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Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007

Climate Change
and
Seed Germination
- a scientific and technical approach

Costas Thanos - UNKA

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SEED: the most tolerant stage in the life cycle of a plant

SEEDLING: the most vulnerable stage in the life cycle of a plant

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Dormancy types vs Germination strategies

Instead of studying Dormancy Types we should concentrate on Germination Strategies

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The GERMINATION STRATEGY is a long term plan of action designed to achieve the particular goal of the successful transition from the seed stage to the seedling stage.

A GERMINATION STRATEGY encompasses various adaptations (or adaptive traits) at the structural and physiological level during:

seed maturation
post-dispersal / pre-germination
germination (s.s.)

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GERMINATION ADAPTIVE TRAITS I (MATURATION)

- Life history of seed maturation
- Conditions of seed maturation
- Desiccation tolerance

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GERMINATION ADAPTIVE TRAITS II (POST MATURATION)

- Dispersal
- Predation
- Soil and canopy seed banks
- Seed viability

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GERMINATION ADAPTIVE TRAITS III (PREREQUISITES)

- An undeveloped (or underdeveloped) embryo
- An ‘after-ripening’ requirement
- Hard (water-impermeable) seed/fruit coats
- Chemically inhibiting substances in the germination unit
- A (cold or warm) stratification need

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GERMINATION ADAPTIVE TRAITS IV (GERMINATION s.s.)

- Temperature range
- Light quality and quantity
- Speed (rate) of germination
- Osmotic and salinity stress
- Promoting or inhibiting chemicals
- Season of field germination

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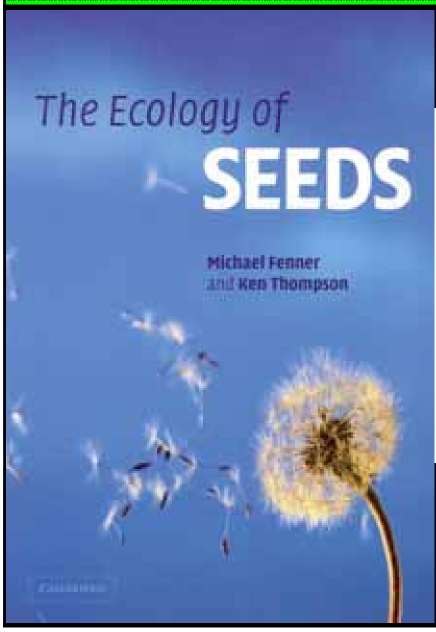

5 Seed dormancy 97
5.1 Types of seed dormancy 97
5.2 The function of seed dormancy 98
5.3 Defining dormancy 99
5.4 Microbes and seed dormancy 103
5.5 Effects of parental environment on dormancy 104

6 Germination 110
6.1 Temperature and germination 110
6.2 Responses of seeds to light 116
6.3 Water availability during germination 121
6.4 The soil chemical environment 123
6.5 Effects of climate change 131

6.5 Effects of climate change

The consequences of climate change for regeneration from seeds are likely to be complex and far-reaching, and some effects go beyond what can reasonably be considered here.

Regeneration from seed is generally expected to benefit from climate warming, but perhaps this is because attention has tended to focus on the colder parts of the globe. For example, alpine populations of *Gentianella germanica* may set hardly any seed in cool years and would be expected to produce more regular seed crops in a warmer climate (Wagner & Mitterhofer, 1998). Similarly, the phenology of *Dryas octopetala* was advanced by experimental warming at four tundra sites (Welker *et al.*, 1997). Enhanced seed maturation, germination and seedling survival of the only two native Antarctic vascular plant species (*Colobanthus quitensis* and *Deschampsia antarctica*) seems to be a more sensitive indicator of climate change in west Antarctica than the response of the dominant cryptogams (Smith, 1994). However, improved seed production does not necessarily translate into larger populations of Arctic and alpine plants. Neither alpine *Ranunculus acris* nor three Arctic and alpine populations of *Saxifraga oppositifolia*

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Une traité récente synthétique du sujet (Fenner & Thompson 2005) a conclut que les conséquences du changement climatique sur la régénération par semences sont probablement très compliquées. Quelques aspects de la biologie reproductive que puissent être impliquées et influencées sont: l'augmentation ou la diminution de la régularité de la production des semences aux plantes alpines ou maritimes, respectivement, des types altérés de 'masting' aux arbres et arbustes, l'augmentation ou la diminution de la production des semences aux limites extrêmes de la distribution d'un espèce avec une changement parallèle de la distribution, le délai ou l'inhibition complète de la germination et de l'émergence de la plantule aux conditions de plus en plus arides de la saison de la recrutement habituelle (automne ou printemps), l'échec (ou timing inapproprié) de recevoir des 'doses' suffisantes des exigences climatiques spécifiques, comme post-maturation, stratification etc que induisent la germination.

Effects of climate change on:

- Flowering and reproduction (in general)
- Seedling survival and establishment
- Seed yield and maturation (incl. masting)
- Soil seed banks
- Seed germination requirements

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Effects of climate change on
Seed germination requirements:

- Underdeveloped embryo
- Afterripening
- Hard seed coat
- Soil moisture (for recalcitrant seeds)
- Stratification
- Rate (speed) of germination
- Temperature

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CASE STUDY I

Cistus spp.
(fire-adapted rockroses)

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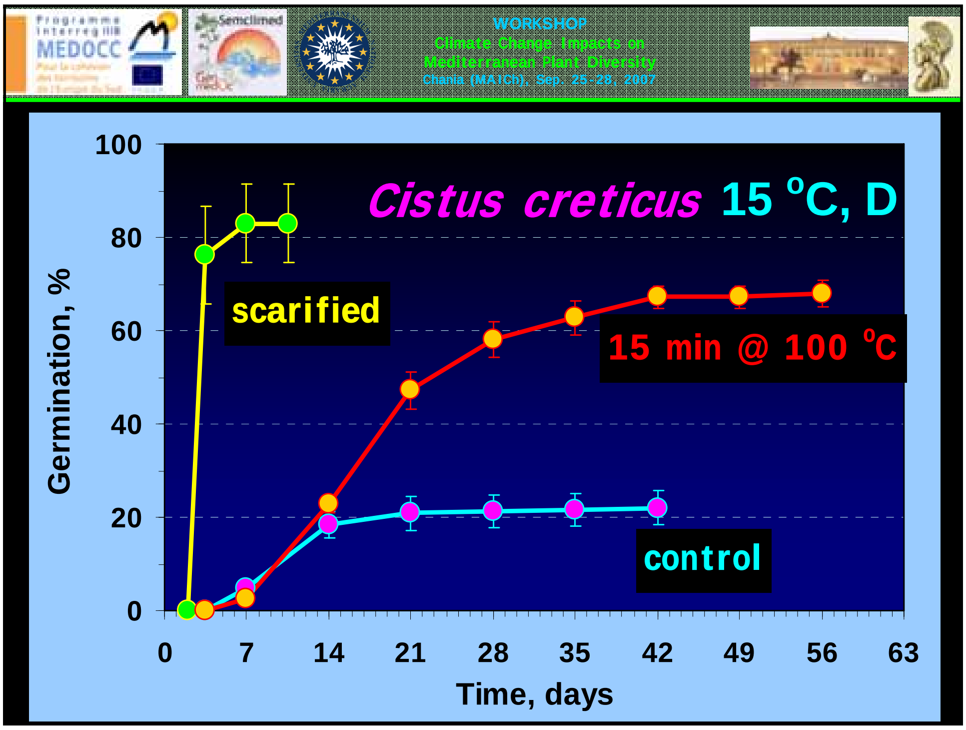

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Chania (MAICh), Sep. 25-28, 2007

Moreover, (in *Cistus creticus*) the promotive effect caused by fire or thermal shock seems to be clearly different from that brought about by mechanical scarification.

This latter treatment results in an impressive enhancement of germination which is completed in less than 1 week. On the other hand, a thermal pretreatment does allow the penetration of water but the eventual germination is markedly slow.

(Thanos & Georghiou, Plant, Cell & Environ. 1988)

CASE STUDY II

Coridothymus capitatus

(thyme)

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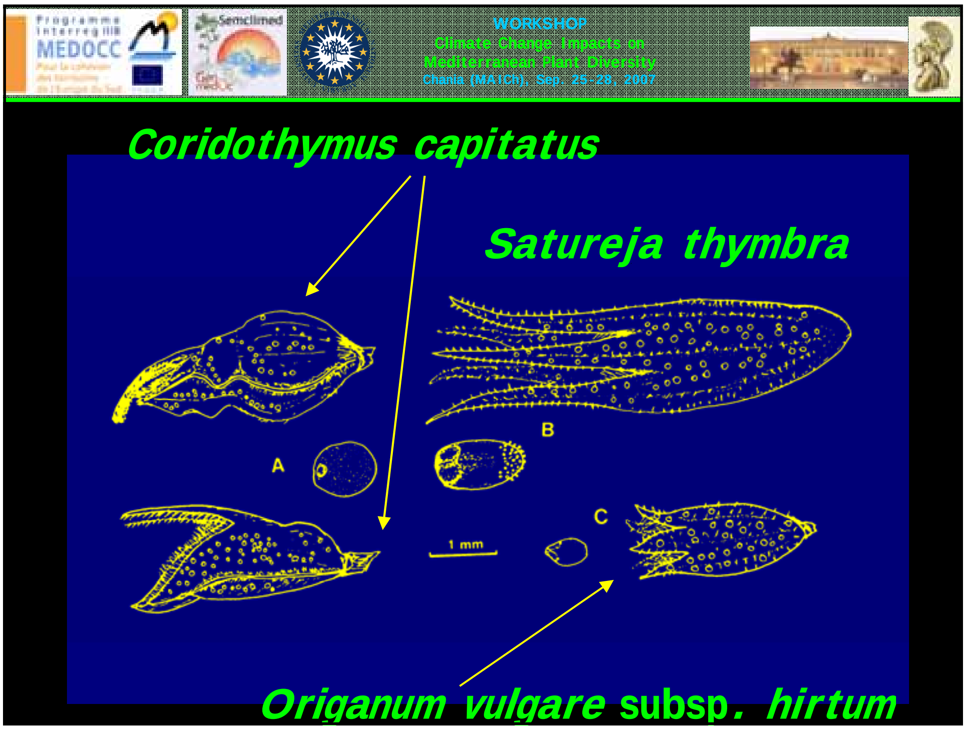
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Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Coridothymus capitatus
Satureja thymbra
A
B
C
1 mm
Origanum vulgare subsp. hirtum


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Coridothymus capitatus

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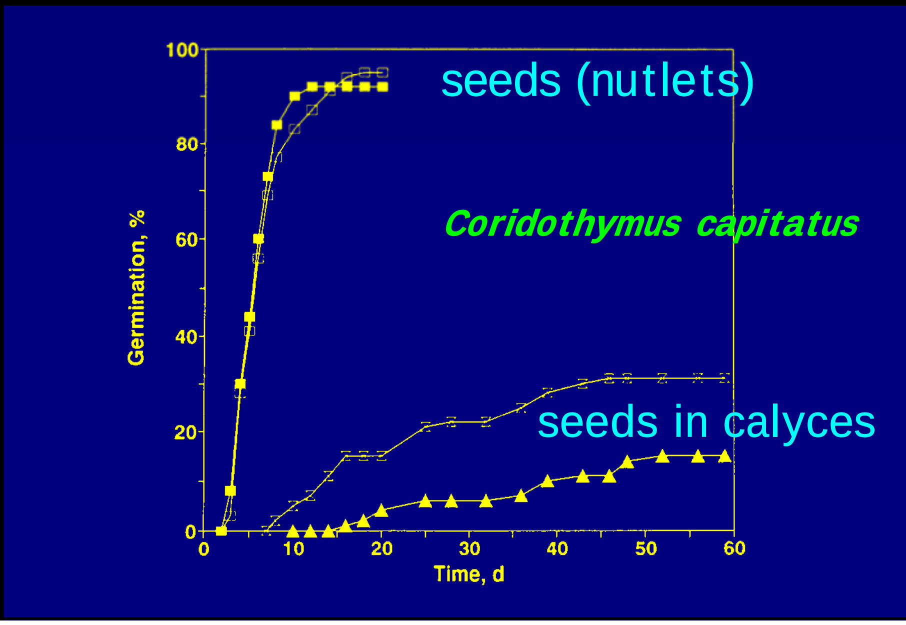

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CASE STUDY III

Aesculus hippocastanum

(the Balkan Horse-chestnut)

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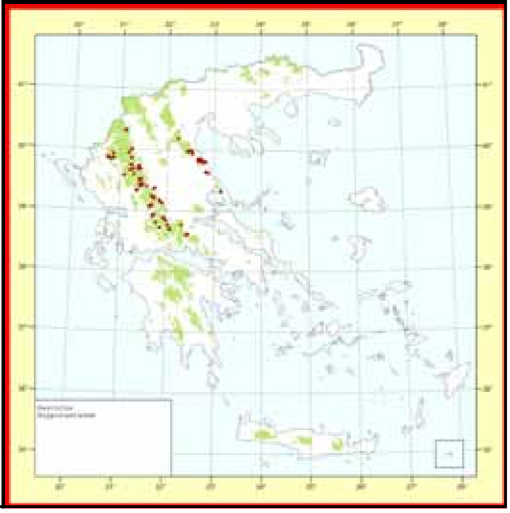
Chania (MAICh), Sep. 25-28, 2007

Aesculus hippocastanum



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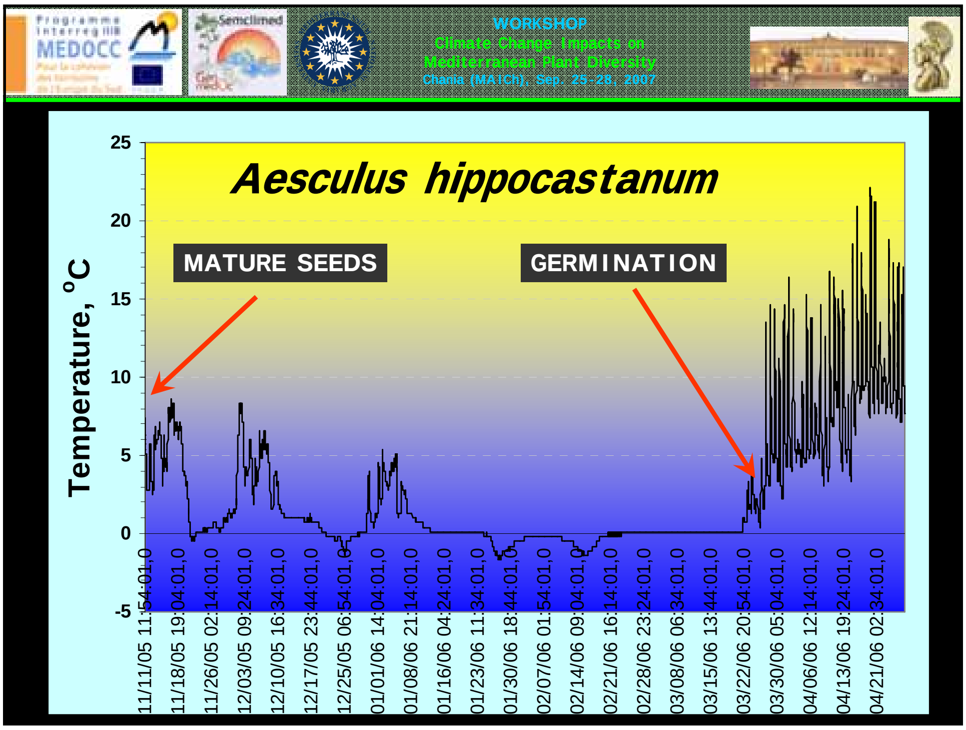
Aesculus hippocastanum

Water content of seeds: 52.3 % (fwb)

Seeds can germinate without any external water supply after a period of 6-month storage at 5 °C



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CASE STUDY IV

Anthemis glaberrima

(an endangered Cretan endemic annual)


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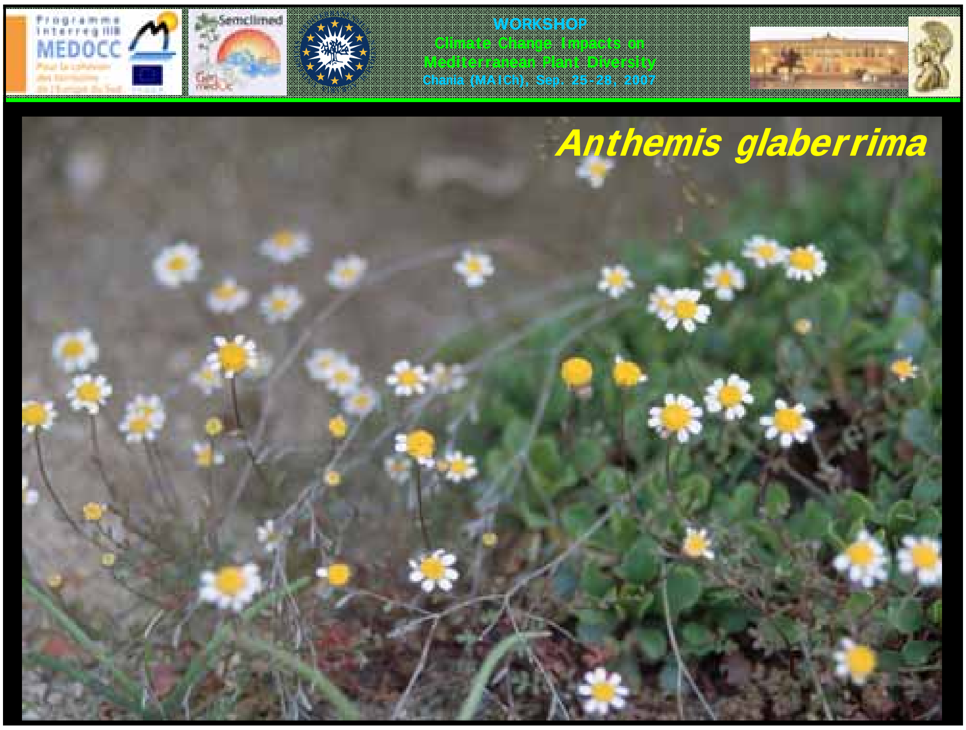
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Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Anthemis glaberrima

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Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007

Anthemis glaberrima

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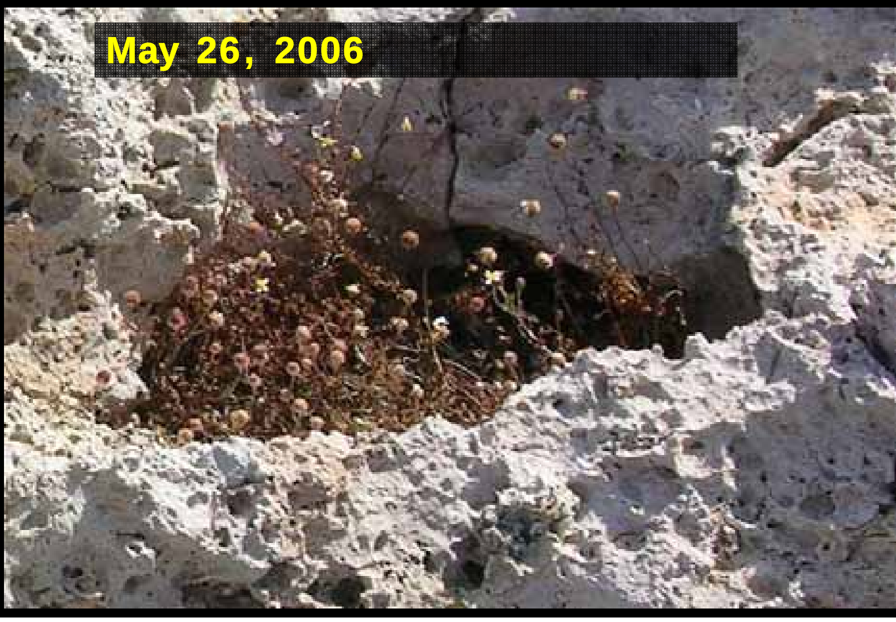
Chania (MAICh), Sep. 25-28, 2007



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December 3, 2006

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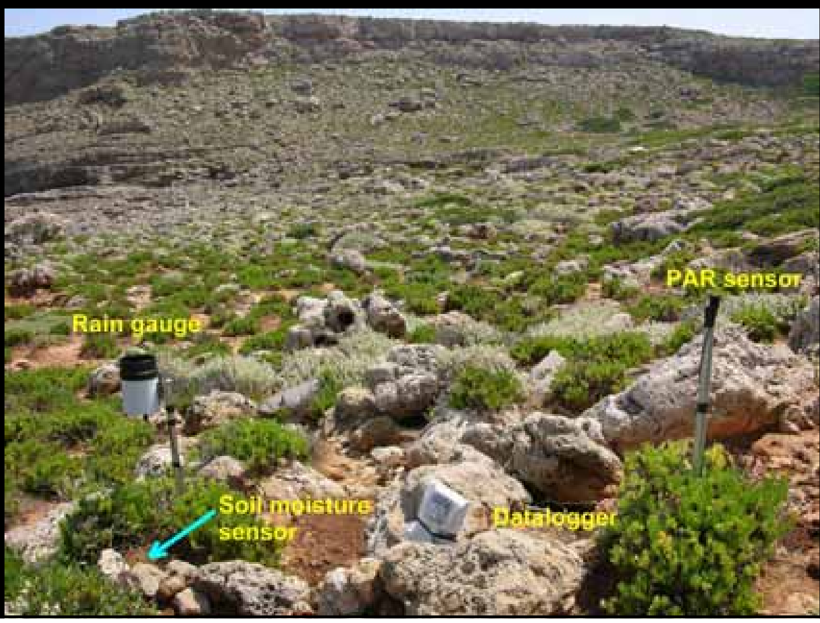

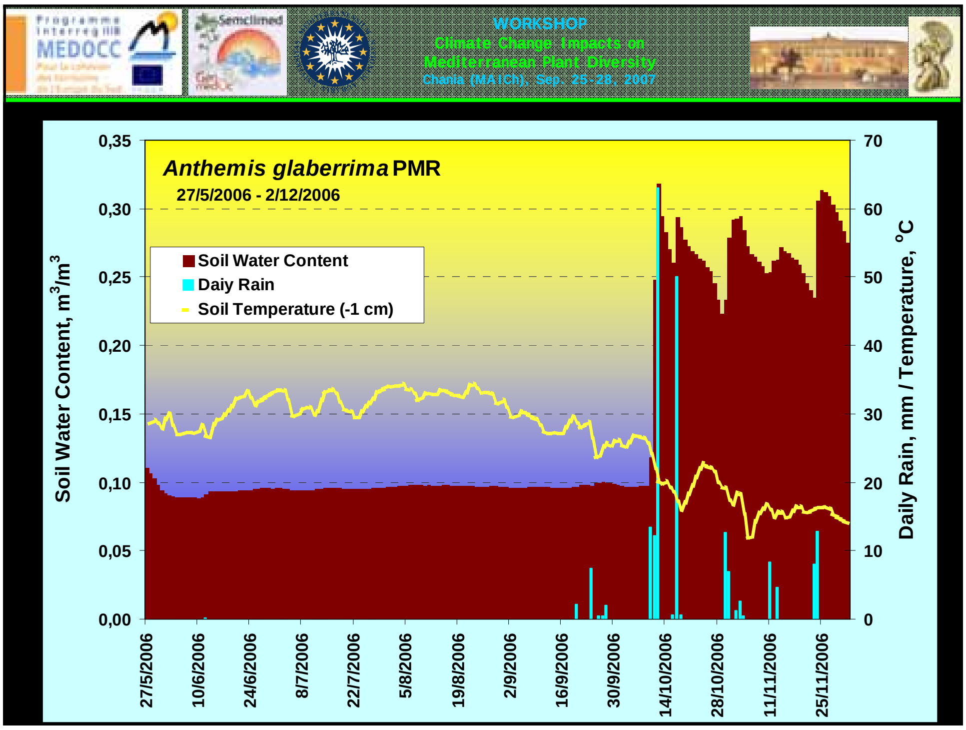
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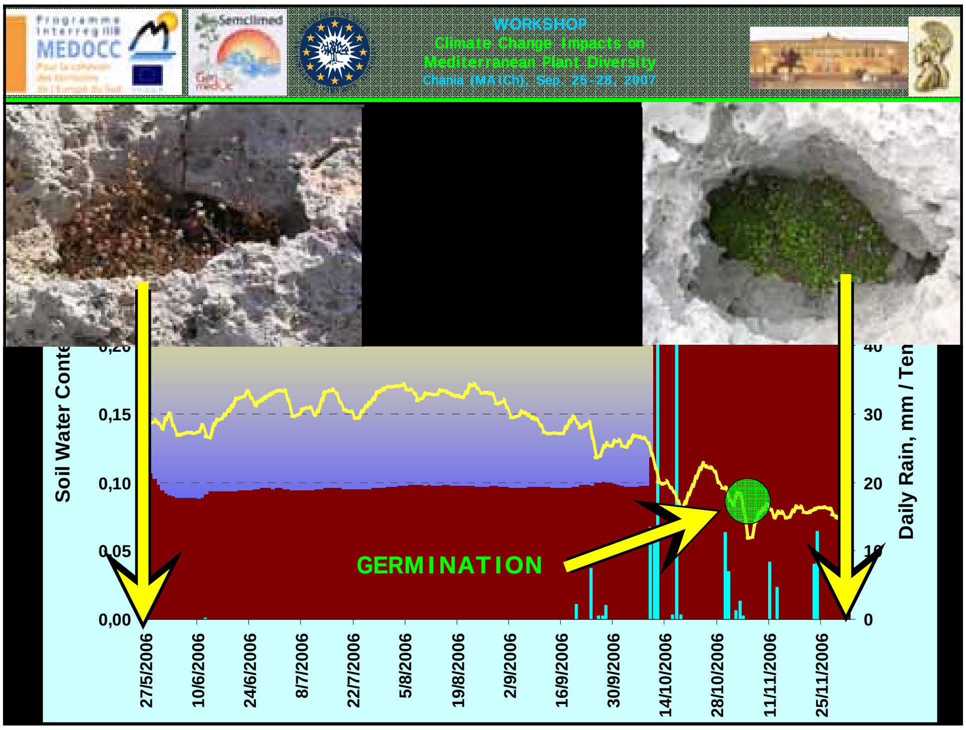
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Anthemis glaberrima PMR
27/5/2006 - 2/12/2006
Soil Water Content
Daiy Rain
Soil Temperature (-1 cm)
Soil Water Content, m3/m3
Daily Rain, mm / Temperature, °C
0,35
0,30
0,25
0,20
0,15
0,10
0,05
0,00
70
60
50
40
30
20
10
0
27/5/2006
10/6/2006
24/6/2006
8/7/2006
22/7/2006
5/8/2006
19/8/2006
2/9/2006
16/9/2006
30/9/2006
14/10/2006
28/10/2006
11/11/2006
25/11/2006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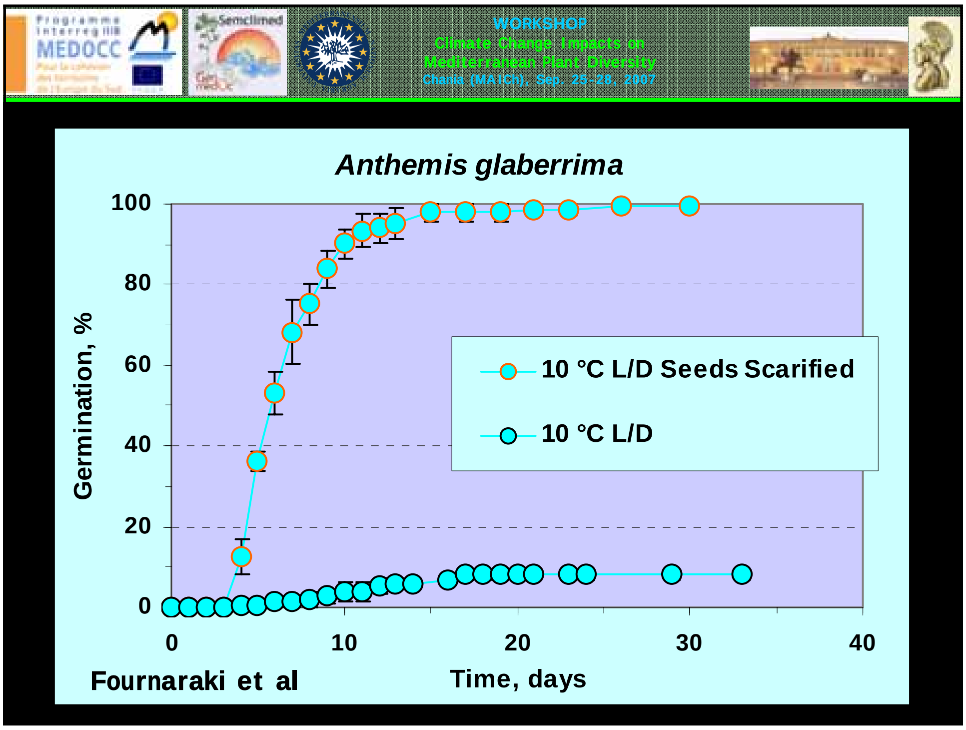
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
GERMINATION
0,15
0,10
0,05
0,00
30
20
0
27/5/2006
10/6/2006
24/6/2006
8/7/2006
22/7/2006
5/8/2006
19/8/2006
2/9/2006
16/9/2006
30/9/2006
14/10/2006
28/10/2006
11/11/2006
25/11/2006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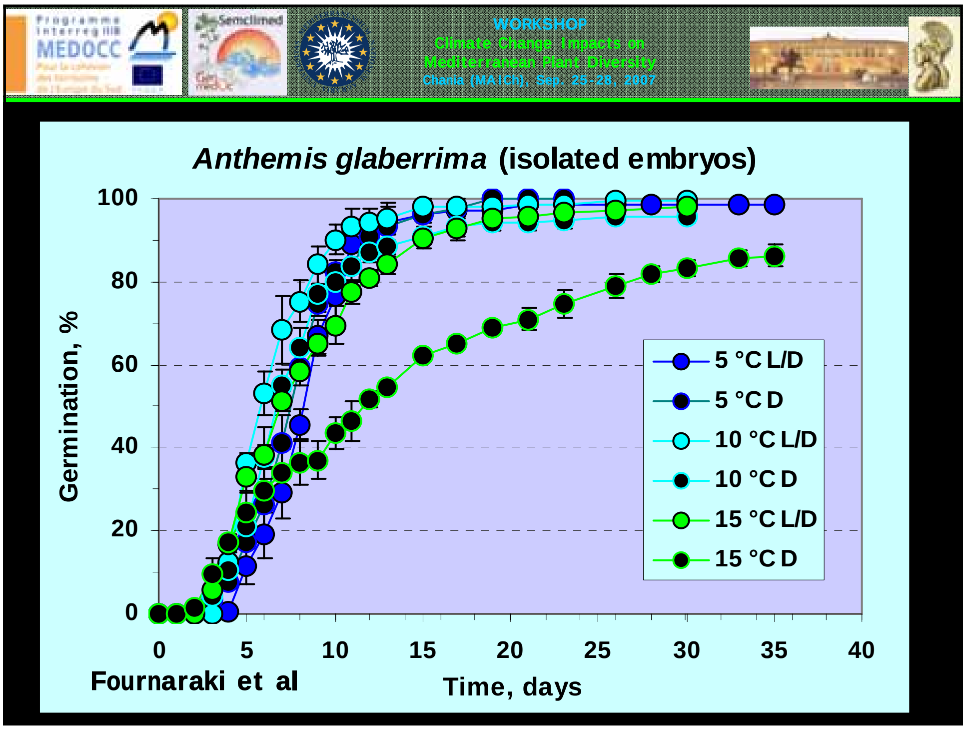
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Anthemis glaberrima
Germination, %
100
80
60
40
20
0
0
10
20
30
40
10 °C L/D Seeds Scarified
10 °C L/D
Fournaraki et al
Time, days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Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Anthemis glaberrima (isolated embryos)
Germination, %
100
80
60
40
20
0
0
5
10
15
20
25
30
35
40
5 °C L/D
5 °C D
10 °C L/D
10 °C D
15 °C L/D
15 °C D
Fournaraki et al
Time, days

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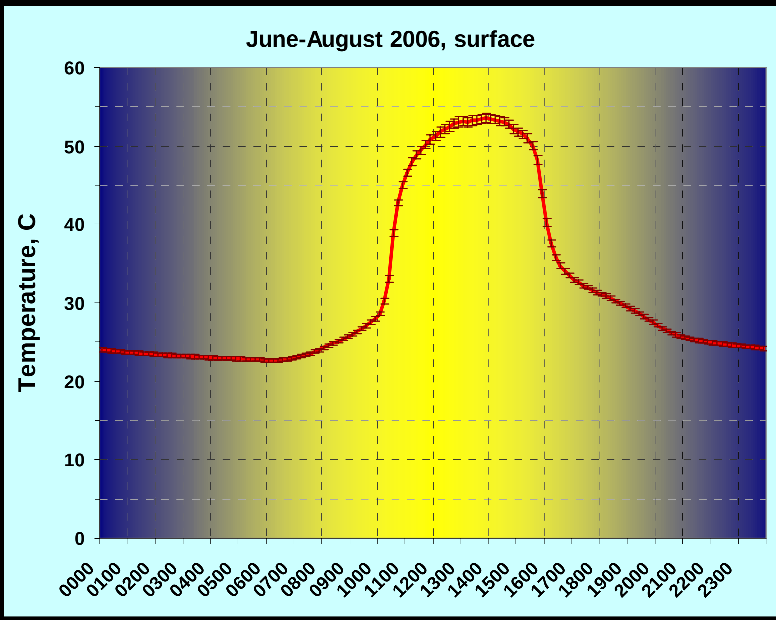
Chania (MAICh), Sep. 25-28, 2007



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Chania (MAICh), Sep. 25-28, 2007

Anthemis glaberrima

UNANSWERED QUESTIONS

- ? The role of high, summer temperatures
- ? Presence of inhibitors in the seed coat
- ? A persistent soil seed bank

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CASE STUDY V

Phoenix theophrasti

(Theophrastus' palm, a Cretan subendemic)

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Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Phoenix theophrasti


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Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Phoenix theophrasti


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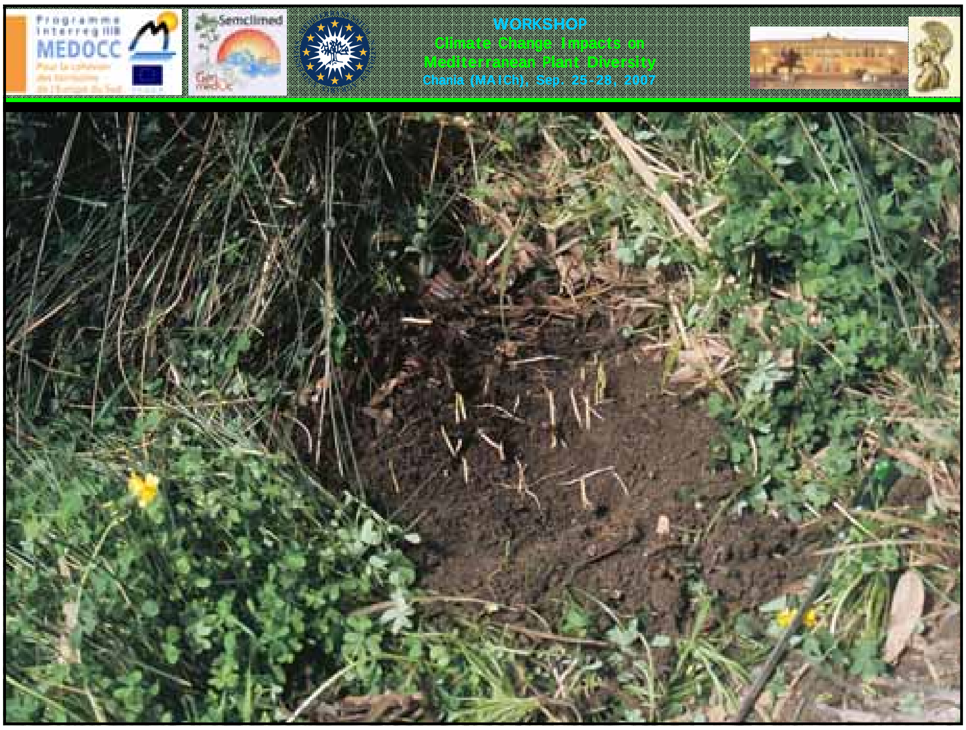
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Phoenix theophrasti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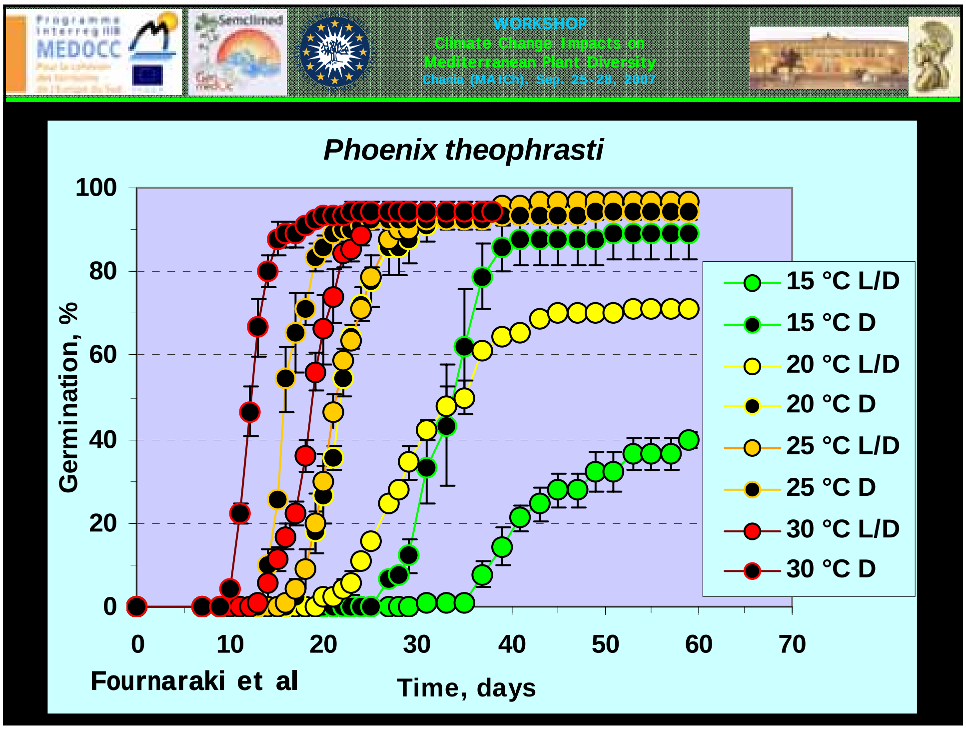
Chania (MAICh), Sep. 25-28, 2007



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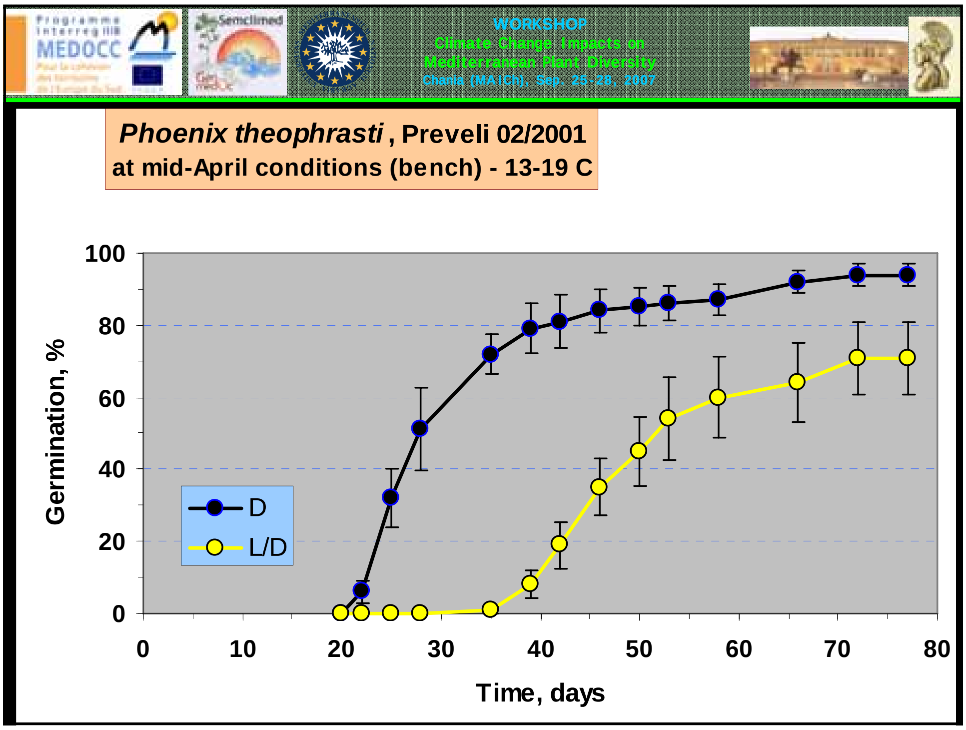
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Phoenix theophrasti
Germination, %
100
80
60
40
20
0
0
10
20
30
40
50
60
70
Time, days
15 °C L/D
15 °C D
20 °C L/D
20 °C D
25 °C L/D
25 °C D
30 °C L/D
30 °C D
Fournaraki et al



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Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Phoenix theophrasti, Preveli 02/2001
at mid-April conditions (bench) - 13-19 C
Germination, %
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
Time, days
D
L/D

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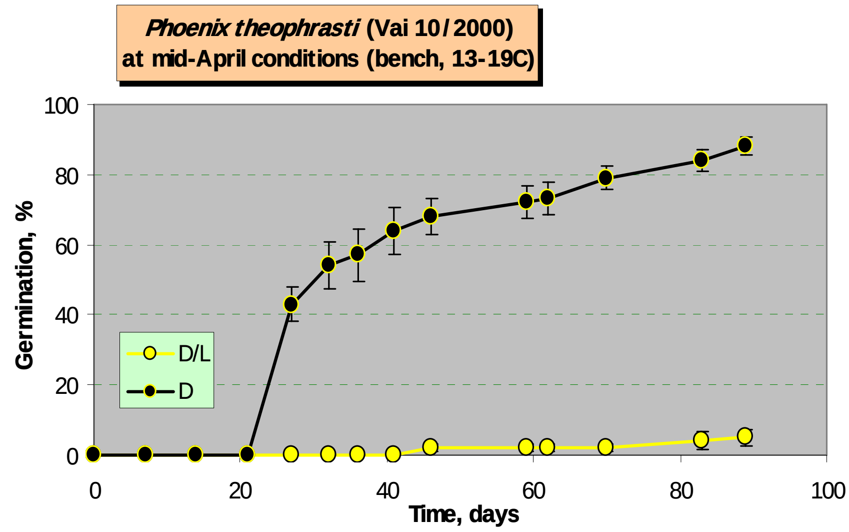
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007



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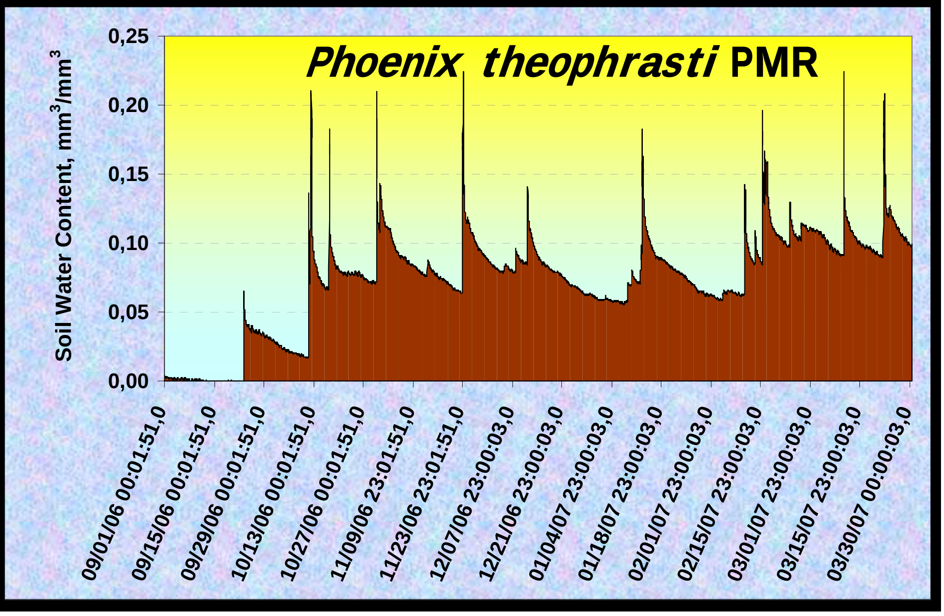

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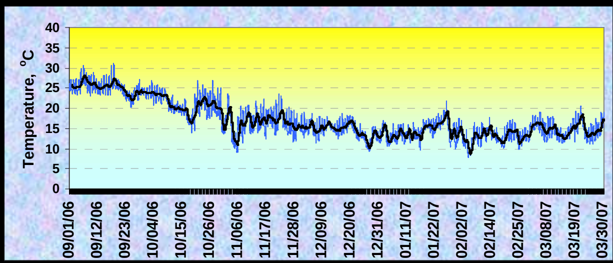
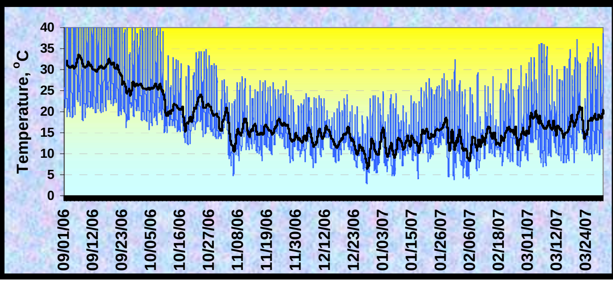
Chania (MAICh), Sep. 25-28, 2007

Phoenix theophrasti PMR



open space

Temperature at -1 cm



shaded

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Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007

CASE STUDY VI

Nepeta sphaciotica

(an endangered mountainous labiate)

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Chania (MAICh), Sep. 25-28, 2007

Nepeta sphaciotica **P.H. Davis**


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Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Nepeta sphaciotica


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Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Nepeta sphaciotica PMR
2350 m asl
Lefka Ori (Crete)

Nepeta sphaciotica P.H. Davis

Une population seule,
ca. 30000 individus
à une surface
moins de 4 ha

Critically Endangered: CR

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Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007


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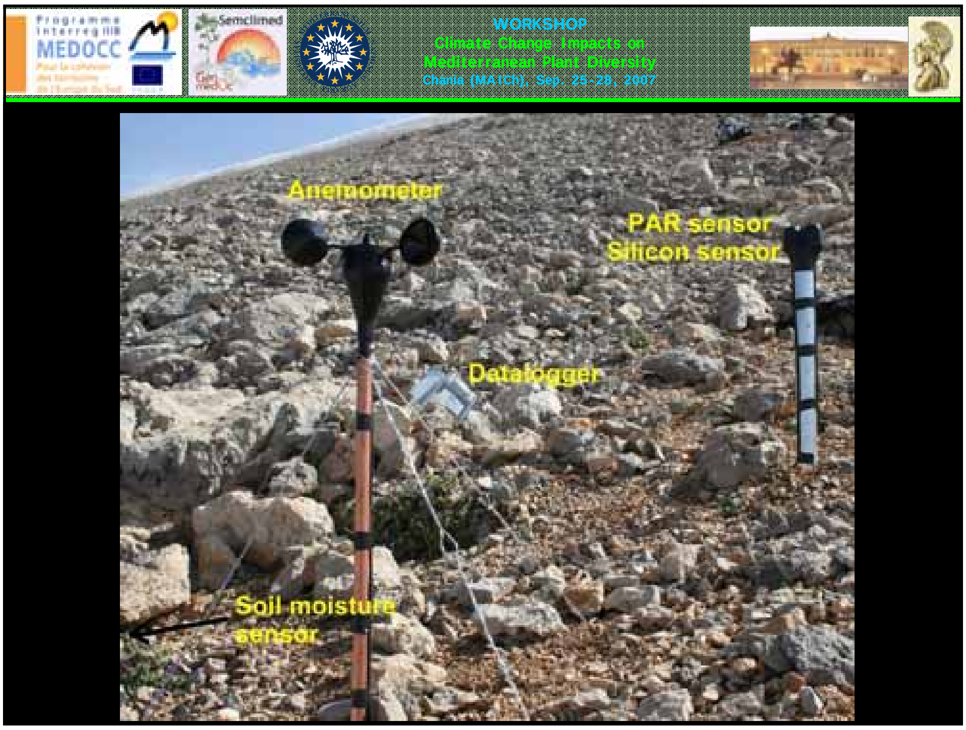
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Nepeta sphaciotica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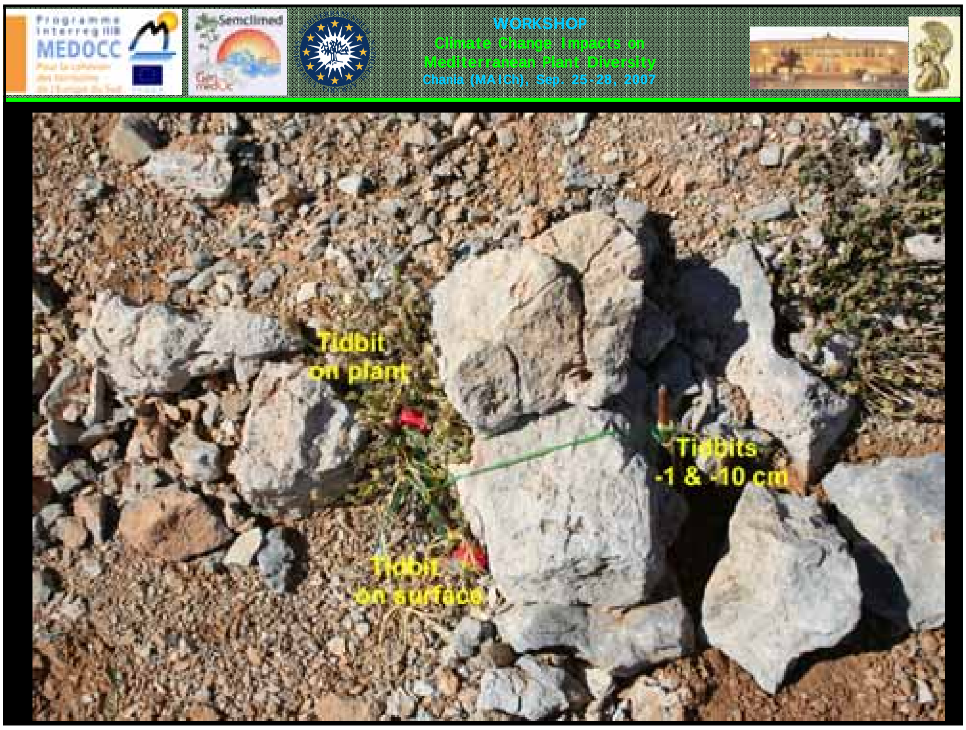
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Anemometer
PAR sensor
Silicon sensor
Datalogger
Soil moisture
sensor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Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Tidbit
on plant
Tidbits
-1 & -10 cm
Tidbit
on surface


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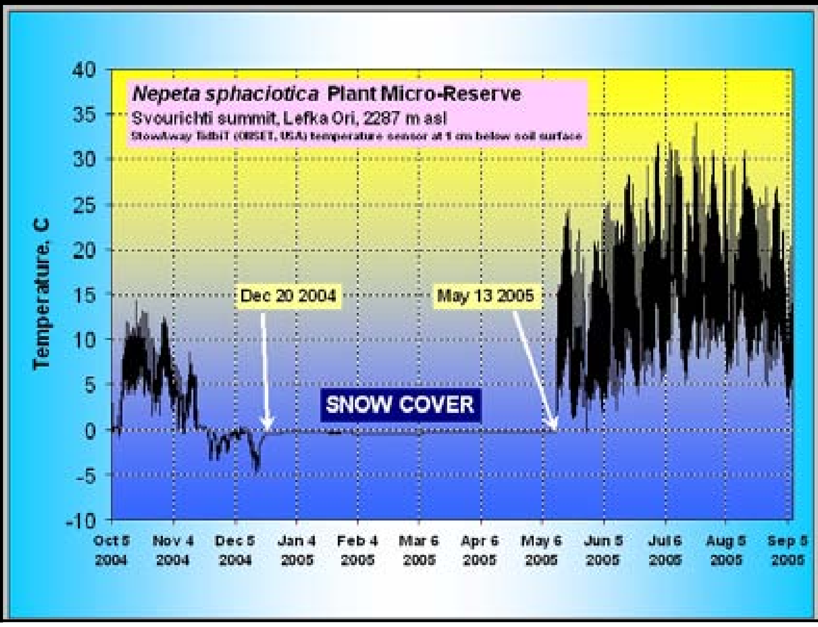
Chania (MAICh), Sep. 25-28, 2007

WORKSHOP
Climate Change Impacts on Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007



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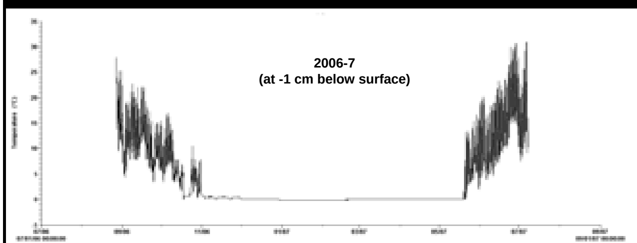
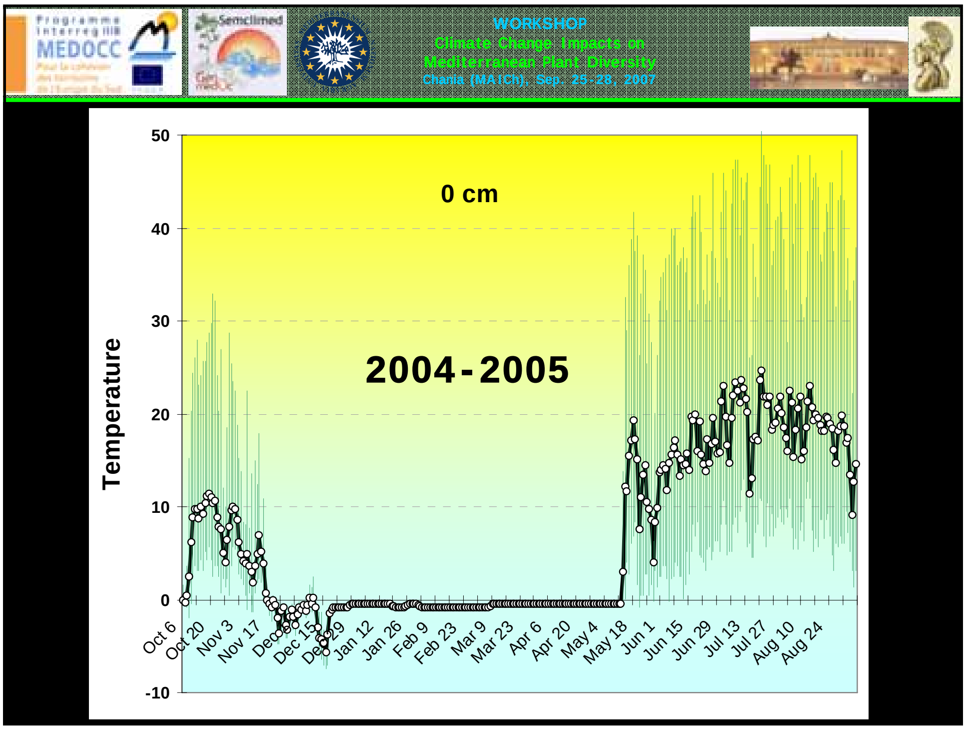
Chania (MAICh), Sep. 25-28, 2007

Snow cover duration (Svourichti, Lefka Ori)



Nov 3, 2006 – May 18, 2007
195 days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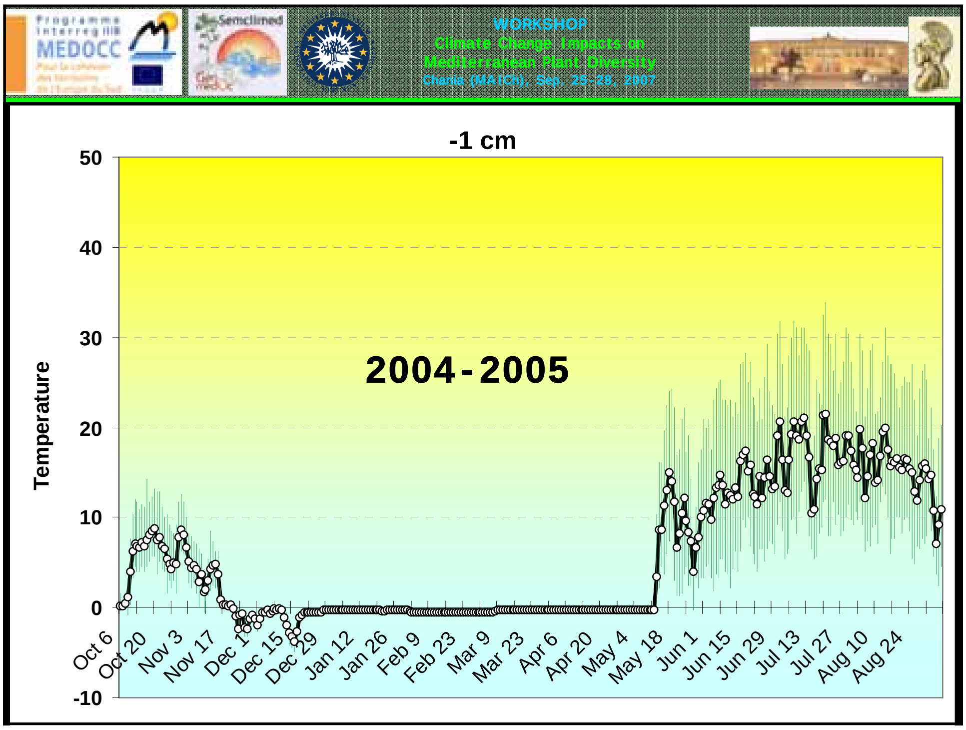
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
0 cm
2004-2005
Temperature
50
40
30
20
10
0
-10
Oct 6
Oct 20
Nov 3
Nov 17
Dec 1
Dec 15
Dec 29
Jan 12
Jan 26
Feb 9
Feb 23
Mar 9
Mar 23
Apr 6
Apr 20
May 4
May 18
Jun 1
Jun 15
Jun 29
Jul 13
Jul 27
Aug 10
Aug 24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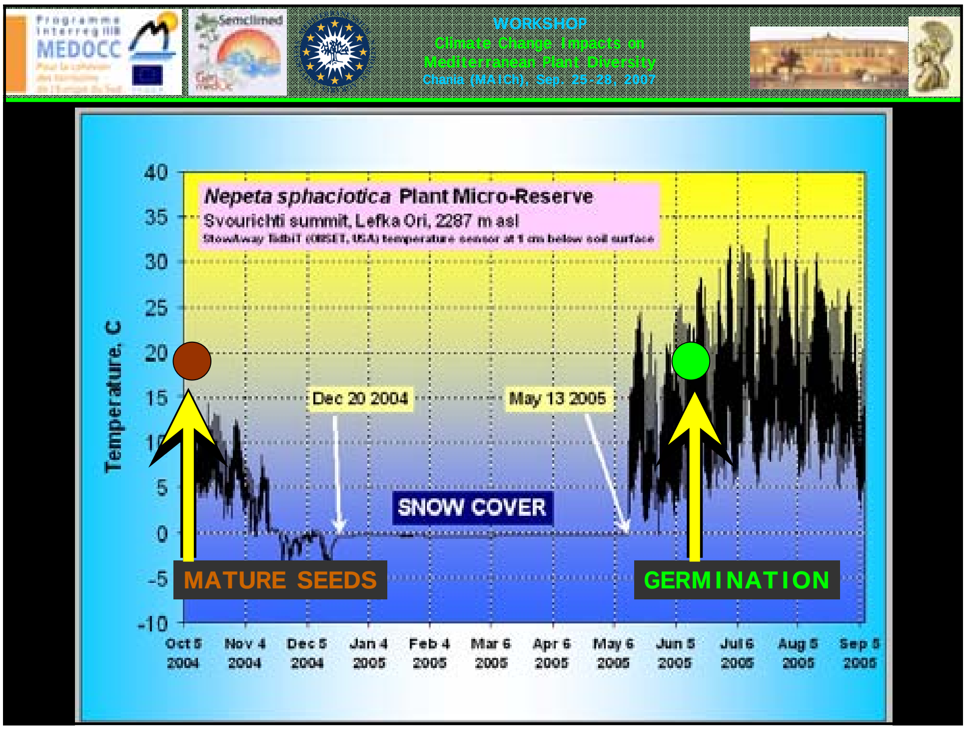
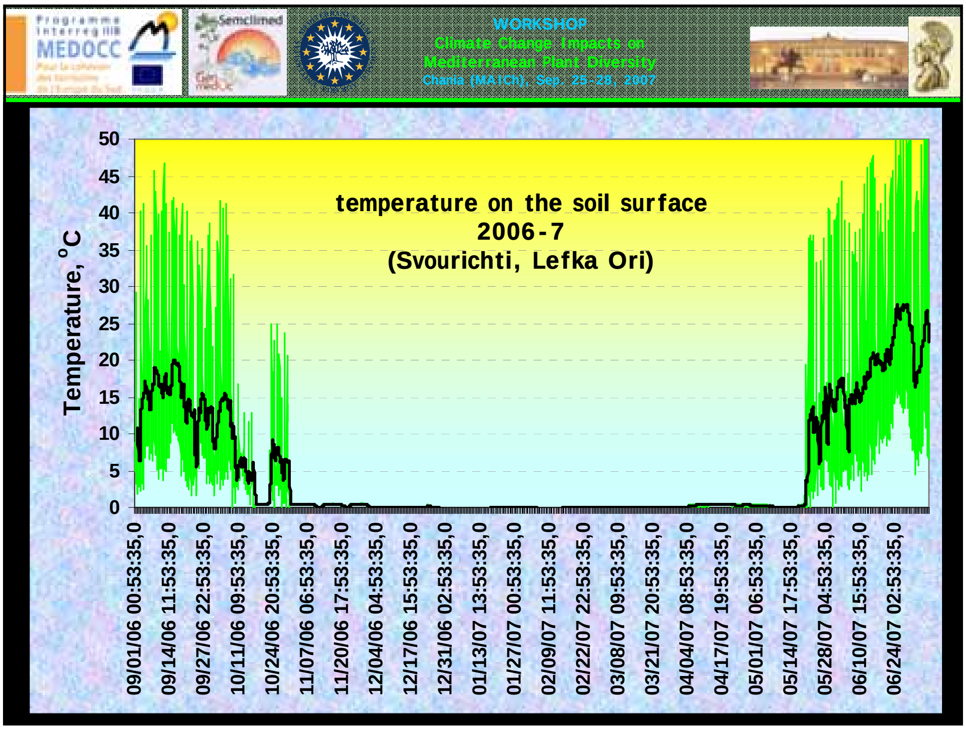
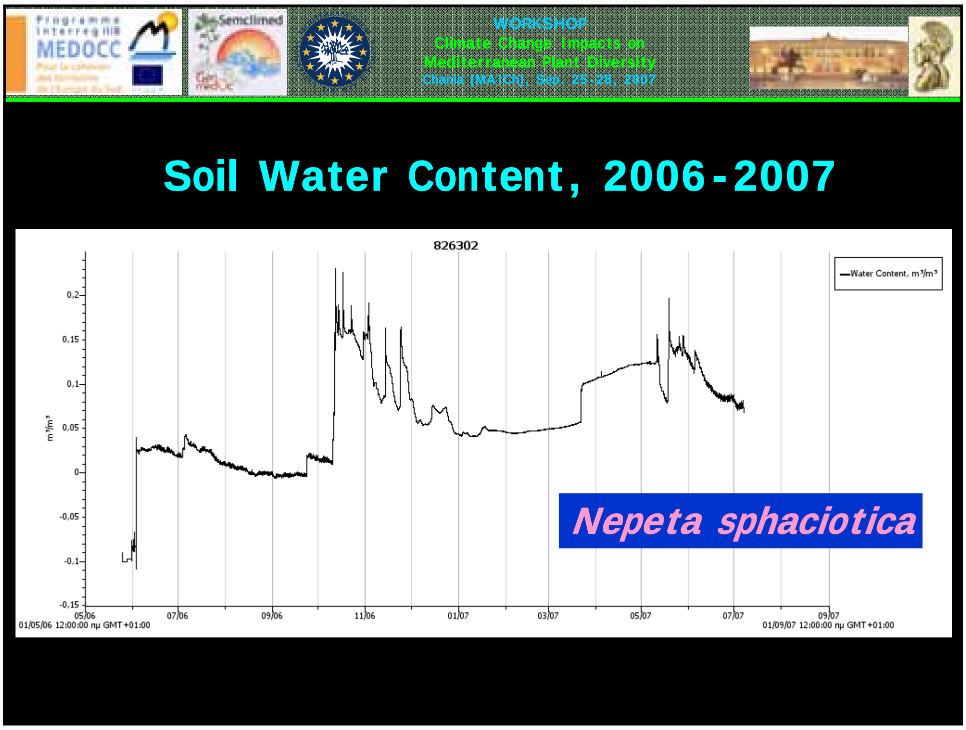
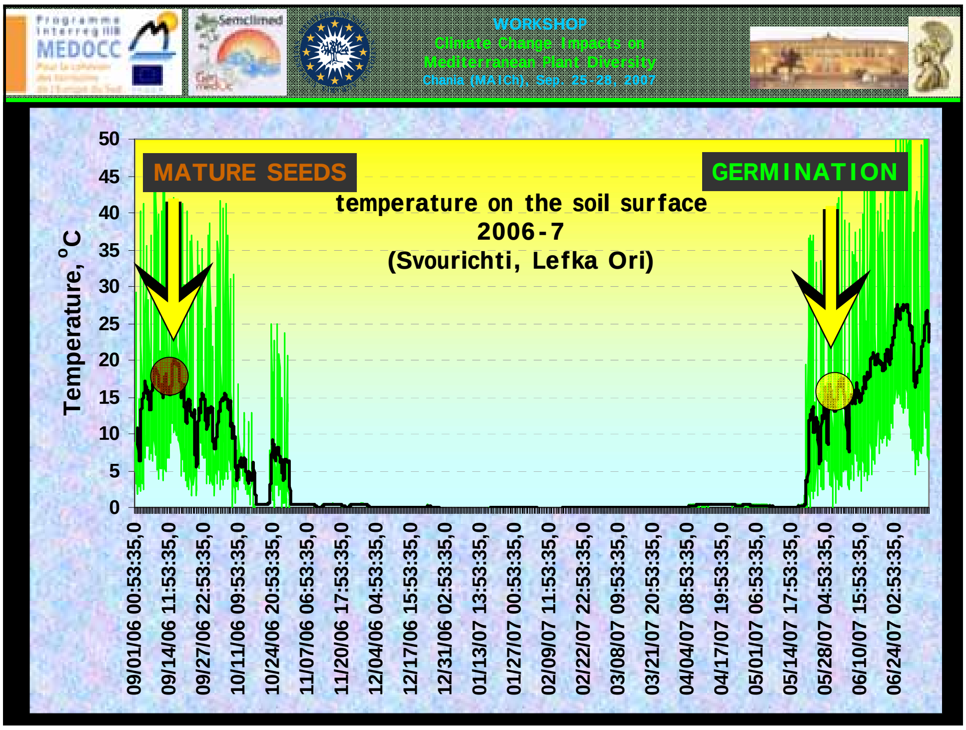
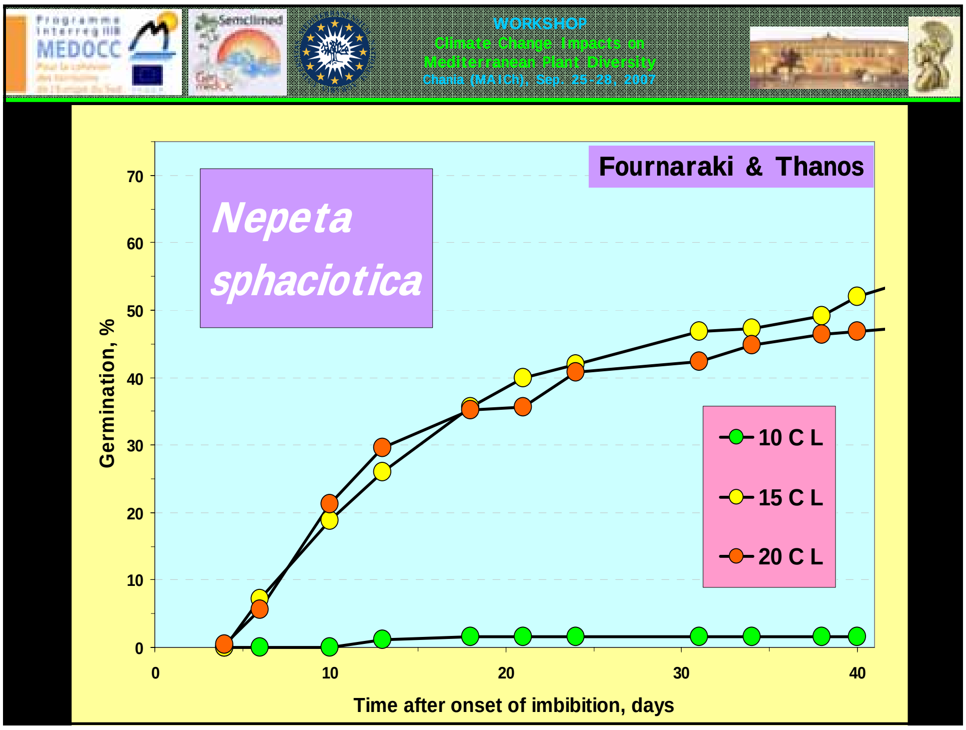
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
-1 cm
2004-2005
Temperature
50
40
30
20
10
0
-10
Oct 6
Oct 20
Nov 3
Nov 17
Dec 1
Dec 15
Dec 29
Jan 12
Jan 26
Feb 9
Feb 23
Mar 9
Mar 23
Apr 6
Apr 20
May 4
May 18
Jun 1
Jun 15
Jun 29
Jul 13
Jul 27
Aug 10
Aug 24

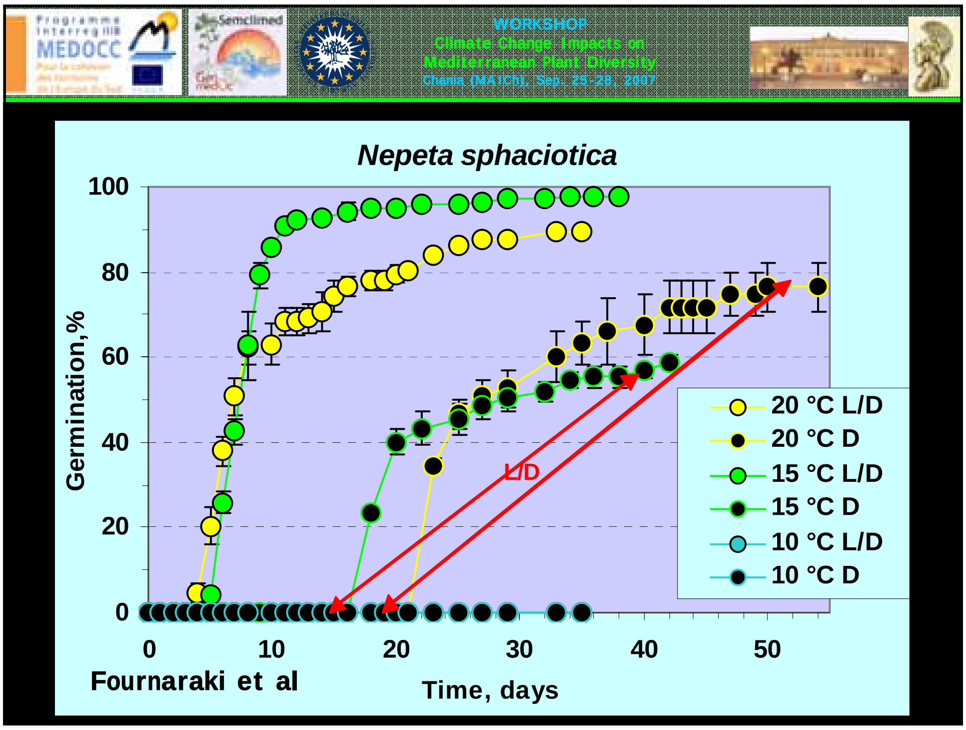

WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Nepeta sphaciotica Plant Micro-Reserve
Svourichti summit, Lefka Ori, 2287 m asl
StowAway TidbiT (ONSET, USA) temperature sensor at 1 cm below soil surface
Temperature, C
Dec 20 2004
May 13 2005
SNOW COVER
MATURE SEEDS
GERMINATION
Oct 5 2004
Nov 4 2004
Dec 5 2004
Jan 4 2005
Feb 4 2005
Mar 6 2005
Apr 6 2005
May 6 2005
Jun 5 2005
Jul 6 2005
Aug 5 2005
Sep 5 2005

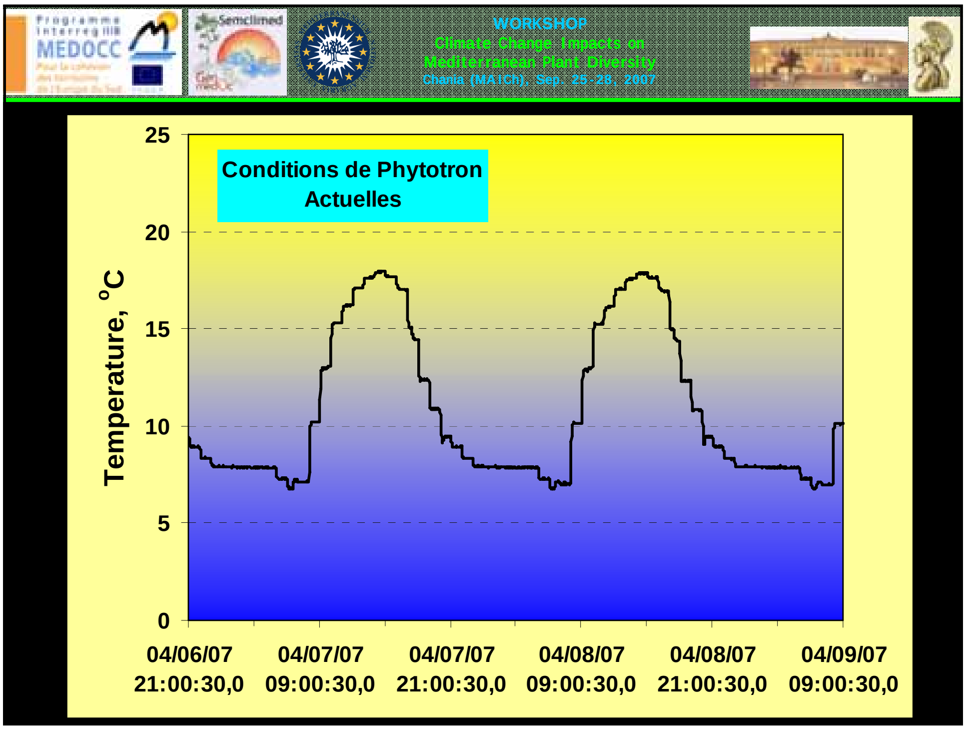

WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
temperature on the soil surface
2006-7
(Svourichti, Lefka Ori)
Temperature, °C


WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Soil Water Content, 2006-2007
826302
Water Content, m³/m³
m³/m³
Nepeta sphaciotica
01/05/06 12:00:00 πμ GMT+01:00
01/09/07 12:00:00 πμ GMT+01:00

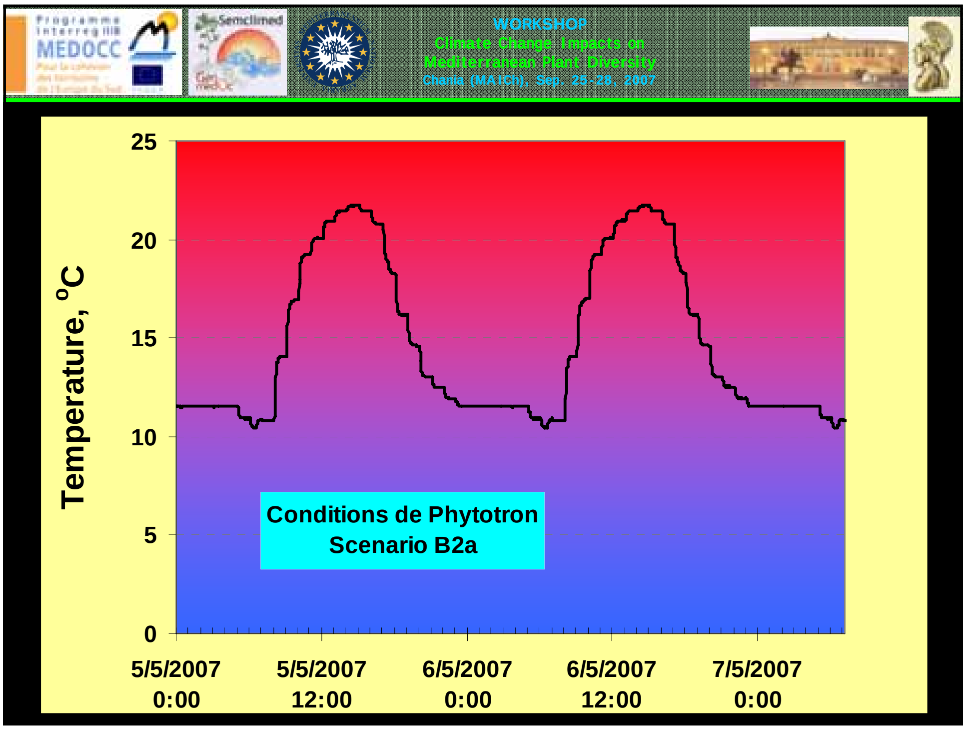

WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
MATURE SEEDS
GERMINATION
temperature on the soil surface
2006-7
(Svourichti, Lefka Ori)
Temperature, °C
09/01/06 00:53:35,0
09/14/06 11:53:35,0
09/27/06 22:53:35,0
10/11/06 09:53:35,0
10/24/06 20:53:35,0
11/07/06 06:53:35,0
11/20/06 17:53:35,0
12/04/06 04:53:35,0
12/17/06 15:53:35,0
12/31/06 02:53:35,0
01/13/07 13:53:35,0
01/27/07 00:53:35,0
02/09/07 11:53:35,0
02/22/07 22:53:35,0
03/08/07 09:53:35,0
03/21/07 20:53:35,0
04/04/07 08:53:35,0
04/17/07 19:53:35,0
05/01/07 06:53:35,0
05/14/07 17:53:35,0
05/28/07 04:53:35,0
06/10/07 15:53:35,0
06/24/07 02:53:35,0


WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Fournaraki & Thanos
Nepeta sphaciotica
Germination, %
70
60
50
40
30
20
10
0
0
10
20
30
40
10 C L
15 C L
20 C L
Time after onset of imbibition, days

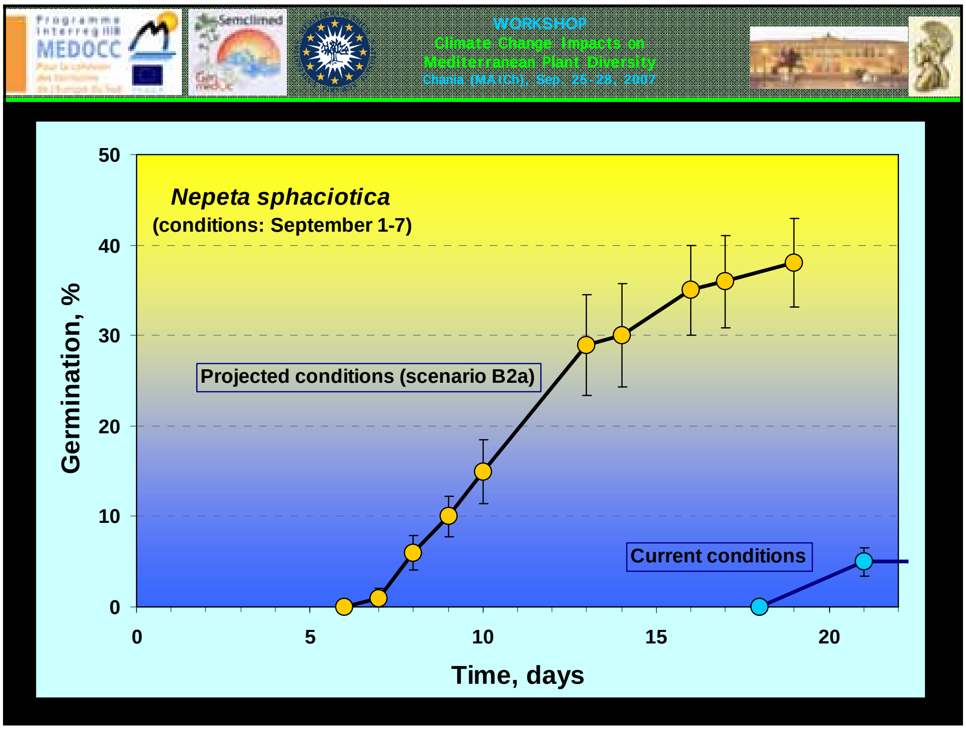

WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Nepeta sphaciotica
Germination, %
100
80
60
40
20
0
0
10
20
30
40
50
L/D
20 °C L/D
20 °C D
15 °C L/D
15 °C D
10 °C L/D
10 °C D
Fournaraki et al
Time, days

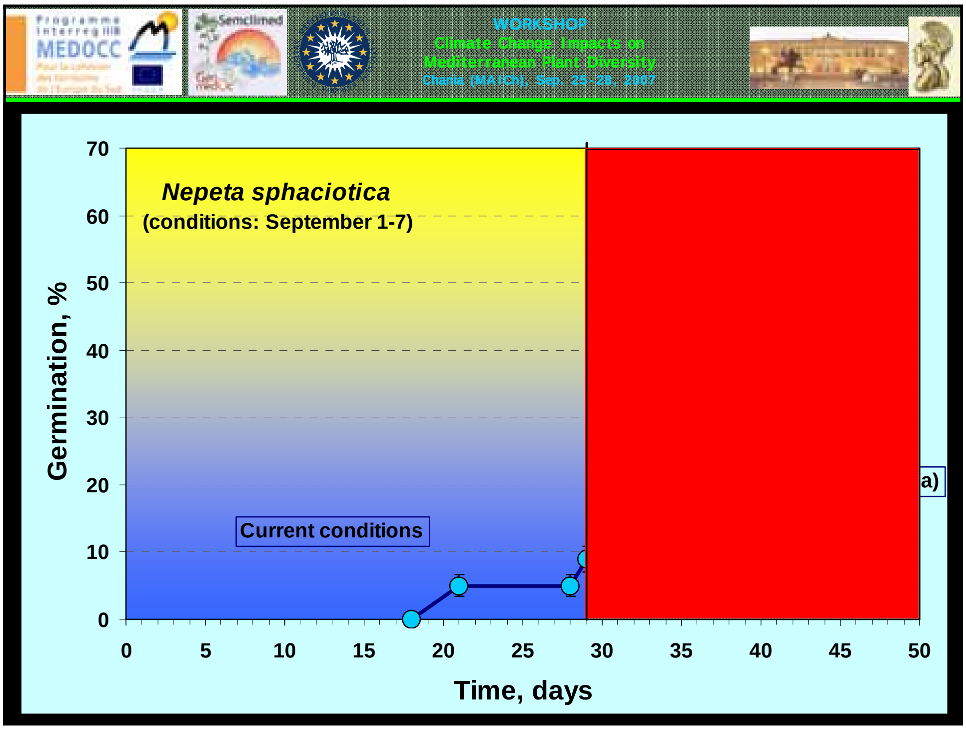


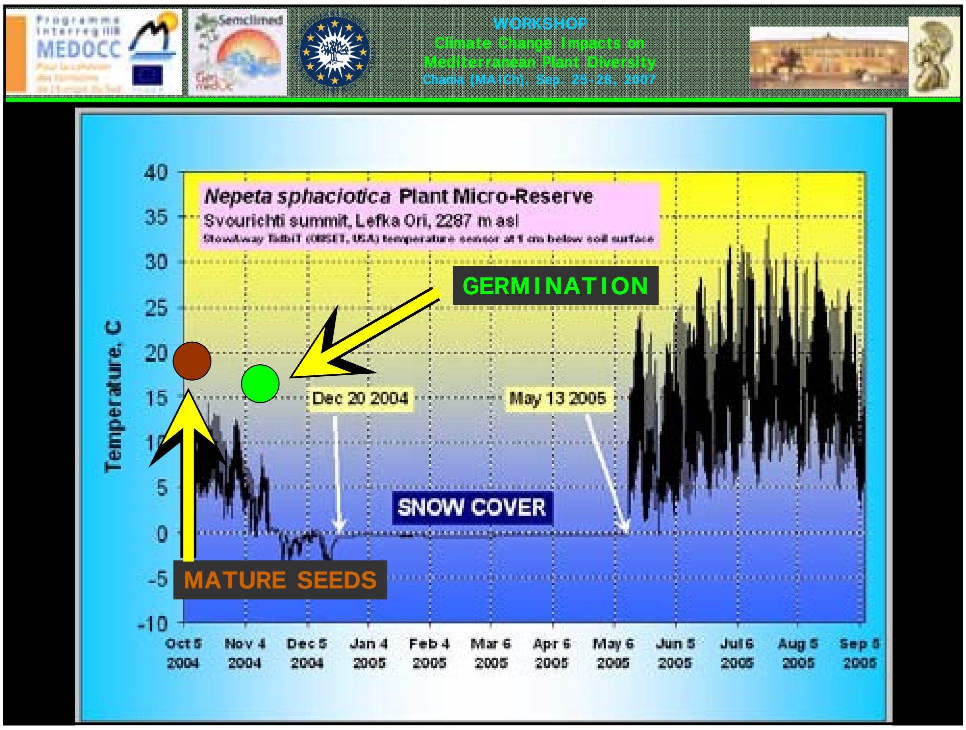
WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Conditions de Phytotron
Actuelles
Temperature, °C
25
20
15
10
5
0
04/06/07 21:00:30,0
04/07/07 09:00:30,0
04/07/07 21:00:30,0
04/08/07 09:00:30,0
04/08/07 21:00:30,0
04/09/07 09:00:30,0



WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Temperature, °C
25
20
15
10
5
0
Conditions de Phytotron
Scenario B2a
5/5/2007 0:00
5/5/2007 12:00
6/5/2007 0:00
6/5/2007 12:00
7/5/2007 0:00


WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Nepeta sphaciotica
(conditions: September 1-7)
Projected conditions (scenario B2a)
Current conditions
Germination, %
Time, days


WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Nepeta sphaciotica
(conditions: September 1-7)
Current conditions
Germination, %
Time, days


Programme Interreg IIIB MEDOCC
Semclimed
WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Nepeta sphaciotica Plant Micro-Reserve
Svourichti summit, Lefka Ori, 2287 m asl
StowAway TidbiT (ONSET, USA) temperature sensor at 1 cm below soil surface
GERMINATION
Dec 20 2004
May 13 2005
SNOW COVER
MATURE SEEDS
Temperature, C
40
35
30
25
20
15
5
0
-5
-10
Oct 5 2004
Nov 4 2004
Dec 5 2004
Jan 4 2005
Feb 4 2005
Mar 6 2005
Apr 6 2005
May 6 2005
Jun 5 2005
Jul 6 2005
Aug 5 2005
Sep 5 2005


Programme Interreg IIIB MEDOCC
Semclimed
WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Technical and practical aspects

WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007

EXPERIMENTATION sur la GERMINATION

- en conditions de culture simple (températures et photopériodes d'essais habituels) et

- en conditions de culture en phytotrons que simuleront les scénarios climatiques sélectionnés

- en conditions du terrain qu'on monitorage

BUT: la connaissance de l'écologie de germination pour les espèces choisis
Très important de savoir la saison de germination!

WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007

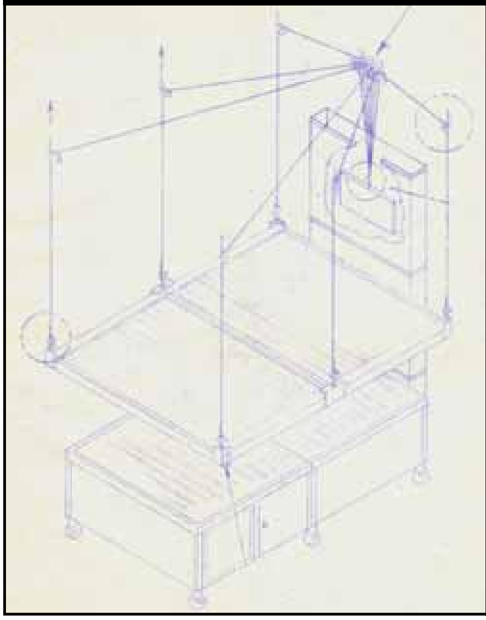
?Comment?

on peut simuler des conditions environmentaux
en phytotrons

conditions actuelles et
conditions qui simulent les scénarios climatiques sélectionnés

WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007

Phytotron GB48



CONVIRON (CONTROLLED ENVIRONMENTS, Canada)

WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007


WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007


WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007

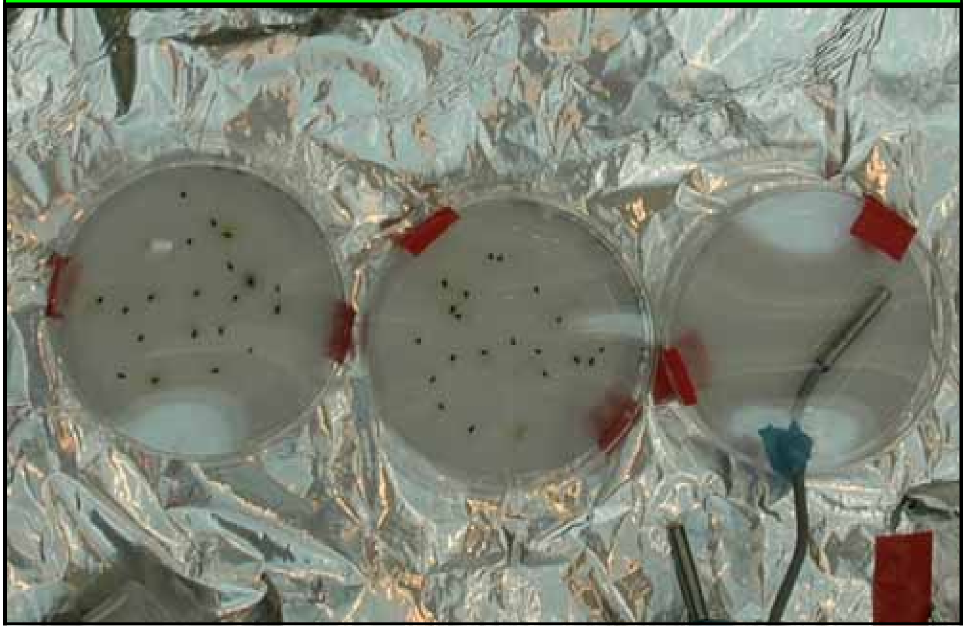
WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007

WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007


WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007


WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007

WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007



WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007

La température

La lumière

- photoperiode
- qualité
- quantité

U.S. Naval Observatory
Astronomical Applications Department

**Table of Sunrise/Sunset,
Moonrise/Moonset,
or Twilight Times
for an Entire Year**

http://aa.usno.navy.mil/

WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007

Form B - Locations Worldwide

USNO Astronomical Applications Department

Specify year, type of table, and place:

Year: 2007 Type of table: sunrise/sunset

Place Name:

The place name you enter above is used only in the table header; you can enter any identifier, or none (do not use punctuation characters).

Longitude: ○ east ◉ west degrees minutes

Latitude: ◉ north ○ south degrees minutes

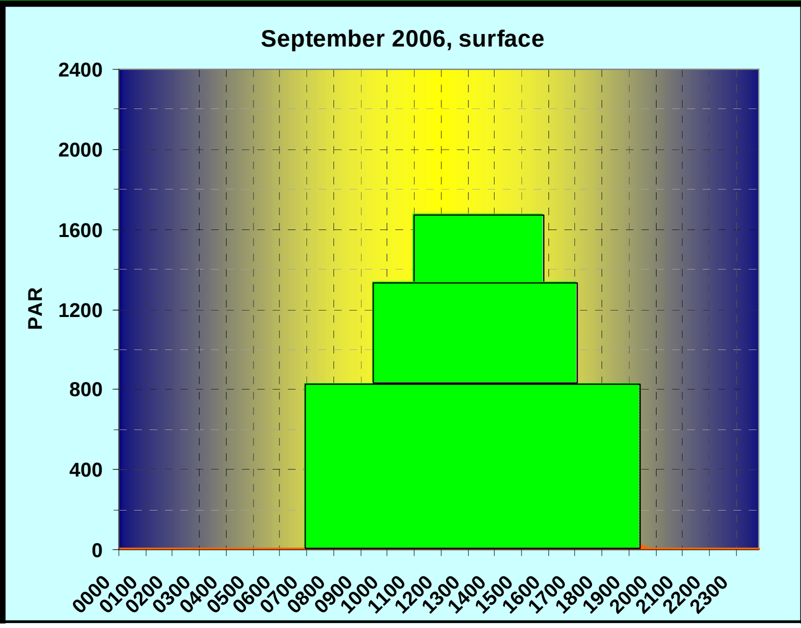
Time Zone: hours ○ east of Greenwich ◉ west of Greenwich

For locations that require it, the time zone can be entered in hours and a fraction. For example, for locations in India, the time zone may be entered as 5.5 hours east of Greenwich. The time zone field can accommodate up to five characters.

Need coordinates? Try NGA's GEOnet Names Server (click on the "GNS Search" link at the top of the left frame).
Need U.S. coordinates? Try this USGS web page.
Need a time zone? Try the time zone map.

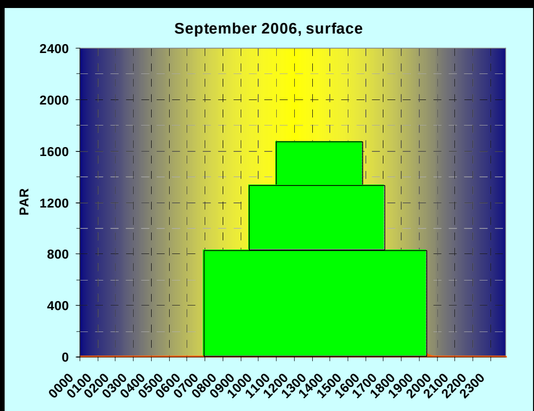
Compute Table | Clear all fields

WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007



WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007

3 niveaux d'intensité lumineuse N1, N2, N3 (N3=3×N1; N2=2×N1)

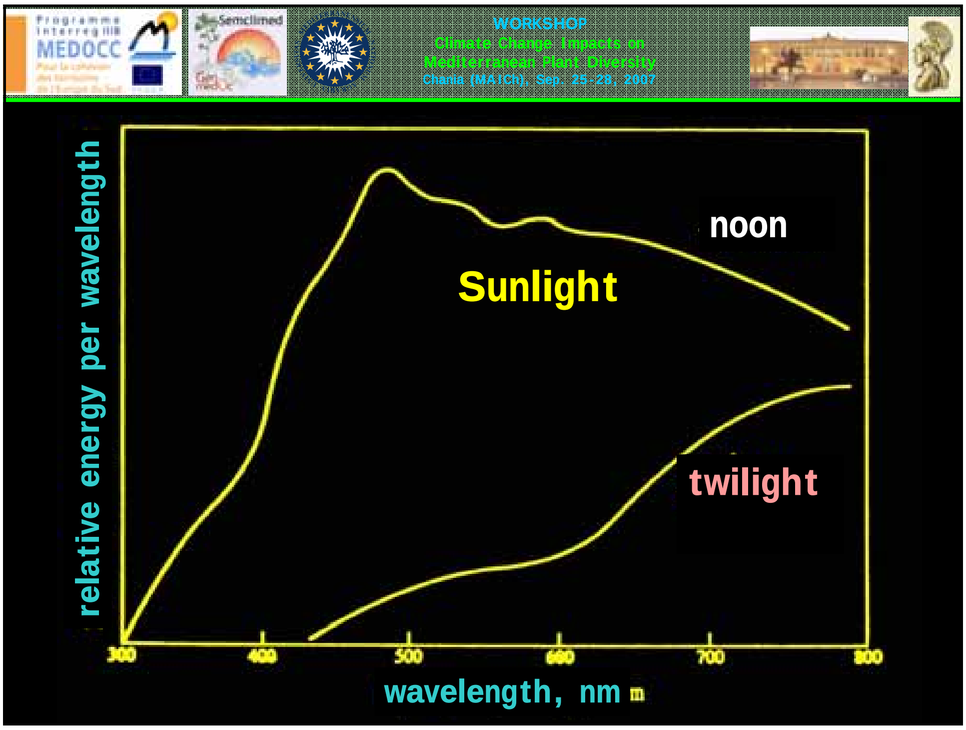


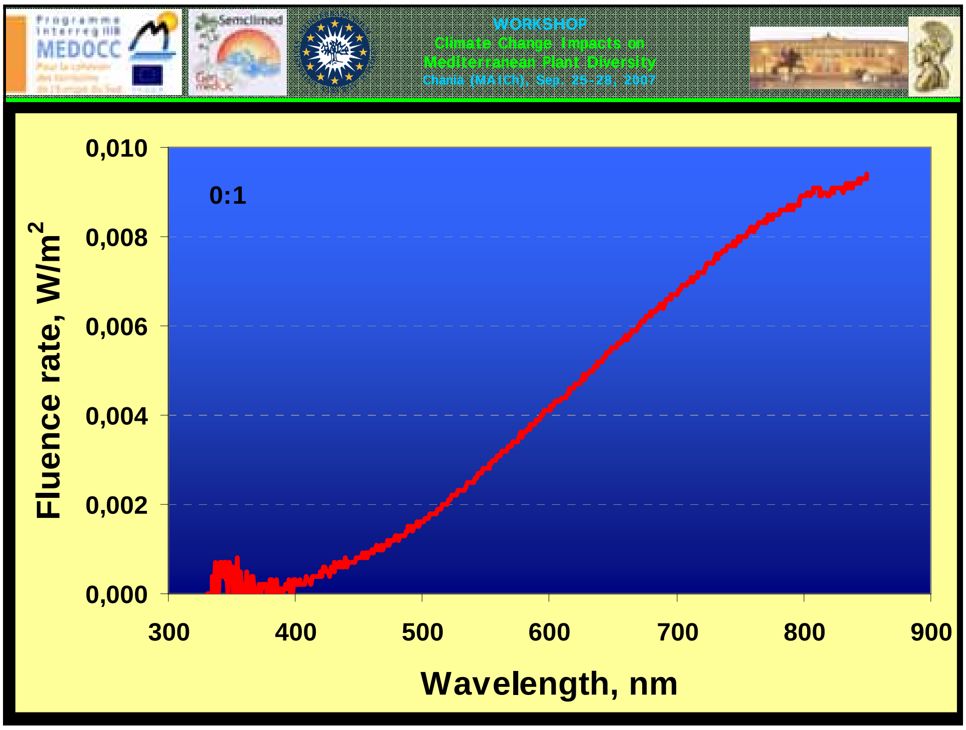
N3: 5 h

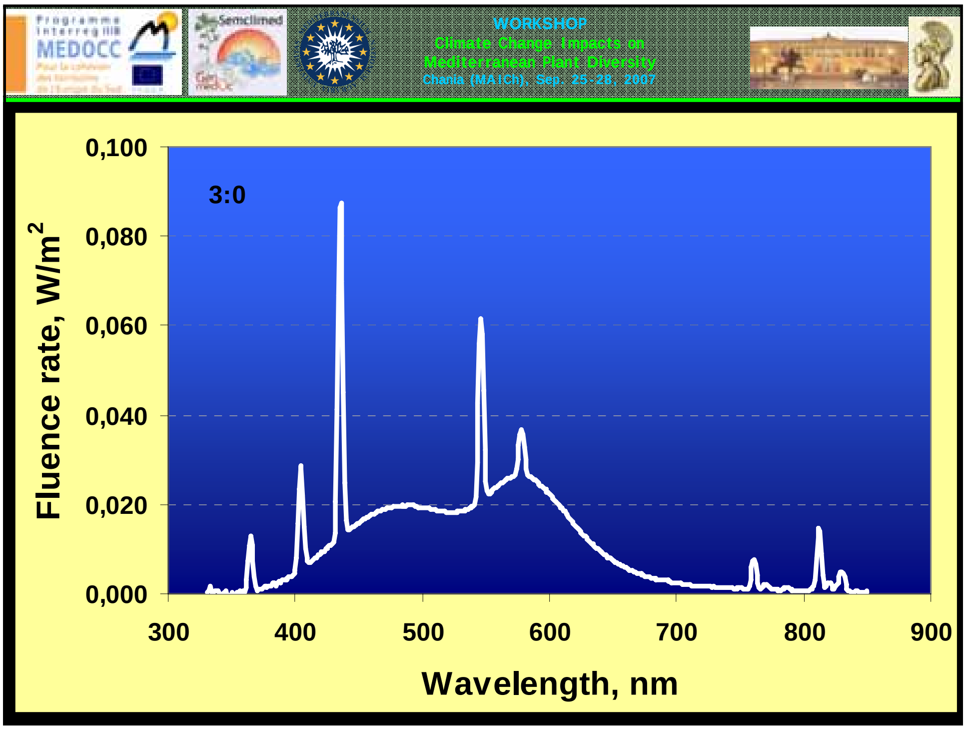
N2: ~3 h

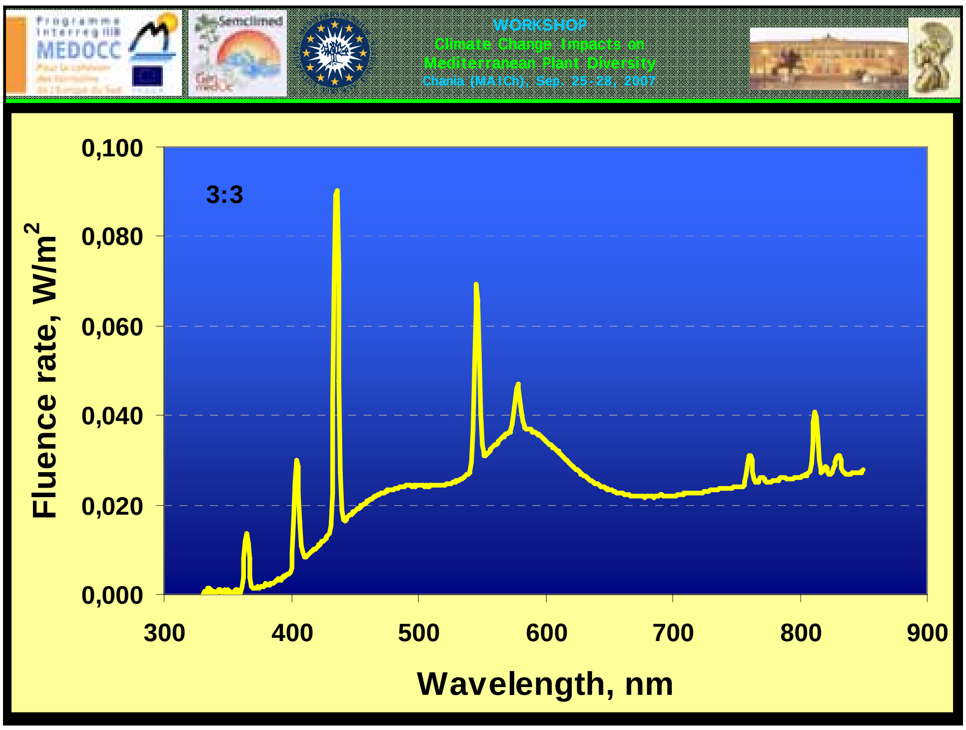
N1: 5 h

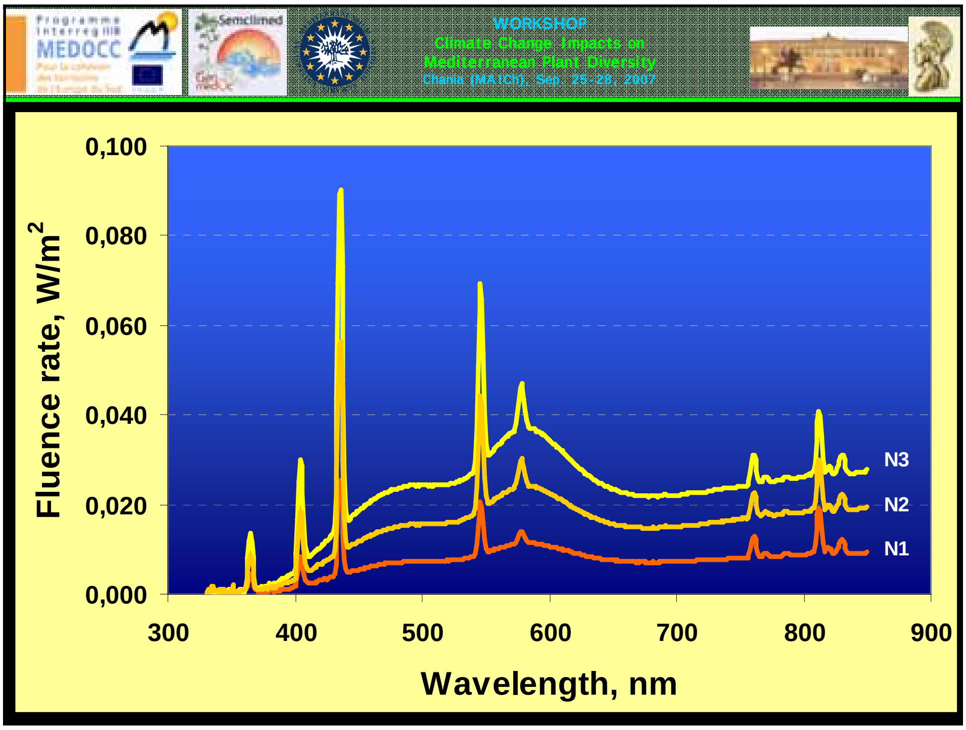
2,5 h N1 – 1,5 h N2 - 5 h N3 – 1,5 h N2 – 2,5 h N1


WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
relative energy per wavelength
noon
Sunlight
twilight
300
400
500
600
700
800
wavelength, nm

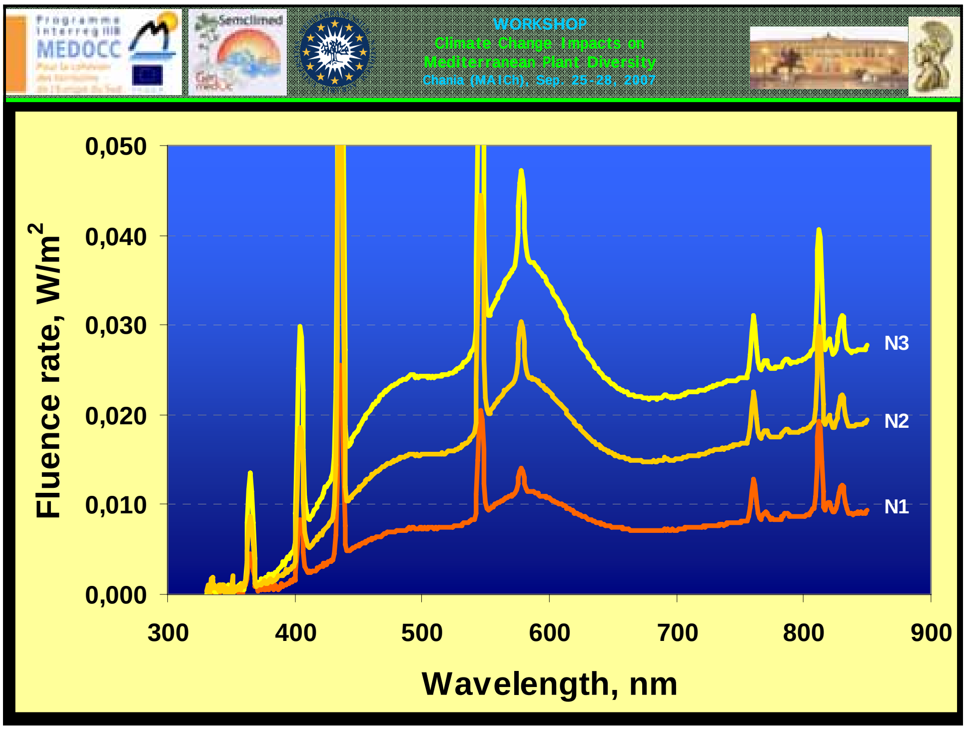

WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Fluence rate, W/m2
0,010
0,008
0,006
0,004
0,002
0,000
0:1
300
400
500
600
700
800
900
Wavelength, nm


WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
3:0
Fluence rate, W/m2
0,100
0,080
0,060
0,040
0,020
0,000
300
400
500
600
700
800
900
Wavelength, nm

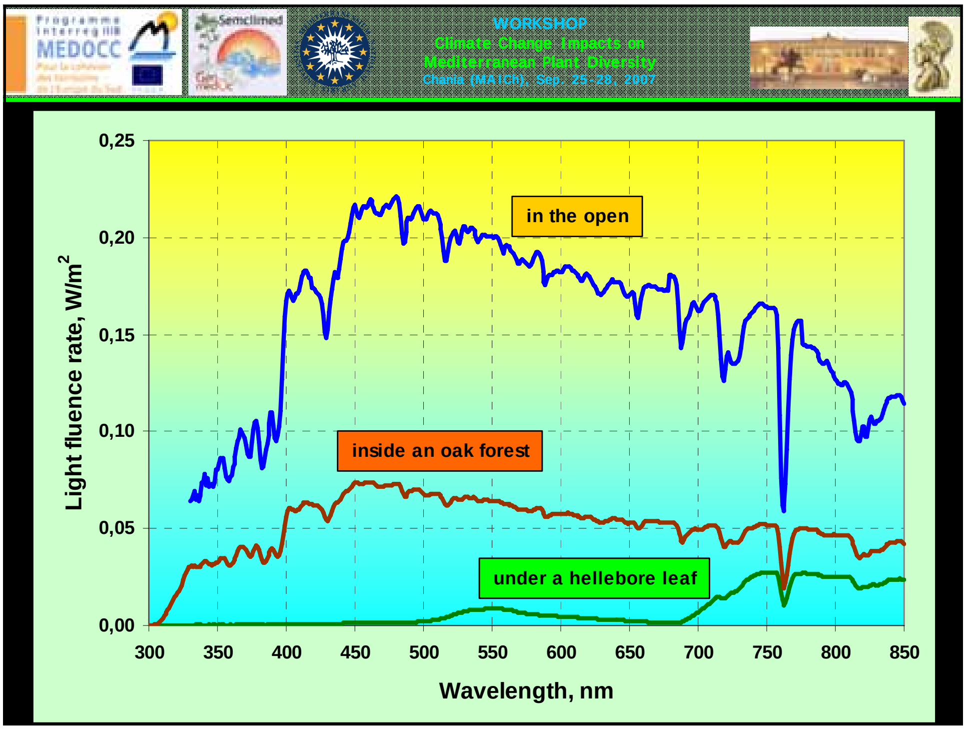

WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
3:3
Fluence rate, W/m2
0,100
0,080
0,060
0,040
0,020
0,000
300
400
500
600
700
800
900
Wavelength, nm



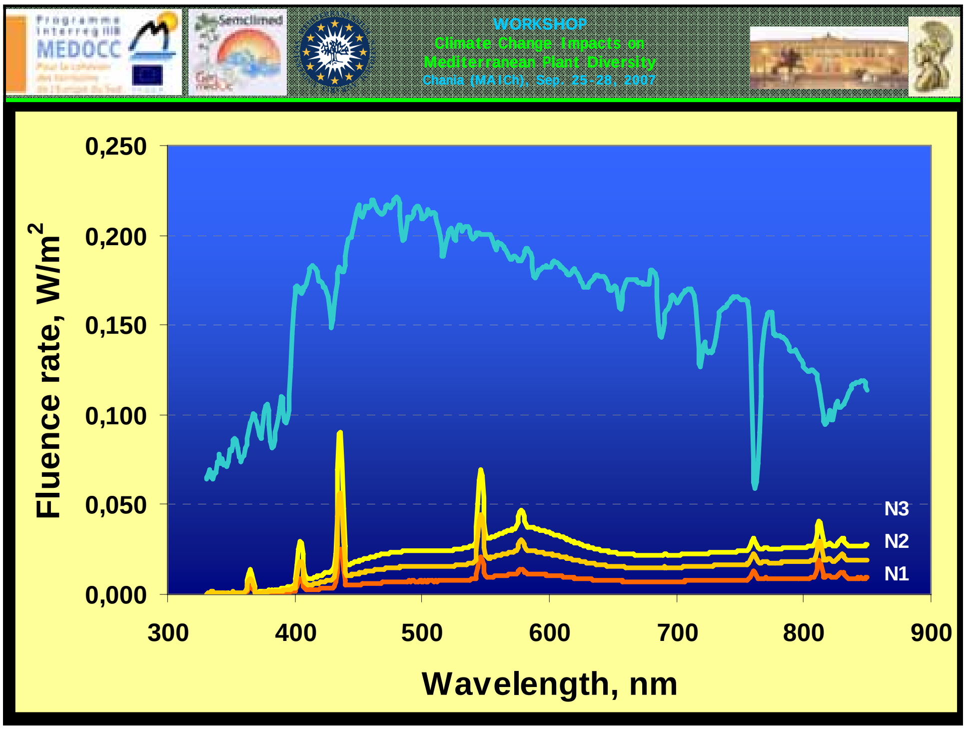
WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Semclimed
MEDOCC
0,100
0,080
0,060
0,040
0,020
0,000
Fluence rate, W/m2
300
400
500
600
700
800
900
Wavelength, nm
N3
N2
N1



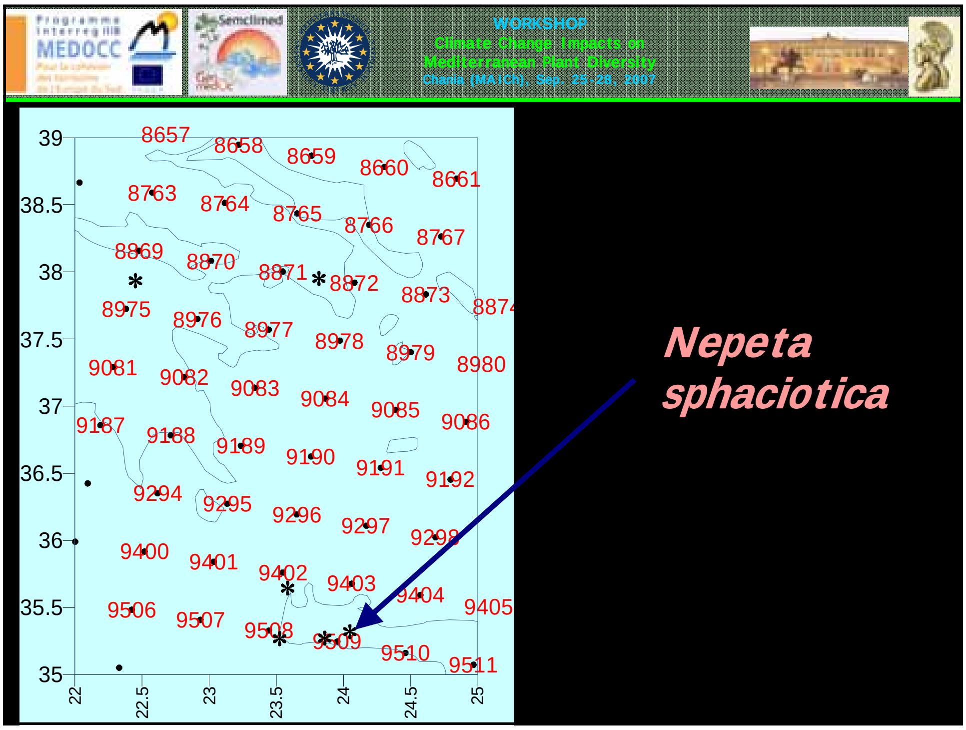
WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
Semclimed
MEDOCC
0,050
0,040
0,030
0,020
0,010
0,000
Fluence rate, W/m2
300
400
500
600
700
800
900
Wavelength, nm
N3
N2
N1

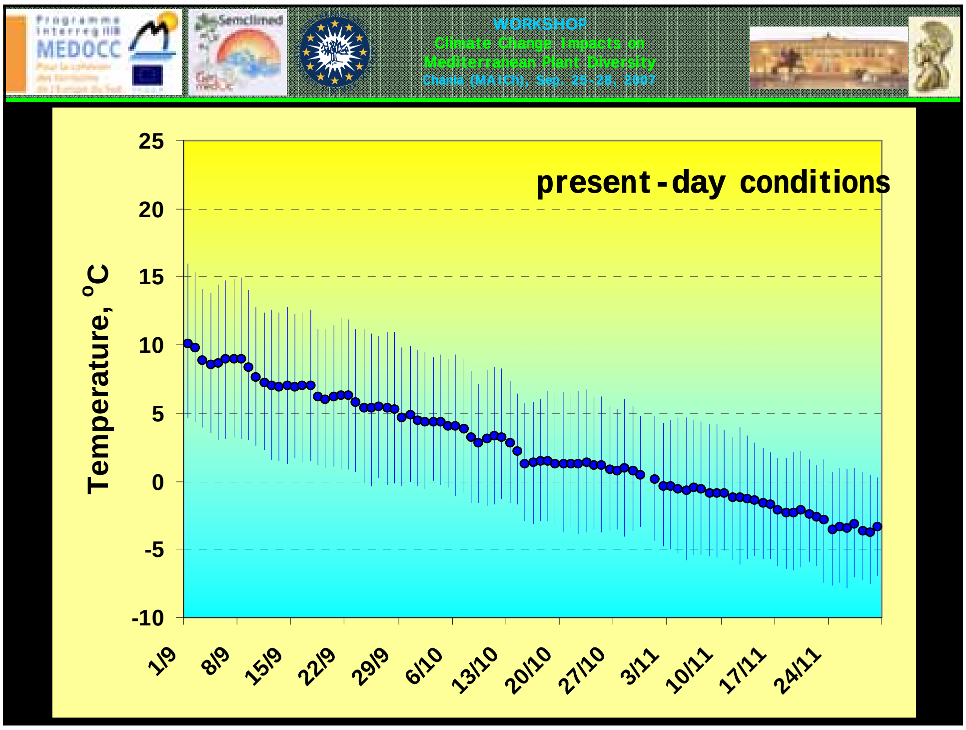


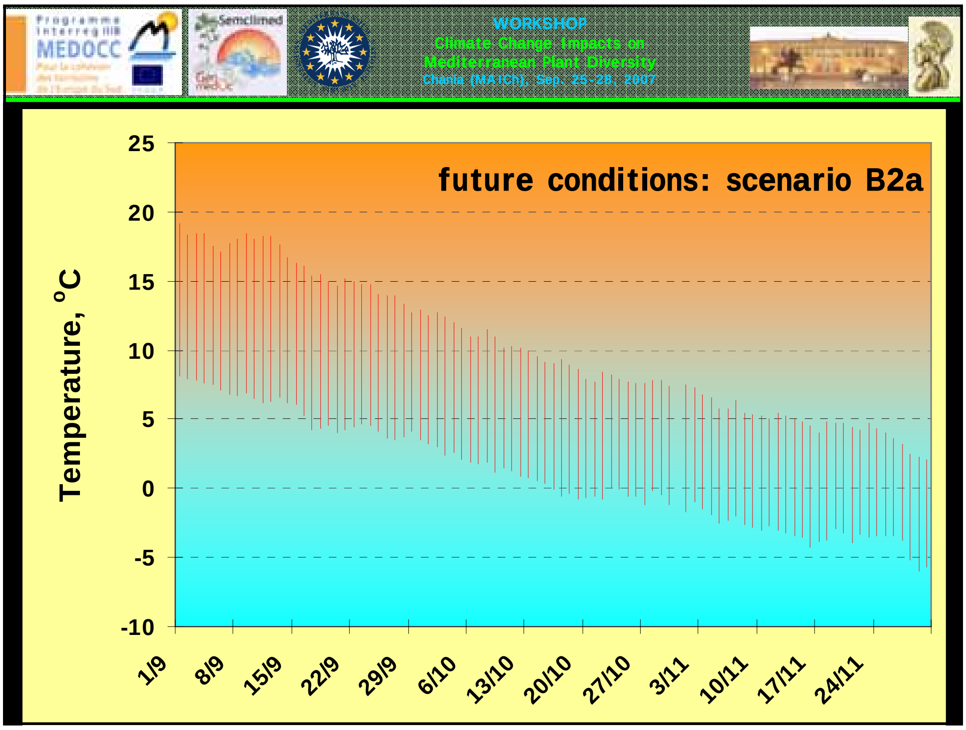
WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
MEDOCC
Semclimed
in the open
inside an oak forest
under a hellebore leaf
Light fluence rate, W/m2
0,25
0,20
0,15
0,10
0,05
0,00
300
350
400
450
500
550
600
650
700
750
800
850
Wavelength, nm

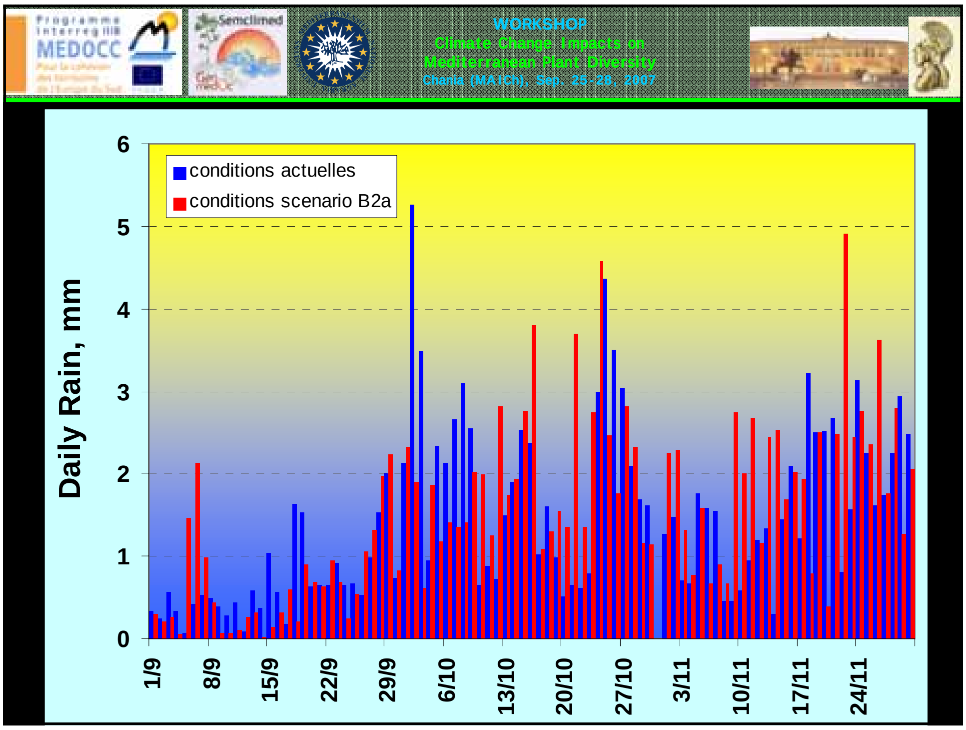


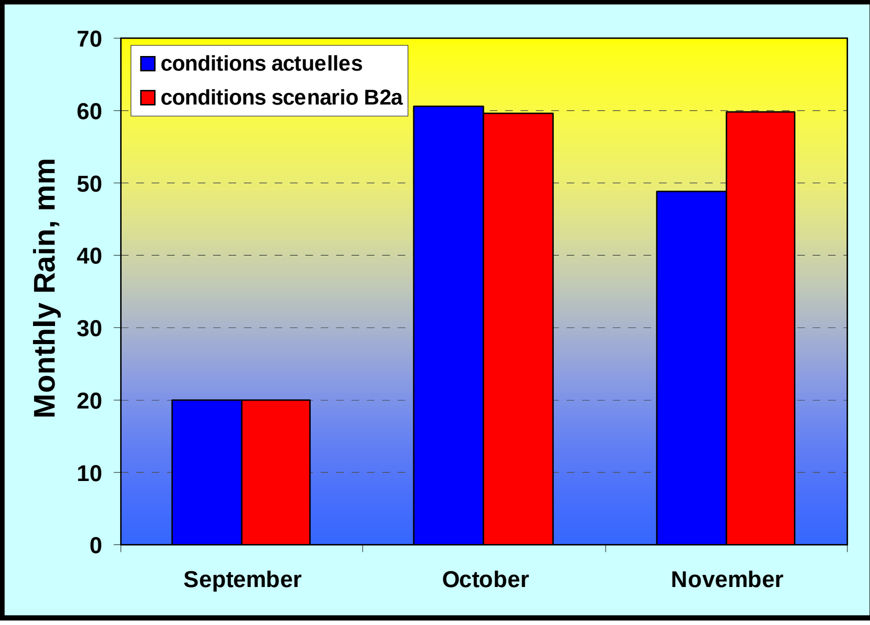
WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
MEDOCC
Semclimed
Fluence rate, W/m2
0,250
0,200
0,150
0,100
0,050
0,000
300
400
500
600
700
800
900
Wavelength, nm
N3
N2
N1


Programme Interreg IIIB MEDOCC
Semclimed
WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
39
38.5
38
37.5
37
36.5
36
35.5
35
22
22.5
23
23.5
24
24.5
25
8657 8658 8659 8660 8661
8763 8764 8765 8766 8767
8869 8870 8871 8872 8873
8975 8976 8977 8978 8979 8980
9081 9082 9083 9084 9085 9086
9187 9188 9189 9190 9191 9192
9294 9295 9296 9297 9298
9400 9401 9402 9403 9404 9405
9506 9507 9508 9509 9510 9511
Nepeta sphaciotica


Programme Interreg IIIB MEDOCC
Semclimed
WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
present-day conditions
Temperature, °C
25
20
15
10
5
0
-5
-10
1/9
8/9
15/9
22/9
29/9
6/10
13/10
20/10
27/10
3/11
10/11
17/11
24/11


MEDOCC
Semclimed
WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
future conditions: scenario B2a
Temperature, °C
25
20
15
10
5
0
-5
-10
1/9
8/9
15/9
22/9
29/9
6/10
13/10
20/10
27/10
3/11
10/11
17/11
24/11


MEDOCC
Semclimed
WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007
conditions actuelles
conditions scenario B2a
Daily Rain, mm
6
5
4
3
2
1
0
1/9
8/9
15/9
22/9
29/9
6/10
13/10
20/10
27/10
3/11
10/11
17/11
24/11



WORKSHOP
Climate Change Impacts on
Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007

SVOURICHTI, 2280 m asl
PRESENT CONDITIONS (1-7 September)
at 1 cm below soil surface

	time	Temperature (controller)	Light Fluorescent	Light Incandescent	Light Temperature (in Petri dish)
	5:00	6,7	0	0	7,3
	6:00	6,2	0	0	6,8
TWILIGHT	6:31	6,2	0	1	7,2
SUNRISE	6:57	6,0	1	1	7,1
	8:00	9,2	1	1	10,2
	9:00	12,0	1	1	13,0
	9:27	11,5	2	2	13,1
	10:00	13,8	2	2	15,3
	11:00	14,2	3	3	16,2
	12:00	15,1	3	3	17,1
	13:00	15,6	3	3	17,6
	14:00	15,9	3	3	17,9
	15:00	15,6	3	3	17,6
	16:00	15,4	2	2	17,0
	17:00	13,4	2	2	15,0
	17:25	13,4	1	1	14,4
	18:00	11,3	1	1	12,4
	19:00	9,8	1	1	10,8
SUNSET	19:48	9,8	0	1	10,8
	20:00	8,3	0	1	9,4
TWILIGHT	20:14	8,8	0	0	9,4
	21:00	8,3	0	0	8,9
	22:00	7,7	0	0	8,3
	23:00	7,3	0	0	7,9

WORKSHOP
Climate Change Impacts on Mediterranean Plant Diversity
Chania (MAICh), Sep. 25-28, 2007

SVOURICHTI, 2280 m asl
B2a CLIMATE CHANGE SCENARIO (1-7 September) [+4 DEGREES]
at 1 cm below soil surface

	time	Temperature (controller)	Light Fluorescent	Light Incandescent	Light Temperature (in Petri dish)
	5:00	10,7	0	0	11,2
	6:00	10,2	0	0	10,7
TWILIGHT	6:31	10,2	0	1	11,1
SUNRISE	6:57	10,0	1	1	10,9
	8:00	13,2	1	1	14,1
	9:00	16,0	1	1	16,8
	9:27	15,5	2	2	16,8
	10:00	17,8	2	2	19,0
	11:00	18,2	3	3	19,6
	12:00	19,1	3	3	20,6
	13:00	19,6	3	3	21,1
	14:00	19,9	3	3	21,5
	15:00	19,6	3	3	21,1
	16:00	19,4	2	2	20,6
	17:00	17,4	2	2	18,6
	17:25	17,4	1	1	18,3
	18:00	15,3	1	1	16,2
	19:00	13,8	1	1	14,6
SUNSET	19:48	13,8	0	1	14,6
	20:00	12,3	0	1	13,3
TWILIGHT	20:14	12,8	0	0	13,3
	21:00	12,3	0	0	12,8
	22:00	11,7	0	0	12,2
	23:00	11,3	0	0	11,7

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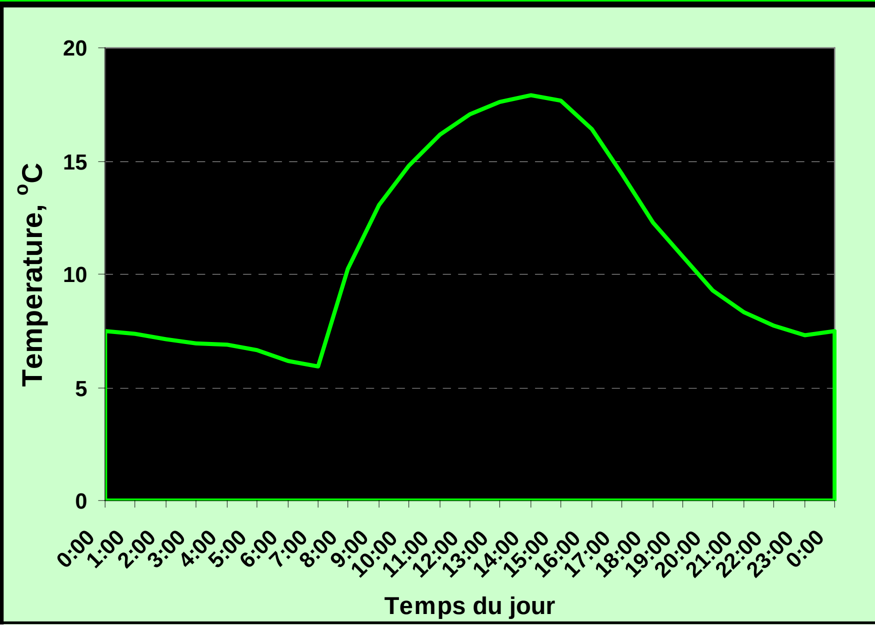

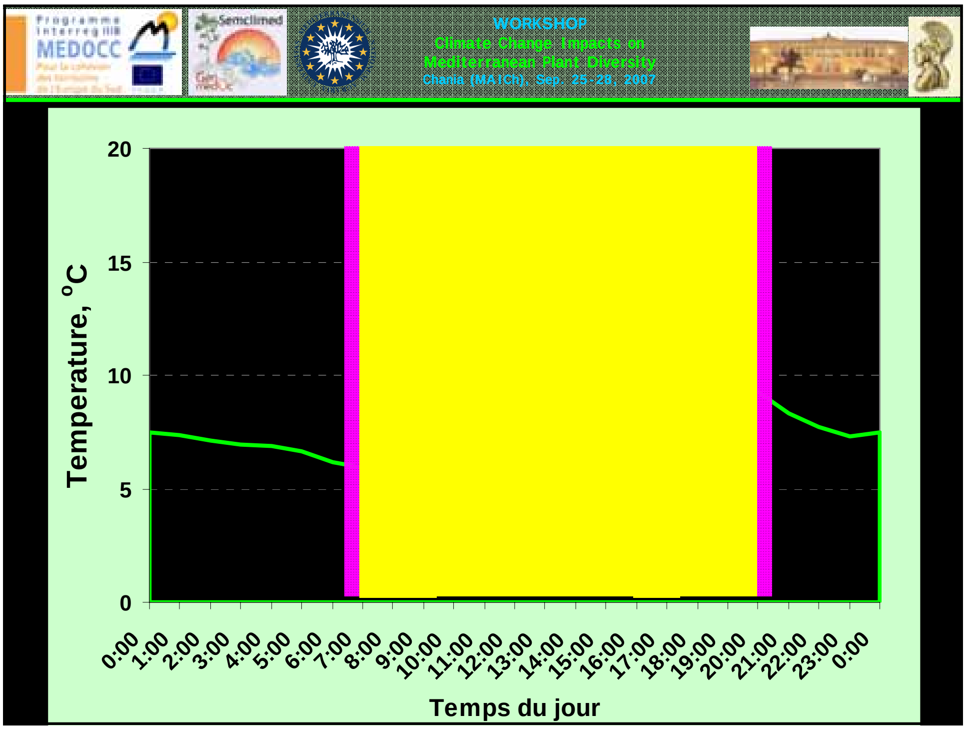
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Semclimed
Temperature, °C
Temps du jour
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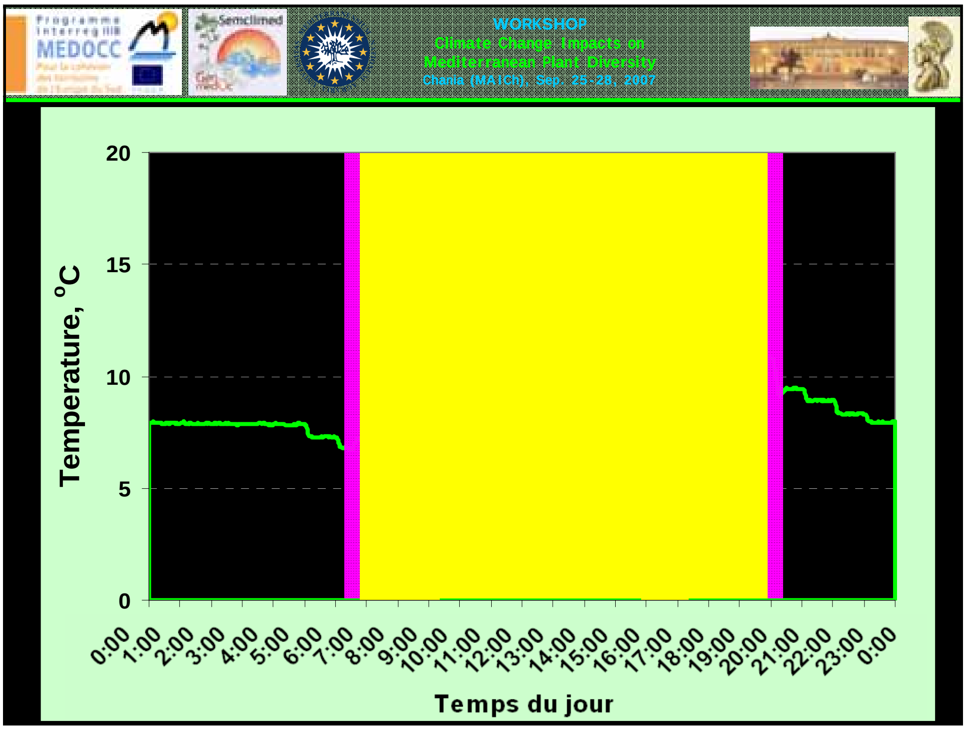
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Research Opinion

Mistakes in germination ecology and how to avoid them

Carol C. Baskin[1,2*], Ken Thompson[3] and Jerry M. Baskin[1]
[1]Department of Biology, University of Kentucky, Lexington, KY 40506-0225 USA; [2]Department of Plant and Soil Sciences, University of Kentucky, Lexington, KY 40546-0312 USA; [3]Department of Animal and Plant Sciences, University of Sheffield, Sheffield S10 2TN UK

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1. What should I try to germinate?

As far as possible, you should use the intact natural dispersal unit, because removal of parts from it may increase/decrease germination percentages. The 'intact natural dispersal unit' means the fruit or seed in the form in which it would normally occur in nature after dispersal. For fleshy fruits, this means removing the flesh, which often contains germination inhibitors. Unless it is likely to happen in the field, you should not attempt to remove structures such as the lemma and palea that remain tightly bound to many grass grains, even if their removal promotes germination.

2. What conditions should I use?

It is best to test seeds/fruits over a range of alternating temperatures regimes, simulating those in the natural habitat during the growing season, and also place seeds/fruits in light and in darkness. If possible, constant temperatures and continuous light should be avoided; obviously, these conditions are not encountered frequently in nature, and in some species may decrease germination percentages. Also, high photon irradiance can inhibit germination. To answer this question, consider the sequence of environmental factors to which the seeds are exposed between maturity and germination. For example, if a seed is dormant at maturity in spring and germinates in autumn, it obviously does not need to be cold stratified.

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3. Why should fresh seeds be used when determining if seeds are dormant?

If seeds have non-deep physiological dormancy, after-ripening (dormancy break) can occur during dry storage, especially at room temperatures. In a few species, drying can cause seeds to enter dormancy. If seeds have physical dormancy, drying may cause the water gap to open. The key point is that if your seeds have already received any 'treatment' (however inadvertent) before you try to germinate them, you cannot know what the effects of this treatment have been.

5. When should a germination test be terminated?

Depending on the species, considerable dormancy break can occur in dry seeds at room temperatures within a few weeks; thus, we suggest that a test should be stopped within about 4 weeks. If you want to know if dormancy break and germination would eventually occur at a certain temperature regime, seeds could be checked at 2-week intervals and kept for years. Seeds at all test conditions should be given the same period of time for germination.

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6. If fresh seeds germinate to a high percentage at only a portion of the test temperatures, are the seeds non-dormant?

Some freshly matured seeds are non-dormant, but they germinate only at high or at low temperatures, depending on the species. If the range of temperatures over which seeds will germinate cannot be increased, then seeds are non-dormant. However, in many species, the temperature range for germination will increase if seeds are given a dormancy-breaking treatment, e.g. cold stratification or exposure to high summer temperatures. If the temperature range increases, then the fresh seeds were conditionally dormant. The only way to know if fresh seeds are non-dormant (with a high or a low temperature requirement for germination) or conditionally dormant is to test them over a range of temperatures, give them a dormancy-breaking treatment and then test over the same range of temperatures. If the temperature range for germination increases, the fresh seeds were conditionally dormant. Try to make sure your test temperatures cover the whole range over which the seeds will germinate; even if your seeds germinate well at 25°C, test them at 30°C and 35°C before concluding that 25°C is the optimum temperature for germination.

7. How can I tell if seeds have physical dormancy?

Physical dormancy means the seed (or fruit) coat is water impermeable. To determine if diaspores are water impermeable, they should be weighed before and after a period of incubation (e.g. 24h) on a wet substrate. Physical dormancy is currently known in the *Anacardiaceae, Bixaceae, Cannaceae, Cistaceae, Cochlospermaceae, Convolvulaceae* (including *Cuscutaceae*), *Curcurbitaceae, Dipterocarpaceae* (subfamilies *Monotoideae* and *Pakaraimoideae*, but not *Dipterocarpoideae*), *Fabaceae* (all three subfamilies), *Geraniaceae, Malvaceae* (including *Bombacaceae, Sterculiaceae* and *Tiliaceae*), *Nelumbonaceae, Rhamnaceae, Sarcolaenaceae, Sapindaceae and Surianaceae*. If your species is not in one of these families, it probably has water-permeable seeds/fruits. It should be noted that not all members of all of these families have water-impermeable seeds. For example, in *Anacardiaceae* only members of the '*Rhus* complex' have physical dormancy, and seeds of the other 70 or so genera in the family have either physiological dormancy or are non-dormant.

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10. If seeds are water permeable, why would mechanical or acid scarification promote germination?

Acid and mechanical scarification reduce the mechanical restriction of the seed/fruit coat. Thus, the radicle is able to emerge from the seed, although growth potential of the embryo has not been increased. Scarification also may overcome a light requirement for germination, reduce sensitivity to far-red light and increase sensitivity to gibberellic acid.

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12. How can I tell if seeds have morphological dormancy (MD)?

Seeds will imbibe water. They have a relatively small (low embryo length/seed length ratio) embryo in a relatively large seed with much endosperm. In MD, the embryo has to grow (inside the seed) before the seed germinates, and seeds germinate in about 4 weeks from the start of incubation. However, not every seed with a relatively small embryo has MD. To verify that seeds have MD, you need to demonstrate that the embryo grows inside the seed before the radicle emerges. To do this, measure the embryo in at least 15 freshly matured, imbibed seeds, and then measure the embryo in other seeds when the seed coat splits, i.e. just prior to radicle emergence.

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14. Cold stratification is reported to break dormancy in my seeds. Thus, I put dry seeds in a paper bag in the refrigerator at 5°C for 12 weeks, but none of them germinated, regardless of the test temperature. Why?

The seeds did not germinate because they were still dormant. Seeds that require cold stratification must be imbibed for dormancy break to occur. In addition, it is not a wise general practice to store unimbibed seeds in paper bags at any temperature; doing so allows the seed moisture to change continually as a function of atmospheric relative humidity (RH). Any physiological change that is moisture content dependent (such as after-ripening) will be subject to the RH variability.

17. In my experiment, dark-incubated seeds were exposed to dim white (or room) light for about 2–3 min each day while germination was being checked. My results show that germination percentages were equally high in both light and darkness; thus, can I conclude that the seeds do not have a light requirement for germination?

No. During the brief period of exposure to light, the light requirement for germination may have been fulfilled in the 'dark-incubated' seeds. Only a few seconds of light are required to fulfil the light requirement of seeds of some species.

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18. How safe are green safe lights for checking germination of dark-incubated seeds?

It depends on the species, time of year (i.e. stage of after-ripening) and quality of the light. Green light actually promotes seeds of some species to germinate, while seeds of other species are more sensitive to green light at some times of the year than at other times. The quality of the green light is important. It is not easy to get a narrow-band green safe light. Thus, at different stages of dormancy break, it is important to compare germination of seeds exposed to the green light with that of seeds not receiving any green light. A green safe light may not stimulate germination in the early stages of dormancy break, but may stimulate germination in the late stages of dormancy break, i.e. when the seeds are more sensitive to germination-stimulating factors.

19. Is it OK to collect the seeds, although they still look a little green?

Testing green seeds may not give you a true picture about seed dormancy, but you might get seedlings (if that is your aim), depending on the species. One way to avoid the problem of physical dormancy in seeds of some species is to collect seeds/fruits before they dry on the mother plant, i.e. before the seed/fruit coat becomes water impermeable during the drying process. In a few species whose seeds have physiological dormancy, picking green seeds can also be a way of avoiding the problem of dormancy. However, some seeds with physiological dormancy may never germinate if they are not allowed to dry. Sometimes, seeds can be picked while slightly immature, and they will be normal with respect to dormancy. If seeds must be collected before they are fully ripe, it is best to leave the seeds attached to as much plant material as possible and to store them in a damp place where they will dry slowly.

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21. If leaching in running water increases germination percentages, does this mean a chemical inhibitor was removed from the seeds?

Maybe, but maybe not. Proving that a particular compound is present and that it prevents germination *in situ* is very difficult. Further, depending on the temperature and on length of the leaching period, seeds may have actually received a period of warm or cold stratification.


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THANK YOU!!