Advanced technology of horticulture in The Netherlands

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Wageningen University & Research

- 2 organisations:
  - Wageningen University
  - Wageningen Research
- Ca. €600 million turn-over
- Ca. 6000 employees, ca. 12000 students
- 30 locations in The Netherlands
- Best Dutch university (14x)
- No. 1 in our domain worldwide
- 120 nationalities
Wageningen – Way of working

Wageningen University

Wageningen Research: Contract research organisation

Industry

Fundamental research

Applied Research

Prototypes/demonstrators

Value generation/spin-offs

National Science Organisation (NWO)/EU funding

Public-private partnerships

Bilateral contract research

Knowledge Push

Market Pull
WUR Business Unit Greenhouse Horticulture

- Initiate and stimulate innovations for a sustainable greenhouse sector
- Strategic and applied research
- Staff: ca. 110 fte researchers
- Turn over: ca. M€15
Strategy: why do we exist (since 2007)

Mission:
“Research for an international sustainable greenhouse horticulture”.

More (product, quality, added value) with less (Energy, water, chemicals, human labour)
Focus of the Business Unit

Breeding & Propagation
- Selection varieties
- Proper plant propagation

Greenhouse production
- Climate control
- Crop protection
- Crop management
- Water and fertigation
- Automation

Post harvest
- Sorting
- Grading
- Storing

Logistics, marketing
- Branding
- Labelling
- Selling
- Distributing
Location: Bleiswijk

- 85 greenhouse compartments
- Crop protection laboratories incl. DNA lab
- Test facility taste of products
- Innovation and Demo Centres:
  - IDC Energy
  - IDC Water
  - IDC LED
  - IDC Taste
  - Autonomous Greenhouses
cooling
diffuse covering
dehumidification
artificial lighting
Location: Wageningen

✓ Laboratories AgroFoodRobotics (e.g. robotics, computer vision and imaging, phenotyping)

✓ WUR LightLab (properties greenhouse coverings, screens, netting)
Research topics & expertise

- Greenhouse climate and Energy
- Water and nutrient efficiency
- Advanced cropping systems, sensors and robotics
- Sustainable crop health
- Quality and production
Research 2019

**Sensors and robotics**
- EU AgRoboFood
- EU Trimbot
- EU IoF
- EU PeMaTo-EuroPEP
- EU OPTIMA
- EU INVITE
- EU EMPHASIS
- EU Aquaimpact
- PPS Gebera Scout (cv100)
- PPS Phenotyping (cv100)
- PPS Rob2Pheno
- PPS Augmented Reality
- PPS Fresh on Demand
- PPS Flower bulbs 4.0
WUR Agro Food Robotics

- Joint program by research groups of Wageningen University & Research.
- Engineers and researchers work together with industrial partners on new robotic systems for agriculture and food.
- We design agricultural robotic systems for open field, horticulture, fresh chains and food.
- We specialise in artificial intelligence and sensing, especially spectral, learning and vision.

www.wur.eu/agrofoodrobotics
Technology Trends ...
... to replace eyes, hands and brains of growers

- **Computer Vision**
  - 3D-cameras
  - Hyperspectral

- **Robotics**
  - Fine/soft mechanics
  - Advanced/precision tools

- **Digitalisation**
  - Big Data
  - Deep-learning

New Applications

Monitoring – Handling – Decision Support
Innovation directions

Precision agriculture:
More and better with less

Precision horticulture:
Intelligence makes sense

Plant phenotyping:
Understand & maximize plant performance

Hands-free food production:
A skilled worker available 24/7, anytime anywhere
PhenoBot – Greenhouse crop data

- No of internodes
- No of fruits per plant
- No of harvested fruits
- Weight harvested fruits
- Biomass partitioning
- Leaf area

3D Light Field Camera (Raytrix)
One camera, one lens
One shot for 3D and 2D data
7MP effective resolution

Gerrit Polder (Wageningen UR)
Monitoring gerbera

Targets:

• Spatial resolution: 1 m²
• Plant load (yield prediction)
• Powdery mildew
• Stress
• Decision Support

Using:

• a.o. Hyperspectral camera
Automatic counting of white fly and beneficial insects trapped on yellow sticky

- Use of a deep-learning image analysis network (F-RCNN, bounding boxes)
- Use smartphone to capture images

Photo: Wageningen University, Laboratory of Plant Breeding

PeMaTo-EuroPep (2017–2019)
Harvesting robot projects by WUR

- Harvesting cucumber
- Harvesting sweet-pepper (Crops & Sweeper)
- Selective harvesting of Broccoli
- ...

Contact: Jochen Hemming (WUR)
Augmented Horticulture (TU18145)

- Understanding Plants via Augmented Reality

General information 2019

- Jos Balendonck/Rick van de Zedde
Augmented Reality in the Greenhouse

Scope of the project, people wear glass with augmented reality to:

- Visualize sensor data/ climate control info in augmented way
- Data annotation in the greenhouse via speech recognition
- Receive on the spot expert training
- Give manual harvesting assistance
- Collect data for harvest forecast
- Assist with disease detection

Consortium Augmented Horticulture: Syngenta Seeds, Wageningen University & Research, Florensis, LetsGrow.com, Itelligence, Mprise Agriware en KPN.
WP2 - Advanced methods for prediction and early detection of plant diseases.

- develop a Decision Support System (DSS) for disease control scheduling;
- develop advanced detection systems for in-field localization and monitoring of the selected diseases in the use-case crops;
- use pattern recognition through artificial intelligence/deep learning to detect, segment and quantify plant diseases.
Task 2.3 - Spectra of Downy Mildew in Grapes

![Image of grape leaves with mildew and healthy leaves]

![Graph showing normalized intensity vs. wavelength for mildew and healthy grapes]

- **Normalized Intensity (A.U.)**
- **Wavelength (nm)**
- **Mildew**
- **Healthy**
Research 2019

Sensors and robotics

- Phytotec e.g. pests in Mango, Apples...
- Control leave edge damage in lettuce
- ZonMW in-situ tomato quality detection
- New Phenotyping facility NPEC
- KB Phenotyping Deep Learning
- KB High throughput phenotyping
- KB Autonomous collaborative robots
- Full documented fisheries
- Bin picking chicken and fish (B2B)
- Broccoli harvest robot (B2B)
- Precision technology seed potatoes
- Detection diseases in potato
- Strategic project: SympSpec
- Diverse B2B projects
Netherlands Plant Eco-phenotyping Centre

NPEC on the **NWO roadmap** for large scale research infrastructure.

**Budget:** 22 million euros (10 years), funded by the Dutch Science Organization (NWO), Wageningen University and Utrecht University.

Open for access in 2020 for universities and industry.

Opportunities for industry to team up with WUR to work and learn on:

- Automated screening tools with new sensors.
- Apply and explore deep learning/ AI tools
- Implement big data approaches on NPEC data.

[www.npec.nl](http://www.npec.nl)
Programme Kas als Energiebron
- Monitoring energy innovations growers
- With LED climate neutral chrysanthemum
- Alstroemeria crop of the future
- Total concept “Het Nieuwe Telen”
- The greenest cucumber
- Groenlabelkas

IDC Energy
- Winterlight greenhouse (ultra light roof)
- 2SaveEnergy greenhouse (glass and film in roof)
- BEST greenhouse (Noppenfolie)

Fossilfree demo greenhouses Kas2030
Research 2019

LightLab and materials

- PPS Smart Materials
- PPS Ageing of glass (Hortivation)
- PPS Redesign Daylight greenhouse (PV on screens)
- Light measurements transmission, scattering, condensation
- Modelling diffuse glass and screens (Saint-Gobain, AGC, LS)
- KaEb Diffuse light in commercial greenhouses
- KaEb Without emission to high transmission (low-e coatings)
- KaEb Semi-transparent PV
- KaEb "Kaskieswijzer"
- KaEb Wet energy saving screens
- Testing of toxicity of materials
- Diverse B2B projects
Research 2019

Models
- KB KASPRO&INTKAM integration and update
- KB Digital Twin
- KASSIM – education platform
- KWIN 2018-2019

New farming systems
- EFRO Field Lab Fresh Tag (phd, cv100)
- EU EDEN ISS
- EU FOODe
- Diverse B2B projects VF
- EU GEOFOOD
- KB Circular horticulture

Digital farming
- Data in horticulture (cv100)
- Autonomous greenhouses
- R&D Tencent
- KB Sensing Potential
- Strategic project: GrowDat
Greenhouse production: from digital information to autonomous control

**Autonomous greenhouse challenge**

REMOTE

DATA

INTELLIGENT ALGORITHM

DECISIONS

Sensors

Greenhouse System

Actions

Climate Computer

Data Exchange Interface

Let'sGrow.com

Microsoft Research

Tencent

Intel

Net Profit (€)


+17%

Ref

Isabella Righini – Greenhouse Horticulture
Greenhouse production: from digital information to autonomous control

History:
What happened?

Information

Now:
What is happening?
Is it good or bad?
Why did it happen?

Interpretation

Future:
What will happen?
What should I do?

Prediction

Autonomous Greenhouses Control

Contact: isabella.righini@wur.nl
Visit: http://www.autonomousgreenhouses.com/

2nd edition Autonomous challenge
Greenhouse horticulture and the Circular Economy
Our vision and goals for future research

Alexander Boedijn
Transition to a Circular Economy

Source: Rli 2015
Efficient, Clean and Connected

Incoming flows from:
• Other production or processing systems
• Natural cycles

Outgoing flows as:
• Part of products
• Resource for other processes
• Part of natural cycles
Aquareuse

Source: www.aquareuse.nl
Research 2019

Water and emissions

- EU AGRINuPeS
- Emission from substrate cultivation systems
- Prevent and remedy disinfection
- PPS Ion-specific sensors
- PPS Root environment (cv100)
- PPS Nutrient supply advice 2.0 (cv100)
- Water flow model
- Chips & sensors
- ...
WUR@International Indoor farming different regions in the world
The adaptive greenhouse method:

- **Climate**
  - temperature
  - humidity
  - sun
  - radiation
  - wind

- **Greenhouse model**
  - heating
  - CO₂ supply
  - cooling
  - lighting

- **Active means**
  - fuel
  - electricity
  - CO₂
  - water

- **Needed resources**
  - CO₂
  - electricity
  - fuel
  - water

- **Best possible passive structure**
  - Radiation
  - properties of the cover
  - ventilation (including screens)

- **Crop model**

- **Production**

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The image depicts a flowchart illustrating the adaptive greenhouse method, emphasizing the integration of climate, greenhouse model, active means, needed resources, and production. The diagram highlights the key factors such as temperature, humidity, sun, radiation, wind, heating, CO₂ supply, cooling, lighting, and various resources like fuel, electricity, CO₂, and water. The flowchart underscores the importance of integrating passive and active strategies to optimize crop production within a greenhouse environment.
Adaptive greenhouse model

Vanthoor, 2011
Research 2019

**International**

- Research Centre in Saudi Arabia (Estidamah)
- Demonstration water saving Saudi Arabia (King Faisal University)
- Hydroponic systems in Jordan
- Adaptive greenhouse design Libanon
- Adaptive greenhouse design Uruguay
- Greenhouse demo centre design in Marokko
- Biofresh: adaptive greenhouse model, lighting
- Consultancy: greenhouses Qatar (Yara)
- Consultancy: greenhouse growers Japan (NARO)
- Consultancy: Fresh tomato production Kikkoman
- Consultancy: Aleia Roses
- Consultancy: greenhouses in China (CAAE)
- Collaboration California
Research 2019

Training and knowledge Days
- Summerschool Greenhouse Horticulture
- Summerschool Image analysis in plant phenotyping
- Courses Saudi Arabia, China, Murcia etc.
- Knowledge day Substrates
- EnergiekEvent
- WaterEvent
- PlantgezondheidsEvent
- AgriFoodRobotics Parcours
Added value of flavour

Price/kg:

€ 2,44  € 4,08  € 10,96  € 17,06

For tomato added value, but must be recognizable

www.ah.nl, 8 jan 2019
Aim

Increase of fruit and vegetable intake, by developing knowledge and tools for supply chain to make F&V more attractive to consumers;

- Development of a non invasive flavour model for tomato + webservice
- Development of a flavour model for...
Quantification of liking using Flavour models

IN: data from instrumental measurements

OUT: Flavour score on a 0 – 100 scale

Judgement liking by consumer panel

Flavour model:
Formula predicting the outcome in liking of a consumer panel
Data: consumer- and sensory panels
Data: regular destructive measurements
Data: hyperspectral setup

Predicting biochemicals or diseases in a spatial preserving way
Data: low cost sensors
Data analysis: to a flavour model
Vision

Quick Scan
Tomato

Flavour
72

Brix
9

Acid
10

%Juice
52

Firmness

WAGENINGEN
UNIVERSITY & RESEARCH
The Greenhouse Pharmacy

- Two branches:
  - Horticulture for natural, plant-based Ingredients
  - Innovation & Demo Centre Tropical Crops

- Four types of projects:
  - Food Ingredients
  - Cosmeceuticals
  - Plant-based medicine
  - Tropical fruits
The future

Completely Automated, circular greenhouse fruit, vegetable & flower production
WUR Greenhouse Horticulture

Innovations for the horticultural sector