



## Phenotyping for horticulture

Eva Rosenqvist, Dept. of Agriculture and Ecology, Copenhagen, Denmark

EPSO: The European Plant Science Organisation  
EPSO Workshop on Plant Phenotyping  
November 02-03, 2009  
Forschungszentrum Jülich, Germany

Forschungszentrum Jülich, Germany  
ICG-3: Phytosphere  
Jülich Plant Phenotyping Centre (JPPC)  
Website: <http://www.jppc.de>

<http://www.plantphenomics.com/phenotyping2009>




UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

Department of Agriculture and Ecology

## Phenotyping for Horticulture

Eva Rosenqvist<sup>1)</sup> and Carl-Otto Ottosen<sup>2)</sup>

<sup>1)</sup> Dept. of Agriculture and Ecology, Copenhagen University, Højbakkegaard Allé 9, 2630 Taastrup, Denmark  
<sup>2)</sup> Dept. of Horticulture, Aarhus University, Kirstinebjergvej 10, 5792 Aarslev, Denmark

Eva Rosenqvist, EPSO Workshop on Phenotyping Jülich, 3 November 2009 (1)

UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

## Content

- Horticulture – an overview
- Greenhouse production – state of the art
- Climate control with focus on plant performance
- Physiological screening and quality control

Eva Rosenqvist, EPSO Workshop on Phenotyping Jülich, 3 November 2009 (2)

UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

## Horticulture – an overview

- High value crops
  - ✓ Vegetables, fruits and ornamental plants
  - ✓ Enormous number of cultivars – genotypes
    - Vegetables and bedding plants from F1 hybrids
    - Ornamentals propagated by cuttings
- All ecophysiological adaptations
  - ✓ C<sub>3</sub>, C<sub>4</sub>, CAM
  - ✓ From mesophytes to xerophytes
  - ✓ From herbs to trees
- Critical with respect to quality of seeds or cuttings
- High input of resources requires high investments
- Focus on quality – visual and internal

Eva Rosenqvist, EPSO Workshop on Phenotyping Jülich, 3 November 2009 (3)

UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

## Horticulture – once upon a time...



Ambrosius Bosschaert the Elder, 1614


Eva Rosenqvist, EPSO Workshop on Phenotyping Jülich, 3 November 2009 (4)

UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

### Content

- Horticulture – once upon a time
- Greenhouse production – state of the art
- Climate control with focus on plant performance
- Physiological screening and quality control

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (5)



UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

### The Palm House 1842, Kew Gardens, UK



Cast iron superstructure  
110 m long  
30 m wide  
20 m high

Constructed by  
Joseph Paxton

Plants grown out  
of their natural  
climate range

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (6)



UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

### Parade greenhouse 1850 from Bernsdorff Castle, DK




The phenotypic  
expression of the  
genotype is now  
up to the grower!

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (7)



UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES


### Modern greenhouses – a different story

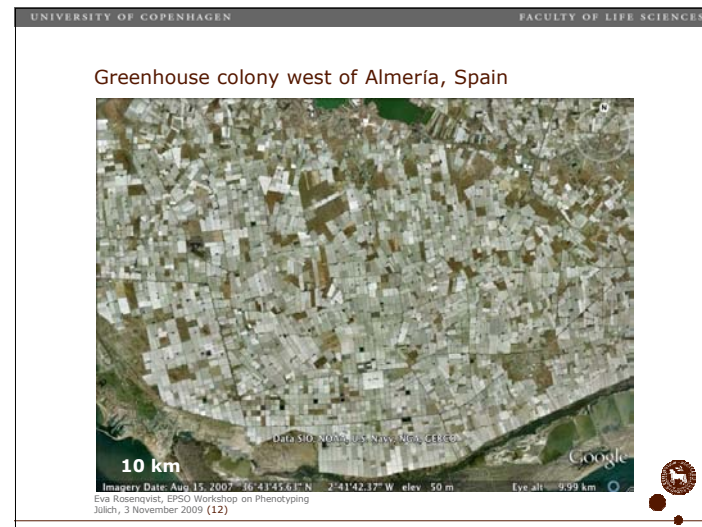
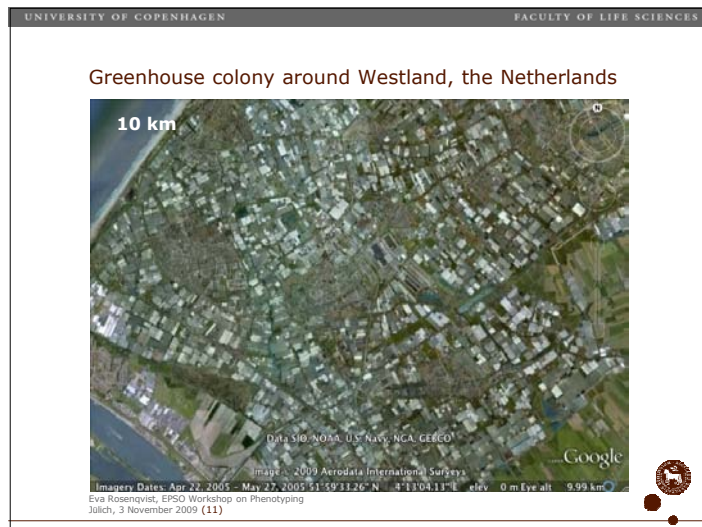
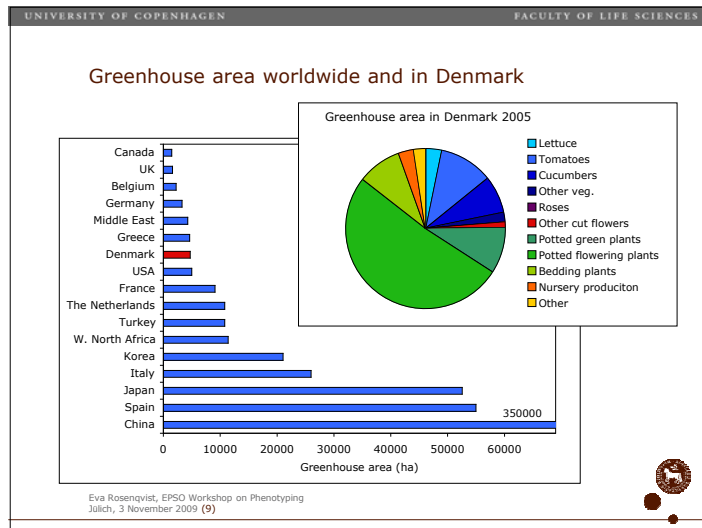


A fully automated world

Kalanchoe blossfeldiana at Knud Jepsen A/S, Denmark

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (8)






UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

### Greenhouse production – state of the art

- Management on high level – few things left uncontrolled
- Focus on optimal growth using climate management
  - ✓ Temperature, CO<sub>2</sub> and supplementary light
- Sensors, sensors and sensors – and where to measure
- Humidity management requiring energy
- Detailed knowledge about plant responses on cultivar level
  - ✓ Growth, development, shaping, stem elongation, flowering
  - ✓ Keeping-quality – stress tolerance
- Often highly specialized nurseries

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (13)




UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

### Greenhouse production – state of the art

- Fully automated climate control
- Automated, re-circulating watering with full nutrient solution
- Focus on energy saving
- Robots for plant logistics
- Tracking of plants
- Automated sorting of plants: size, flower, quality


An example from Rosa Danica, DK

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (14)




UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

### Potted miniature roses – propagated by cuttings




Rosa Danica A/S, Denmark

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (15)




UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

### Potted miniature roses – mobile bench system




Rosa Danica A/S, Denmark

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (16)



UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

Potted miniature roses – mobile bench system




Automatic climate control  
Re-circulating nutrients  
Tracking of plants

Rosa Danica A/S, Denmark

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (17)

UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

Potted miniature roses – mobile bench system



Different colours for different seasons

Rosa Danica A/S, Denmark

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (18)

UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

Potted miniature roses – quality sorting by images

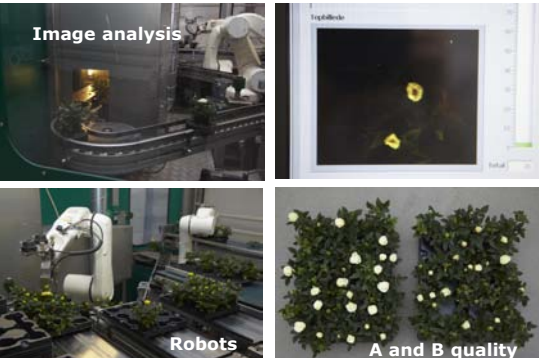


Image analysis

Robots


A and B quality

Rosa Danica A/S, Denmark

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (19)

UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

Potted miniature roses – quality sorting by images



50 L2-6

Rosa Danica A/S, Denmark

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (20)

UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

### Content

- Horticulture – once upon a time
- Greenhouse production – state of the art
- Climate control with focus on plant performance
- Physiological screening and quality control

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (21)

UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

### IntelliGrow® – component based climate control system

Danish research in energy saving climate control based on photosynthesis models  
Now in use

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (22)

UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

### Photosynthesis models to control the climate

**Effect of light**  
(350 ppm CO<sub>2</sub>)

**Effect of CO<sub>2</sub>**  
(PPFD = 850 μmol m<sup>-2</sup> s<sup>-1</sup>)

*Chrysanthemum indicum*-hybr. 'Coral Charm'

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (23)

UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

### IntelliGrow® – principles of dynamic climate control


Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (24)

UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

### IntelliGrow® – combined with mean temperature

*Hibiscus rosa-sinensis* 'Rosario Red'  
 Not chemical growth regulation  
 Mean temperature modification of IntelliGrow® climates

Positive effect on compactness      Standard: 0% energy saved




**One genotype expressed as six phenotypes**

Eva Rosenqvist, EPSO Workshop on Phenotyping  
 Jülich, 3 November 2009 (25)

UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

### IntelliGrow® – combined with mean temperature

Standard climate      Rosa 'Vanilla' grown without chemical growth regulators



Energy savings...  
 31%    0%    24%    24%    20%    14%

**One genotype expressed as six phenotypes**

Eva Rosenqvist, EPSO Workshop on Phenotyping  
 Jülich, 3 November 2009 (26)


UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

### IntelliGrow® – combined with mean temperature

Production September – November 2001  
 Chemically growth regulated plants  
 Mean temperature modification of IntelliGrow® climates

→ No delay in production

**– and the winner is...**



Energy savings...      Standard  
 35%    29%    24%    49%    30%    0%

**One genotype expressed as one phenotype**

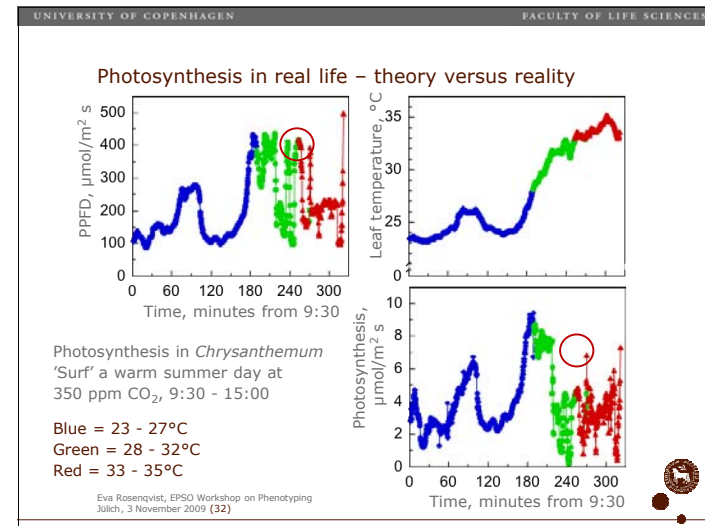
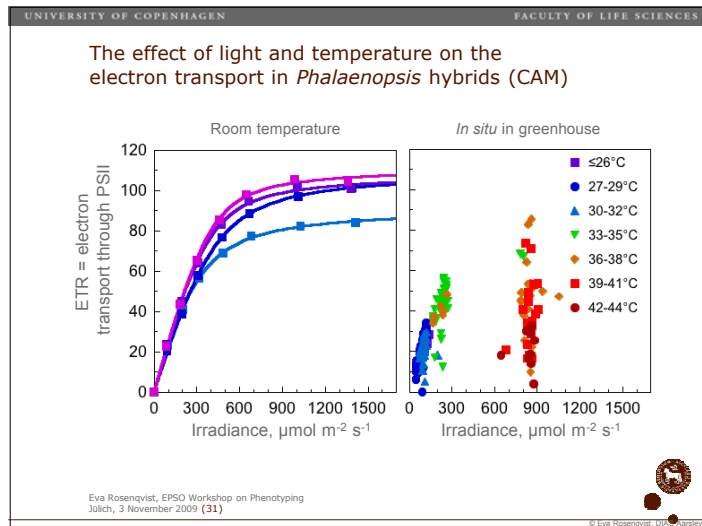
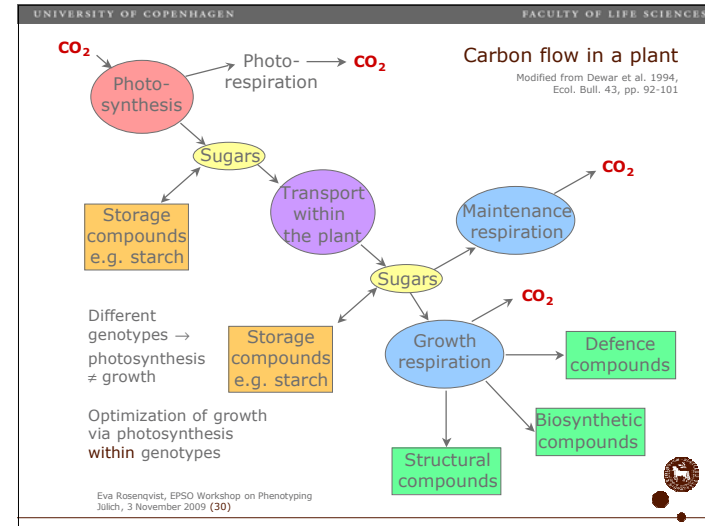
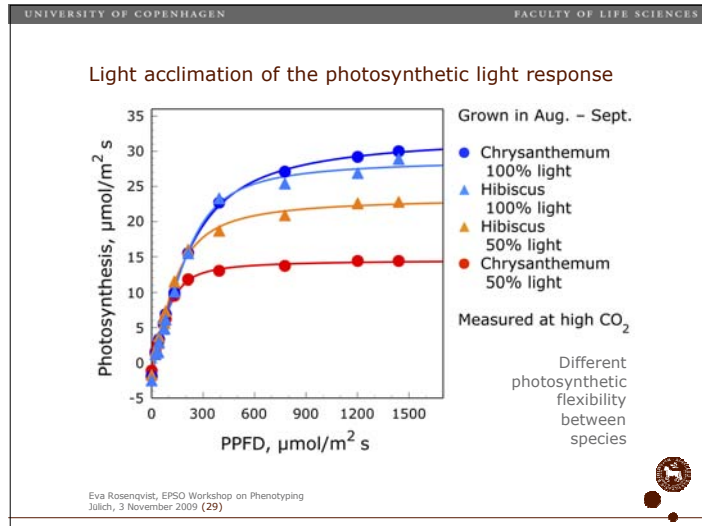
Eva Rosenqvist, EPSO Workshop on Phenotyping  
 Jülich, 3 November 2009 (27)

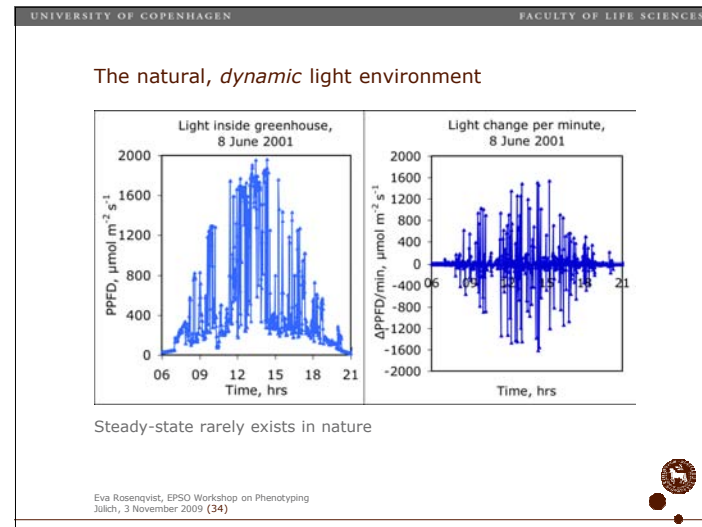
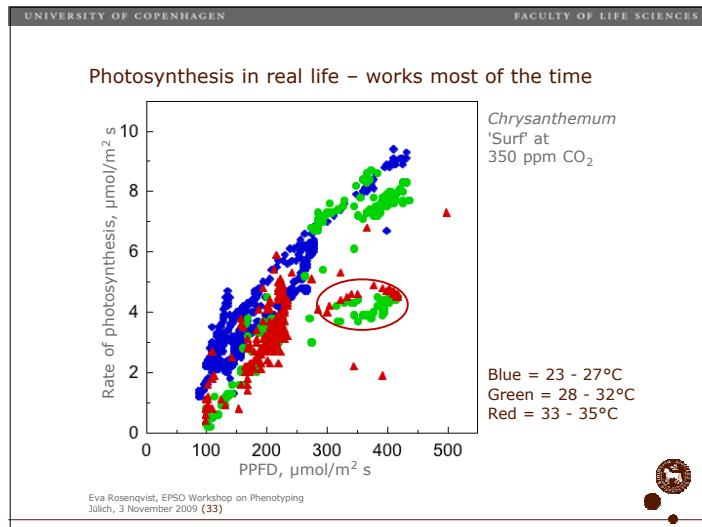
UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

### Content

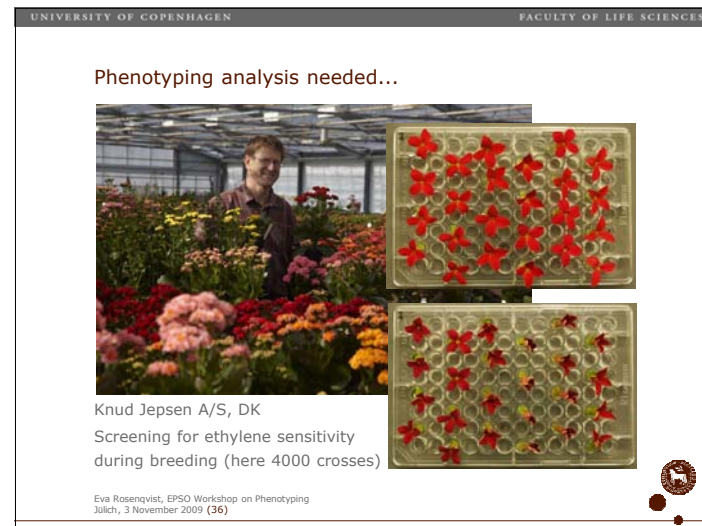
- Horticulture – once upon a time
- Greenhouse production – state of the art
- Climate control with focus on plant performance
- Physiological screening and quality control

Eva Rosenqvist, EPSO Workshop on Phenotyping  
 Jülich, 3 November 2009 (28)





- UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES
- ### Phenotyping analysis needed...
- for reduced energy use in greenhouse production
  - for better stress tolerance
  - for disease resistance
  - to reduce plant elongation
  - for overall quality assessment
  - for understanding the flexibility of plants
- Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (35)



UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

Phenotyping analysis needed...



One genotype, two phenotypes  
Mechanical stress

Rosa Danica A/S, DK

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (37)




UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

Phenotyping analysis needed...

Examples related to the use of energy and chemicals

- How does a species/cultivar react to low temperature?
  - ✓ Short spells of very low temperature
  - ✓ Low mean temperature
- What affects stem elongation?
  - ✓ Timing of elongation growth
  - ✓ Climate effects on elongation growth
  - ✓ Mechanical stress versus chemical growth regulation
- Horticultural crops are 3D
- The climate is dynamic!

Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (38)



UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES


Department of Agriculture and Ecology

Phenotyping for Horticulture

Eva Rosenqvist and Carl-Otto Ottosen

We want to thank Jesper Mazanti Aaslyng and co-workers at the Royal Agricultural and Veterinary University, Copenhagen, (now at AgroTech) and the technical staff at Dept. of Horticulture, Aarslev

Thank you for your attention



Eva Rosenqvist, EPSO Workshop on Phenotyping  
Jülich, 3 November 2009 (39)