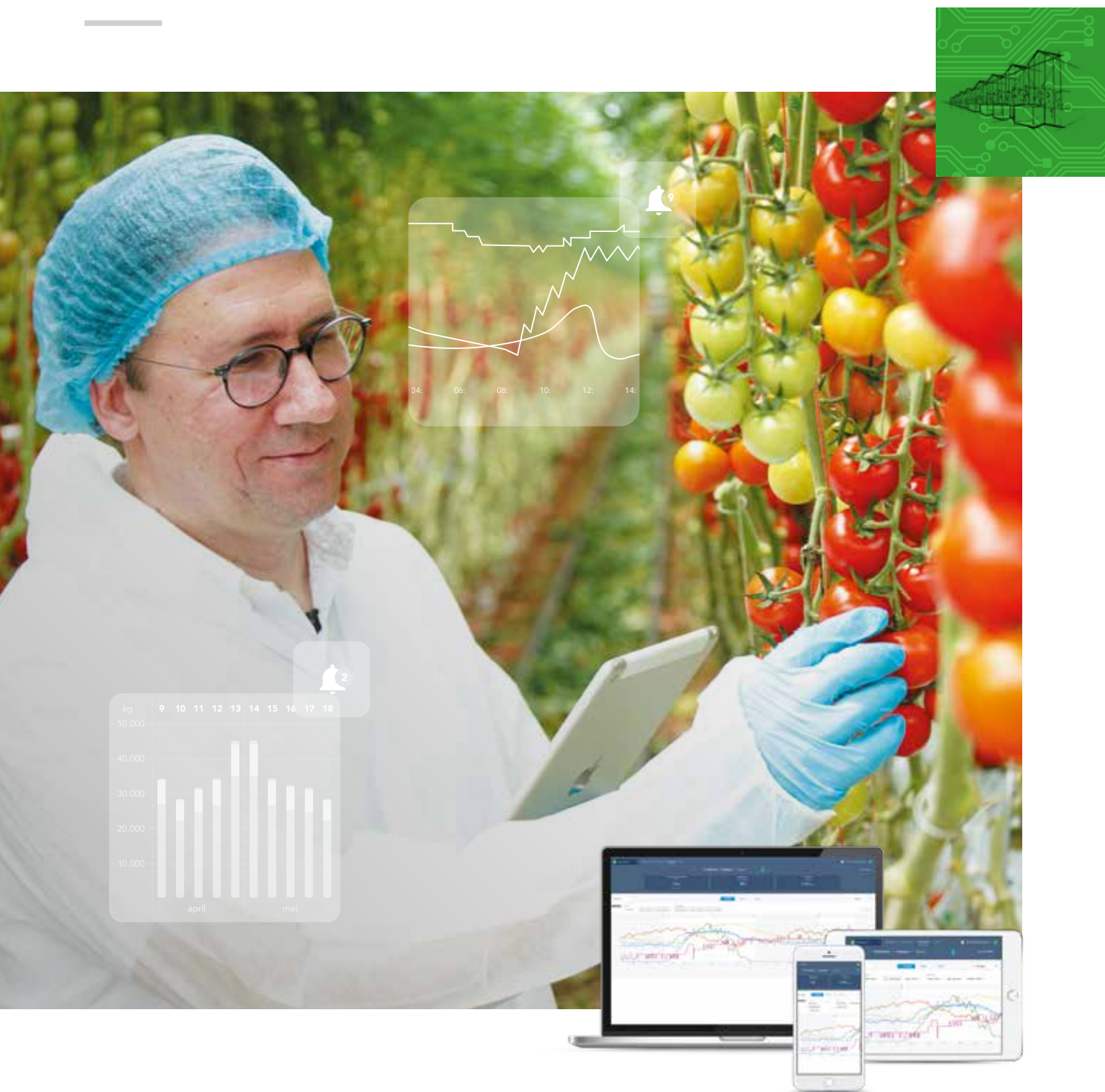# Food Forward: Unlock the potential of data driven decision making

Whitepaper by Gursel Karacor, Senior Data Scientist e-Gro

Grodan®

Table of content

Introduction

Digital data cultivation, analysis and automation are the future of the greenhouse. Artificial intelligence (AI) and data science will result in game-changing efficiencies and yield improvements. But what exactly are these technologies, how do they work and how can you, as a grower, actually make use of them?

What to expect from this whitepaper?
In this whitepaper, Gursel Karacor, Senior Data Scientist at Grodan, zooms in on:

→   Five reasons why AI will transform the greenhouse industry and what these trends and developments mean for growers.
→   He addresses common misconceptions, busting myths and providing truths.
→   Lastly, Karacor explains the combination of plant and data science and outlines practical resources and tips on how to successfully get started.

Better predictions, recommendations and forecasting
According to Karacor, AI, and its subsets, which include machine and deep learning, supported by imaging and automatization (robots) can automate much of the insight gathering and decision making for better predictions, recommendations and forecasting. Much of the work and data collection, like crop planting, registration and harvesting, being executed in greenhouses is currently still performed manually. This is tedious and time consuming work, prone to errors and inefficiencies. Nearly everything related to plants, their growth and the rootzone as well as climate conditions can be collected as usable data. AI and data science provides you with a quantifiable and data-driven process that takes the guesswork out of growing to provide an increased yield, greater efficiency and personalized solutions.

Magic happens with data and plant science
Additionally, Karacor recommends to make use of both plant and data science. When these two sciences are combined, magic happens and smart solutions and valuable insights are generated. When decisions are made in a data-driven approach it will guide and support growers in optimal growing. It might seem quite complex, but luckily you don't have to be an expert in data science to apply these technologies. When you work with the right people, you are supported every step of the way.

Data science and AI technologies present us with so many opportunities to collect and mine data in the greenhouse. This paper will help you begin your journey to get the best out of your greenhouse data. There's a bright future ahead!
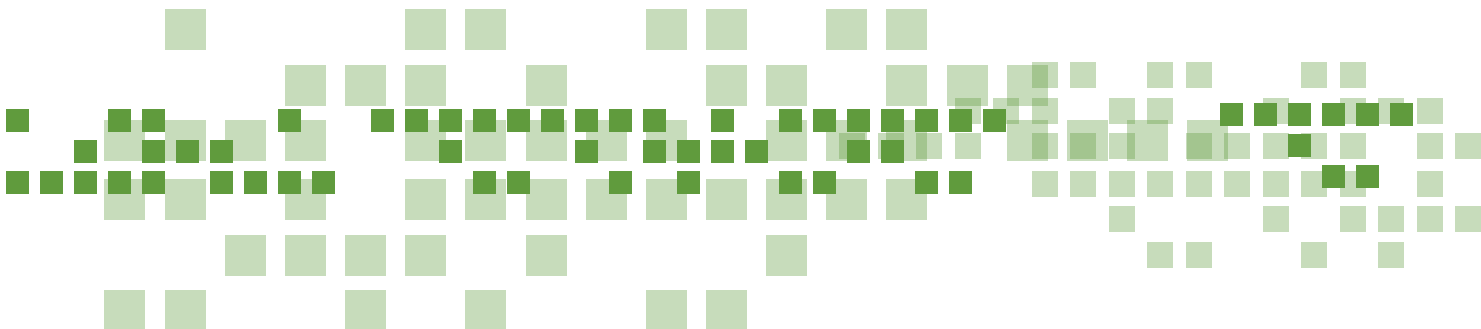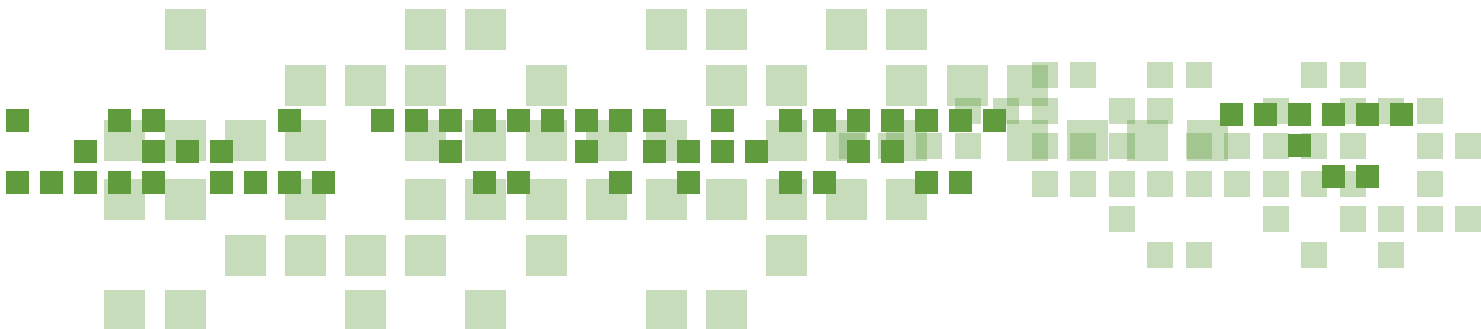
About the author:
Gursel Karakor

My name is Gursel Karacor and I work as Senior Data Scientist for our software/data platform e-Gro at Grodan. My background is in Computer Engineering, and I hold a PhD in Artificial Intelligence (AI). I have more than 20 years of experience in various domains, companies and institutions.

My mission
Here at e-Gro, I build data driven models and solutions to make life easier for the greenhouse growers and get the best out of their crops. With all the new technology, sensors, Internet of Things (IoT), etc. and data from the greenhouses are flowing in, my mission is to extract valuable and actionable knowledge from that and build state of the art predictive and prescriptive models, with the help of modern tools and Machine Learning. Yield prediction and data driven recommendations are a couple of examples of such smart models. Another important task for me is to keep these solutions up to date, on par with the new data and new advances in technology, and try to improve them every day.

Share idea's or questions?
Do not hesitate to contact me with your thoughts, ideas, feedback or questions at gursel.karacor@grodan.com

Chapter 1
5 Reasons Why AI Will Transform the Greenhouse Industry

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There are so many advances and innovative developments in AI and other state-of-the-art technologies in the horticultural sector that it sometimes seems hard to keep up. As Senior Data Scientist at Grodan and 20 years of experience in the field, I keep a close eye on all things AI and data. In this article, I will zoom in on the five reasons why AI will transform the greenhouse industry. Everyone is talking about big data, but the only practice I see happening is using the phrase in a sentence.

That's why I'm on a mission to get these game-changing technologies into the hands of users in the greenhouse. But what do all these developments mean for growers? Before I go into detail, a short description of how AI exactly works:

Artificial Intelligence (AI) involves using computers to do things that traditionally require human intelligence. This means creating algorithms to classify, analyse, and draw predictions from data. It also involves acting on data, learning from new data, and improving over time[1].

Below I share my top 5 top reasons why AI will change the way you work (for the better):

1 **The demand for food will continue to increase**
There is an ever-growing need for fresh and sustainable food created with more and more efficiency. Resources like farmlands and people working in rural areas is decreasing while the demand for food and fresh produce is on the rise. I think greenhouses and other indoor growing facilities will play an increasingly important role in meeting the demands for food in the future. Therefore, support of intelligent technology and AI is necessary now more than ever.

2 **The maturity level of technology is ready**
Here are the key trends and topics I currently see in the greenhouse:
- Machine Learning (ML) is a subset of AI and makes software learn from data, so it is purely data driven. As seen above, there's quite a lot of data and potential for accumulating this big data in greenhouse.
- Imaging Technology, or Deep Image Recognition, enables machines to "see" through the use of photographs. As they say, a picture is worth a thousand words and nothing could be more true here. It's easier than sensor data and manual recordings.
- Robots are autonomous or semi-autonomous devices for certain tasks that are often tedious, repetitive, time consuming or dangerous.
- Edge-AI: While general AI calculations and modelling is executed on a main server/cloud (which is time consuming), in Edge-AI all calculations are done on the 'edge' of the device or robot. The calculations are carried out right there on the robot itself, hence making much faster decisions possible. This is especially important for real-time operations.

[1] Source: https://medium.com/mytake/artificial-intelligence-explained-in-simple-english-part-1-2-1b28c1f762cf

3 Growers are ready

Growers are following the advances in technologies closely. They still struggle with questions like: I have lots of data but how can I make use of that? Will I fall behind my competitors? Is my growing strategy optimal? They are very keen to learn and willing to make use of the data they get from popular technologies like AI.

4 Big data creates great potential for personal and local solutions

The quality and quantity of data is so important, but very tedious for growers to collect. By using only a few photographs, AI technologies can help growers to register crops. This data can be used in many applications, including forecasting. Grodan's latest innovation e-Gro, for example, enables yield prediction up to 4 weeks. Additionally, growers can benefit from more general AI-based predictions and data-driven recommendations in the greenhouse. Big data also presents the potential for grower-specific intelligent solutions. Human experts have generic rules, but specific growers in certain regions with specific climates should have customized solutions. This will make a real difference as a continuous flow of big data by Machine Learning and AI will let us utilize all these assets. It's all very exciting.

5 Automation for utmost efficiency.

There is still a lot of manual labour in the greenhouse for tasks such as planting, crop registration, harvesting, etc. These are tedious, repetitive and time-consuming tasks that could be performed by, for example, robots. The need for automation is not just for efficiency related reasons, but also health and security issues e.g. transmission of virus, bacteria and diseases (reducing human to human, human to plant contact), as we have clearly realized during the COVID-19 pandemic.

The good thing is that these solutions are user-friendly. If you work with the right people, it will be surprisingly easy and very fruitful.

The autonomous greenhouse: within 5 years?
In the future greenhouses will, to a large extent, be autonomous. AI-solutions will make life easier for the experts and growers. My mission is the realization of autonomous greenhouses through the use of all this data with state-of-the-art ML and AI methodologies. And I want to realize this goal step-by-step in 5 years. The future may be closer than you think
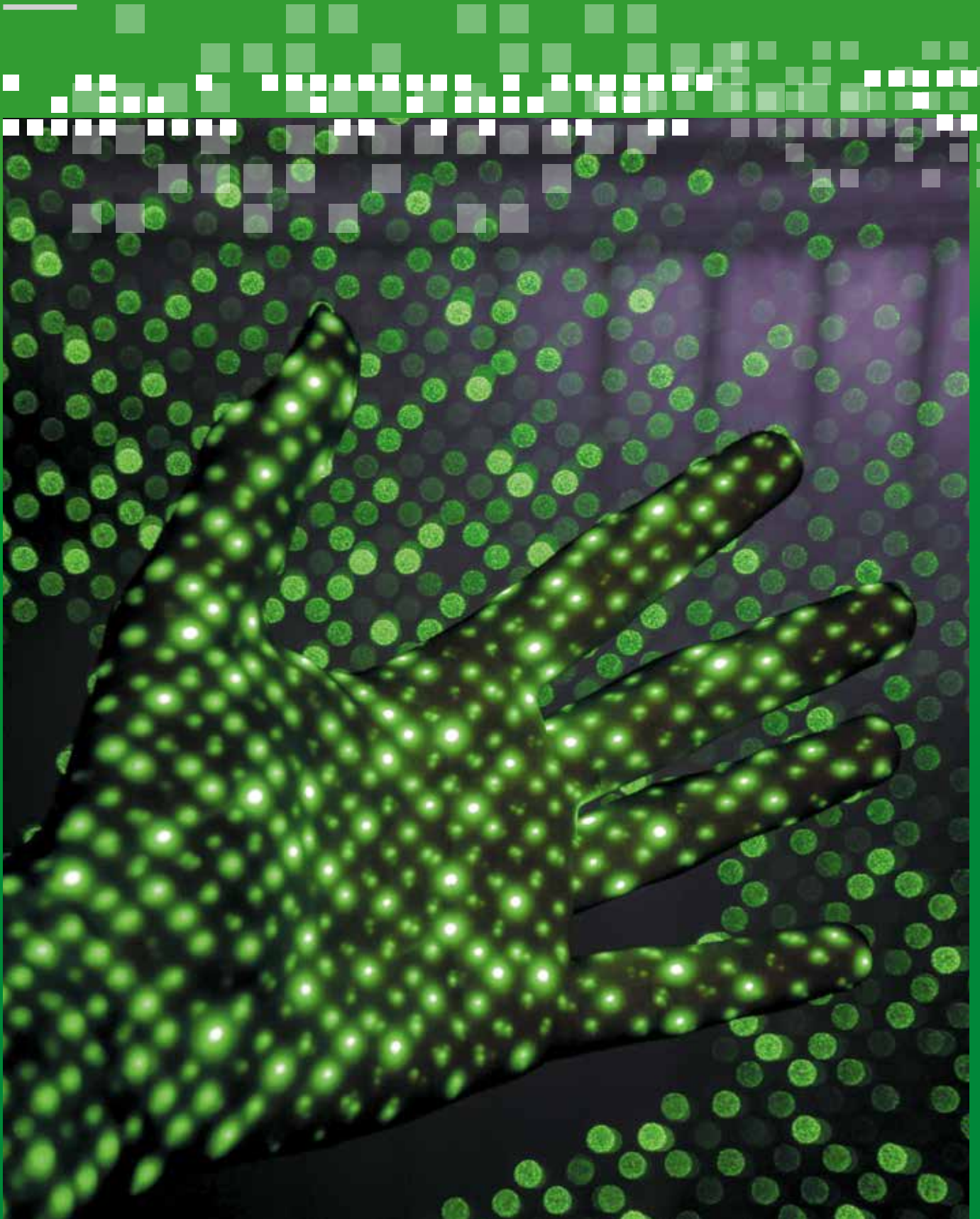
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They are very keen to learn and willing to make use of the data they get from popular technologies like AI.

Chapter 2
Where the Magic Happens: Combining Data and Plant Science

Combining data and plant science is more relevant than ever. If we apply it in the correct way, we could potentially grow fruits and vegetables more efficiently and sustainably, but how do you combine plant and data science? As I mentioned in chapter 1, nearly everything related to plants, their growth and the rootzone as well as climate conditions can be collected as usable data. This can be done manually, which is time-consuming and prone to errors, or via high tech systems such as sensors and images. There is so much data available, but what to do with it? And how do you combine the best of both worlds, using valuable insights from plant science and data science within the greenhouse?

Plant science vs. data science

Plant science dates back to ancient times, but data science is relatively new. Plant science is a classical science involving the plant physiology, genetics and the growing of the crops. It's structured and systematic. On the other hand, data science is the science of extracting useful and actionable knowledge from raw data. Data science can be seen as more of an art form, without set rules.

What brings them together is that they both make use of the latest technology and contain a strong research element. Data science can be combined with almost any science or domain, such as medicine, finance, astrophysics, and so on. When data science practices are combined with dynamic plant science, magic happens. The grower has more reassurance and can do more while using less (water, fertilizer and chemicals). This combination can give us a better crop quality, more yield, and more efficiency in the greenhouse.

How to combine plant and data science

Since this practice is fairly new, I notice that there are many misconceptions and assumptions about combining plant science with data science and the introduction of new technologies in the greenhouse. Below I share some of the main misconceptions (and the truths) I frequently come across.

Misconception 1: "My gut feeling is accurate. I don't need to use new technologies and apply data science in my company

Truth: There's no question that data and AI could be very helpful for a company: smart algorithms can effectively identify correlations and data technology has the ability to record historical data. However, you need a good combination of plant science and data science. This means that the growers' expertise (green knowledge or the green thumbs)

need to be taken into account. The predictions, suggestions and recommendations are merely data driven support. I like to use the metaphor of a pilot flying a plane. Much of a pilot's work is currently done by a computer. However, the pilot is still essential for making the actual decisions and taking informed decisions. Even the most successful growers can use data driven insights, data, predictions from time to time. We see more often that different greenhouse companies apply data science to improve the cultivation strategy.

Misconception 2: "Generic plant and data science models are valid for all growers."

Truth: Every grower is different and their specific information and growing conditions should be taken into consideration. Each greenhouse location, type of the greenhouse (lit or non-lit) and growing media type, etc. is unique.

The more you know the better you grow

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This variety directly affects growth and yield. Personalized data modelling and working with the right program is essential. Grodan developed a data platform "e-Gro" which analyses your personal greenhouse data in real-time. Read more about e-Gro via www.grodan.com/e-Gro.

Misconception 3: "Once I start working with data science and AI, I will immediately see results."

Truth: There's an assumption that you're presented with a solution once the data has been fed into the model. As you can imagine, it's not that simple. Although you can perform descriptive analytics immediately, predictive analytics (using data for forecasting) and prescriptive analytics (the use of data in order to make better decisions) take more time, see image below. You'll typically need to collect data for at least one growing season and it takes a lot of data science knowledge, experience and skills. The data needs a lot of preparation, processing, selection of the existing features and adding new ones (feature engineering). It's not the raw data, but instead the refined insights that

are of high value. Here is also where big data comes into play and the importance of working with the right people.

Misconception 4: "Plant models will work directly as data science models and generic data science models will work directly on plants."

Fact: The "real-life" behavior of plants might considerably differ from the theoretical plant physiology models, as there are many external and unexpected factors involved in growing, such as extreme climate conditions, price fluctuations, pests and diseases, labor issues, etc. What might be valid in a lab type environment will not work directly in real life (one size does not fit all). This also works the other way around. You cannot assume that well known generic data science models and recipes will directly work on plants. These predictive models need be customized according to the domain knowledge of plants and horticulture specific practices.

Misconception 5: "Just hiring a data scientist and a developer will do the job."

Truth: As mentioned, it is very important to work with the right people, whether outsourced or in-house. A team to develop a valuable data science product should contain suitable data scientists, developers, domain experts (multiple), product managers and user experience designers, in order to make sure you are able to develop good algorithms. I suggest finding an established platform that supplies you with a comprehensive team to work with. Next to this, a lot of good data is needed from the greenhouse to build impactful algorithms, please read the next chapter about how to get the best out of your greenhouse data.

How to get started
Not quite sure where to start? My advice would be to first learn data science basics and consult the right people. This takes reading relevant books and articles, some hands-on data wrangling, and trial and error as well. I would recommend following as many data science, machine learning, AI, plant science and horticulture related groups.

Figure 1: Analytic value scale for plant and data science

Chapter 3
How to Get Started: Five Tips for Success When Using Greenhouse Data

Data science and AI technologies present us with so many opportunities to collect and mine data in the greenhouse to increase efficiency, quality and yield. I discussed all the ways to collect data (sensors, imaging technology, climate computer) in my previous chapters. I also mentioned that raw data is, in itself, not very valuable. The next step is organizing and mining the data: organize, group, segment, cluster and analyze, and then combine all the valuable findings. As you can imagine, this is not an easy or straightforward process and takes most of a data scientist's or analyst's time. Additionally, you need to maintain a good data flow (this is a must!), storage and backup system.

Perhaps this all seems overwhelming and it is indeed a lot of work, but the good news is that if you work with the right people and system(s) you can attain great results without extensive effort. Your team executes the data mining, analysis and creates findings. Aside from a good team and system, there's also a great benefit when growers join forces. I call this the virtuous (not vicious!) circle. More on this below.

So what do you need to know to be successful when using greenhouse data? Here are my top five tips:

Quick wins to start using greenhouse data:

1 Connect
For any single grower it's difficult to connect with other growers in order to utilize and learn from big data. I encourage growers to join existing connections like Grodan data platform e-Gro (www.grodan.com/e-Gro) to get more out of your greenhouse data. Next to working with a system, it's also important that you get the right guidance and help to learn how to interpret your data. Try to connect with the right people and discuss how you can use the data in order to better grow your crops.

2 More data
When it comes to data, quantity is the most important. And the more the merrier; collect as much data as possible. Testing and analysis takes time and

some data may not be used immediately but will be helpful in the future. Next to the quantity, the quality of the data is also important. Be consistent in the way you collect data. Try, for example, to capture data of the plant at the same moment, each week.

3 Use state-of-the-art technology
Stay on top of latest developments and use state-of-the-art data science, machine learning and AI. Products are continually evolving to become more accurate and efficient. Read how one of the e-Gro users, Ger Derikx, has started implementing data-driven cultivation here or see image on the next page. Through each stage in the growing season this grower is discovering the advantages of this platform and how to leverage his data in meaningful ways.

4 Complete the cycle and start again
Data science and AI allows for continuous improvement. By completing the cycle and starting again you gather more data which produces an even better product and outcome. Just one season of data does not provide much insights and advice. The more, and the better, the data, the more you can do with it.

5 Spread the word
I urge all growers to share their experience and data. Spread the word to get even more growers in the game. The virtuous circle shows that knowledge grows through sharing (big data).

Bright future

So what is the "more" you get out of your greenhouse data? You will be able to easily see, and remotely access, trends in the balance of your plants (is it trending generative or vegetative?), create a more stable environment for increased and more consistent yields, crop registration for consistency and reduced use of fertilizer and chemicals, crop steering indicators to make informed decisions, and much more. There's a bright future ahead when you capture data in a consistent way and work with the right system and people.

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> I use the Conditions Module and Dashboard to monitor the crop control indicators. For example, I analyse the real-time KPI's to see what the average water intake of the stone wool mat was during the night. I can then see if that was a generative of vegetative action and adjust accordingly. This gives me more insight into the cultivation growth and based on this information I can make better cultivation decisions. It has become an important part of my day.
>
> - Ger Derikx

Figure 2: Testimonial e-Gro user on how to use data in a greenhouse with e-Gro

Grodan supplies innovative, sustainable stone wool media solutions for the professional horticulture sector, based on Precision Growing principles. These solutions are applied for the cultivation of vegetables and flowers, such as tomatoes, cucumbers, sweet peppers, aubergines, roses and gerberas. Grodan offers stone wool substrates together with tailor-made advice and innovative tools to support Precision Growing and therefore facilitate the sustainable production of healthy and safe and tasty fresh food and products for consumers.

Grodan is the only stone wool substrate with the EU-Ecolabel.

EU Ecolabel
www.ecolabel.eu

EU Ecolabel: NL/048/001