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Nutrient Dynamics of Planted Forests

November 27-28, 2012 • Vancouver, Washington

Seedling nutrient loading to improve planting success. A Mediterranean perspective

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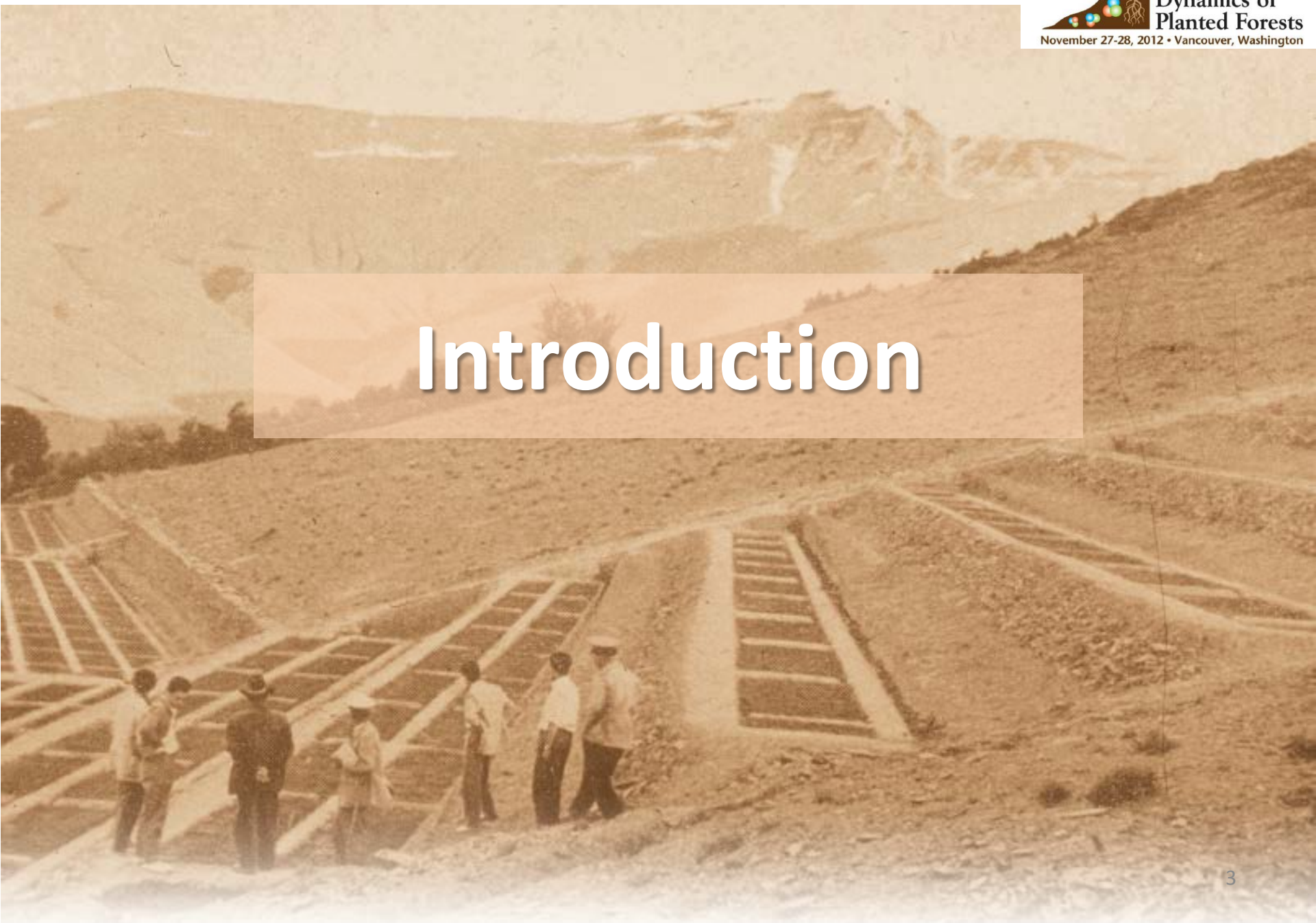


Introduction

Introduction

- Afforestation in Spain from the 1940s to the 1980s leaded to more than 3 M of ha transformed to forests
- Many highly degraded areas were afforested on harsh dry sites
- Low nursery technologies and low seedling quality requirements
- Soil erosion control and forest production improvement were main objectives

Introduction

Introduction

- Keystone aspects of the establishment success?:

✓ Mostly pines were used

✓ High planting densities guaranteed stand establishment

✓ Low labor costs permitted fails replacement from year to year

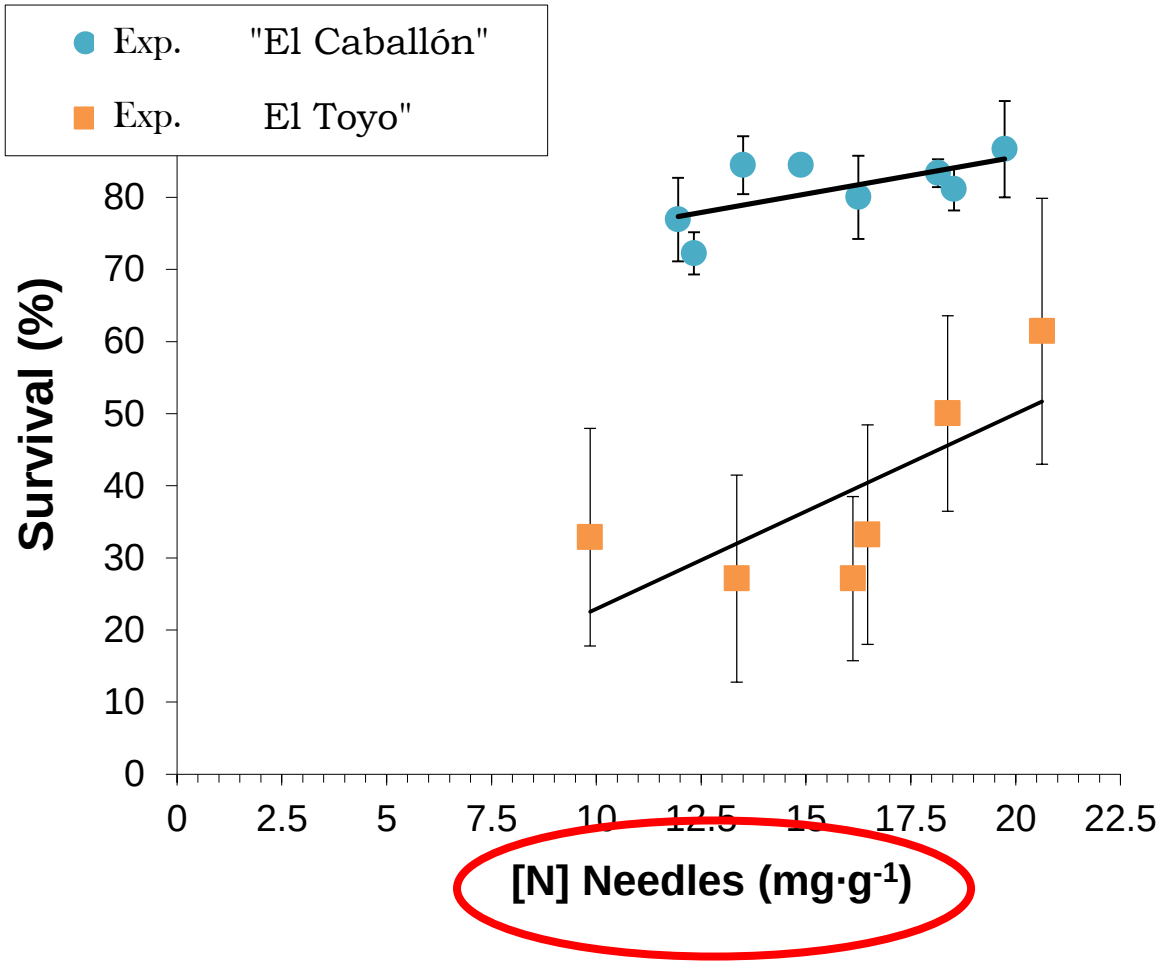
Introduction

➢Changes from the 1980s to present:

- From **soil erosion control** to forests and other ecosystems **restoration**
- Much higher forestation **costs**
- Plant production in larger and **centralized** nurseries
- Needs to **widen** the pool of **species**
- **Global change** is the "dressing of every salads", even more important in Mediterranean areas

The necessity to improve seedling quality clearly emerges …

…and there is room for improvements:



Even for pines species

Pinus halepensis.
(Oliet et al., 1997, 2009)

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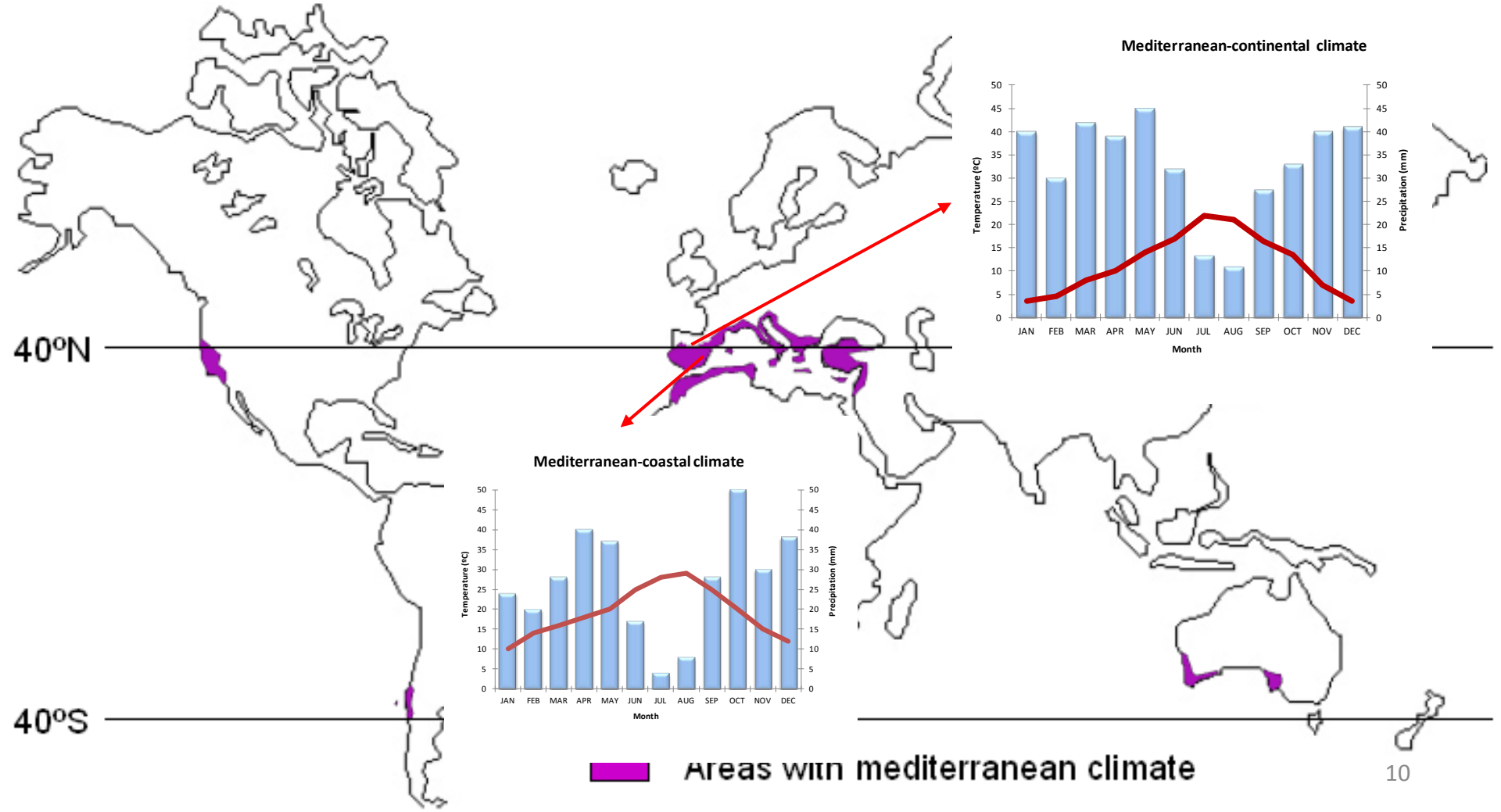
A Mediterranean perspective?

Specificities about artificial regeneration in the Mediterranean

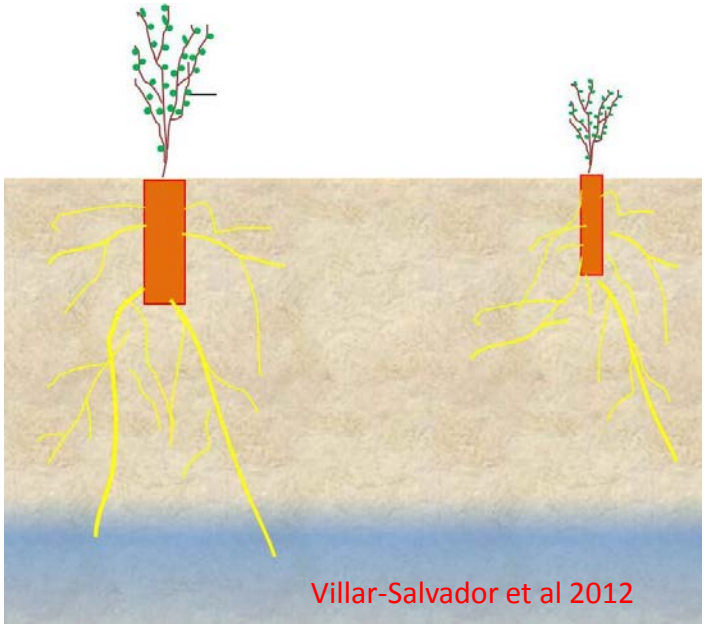
Specificities about Mediterranean artificial regeneration

- Mediterranean climate
  - Strong summer drought preceded by unpredictable springs



Specificities about Mediterranean artificial regeneration

- **Field constraints and facts**: planting window. We must plant *asap*, from early fall rains to February



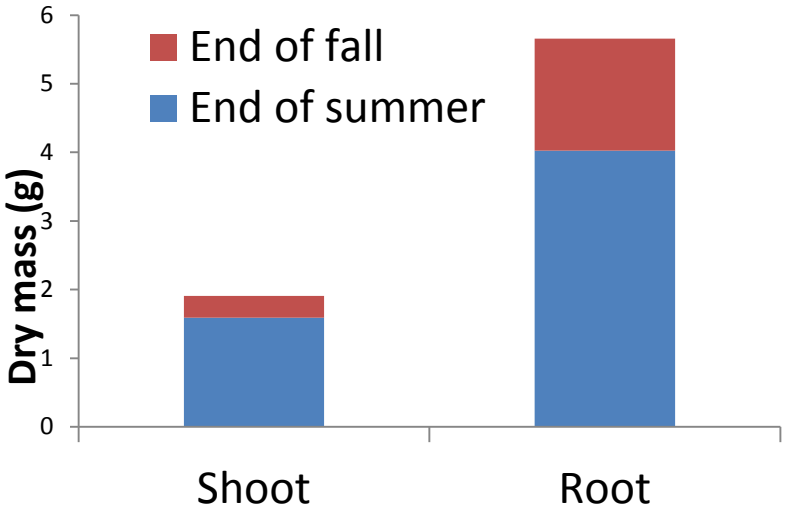
➢Seedlings must emit new roots in depth as soon as possible to avoid subsequent summer drought

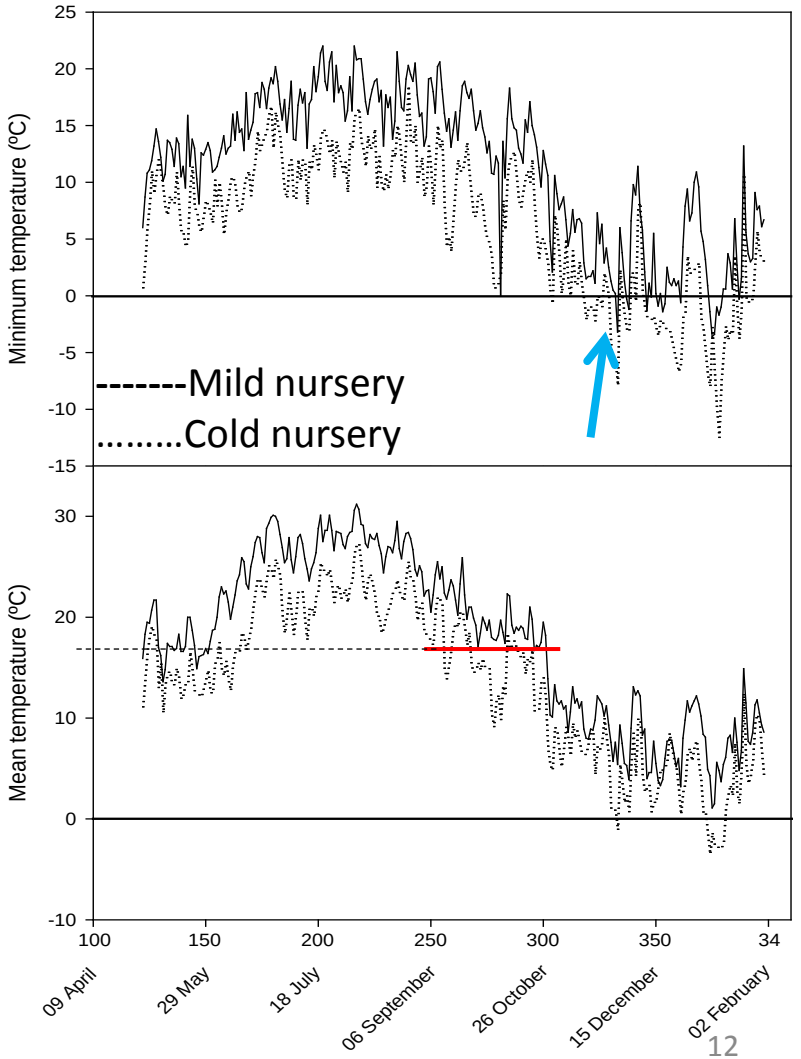
➢Early frost after planting in fall can damage the seedlings

D. Close

- **Nursery production facts**.

  Raising seedlings outdoors:
  - **Frosts** occur during fall in inland (continental) nurseries (*hidden death* of seedlings prior to plantation)
  - **Late growth** occurs during fall in mild (coastal) nurseries:





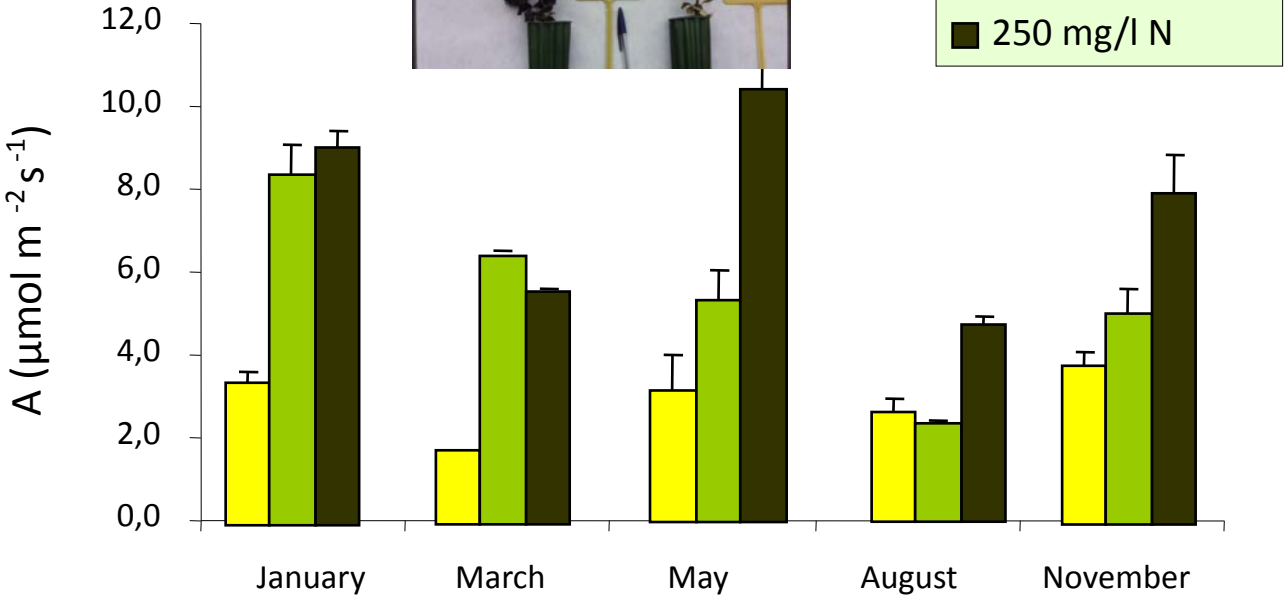
Andivia et al 2011, *Quercus ilex*

Importance of seedling nutrient status at planting in Mediterranean zones: why loading?

Why loading in Mediterranean zones?

- **Photosynthesis activation** to resume growth after planting is strongly related to nutrient **(mostly N)** status

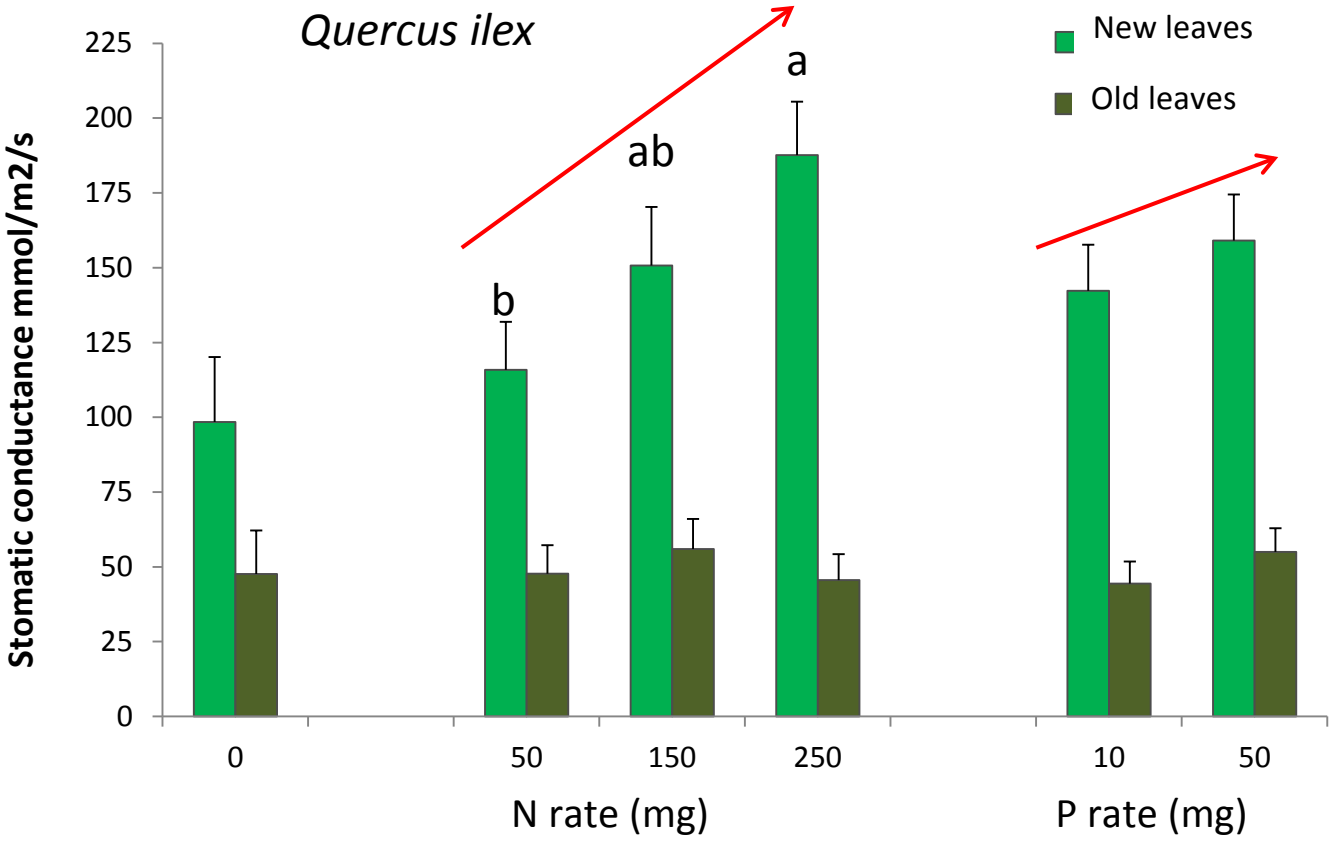
Ceratonia siliqua



(Planelles 2004)

Why loading in Mediterranean zones?

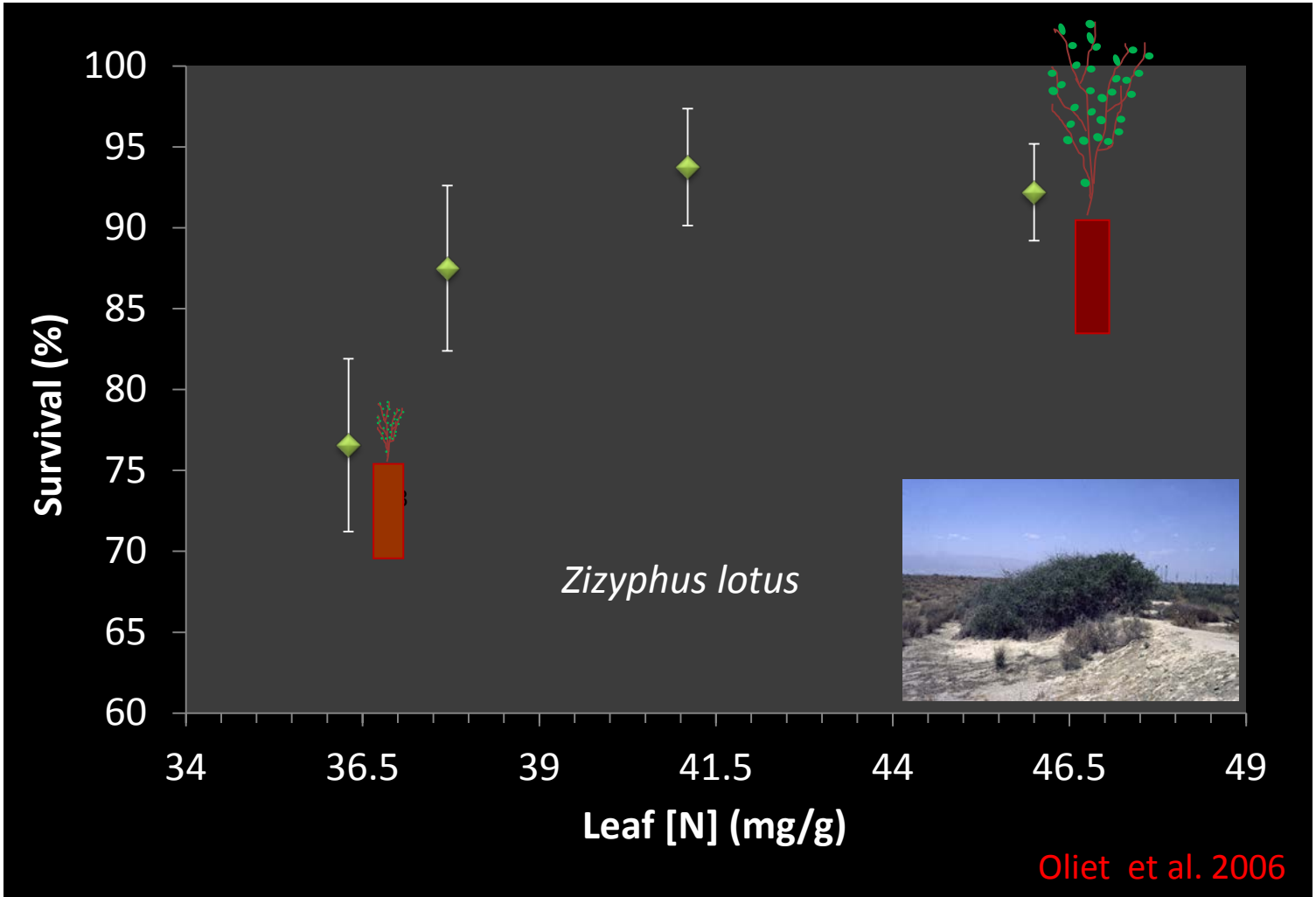
- Nitrogen loaded seedlings of sclerophyllous species increase stomatic conductance after planting



(Oliet et al. unpub data)

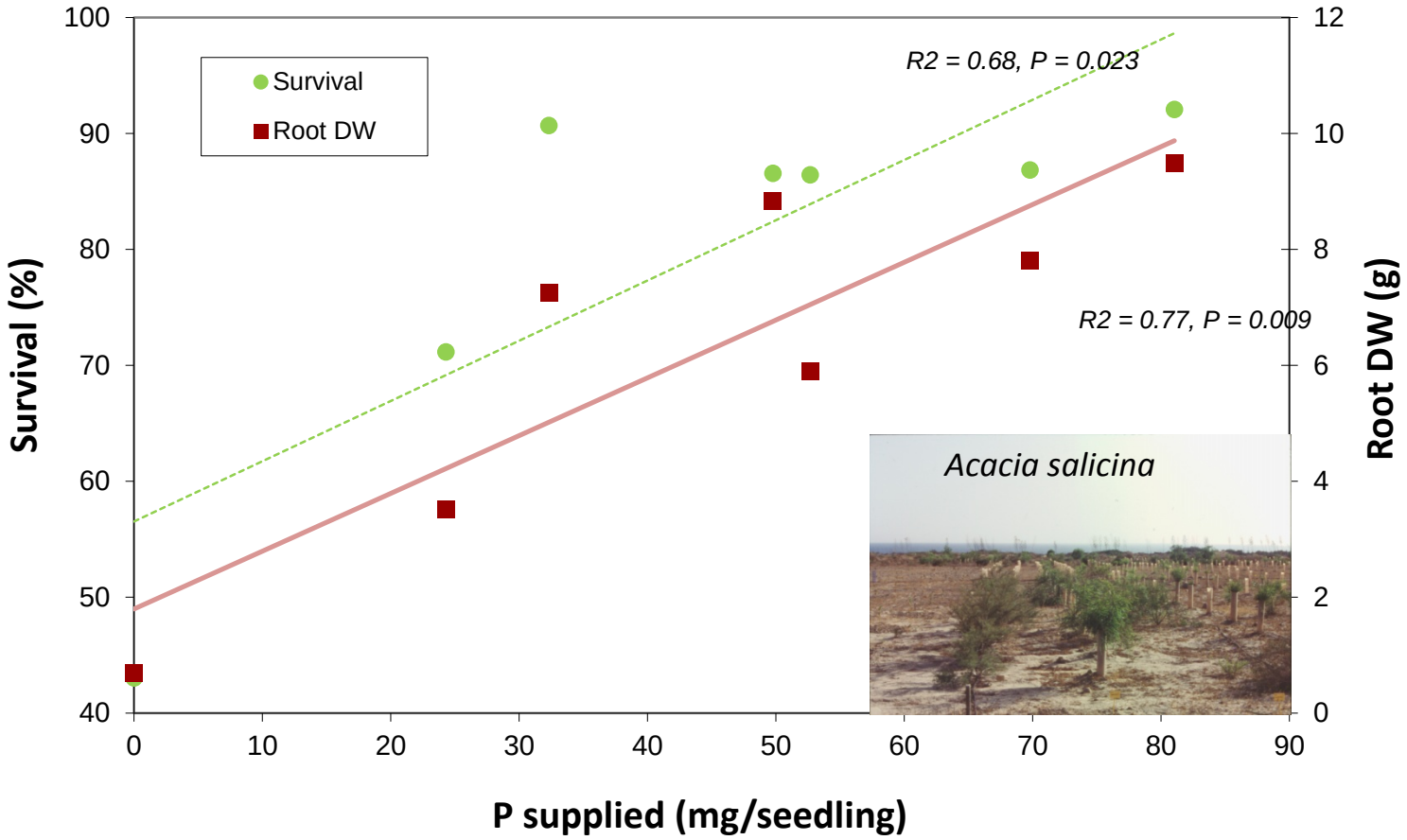
Why loading in Mediterranean zones?

- A large body of evidence shows how nitrogen loaded seedlings survive better under very dry conditions



Why loading in Mediterranean zones?

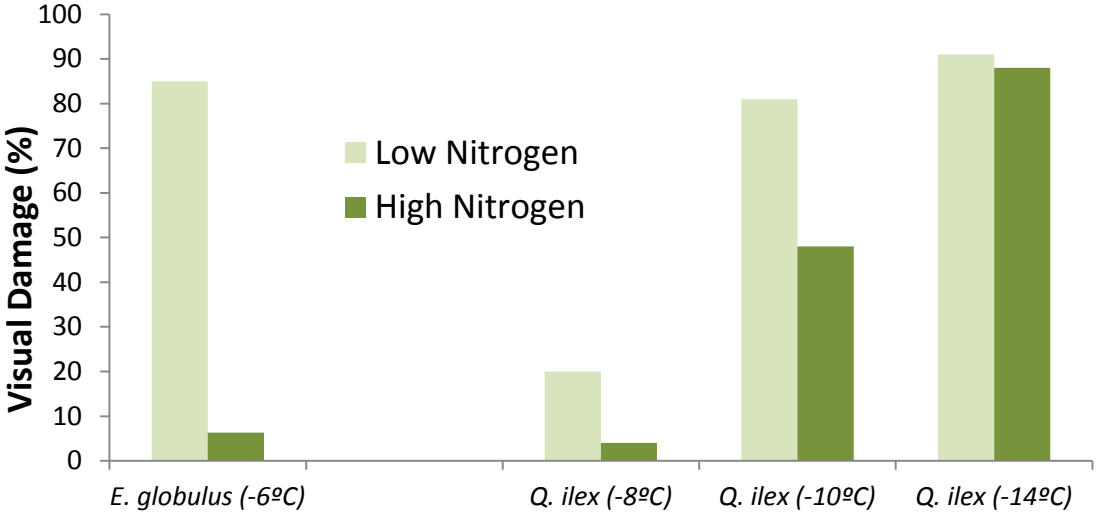
- Is only nitrogen? **Phosphrus** loaded seedlings also show a superior response afer planting



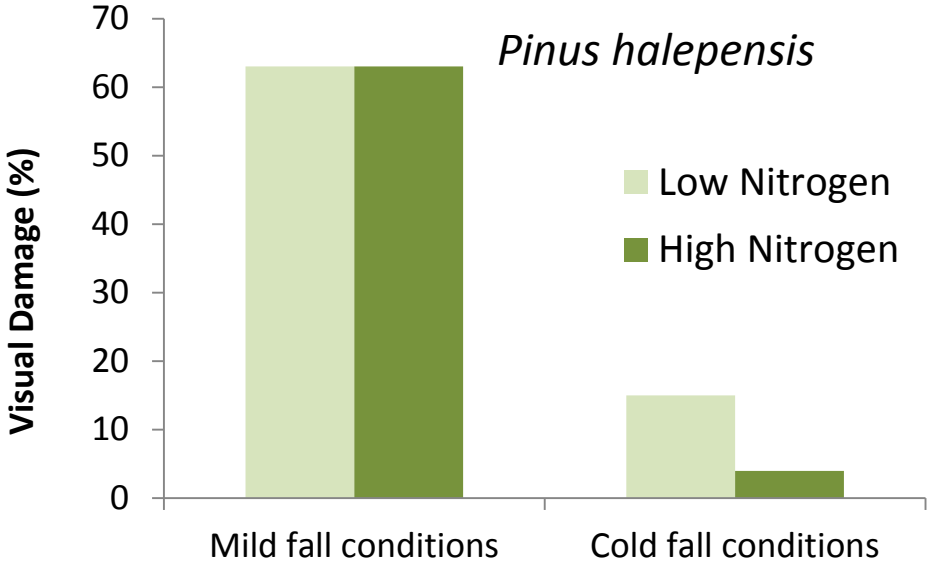
Oliet et al. 2005

Why loading in Mediterranean zones?

- **Cold resistance** of seedlings in both nursery and plantations can be critical Cold resistance is closely related to nutrient (mostly N) status



Fernández et al. 2007
Andivia et al., 2011

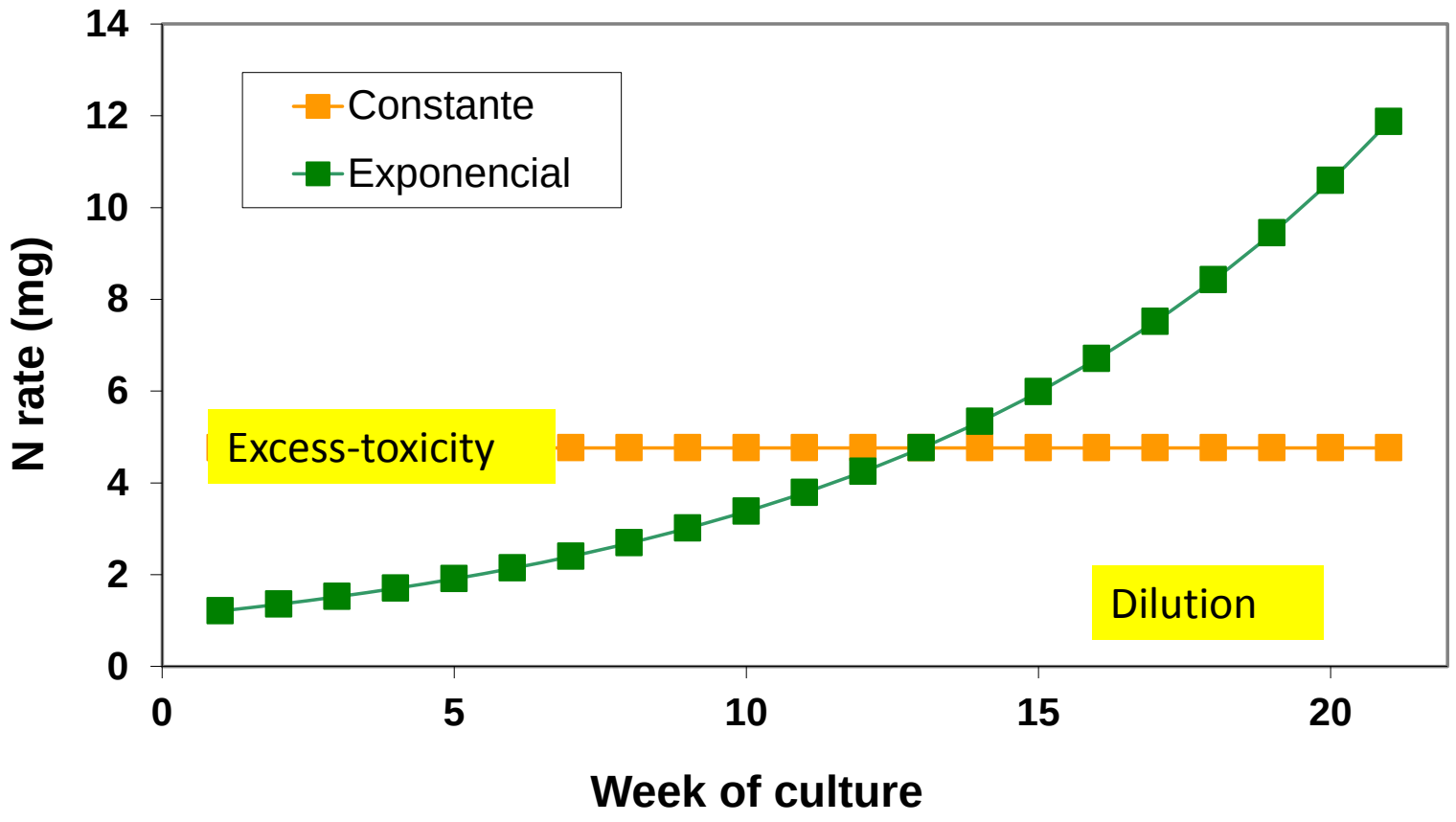


Interaction N × environment on frost resistance

Puértolas et al. 2005

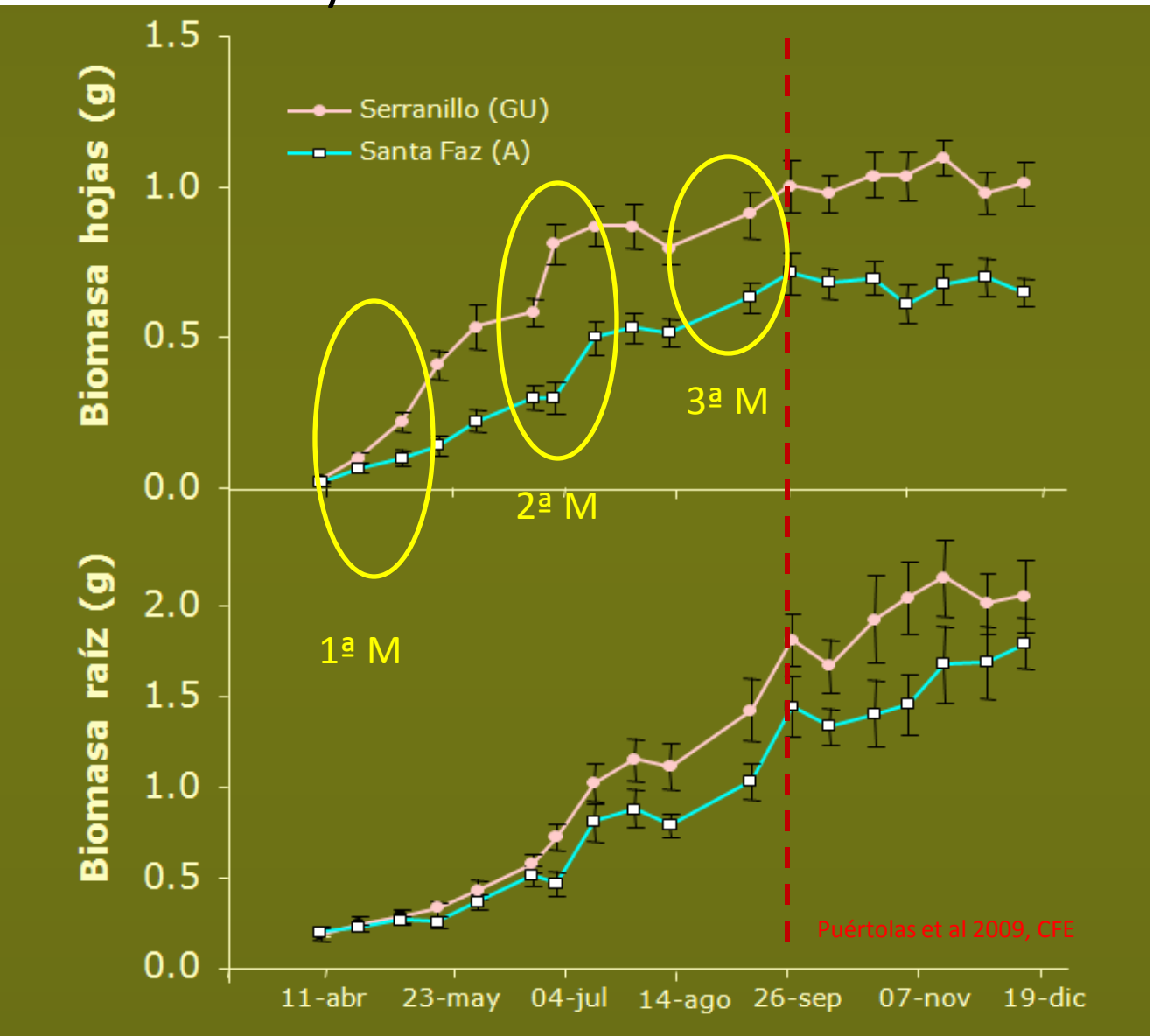
How can we nutrient load our seedlings in Mediterranean nurseries?

- Is exponential regime effective in nutrient loading every species?



Nutrient loading in Mediterranean nurseries

- Oak species like *Quercus ilex* exhibits a rhythmic growth pattern in the nursery:

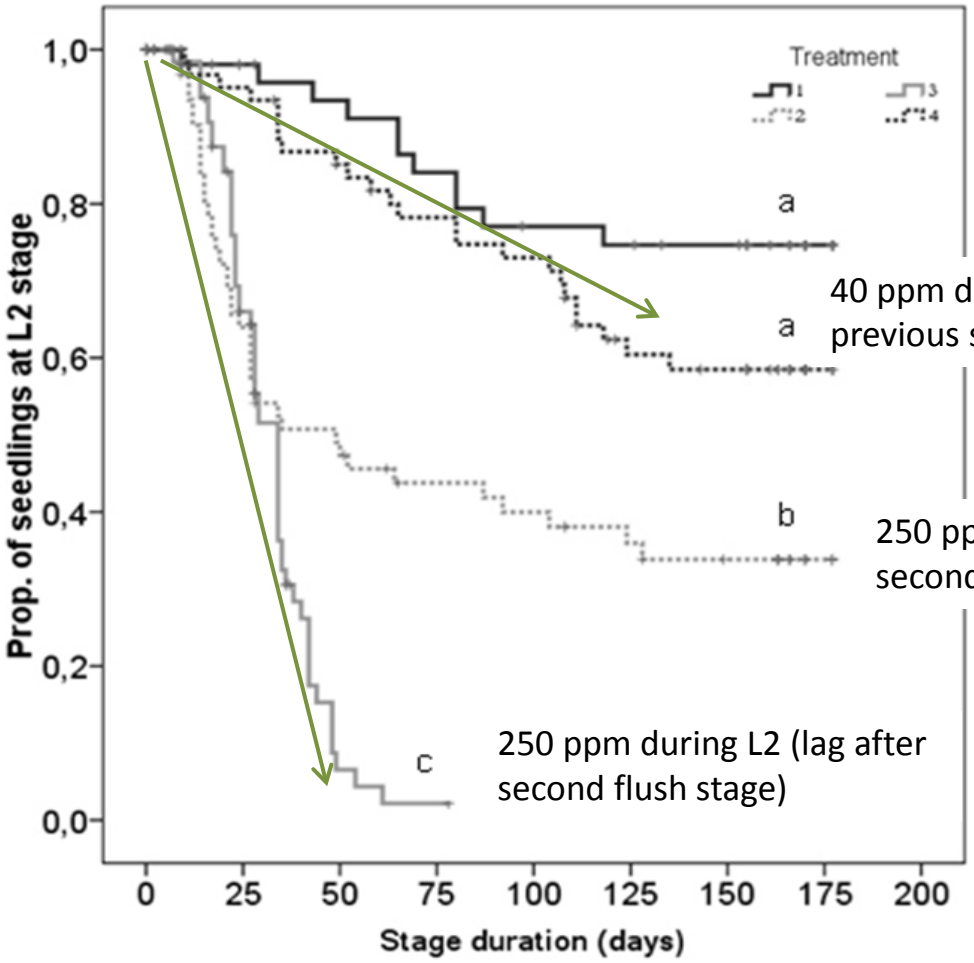


Several active growth periods are followed by lag stages
Those intervals are not synchronized

Roots still growth during late fall

Nutrient loading in Mediterranean nurseries

- How nutrient availability during growth affects ontogeny of species with rhythmic growing pattern *(Quercus ilex)*:



40 ppm during previous stages

250 ppm during second flush stage

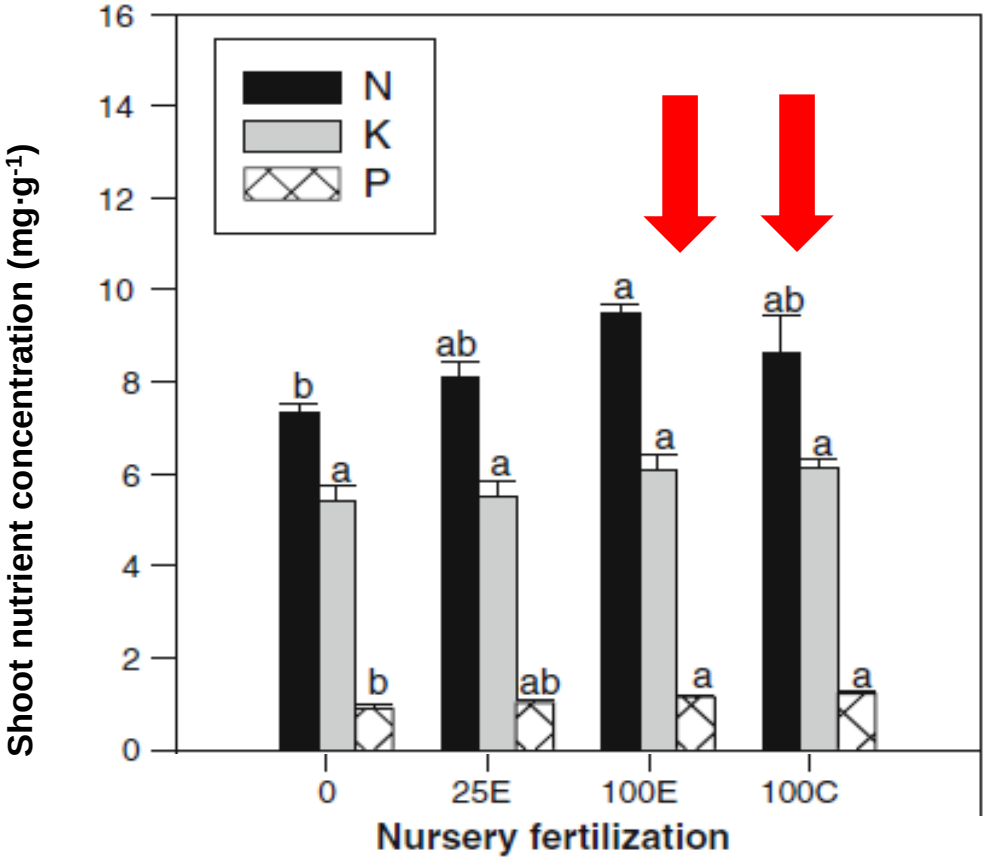
250 ppm during L2 (lag after second flush stage)

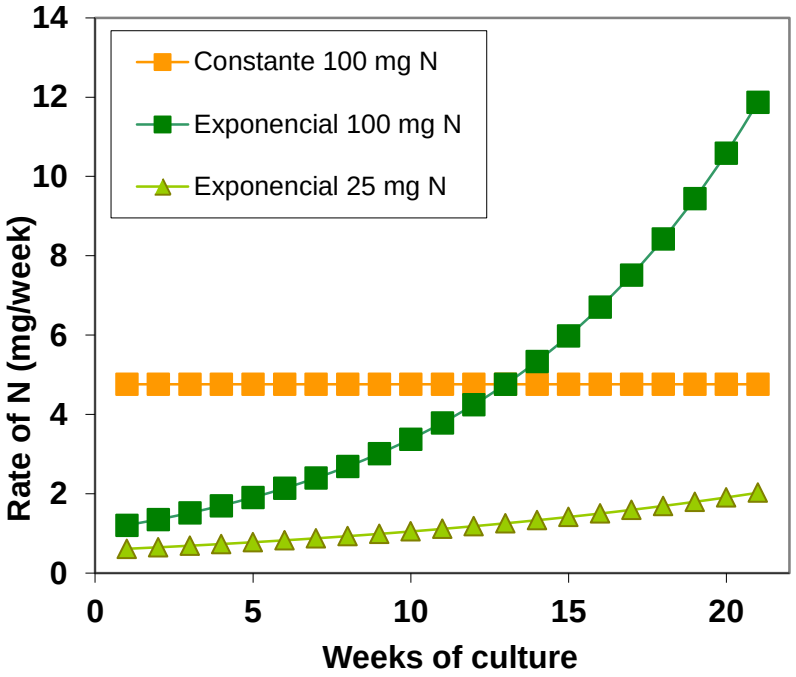
1. Higher synchronicity for highly fertilized seedlings during second lag
2. More seedlings reaching advanced stages in ontogeny

Vizcaino et al. In preparation

Nutrient loading in Mediterranean nurseries

- Potential ability of exponential regime to nutrient load species with growth patterns at intervals is very low

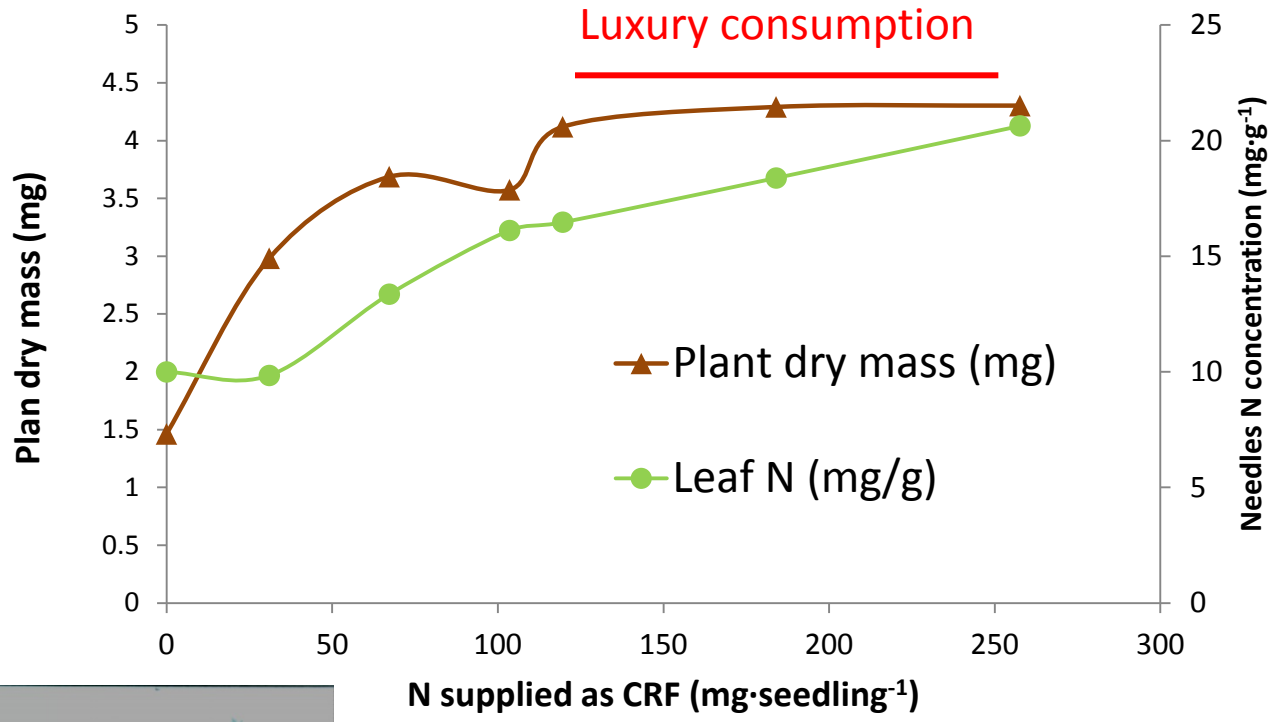


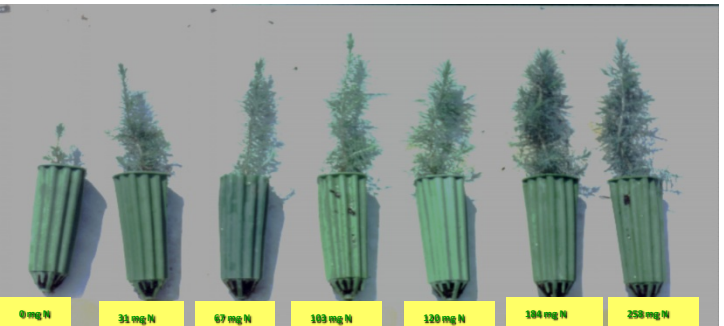


Quercus ilex (Oliet et al. 2009)

Nutrient loading in Mediterranean nurseries

- **Controlled release fertilizers** are a good alternative to nutrient load seedlings by using high rates with high fertilizer recovery





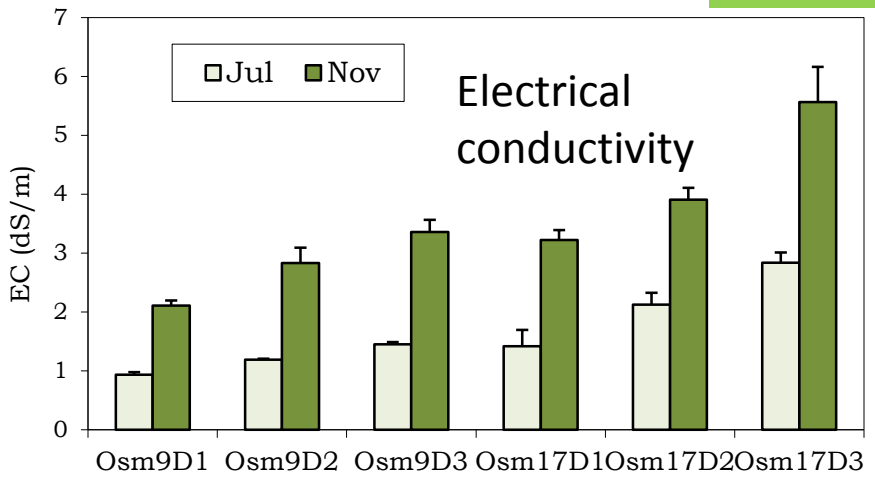
Pinus halepensis

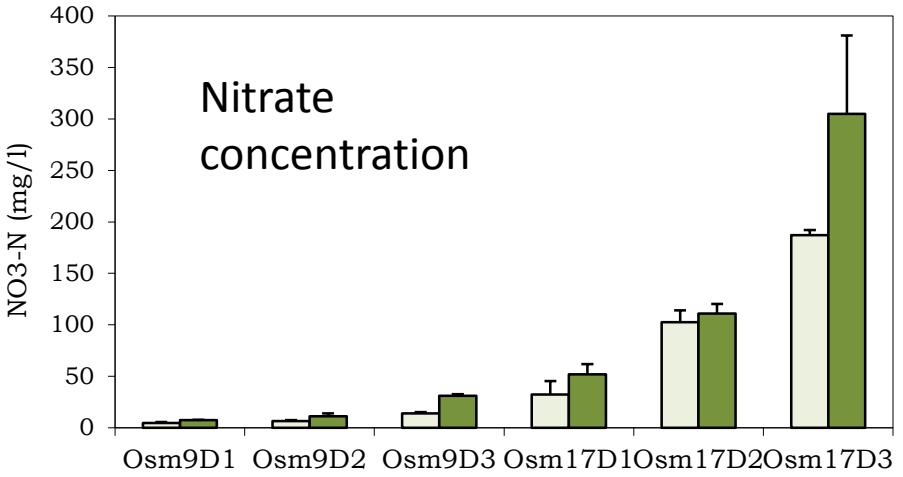
Oliet et al 1999

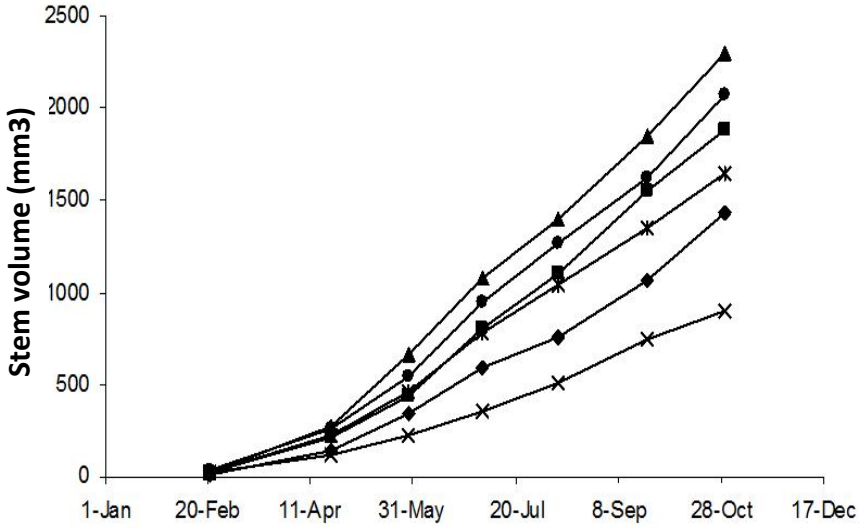
Nutrient loading in Mediterranean nurseries

- **CRF** provide nutrients till late fall to avoid nutrient dilution

Saturation extract







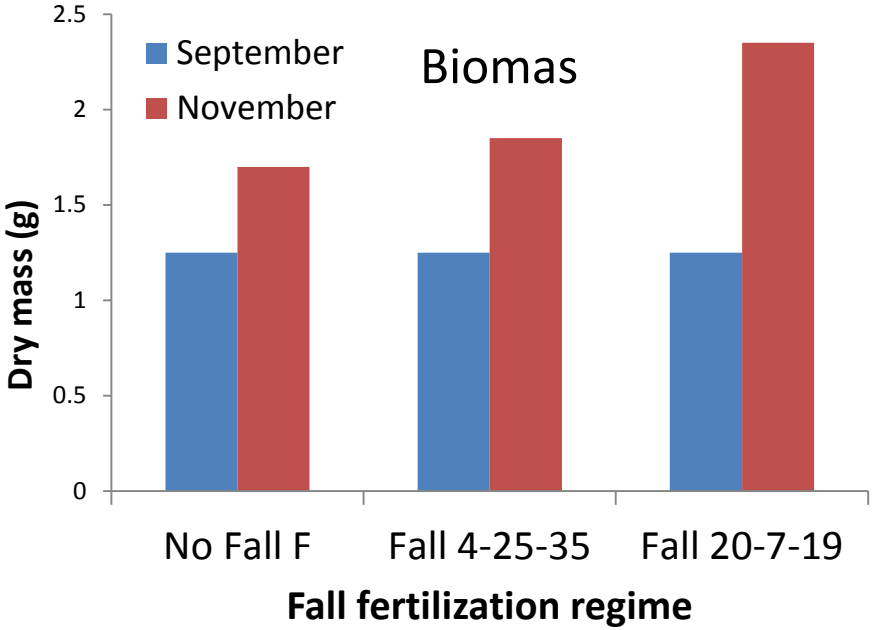
Pinus halepensis

Oliet et al 2004

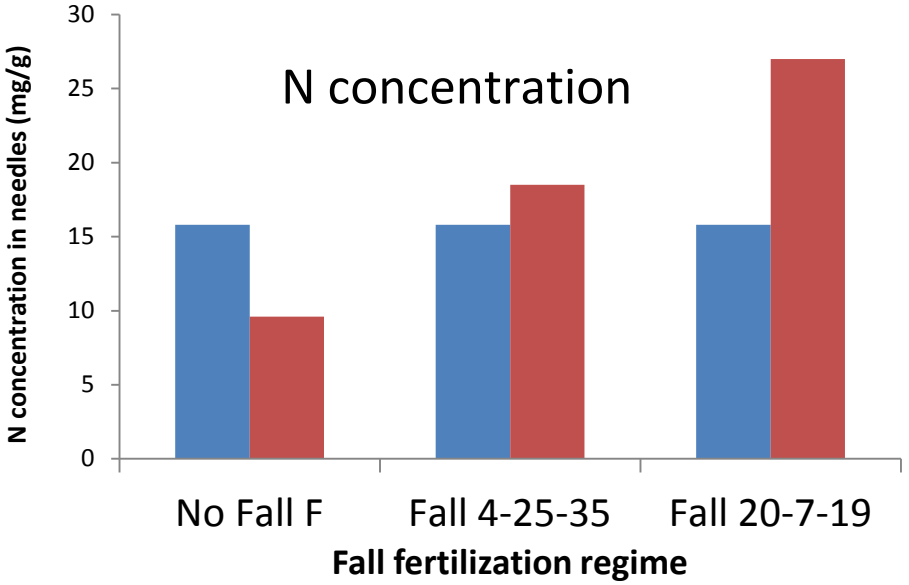
Nutrient loading in Mediterranean nurseries

- **Nutrient dilution** during fall occurs precluding nutrient loading. Is fall fertilization a solution?

Fall fertilization promotes growth …



… but also nutrient loading

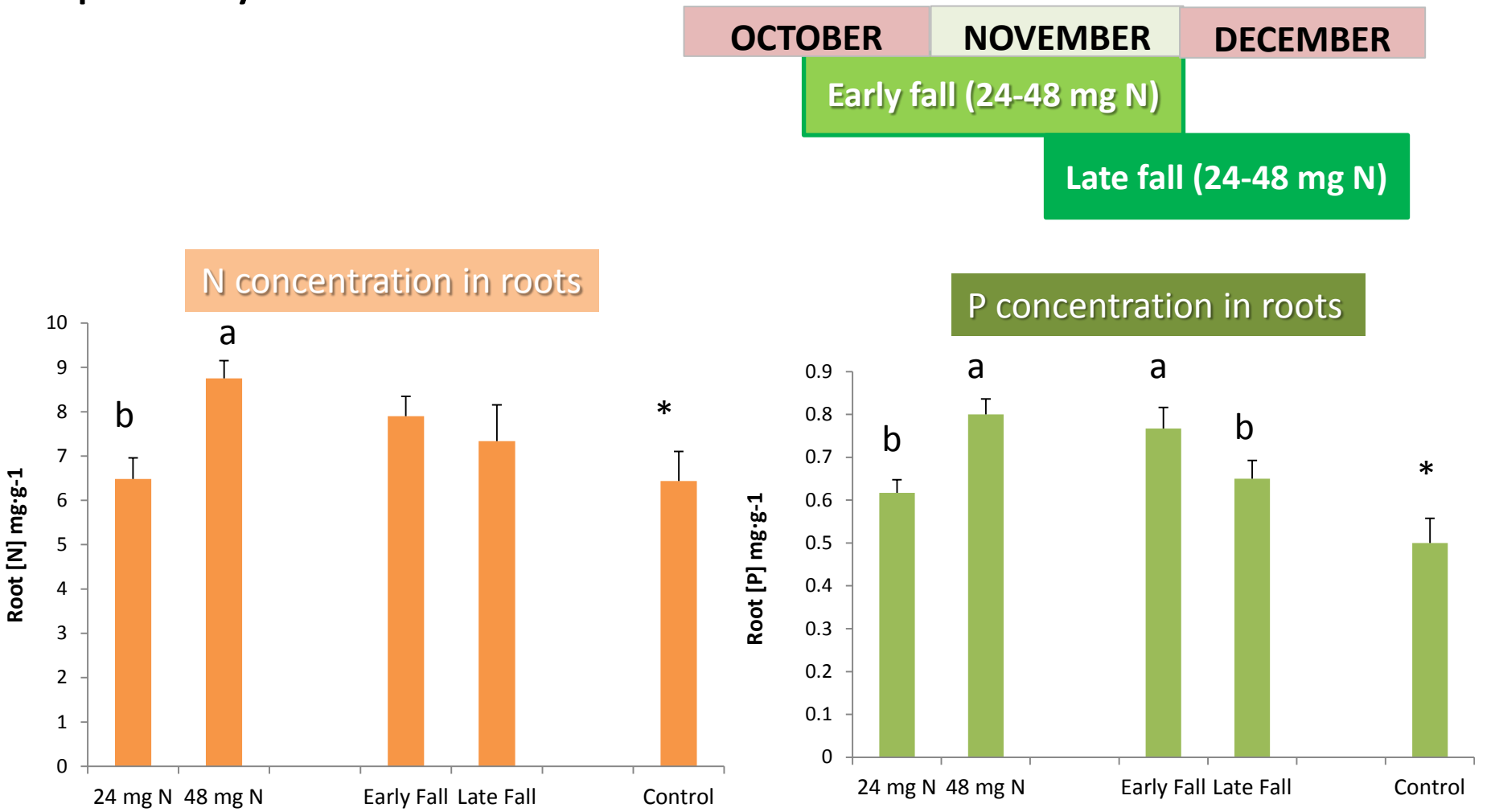


Pinus halepensis

Puértolas et al unpub data

Nutrient loading in Mediterranean nurseries

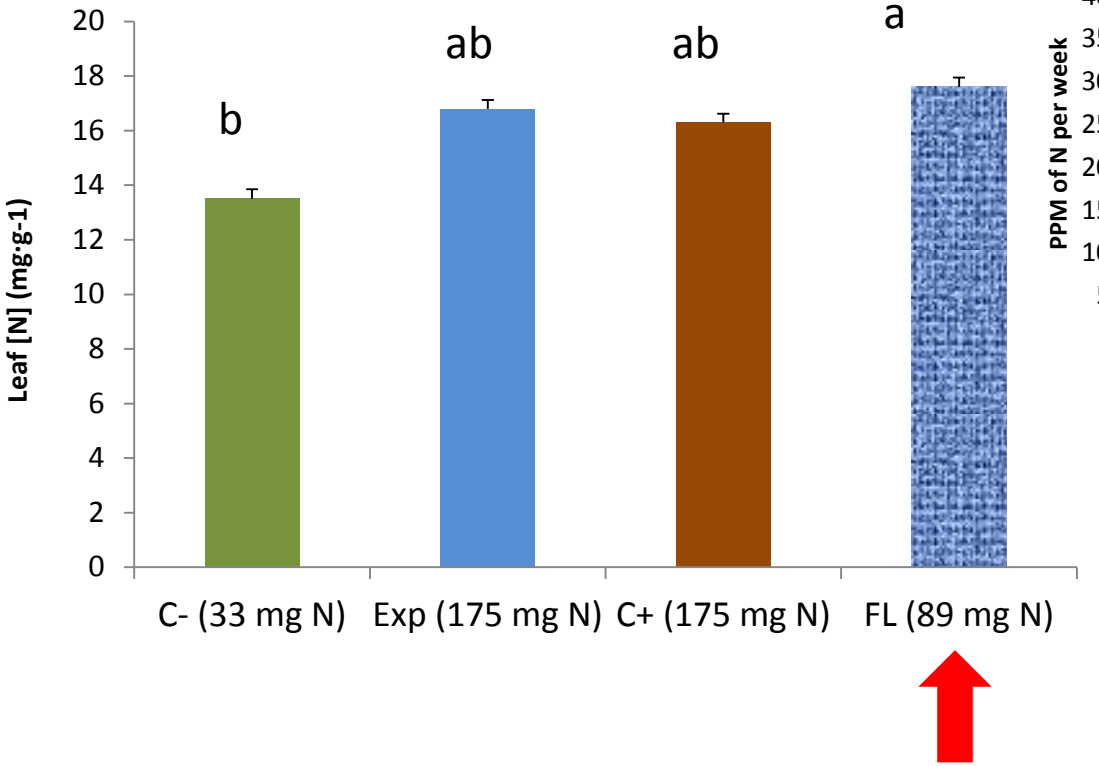
- **Early** fall fertilization is more effective to load Holm oak, specially with P

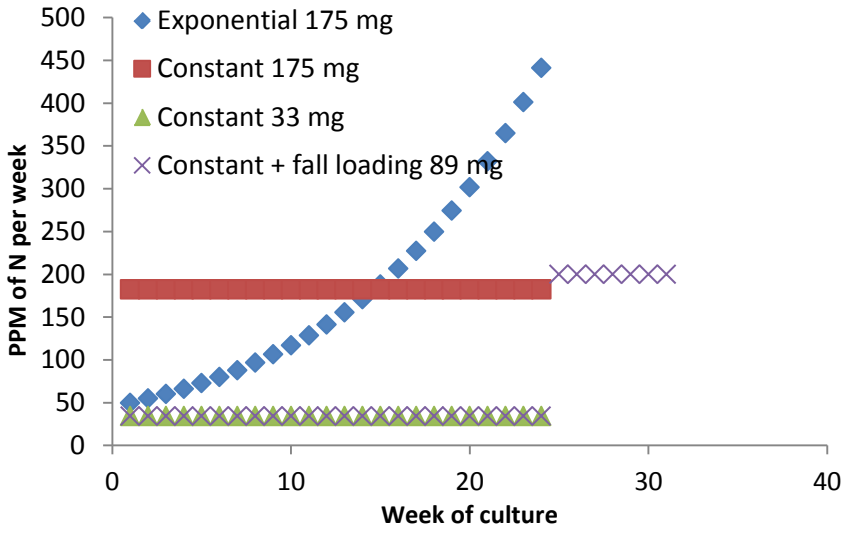


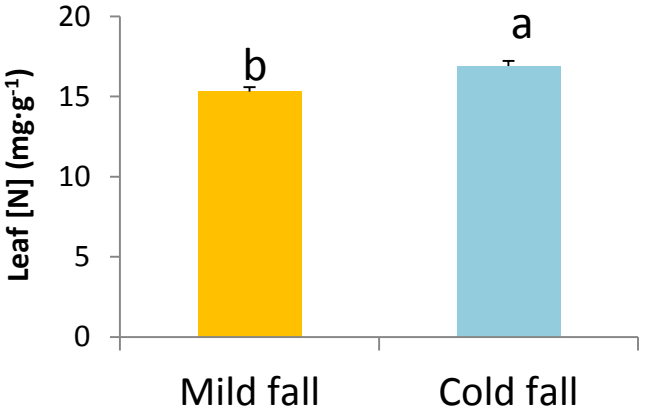
Oliet et al. 2011

Nutrient loading in Mediterranean nurseries

- Fall fertilization is an adequate strategy to nutrient load these species (Holm oak)







Fall fertilization seems more effective in cold fall nurseries

Heredia et al (in prep)

Future research

- Developing fertilization programs for Mediterranean species of interest to reach effective nutrient loading:
  - Improve the knowledge of specific growing patterns in the nursery
  - Understand nutrient dynamics during hardening and fall (uptake and remobilization) to improve efficiency of late season fertilization
  - Improve knowledge of interactive relationships between cold acclimation, nutrient uptake and environment during hardening. Cold resistance of roots deserves special attention.

Thank you very much! ¡Muchas gracias!

Special thanks to people from:

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