

# Autonomous greenhouses - research on intelligent greenhouses and robotics

*Netherlands-Japan Horticulture Seminar, 21 November 2018, Tokyo, Japan*

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Wageningen University & Research, Business Unit Greenhouse Horticulture



# Why do we need "Autonomous greenhouses"?

# BENEFITS OF INDOOR FARMING



## WATER EFFICIENCY

Can decrease water usage  
by as much as 90%



## LESS LAND

Can produce same volume  
of crops with 1/10 the  
space



## SAFER

Requires little to no  
pesticides or chemicals

# Challenges greenhouse production

- Average farmer age in Japan is 66 years: attract young people by ICT and high-tech, modern working conditions
  - Knowledge and skills of farmers on modern crop management
  - Use of ICT is essential: climate computers, ICT for data collection on climate, water, nutrients, crop growth, labour
  - Still: data often not connected, grower needs to decide on setpoints, grower needs to weigh yield vs. resource need
- Autonomous greenhouses?



# Artificial intelligence vs. Human intelligence



**IBM DeepBlue  
defeats chess master  
Garry Kasparov  
in 1996**



**Alphabet Inc's Google DeepMind  
defeats Go champion  
Fan Hui in 2015 (European champion)  
Lee Sedol in 2016 (ranked 6 in world)**

**Tencent**

**Tencent Fine Art  
wins Computer Go UEC Cup  
In 2017**

# The Challenge

# Autonomous Greenhouses

## BUILD THE GREENHOUSE OF THE FUTURE

Follow our international challenge  
to improve greenhouses through  
AI and sensors



[Learn more about our teams!](#)

# International challenge “Autonomous greenhouses”





# Hackathon

24-h

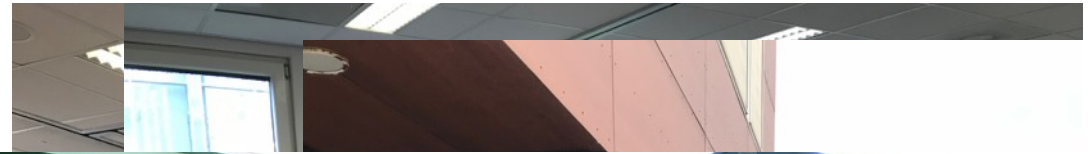
Virtual cucumber growing

Using WUR's advanced greenhouse climate & crop models

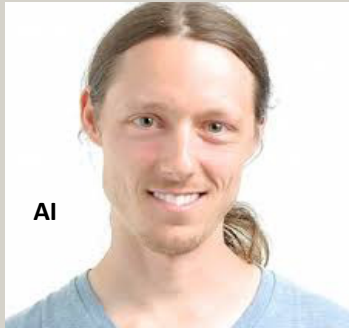
Show skills



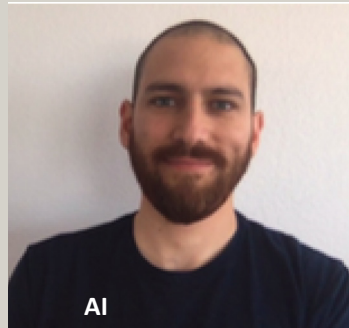
# Hackathon



# deep\_greens



Zach Dwiell  
Intel



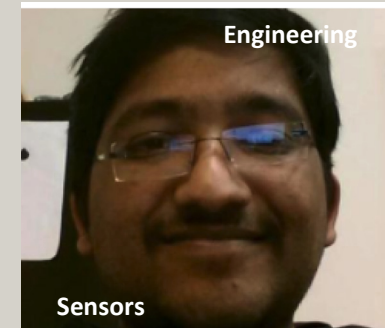
Alexei Bastidas  
Intel



Mariano Phielipp  
Intel



Anna Bethke  
Intel



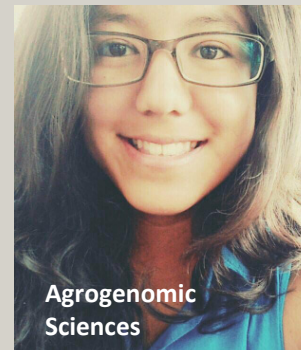
ChinniKrishna Kothapalli  
Intel Corp.



Laura Rosina Torres Ortega  
BSc student at National  
Autonomous University of Mexico



Uriel Guadalupe Pérez Guerrero  
BSc student at National  
Autonomous University of Mexico



Julia Paulina Garía González  
BSc student at National  
Autonomous University of Mexico



Aarón Iván Vélez Ramírez  
National Autonomous University  
of Mexico, prof.

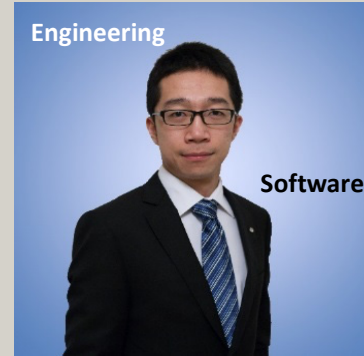
# AiCU



Xixi Minglan  
phD student WUR



Xing Zhao  
Eurotiss B.V.



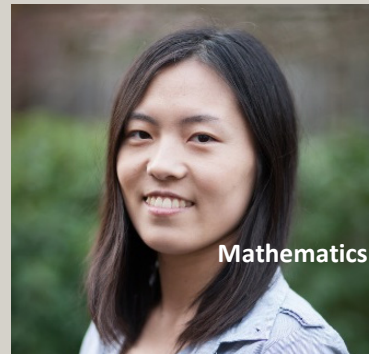
Liang Li  
NXP Semiconductors



Zao Ye  
IGMPR Flower, Parks & More



Ningyi Zhang  
phD student WUR

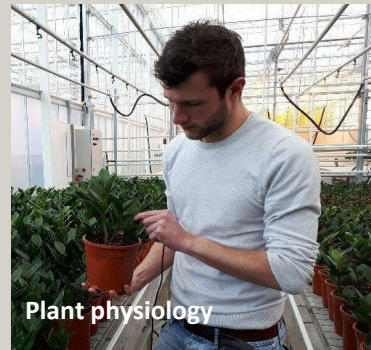


Xinwei Bai  
phD student University of Twente

# The Croperators



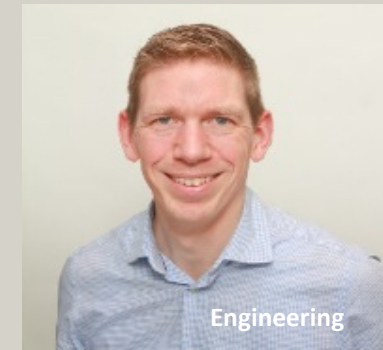
Klaas van Egmond  
Delphy B.V.



Jeroen Boonekamp  
Delphy B.V./ MSc student WUR



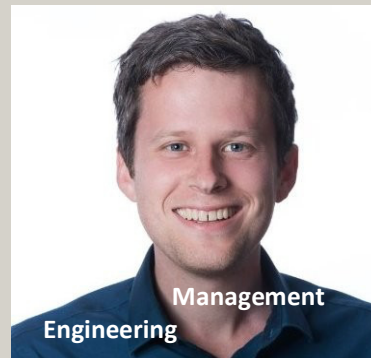
Rens Schmidt  
Delphy B.V.



Rudolf de Vetten  
AgroEnergy B.V.



Jitse Schöne  
Delphy B.V. / BSc student  
InHolland



Peter Goudswaard  
AgroEnergy B.V.



Wim van der Ende  
Delphy B.V.



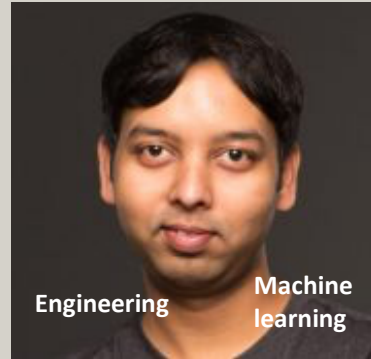
Bram van Rens  
AgroEnergy B.V.

# Sonoma



AI

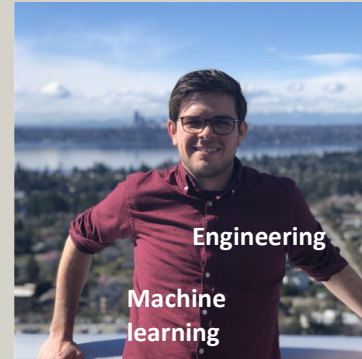
Kenneth Tran  
Microsoft Research



Engineering

Machine learning

Chetan Bansal  
Microsoft Research



Engineering

Machine learning

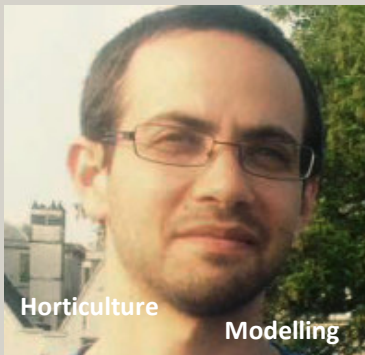
Thomas Grossfeld  
Microsoft Nederland



Business

Food technology

Janine Kemmeren  
Microsoft Nederland



Horticulture

Modelling

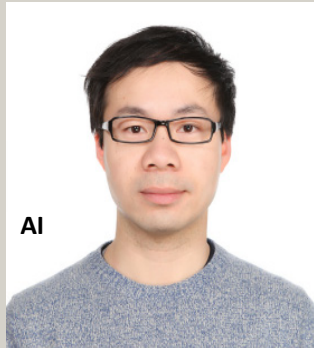
David Katzin  
PhD student WUR



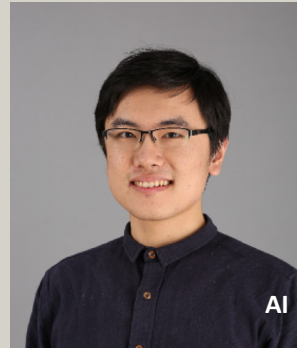
Crop protection

Hong Phan  
PhD student University of  
Copenhagen

# iGrow



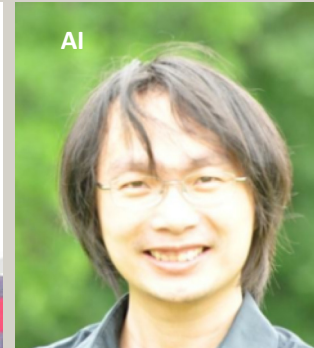
Jinlong Hou  
Tencent



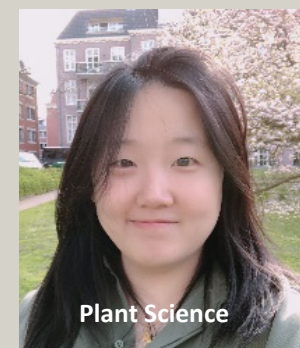
Qing Wang  
Tencent



Wei Liu  
Tencent



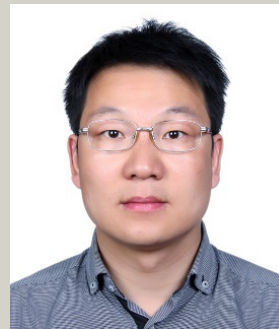
Dijun Luo  
Tencent



Yi Zhang  
MSc student WUR



Bo Zhou  
Beijing Research Center for  
Information Technology in  
Agriculture



Tao Li  
Chinese Academy of  
Agricultural Science  
CAAS



Shengping Liu  
Chinese Academy of  
Agricultural Science  
CAAS



Ge Zu  
Botanical Society  
of Heilongjiang  
Province



Lulei Yan  
Syngenta Seeds

# The manual-grown human intelligence Reference

## **Reference realised by team of Dutch growers:**

Kees Scheffers (grower @WUR)

Corné van Boxel (cucumber grower, Delfgauw)

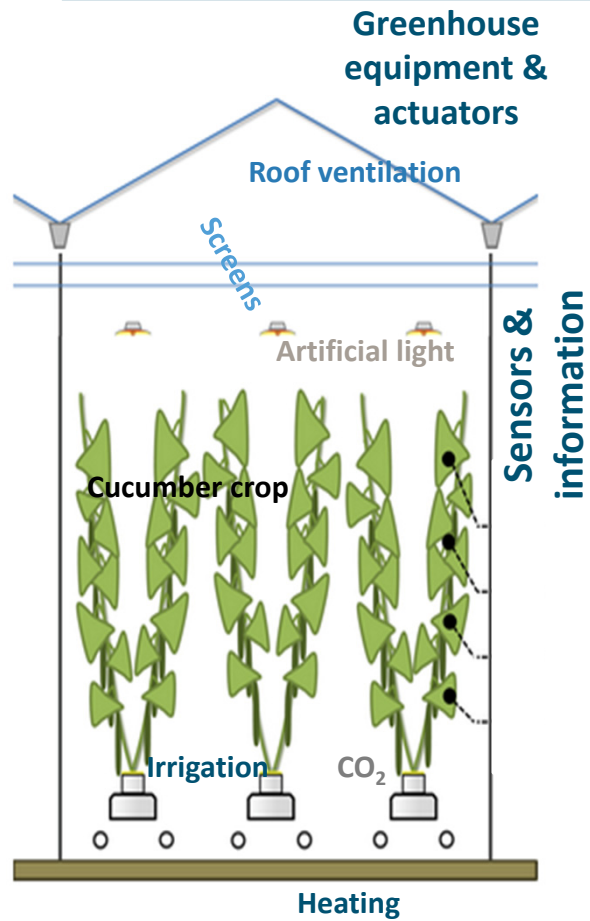
John van Marrewijk (sweet pepper grower, Kwekerij de Wieringermeer)



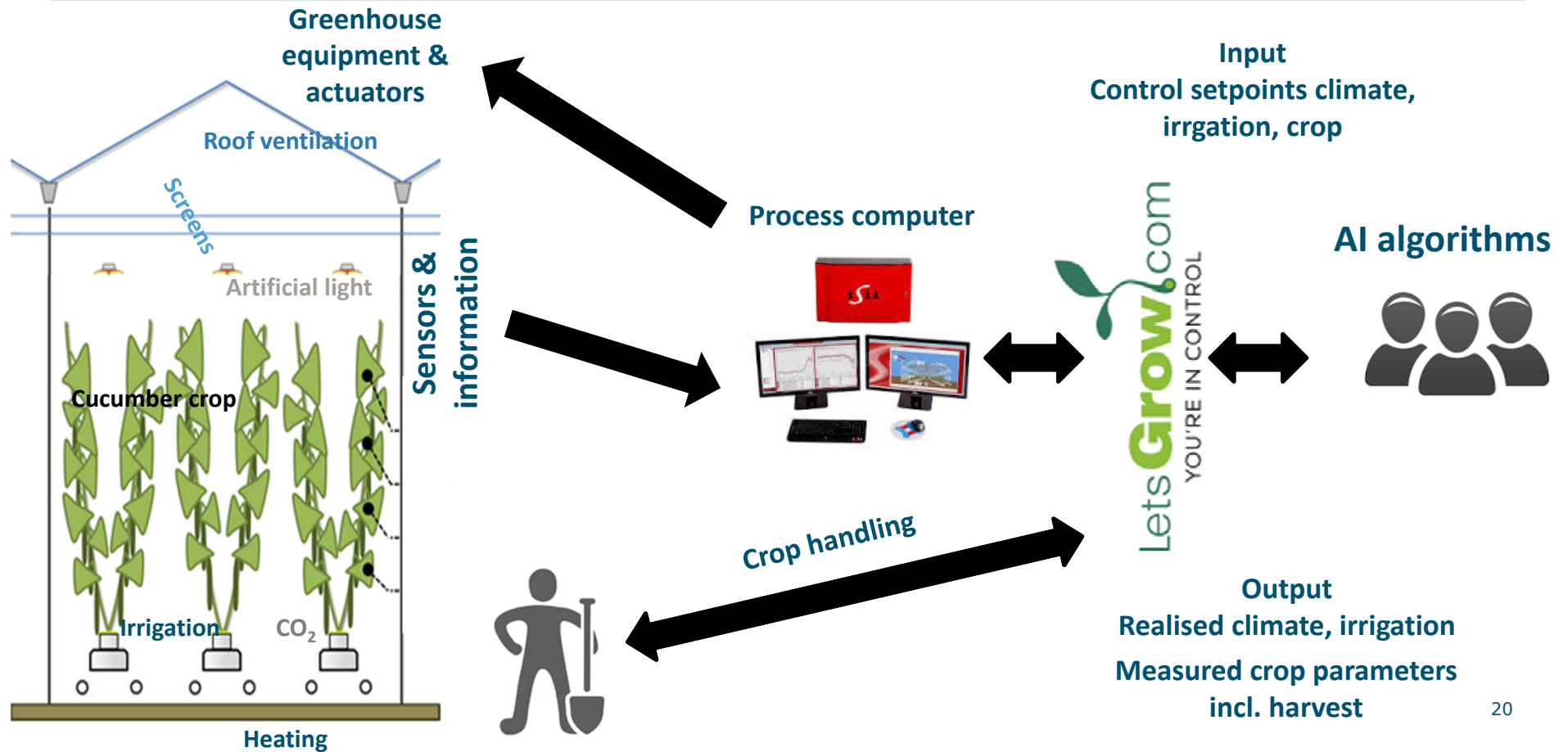
# The Growing experiment




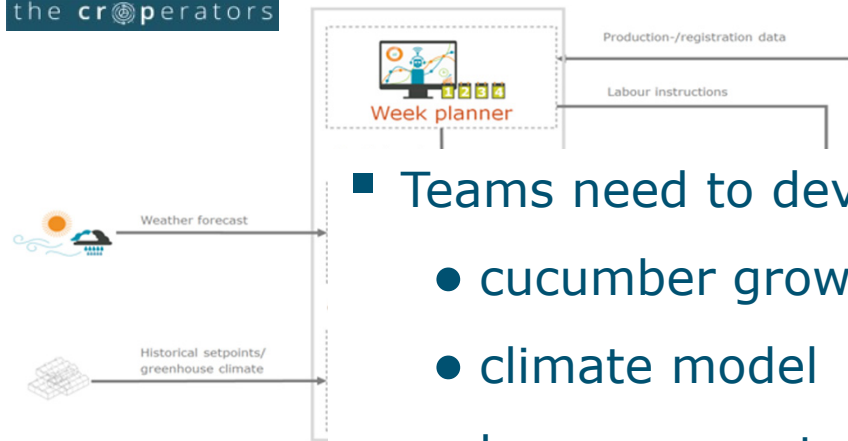
# Greenhouse actuators-sensors-setpoints- interface



# Greenhouse actuators-sensors-setpoints- interface

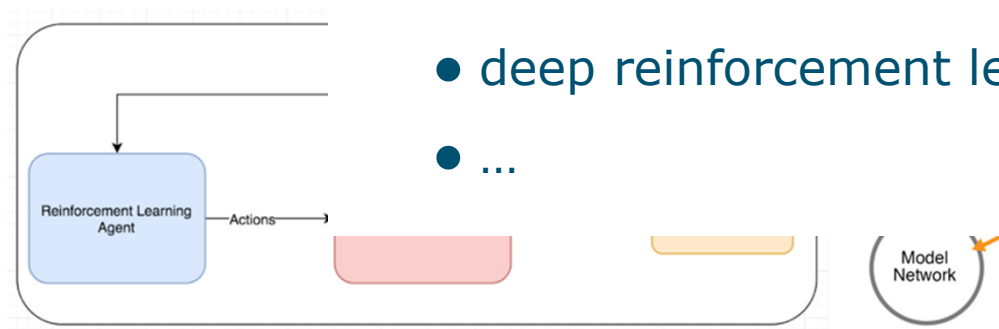


- 
- Teams are allowed to install additional **sensors**
    - RGB camera
    - thermal camera (own design)
    - wireless sensor networks (own design)
    - root zone sensors
    - net radiation sensor
    - crop and substrate weighing sensors, crop sap flow meters, stem diameter
    - no sensors



Teams need to develop their own **AI algorithms**

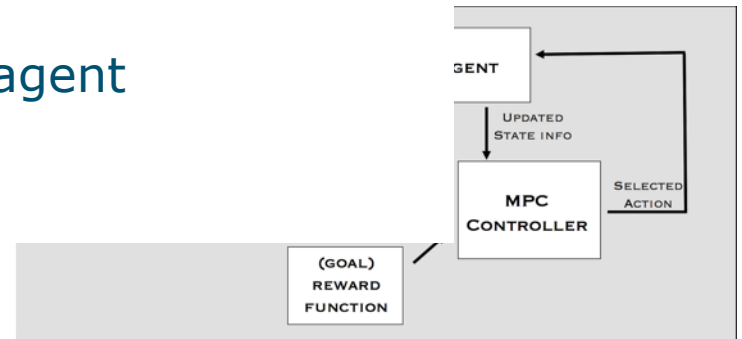
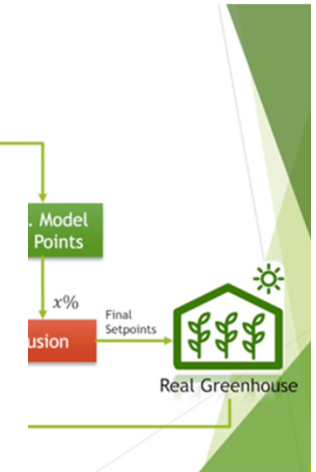
- cucumber growth model
- climate model
- human expert decision
- machine learning trained on artificial data
- dynamic regression analysis
- neural networks
- deep reinforcement learning agent
- ...



AiCU AI Approach

Initial Set of Training data (from simulation)

Mathematical Method to find  $GH_{optimal} = \text{Argmax } f(\cdot)$



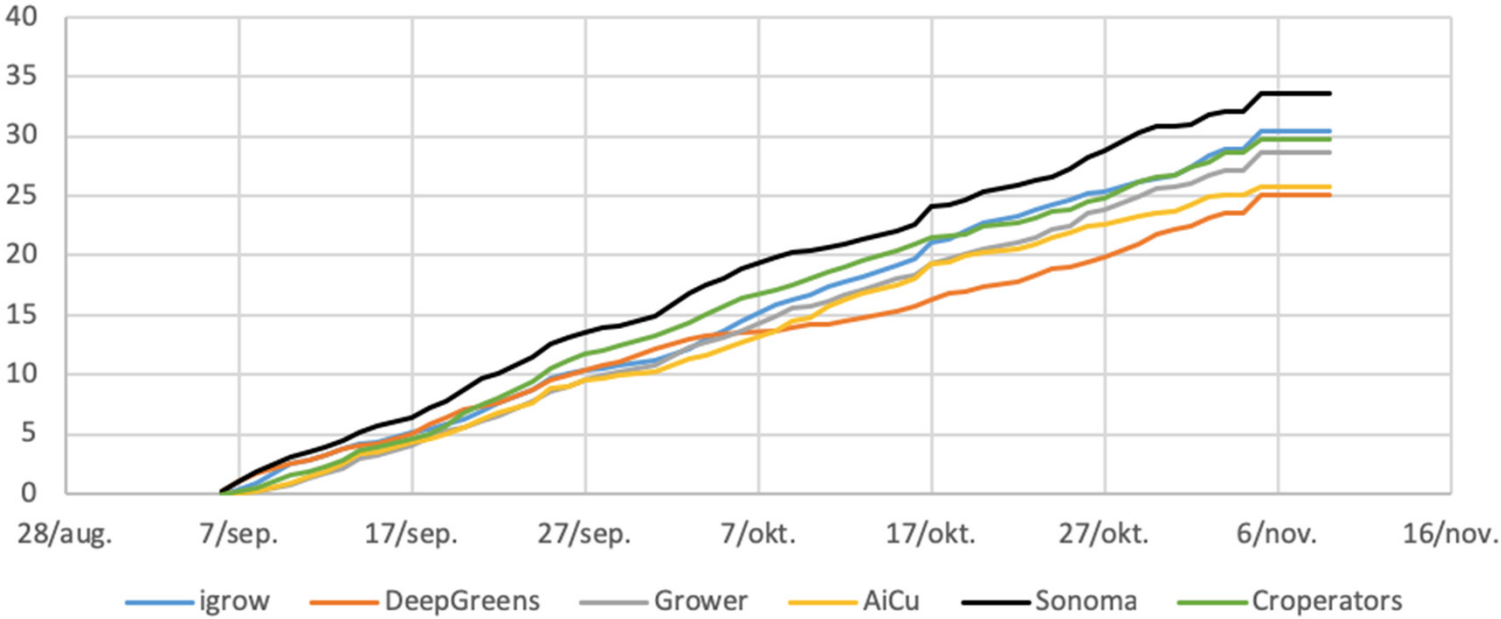
# The Results





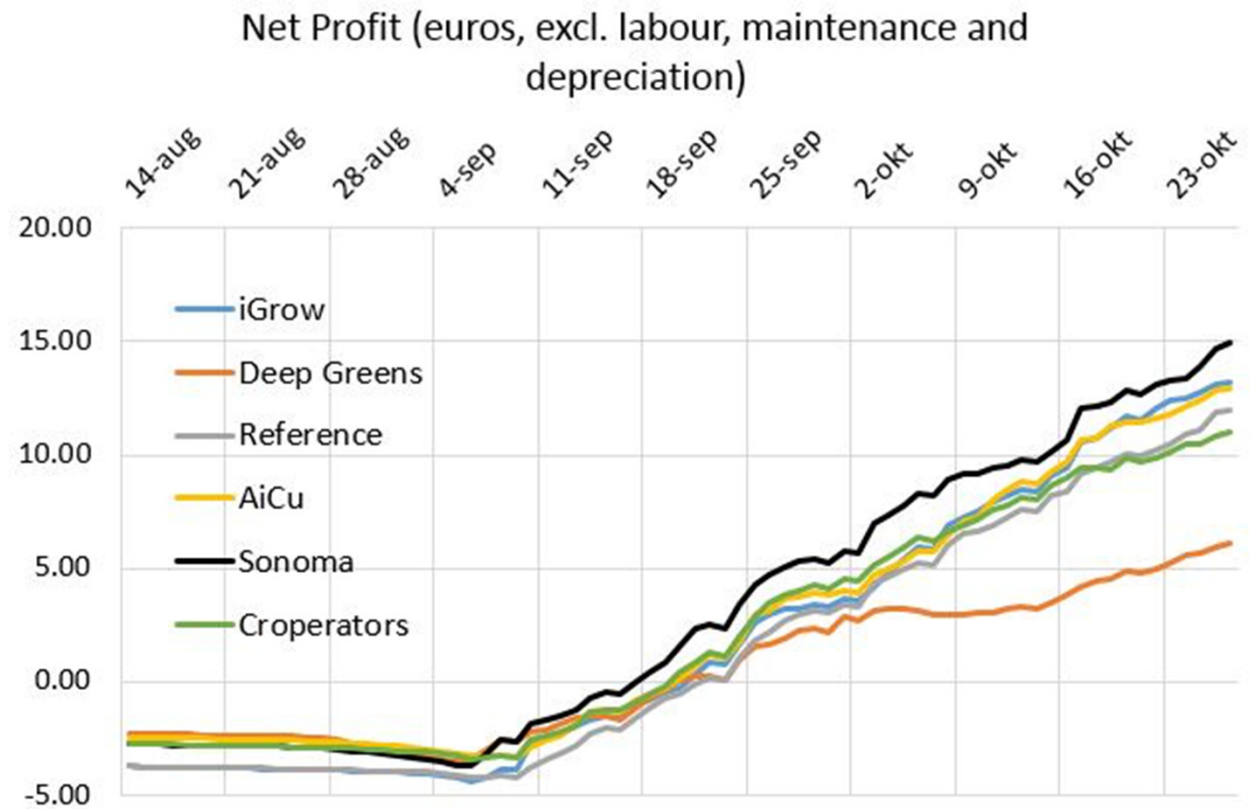
# Total production

Per 6/11



# Net profit

Per 27/10



# Sustainability factors

per 27/10

	<b>kg CO<sub>2</sub>/ kg cucumber</b>	<b>kWh electricity/ kg cucumber</b>	<b>kWh heat/ kg cucumber</b>	<b>L water use/ kg cucumber</b>
<b>iGrow</b>	0.33	2.65	4.14	8.73
<b>deep_greens</b>	0.66	5.45	12.56	7.66
<b>Reference</b>	0.38	2.73	3.71	8.71
<b>AiCU</b>	0.38	2.95	1.76	9.37
<b>Sonoma</b>	0.31	3.44	2.61	6.32
<b>The Croperators</b>	0.39	3.95	1.67	7.74

Some AI outperforms  
the grower!



# Our jury



**Jaco den Bakker-**  
Cucumber grower  
from Brielle,  
Netherlands.  
Studied  
Horticulture and  
Plant Sciences at the  
Wageningen  
University



**Marco Bressan-**  
Chief Data Scientist  
in Satellogic where  
he is bringing  
together a team of AI  
experts to build a  
planet-scale real-  
time analytics  
platform



**Stefania De  
Pascale-** full  
professor at the  
Department of  
Agricultural Sciences  
(DAS) in the  
University of Naples  
Federico II



**Eldert J. van  
Henten -** full  
professor and head  
of the Farm  
Technology Group at  
Wageningen  
University since  
2005



**Leo Marcelis-** full  
professor  
Horticulture and  
Product Physiology  
at Wageningen  
University

# Judgement

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- Teams can get points for:
  - Net profit (50%) – yield vs. resources
  - Sustainability factor (20%) – energy, water, CO<sub>2</sub>, (biolog.) pesticides
  - AI strategy (30%) – novelty, autonomous, robustness, scalability

## Organisator



## WAGENINGEN UNIVERSITY & RESEARCH (WUR)

WUR is the only university in the Netherlands to focus specifically on the theme of 'healthy food and a living environment'



**Tech-partner**

## Sponsors



## TENCENT

Tencent is one of the world's largest Internet and technology companies providing many services including social networks, online games, and ecommerce.



## DAVID WALLERSTEIN

David is the Chief eXploration Officer (CXO) of Tencent where he drives the Company's active participation in new and emerging technologies.

# Robotics



# Sweet pepper harvesting



# Pest and disease scouting



# Thank you for your attention!

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