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Water efficiency in alfalfa cropping systems, reduction of the impact on water quantity and quality

Lloveras J. & Jézéquel S.

Session 3

FROM 03 › TO 06 nov. 2025

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Integrated Evaluation of Drought Tolerance in Moroccan Alfalfa: Role of Osmopriming and Rhizobial Strain Selection

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Introduction

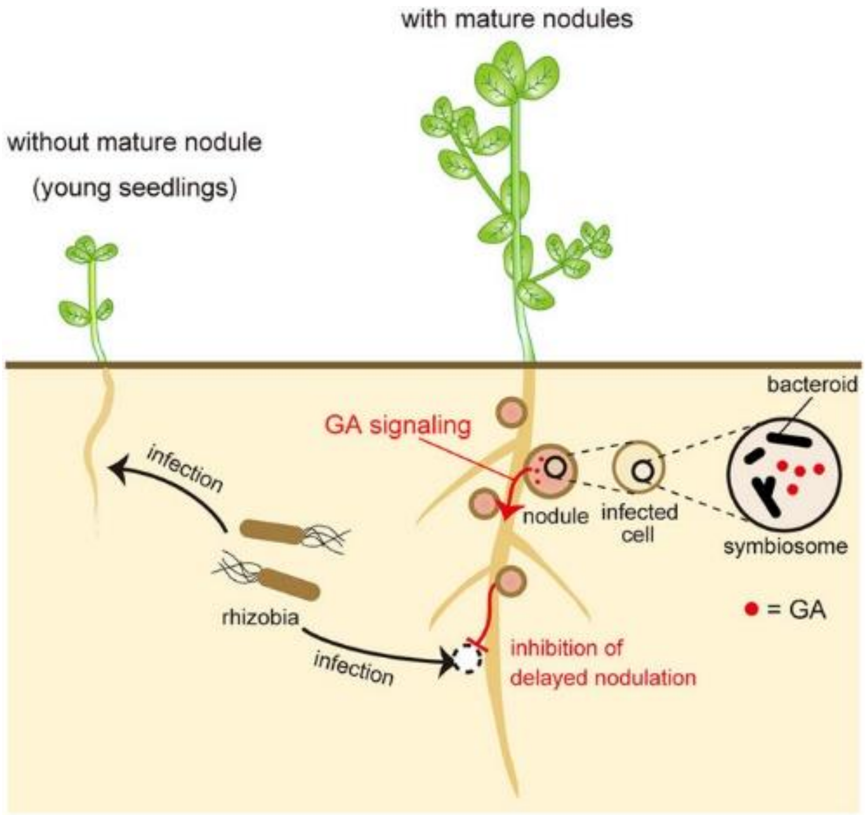
Alfalfa:

- High nutritional quality
- High protein content
- Positive effects on soil fertility (Huyghe, 2003).

In Morocco, alfalfa cultivation covers more than 455,000 hectares.

- It has a high production potential,
- excellent quality, and great flexibility in utilization.
- It is tolerant to grazing, drought, and salinity.

Alfalfa (*Medicago sativa L.*)



N_2 fixing symbiosis

Water deficit

Water deficit → A major challenge for agricultural production in Morocco

Water deficit

is one of the major factors affecting the productivity and persistence of many crops.

Arid and oasis regions:

- High evapotranspiration (≈ 2000 mm $year^{-1}$)
- Low rainfall (200–300 mm $year^{-1}$)

- Impact of climate change:
- Decreasing and erratic rainfall
- Increasing water demand from other economic sectors

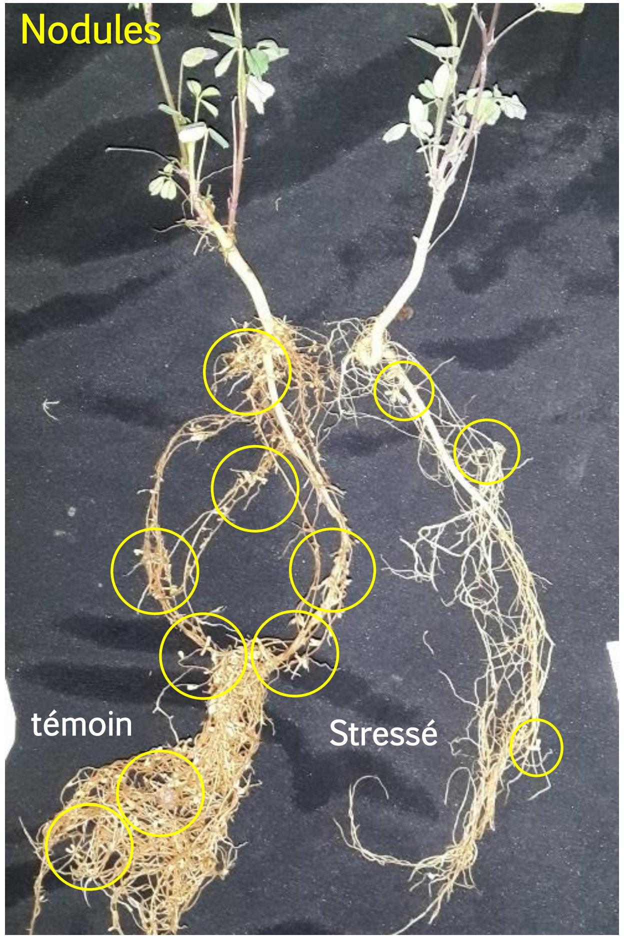
→ Resulting in low water availability for agriculture

Impact on symbiosis

Water deficit → limits alfalfa forage production.

- It affects the genetic diversity of rhizobia
- reduces their populations in the soil,

→impairing the establishment and functioning of N_2-fixing symbioses.



The use of chemical nitrogen fertilizers is costly.

→ It is therefore essential to develop strategies to overcome this problem of water scarcity.

Objectives of the study:

➔Selection of efficient symbiotic combinations (alfalfa genotype–rhizobial strain) under water deficit conditions.

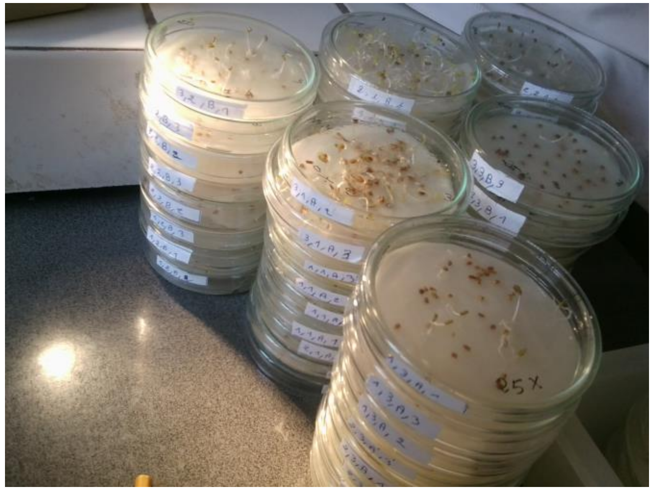
- Evaluation of the tolerance of Moroccan alfalfa populations to water deficit at the most critical developmental stages.
- Isolation and selection of rhizobial strains with high tolerance to osmotic stress.
- Evaluation of the performance of alfalfa–rhizobia symbioses under water stress: physiological and biochemical characterization.
- Assessment of the tolerance of alfalfa genotypes to deficit irrigation under field conditions.

Section 1 :

Effect of seed “osmopriming” pretreatment on seed germination and the performance of young seedlings of Moroccan alfalfa populations under water deficit conditions.

Section 1: Seed "osmopriming" effect on germination

- Experimental design



PEG Priming
(-0.6 MPa during 24 h)

Alfalfa seeds

Tafilalt 1
Adis Tata
Rich
Demnate1
Demnate2

+

Moapa

Disinfection

+ Priming

- Priming

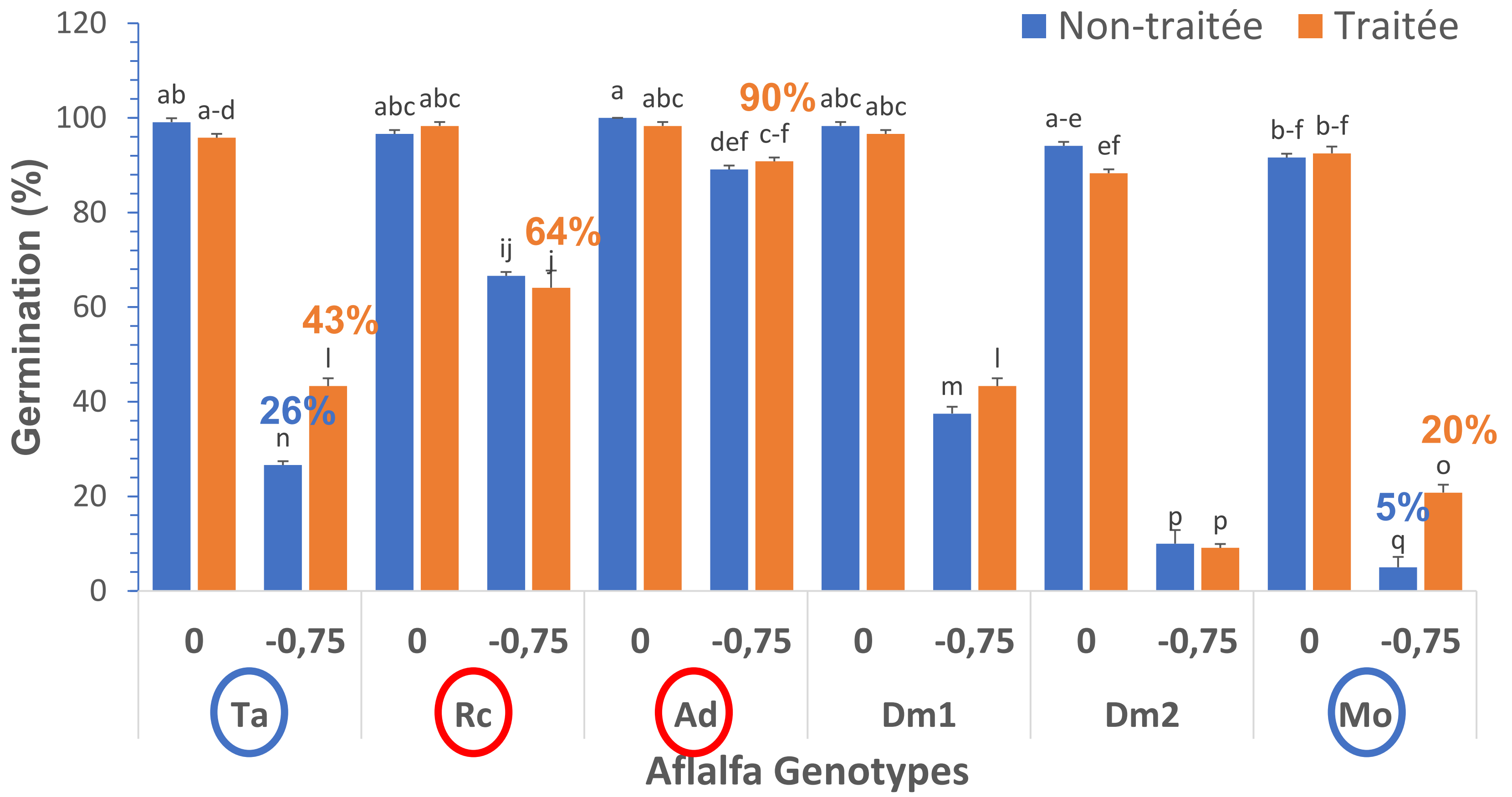
Drying

Germination at 25 °C

Water deficit (-0.45 et -0.75 MPa)

Section 1: Seed "osmopriming" effect on germination

- Effect on germination % under water deficit



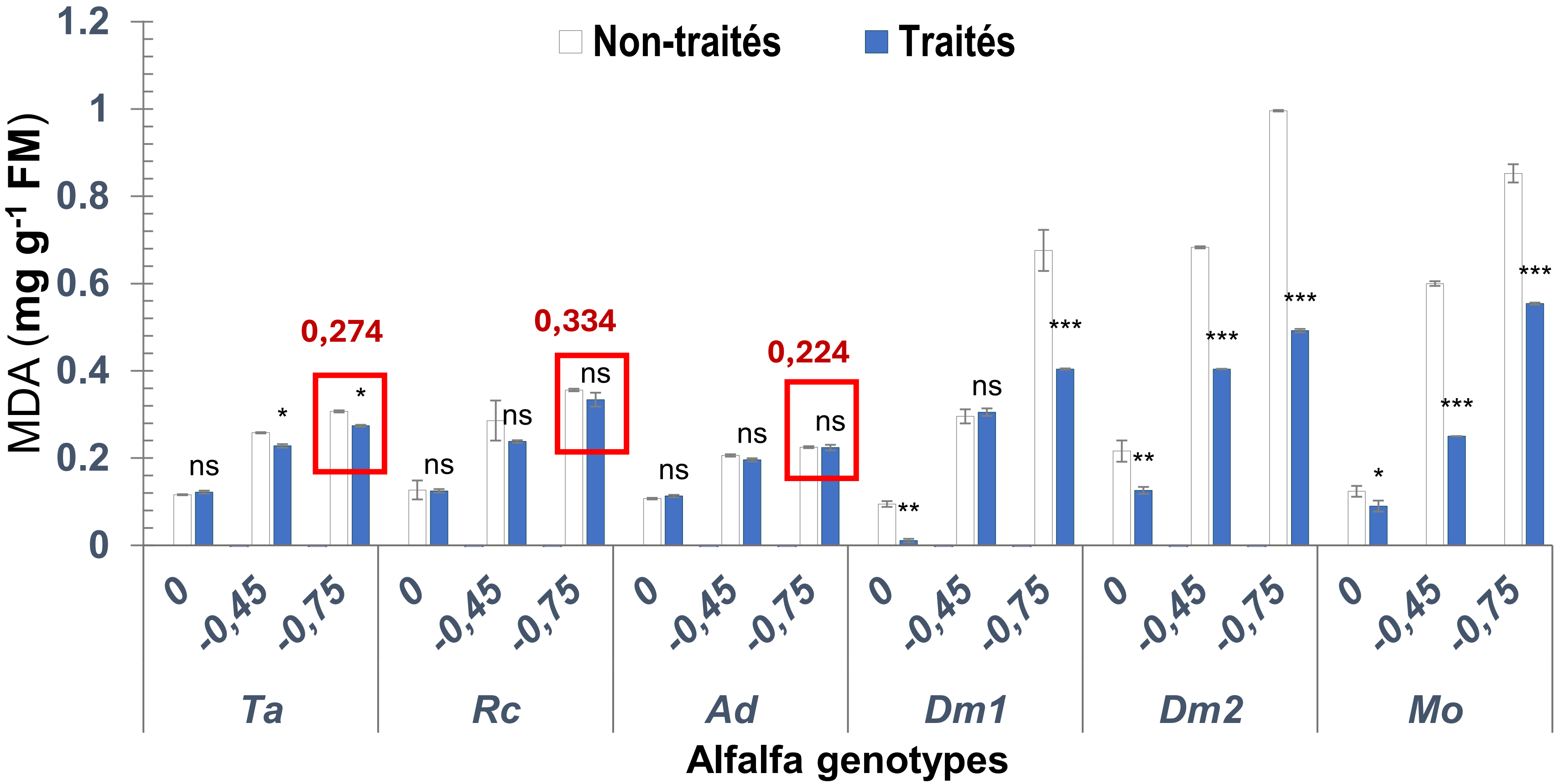
Section 1: Seed "osmopriming" effect on germination

- Effect on Germination parameters under water deficit

	Ψ(- MPa)	Mean Germination Time (MGT) -Priming	Mean Germination Time (MGT) +Priming	Time to 50% of germination (T50) -Priming	Time to 50% of germination (T50) +Priming
Ad	0	0,12 ± 0,001b	0,12 ± 0,002b	0,60 ± 0,01n	0,57 ± 0,01n
	0,75	0,16 ± 0,001b	**0,15 ± 0,002b**	2,36 ± 0,55c-h	**1,20 ± 0,04i-n**
Rc	0	0,12 ± 0,001b	0,12 ± 0,003b	0,76 ± 0,04k-n	0,59 ± 0,03n
	0,75	0,22 ± 0,004b	**0,24 ± 0,022b**	1,63 ± 0,02g-m	**1,24 ± 0,53i-n**
Dm2	0	0,15 ± 0,001b	0,14 ± 0,002b	1,34 ± 0,04i-n	0,61 ± 0,04n
	0,75	2,30 ± 0,007b	**1,76 ± 0,021b**	3,00 ± 1a-d	2,36 ± 0,12c-h
Mo	0	0,15 ± 0,002b	0,14 ± 0,003b	1,46 ± 0,79h-n	0,70 ± 0,05mn
	0,75	8,27 ± 8a	0,83 ± 0,134b	2,75 ± 0,35bcd	**2,95 ± 0,21a-d**

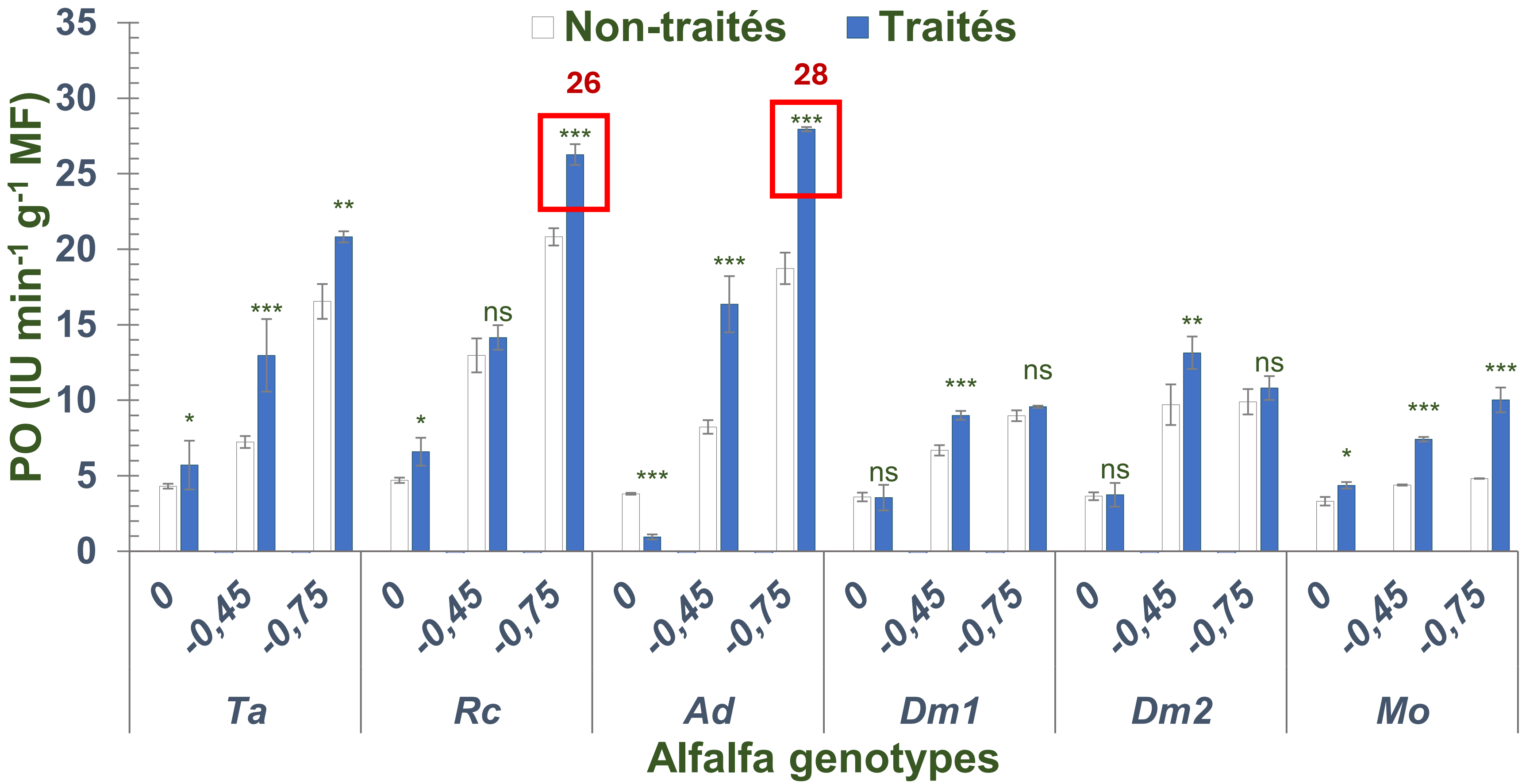
Section 1: Seed "osmopriming" effect on germination

- Effect on MDA content under water deficit



Section 1: Seed “osmopriming” effect on germination

- Effect on PO activity under water deficit



Section 2 :

Isolation and physiological characterization of rhizobial strains nodulating alfalfa (Medicago sativa L.) in Morocco.

Section 2: Isolation of drought tolerant rhizobial strains

- Experiments

Soil samples

1.Troch
2.Riche
3.Aoufous
4.Arfoud
5.Ait ouir
6.Sidi Ghiat
7.Foum el Oued

Soil analyses

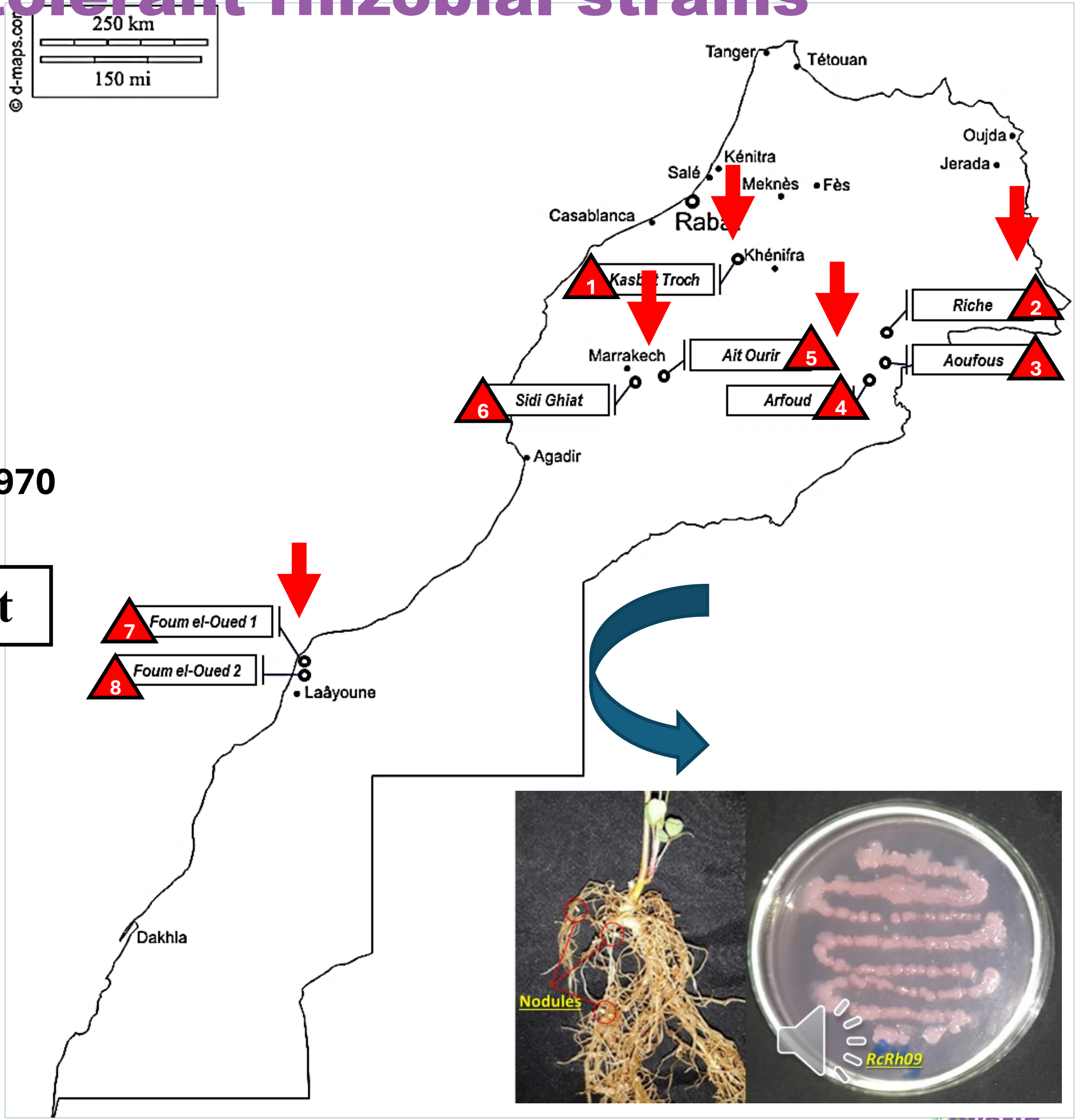
Capture

Isolation — Vincent, 1970

Infectivity & nodulation test

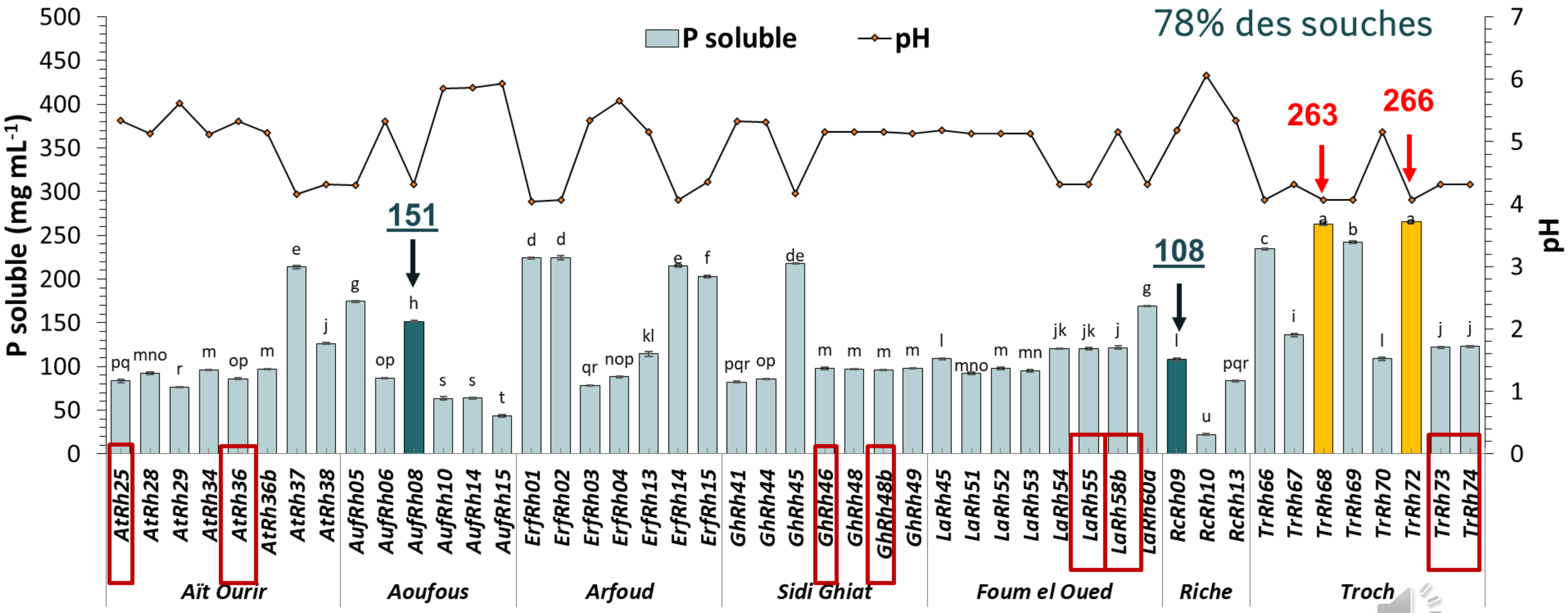
Isolates of rhizobia

- **PEG 6000**
- **NaCl**
- **Temperature**
- **pH**
- **TCP solubilization**



Section 2: Isolation of drought tolerant rhizobial strains

- TCP solubilization and the pH of the liquid NBRIP medium after 96 hours of culture.



Section 3 :

- Evaluation of the tolerance of the alfalfa (Medicago sativa)–rhizobia symbiosis under water deficit and the impact of seed osmopriming on plant response.

Section 3: Effect of seed priming on Drought tolerance of alfalfa–rhizobia symbiosis.

- Methodology

Desinfection & germination (25°C)

Graines de luzerne

Ta
Ad
Dm2

+

Mo

Transplantation

Inoculation (10 mL of 10^9 CFU)

Rhizobia

RcRh09

AufRh10

Greenhouse

Normal Conditions (80% FC)

Water deficit (40% FC)

Point de flétrissement (25% CC)

Harvesting & analyses

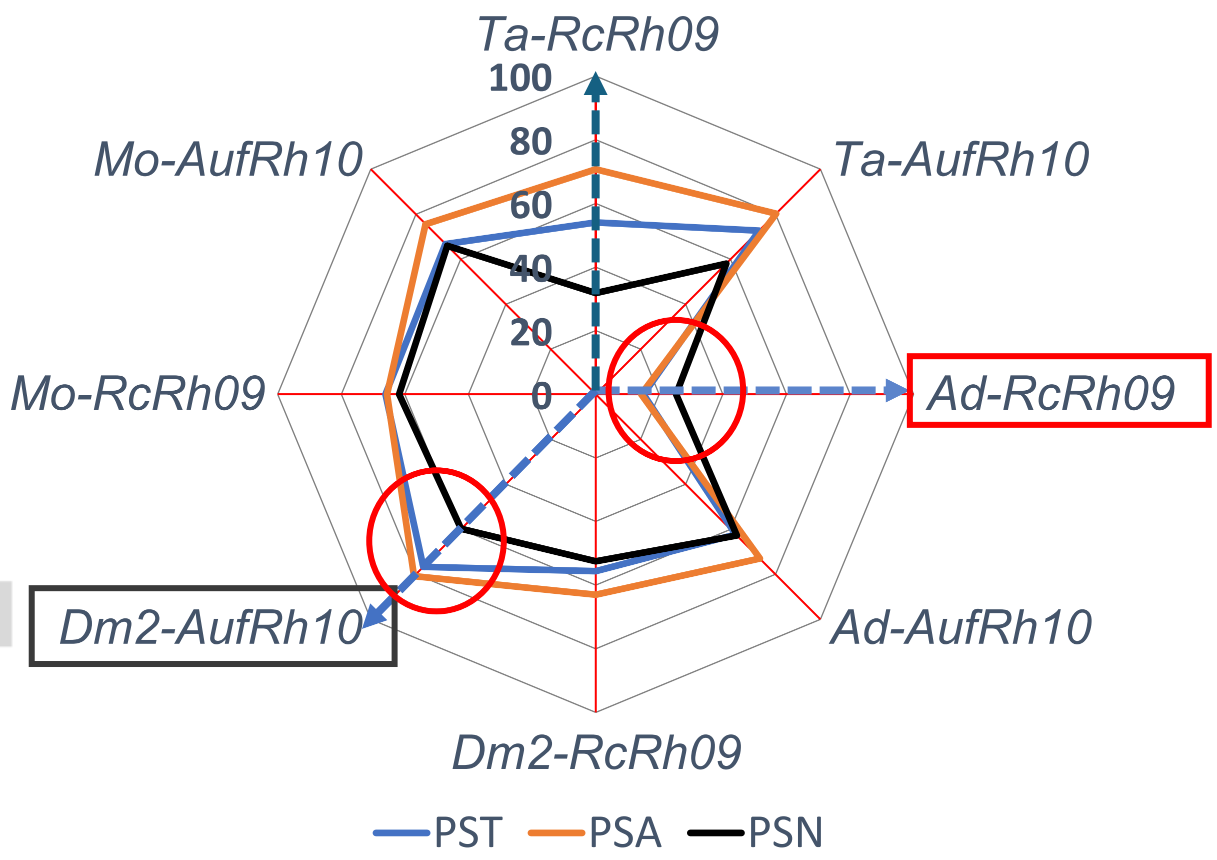
40 % CC

80 % CC

Section 3: Effect of seed priming on Drought tolerance of alfalfa–rhizobia symbiosis.

- Effect of water deficit (40% FC) on total, shoot, and nodular dry weight in the studied symbiotic combinations.

Reduction % under stress



PST	PSA	PSN
15%	14,3%	25,3%

PST	PSA	PSN
76,7%	80,8%	59,8%

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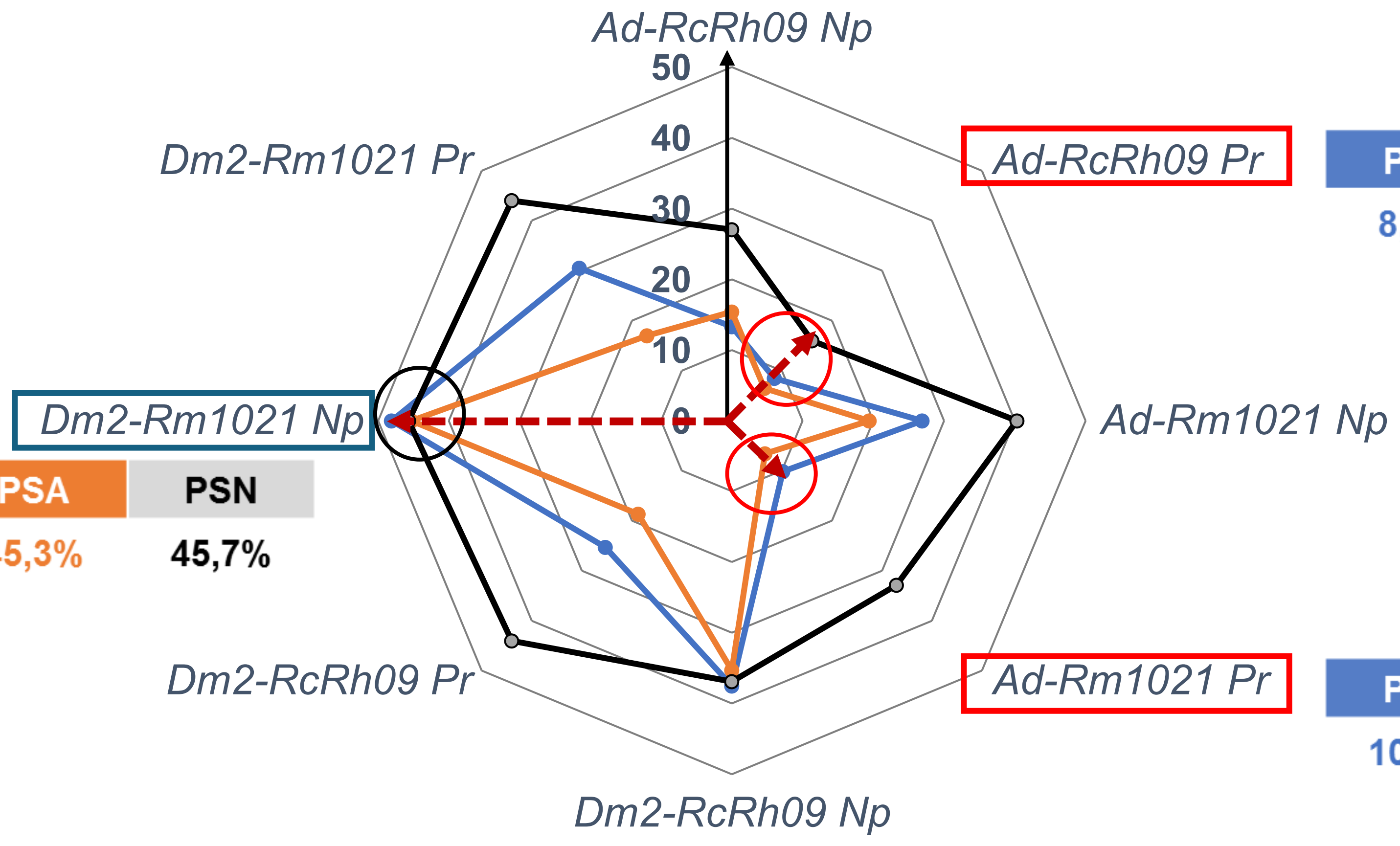
Section 3: Effect of seed priming on Drought tolerance of alfalfa–rhizobia symbiosis

- Effect of osmopriming on growth of selected alfalfa-rhizobia symbiotic combinations

Reduction % under stress



PSA	PSA	PSN
8,5%	6,5%	16%

PSA	PSA	PSN
48,1%	45,3%	45,7%

PSA	PSA	PSN
10,2%	6,6%	32,9%

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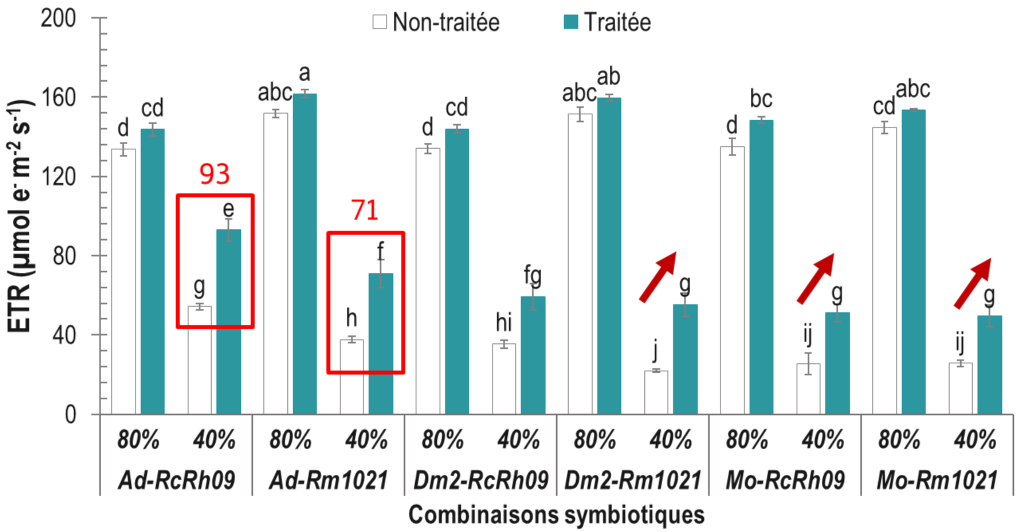
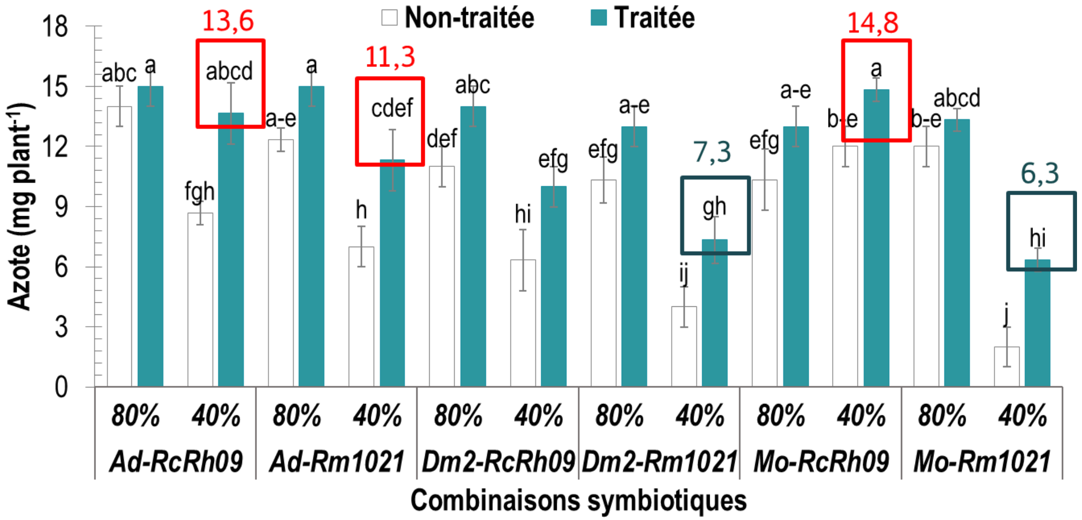
Section 3: Effect of seed priming on Drought tolerance of alfalfa–rhizobia symbiosis

- Electrons Transport rate (ETR)

Nitrogen content





Section 4:

- Assessing the tolerance of alfalfa to deficit irrigation under field conditions

Section 4: Tolerance of alfalfa to deficit irrigation under field conditions

- Methodology

Moroccan Alfalfa genotypes

Oasis: ***Adis 1***, ***Tata 2***

Mountains: ***Dem208***, ***Dem206***

\+

Siriver

Random Blocks

Semis en 2012

Deficit Irrigation

Goutte à goutte

100 % ET_c

75 % ET_c

50 % ET_c

FAO-Penman-Monteith (Allen et al, 1998)

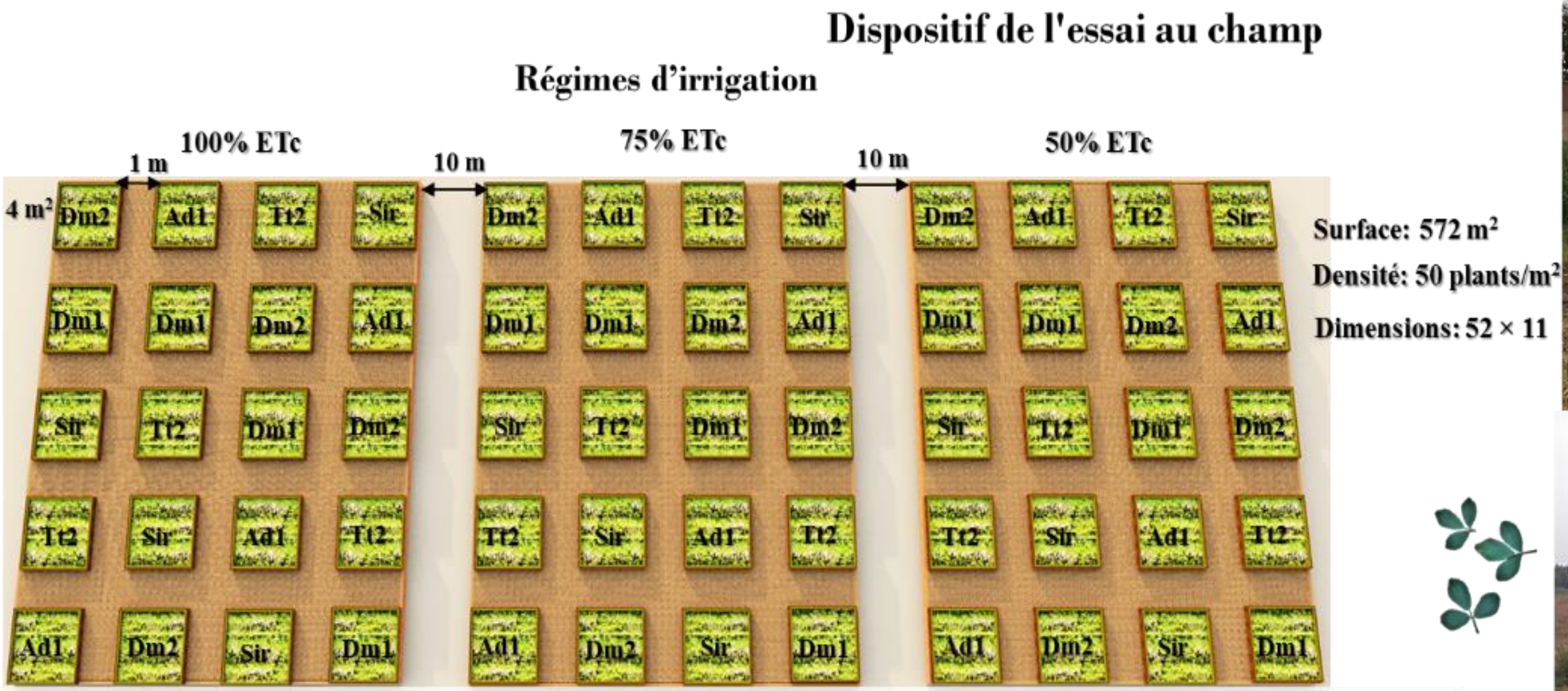
$$Et_c = ET_0 \times K_c$$

CROPWAT version 8.0

Meteorological station

Harvest & Analyse 2012/13/14

Section 4: Tolerance of alfalfa to deficit irrigation under field conditions

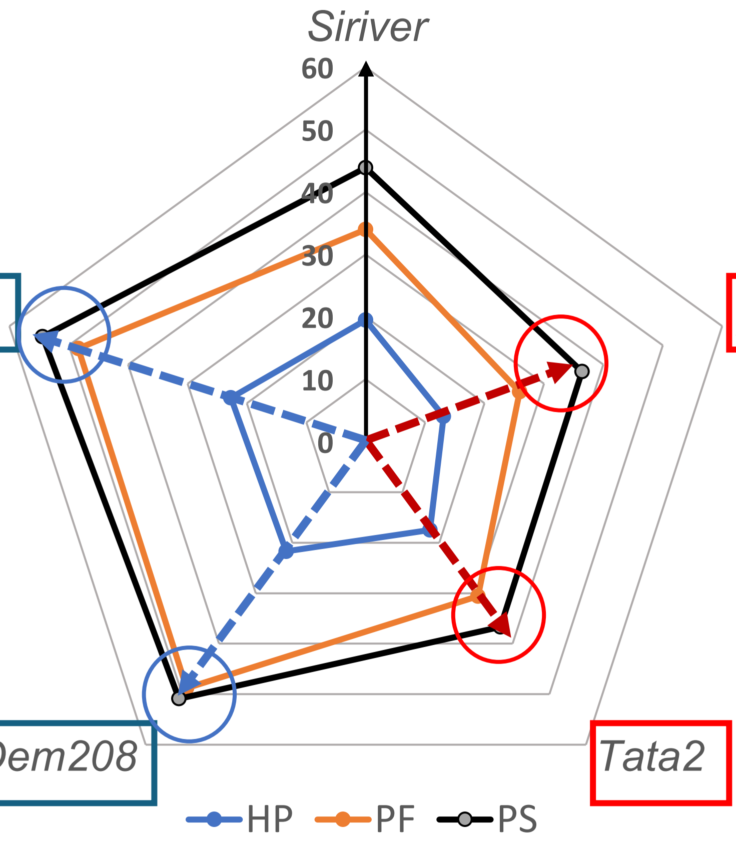


Dispositif de l'essai au champ, Site: Station expérimentale INRA Saada (7 km de Marrakech, 31.62°N, 8.14°E, altitude 421 m)

Section 4: Tolerance of alfalfa to deficit irrigation under field conditions

- Effect of deficit irrigation on the growth of the studied alfalfa genotypes.

Reduction % under severe stress



Dem206

HP	PF	PA
22,7%	48,4%	54,4%

Adis1

HP	PF	PA
13,1%	25,9%	36,4%

Dem208

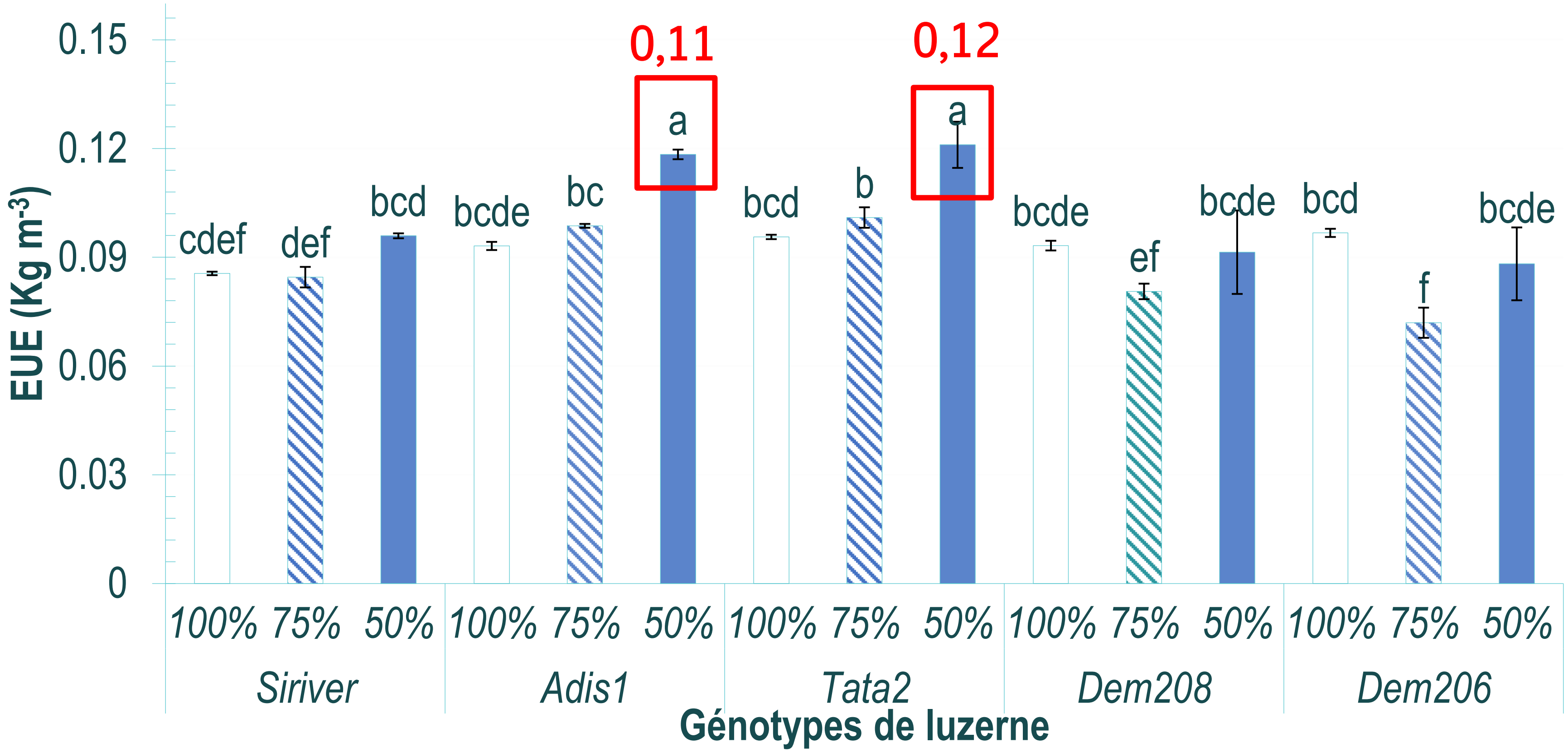
HP	PF	PA
21,7%	48,8%	50,9%

Tata2

HP	PF	PA
17,5%	30,6%	36,7%

Section 4: Tolerance of alfalfa to deficit irrigation under field conditions

- Effect of deficit irrigation on water use efficiency in the studied alfalfa genotypes.



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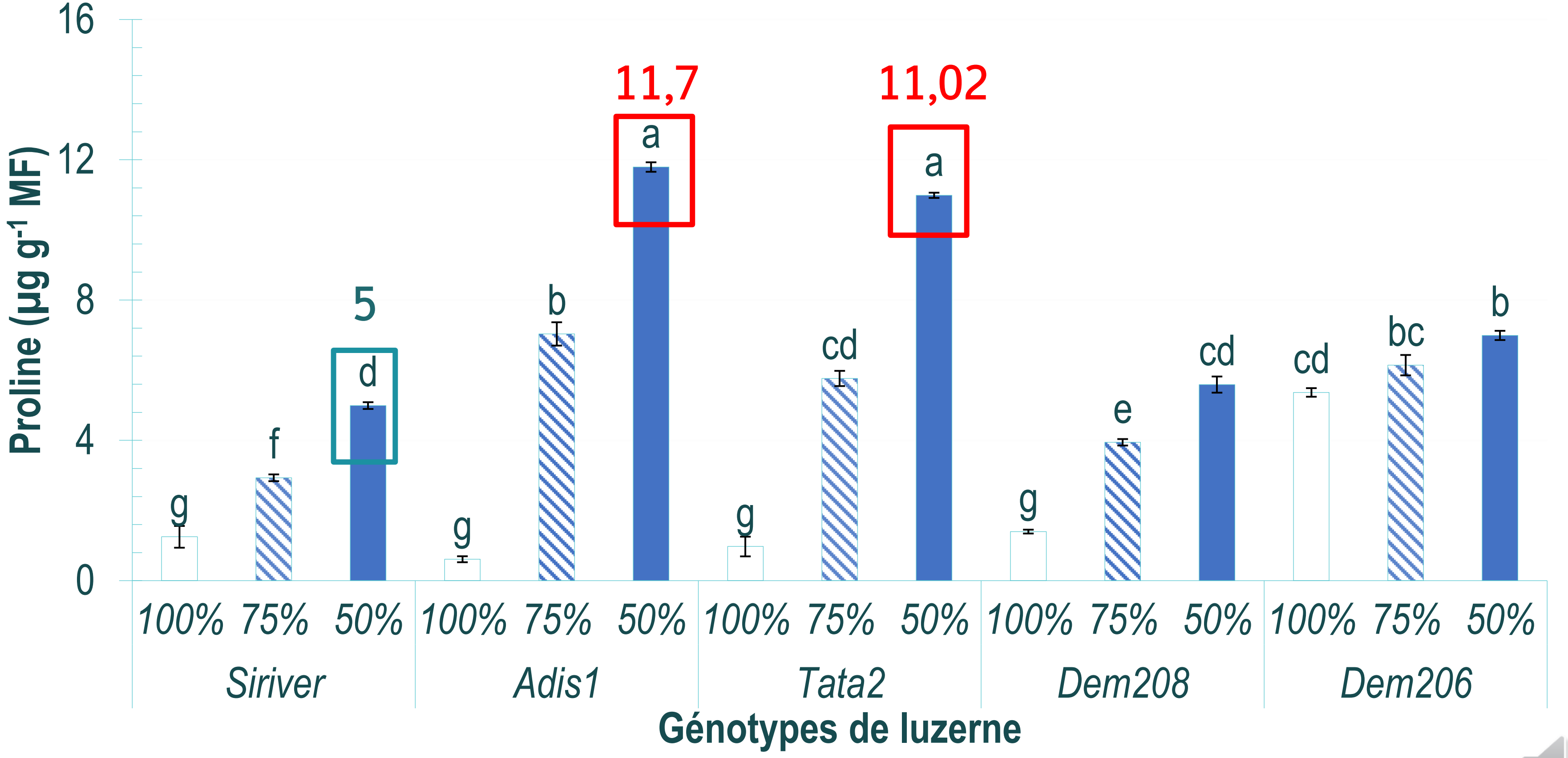
Section 4: Tolerance of alfalfa to deficit irrigation under field conditions

- Effect of deficit irrigation on proline content in the studied alfalfa genotypes.



GENERAL CONCLUSIONS

Alfalfa Genotypes

Ta
Ad
Rc
Dm1
Dm2
Mo

Signifiant Variations

<u>Water deficit</u>

Stage of germination

-Germination rate
-Seedlings growth

Growth stage

Negative Effect (-)

GENERAL CONCLUSION

Osmopriming
(-0,6 MPa, 24h à 25°C)

Combinaisons symbiotiques

growth

Nodulation

Under water deficit (40% CC)

Variations significatives

Growth stage (Osmopriming)

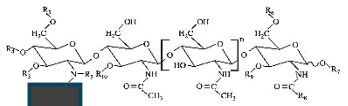
Treated seeds

Ad-RcRh09

More Tolerant Combinaison

Dm-Rm1021

Less tolerant Combinaison



Efficacity PS II

Content N

Content K^+

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