Annual report
Y1-2023-2024

CropXR

Table of contents

Introduction

1. Summary: General developments CropXR & PlantXR over the past year

2. Building the CropXR institute

2.1 Mission and Strategies
2.1.1. Mission
2.1.2. Success strategies
2.1.3 Implementation of mission-driven management

2.2. Collaboration
2.2.1 Facilitating (internal) collaboration
2.2.2 Community building: events and meetings
2.2.3 Collaboration with external stakeholders

2.3 A new legal framework
2.3.1 The need for a new CropXR consortium agreement
2.3.2 The partners and the process

3. State of affairs for scientific excellence and value creation

3.1 Data-driven design: smart data breeding methods. Overview of activities and results from work packages C1-C6

3.2 From model to crop

3.3 Breeding for resilient production systems

3.4 The first satellite program on potato

3.5 The Flagship program

3.6 Innovation dynamics and societal impact

3.7 Education
3.7.1 EduXR
3.7.2 Development of a minor
3.7.3 Learning community

3.8 Data infrastructure
3.8.1 DataXR
3.8.2 Resilience hub
3.8.3 Data governance
3.8.4 Code of conduct
3.8.5 Quality of data and metadata, application of FAIR principles
3.8.6 SURF research drive
3.8.7 Liaisons with other research data infrastructure initiatives

4. Communication

5. Organization

6. Monitoring & evaluation
6.1 Milestones and KPIs & deliverables

Appendix

Connections for possible future collaborations with external stakeholders
Events & presentations 2023-2024

Introduction

1 October 2024

The CropXR institute engages in the development of robust and resilient crops for sustainable and climate-adapted agriculture. Its multidisciplinary approach combines plant sciences, data sciences, artificial intelligence and social sciences. One of its aims is to create 'smart data' methods that lead to accelerated breeding and the production of e**X**tra **R**esilient crops.

CropXR officially started on July 1, 2023. This annual report summarizes the activities of the first year of the institute. It reflects the period from 1-7-2023 until 1-7-2024. This report also includes a financial report.

The activities of the consortium are financed in various ways. Partners contribute in-kind and in cash. In addition, there is funding from three external fund-giving bodies: the Dutch Research Council (NWO), the National Growth Fund and the Foundation for Food and Agriculture Research (FFAR). Consequently, this annual report includes the information these three donor agencies have requested to be included in an annual report.

1. Summary: General developments CropXR & PlantXR over the past year

Groundwork

On the first of July 2024, CropXR celebrated its first anniversary. The CropXR team is proud of what has been achieved in the first year of the existence of our unique consortium. We welcomed many new employees, started our research and finetuned our organizational structure. Furthermore, members of the Board of Directors and researchers attended numerous conferences and events, both in the Netherlands and abroad. They presented the work of CropXR to other actors in the field and forged new connections.

CropXR

CropXR consists of several programs dedicated to: the development of a new generation of breeding tools for extra resilient crops (PlantXR); breeding for resilient cropping systems (AgroXR); development of Data infrastructure (DataXR); human capital development (EduXR) and valorization and knowledge transfer (TransferXR). All dedicated programs consist of several work packages. Most of these programs and work packages started in the reporting period. Their activities can be summed up as follows: preparing the work, drafting plans and protocols and hiring employees. Research projects started, and necessary measures were taken to organize the work and data collection properly. All teams needed to establish

relationships, both within their teams, and with the community at large. Many meetings and events were organized to get to know each other, set goals and exchange information. All teams engaged with vital questions, such as: How do we collaborate, how do we structure the work, how do we reach our goals and exchange information?

Mission & communication

In the first months after the foundation of the institute, the CropXR mission was refined. Because it is important to navigate towards a crystal-clear spot on the horizon. Sessions on formulating the strategy of CropXR followed from this work. In addition, 3-year and 1-year goals have been formulated to give a clear direction towards reaching the mission.

To communicate to others about the existence of CropXR, the website of CropXR was launched as well as the LinkedIn page of CropXR. Partners were regularly updated by mail and corporate branding content was created. Moreover, various (media) organizations paid attention to CropXR. Throughout the year, CropXR has further professionalized its internal and external communication activities. A newsletter was created and the amount of activity on LinkedIn and other external platforms and websites increased. In addition, a first draft of a strategic communication plan was created. This will be further developed and implemented in the coming year.

Human resources

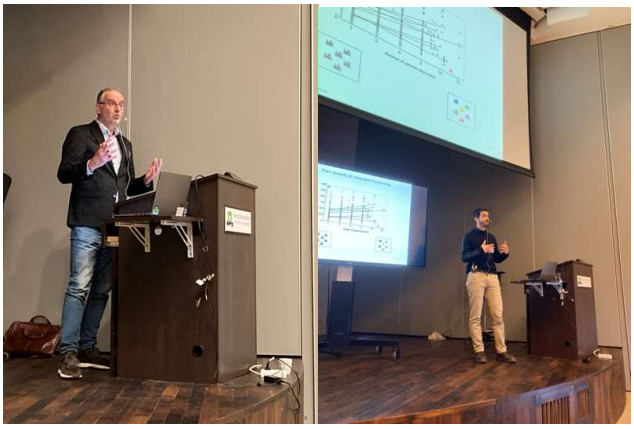
We look back on successful human resources management in the first year. In the summer of 2023 Managing Director, Hedwich Teunissen (0,9 fte), was appointed. In addition, Scientific Director Guido van den Ackerveken (0,5 fte) and Technology Director Auke Damstra (initially 0,5 fte) started. All three directors are part of the Board of Directors, a governance body that meets every week. A fourth Director (Christa Testerink) dedicated for the education program EduXR was appointed (0,09 fte). In addition to leading Work Package C3 in PlantXR, Christa Testerink is responsible for the human capital agenda. Furthermore, the controller (0,4 fte) and a management office assistant (0,6 fte) were hired. Three liaison officers (0,2 fte – secondment) also started. Their objective is to strengthen the connections between the scientific and industrial partners in the fields of use (vegetables, potato, ornamentals). Moreover, members of the Scientific Committee, the Program Commitee, Advisory Boards and Supervisory Board were appointed. All these bodies have held various meetings throughout the first year. The frequency and structure of those meetings was established as well.

At the beginning of 2024, the team of the CropXR office welcomed a communication advisor. Uniform recruitment templates were created as well as a uniform vocabulary that enhances smooth and clear collaboration. CropXR started using the tool Sharepoint to store information and data. This Sharepoint was set up and its look-and-feel and infrastructure were further developed. The application Slack was chosen for internal communication.

Highlights 2023-2024

In this first year, several highlights can be mentioned:

AgroXR is the program that aims to connect research on resilient crops and research on the properties of more resilient agronomic systems in which crops are grown. In the fall of 2023, the team of AgroXR organized various meetings to transfer the knowledge of already existing initiatives at Wageningen University and Research (WUR) and one of the breeding companies for CropXR on intercropping. Furthermore, the team of AgroXR visited the Farm of the Future (Boerderij van de Toekomst) in Lelystad to explore the possibilities of strip cultivation. Some team members also visited breeding company Vitalis in Voorst to look at the field trial of the EU project CropMix. The visit and the ensuing conversations fueled the ideas for the fruitful **AgroXR symposium** that was held in February 2024.



Pictures above: the AgroXR symposium was full of fruitful exchange.

EduXR kicked-off its Learning Community and activities related to this as well. In September 2023, Enza Zaden in Enkhuized welcomed students, scientists, lecturers and representatives of the industrial companies of CropXR for a kick-off event. There were matchmaking sessions to connect scientists working for the companies with lectors and lecturers affiliated to the green Universities of Applied Sciences. In November 2023 a similar event took place in the botanical gardens in Utrecht which was again a grand success!

Pictures above: The Learning Community of EduXR is off to a great start.

On the 29th of February 2024 the vibrant **Kick-off Event** took place. CropXR organized this festive event to officially commence its activities. Over two hundred CropXR partners, participants and outside stakeholders gathered at the Fabrique in Utrecht in the Netherlands. During the day there were presentations, interactive break-out sessions and many occasions to network and connect. All those present discussed the goals of CropXR and the way the partners can collaborate in the best possible way. At the end of the day, Marten van den Berg, Director General-Agro at the Dutch Ministry of Agriculture, Nature and Food quality, officially (and literally) kicked off the activities of CropXR.

Pictures above: bursting with energy – the CropXR Kick-off event.

In March, the **CropXR potato satellite program kicked off**. CropXR Potato is the first and front-runner crop-specific program. All those involved in this program met to discuss the aims of the program. The day also marked the official start of many newly appointed PhD candidates, post-docs, and Universities of Applied Sciences students. CropXR warmly welcomed everybody.

In May, the **first field trials of the potato satellite program commenced** at Experimental farm SPNA and Experimental farm De Rusthoeve. The exceptionally wet season proved to be challenging to investigate plant responses to drought stress as was envisioned. Fortunately, despite weather challenges and the intense labor these trials require, fruitful results have been obtained.

A new CropXR agreement

In May the consortium also started working on optimizing its underlying legal structure. Initially, the PlantXR and CropXR programs were regarded as separate entities, with different underlying legal agreements. However, as the first year of CropXR progressed, the realization arose that the two programs are in fact very much interconnected. The need to reassess the legal infrastructure and formulate a new generic CropXR agreement, therefore, became apparent. During the summer of 2024, we have worked on this new agreement. We estimate that the final version of the new agreement will be signed and in place in the autumn of 2024.

CropXR publications

We would like to point to yet another highlight of this first year: the first CropXR publications. A review article has been published in an established and recognized scientific journal (‘The rise of scientific machine learning: a perspective on combining mechanistic modelling with machine learning for systems biology’, published in Frontiers in Systems Biology). Furthermore, an article of CropXR team members has been published on a topic closely affiliated to the work of CropXR. In addition, the first CropXR report was realized by AgroXR. Lastly, it is with great pride that we would also like to mention the prize one of our PhD candidates won for an illustrated prose story depicting her PhD research.

All in all, a lot of work has been done in only one year. We look forward to continuing this work in the year that lies ahead!

2. Building the CropXR institute

2.1 Mission and strategies

2.1.1 Mission

CropXR is a unique consortium comprising scientists and industrial partners. It is committed to advancing the smart-data development of more resilient crop varieties. Such varieties will benefit both farmers and consumers and will help to protect our planet. In the face of a rapidly changing climate, more resilient crops are needed. Such resilient crops should withstand a wide array of stressors like drought or salinisation. Moreover, they should be able to grow without relying on agricultural practices that harm the environment.

As a public-private collaboration, CropXR is dedicated to driving breakthrough innovations for more sustainable and climate-adapted agriculture worldwide.

Our mission is ambitious: *"In 2033, we have developed resilient crops through data-driven design*."

2.1.2 Success strategies

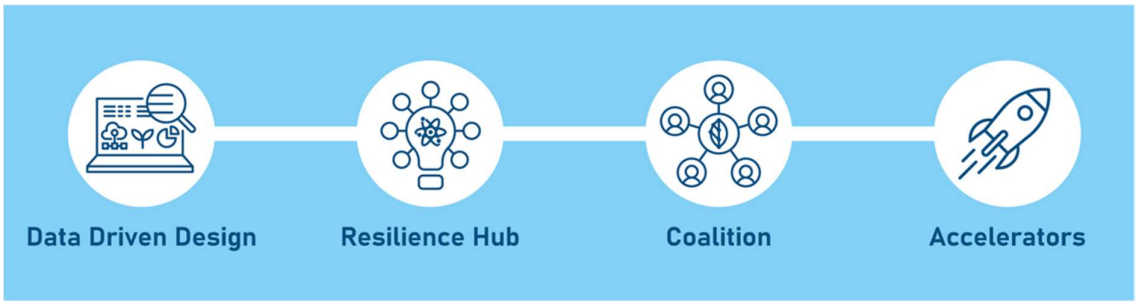
CropXR works on attaining its mission by deploying four success strategies:

1. *Data-Driven Design* CropXR studies and unravels crop resilience by using a clever and intricate combination of biology, data, modelling, simulations, and artificial intelligence. This creates the ability to accurately predict resilience in crops.

2. *Resilience Hub* CropXR envisions to become the world's pivotal center of expertise in the realm of crop resilience. It will be the hub for all the worldwide knowledge, data, tools, and expertise on crop resilience. Its excellent data infrastructure enables easy access to a global community.

3. *CropXR Coalition* By bringing together bright minds with different backgrounds, CropXR creates the optimal environment for breakthrough innovations. The various partners, affiliated to academia or the industry, work closely together on a common mission. Diversity is embraced and the many different talents of all those who participate are cherished as a unique competence. This strong coalition strives for societal impact.

4. *Accelerators* There is a constant awareness that the knowledge and insights CropXR gains can be advanced. CropXR continuously improves its pace and performance by deploying accelerators. Such accelerators can be: ameliorating collaboration, smarter experimentation, innovative data approaches or tapping into new resources, partners, and knowledge. Our approach is open-minded and inquisitive which creates ample opportunity for innovation.



2.1.3 Implementation of mission-driven program management

CropXR is driven to have societal impact. The CropXR management team believes that a mission-driven developmental pathway, as opposed to a linear approach, will increase and accelerate this societal impact. This year's strategic sessions with all Directors and the Liaison Officers have resulted in honing the CropXR mission and formulating clear strategies. These ambitious strategies help to steer towards realizing the mission.

The current challenge is to implement the mission-driven program management. This is based on the 'scaling-up' methodology which is adapted to the specific needs of our public-private partnership. The Directors and Liaison Officers meet four times per year to translate small steps (quarterly goals) to accelerate and work towards the mission. The aim of defining quarterly goals, in parallel to daily affairs, is to give impulses that enhance agility. In addition, these goals accelerate developments that are needed to reach our mission in time.

The coming year, we will finetune the implementation of the scaling-up methodology into day-to-day management. Similarly, the connection to the work packages and programs will be advanced. Furthermore, the methodology will be embedded into the governance and meeting cycle of governance bodies throughout the year. We will further familiarize the CropXR community with this approach and we will stimulate them to embrace it. By enhancing the commitment to, and support of, mission-driven program management, we strongly believe that this method will lead to a successful realization of our mission.

2.2 Collaboration

2.2.1 Facilitating (internal) collaboration

As a public-private consortium that includes scientific institutions, industrial partners and technology innovation companies, our organizational structure can be defined as ‘hybrid’. To enable optimal collaboration between this diverse group of employees, we use various tools and strategies.

The tool Sharepoint is used to store, organize, share and access CropXR information and data. The entire community of CropXR can access this Sharepoint. Some folders have access restrictions, yet most folders are available for all. The idea behind this is to stimulate cross-pollination and exchange. The past year, our Sharepoint has been further set up and professionalized. Numerous documents were created that list procedures, uniform vocabulary and the way to report CropXR related external activities.

On Sharepoint, the CropXR community can also find a team page. This page corrals all kinds of important information, such as information on CropXR software, recruiting and onboarding, procedures, reporting outreach activities and corporate branding.

The application Slack was chosen to serve a social intranet that aims to unite our community on a professional and personal level. It should strengthen the connection of all to the CropXR mission, mission strategies and values. As we have just commenced, we will further assess the effectiveness of this tool in the coming year.

2.2.2. Community building: events and meetings

CropXR recognizes the importance of connecting all the new employees to enable optimal collaboration and exchange. The CropXR community is diverse on many levels. The educational backgrounds of community members span plant sciences, data sciences, social sciences or agronomy. Furthermore, employees are connected to numerous scientific or industrial organizations. Meeting in-person is important to unite this unique community. In this paragraph, we highlight a couple of important meetings and events that were organized this year.

Every year, the entire community will meet jointly twice a year during special one- or two-day event. This large-scale meeting is intended to strengthen collaboration and facilitate direct knowledge exchange with everybody involved. In February 2024, the **CropXR Kick-off event** was organized to start these kinds of collective meetings. This event proved to be inspirational and motivational. It kick-started work packages and programs and reiterated the goals, mission and strategies of CropXR.

As the CropXR community includes employees with different professional career levels, from early career professionals to accoladed Professors, we recognize that the needs for professional guidance or exchange among peers differs greatly. CropXR has, therefore, established the **CropXR Young** network. This is an initiative meant to strengthen the ties between CropXR's early career professionals. In May 2024, the first meeting of CropXR Young took place. Young-hearted members of the CropXR community presented their work to each other and met in an informal setting. Those who are part of CropXR Young warmly welcomed the initiative and have responded enthusiastically. They intend to continue meeting from time to time in an informal way to learn from each other and strengthen ties.

Picture above: Young CropXR unites the young-hearted members of the CropXR community who work in the work packages.

In May, the **CropXR Potato Kick-off** was held. CropXR-Potato brings together researchers from Delft University of Technology, Wageningen University & Research and Utrecht University, potato breeders and processing companies united in Holland Innovative Potato. During the CropXR-Potato Kick-off, the activities of the program were discussed. These include extensive field experiments, which take place at AIKC Rusthoeve and SPNA agro research. The field trials provide a wealth of data on drought and nitrogen stress responses. This data fuel subsequent potato crop modelling.

Pictures above: The kick-off event of the front-running satellite program CropXR-Potato.

Work package C1 organized a workshop to better align its activities. This inspiring brainstorm took place on the 2nd of July 2024. People involved in modeling, bioinformatics and machine learning were present. The workshops had various aims. Firstly, to get to know each other better. As a variety of academic disciplines is united in C1 or Demonstrator work package, those involved are experts in different fields and speak different so-called academic 'languages'. Hence, the need to familiarize each other with the background colleagues and their approaches was another important aim. Together, scientific goals were defined and a roadmap was constructed. It became evident that more work needs to be done regarding control theory to analyze model parameter sensitivity. This applies as well to predicting the most informative experimental efforts. Likewise, the subject of how to integrate mechanistic and machine learning modeling requires more attention. Overall, the workshop has helped the team to move forward and readjust some of its endeavors.

On 8th February 2024, in collaboration with the graduate schools Production Ecology and Resource Conservation (PE&RC) and Experimental Plant Sciences (EPS), **AgroXR** organized a **conference** along the theme of Breeding for Resilient Cropping Systems at Wageningen University & Research (WUR). After a welcoming address from Dr Olga Scholten (WUR plant breeding) Dr Germain Montazeaud (Institute Agro, Montpellier, France) gave an excellent keynote talk on the genetics of plant-plant interactions for agroecology. Dr Peter Bourke (WUR Plant Breeding) gave details of ongoing experimental work on breeding for intercropping at WUR, while Aron Ortega and Marcel van Diemen (Vitalis B.V.) presented results from a strip cropping experiment at their breeding station in Voorst, the Netherlands. There were also excellent talks on the CropMix project (Dr Dirk van Apeldoorn, Farming

Systems Ecology, WUR) and the Farm of the Future (Dr Marleen Riemens, PSG, WUR). A closing address was given by Prof. Guido van den Ackerveken (Utrecht University and Scientific Director CropXR). The event was attended by over 100 participants.

In the afternoon, participants were divided into smaller groups. Using a 'fish-bowl' format, three topics were discussed: 1. What is resilience; 2. What are the knowledge gaps that need to be addressed in order to breed for resilient systems, and 3. What crop traits are needed for this. These discussions gave valuable insights and direction to future research within CropXR regarding breeding for resilient cropping systems.

Although many of the participants were WUR-affiliated (60%), a large number came from the breeding sector (25%) and other knowledge institutes (15%). In a plenary discussion, participants could vote and discuss a series of propositions coming from each of the discussion rooms, leading to a lively and entertaining discussion on these topics. For the final question, participants were asked to identify the most important step to embrace complexity. In keeping with the multi-actor and multi-disciplinary nature of the workshop, the most popular response turned out to be 'communication'.

2.2.3 Collaboration with external stakeholders

The CropXR team has been very active attending events, conferences and networking meetings both in the Netherlands and abroad. This has resulted in many new connections with national and international organizations that may lead to future collaborations. Organizations have reached out to CropXR this past year with a similar objective.

In the appendix you can find an extended list which entails some of the organizations CropXR has connected with and a brief explanation. In the coming years, CropXR will further explore these connections and possible collaborations. A few promising encounters are noteworthy mentioning. The GreenRobust initiative, a German cluster around plant robustness, could be a very interesting partner to expand the international scope of CropXR. Likewise, the activities of company Plense Technologies, which develops innovative ultrasound sensors to monitor and phenotype plants, are innovative and it would be good to further strengthen this connection. This applies to the Alliance for Science as well. As executive director of Alliance for Science, Sheila Ochugboju, is on the board of the CropXR Advisory Board, there is already a warm relationship with this organization. Lastly, The World Vegetable Center, located in Taiwan, could be an interesting partner to team-up with for the CropXR Flagship program.

2.3 A new legal framework

2.3.1. The need for a new CropXR consortium agreement

To understand the necessity for some amendments in the underlying legal structure of

CropXR, it is useful to offer a brief overview of past actions.

NWO granted the program PlantXR a subsidy. The program is dedicated to fundamental research on a new generation of breeding tools for extra-resilient crops. This led to the so-called PlantXR consortium agreement which has been signed by the nineteen parties involved. The PlantXR program is part of the wider CropXR program, yet it has its own budget and plan.

The National Growth Fund also gave the consortium an endowment to enhance its societal impact. For these accompanying programs, the so-called CropXR 'institute' agreement was created. In addition to fundamental research (PlantXR), it includes Agronomy (AgroXR), data-infrastructure (DataXR), human capital development (EduXR) and knowledge transfer and valorization (TransferXR).

Today, the PlantXR program is fully integrated into CropXR. The underlying legal structure, however, differs from the other programs. Originally, the different programs were considered independent pillars for which separate sets of arrangements would be best. As the first year of CropXR progressed, the realization arose that these two programs are very much interconnected. The need to reassess this situation and formulate a new generic CropXR agreement, therefore, became apparent. This new agreement will better align the execution of CropXR and its underlying programs in the next 10 years. The PlantXR agreement, which will stay in place as it is, has been used as a basis for this new agreement.

2.3.2 The partners and the process

After consulting the Supervisory board and the Founders assembly and receiving their approval, the process of drafting a new CropXR agreement started. All parties involved were informed and requested to give their input during a consulting round table meeting. Subsequently, a lean working group was set up, consisting of two universities, two industrial full parties. The two technology parties also joined. This working group started drafting a concept agreement.

Two independent external experts have supported us in this process. Bas Allart, who was involved as a quartermaster during CropXR's preparatory phase, supervises the overall process. Fleur Tuinzing, legal counsel at the law firm Houthoff, supervises the legal procedure.

All partners will be invited to give their feedback on the draft agreement. We estimate that the final version of the new agreement will be signed and in place in the autumn of 2024.

3. State of affairs for scientific excellence and value creation

3.1 Data-driven design: smart data breeding methods. Overview of activities and results from the work packages C1-C6

CropXR aims to accelerate much-needed changes in agriculture. In today's world, we face enormous challenges such as climate change and reduced food security. To withstand such environmental challenges, crops should be more resilient. CropXR is on a mission to make crops more resilient, climate-adapted and sustainable. New crop varieties should become less dependent on fertilizers and pesticides. In addition, they should be better capable of dealing with weather extremes, yet the quality of the produce and the yield should remain high.

This is not an easy task as plant resilience is genetically complex. Many genes interact when a plant experiences stressors such as flooding, drought, or salinization. To unravel the building blocks of resilience, we need to examine it from a systems biology perspective. Deploying such a holistic and interdisciplinary approach means studying the interconnected functioning of the entire plant. Computational and mathematical analyses are used for this. By gathering diverse data sets and deploying advanced technologies such as artificial intelligence, the CropXR team will develop mechanistic models. With these models, we aim to define and predict resilience traits. This is the innovative 'smart data breeding' approach that we envision.

In 2023-2024 the following building blocks for smart data breeding methods have been created in our six work packages:

- **Work packages C1: Demonstrator - the data catalyst**
  This team has made an inventory of existing public and in-house experimental transcriptomics data regarding temperature and drought stress that has been made available to the consortium. In addition, an alternative approach based on the PlantConnectome was developed to mine literature abstracts for relevant interactions between genes, hormones, environmental conditions and phenotypes that can complement transcriptomics data. Furthermore, regarding the mechanistic models, progress has been made to identify plant responses to certain stresses. After examining the literature, the team has developed network models.

- **Work package C2: Managing plant disease in a changing climate**
  This team aims to generate multilevel metabolic network models (MNMs) based on differential equations and connect these to deep learning-based gene-regulatory networks (GRNs). This first year, the team had found that it is indeed possible to construct functions of DNA that can generalize unseen genes and environmental conditions. The team aims to provide a methodological framework for GRN inference

and in-silico prediction of the effects of mutations on gene-transcription factor relationships and, hence, transcriptional response.

Furthermore, the team created two models replicating the results previously seen in atomical studies and identified areas for improvement of these models. Moreover, it prepared the work for the acquisition of data on RNA-sequencing of leaf samples from the timeseries of plants treated with hormones combinations. Good RNA quality and sequence results from mock samples have been obtained.

- **Work package C3: Optimizing root architecture for drought stress resilience**
  This team focuses on acclimation of plant root system architecture (RSA) to water deficit, with a two-fold aim. First, to understand how water deficit steers root development, in particular root branching. Second, how these developmental changes contribute to water uptake and overall resilience of the plant to drought. This work package has started only very recently in June 2024. In the next annual report more progress will be reported.

- **Work package C4: Molecular mechanisms of growth-resilience trade**
  This team aims to decipher the molecular-genetic networks that plants use to regulate trade-offs between growth and stress resilience. This first year, preparatory work has been executed. Proteomics workflows for the project have been prepared. Furthermore, work has been done on sourcing and developing genetic resources for TurboID-based proteomics.

- **Work package C5: Maintaining flower, fruit and seed yield, and viability under abiotic stress**
  This team aims to unravel how a plants' processes and regulatory networks are influenced by temperature and drought stress. Furthermore, it aims to design possible strategies to support a plant to overcome less optimal conditions. This first year, pilot experiments have been performed to set up the large-scale phenotyping of reproductive traits in wild-type Arabidopsis plants under temperature and mild-drought stress.

- **Work package C6: Optimizing carbon use for yield in drought-stressed storage organ crops – in potato and onion**
  This team investigates the physiological and molecular adaptations to drought stress in potato and onion, with a focus on carbon partitioning to the storage organs. The aim is to identify key regulators of carbon partitioning. Furthermore, the team aims to unravel the influence of physiological parameters by a modeling approach. In the reporting period two PhD students have recently been appointed. First greenhouse experiments have been designed, implemented and executed.

3.2 From model to crop

During the first five years of our consortium, we will conduct our research on *Arabidopsis*, a so-called 'model' plant that makes it very suitable for research. We will concentrate on gathering experimental data and will use the wealth of available Arabidopsis knowledge. With the help of AI, this data will be transformed into models that will give us insights into the inner workings of the involved resilience processes. Think of the links between genotype, metabolic pathway, cells and tissues, and external stress. These models allow an efficient translation of findings from *Arabidopsis* to crop species. Furthermore, they enable us to better understand crop resilience and how this can be improved.

In the ensuing five years, we will convert the fundamental knowledge we have gained into practical breeding tools for six crops: tomato, lettuce, onion, brassica, and potato and chrysanthemum. This diverse selection of crops gives us insights into resilience on many levels. Some of the crops are cultivated in greenhouses. These relatively controlled environments have their own challenges. Take, for instance, chrysanthemum that is bred and grown in a greenhouse. Thrips, minute slender insects, pose a severe threat to these crops, and can severely harm practically every existing crop. How chrysanthemum can become more resistant to this insect is one of the pivotal questions we will try to answer. Crops that grow in the field, on the other hand, face other challenges. Excessive rain or drought, for instance, test the resilience of such crops in a different way.

Picture above: CropXR studies stresses plants face in a changing climate such as heat waves, droughts, flooding, pests and disease.

Crops are genetically complex. The crops we have selected represent this complexity. They vary in genome size, the number of sets of chromosomes in a cell or organism (ploidy level) and heterogeneity or other characteristics. Researching genetically different crops is, therefore, very insightful.

CropXR aims to know and predict the intricate dynamics of complex traits and genes. We pursue the creation of new plant models that will provide insights into how the interplay of multiple genes together shape plant resilience. The smart data breeding technology that we will develop looks at how multiple stresses impact a plant. We will deploy the smart data breeding methods to our selected crops to deliver concrete results.

3.3 Breeding for resilient production systems

Crop resilience is an important component of sustainable and climate-adapted production systems. To have the most effect, it should be integrated into more resilient cropping systems or combined with improved management practices in crop production. As the research on resilient cropping systems is a scientific area on its own, we focus on how resilient crops can best perform in agronomic practices. This is why we developed the program AgroXR. It is subdivided into three research lines: 1. Integration of resilient crops into resilient production systems (A1), 2. Breeding for resilient cropping systems (A2), and 3. Phenotyping and measurement of stress resilience (A3).

This first year has been mainly a preparatory year for AgroXR. In the coming year, this program will fully commence. The following will be studied:

The first research line A1 will focus on social and innovation aspects of integrating breeding and agronomy to realize resilient production systems. A post-doc will start working on this topic (expected to start in the course of 2025).

In the second research line A2, four PhD projects are planned. Two PhD projects have already started. These projects aim to understand the effect of drought and reduced nitrogen levels on potato production. They are also being part of CropXT Potato and align with WP-S1 where they jointly work on the large field trials. The other two PhD positions will be filled in 2025 and focus on breeding for resilient cropping systems. The AgroXR workshop at the beginning of 2024, in combination with a report written by a post-doc in A2, was very helpful to make an inventory and develop two PhD projects. The scientific plans will be discussed with CropXR participants before they will be finalized.

So far, the third line A3 has appointed a part-time post-doc for CropXR Potato to develop phenotyping methodology in NPEC in relation to microbiome studies on potato. Other parts of the budget are envisioned to aid the development of the Flagship program but need to be further discussed.

3.4 The first satellite program on potato

The research of CropXR Potato aims to contribute to the development of robust potato varieties and to develop future-proof potato cultivation practices. AI-driven models play an important role in these activities. The CropXR Potato satellite is a front-runner program within the consortium. Industrial partners within the potato value chain are actively involved in this research and closely collaborate with CropXR colleagues from scientific institutions. In this first year, eight PhD candidates were hired and started their research.

In CropXR Potato, we aim to obtain unprecedented new data on the genotypic variation in potato physiological and performance responses to both drought and nitrogen availability. These conditions were chosen as they are expected to become more constrained in the future due to climate change. We will use the data gathered to build a new generation of potato crop models that describe these connections and predict their influence on quality and yield. These models will support farmers' decisions on sustainable crop management and accelerate targeted breeding for new environmentally friendly climate-resilient varieties. They will also provide more scenarios of what the future holds for potato production and potential positive impact that new breeding and agronomic strategies may have. The overall CropXR approach and translation methods will be important to support the development of these models, as they will enable prediction of yield and product quality of a crop in response to abiotic factors such as water limitation, and other factors in the environment of the crop, such as microbial soil health.

After kicking off in March 2024, the CropXR Potato commenced its field trials at two experimental farms. The researchers involved planted seed tubers of twenty commercial potato varieties to test their response to varying levels of water and nitrogen availability. The objective of these trails is to determine and understand genetic variation in drought tolerance and nitrogen use under real agronomic field conditions. This is critical both to identify useful breeding markers and to develop modelling approaches that can inform agronomic and breeding strategies to make the Dutch potato sector more resilient.

In the spring of 2024, the Netherlands experienced heavy rains. They hindered our field trials, making it unable to conduct the water treatments. Due to these circumstances, it was necessary to adjust the design of the experiments. This has been done in close collaboration with the CropXR Potato partners. The nitrogen treatments, however, were not altered. Fortunately, they appear to be showing some clear effects.

For the microbiome part of the program, we have started with initial experiments at the Netherlands Plant Ecophenotyping Centre (NPEC) in Utrecht. The objective is to design a reliable pipeline that enables phenotyping the effect of soil microbiota on the growth performance of a diverse set of potato genotypes. We have made a start with selecting and collecting hundred Dutch potato soils. They will be prepared to test the effect of their soil microbiota in the NPEC phenotyping set-up. Additionally, we have harvested roots of control and high nitrogen availability treatments of all twenty genotypes at 1 timepoint at both test

locations for microbiome profiling.

3.5 The Flagship program

The Cauliflower Flagship project idea is a unique and relatively new addition to our program. This proposed new project strives to immediately test the insights the various work packages and program lines yield to improve the resilience of the cauliflower. Thanks to the iterative and integrated approach of this project, we expect to speed up the concrete results we aim to obtain. The Cauliflower project contrasts with the linear set up of our program. Instead of waiting to apply the results of our fundamental research to our satellite programs after the first five years, we will immediately deploy all the knowledge of the various work packages and programs. This innovative way of operating is in line with CropXR mission strategies. These leading principles state that we actively seek ways to enhance our activities and results.

The added value of the Cauliflower Flagship demonstrates itself on many levels. The project not only unites the knowledge of all the work packages and program lines of CropXR. It also brings together the entire community of CropXR. This is stimulating and will increase the feeling of connectedness amongst the CropXR employees. Collectively, we will work on developing a more resilient cauliflower to be grown in a subequatorial climate. We have chosen the cauliflower because of its genetic resemblance to Arabidopsis. This makes it the perfect fit for this kind of spin-off project. Moreover, cauliflowers are consumed in many countries around the world. The potential market is, therefore, considerate. In addition, there is already a lot of knowledge available on this vegetable regarding cell and tissue culture and engineering methods.

The Cauliflower Flagships project has been developed based on various brainstorm sessions that were held during this first year. A preliminary plan has been drafted describing the reverse-genetics and the forward-genetics approaches. The reverse-genetics approach (going from known genes to get interesting phenotypes) is being worked out and will be based on knowledge on gene functions generated in the PlantXR core program. The forward approach (going from phenotype to the underlying genes) shows the unique pre-competitive nature of CropXR in which the industrial parties active in vegetable breeding will bring together and share their genetics germplasm. By doing so, they can create a totally new breeding-pool consisting of a so-called MAGIC population, that make up inbred lines that are a mosaic of the genomes of ~8 unique parental lines. It is unique that in fact competing breeding companies collaborate on this level of sharing their genetics for the purpose of the Flagship program. The actual plan needs to be drawn up in the coming year. Subsequently, the execution of this plan will start. As a parallel program, we expect that this project will yield its first results in the following years.

3.6 Innovation dynamics and societal impact

The work package Innovation dynamics and societal impact examines how smart breeding can meet the needs, interests and values of stakeholders. It aims to answer questions such as: How can we make sure that the smart breeding concept is accepted in society? How to accelerate the transition towards breeding extra-resilient crops? Ethical, legal, innovation dynamics and societal aspects of smart breeding are included in this holistic approach.

The studies that are part of this work package explore the opportunities and implications of the smart breeding concept for the Dutch plant breeding sector and society at large. The aim is to grasp which factors can enhance the impact of smart breeding in relation to sustainability goals, on the local and international level. The studies tap into the methodologies used by innovation studies (IS), science, technology and society (STS) and responsible research and innovation (RRI). The research conducted in individual studies that are part of this work package informs the research of team members, which leads to desired cross-pollination.

This first year, the work package has been very active. PhD students were hired and started their research. Team members of CropXR worked together on a project related to CropXR, which resulted in the publication of the article 'The societal roles and responsibilities of plant scientists in the context of genome-edited crops'. Furthermore, PhD candidate Aisha So won a prize in the poetry, short story, flash fiction competition of the European Association for the Study of Science and Technology (EASST). Her submission 'Hero, who cared about the forest and wanted to transform it' was considered outstanding. This illustrative story visually depicts So's CropXR subproject on the societal aspects in which she focuses on the notion of resilience.

This first year, the team of C7 has structured the workflow in an optimal way to stimulate exchange within the team and with the consortium at large. Furthermore, members of the team attended many events and conferences. They gave lectures and workshops on their work, both for the CropXR community and external audiences. At this stage, it is too early for empirical results of the studies of this work package. The future results are expected to contribute to the societal impact CropXR envisions.

3.7 Education

3.7.1 EduXR

EduXR is the education program line of CropXR that engages in knowledge transfer and knowledge development. UvA and its Amsterdam Green Campus lead the EduXR activities.

The core team consists of a coordinator and two executing staff members and Christa Testerink as a Director of Education.

In this first year, the activities of EduXR included: taking stock of the existing education the consortium partners offer on plant resilience and smart data. Subsequently, plans were developed to incorporate new knowledge into existing education in collaboration with the professional field. It was necessary to create agreements between scientific institutions and higher education institutions.

Secondly, EduXR has worked on the development and implementation of new minors in plant resilience. Thirdly, work has been done on the development, implementation and improvement of lifelong learning modules. Professionals working in the (agricultural) field should have access to new insights to acquire knowledge on resilient crops. A fourth pillar of EduXR is to translate the knowledge accumulated by scientific institutions and higher education organizations to professional fields related to agriculture (from ICT to policy) to enable practical applications of this knowledge. A road map has been drawn up for this purpose. Furthermore, the team of EduXR tries to connect to already existing similar initiatives to create the most impact possible. These various activities of this knowledge translation take place under the umbrella of the CropXR learning community.

3.7.2 Development of a minor

After examining the current education on plant science and smart data offered by the consortium partners, a working group within EduXR decided to start with the development of a Bachelor (Bsc) level minor for students of scientific (Dutch: WO) and higher education (Dutch: HBO) students. Later, EduXR might include the development of a Master's level minor / EPS as well. For now, an interdisciplinary Bsc minor will touch on plant science, data science and social science. Two new courses are being developed with multiple modules, which will be available to all educational parties. The EduXR team is also investigating opportunities to share modules and the usage of platforms. The pilot of the first course of the Bsc is scheduled for the academic year 2024-2025. The aim is to kick off the complete minor in September 2025, as part of several Bachelor programs at Wageningen University and Research.

3.7.3 Learning community

The CropXR learning community unites researchers, students, teachers/Professors and breeders from the industrial partners with the aim to learn from each other and collaborate. The learning community really took shape this first year. Seven events were organized where students presented their CropXR project. In addition, all those present had ample opportunity to network and exchange information. Professionals working for industrial partners were asked to formulate the questions they would like to have researched in order to make progress in their activities. These questions relate to resilience traits in the six crops

that are part of the program. Subsequently, various matchmaking sessions were held between teachers and industrial partners. This had led to students and industrials partners teaming up to find questions to urgent and relevant questions.

All those involved successfully collaborate. The learning community members are clearly very enthusiastic and committed. Approximately hundred people are involved in this network after the first year and thirty-three students have executed their research projects. Fifteen of those projects have been done in collaboration with the companies and CoE Groen in this first year. For the projects on the onion, students team up with Delphy, an agricultural consultancy organization.

One of the many achievements of EduXR has been the applied research activities that were exploited as an input for other CropXR programs (PlantXR and DataXR) for which collaboration with Universities of Applied Sciences were established. The teams set up applied research projects to introduce University of Applied Sciences students to breeding for resilience. Moreover, these projects engaged the students with the professional field. Simultaneously, companies wanted to start doing preliminary work for the satellite program. These collaborations have created a bridge between industrial partners and academia. As a result, the applied research projects connect the core program and the satellite program, enhancing their effectiveness.

3.8 Data infrastructure

3.8.1 DataXR

DataXR is the department within CropXR that manages the data within our consortium. Our team of data scientists, led by Technology Director Auke Damstra, works on the creation of a robust data infrastructure to store, manage and access all the data decently and safely. This infrastructure supports data analysis and is based on the FAIR principles (Fair, Accessible, Interoperable, Reusable). Moreover, DataXR intend to create an inclusive data culture. This means that all those within the consortium should be able to access the data. DataXR works on creating uniform standards and protocols and supports operational services to CropXR partners. Furthermore, it engages in analyses and the development of applications. Lastly, it closely collaborates with other work packages that work on bioinformatics, machine learning and modelling. The development of AI in society at large poses ethical implications. They effect the data infrastructure and tools that CropXR develops. DataXR sees it, therefore, as one of its tasks to raise awareness and communicate about this.

3.8.2 Resilience hub

CropXR has the ambition to become a center of expertise in the realm of breeding for crop resilience and associated data and computational/AI methodologies. This Resilience hub will

unite knowledge, data, tools, and expertise on crop resilience. Realizing this ambition starts with storing and structuring all the data we use and create within our consortium properly. Eventually, a global community will be able to access the hub as well. The requirements and possibilities to access the hub by others outside the consortium will be further developed in the coming years.

3.8.3 Data governance

This first year, DataXR has established the groundwork for the CropXR data infrastructure. A key element has been to establish the governance of DataXR and the communication structure between the various partners involved in DataXR. This had led to implement a central repository, CropXR Sharepoint, to store and share relevant documents. Furthermore, DataXR has introduced the app Slack. All CropXR partners can use this app for direct informal and formal internal communication purposes. In addition, DataXR has created a central storage facility, the CropXR ResearchDrive, to store, share and analyze research data.

DataXR has also created a Data Governance Framework. This document describes the governance of DataXR, comprising the following bodies:

- **DataXR Management Team (MT)**: the MT steers DataXR work and takes management decisions that enable the daily work of DataXR. It does not take decisions that require significant budget changes or that may have a lot of impact. In those cases, the CropXR Board will be involved and, if necessary, the Program Committee as well. The MT consists of Technology Director Auke Damstra and AI Technical Coordinator Marcel Reijnders and Dr Thomas Abeel. Narges Yoesefi is the executive secretary of the MT.
- **DataXR Work group**: this group builds the data infrastructure and supports the program on operational/IT/data level with trainings, protocols, workshops etc. It consists of a research engineer and data architect (both positions have been filled) and data-engineer/steward (vacant). Thomas Abeel manages this group on a daily basis.
- **DataXR User group**: this group gives input on requirements, reviews documents, and serves as the key advisory board for the data infrastructure Because of its advisory role, the group can be compared to the Scientific Board for PlantXR. As of today, the group has organized four workshops to discuss topics like data architecture, data types, data governance and the resilience hub.
- **SAME group #1 - Standard Expert group**: this group works on the creation of standards. It consists of people from different work packages.
- **SAME group #2 - Metadata Expert group**: this groups focuses on the metadata. It also includes people from different work packages.

3.8.4 Code of conduct

To handle all the data within the consortium, a (public) Data Code of Conduct has been created. This document serves as a guideline for all the data management of the consortium. The DataXR User group has provided input for this document and other codes of conduct has served as examples to create this document. In addition, we have listed all the various data types in a Data Types document.

3.8.5 Quality of data and metadata, application of FAIR principles

CropXR is keen on using high-quality data since the accuracy of models and predictions depends on this. Metadata, the data that provides information about other data, is important for the CropXR data infrastructure. As researchers tend to focus on their own research, they do not always spend sufficient time on sharing their data and label it properly. Optimizing metadata usage and creation is, therefore, a topic deserves special attention. DataXR has created a PhD position that will research metadata management. This research will, among others, examine social factors that influence people in the willingness to fill out metadata. Furthermore, technical challenges and solutions will be studied as well.

3.8.6 SURF research drive

DataXR has started a collaboration with the SURF Foundation (SURF) that has years of experience in developing Research infrastructures. SURF provides a data storage platform for CropXR, called Research Drive. To analyze how people use this drive and to be able to improve its effectiveness, a survey has been conducted.

3.8.7 Liaisons with other research data infrastructure initiatives

DataXR intends to operate efficiently in every possible way. This means that we actively try to utilize knowledge from other, similar initiatives to design and handle our own data and data infrastrucure. There are, therefore, warm relationships with other initiatives. This can be organizations in the realm of the so-called ‘green sciences’ but also those outside of this field of interest.

This year, we have frequently exchanged information with the following parties: Health-RI, other National Growth Fund initiatives, commercial infrastructures, Unlock, VIB, IPK Gatersleben, Cornell University and AgBioData.

A milestone in our networking activities has been the inclusion of CropXR in the Elixir Europe network. This means that DataXR can now liaise with all European initiatives on life sciences

infrastructures. This enables direct discussions on (much needed) standards, for instance, on phenotyping. In the coming years, DataXR aims to further develop such (international) standards, which aligns with the FAIR (re-)use of data. Collaboration with external stakeholders will, therefore, be further expanded in the future.

4. Communication

CropXR brings together bright minds who are affiliated to different organizations. The academic backgrounds of the CropXR personnel varies greatly. Communication is, therefore, a crucial element to align all partners and facilitate optimal collaboration.

This first year, CropXR had to create its so-called 'communication building blocks' from scratch. First, basic tools were realized to ignite our communication. Subsequently, throughout the year, CropXR has tried to step up the amount and professional look-and-feel of its communication activities. This is still work-in-progress as we constantly strive to enhance the effectiveness of our communication. Today, we have created the following communication outputs and activities:

Website launch The CropXR website summarizes the mission, strategies and activities of CropXR. In addition, it informs external audiences on members of the team and latest developments within the consortium. By portraying members of the community, we aim to familiarize both the community and external audiences with our people and work. The website was recently transferred to a server of Utrecht University. The aim is to revamp the website in the coming year.

CropXR LinkedIn page This page connects the consortium with professionals and professional communities engaging on this social media platform. Over the course of just one year, the LinkedIn page has attracted a significant number of followers. Today, 2.467 people are listed as CropXR followers. Publishing posts on this platform has intensified over the course of the year. Starting with a couple of posts per month, the activity has increased, cumulating in approximately 2 posts per week. The total number of posts over the course of one year: approximately 70 (re)posts. In the first half year, approximately 8.000 people per month engaged with our feed. The past half year, this number has tripled, peeking to almost 25.000 people engaging with the CropXR posts in the month of June. There is still tremendous growth potential for CropXR on this platform which we aim to realize in the upcoming year.

Corporate branding Essential corporate branding content was created such as the CropXR logo, email signatures and icons. Furthermore, various PowerPoint templates were realized and physical communication materials such as banners.

Partner updates & CropXR official newsletter The first approximately six months, partners were regularly informed on news and activities by so-called 'partner updates' by mail. In the

spring of 2024, we started using a professional newsletter CRM. With the assistance of graphic designers, we created a newsletter template to optimize the workflow and distribution possibilities of this vital communication tool. This has resulted in the distribution of four newsletters – sent in the spring and summer of 2025. The newsletter has approximately 300 people who belong to the CropXR team or are closely affiliated to it. The aim is to further develop the newsletter and enable external audiences to subscribe to it as well in the following year.

Visibility The following (media) organizations paid attention to CropXR:

(Media)organization	**Content**
National Growth Fund	Video pitch about CropXR by Managing Director Hedwich Teunissen
Wageningen University & Research (WUR)	'Increasing soil salinity: new discovery may help make crops more resilient' – website article
Dutch Seeds – Innovation with a global reach (brochure created by the Ministry of Agriculture, Nature and Food Quality)	Mission and goals of CropXR – print article
Keygene	'Smart breeding for resilient agriculture: interviewing CropXR director Hedwich Teunissen' – website article
Prophyta – The Annual (magazine published for the ISF Seed World Congress)	'A new institute in the Netherlands: CropXR' – print article
EPSO Spring 2024 Newsletter	'New long term research consortium in the Netherlands CropXR' – print article
National Growth Fund	Video about CropXR
Seed World	'Twenty most influential women in the EU Seed Sector in 2023' – website & print article
Potato World Magazine	'CropXR – Using data science in search of stronger potato plants' – website article
Akkerbouw	'Veredelaars geholpen met versnelde technieken' – print article
EPSO Autumn 2023 Newsletter	'CropXR – making crops more resilient, sutainable & climate-adaptive' – print article
Nieuwsuur	Wetenschappers ontwikkelen gewassen die beter tegen droogte en hitte kunnen – Scientific Director Guido Van den Ackerveken – broadcasting item Dutch national television
National Growth Fund	CropXR - weerbare gewassen voor duurzame landbouw – video with Scientific Director Guido Van den Ackerveken
NWO Teknowlogy festival	Guiding transition - live podcast during meeting with Scientific Director Guido Van den Ackerveken

Communication strategy The CropXR communication strategy document serves as a guideline to determine priorities and activities in the realm of communication. In the summer of 2025, a draft of this document was created. It will be further developed and implemented.

Internal communication Strategically, the focus of CropXR in this initial phase is on establishing and enhancing the effectiveness of its internal communication. CropXR unites a variety of employees who work on different locations, and who often have to divide their time between different research projects. Employees need to feel connected to the mission and strategies of CropXR. Moreover, they should feel part of a community and sense the (virtual) proximity of colleagues to learn from each other and work jointly on creating breakthrough innovations. We introduced the application Slack to facilitate and stimulate internal communication. Furthermore, we focus on organizing (internal) events and in-person meetings to enable the team to strengthen relationships and exchange information. We celebrate successes and give employees the opportunity to contribute to CropXR in various ways. Moreover, we encourage ownership by giving community members an active role with responsibility. The expectation is that in the years to come, the CropXR team will obtain (more) results. Consequently, the importance of communicating about these results to an external audience will increase. Hence, the external communication activities of CropXR will then move more from inwards to outwards.

Events & presentations

The CropXR community has been very active attending conferences and other events. In the appendix, you can find a list of these events, the date, and the person present. Here we spotlight a few outreach activities which are listed in the appendix:

- Professor Dick de Ridder held a presentation on practical pangenomics at the International ITU Molecular Biology and Genetics Student Congress 2023, Istanbul, Turkey, 21st of October 2023.
- Professor Kirsten ten Tusscher held a pitch on CropXR at the event NWO Life in Egmond aan Zee, 22-23 May 2024.
- Professor Koen Beumer, together with Paola Velasco-Herrejón, Martin Calisto Friant, and Thomas Bauwens, held the presentation ‘Pluriversal technologies. Conceptualizing just transitions for encounters between modernist and indigenous worldviews’ at the International Sustainability Transitions (IST) conference, University of Oslo, Oslo, Norway. 16-19 June 2024.

Press release

CropXR disseminated a press release when the Netherlands Organization for Scientific Research (NWO) contributed 15 million euros to the CropXR research program. NWO's grant marked the start of the institute. In collaboration with communication professionals of all the partners involved, this press release was distributed among a long list of press contacts.

5. Organization

Both the PlantXR agreement, signed by 19 partners, and the CropXR overarching 'institute' agreement, signed by the 5 founders, describe the governance, the different bodies with their roles and responsibilities. Recent negotiations and discussions in the process towards a new CropXR agreement have resulted in proposals to adapt the governance. As this new CropXR agreement is not yet adopted, the governance that is currently in place is described below.

Founders Assembly: This is the highest body within CropXR and has the task of supervising the policy of CropXR. It consists of one representative of each of the founding parties (UU, UvA, WUR, TUD and Plantum) at least at the level of the (vice) Dean of a faculty for academic parties and a decision authorized representative for industrial parties. The main responsibilities of the Founders Assembly are taking decisions on:

- Financial arrangements that fall outside the original budget of CropXR and that have consequences for parties;
- Appointment of a new party within the CropXR agreement;
- A change of a (legal) structure and liability of CropXR directly involving a party. The Founders Assembly gave its approval to draft a new CropXR consortium agreement to settle CropXR wide arrangements on, among others, foreground, IP and access rights.

Supervisory Board: The Supervisory Board has the task of supervising the policy of the Board of Directors and the general course of affairs of CropXR and provides solicited and unsolicited advice to the Board of Directors in all fields related to CropXR. The appointed Supervisory Board members are:

- Prof. Dr Martin Kropff (chair) – former Managing Director, Resilient Agri-Food Systems, CGIAR.
- Prof. Dr Dirk Inzé - Full Professor at Ghent University and Scientific Director of the VIB, Department of Plant Systems Biology (Ghent, Belgium).
- Prof. Dr Ir. Geert-Jan Houben, Full Professor Web Information Systems / Pro Vice Rector Magnificus AI, Data & Digitalisation, TU Delft.
- Dr An Michiels - Consultant and Advisor for AgTech / Independent director at AgKnowledge Partnering
- Dr Nelleke Kreike - Lector Green Biotechnology, InHolland University of Applied

Sciences.
- Dr Karin Metzlaff - Executive Director European Plant Science Organization (EPSO)

In the reporting period, one official meeting of the Supervisory Board - together with the Board of Directors - has taken place. In addition, regular online meetings have taken (and take) place between the SB chair and the CropXR Managing Director. The Supervisory Board was consulted and approved the drafting of the new CropXR consortium agreement.

Stakeholder Advisory Board: consists of representatives of broad societal interests such as experts in the field of climate adaptation, water, nature, the environment, farmers/growers (sector organizations for arable and horticulture), retail companies, consumers, top sectors, NGOs in the field of international development, et cetera. The members of the Stakeholder Advisory Board are:

- Andre Hoogendijk (Director of BO Akkerbouw)
- Maaike Raaijmakers (Bionext)
- Mirka Macel (Lector Sustainable solution for plant resilience at Aeres University of Applied Sciences)
- Sheila Ochugboju (Executive Director Alliance for Science)
- Jim Woodhill (Head Foresight4Food and Director AgriFoodNexus Consulting)
- Eefje Cuppen (Director of Rathenau Institute)

Scientific Advisory Board: consists of renowned international experts in the scientific fields relevant for CropXR. The members of the Scientific Advisory Board are:

- Klaas Vandepoele (Full Professor at Ghent University and group leader in the VIB-UGent Center for Plant Systems Biology)
- Diana Horvath (President at 2Blades)
- Julia Bailey-Serres (Professor of Genetics / Director of the Center for Plant Cell Biology at University of California Riverside)
- Edward Buckler (Research Geneticist / Quantitative and statistical plant genetics at Cornell University & USDA)

Board of Directors: is in charge of the day-to-day management of CropXR. The Board of Directors monitors and safeguards that the obligations of CropXR resulting from the applicable grant rules and the legal framework are met on a consistent basis. The Board of Directors consists of a Managing Director, Scientific Director, Technology Director and an Education Director. The first three mentioned Directors are responsible for the day-tot-day management of the consortium.

Program Committee: All consortium parties are directly or indirectly represented in the Program Committee. This body takes decisions on the content of the program. More specific on research plans and budgets as well as modifications thereof; publications; nomination of entry and withdrawal of (new) parties to the consortium.

Scientific Committee: consists of all work package leads and are together with the respective Director responsible for the execution of the research activities.

Recruitment: overview positions

Program / WP	PhD	Postdoc	Other
PlantXR WP-C1	3	2	0
PlantXR WP-C2	3	1	1
PlantXR WP-C3	0	0	0
PlantXR WP-C4	1	0	1
PlantXR WP-C5	1	1	1
PlantXR WP-C6	2	0	0
PlantXR WP-C7	4	0	0
PlantXR-S1	8	1	2
PlantXR WP-T	0	0	0
AgroXR	1	1	0
DataXR (incl WP-D)	0	0	1
EduXR	0	0	8
Management /Office	0	0	7

Overview of people involved

In addition to the people recruited for the positions in the programs and work packages, many more people are involved in CropXR. In total, approximately 225 persons play an active role. This can be a PI, actively executing research activities and supervising PhD candidates, or people who participate in SAME groups or the EduXR learning community. Approximately 115 people from the academic parties including the Universities of Applied Sciences and approximately 110 persons from one of the industrial parties are in a way actively involved in CropXR. These numbers strikingly reflect the collaboration of public and private partners in this public-private partnership.

6. Monitoring & evaluation

6.1 Milestones and KPIs & deliverables

Milestones on Program level:

Program	Milestone	Date	Result/status
CROP-XR (Overarching organization)	Kick-off virtual institute, governance and organization developed and operative (based on description NGF proposal)	Q1, 2023	Milestone achieved

Plant-XR	Proof of Concept (Arabidopsis) plant model in demonstrator (WP-C1)	Q1, 2025	Initial model has been developed. Experimental setup is ready for large scale measurements
Plant-XR	Smart data sets generated to detect complex resilience traits (WP-C2-WP-C6)	Q4, 2025	Pilot projects ongoing
Plant-XR	Acquiring insights into of systemic obstacles and societal needs and worries (WP-7)	Q4, 2027	First data has been collected from interviews and literature
Plant-XR	Knowledge and insights into resilience mechanisms for translation to crops (WP-C2 t/m WP-C6 en WP-T)	Q4, 2027	Not yet started
Data-XR	Data management plan & inventorize needs for data infrastructure.	Q2, 2023	Milestone achieved
Data-XR	First draft analysis platform (PXR WP-D)	Q1, 2025	On schedule
Agro-XR	Insights into scenarios to reach resilient production systems	Q4, 2024	Report written on this topic: 'Exploring WUR intercropping research landscape – Experts' outlook on breeding directions for intercropping systems', and successful workshop organized on this topic
Agro-XR	Develop methods to detect traits of crops for breeding	Q4,2025	Just started for potato, not yet for other crops
Agro-XR	Develop methods to measure stress resilience and resilience in crops at NPEC	Q2, 2024	Pilots on potato for microbiome effects are on schedule. Others experiments to be started in 2025.
Edu-XR	Applied research by higher education and academic institutions – start 1st phase	Q1, 2024	Milestone achieved
Edu-XR	Inventary of existing education + development of plan	Q4, 2024	On schedule

CropXR specific KPIs

KPI	*Streefwaarde 2032*	*Status 2023-2024*
Wetenschappelijke publicaties in 'peer-reviewed' tijdschriften	*~160*	*1*
Invention disclosures	*5-20*	*0*
Patentaanvragen	*2-5*	*0*
Start-ups (spinoff op basis van uitkomsten van CROP-XR)	*1-4*	*0*
Promoties (een hoog % van de promovendi zal direct werk vinden bij betrokken bedrijven)	*40-50*	*0*
Nieuwe AI/modelleringsmethoden (aantal software modules & manuals)	*5-10*	*0*

Aantal individuele gebruikers van de modellen/applicaties (downloads, geregistreerd gebruikers op Data-XR platform)	*100-200*	*0*
Minoren programma (nieuwe/aangepaste cursussen)	*2-8*	*0*
Aantal studenten dat heeft deelgenomen in nieuwe minoren/cursussen (~15/per minor)	*30-120*	*0*
Nieuwe toepassingsprojecten	*6-12*	*0*
Internationale samenwerkingsprojecten waarbij consortium samenwerkt met 1 of meer internationale partijen.	*2-6*	*0*
Aantal nieuwe deelnemende bedrijven en organisaties (o.a. nieuwe deelnemers Plant-XR satelliet, data support bedrijven, Transfer-XR projecten)	*10-15*	*0*
Aantal weerbaarheidseigenschappen in gewassen op basis van Plant-XR methodiek in veredelingsprogramma's van deelnemende bedrijven	*3-10*	*0*

NGF overarching KPIs

KPI's	**Benodigde data**	**Moment van verzamelen**	
i. Input			**2023-2024**
i.1: Identificatie partners	Deelnemende partners per project (incl. KvK-nummer)	Start, monitoring, einde van fase	Beschreven bij start en onveranderd
i.2: Financiële inbreng	Financiële inbreng per partner, voor gehele project, in EUR	Start, monitoring, einde van fase	Beschreven bij start en onveranderd
i.3: Aantal partners per type	Label per partner (privaat/publiek én grootbedrijf/mkb/ kennisinstelling/Rijksoverheid/regio/gemeente/EU/ANBI/ anders)	Start, monitoring, einde van fase	Beschreven bij start en onveranderd
ii. (tussen)Resultaat	Het is mogelijk dat output in de vorm van een product of artikel niet volledig aan één project is toe te schrijven. Voor alle outputindicatoren geldt dat het project in elk geval aanzienlijk moet hebben bijgedragen aan de vermelde output om hier te worden opgenomen.		
ii.1: Tussenresultaat	Op basis van planning, mijlpalen en output zijn er vier keuzes: • De tussentijdse resultaten zijn boven verwachting • De tussentijdse resultaten zijn gelijk aan de verwachting • De tussentijdse resultaten zijn onder verwachting • Er zijn (nog) geen tussenresultaten	Monitoring	Resultaten volgens verwachting, d.w.z. net gestart en dus minimaal.
ii.2: Hoeveel maanden verschil met de planning	Getal uitgedrukt in maanden	Monitoring	Startdatum was 1 juli 2023 ipv eerder

			verwachte 1 januari 2023. Dus jaar 1 is van 1 juli 2023 tot 1 juli 2024.
ii.3: Projectsucces	Drie keuzes: • Het project is afgerond conform de oorspronkelijk scope. Alle mijlpalen zijn behaald. • Het project is naar tevredenheid afgerond, maar de inhoud van de mijlpalen is gewijzigd. • Het project is niet afgerond en definitief afgesloten.	Einde van fase	n.v.t.
ii.4: Aantal publicaties (indien van toepassing)	a. Aantal gerealiseerde peer-reviewed publicaties en hun doi's b. Het aantal publicaties dat is ingediend bij wetenschappelijk journal, maar nog in het peer-review proces zitten. c. Het aantal gepubliceerde artikelen in een niet-peer-reviewed journal. Denk aan artikelen in een vakblad.	Monitoring, einde van fase	A = 1 B = 0 C = 1
ii.5: Aantal patenten (indien van toepassing)	Aantal patenten aangevraagd en hun doi's	Monitoring, einde van fase	0
ii.6: Aantal verleende licenties (indien van toepassing)	Het aantal verleende licenties die op basis van onderzoek uit het project zijn verleend.	Monitoring, einde van fase	0
ii.7: Aantal ontwikkelde prototypes (indien van toepassing)	Aantal ontwikkelde prototypes die op basis van onderzoek uit het project zijn ontwikkeld + korte toelichting per prototype. (TRL 6-7)	Monitoring, einde van fase	0
ii.8: Aantal ontwikkelde demonstrators (indien van toepassing)	Aantal ontwikkelde demonstrators die op basis van onderzoek uit het project zijn ontwikkeld + korte toelichting per demonstrator (TRL 8-9)	Monitoring, einde van fase	0
ii.9: Aantal spin-offs / spin-outs (indien van toepassing)	Aantal spin-offs / spin-outs (gebruikmakend van de technologie ontwikkeld binnen project) en hun doi's (KvK of Orbis nummer)	Monitoring, einde van fase	0
ii.10: Aantal opgeleide mensen (indien van toepassing)	Gesegmenteerd naar aantal MBO, HBO, WO, PhD, PD-Eng, Werkenden.	Monitoring, einde van fase	0
ii.11: Aantal nieuwe of verbeterde producten/ processen/diensten geïntroduceerd (indien van toepassing)	Het aantal producten dat verbeterd of nieuw ontwikkeld is en het aantal processen en diensten die verbeterd of nieuw is op basis van onderzoek ut het project. Geef zo nodig een toelichting bij de indicator iii.3	Einde van fase	0

iii. Impact			
iii.1: Geschat BBP-effect	Geschatte omvang in euro's	Start, Einde van fase	Niet geschat bij start
iii.2: Het verhaal van het project	Kwalitatieve omschrijving van hoe het project bijdraagt/heeft bijgedragen aan het langdurig verdienvermogen van Nederland en de missies/brede maatschappelijke welvaart Maak hierbij de link concreet naar het gerapporteerde op indicatoren in ii. (tussen) Resultaat.	Einde van fase	n.v.t.

Appendix

Connections for possible future collaborations with external stakeholders

Organisation	Information
Embassy Council for innovation in Brazil on behalf of the Ministry of Economic Affairs, part of the innovation attaché network – contact person: Robert Thijssen	The council stimulates bilateral collaboration in the field of science, technology, innovation between the Netherlands and Brazil. CropXR has explored possible collaboration and market opportunities for Dutch companies and knowledge organizations regarding 'climate resilient agriculture'.
SatSure, a global space data application company involved in solving sustainability & financial inclusion challenges, contact: Melissa Spitteler and Prateep Basu	This company is active in the field of satellite images and algorithms that can provide information on soil and crops.
KD-BIO	Large-scale research infrastructure facility for data science & AI for (green) life sciences.
Biotech Booster	National program to support commercialization of biotechnology findings in The Netherlands.
NXTGEN Hightech	NXTGEN Hightech will invest until 2030 roughly €1 billion euros and will give the Dutch economy a boost.
Japan-Netherlands Dialogue on Agricultural Cooperation - Resilient Crops – through the	Potential cooperation with NARO and MAFF

Japanese agriculture attaché, contact persons: Denise Lutz, Yuko Saito, Marien Valstar	
The World Vegetable Center : Marco Wolpereis and Roland Schaftleitner	Promotes healthier lives and more resilient livelihoods through greater food diversity. Interesting for the CropXR Flagship Program, connected to CropXR via consortium of Taiwanese research organizations on the development -omic tools for Brassica vegetables including the cauliflower.
Academia Sinica-Taiwan, contact person: Hi Yao-Cheng	Taiwan's national academic institution
Seed Central van UC Davis, contact person: Jack de Wit	A public-private partnership energizing the seed and agbiotech industry cluster surrounding UC Davis
GreenRobust initiative	German cluster of Excellence initiative around plant robustness
European Integrated System AEGIS	A (virtual) European Genebank Integrated System, legal mechanism for establishing AEGIS is the Memorandum of Understanding (MoU)
Future Food Utrecht	Future Food offers a platform for scientists and external stakeholders on which they contribute to the transition of the food chain for a sustainable world.
Sugar Rush Film, contact person: Hidde Boersma	Production company that addresses topical issues in the realm of sustainability and food.
VIB, Center for Plant Systems Biology	Concerning BREEDIT technology (Hilde Nelissen), also via their spin-off Rainbow Crops
Kas voor de Toekomst on the Westlands Flora Campus	Fieldlab initiative

Plense Technologies	Develops innovative ultrasound sensors to monitor and phenotype plants.
Unlock, contact persons: Sven Warris, Peter Schaap, Jasper Koehorst	Develops metadata workflow via Fair Data Station
Horizon Europe Mission Calls 2024	
UN-NSF - Innovation engines	Public-private partnerships focusing on ecosystems improvement. Field of plant sciene and advanced agriculture.
EPSO working group Photosynthesis, Abiotic Stress, Input Use Efficiency	Previously known as Future Proofed Crops. GvdA as member
Plant & Animal Genome conference (PAG)	Initiative from CropXR to organize workshop on "Scientific machine learning for systems biology" starting January 2025 and to be continued annualy
BioNext	Presentation of CropXR
NPEC	Coaching and advice meeting with NWO (GvdA)
Sounding board group TKI, Biotechnology and Breeding (ST2)	Annual meeting (GvdA)
Alliance for Science, Sheila Ochugboju	Connection to AfS and welcome Sheila in Stakeholder Advisory Board
F&A Next	Presentation in 2024 meeting
Crop-IB	Presentation in 2024 meeting
International Seed Federation	Presidential dinner during meeting in Rotterdam
Dutch Science Agenda (NWA)	Panel discussion on connecting HBO
NWO Teknowlogy meeting	Contribution to podcast
CBBC, Bert Weckhuijsen	Update on leading a large PPS

CropXR

Events & presentations 2023-2024

Event	Activity	Title	Name
CUPGRA meeting 2023 Cambridge, 12-13 December 2023	Visitor		Liaison Officer Potato Bernhard de Geus
NWO Life, Egmond aan Zee, 22-23 May 2024	Presentation	CropXR pitch	Kirsten ten Tusscher
EPS Annual Meeting, Egmond aan Zee, April 2024 EPS Get2Gether, Soest, May 2024 BioSB, Egmond aan Zee, June 2024	Poster	How do we model gene regulatory networks when there are too many genes?	Ben Noordijk
Int. Symp. Recent Developments in Applied Bioinformatics using AI, Faisalabad, Pakistan, June 6 2024	Online presentation	Plant pangenomics and machine learning	Dick de Ridder
EPS Theme 4 meeting, Wageningen, October 23 2023	Presentation	Practical pangenomics	Dick de Ridder
Int. ITU Molecular Biology and Genetics Student Congress 2023, Istanbul, Turkey, October 21 2023	Presentation	Practical pangenomics	Dick de Ridder
Pint of Science Festival, 13-15 May 2024	Lecture for a general public	AI in plant Science	Prof. Aalt-Jan van Dijk
MSc track Green Life Sciences, UvA	MSc literature thesis (education)	Evaluating the current capabilities for mathematical modelling of the *A. thaliana* glucosinolate biosynthetic pathway	Boris Schotman (student), Dr Petra Bleeker, Dr Huub Hoefsloot
UvA MSc track Bioinformatics and Systems Biology.	MSc research project (education)	Enkyme: kcat and Km prediction in seed plants with XGBoost	Marlene van Laar (student), Dr Huub Hoefsloot
International Symposium on Recent Developments in Applied Bioinformatics using AI, Faisalabad, Pakistan (online), 5 June 2024	Presentation	AI in plant science	Aalt-Jan van Dijk
NL-AIC, 24 April 2024	Presentation	Smart Breeding: Crop-XR	Aalt-Jan van Dijk

Breeding for resilient cropping systems. Opportunities and challenges. Wageningen, the Netherlands, 8 February 2024	Workshop organizer, session organizer	Organized full workshop, plus session entitled 'understanding resilience'	Aisha So, Koen Beumer, and many others from CropXR Agro
4th Politics of Machines Conference. KäteHamburger Kolleg: Cultures of Research, RWTH Aachen University, Aachen, Germany, 22-27 April 2024	Presentation	Reframing (the ethics of) deception: ChatGPT and Sex Robots through Derrida and Lacan	Víctor Betriu and Maaike van der Horst
Environmental Philosophy Summer School. University of Pardubice, Hejnice, Czech Republic, 8 June 2024	Visitor	-	Víctor Betriu
8th Derrida Today Conference. National and Kapodistrian University of Athens, Athens, Greece. 10-14 June 2024	Presentation	ChatGPT through Derrida: Teletechnological writing and logocentrism	Víctor Betriu
ESDiT & 4TU Ethics Conference Rethinking Ethics – Reimagining Technology. University of Twente, Enschede, The Netherlands, 2-4 October 2024	Presentation	Do artefacts have promises? Do promises have artefacts? On why AI ethics should pay attention to the question of the performative	Víctor Betriu
Annual meeting Experimental Plant Sciences (EPS), Egmond aan Zee, the Netherlands. 8-9 April 2024	Presentation	Democratizing the Delphi method. Ranking the societal implications of crop gene editing for smallholder farmers	Koen Beumer
International Sustainability Transitions (IST) conference, University of Oslo, Oslo, Norway. 16-19 June 2024	Presentation	Pluriversal technologies. Conceptualizing just transitions for encounters between modernist and indigenous worldviews.	Koen Beumer (with Paola Velasco-Herrejón, Martin Calisto Friant, Thomas Bauwens)
4S/EASST conference, Vrije Universiteit Amsterdam, Amsterdam, the Netherlands. 15-19 July 2024	Presentation	Democratizing the Delphi method. Ranking the societal implications of crop gene editing for smallholder farmers	Koen Beumer (with Sarah Linnartz, Aalok Khandekar)
4S/EASST Conference Vrije Universiteit Amsterdam, Amsterdam, the Netherlands. 15-19 July 2024	Presentation paper	Creating societal impact through impact practices in large-scale transdisciplinary research projects	Tessel Wijne, Ellen Moors, Wouter Boon, Jarno Hoekman
European Forum for Studies of Policies for Research and Innovation (Eu-SPRI) conference, University of Twente, Enschede, the Netherlands. 5-7 June 2024	Panel discussion	Better world through interdisciplinary research? Unpacking benefits, challenges, and the role of science policy to reduce barriers	Ellen Moors
Annual meeting Experimental Plant Sciences (EPS), Egmond aan Zee, the Netherlands. 8-9 April 2024	Poster	What is resilience? Societal aspects of plant breeding innovation	Aisha So
Annual meeting Experimental Plant Sciences (EPS), Egmond	Presentation	The societal roles and responsibilities of plant	Aisha So

aan Zee, the Netherlands. 8-9 April 2024		scientists, in the context of genome-edited crops	
4S/EASST conference, Vrije Universiteit Amsterdam, Amsterdam, the Netherlands. 16-19 July 2024	Presentation	The roles and responsibilities of plant scientists in the governance of genome-edited crops: the role of scientists and STS in controversy	Aisha So
Transformative research for sustainability challenges workshop, University of Twente, Enschede, the Netherlands, 22 April – 3 May 2024	Visitor	-	Aisha So
WTMC summer school on epistemic inequities, Soetenbeeck, Netherlands. 8-12 July 2024	Visitor	-	Aisha So
International Sustainability Transitions (IST) conference, University of Oslo, Oslo, Norway. 16-19 June 2024	Presentation	Using system thinking tools for sustainable food transformations in the Global South	Eva M. Valencia Leñero, Katharina Schiller, Lennart Woltering
International Sustainability Transitions (IST) conference, University of Oslo, Oslo, Norway. 16-19 June 2024	Presentation	Supporting micro-level sustainability transitions: the role of living labs for Mexico City's water management systems	Eva M. Valencia Leñero, Ina Daniela Maza
European Forum for Studies of Policies for Research and Innovation (Eu-SPRI) conference, University of Twente, Enschede, the Netherlands. 5-7 June 2024	Presentation	Putting governance into practice in Mexico City: Living Labs opportunities and challenges to develop innovations for sustainability	Eva M. Valencia Leñero, Ina Daniela Maza
4S/EASST conference, Vrije Universiteit Amsterdam, Amsterdam, the Netherlands, 16-19 July 2024	Prose presentation	Hero, who cared about the forest and wanted to transform it	Aisha So
University of California, Davis, 22 May 2024 - Innovating and scaling for social transformation in international food systems course	Education - Workshop at course	Applying social theory to agricultural innovation system frameworks	Aisha So
CropIB meeting, Ghent, March 23, 2024	Presentation	Building a mission-driven public-private partnership	Guido Van den Ackerveken
F&A Next meeting, Wageningen, May 25, 2024	Presentation	CropXR: resilient crops for sustainable agriculture	Guido Van den Ackerveken
Meet the professor	Teaching - primary school in Meern	Utrecht University	Guido Van den Ackerveken
TAIEX Mission Japan November 2023	Presentation at MAFF and NARO institute	CropXR – resilient crops through data-driven design	Hedwich Teunissen
4th Japan-Netherlands Dialoque on Agricultural Coorperation – 2nd Sub-committee meeting on resilient crops- May 2024	Presentation	Dutch CropXR research program for resilient crops through data-driven design	Hedwich Teunissen

Science meets business meeting Leiden – November 2023	Presentation	CropXR – resilient crops through data-driven design	Hedwich Teunissen
CIOPORA-AGM meeting Marrakech April 18, 2024	Presentation	CropXR – resilient crops through data-driven design	Hedwich Teunissen
Guest lecture for Nelleke Kreike 10 year Green Biotechnology – InHolland – April 24, 2024	Presentation	CropXR – resilient crops through data-driven design	Hedwich Teunissen
AI in de plantenwetenschappen, Wageningen	Talk / outreach activity	BBLTHK	Dick de Ridder
AI and machine learning in plant bioinformatics, Udine, Italy	Education – online lecture	PhD Winter School “Systems Biology and Artificial Intelligence in Agriculture”	Dick de Ridder