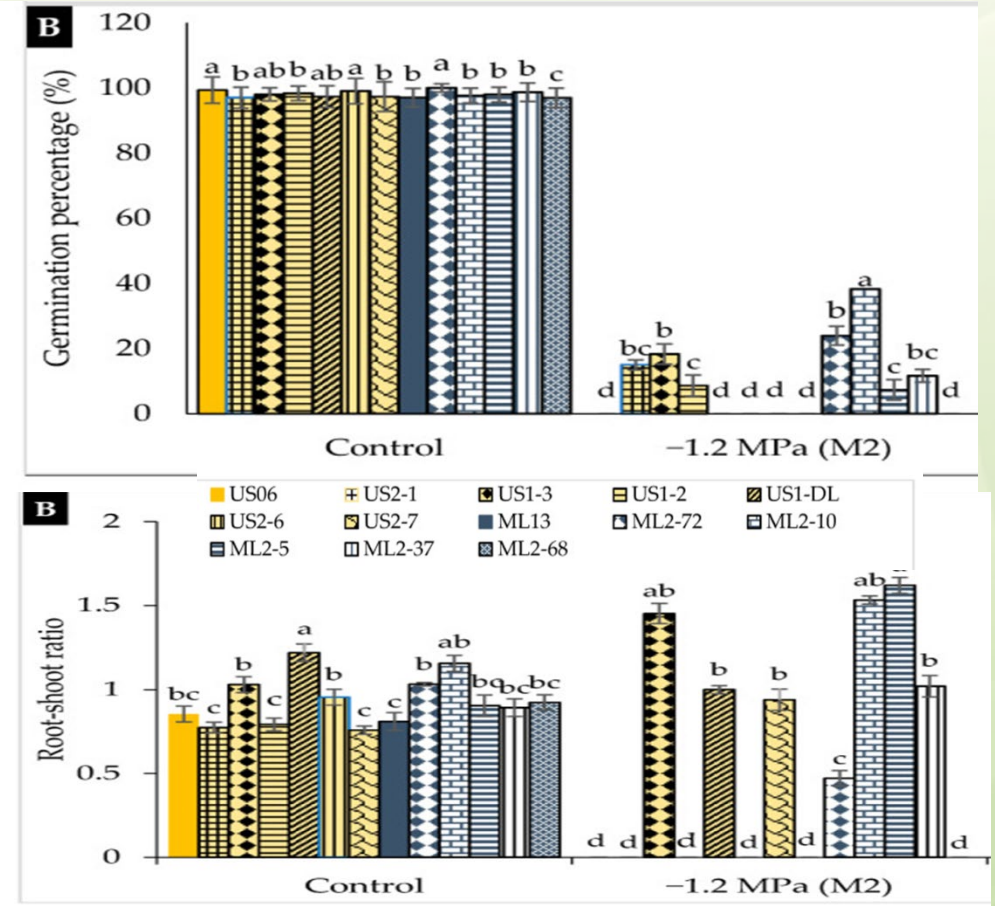
Drought during flowering

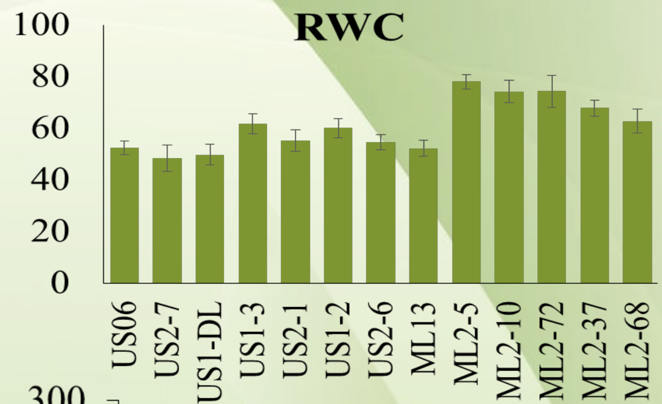
ML2-5

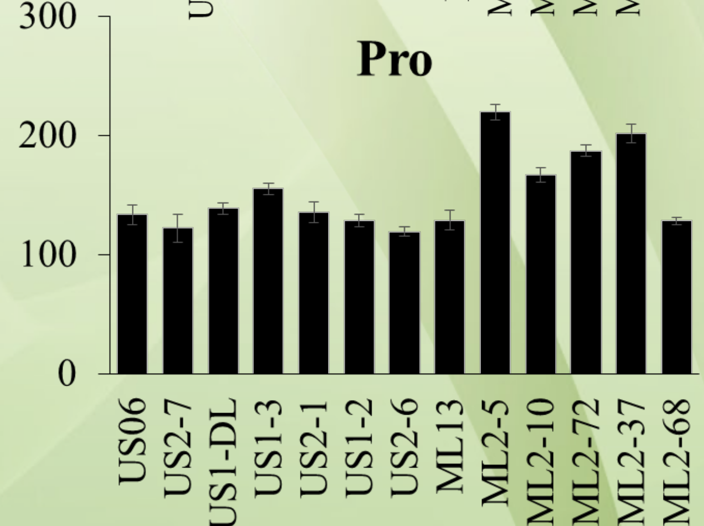
ML2-37

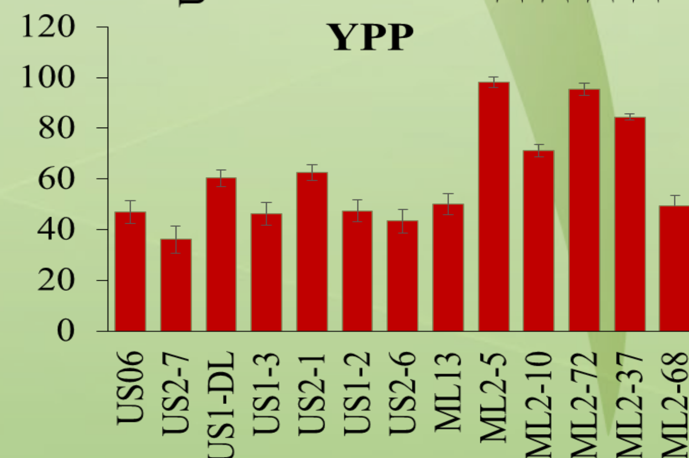
Sensitive wild-type cultivars

Tolerant mutants



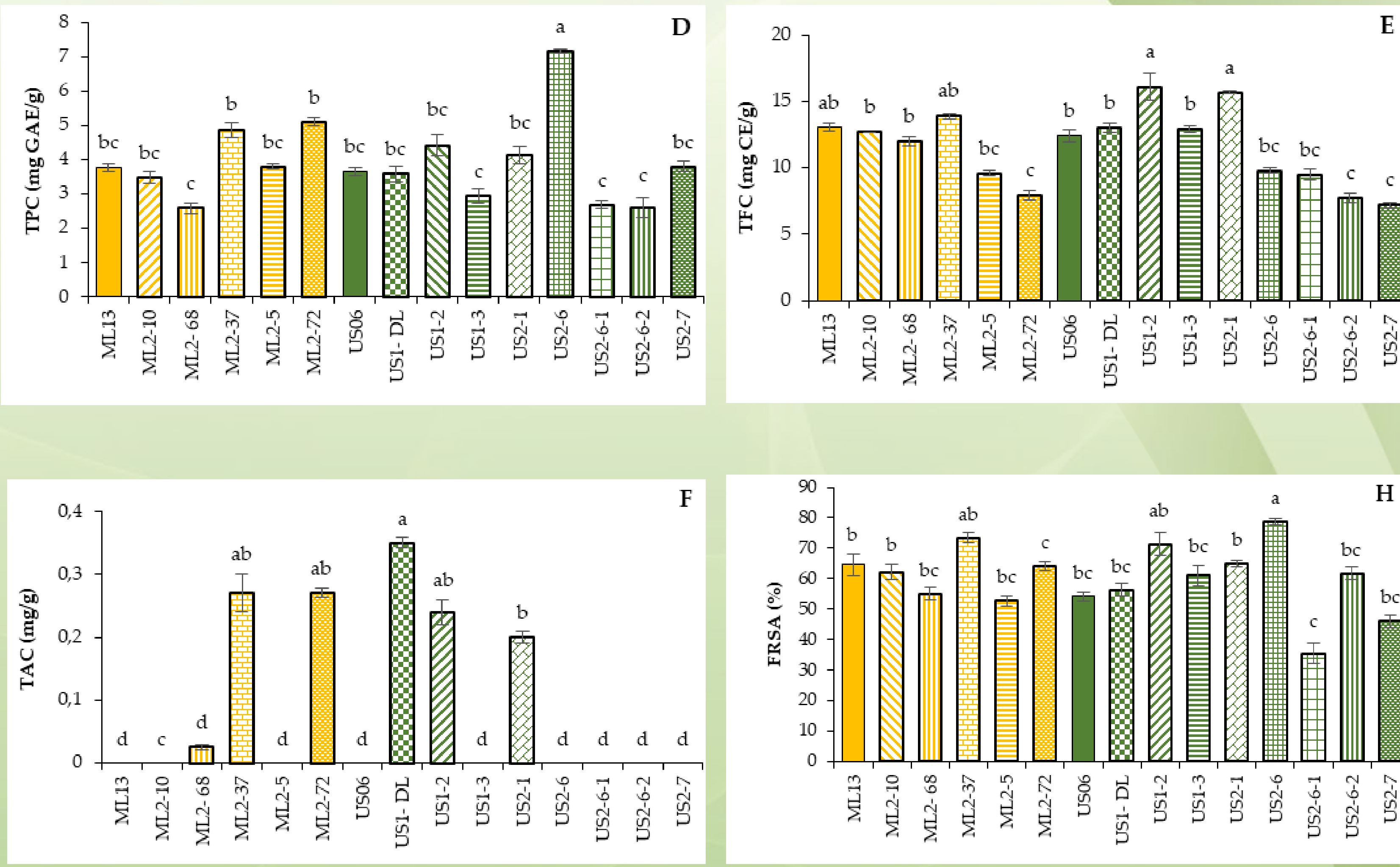




Development and selection of sesame mutant lines with higher tolerance to drought stress during germination and flowering stages: **ML2-5, ML2-10 et ML2-37**.

Kouighat et al. 2021 (Plants)
Kouighat et al. 2022 (J. Crop Improv.)




In addition, mutant lines with genetic gain in terms of nutritional quality traits were identified and selected.

Kouighat et al. 2022 (Plants).

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# Conclusions and prospects

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- In Morocco: Decline in sunflower and sesame cultivation vs. Increase in rapeseed cultivation were observed in the last decade.
- In the future: Rising temperature trend vs. Downward trend in precipitation: All sub-regions of the Mediterranean Basin, including Morocco, are increasingly impacted and threatened by climate change (CC).
- Need to develop and implement a global strategy to cope with CC.
- Integrated breeding strategy: Introductions (including novel resilient and alternative oilseed crops), intra & interspecific hybridizations, mutagenesis.

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# Conclusions and prospects

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- **Mutagenesis breeding effectively used in rapeseed and sesame: Novel and promising germplasms tolerant to severe drought during germination and flowering stages.**

- **Usefulness of these germplasms to develop and release drought-tolerant and high-yielding varieties of rapeseed and sesame.**

- **Need to work also on heat and develop tolerant germplasm.**

- **Evaluation, monitoring and selection of high-performing and adapted lines under stressed field conditions for many years.**

- **TILLING and CRISPR Techniques towards genomic selection.**

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# Thank you