UNIVERSITÀ DEGLI STUDI DELLA Tuscia

METTIAMOCI IN RIGA

12 giugno 2019

Bartolomeo SCHIRONE

ZEPHYR

Tecnologie innovative a impatto zero per la produzione di piante per uso forestale

UNIONE EUROPEA
Fondo Sociale Europeo
Fondo Europeo di Sviluppo Regionale

Agenzia per la Coesione Territoriale

MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE

PON GOVERNANCE E CAPACITÀ ISTITUZIONALE 2014-2020

SOGESID SPA
INGEGNERIA TERRITORIO AMBIENTE

Zero Impact Innovative Technology in Forest Plant Production

Total Cost: 4,284,275 €

EC Contribution: 3,438,252 €

Duration: 36 months

Start Date: 01/10/2012

End of the Project: 01/10/2015

Consortium: 14 partners from 10 countries

Project Coordinator: Tuscia University – DAFNE Department (Italy)

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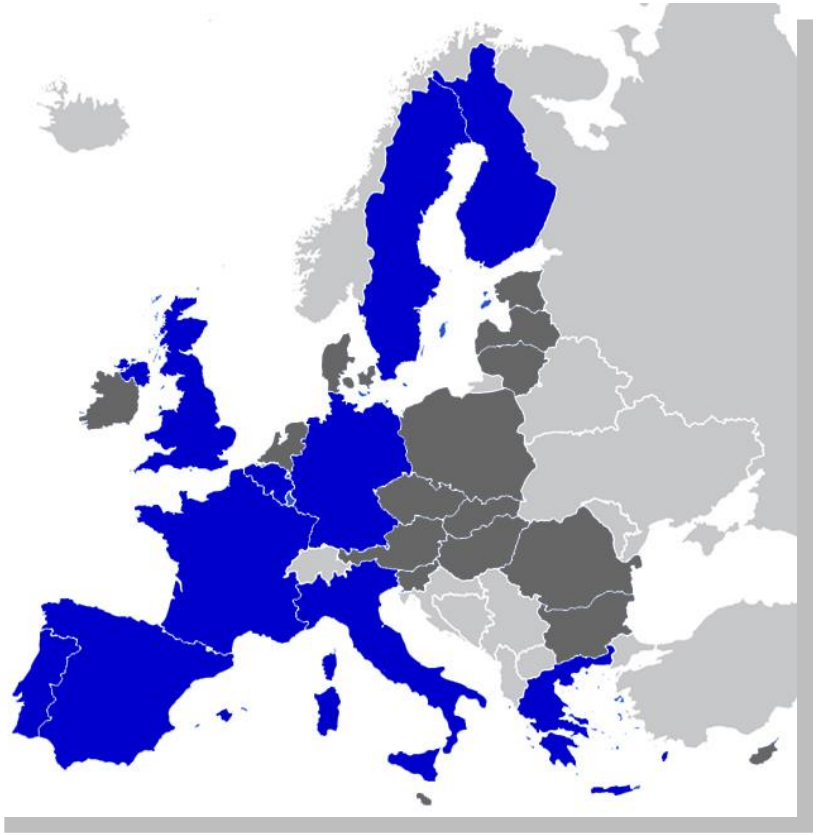
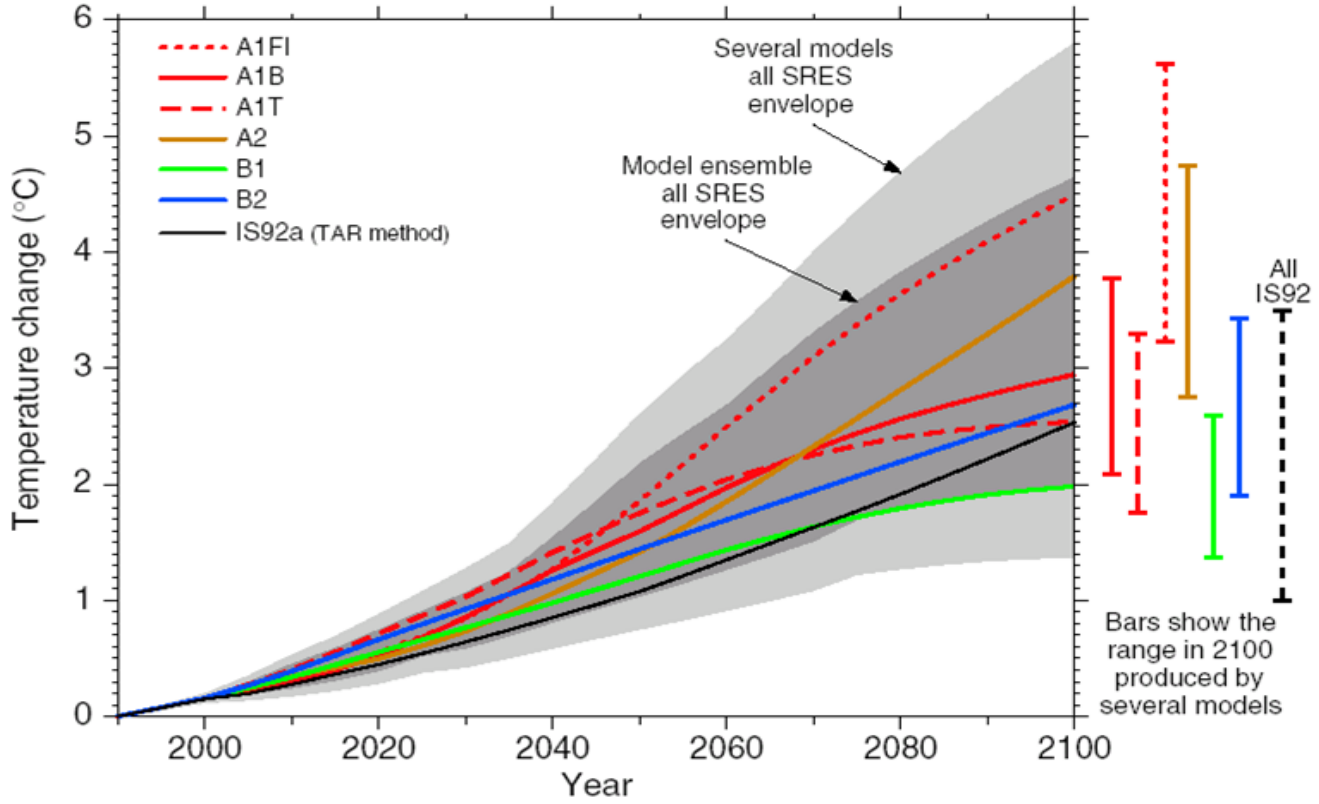
PROJECT PARTNERS

Dept. DAFNE, Tuscia University - IT	IT
DEMOCRITUS UNIVERSITY OF THRACE	GR
CO.MET.ART. SAS	IT
VALOYA OY	FI
ROBOSOFT SA	FR
VIVAI TORSANLORENZO Società Agricola	IT
FRAUNHOFER IFAM	DE
ACREO AB.	SE
HOGSKOLAN DALARNA	SE
VELTHA IVZW	BE
INSUBRIA University	IT
ADVANTIC SISTEMAS Y SERVICIOS	ES
AZORINA SA	PT
EXERGY LTD	UK



CLIMATE CHANGE: GLOBAL WARMING PROJECTIONS



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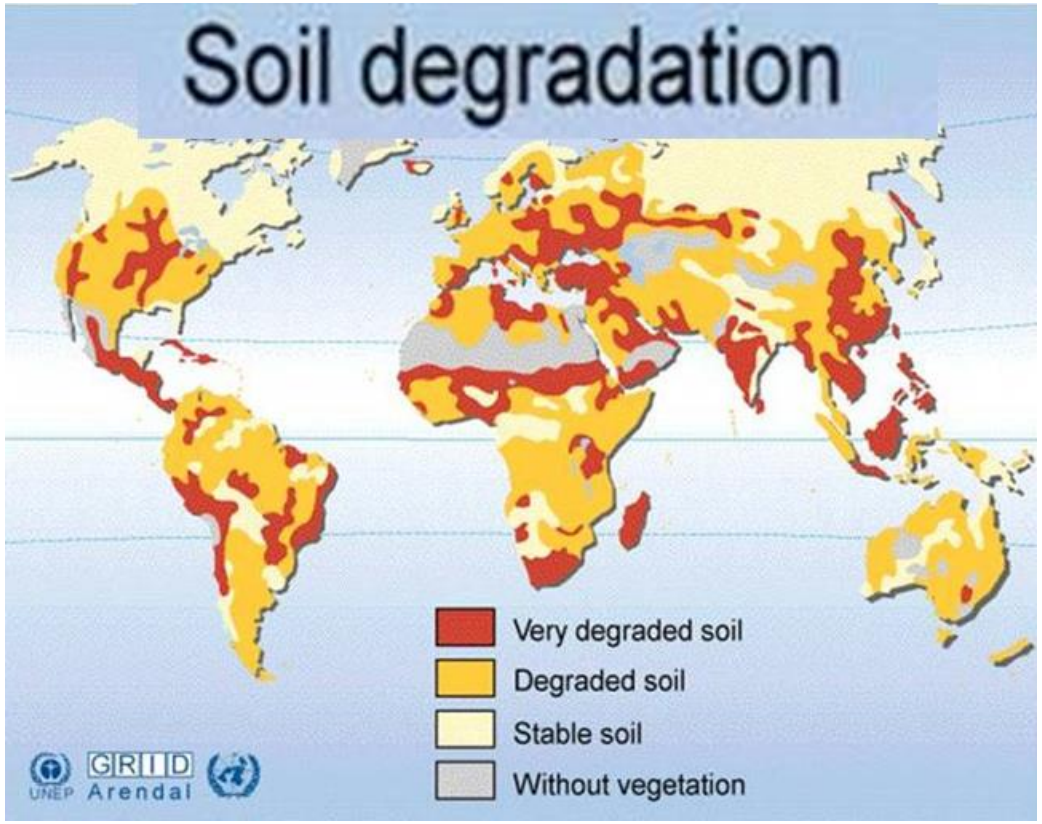
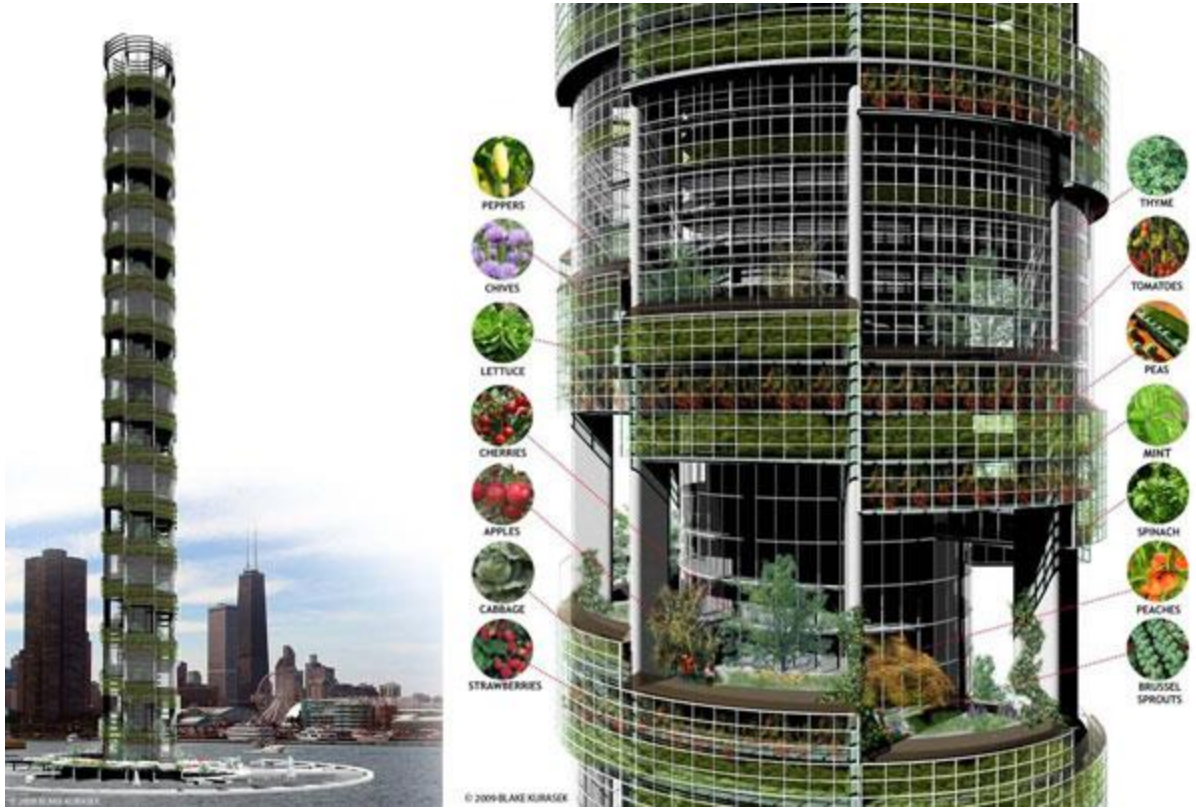
Climate change and over-exploitation of the earth resources by humans are causing a major increase of environmental disasters (floods, large fires, etc..) and a progressive loss of fertile soil and of fresh water reserves.

Soil degradation, including soil erosion, salinization and land drying due to overgrazing, concerns quite all the world lands.



To face the decrease of arable land, in the agricultural sector, they are now more and more spreading large plant factories …

… and the architects are planning real skyscrapers for the production of plants for human nutrition

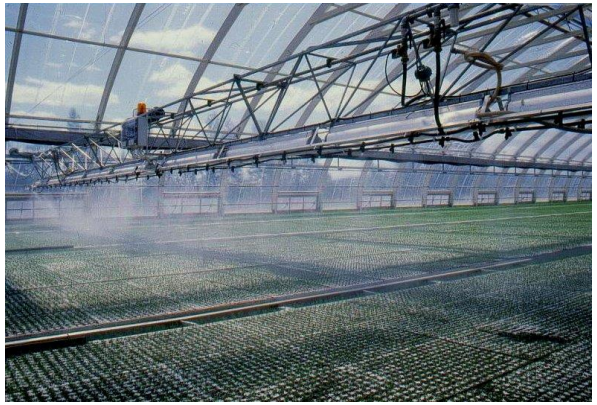


On the other hand, the problem of soil degradation concerns also the forest areas, the ‘lungs’ of the earth. And the loss of forest ecosystems and their biodiversity can affect the very life of people on the planet.

The reduction of arable lands and forests requires a more and more sustainable management of natural resources, water and energy.
This is also the basic concept of the circular economy

In forest restoration activities, the production of seedlings for reforestation is highly expensive in terms of space, water, energy and other resources.

Germination and early growth



Irrigation and fertilization

Large container stock

Outdoor growth

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Starting from these assumptions, Zephyr project aims to contribute to an efficient and sustainable production of plantlets for environment restoration purposes. In particular, we are trying to apply the concept of plant factory also to forest plants. After several national and European projects, such as Pre-Forest and Regen-forest, we arrived to Zephyr approach.

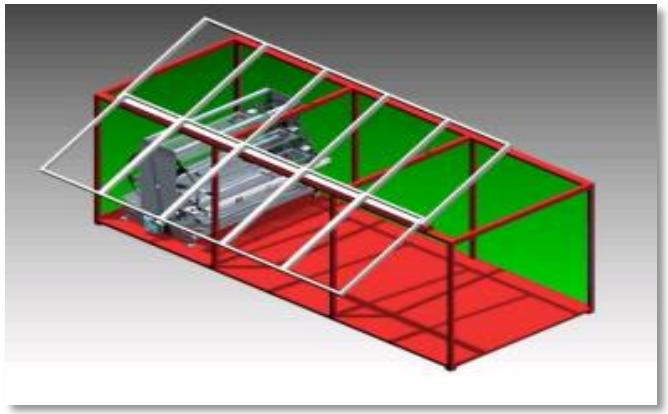
Zephyr proposes a new concept of forest nursery. In fact, the final product of Zephyr project is a transportable, energy saving and autonomous growth chamber, totally robotized, that can be considered as the basal unit of a new kind of plant factory. In fact, it is possible to design a plant factory by adding many Zephyr units.

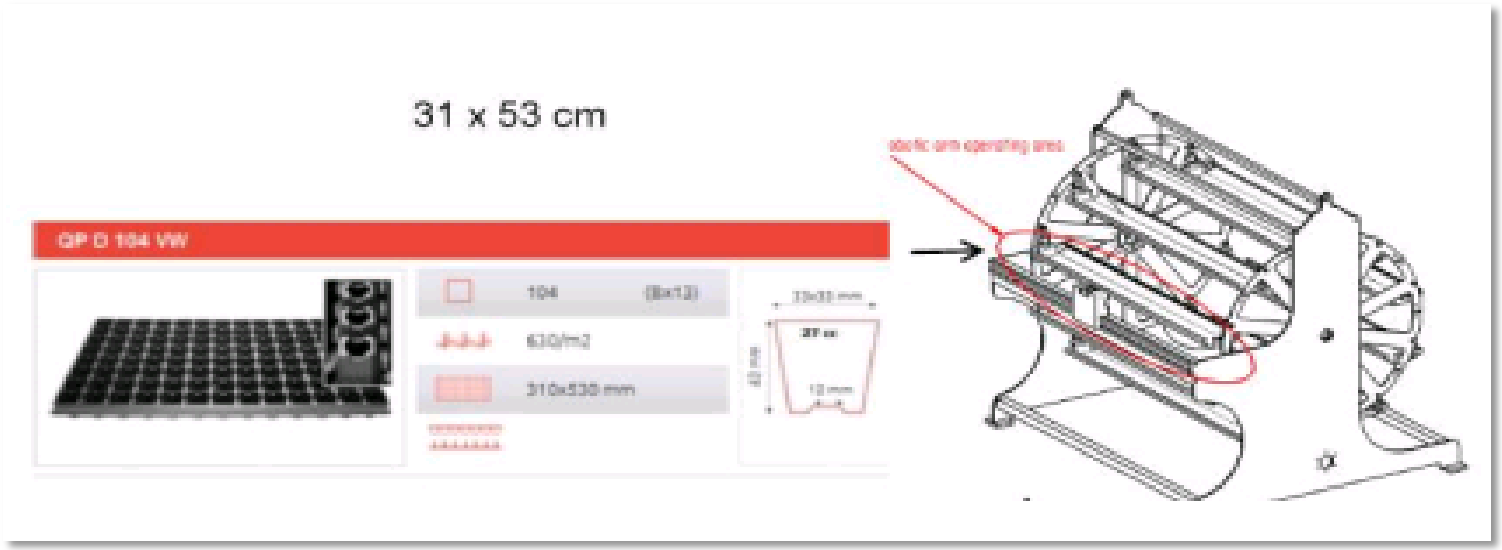
ZEPHYR

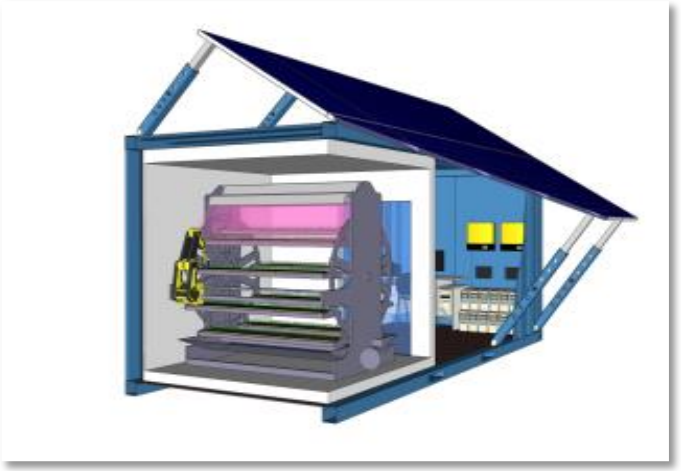
PROTOTYPE

Zephyr Project: Engineering

The prototype design has taken into account the most advanced systems to save energy and recycle a valuable resource such as water.







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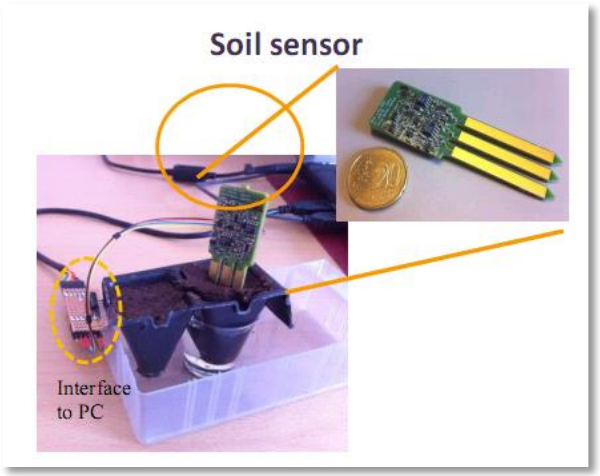
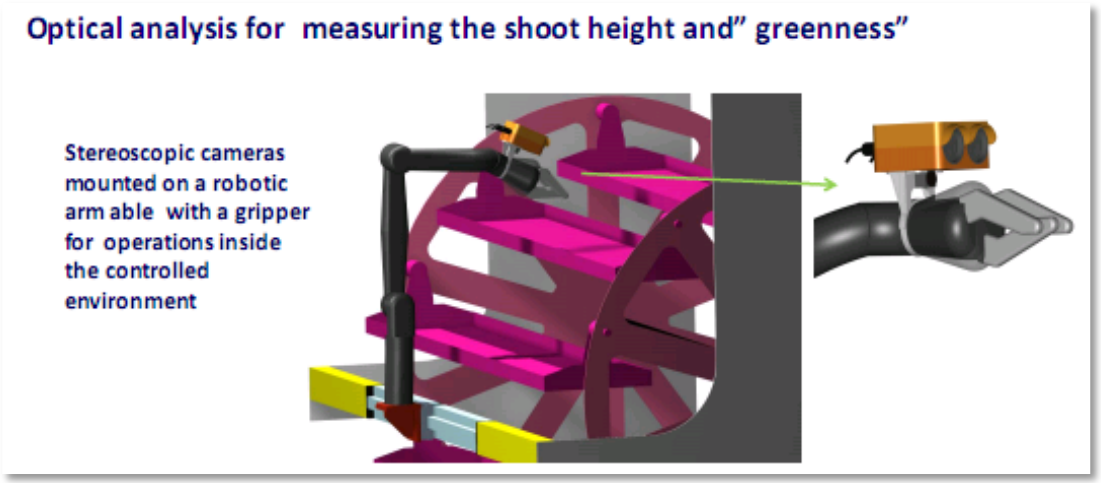
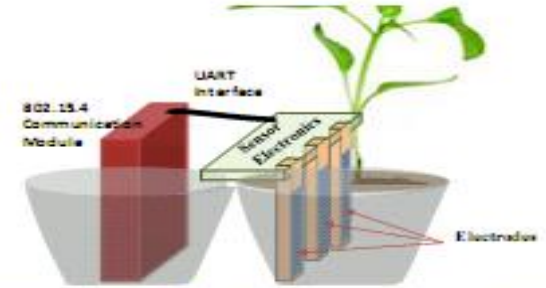
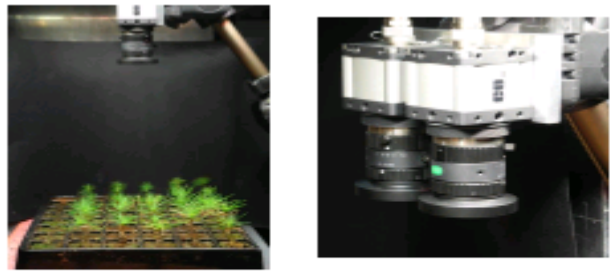
Zephyr Project: Design of the sensors



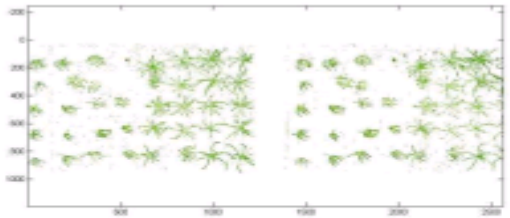




Schematic of the first sensor stick with its electronics and communication modules



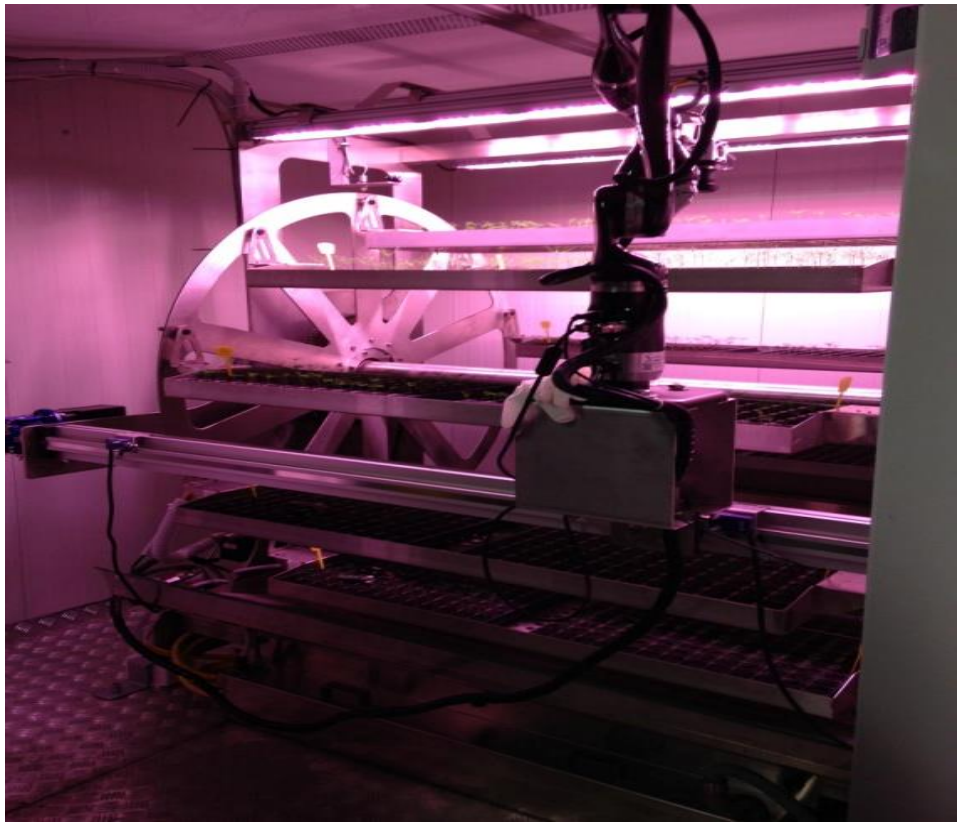
Photos of the optical system for measuring the shoot height and 'greenness'. (a) typical position of optical cameras on top of seedlings; (b) optical cameras zoom-in showing the dual cameras for stereoscopic imaging.



Green pixels for a special setup of very young plants (stereographic view).

ZEro ImPact Innovative tecHnologY in FoRest Plant Production
Plant factory mobile per la coltivazione di specie forestali

- Tamburo rotante (10 ripiani)
- Sistema di condizionamento dell'aria
- Sistema di irrigazione ebb&flood
- Braccio robotico
- Sensori wireless (per monitorare il substrato)
- Sensori ottici



Differences between horticultural and forest plants

The first problem that Zephyr had to deal with was one of the conservation of forest biodiversity that ensures best adaptation to

environmental changes. The forests, unlike the agricultural crops, are not simple sets of plants, but complex systems that can survive and evolve spontaneously only if the genetic variability of the trees is safeguarded. This is achieved by producing plants from seed and not from cuttings.

LED = Light Emitting Diode (diodo ad emissione di luce)

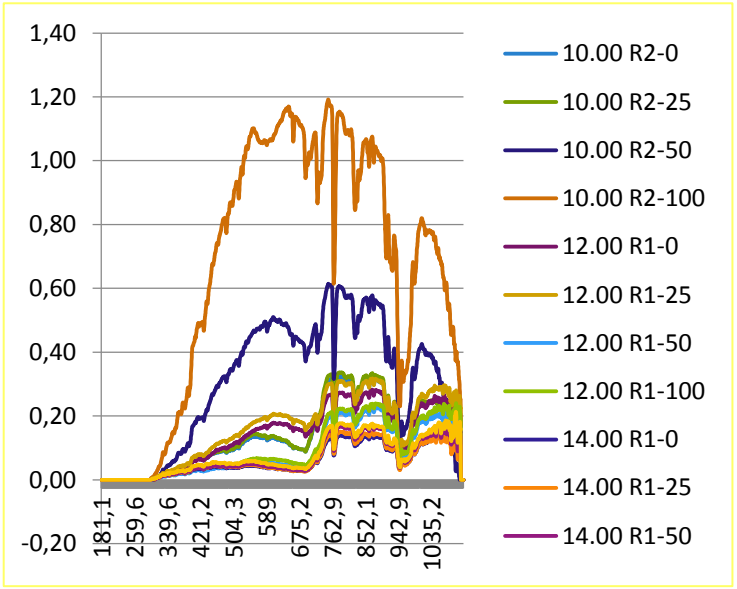
La scelta del semiconduttore determina la lunghezza d'onda d'emissione

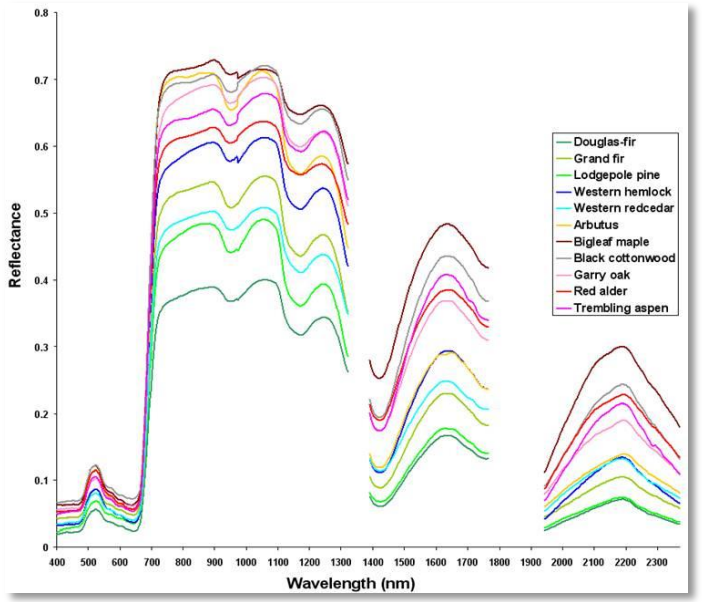
Infinite combinazioni di singoli LED -> creazione di infiniti spettri continui (400-1100 nm)

Fonte luminosa più idonea per *replacement lighting*

Light Spectrum

The light spectra depend on the photoperiod and the light intensity but also on the tree cover (difference in height species and density)





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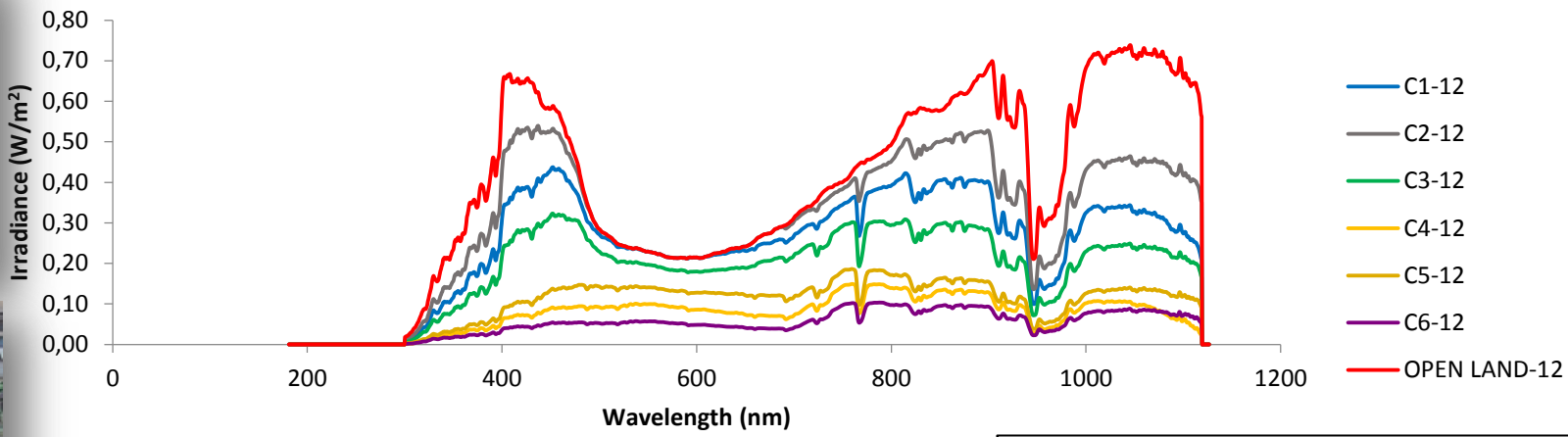
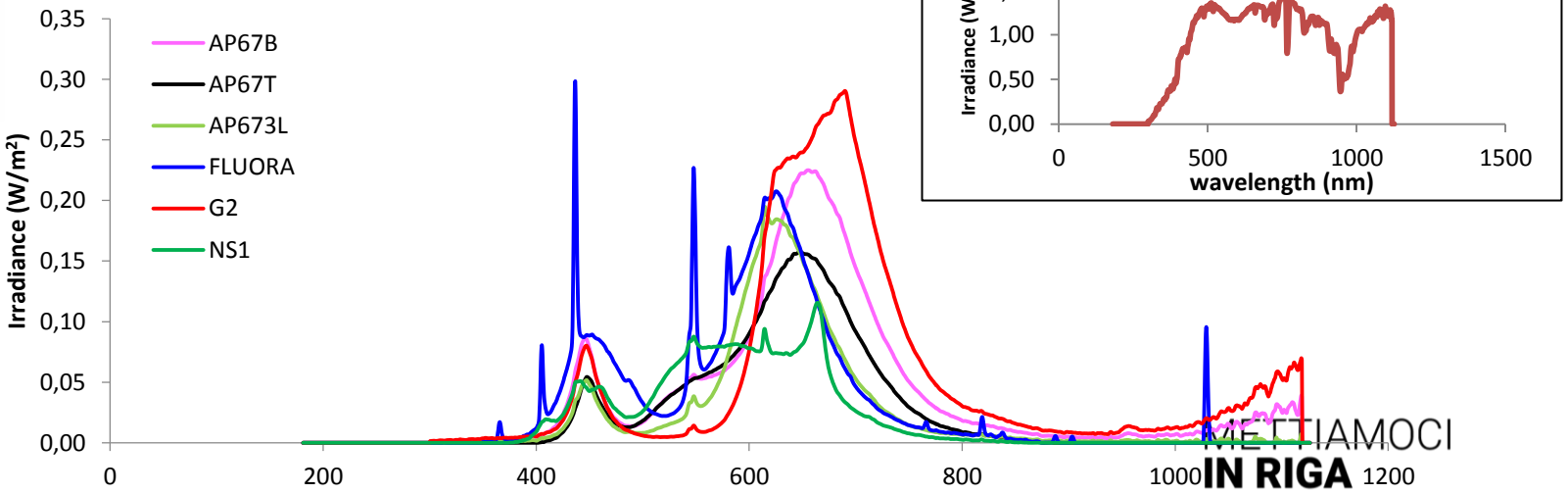
Zephyr Project: bio-ecological studies

To achieve this goal, the project has involved long and complex bio-ecological studies in the field and laboratory, especially to determine the most efficient light sources

Task 3.3 Growth tests performed in normal growth chambers with LED lamps (Task leader UNITUS)

The new LED lights provided by Valoya ® have **low PAR intensity** if compared to sunlight and almost totally absence of **UV** (< 400 nm) and **INFRARED** light (> 700 nm)





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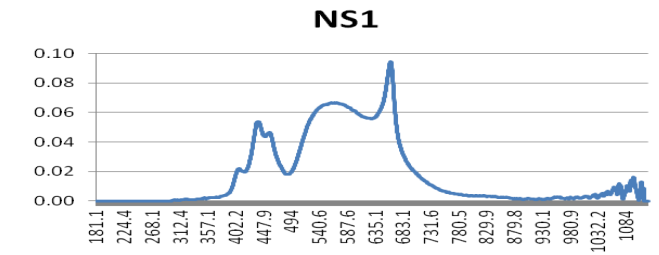
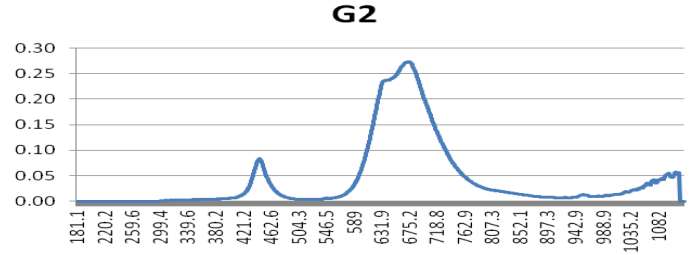
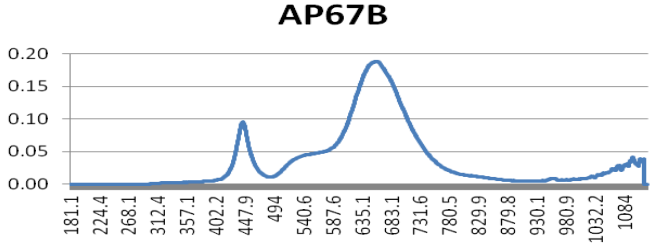
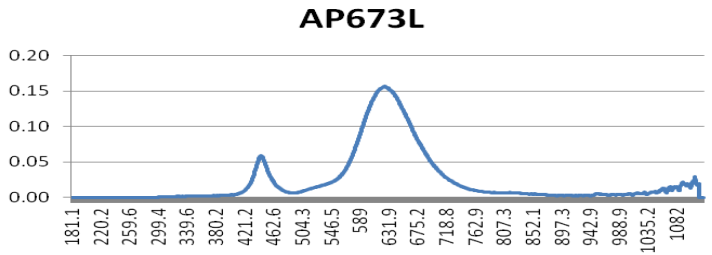
Task 3.3 Growth tests performed in normal growth chambers with LED lamps (Task leader UNITUS)

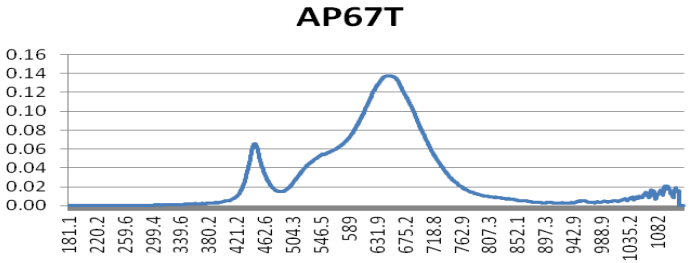
Different LED light sources tested

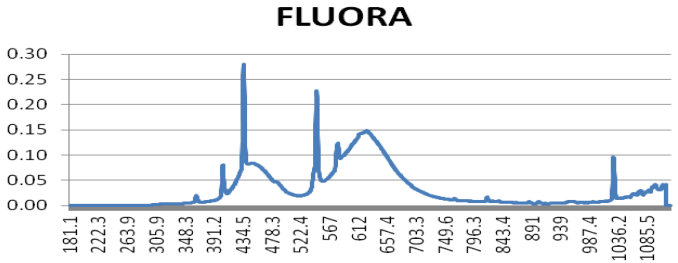












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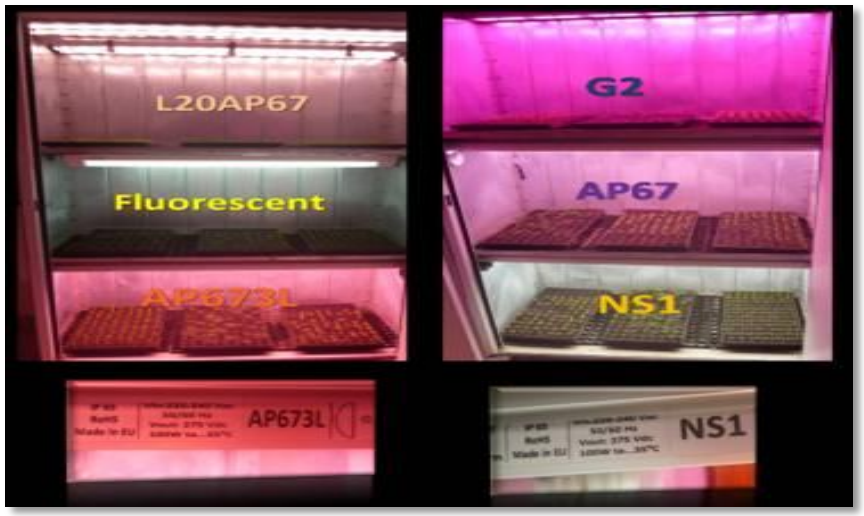
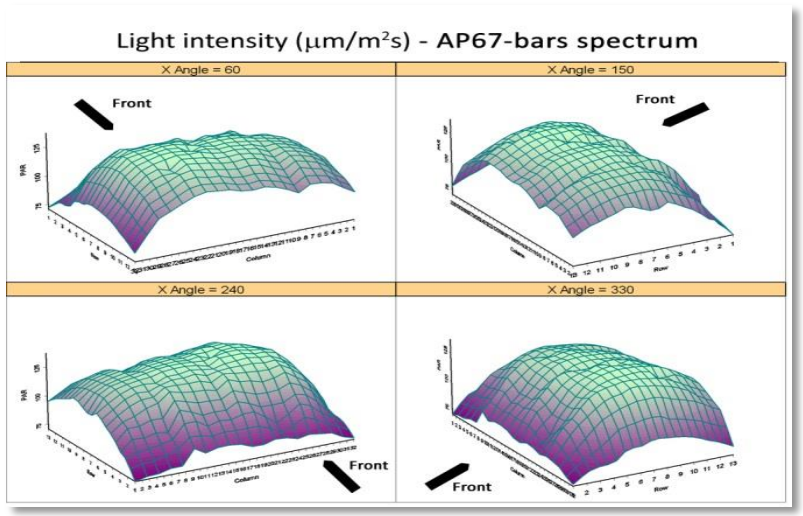
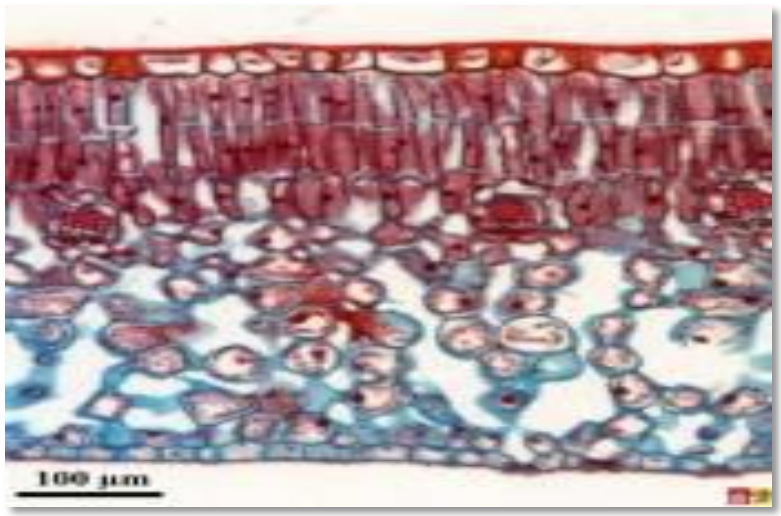
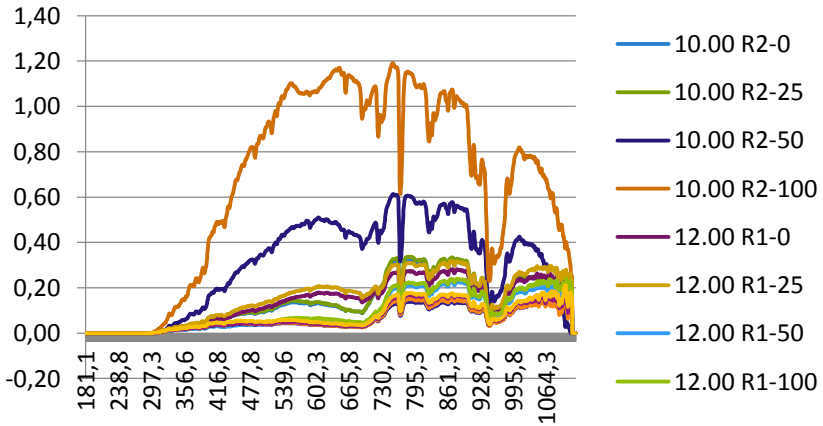
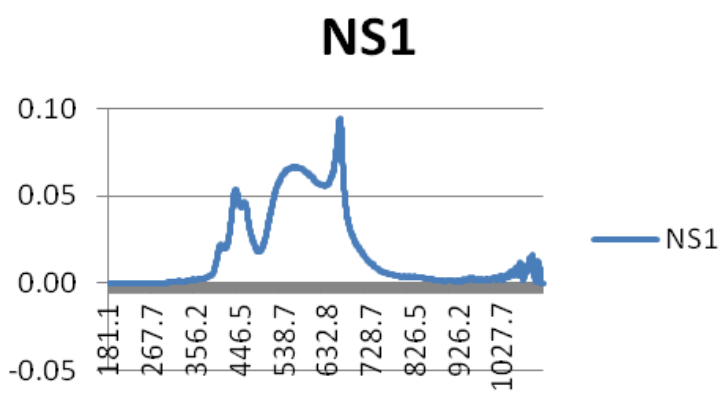
Zephyr Project: The research on light sources

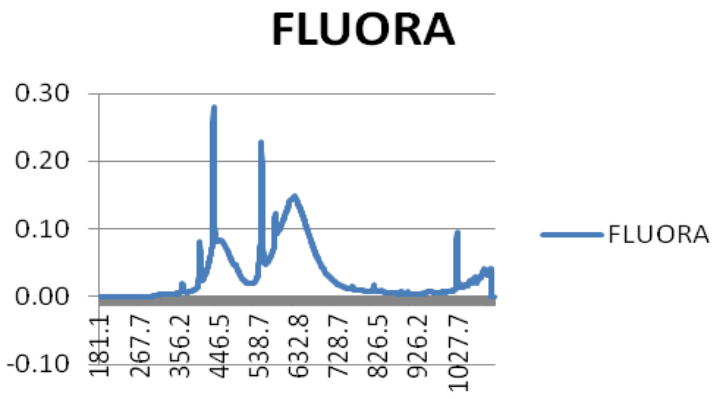












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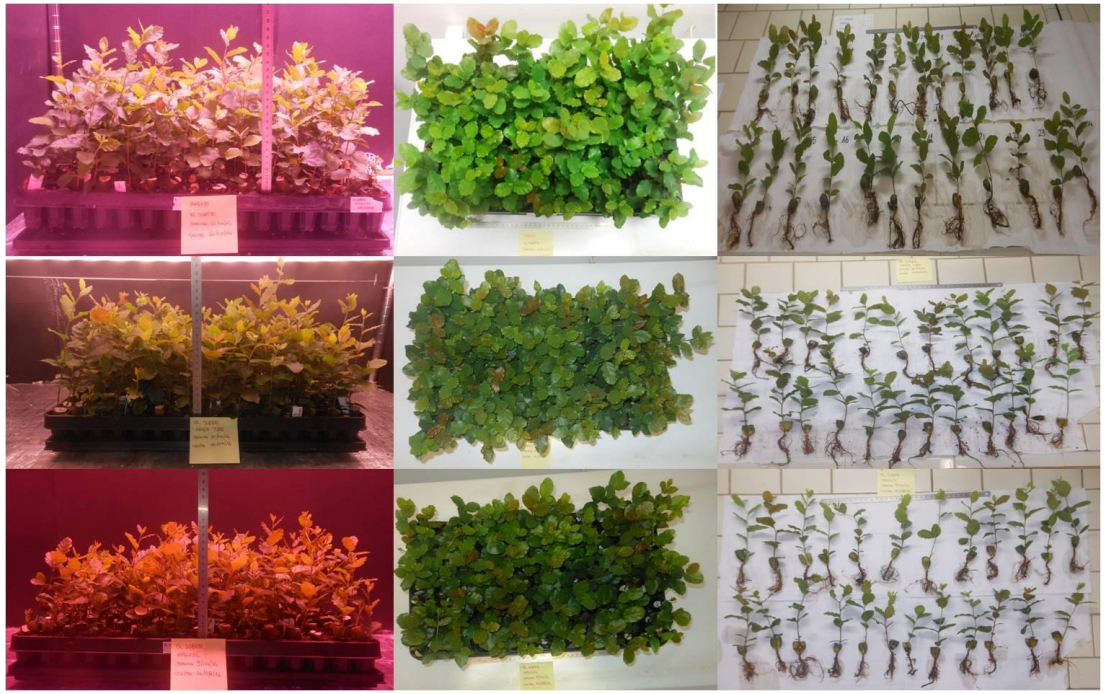
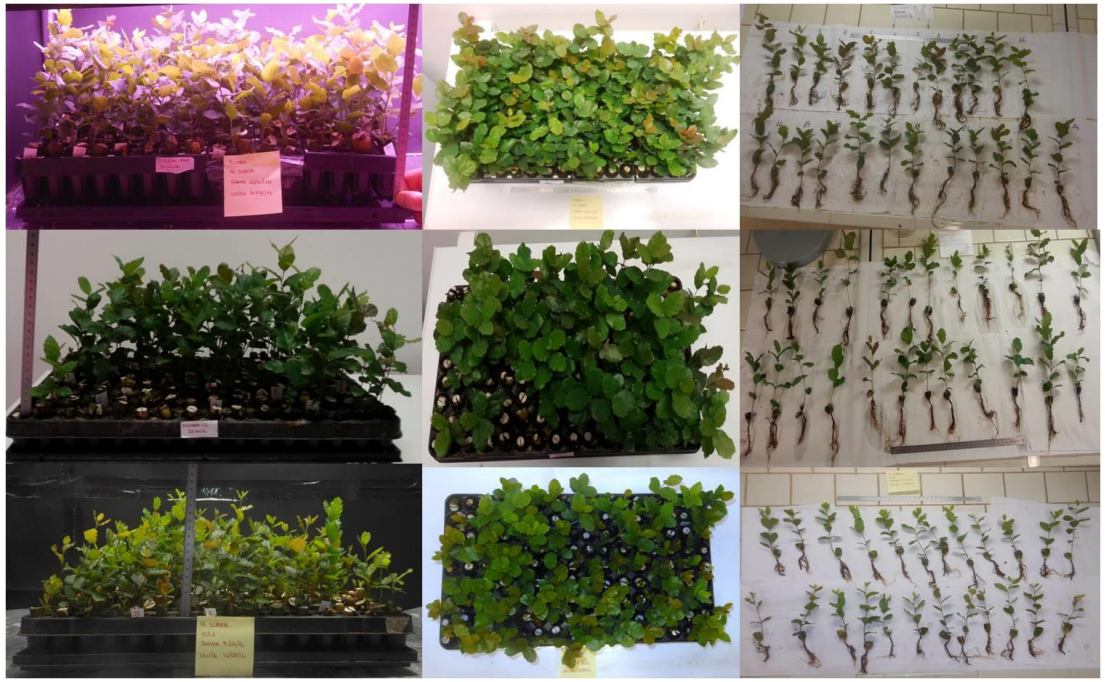
Zephyr Project: The research on light sources





Analisi morfometriche:

Altezza del fusto

Diametro dello stelo

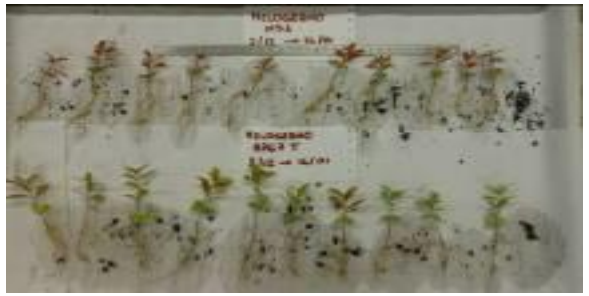
Numero di foglie

Peso fresco (e secco) dello stelo

Peso fresco (e secco) delle radici

Peso fresco (e secco) delle foglie

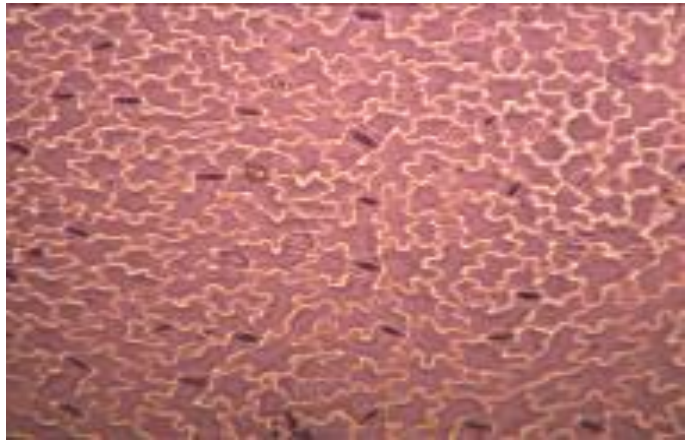
Area fogliare

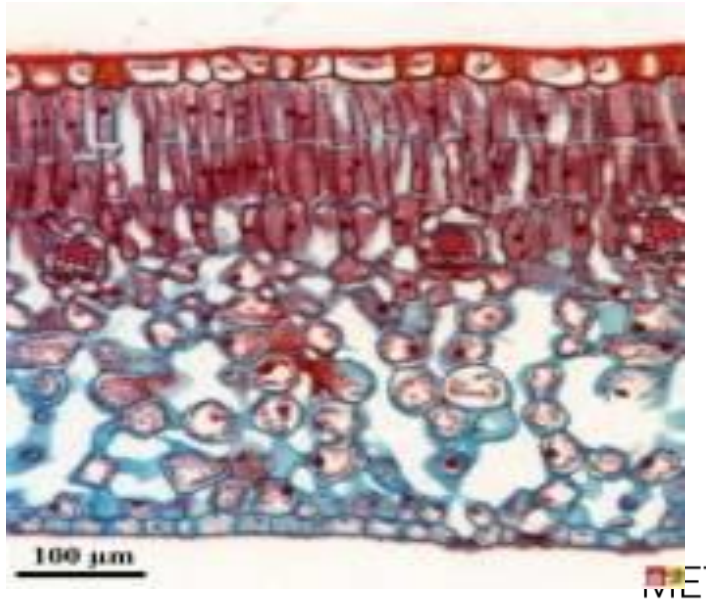


Analisi microscopiche:

Densità e dimensioni degli stomi

Sezioni trasversali foglia





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Analisi biochimiche:

SPAD

Contenuto proteine

Attività enzimatica GS

Attività enzimatica NR

Perossidazione dei lipidi

Contenuto di clorofilla a, b

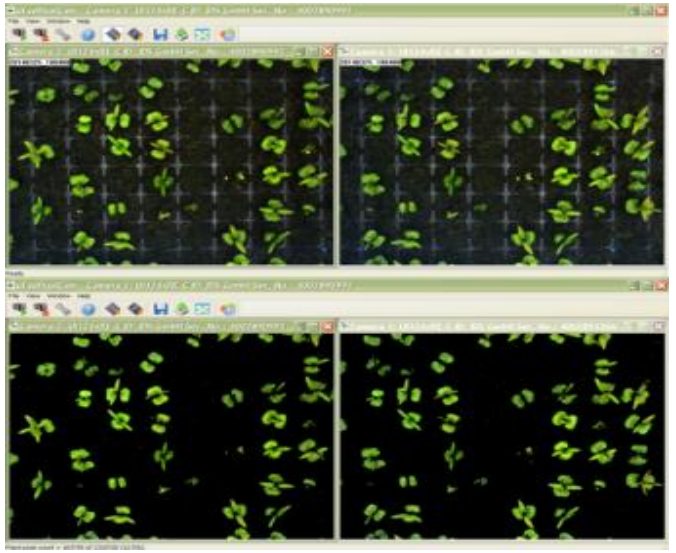
Contenuto di carotenoidi

Task 3.4 Growth tests with the new sensors (Task leader UNINSUBRIA)

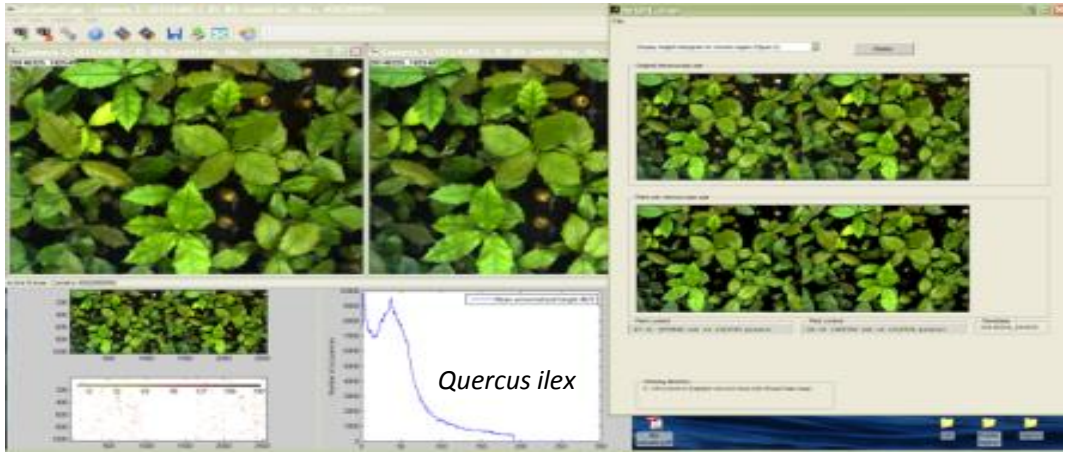
Non-destructive analysis: Greenness measurement and Plant height

Greenness (%) was estimated as percentage of shoot cover projected on tray ground and data were obtained with optical sensors (*Dualcam* - ACREO)

Plant height was manually taken during the growth period to find a relationship with plant biomass, and furthermore, compared with data obtained from images acquired by optical sensors and analysed by *uEyeDualcam* and *HeightMap* softwares (ACREO)



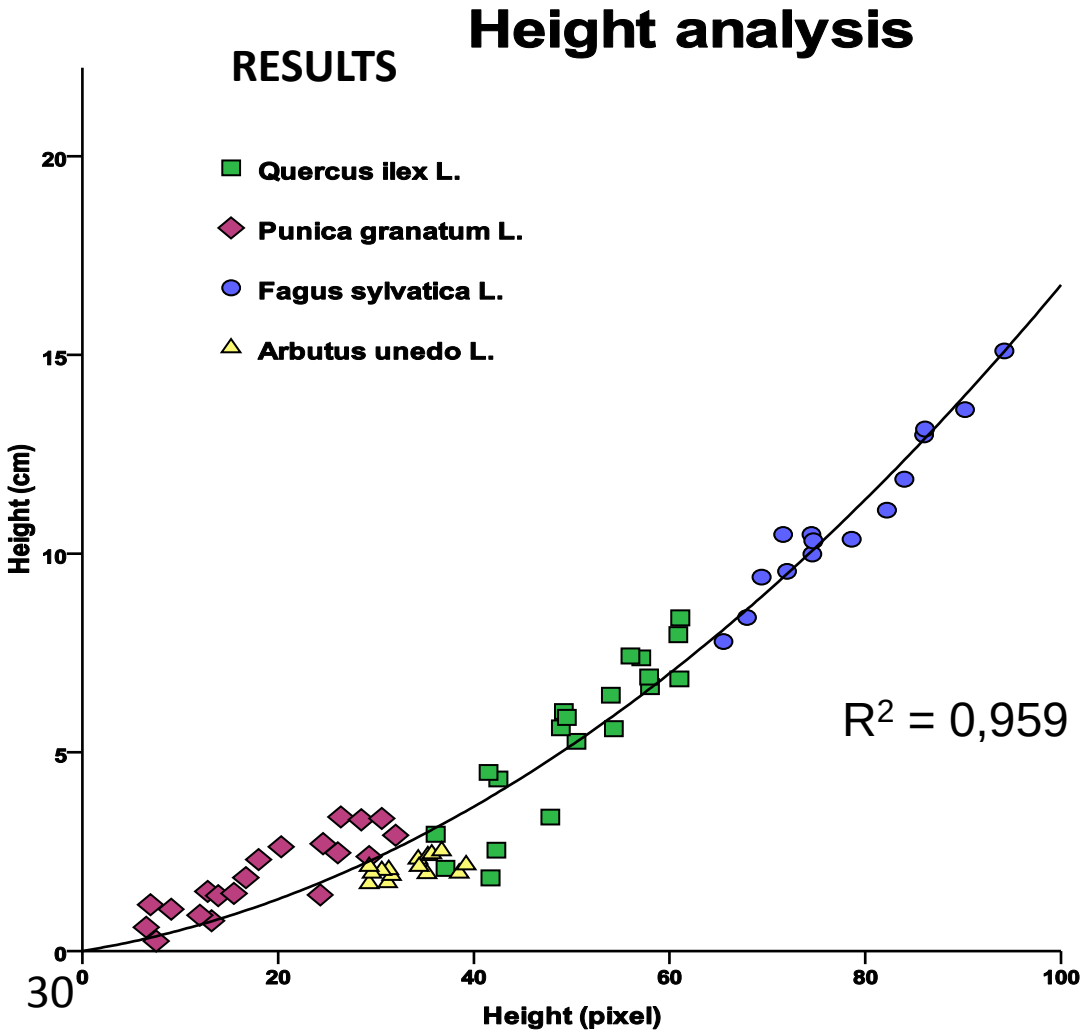
Images of greenness analysis for Pomegranate (*uEyeDualCam* software)



Above, stereoscopic photo of Holm oak plant tray. Below, Height map and Height histogram obtain by *Height MAP* software analysed

Task 3.4 Growth tests with the new sensors

(Task leader UNINSUBRIA)



Optical sensors

- 4 new species were tested

- Softwares are able to follow the growth of different species (different plant height and leaf color)

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Task 3.2 Implementation of the new growth protocols (Task leader DU)

From the growth chamber to the field trials

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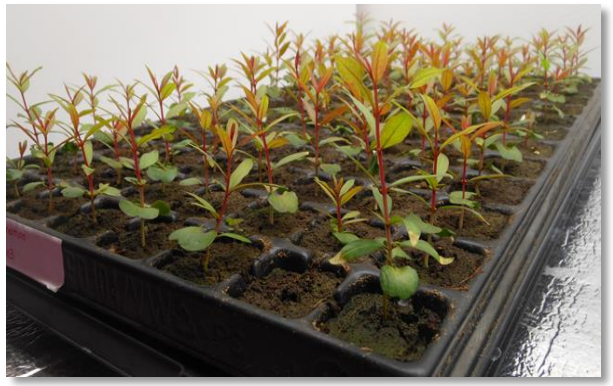
The tests on Zephyr forest plants

The first results of the cultivation tests on forest plants in the laboratory, greenhouse and field using the protocols developed for the prototype Zephyr are very promising.

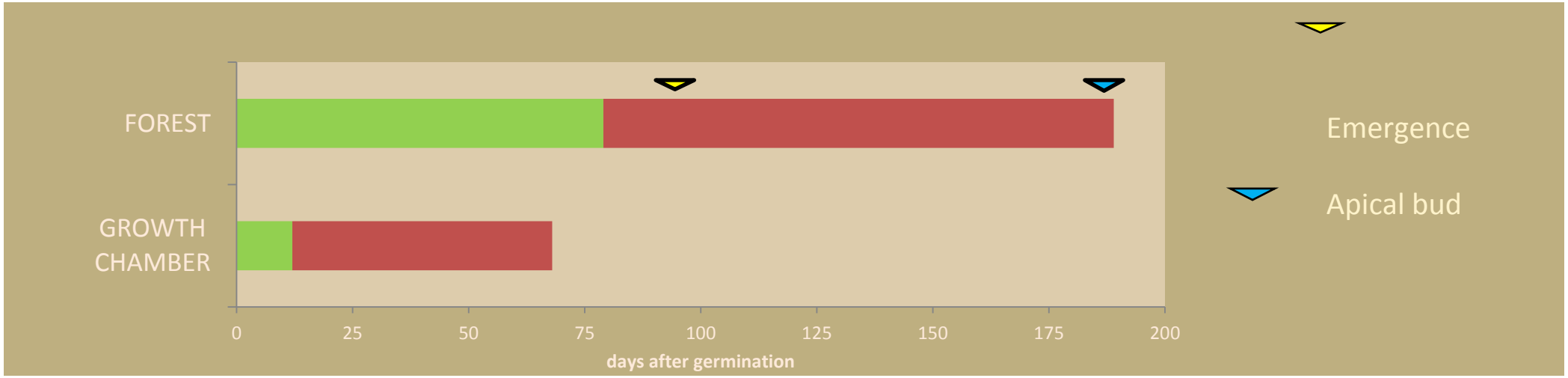


Specie oggetto di studio

1. *Abies alba Mill.*
2. *Arbutus unedo L.*
3. *Arctostaphylos uva-ursi L.*
4. *Azorina vidalii*
5. *Castanea sativa Mill.*
6. *Cornus sanguinea L.*
7. *Coryus avellana L.*
8. *Crataegus monogyna Jacq.*
9. *Fagus sylvatica L.*
10. *Frangula azorica*
11. *Fraxinus excelsior L.*
12. *Fraxinus ornus L.*
13. *Hypericum foliosum Aiton*
14. *Juniperus brevifolia (Seub.) Antoine*
15. *Myrtus communis L.*
16. *Picea abies L.*
17. *Pinus nigra J.F. Arnold*
18. *Pinus sylvestris L.*
19. *Platanus orientalis L.*
20. *Populus nigra L.*
21. *Prunus avium L.*
22. *Prunus azorica L. ssp. azorica (Mouillefert) Franco*
23. *Punica granatum L.*
24. *Quercus ilex L.*
25. *Quercus ithaburensis* var. *macrolepis (Kotschy) Hedge & Yalt*
26. *Quercus suber L.*
27. *Sambucus nigra L.*
28. *Taxus baccata L.*
29. *Vitex agnus-castus L*

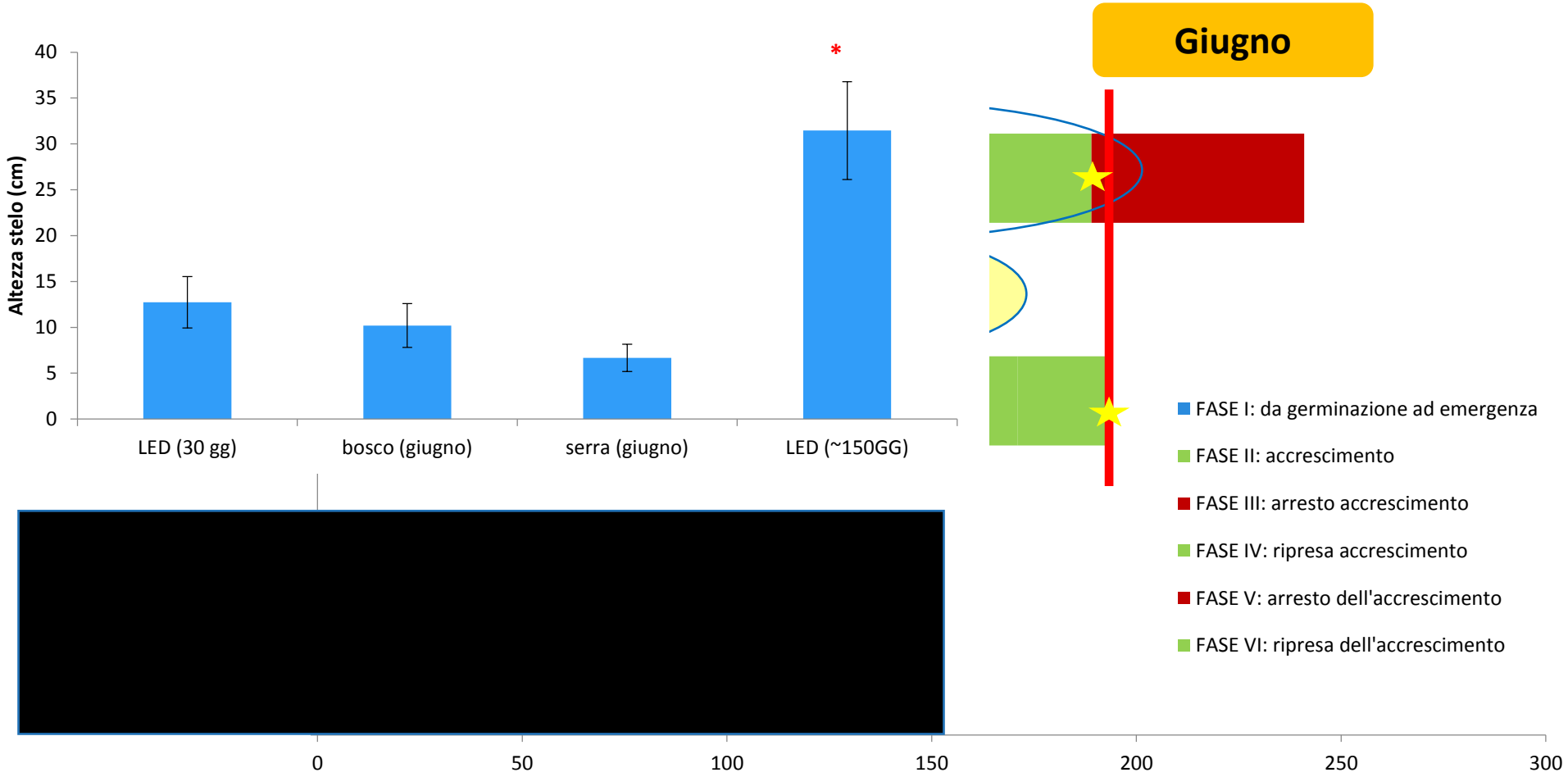
1. *Corylus avellana L.*
2. *Frangula azorica Grubov*
3. *Fraxinus excelsior L.*
4. *Fraxinus ornus L.*
5. *Hypericum foliosum Aiton*
6. *Laurus azorica (Seub.) Franco*
7. *Morella Faya (Aiton) Wilbur*
8. *Platanus orientalis L.*
9. *Prunus lusitanica L.*
   ssp. azorica (Mouillefert) Franco
10. *Quercus suber L.*
11. *Taxus baccata L.*

PHENOLOGICAL COMPARISON



	Forest	Growth chamber	Time reduction (%)
Days between germination and emergence	79	12	**84%**
Days between germination and apical bud closing	189	68	**64%**

Analisi fenologica dei semenzali di sughera in ambiente naturale (bosco), seminaturale (serra) e artificiale (camera di crescita con luci LED)



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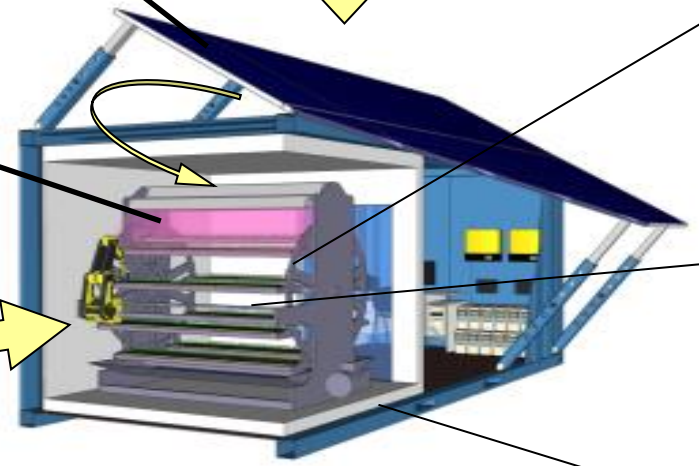
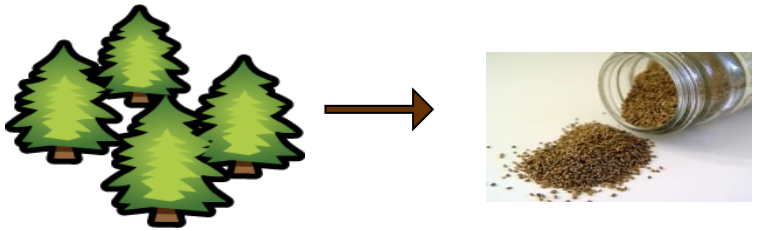
REUSE: Renewable energy source (PV panels)

REDUCE human intervention: Wireless sensors connected to a central control system regulating environmental parameters

REDUCE energy consumption: LEDs



REDUCE space: rotating systemand multiplug trays



Forest seeds (not cuttings to ensure genetic diversity)

RECYCLE: irrigation system based on water recycling

REFOREST

Zephyr Project: Applications

The high quality plantlets produced by Zephyr will be used in reforestation programs and in urban forestry. Probably, the first application of Zephyr approach will be the forest landscape restoration in Azores Islands, where alien species have supplanted the natural vegetation.

Reforestation

Urban forestry

Environmental Restoration

12 giugno 2019

Bartolomeo Schirone

METTIAMOCI
IN RIGA

GRAZIE

UNIONE EUROPEA
Fondo Sociale Europeo
Fondo Europeo di Sviluppo Regionale

Agenzia per la Coesione Territoriale

MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

PON GOVERNANCE E CAPACITÀ ISTITUZIONALE 2014-2020

SOGESID SPA
INGEGNERIA TERRITORIO AMBIENTE