

*Water stress resistance of C3 and C4 turfgrass species
and the impact of wetting agents and biostimulants
in Mediterranean regions.*

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OBJECTIVES

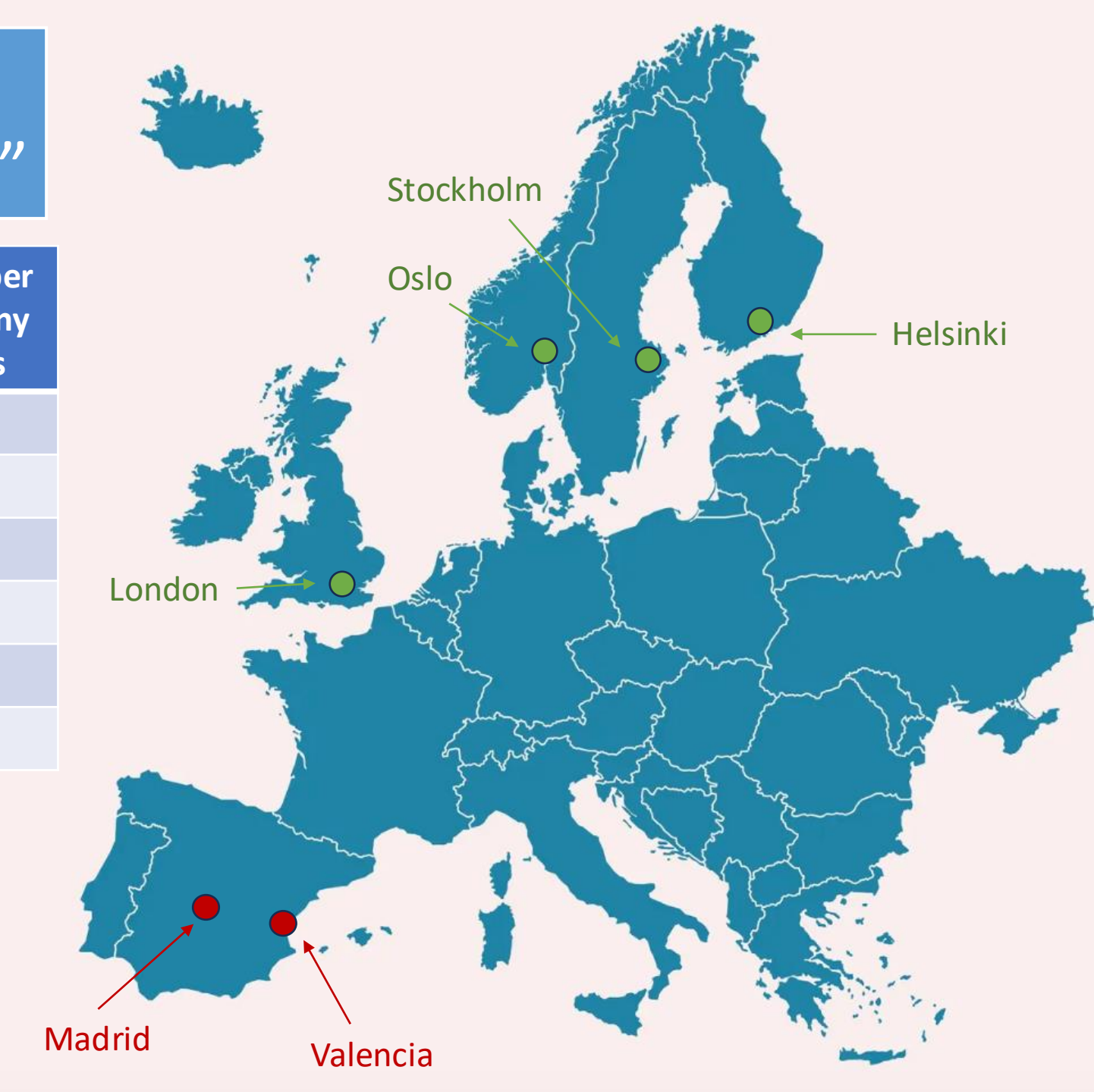
TO SHOW THE **DIFFERENT BEHAVIOUR OF 7 COOL SEASON SPECIES** (26 CULTIVARS) UNDER 2 MONTHS OF **DEFICIT IRRIGATION IN SUMMER**, WITH THE **SEPTEMBER RECOVERY** IN A REAL MEDITERRANEAN CLIMATE (VALENCIA, SPAIN)

TO SHOW RESULTS OF **DIFFERENT EXPERIENCIES TO IMPROVE WATER EFFICIENCY** AND EVALUATE TURFGRASS PERFORMANCE OF **WARM SEASON SPECIES AND COOL/WARM SEASON MIXES** IN MEDITERRANEAN CLIMATE (MADRID, SPAIN)



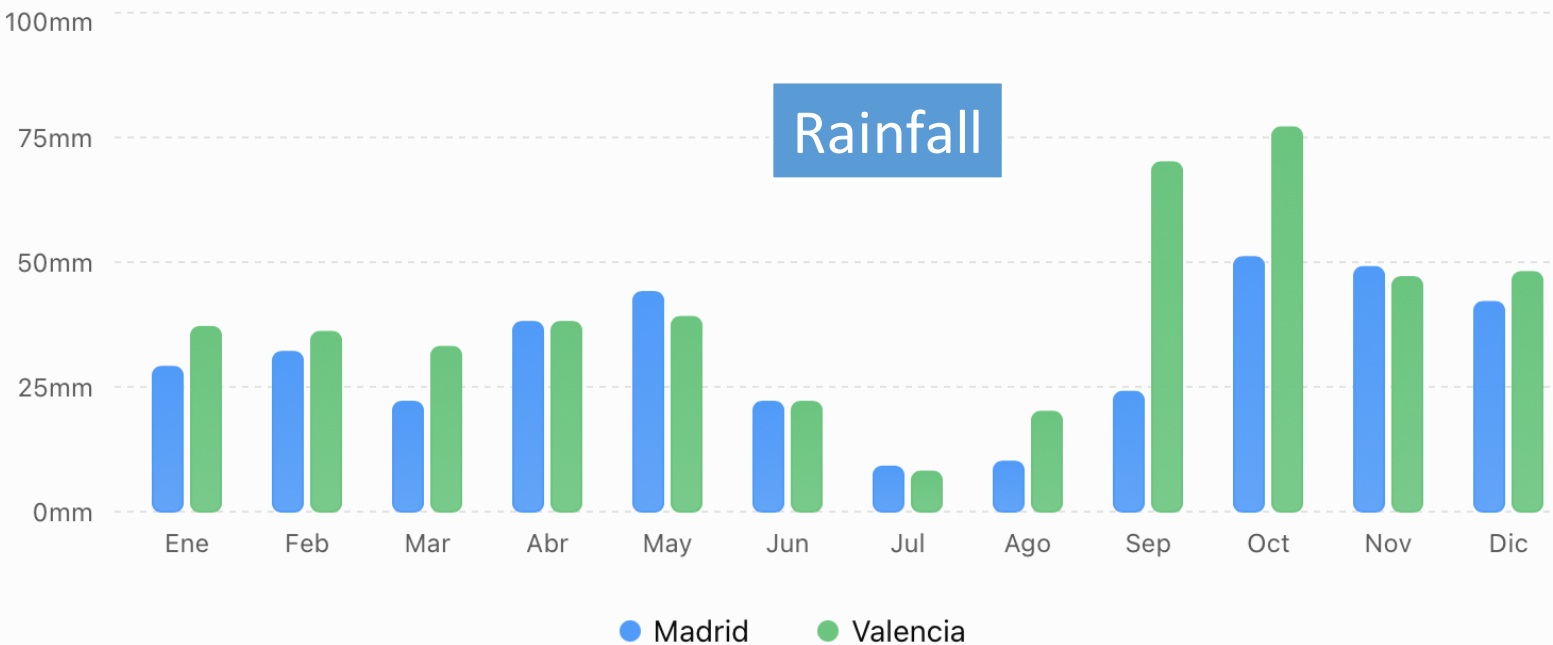
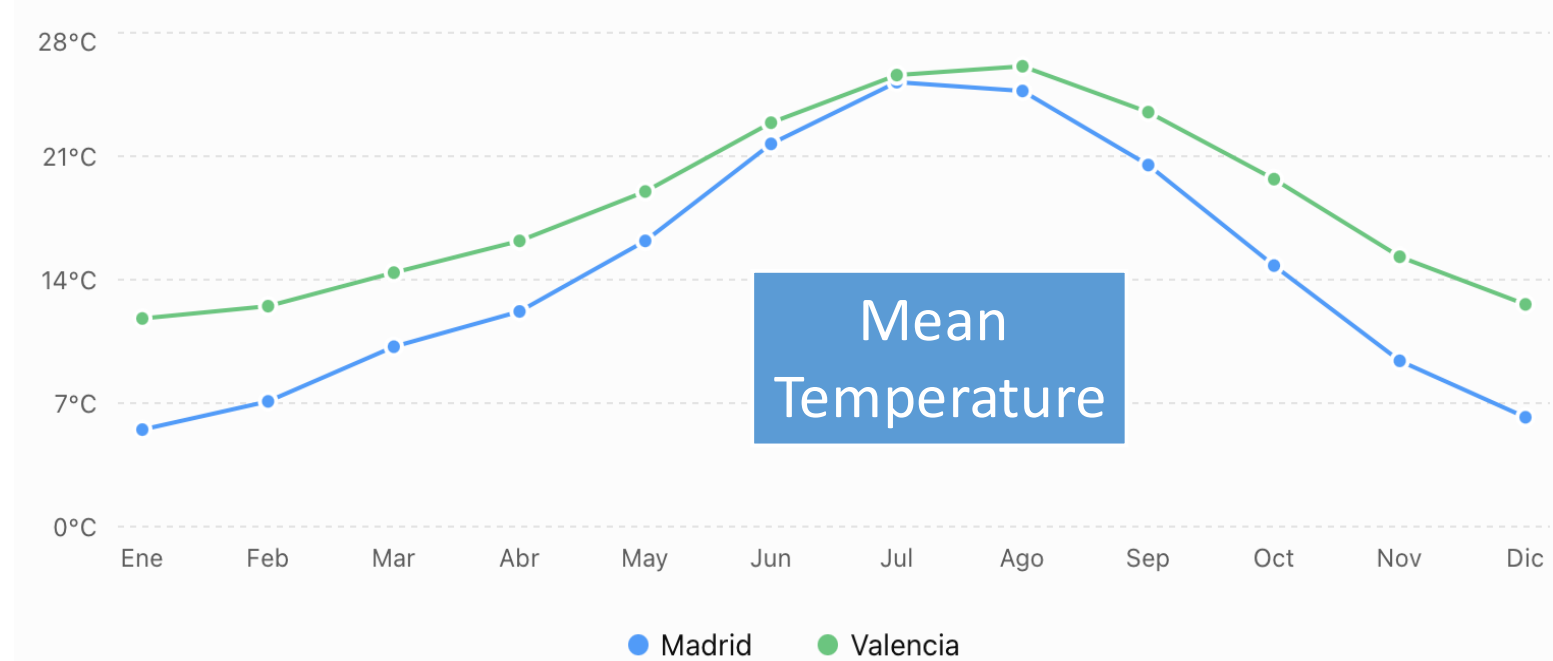
Climate differences among “webinar countries”

	Latitude (°)	Mean Temp. (°C)	Year rainfall (mm)	Number of rainy days
Oslo	59	6.0	750	160
Stockholm	59	7.3	620	170
Helsinki	60	5.5	650	180
London	51	10.8	650	130
Madrid	40	15.0	400	59
Valencia	39	18.5	450	45



Climate differences between Madrid-Valencia

- **Madrid:** more continental climate than Valencia.
- **Valencia:** milder winter than Madrid
- **Valencia:** warmer night temperature in summer than Madrid
- Similar precipitation, but more irregular in Valencia



“NEW” RESEARCH FACILITIES

- 5.000 m² surface
- Homogeneous soil (sandy-loam)
- Homogeneous climate:
 - a) Mild Winter
 - b) Hot and humid summer
 - c) Irregular rainfall (425 mm per year)
- Homogeneous Irrigation system



Cool-season
species
and
varieties

Warm-season
species
and
varieties

20th March
2024

Warm-season
species
and
varieties



Cool-season
species
and
varieties



**Deficit
irrigation**
area
(50 C3 varieties
replicated 3 times
in 3x1 m plots)

**Optimal
irrigation**
area
(50 C3 varieties
replicated 3 times
in 3x1 m plots)



Lolium perenne (8)
Lolium arundinaceum (formerly: *Festuca arundinacea*) (6)
Poa pratensis (4)
Poa trivialis (2)
Festuca rubra conmutata (1)
Festuca rubra rubra (2)
Festuca rubra trichophylla (1)
Festuca ovina duriuscula (1)
Festuca trachyphylla (1)

100 % vs 80% ET_C

WATER STRESS RESISTANCE EXPERIMENT
WITH COOL SEASON SPECIES AND CULTIVARS
DURING JULY AND AUGUST
AND RECOVERY IN SEPTEMBER

2023
2024
2025
2026

Weekly determinations

1.- Visual general quality (1 to 9 subjective scale)

2.- Green colour (1 to 9 subjective scale)

3.- Normalized Difference Vegetation Index, NDVI (0 to 1 objective scale)

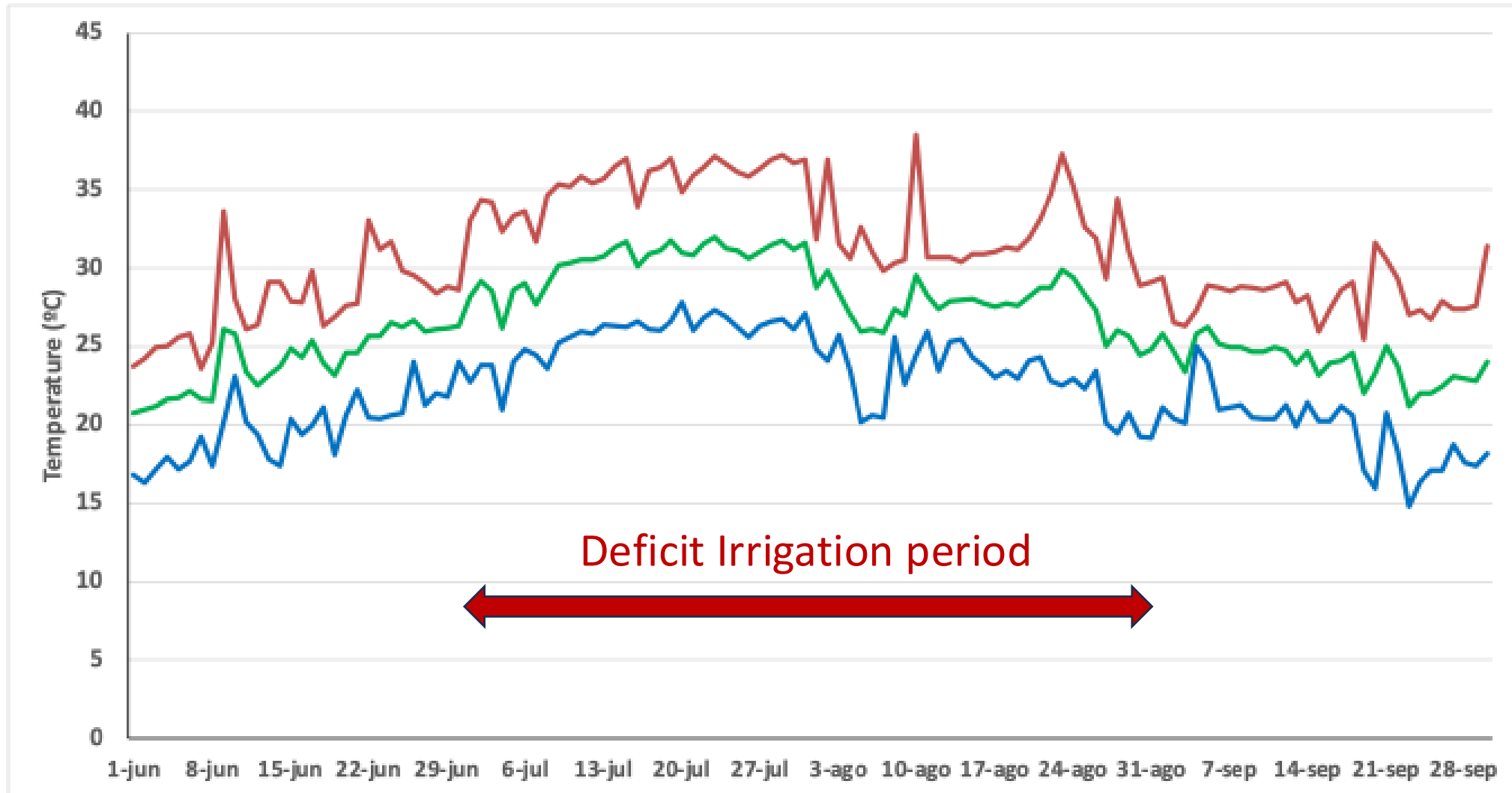


Generally, a higher NDVI number indicates healthier, denser, and more vigorous turfgrass

DAILY TEMPERATURE EVOLUTION DURING THE EXPERIMENT IN 2023



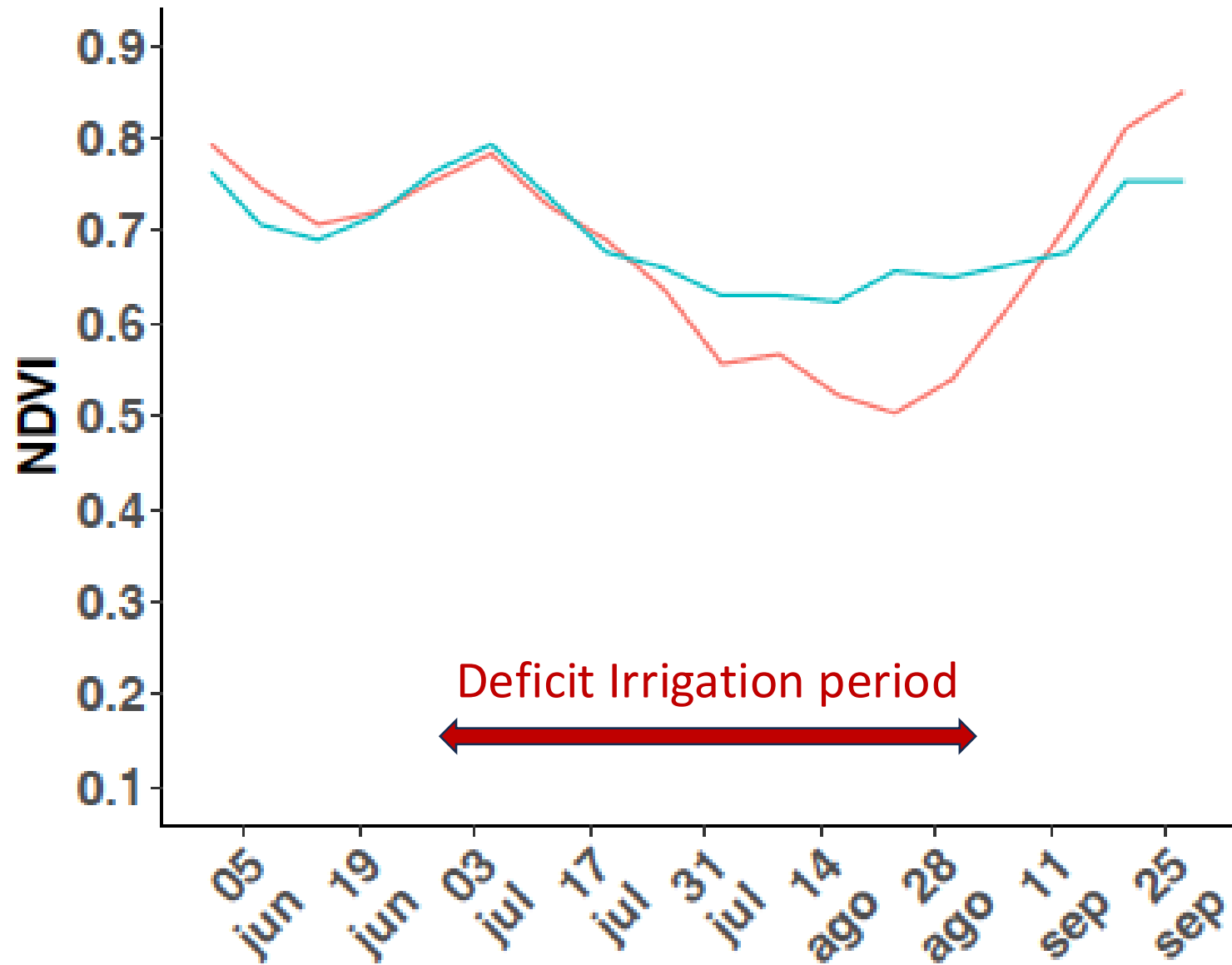
RED LINE: MAXIMUM
GREEN LINE: MEAN
BLUE LINE: MINIMUM



Lolium perenne
(perennial ryegrass)

CT7

BLUE LINE: OPTIMAL IRRIGATION
RED LINE: DEFICIT IRRIGATION



2024

Lolium perenne
(perennial ryegrass)

BLUE LINE: OPTIMAL IRRIGATION
RED LINE: DEFICIT IRRIGATION

Cultivars tolerant to neither water regime

BELIDA
PLATINUM
SIRTAKY

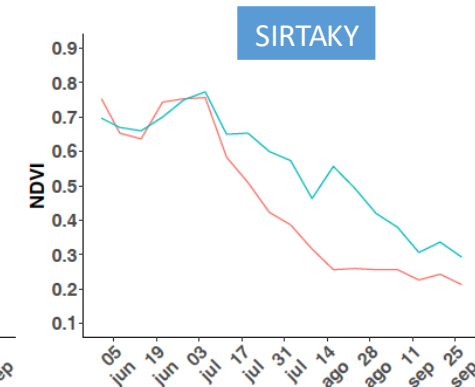
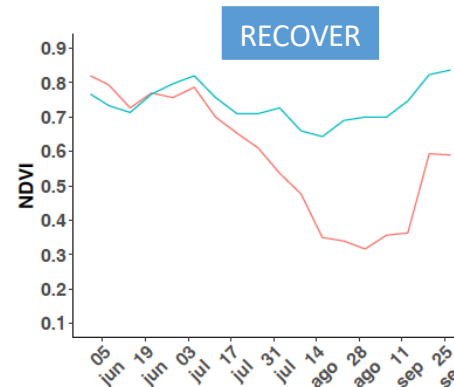
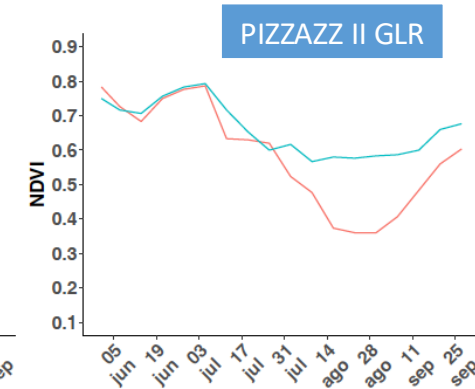
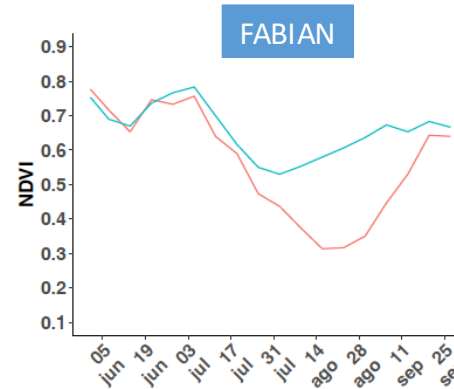
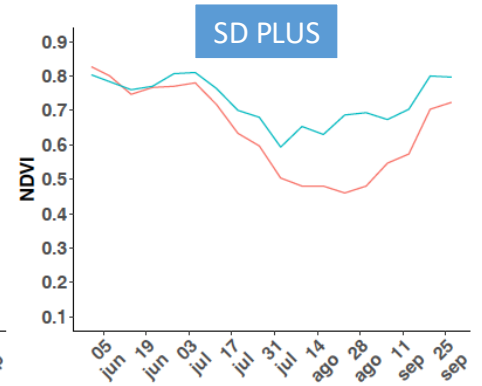
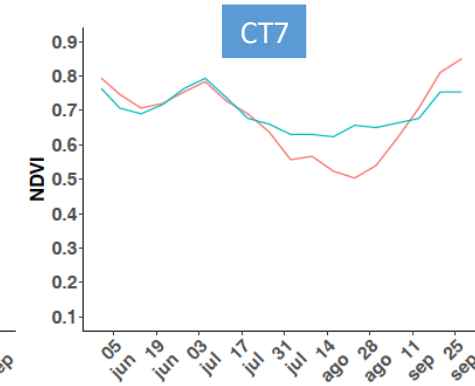
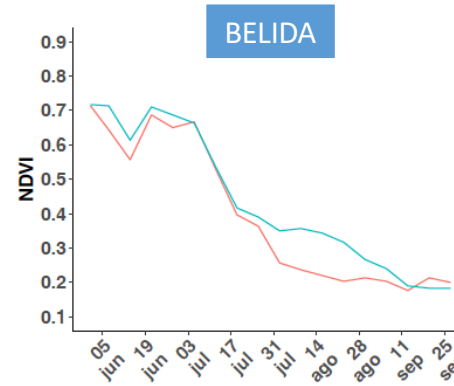
Cultivars affected by water deficit but recovering

RECOVER
PIZZAZZ II GLR
FABIAN

Barely affected, fully recovered cultivars

CT7
SD PLUS

NDVI 2023



Poa pratensis
(Kentucky bluegrass)

BLUE LINE: DEFICIT IRRIGATION
RED LINE: OPTIMAL IRRIGATION

Cultivars tolerant to neither water regime

Cultivars affected by water deficit but recovering

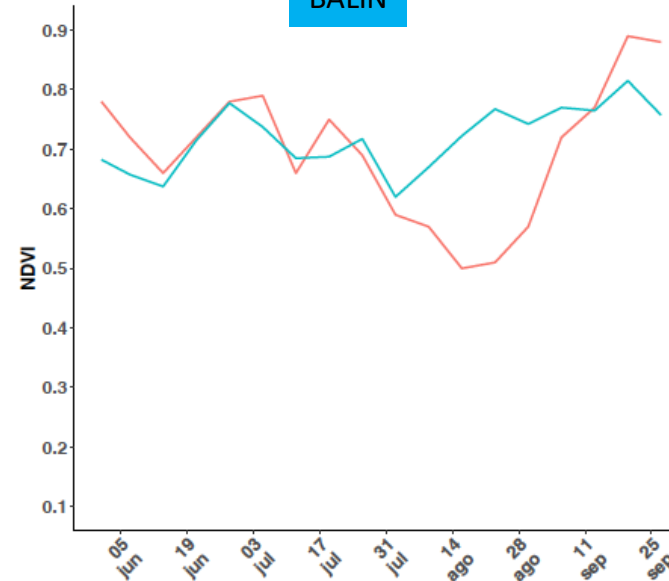
BALIN
BROOKLAWN
MARAUDER

Cultivars affected by water deficit, with slower recovering

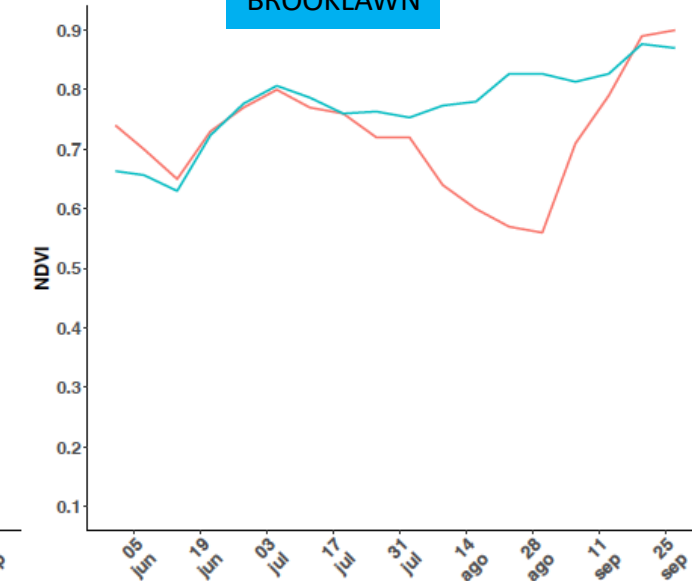
SOMBRERO

NDVI 2023

BALIN

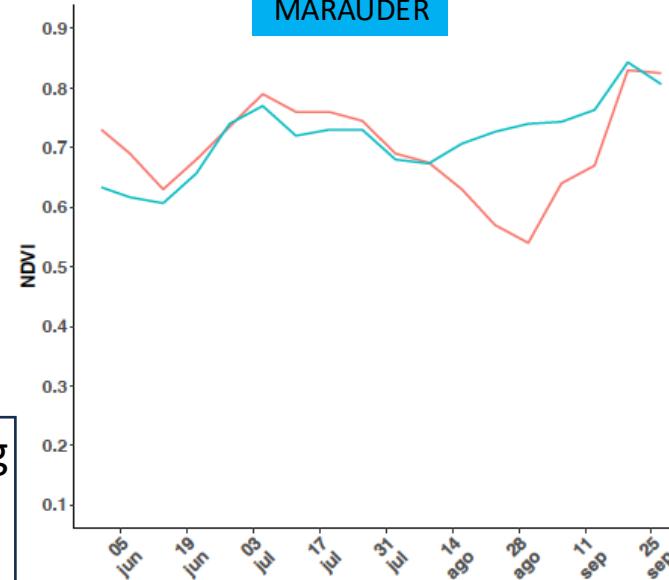


BROOKLAWN

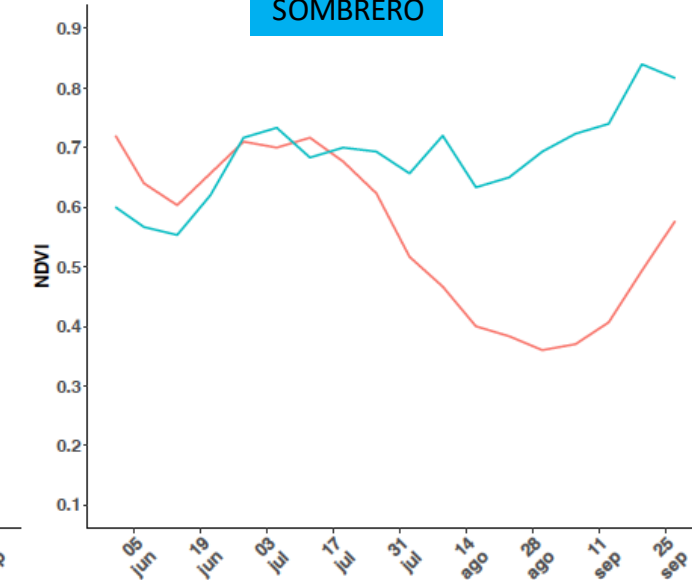


Riego — Riego deficitario — Riego óptimo

MARAUDER



SOMBRERO



Riego — Riego deficitario — Riego óptimo

Riego — Riego deficitario — Riego óptimo

Poa trivialis

BLUE LINE: DEFICIT IRRIGATION
RED LINE: OPTIMAL IRRIGATION

Cultivars tolerant to neither water regime

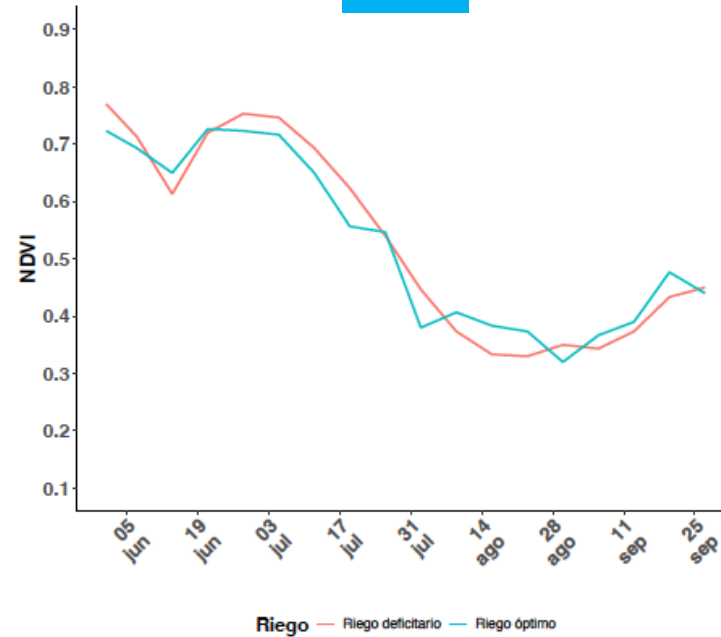
DASAS

Cultivars affected by water deficit, with a slow
recover

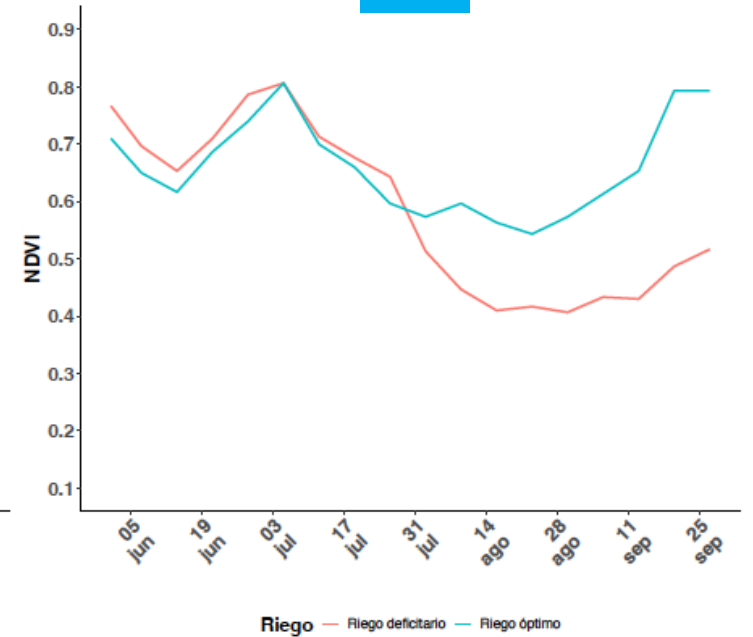
SOLO

NDVI 2023

DASAS



SOLO



Festuca arundinacea

BLUE LINE: DEFICIT IRRIGATION
RED LINE: OPTIMAL IRRIGATION

Cultivars tolerant to neither water regime

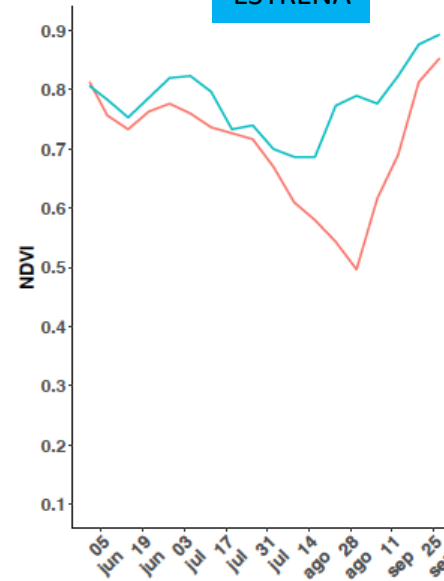
Cultivars affected by water deficit but recovering

ESTRENA
GRANDE II
REBOUNDER
TOMCAT
SITKA
FAWN

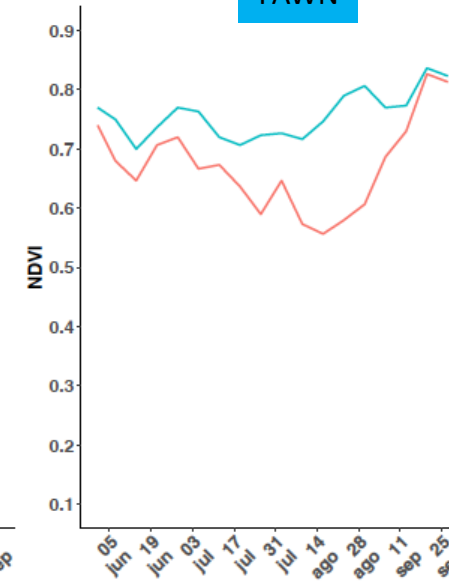
Barely affected, fully recovered Cultivars

NDVI 2023

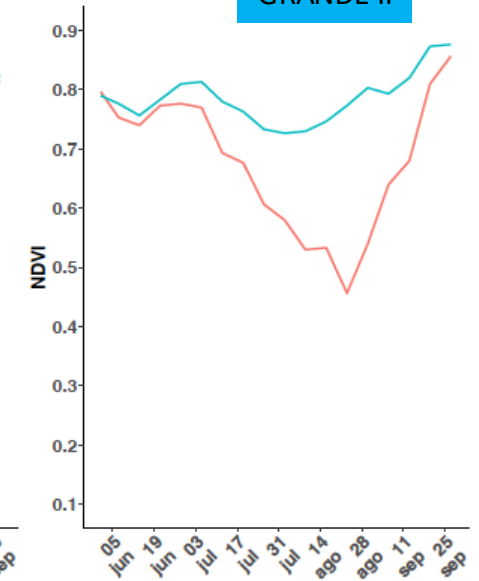
ESTRENA



FAWN

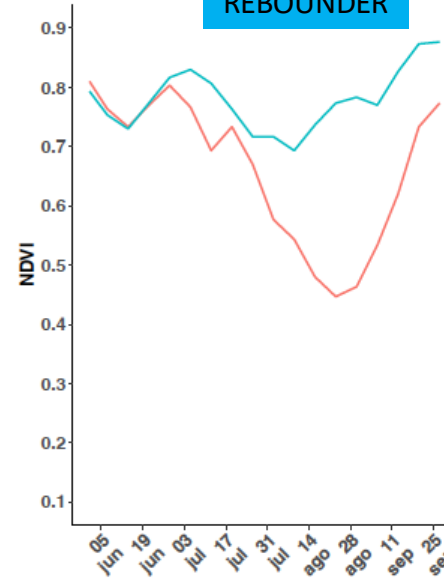


GRANDE II



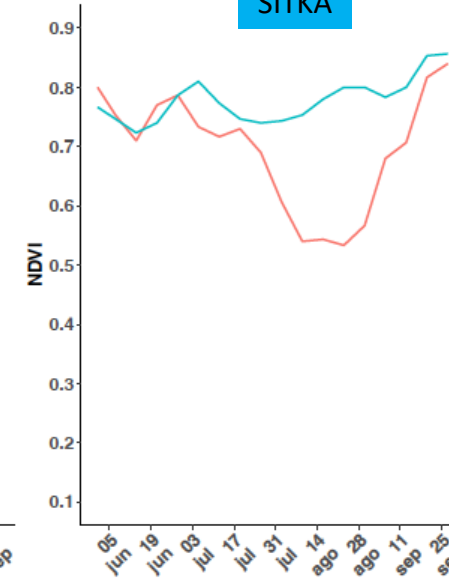
Riego — Riego deficitario — Riego óptimo

REBOUNDER



Riego — Riego deficitario — Riego óptimo

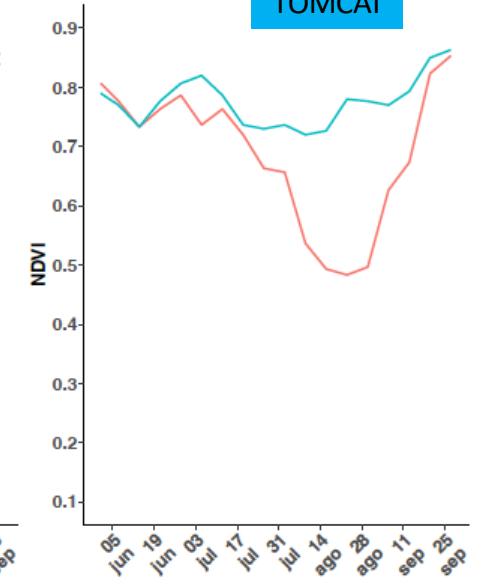
SITKA



Riego — Riego deficitario — Riego óptimo

Riego — Riego deficitario — Riego óptimo

TOMCAT



Riego — Riego deficitario — Riego óptimo

Festuca ovina
Festuca rubra
Festuca trachyphylla

→ *conmutata*
rubra
thrichophylla

BLUE LINE: DEFICIT IRRIGATION
 RED LINE: OPTIMAL IRRIGATION

Varieties tolerant to **neither** water regime

RIDU
 SHAUN

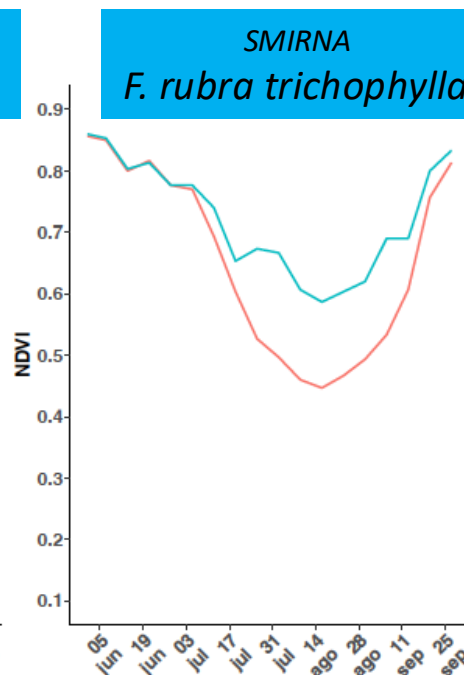
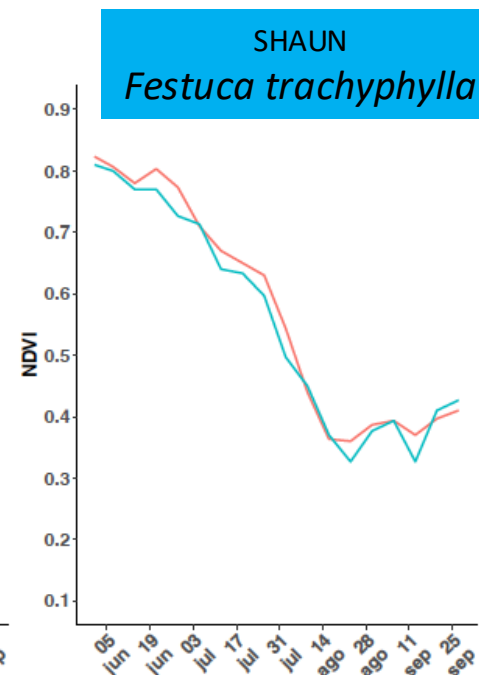
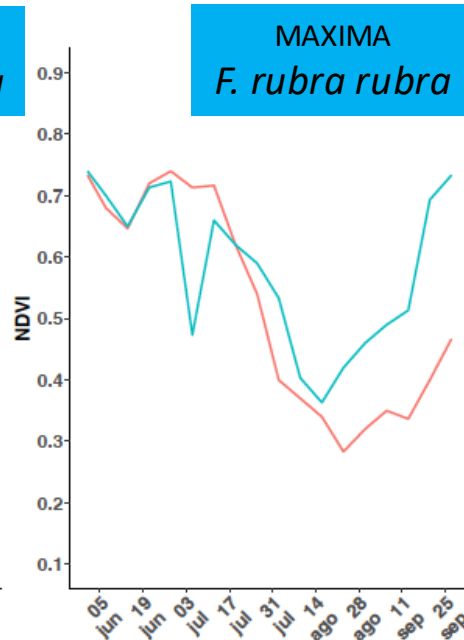
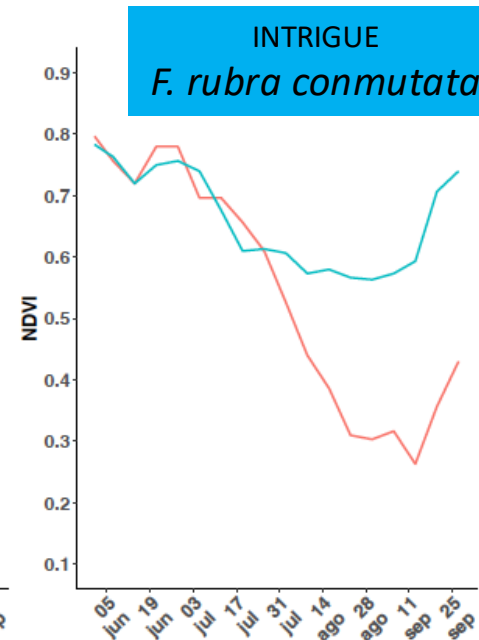
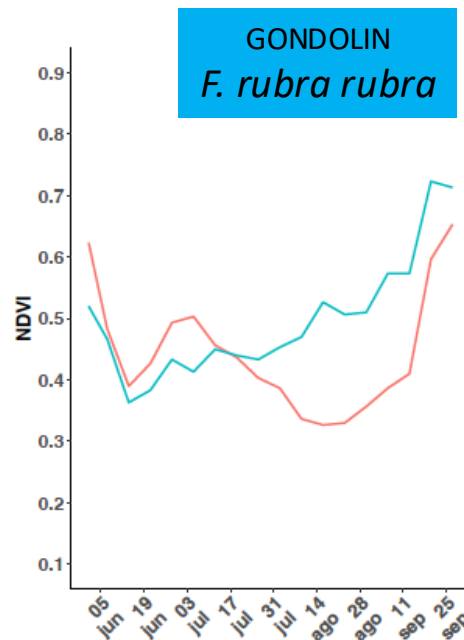
Varieties affected by water deficit, with **fast** recover

GONDOLIN
 SMIRNA

Varieties affected by water deficit, with **slow** recover

MAXIMA
 INTRIGUE

NDVI 2023



Some conclusions

- The tolerance to water deficit (80% ETc), depends more on the cultivar than on the species
- Most of the cultivars recovered during autumn, however at different velocity
- Most of the cultivars didn't performed well after the fourth year of experimentation



Research objectives

Evaluate species under deficit irrigation.

Apply products to improve water use.

IMIDRA Test Site
since 2016



UPM Test Site
since 2024



Materials & methods

2 Different locations in Madrid

More than 8 species, 5 of them warm-season species:

Cynodon dactylon

C. dactylon x *C. transvaalensis*

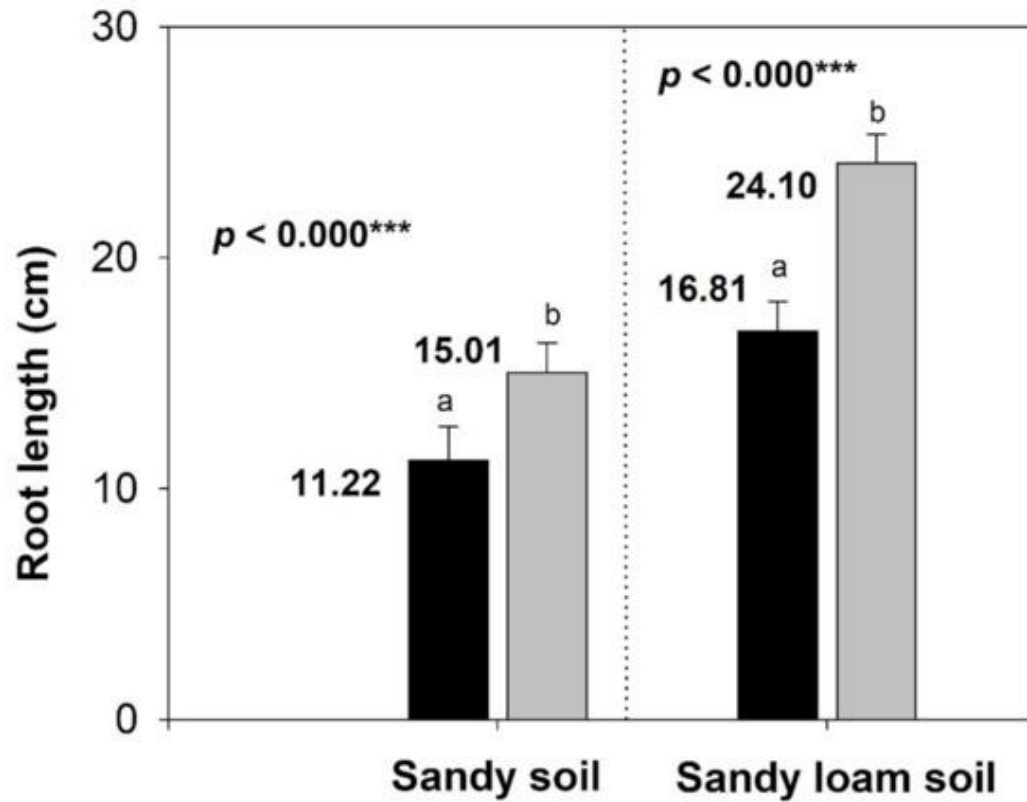
Bluchloe dactyloides

Zoysia japonica

Zoysia matrella

Results

Increased C3 root depth upon application of a biostimulant (fulvic acids)



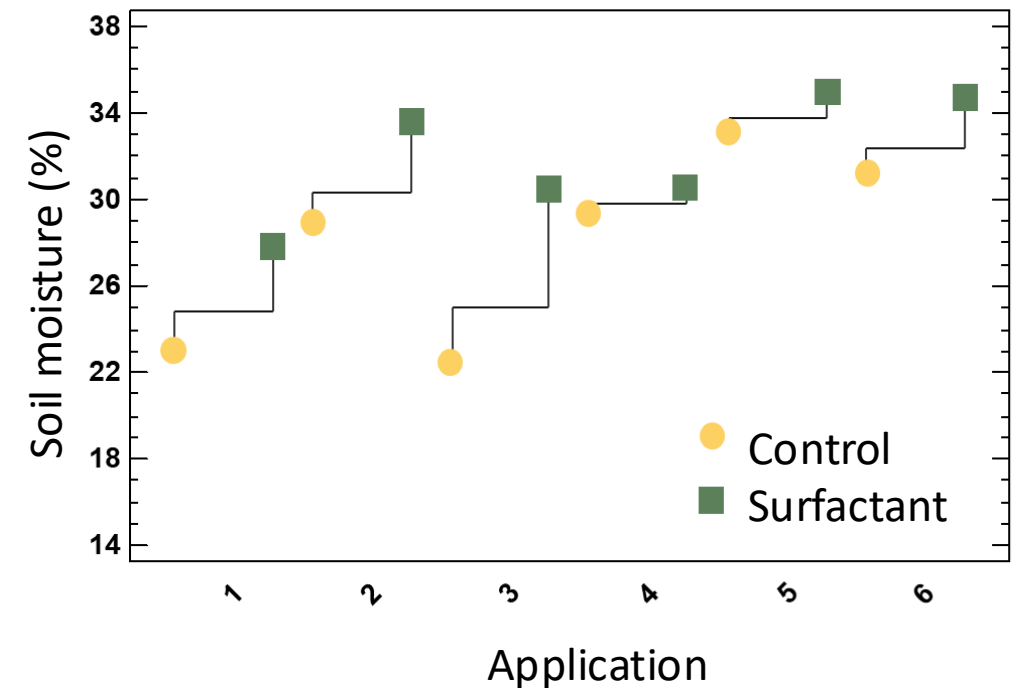
Root length increased
34 to 43 % due to
biostimulant use

There is an increase in both soil types and an increase of soil microbiological activity

Results

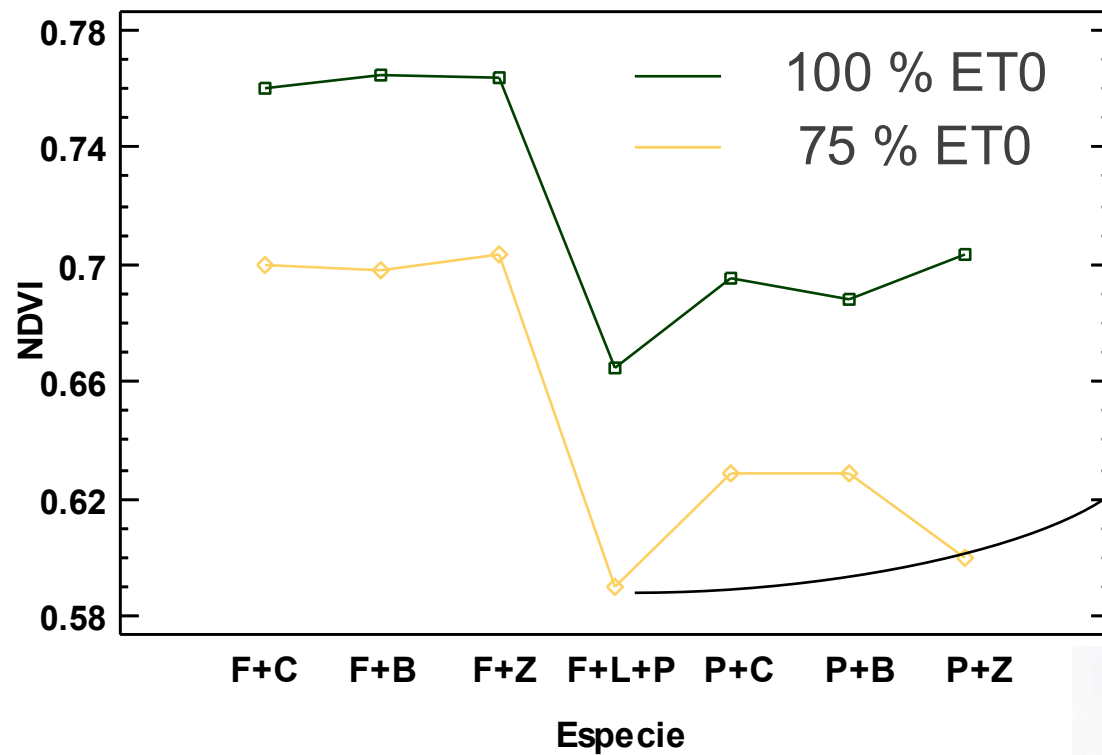
Increase in soil moisture upon application of a wetting agent (surfactant)

Application of surfactant increases soil moisture in 10%



Results

Differences in visual quality between species → NDVI measurements



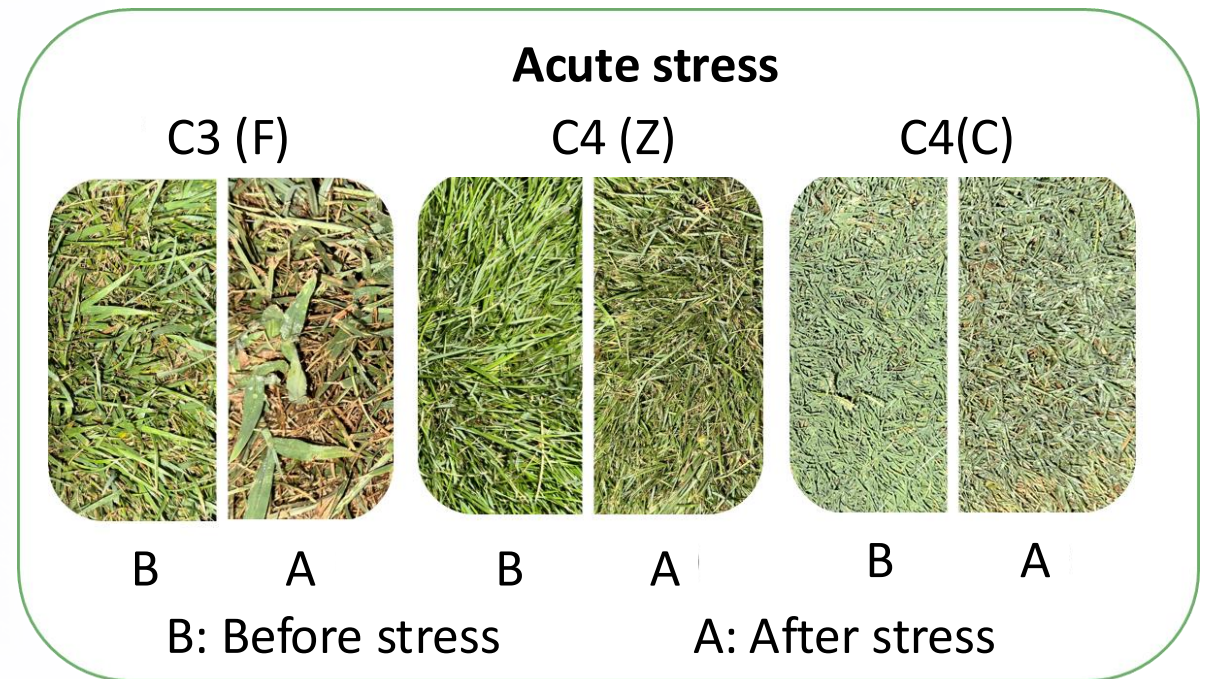
Save 25 % of the water while improving 4% on turfgrass NDVI

With C3/C4 mixture, NDVI (0.7) with deficit irrigation (75%) is higher than C3 turf (0.66) with regular irrigation (100%)

Results

Comparison of C3 vs C4 survival under an acute hydric stress in the summertime

C4 species survived
acute stress while C3
died



100 % Irrigation

Results

Comparison of C4 species to chronic stress over 2 months

Chronic stress

Zoysia



Cynodon



100 %

75 %

50 %

75 % Irrigation (deficit irrigation)

75% irrigated turfgrass
has a similar aspect than
100% irrigated one

50%

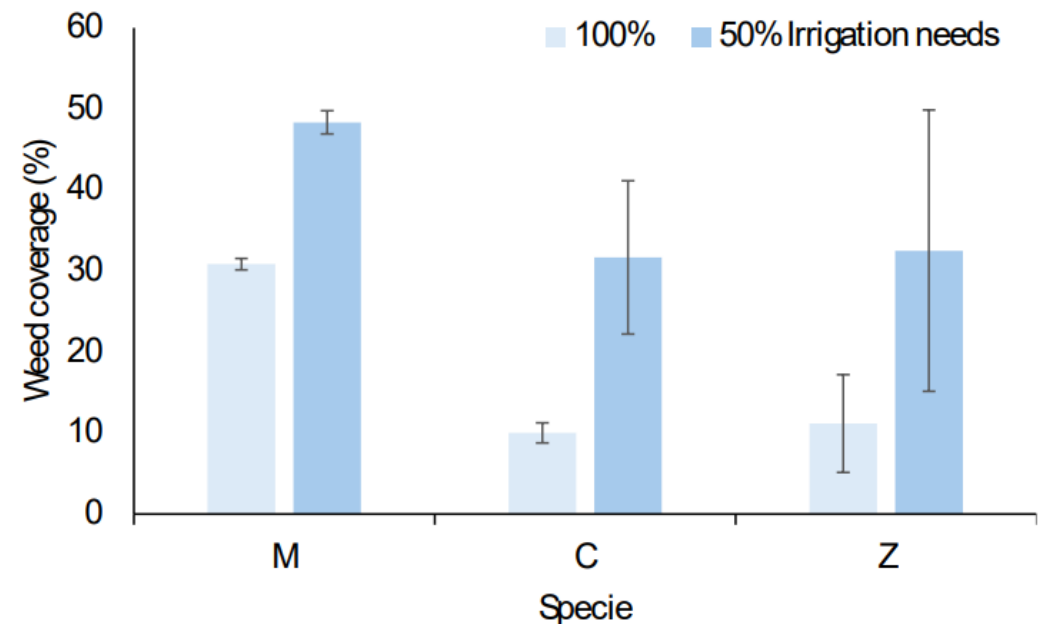
Extreme deficit irrigation)

Results

Weed encroachment during spring green-up over species and summer stress

75 % irrigation had no differences

Weed encroachment increases about 300 % due to hydric stress.



Bite-sized information updates

- Biostimulants can increase root depth by more than 30%, while surfactants increase soil moisture by 10%.
- The impact of reduced irrigation (75 % vs 100 %) in turf NDVI can be overcome by changing the species (C4 vs C3) in Mediterranean regions.
- Drastically reduced summer irrigation can affect turf canopy structure at the end of summer and lead to greater weed encroachment in spring.



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and the impact of wetting agents and biostimulants
in Mediterranean regions.*

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