CropXR

3rd Annual Progress Report

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July 2025 - June 2026

Central office:
H.R. Kruytgebouw (Utrecht Science Park)
Padualaan 8, room 0108
3584 CH Utrecht
The Netherlands

Postal address & delivery
Winthontlaan 30C
3526 KV Utrecht
The Netherlands

WWW: www.cropxr.org

LinkedIn: linkedin.com/company/cropxr

Contact us at info@cropxr.org

Executive summary

CropXR is a Dutch public-private partnership dedicated to making agricultural crops more resilient to climate change and better suited to sustainable farming practices. Its goal is to support breeders in developing crop varieties that can better cope with challenges such as elevated temperatures, drought, disease, and limited nutrient availability. To achieve this, CropXR combines large-scale plant experiments with data science and computer modelling. Insights gained from the model plant Arabidopsis are then used to guide research in crops.

This third annual progress report covers July 2025 to June 2026, a year in which CropXR increasingly shifted from generating individual results to connecting experiments, data, and models.

People and partnerships

By the end of the reporting period, almost 60 FTEs of CropXR researchers and support staff, together with the brain power of more than 150 academics, contributed to the CropXR programme. Researchers from different disciplines achieved synergy by working more closely together, while industrial partners provided crop expertise, plant materials, and feedback to keep the research aligned with breeding needs. The consortium also strengthened links with national and European organisations and networks, drawing on existing expertise and standards to align the development of CropXR's data infrastructure with the wider research ecosystem.

Activities and achievements

- Conducted major experiments to investigate how Arabidopsis responds to drought, elevated temperature, immune signals and combinations of these conditions. Researchers also developed methods to measure plant traits and computational models to better understand the biological processes involved.
- Studied how potato varieties respond to drought and limited nitrogen levels, revealing striking differences between varieties. A strong effect of soil microorganisms on potato growth was discovered that also depended on the potato variety.
- Investigated how onion responds to drought and developed new methods to measure growth, photosynthesis and bulb development. These measurements helped reveal differences among eight varieties selected with breeding-company partners.
- Carried out experiments to study how drought and elevated temperature affect seedling establishment in tomato, lettuce, potato and cauliflower. Researchers established experimental protocols for these crops and made progress towards translating findings from Arabidopsis to crops.
- Started field experiments with cauliflower grown in strips alongside other crops and with mixtures of winter-wheat varieties to investigate traits that are needed for breeding for resilient cultivation systems.
- Four seed companies, a technology partner and an academic partner joined forces to develop knowledge and tools to help accelerate breeding for resilient tropical cauliflower varieties in the CropXR Flagship programme.

- Combined data from more than 3,000 published root and soil microbiome samples from different studies, showing how integrating diverse biological data can reveal recurring patterns across studies and experimental conditions.
- Further developed CropXR's data infrastructure for storing, describing and sharing research data. The team also developed a beta version of MetaBuddy, an AI-supported assistant for metadata documentation, to explore how AI could help researchers create structured metadata while retaining control over the output.
- Explored the ethical, legal and societal aspects of smart-data breeding through discussions with plant scientists, breeding companies, and other stakeholders.
- Delivered the first interdisciplinary minor, *Resilient Crops: Interdisciplinary Approaches*, at Wageningen University & Research.

Looking ahead

In its fourth year, CropXR will focus on the mid-term evaluation and preparations for phase 2 (2028-2033). Furthermore, the consortium expects to finalise a new legal framework for both PlantXR and CropXR and formalise the updated governance arrangements. Strengthening industrial commitment and developing mechanisms to accelerate progress towards CropXR's mission will receive particular attention during this period. CropXR will also identify potential national and international collaborations that could further strengthen the consortium.

CropXR's research will build on previous accomplishments and milestones by:

- Expanding the implementation of the data-driven design concept within the consortium and among its stakeholders.
- Continuing large-scale experiments, improving methods for measuring plant traits, and further integrating experimental data with computational models to better understand and predict plant responses to stress.
- Identifying and testing promising genes and biological mechanisms involved in plant resilience.
- Exploring how findings and approaches developed in Arabidopsis can be applied in crops, including potato, tomato, lettuce, carrot, cauliflower, onion and chrysanthemum.
- Further investigating potato performance under drought and limited nitrogen, as well as drought responses and bulb development in onion.
- Continuing field research on resilient cultivation systems, including cauliflower strip intercropping and winter-wheat variety mixtures, and working towards developing breeding populations for tropical cauliflower.
- Further developing CropXR's data infrastructure. The team will continue to improve and test MetaBuddy to support research data management.
- Continuing research and dialogue on the responsible development of smart-data breeding. Researchers will develop and deliver a training course on responsible innovation in plant breeding for PhD candidates and postdoctoral researchers.
- Making CropXR education more accessible by sharing open educational modules from the interdisciplinary minor through the first version of the CropXR Education Hub. The programme will also pilot a lifelong learning activity with CropXR's industry partners.

Preface

From laboratories and greenhouses to field trials and computational models, CropXR's ambitious vision is increasingly taking shape through the efforts of our growing community.

In our third year, our researchers have generated valuable data on plant responses to drought, elevated temperature, nutrient limitations and disease. Experimental research is getting well connected with computational approaches and modelling. We have also made important progress on the Resilience Hub, our shared infrastructure for research data, computing power and running research models.

These developments bring us closer to our ambition: using data-driven design to accelerate the breeding of more resilient crops. Scientific and technical challenges remain, but our foundations are growing stronger, creating opportunities to translate discoveries into practical applications.

But CropXR is about more than scientific and technological progress. It is also about bringing people together. Across disciplines and organisations, all CropXR participants are sharing expertise, and exploring new approaches. Through education and knowledge exchange, we keep extending these connections beyond our research community.

We sincerely thank everyone contributing their expertise and dedication to CropXR, as well as our funders for their continued support and trust.

Looking ahead, we are excited to build on this momentum and take further steps towards our shared goal: resilient crops that contribute to sustainable food production in a changing world.

Utrecht, The Netherlands, October 2026

The CropXR Board of Directors:

Auke Damstra, Technology Director
Hedwich Teunissen, Managing Director
Guido Van den Ackerveken, Scientific Director.

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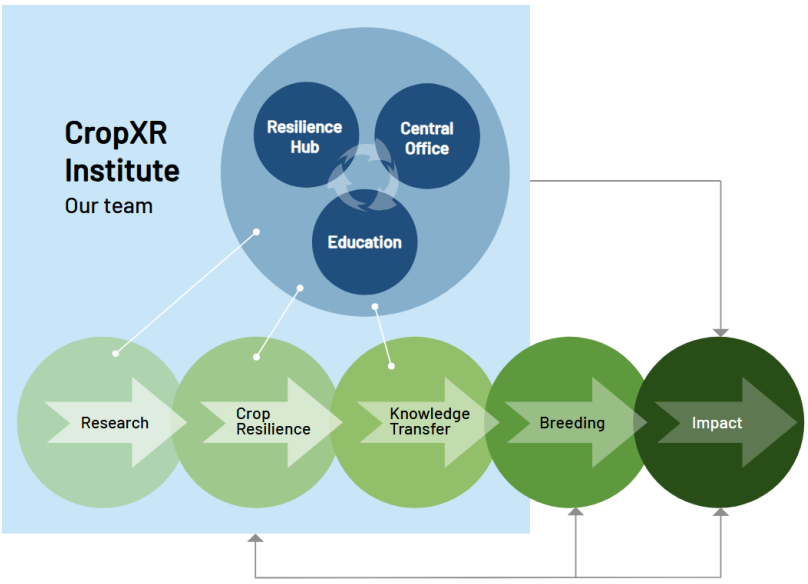
1. Who we are: our community and mission

In a world marked by climate change, population growth, and growing demand for sustainable agriculture, the need for eXtra Resilient ('XR') crops is greater than ever. The CropXR consortium envisions a future in which breeders can more efficiently develop resilient crop varieties that cope better with multiple environmental stresses, such as drought and elevated temperatures, while reducing reliance on agricultural practices that harm the environment.

CropXR is a public-private partnership that brings together universities and leading plant breeding, processing and technology companies. It aims to develop a methodology for breeding extra-resilient crops by identifying the mechanisms and combinations of traits that underpin plant resilience, and by translating insights from model plants to agricultural crops. To achieve this, CropXR combines large-scale plant experiments with data science and state-of-the-art predictive modelling. This integrated approach seeks to improve our understanding of how plants respond to challenges like elevated temperatures, drought, disease, and limited nutrient availability. This knowledge is intended to drive the development and demonstration of a smart-data breeding approach, also referred to within CropXR as "data-driven design". Such novel breeding approaches are needed to address the complexity of crop resilience and help breeders develop extra-resilient crop varieties more quickly and predictably.

The CropXR project was launched in 2023 with generous co-funding from the Dutch Research Council (Nederlandse Organisatie voor Wetenschappelijk Onderzoek, NWO), the National Growth Fund (Nationaal Groeifonds, NGF) and the US-based Foundation for Food & Agriculture Research (FFAR). This funding enables the consortium to carry out its 10-year programme until at least 2033, after which CropXR plans to continue its work with additional partners and funders.



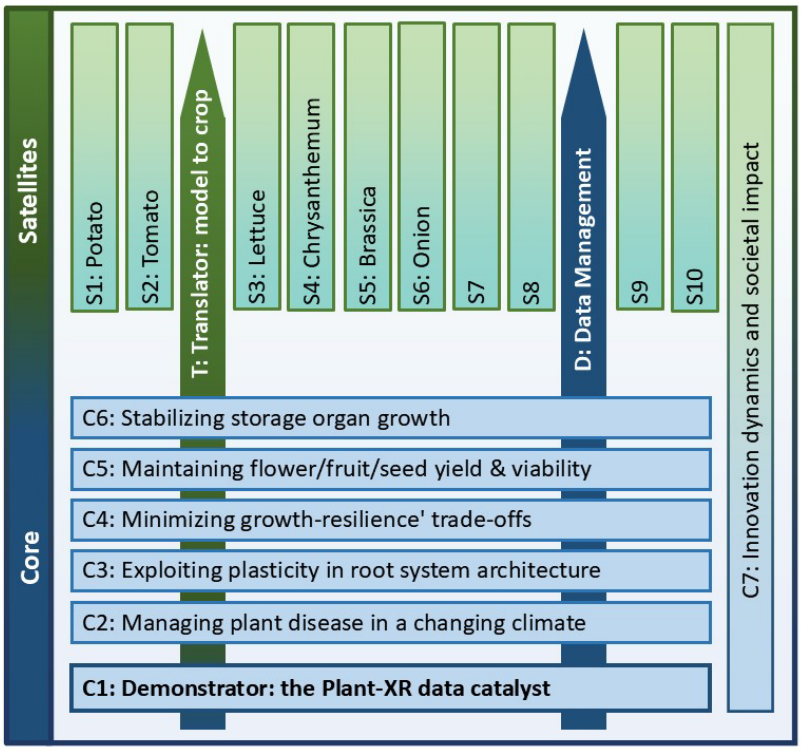
Collaboration across disciplines, institutions and sectors is central to the CropXR mission: to have resilient crops developed through data-driven design by 2033. CropXR is coordinated from our office at Utrecht University in Utrecht, the Netherlands, and brings together scientific contributions from consortium partners based in several Dutch cities, including Utrecht, Wageningen, Delft, and Amsterdam.

During this reporting period, Erasmus University Rotterdam joined CropXR as an Academic Contributing Party, further strengthening the consortium's expertise in societal impact and innovation research. More information on CropXR's founders, partners, and funders is provided in Annex A.

CropXR activities range from experimental research and the development of computational tools and methodologies to education, knowledge transfer, and societal outreach. As an Open Science endeavour, CropXR aims to share its research findings through scientific publications and make its data, knowledge, and smart-data breeding tools available through the Resilience Hub, the data infrastructure being developed within CropXR. At the same time, it works to translate this knowledge and these tools into practical applications in plant breeding.

In phase 1 (2023–2028), CropXR consists of four programme lines: PlantXR, AgroXR, DataXR, and EduXR. Together, they connect research on plant resilience with cropping systems, modelling, shared data infrastructure, and education.

PlantXR is structured into work packages, nine of which (C1–C7, T and D) belong to a 'core' that is primarily driven by public and academic partners and the Industrial Executing Parties (IEPs) Genetwister and KeyGene. Others are set up as 'satellites', meant to apply knowledge and methods from the core programme to specific crop species, with industrial parties playing a greater role in shaping the research based on their needs to apply knowledge and predictive models in future breeding approaches.



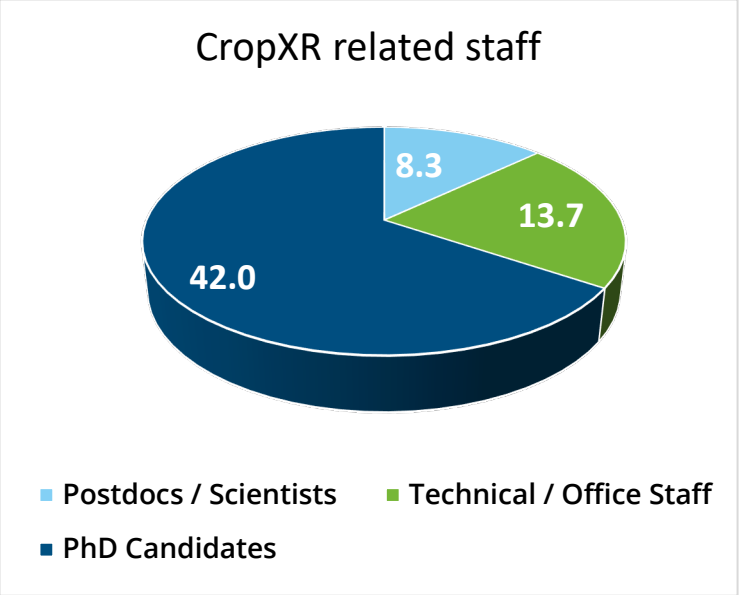
Structure of the PlantXR's research programme.

Alongside PlantXR, AgroXR studies the breeding of crop varieties suitable for resilient cropping systems, including strip intercropping and variety mixtures. The main focus of DataXR is the

development of the Resilience Hub to support data-management, -governance, -sharing, and -use across CropXR. Meanwhile, EduXR focuses on human resource-related challenges and educating a new generation of breeding experts able to bridge the biological and computational spheres.

CropXR also connects these programme lines through crop-specific research initiatives. Established at the beginning of phase 1, CropXR Potato combines research in the core work packages C6 and T, satellite work package S1, and parts of AgroXR. This initiative brings together academic partners, universities of applied sciences, and potato breeding and processing companies to study potato resilience. Another example is the Flagship project on tropical cauliflower, which was launched during this reporting period following an interactive building phase with multiple CropXR partners. It consists of subprojects within AgroXR and DataXR that focus on advancing breeding approaches to enhance resilience of cauliflower. Further crop-specific initiatives are planned for phase 2 (2028–2033).

To reach its mission on time and to guide its activities, CropXR has defined four success strategies: Data-driven design, Resilience Hub, Coalition and Accelerator. Quarterly priorities, referred to as 'Rocks', translate these strategies into concrete actions to accelerate the progress towards our mission. The Cauliflower Flagship was initially launched as an Accelerator Rock, focusing on the improvement of resilience of tropical cauliflower. It has since developed into a satellite project that is envisioned to continue in phase 2 (2028–2033).



CropXR's activities are carried out by a community of researchers, technical staff and support professionals across the consortium. At the end of the reporting period, almost 60 Full-Time Equivalents (FTEs; see Table 1 below) were appointed and contributed to the progress in research and to CropXR's mission. They included PhD candidates, postdoctoral researchers, technicians, and one senior scientist, as well as central office support staff. This group forms the basis of the wider CropXR community, which connects a group of more than 150 scientists (project supervisors and co-supervisors), numerous industry representatives, plant breeders, growers, students, educators, and external stakeholders serving on CropXR's supervisory and advisory boards.

Table 1: CropXR-supported FTE positions at participating universities at the end of the reporting period (30 June 2026).

Work package	Postdocs /scientists	PhD candidates	Technical /office staff	Total
D/DataXR	1,0	2,0	2,5	5,5
C1	2,6	5,0	0,3	7,9
C2	-	4,9	0,4	5,3
C3	0,8	3,8	-	4,6
C4	-	4,0	1,0	5,0
C5	1,0	4,0	0,4	5,4
C6	-	4,0	-	4,0
C7	-	3,0	-	3,0
T	1,0	3,0	2,4	6,4
S1	0,4	5,0	-	5,4
AgroXR	0,9	2,6	-	3,5
EduXR	0,5	0,5	0,8	1,8
Office	-	-	5,9	5,9
Total	**8,3**	**42,0**	**13,7**	**64,0**

The next section of this report describes how these programme lines and success strategies have translated into activities and results during CropXR's third reporting period (1 July 2025 to 30 June 2026). The report highlights key developments across the work packages and projects. For further information, readers are encouraged to visit the CropXR website at www.cropxr.org.

2. Activities and achievements

In its third year, CropXR enabled a productive and collaborative research programme, strengthened its data-management and -infrastructure, and consolidated its governance. Growing connections and synergy across the consortium led to new collaborations and laid the groundwork for the further development of data-driven design approaches in the coming years.

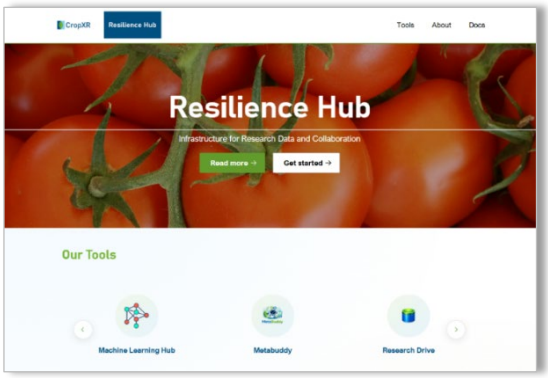
2.1 Major activities and outputs

CropXR made substantial progress across its work packages and projects in the past year. The overall focus steadily shifted from developing individual experiments, datasets and models to exploring how these components fit together. The connections built across the consortium are not only opening up new research questions and opportunities but are also providing a stronger basis for integrated analysis, validation and translation in the coming years.

Work package D and DataXR: Data-management and -infrastructure

During the reporting period, work package D advanced research on AI-supported metadata extraction and biological data integration. Researchers developed a multi-agent system prototype to extract ISA-compliant metadata from electronic laboratory notebooks and explored combining 'data conversations' with large language model (LLM)-based extraction. This work highlighted the importance of human involvement in ensuring metadata quality and contributed to the development of MetaBuddy, an AI-supported assistant for metadata documentation.

Another research line within work package D focused on integrating biological datasets and improving computational analyses. Using standardised processing and batch-correction methods, researchers integrated more than 3,000 published root and soil microbiome samples from 52 plant host genotypes. The analysis revealed a conserved drought-associated shift in plant microbiomes, providing insights into plant–microbiome responses to water limitation and a basis for further computational research. Importantly, this approach can be more broadly used in CropXR to make better use of publicly available data and knowledge.



Resilience Hub screen image

DataXR, meanwhile, further developed the Resilience Hub, CropXR's shared infrastructure for data storage, metadata management, secure data sharing, and reuse. The Hub Horizon project interviewed CropXR scientists and collected 315 user stories that describe the user needs and guide the further development of the Resilience Hub. Work progressed on expanding its compute infrastructure and developing model run-environments. Research Drive became available for file-based storage, and a beta FAIRDOM-SEEK data catalogue was released. In the past year, 17 datasets were deposited in the Hub.

To complement the work on metadata management, DataXR organised its first Data Harvest Day, providing over 20 PhD candidates, postdoctoral researchers, and technicians with hands-on support in metadata documentation. Progress was also made on metadata management and data-access procedures. The Standards and Metadata Expertise (SAME) groups contributed to the development of metadata models and guidelines to support consistent practices for phenotyping, sequencing, and modelling across CropXR. The approval of the Resilience Hub Access and Deposit Manual marked a further step in establishing clear procedures for secure data deposition and access.

In parallel, DataXR produced a beta version of MetaBuddy to help researchers generate structured metadata from natural-language descriptions and documents while retaining control over the results. The tool has attracted interest from CropXR's industrial partners, as well as from Dutch university medical centres and other research organisations in Europe. A pilot in the medical field is planned for the next reporting period to explore the potential of MetaBuddy beyond plant research.

Work package C1: Demonstrator – the CropXR Data Catalyst

In the Demonstrator work package (WP-C1), researchers combined phenotyping, transcriptomics, mechanistic modelling, and machine learning to investigate drought and elevated temperature responses in Arabidopsis. A major milestone was the completion of a large-scale RNA-sequencing experiment with soil-grown Col-0 plants exposed to drought and elevated temperature. The experiment involved researchers from different work packages and was an important joint effort within CropXR. The team also screened the genetically diverse Arabidopsis EcoCore panel under combined elevated temperature and osmotic stress. Additionally, researchers advanced automated phenotyping of leaf, hypocotyl, and root traits and made progress in selecting previously generated mutant lines for subsequent phenotypic validation.

Researchers further developed mechanistic models of seedling growth, hybrid modelling approaches, and machine-learning methods using newly generated WP-C1 data and previously published datasets. This included progress on a mechanistic model of root and hypocotyl

elongation and machine-learning-based identification and evaluation of gene modules. The resulting data are being used to prioritise accessions and design subsequent experiments.

At the same time, comparisons between soil- and agar-based experiments showed that the experimental system can substantially influence observed resilience responses. Soil-grown plants displayed greater hypocotyl elongation and increased root growth under drought and elevated temperature, responses that were not observed in agar-based experiments. The integration of machine learning and mechanistic modelling contributed to the peer-reviewed article *BADDADAN: Mechanistic modelling of time-series gene module expression*. The EcoCore panel was described in the preprint *EcoCore: An ecologically diverse panel of Arabidopsis thaliana accessions for studying plant-environment interactions*.

Work package C2: Managing plant disease in a changing climate

In work package C2, researchers used multi-omics experiments and modelling to investigate how elevated temperature affects plant immunity and defence metabolism. Coordinated hormone, immune-elicitor and temperature experiments generated RNA-sequencing, glucosinolate, immune-response and pathogen-bioassay datasets. A key achievement was a joint multi-omics experiment that generated RNA-sequencing and glucosinolate data from the same plants, creating an opportunity to connect gene regulation and metabolism through integrated modelling. Researchers also established liquid chromatography-mass spectrometry (LC-MS) methods for targeted glucosinolate analysis.

The experiments revealed that prolonged exposure to 28°C abolished the nlp24-induced reactive oxygen species (ROS) response, even though pathogen perception remained functional. Moreover, elevated temperature altered hormone-dependent defence responses and glucosinolate profiles. These findings provided new directions for investigating temperature-sensitive immune signalling and defence metabolism.

On the modelling side, researchers developed condition-specific gene-expression prediction models, a method for inferring transcription-factor–gene relationships, and a dynamic model connecting gene expression, enzymes, and glucosinolate production. Bayesian approaches and additional biological information were introduced to improve the metabolic models. The peer-reviewed article *Can deep learning predict inducibility of stress-responsive gene expression from DNA sequence in Arabidopsis thaliana?* examined the potential and limitations of predicting stress-responsive gene expression from DNA sequence alone.

Work package C3: Optimising root architecture for stress resilience

In work package C3, researchers combined high-throughput phenotyping, molecular studies and computational modelling to investigate how root architecture and plasticity contribute to drought resilience in Arabidopsis. A major milestone was the completion of a large-scale rhizotron experiment involving approximately 175 Arabidopsis accessions under well-watered and mild drought conditions. The experiment generated extensive root and shoot phenotyping data for genome-wide association studies (GWAS). The team also implemented automated shoot-image analysis and made progress on machine-learning methods for extracting root traits.

Molecular and cellular studies examined root development and shoot-to-root signalling under osmotic stress. A key finding was that shoot-derived signals play a major role in inhibiting primary-root growth under osmotic stress, demonstrating the importance of shoot-to-root communication in root developmental responses. Researchers also investigated the ARF7–LBD16 auxin signalling module and its role in lateral root development under osmotic stress.

In parallel, researchers extended a mechanistic root model to include auxin transport through plasmodesmata and developed a functional-structural plant model connecting root development, sugar signalling and carbon allocation with root-system architecture.

Work package C4: Mechanisms of growth-resilience trade-offs

In work package C4, researchers employed proteomics, genetic, physiological and computational approaches to investigate the molecular mechanisms underlying trade-offs between plant growth and resilience. They established a proteomics framework to study growth-regulatory protein complexes and generated transgenic materials for proximity-labelling experiments. Initial assays demonstrated the feasibility of the proximity-labelling approach, and further optimisation is ongoing.

Physiological experiments showed that osmotic stress suppresses growth responses triggered by environmental signals such as elevated temperature and far-red light. High-throughput phenotyping, transcriptomics and mutant screening also generated data on growth inhibition and recovery under stress. These studies identified potential roles for NPR1 and oxidative-stress regulation in growth recovery, while other experiments showed that chloroplast-to-nucleus signalling influences early seedling development under osmotic and salt stress.

Furthermore, researchers advanced computational analyses of growth–stress interactions. Pathway-level analyses identified the BAP-D regulatory module and nitrogen- and sulphate-signalling pathways as important contributors to growth suppression and recovery under salicylic acid-induced stress.

Work package C5: Maintaining flower/fruit/seed yield and viability

In work package C5, researchers investigated how drought and elevated temperature affect flowering, pollen viability, seed development and reproductive yield across the life cycle of Arabidopsis. Experiments conducted at different developmental stages generated extensive phenotyping and gene-expression data. A notable finding was that continuous moderate drought delayed flowering rather than triggering the expected drought-escape response. The experiments also revealed substantial variation in flowering time among individual plants.

Researchers found that high temperature reduced pollen viability and seed set. Moderate drought alone did not affect pollen viability, but its combination with heat produced an integrated response. Timed heat treatments helped identify the stage of flower development at which pollen viability was most strongly affected. Further experiments showed that mild heat during reproduction reduced seed dormancy, whereas mild heat during vegetative growth increased it. Researchers also observed that seed responses to drought varied depending on treatment duration and temperature conditions.

To investigate genetic factors underlying flowering responses to elevated temperature, researchers conducted GWAS and identified associated genomic loci, candidate hub genes and Arabidopsis accessions with contrasting flowering-time responses. In addition, researchers developed an interpretable machine-learning methodology using existing photosynthesis data, which is now being adapted to the reproductive-trait data generated in work package C5.

Work package C6: Optimising yield in drought-stressed storage organ crops

As part of work package C6, researchers investigated how drought and limited nitrogen availability affect potato growth, tuber development and yield. To this end, researchers conducted greenhouse and tunnel experiments to generate extensive phenotypic and physiological data. The tunnel experiments provided conditions close to those in the field while allowing researchers to apply controlled drought stress. Under mild drought, potato plants initially showed reduced transpiration but later adjusted

their growth and water use. More severe drought further reduced transpiration and decreased photosynthetic activity. Researchers observed cultivar-dependent differences in recovery and in the prioritisation of shoot or tuber growth. The greenhouse experiments also revealed differences between potato cultivars in nitrogen remobilisation, nitrogen distribution and carbon partitioning under limited nitrogen availability. They found that plants tended to prioritise tuber development under these conditions.

For onion, researchers investigated drought responses in eight cultivars selected in collaboration with CropXR industrial partners. They established and refined methods for measuring bulb development, leaf area, photosynthetic responses and bulb morphology. The experiments revealed differences between cultivars in growth, bulb development, yield and photosynthetic responses to drought.

Alongside this work, WP-C6 contributed to the development of *Stomatalia*, a deep-learning-based platform for quantitative analysis of stomata and pavement cells.

Work package C7: Innovation dynamics and societal impact

During the reporting period, work package C7 advanced research into the ethical, legal and societal dimensions of smart-data breeding through philosophical and policy analysis, interviews with plant scientists and representatives of breeding companies, and field research in Zimbabwe and Tanzania. The work addressed societal responsiveness, access- and benefit-sharing, regulation of digital sequence information, interpretations of resilience and interdisciplinary collaboration. Research examined how different regulations seek to ensure fair exchanges of genetic resources and how plant scientists' interpretations of resilience influence their research approaches. The work on access- and benefit-sharing was published in the peer-reviewed article *Friends with benefits: What constitutes a 'benefit' in Access and Benefit Sharing (ABS) for plant genetic resources?*.

The CropXR network facilitated contacts with companies for research on the use of digital genetic information and provided opportunities to share findings through lectures and workshops across CropXR. Furthermore, WP-C7's collaboration with EduXR resulted in the first delivery of the minor *Resilient Crops: Interdisciplinary Approaches* at Wageningen University & Research.

Work package T: Translator - from model to crop

In work package T, researchers advanced the translation from Arabidopsis to crops. Working closely with the Demonstrator work package, they aligned experimental protocols, sampling points and phenotypic traits and developed stress-treatment protocols for tomato, lettuce, cauliflower, and potato. These activities generated crop-specific phenotyping data and plant material for RNA-sequencing time series.

The experiments revealed both shared and crop-specific responses to drought and elevated temperature. Lettuce and potato showed weaker or negligible hypocotyl elongation in response to elevated temperature compared with other species studied, and light quality emerged as an important factor influencing stress responses. Comparative-genomics research showed that precise orthology assignments improve the detection of conserved gene-expression patterns, even between more distantly related plant species.

Researchers made progress in establishing plant stress-response networks and began developing methods for translating heat-stress regulatory modules between species. In this context, Genetwister developed literature-derived relationships for its knowledge-graph work. This work informed improvements to the knowledge-graph ontology, allowing it to better accommodate different types of biological information.

Work package S1: Potato

In work package S1, researchers investigated potato performance under field conditions in close collaboration with work package C6, AgroXR, and other researchers involved in CropXR Potato. Two large field trials generated extensive growth, tuber-yield and remote-sensing datasets, which were deposited in the Resilience Hub. The trials revealed cultivar-dependent responses to nitrogen availability. However, the plants experienced limited drought stress under field conditions, so controlled tunnel experiments within work package C6 complemented this work.

Researchers established and validated traits derived from unmanned aerial vehicle (UAV) imaging and developed a Bayesian System Identification of Nonlinear Dynamics (SINDy) framework for modelling potato growth, which is now being tested. Microbiome experiments showed that the effects of inoculation on potato growth varied depending on the soil

microbiome and potato genotype. As part of this research, the team developed an inoculation method for high-throughput evaluation of potato–microbiome interactions.

Cauliflower Flagship: Accelerating the development of resilient tropical cauliflower

The establishment of the Cauliflower Flagship marked an important milestone for CropXR, representing a concrete step towards practical crop breeding applications. This forward genetics project brings together four seed companies, Genetwister and researchers from Wageningen University & Research to develop approaches to improve breeding of more resilient tropical cauliflower. During the reporting period, the partners prepared the project plan, financial arrangements and material transfer agreements, and identified key traits, including maturity, heat tolerance, and curd quality.

The partners selected cauliflower plant material for genetic analysis by Genetwister. Work included DNA isolation and the preparation of sequencing libraries for 139 samples, alongside genetic analyses and simulations to inform the selection of founder lines and the design of new breeding populations. The simulations explored nested association mapping (NAM) and multi-parent advanced generation inter-cross (MAGIC) approaches.

Complementing these activities, the Flagship drew on Genetwister's work to develop a knowledge graph containing gene and protein information and functional annotations across 25 plant species (including cauliflower). Genetwister refined the data-processing workflows, incorporated additional biological information and developed a prototype interface for exploring the graph. Discussions with DataXR also explored how to make the knowledge graph available through the Resilience Hub.

AgroXR: Studying resilience in crop cultivation systems

During the reporting period, AgroXR advanced research into how crop breeding and management practices can contribute to more resilient agricultural production. AgroXR's potato research was closely integrated with work packages C6 and S1. Together, the teams used field experiments, plant phenotyping and crop modelling to investigate how potato cultivars respond to different levels of nitrogen and water availability.

Research on diversified cropping systems focused on two approaches: strip intercropping and genotype mixtures. For cauliflower, researchers established a field experiment at Wageningen involving six genotypes grown alongside grass-clover or triticale, as well as in monoculture. The experiment investigates how differences in light and temperature between cropping systems influence cauliflower development, yield and curd quality. A separate field experiment was established to examine cauliflower responses to elevated temperature.

For winter wheat, researchers initiated a multi-year field experiment across several locations in the Netherlands, comparing 12 genotypes grown individually and in two- or three-genotype mixtures. The research examines whether information on how genotypes perform across different environments can be used to design mixtures with more stable yields. Both projects were in their early experimental stages, with data collection under way.

EduXR and the CropXR Learning Community

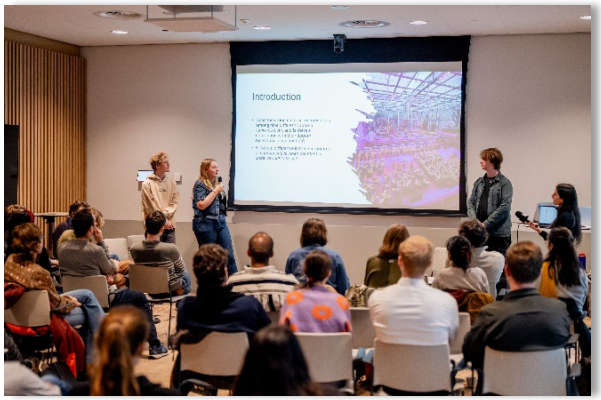
During the reporting period, EduXR continued to foster collaboration between universities, universities of applied sciences and industrial partners through educational activities, the previously established CropXR crop teams and practice-oriented research.

A major milestone was the first delivery of the CropXR minor *Resilient Crops: Interdisciplinary Approaches* at Wageningen University & Research. The minor combined plant science, data science, and social science, drawing on the expertise of CropXR researchers and industrial partners. Student feedback and testimonials are being used to promote and recruit students for the second edition, which will be delivered in September 2026.

Within the Learning Community, 18 practice-oriented experiments were conducted in collaboration with universities, universities of applied sciences and industrial partners. The CropXR crop teams used their shared crop visions to guide research questions and strengthen continuity across student projects. Four CropXR PhD candidates participated in these teams, helping to connect the educational activities with the research programme of PlantXR.

Learning Community days provided additional opportunities for students, researchers, educators and industrial partners to exchange findings and discuss research needs. EduXR also worked with DataXR to improve the alignment of Learning Community data management with CropXR's shared infrastructure.

Beyond these activities, EduXR explored ways to make CropXR educational content more accessible to students across different institutions. To this end, discussions were initiated with Npuls, another NGF-funded project, on potential collaboration in open education and the sharing of educational modules. At the same time, EduXR investigated opportunities for lifelong learning and professional development within the CropXR ecosystem. An inventory showed that consortium partners already offered a broad range of courses and training opportunities. As a result, EduXR shifted its focus from developing standalone lifelong-learning modules to increasing the visibility of existing educational offerings and helping professionals identify relevant training opportunities.



The CropXR community connecting and interacting during Learning Community events.

2.2 Programme coordination and governance

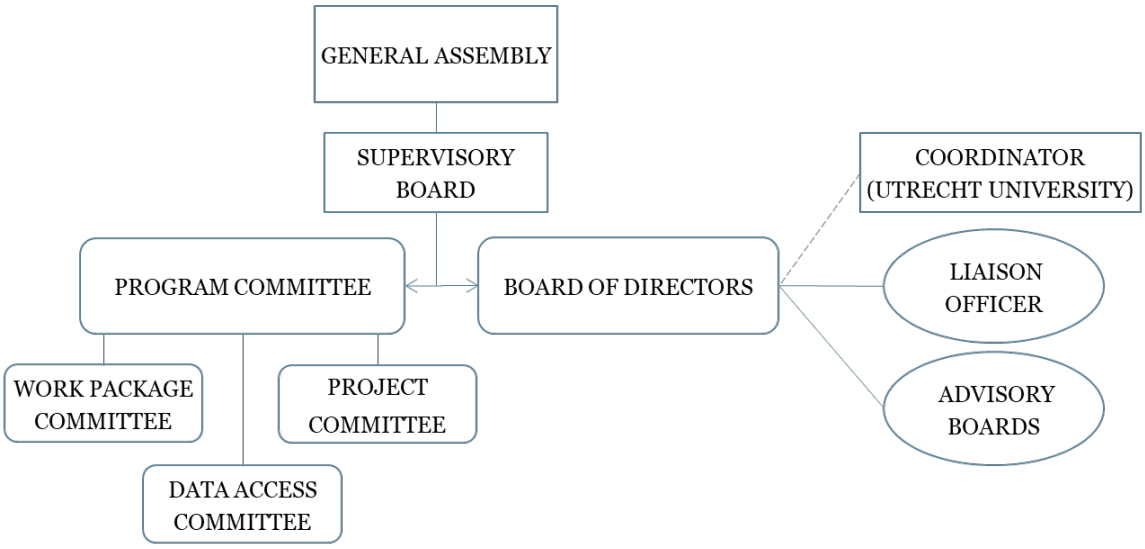
During the reporting period, work continued on the CropXR consortium agreement and the corresponding adjustments to the existing PlantXR consortium agreement. Aligning the agreements on governance, data access, partner roles, and intellectual property (IP) proved complex and time-consuming. Nevertheless, substantial progress was made, and completion is expected in the next reporting period.

One of the major themes of discussion was the overarching governance model, which has now been broadened. The main governance bodies are:

- The General Assembly, responsible for CropXR's highest-level decisions.
- The Supervisory Board, providing independent oversight, supervision, advice, and mediation.
- The Programme Committee, the central decision-making body. The Programme Committee decides on programme plans and (change of) activities and budgets. All consortium partners are directly or indirectly represented, including not only the four founding universities but also the industrial partners.
- The Board of Directors, responsible for the day-to-day organisation and execution of the programme. It interacts closely with the Programme Committee to find broad support for its strategic plans for steering the programme.

Further details on the composition of these governance bodies are provided in Annex A.

This newly shaped organisational structure and the interaction between the Programme Committee (which functions as a parliament) and the Board of Directors (comparable to a cabinet) make this governance well-balanced and effective. In addition, the open culture and collective responsibility for decision-making among consortium partners increase commitment.



CropXR's overarching governance model

Alongside these developments, a research support officer joined CropXR during the reporting period to strengthen the coordination of the scientific programme, support collaboration within the consortium, explore opportunities for external collaboration, and identify and pursue new funding opportunities.

2.3 Collaboration and community building

During the reporting period, collaboration between academic researchers and industrial partners continued to gain momentum. In CropXR Potato, companies participated in experimental planning and discussions of results, while Bejo Zaden and Enza Zaden supported cultivar selection and experimental work in onion. KeyGene contributed to modelling and data architecture, and Genetwister supported automated phenotyping and led the development of knowledge graphs.

Joint experiments, shared pipelines, and aligned protocols brought experimental and computational researchers closer together across CropXR. For instance, computational researchers participated in laboratory work to better understand how data are generated and documented and to help align data collection with modelling needs.

At the consortium level, the CropXR Board of Directors launched an initiative to develop a shared understanding of data-driven design and its practical application. Researchers and industrial partners worked to clarify what this means for their work and identify priorities for connecting experiments, data and models. This ongoing initiative is helping establish a clearer and more consistent approach to data-driven design across CropXR.

These efforts were complemented by activities that supported researchers and facilitated cooperation across the consortium. DataXR's Data Harvest Day offered PhD candidates and postdoctoral researchers hands-on support in metadata documentation and FAIR data management. Young CropXR, the consortium-wide network for early-career researchers, continued to facilitate peer exchange across work packages and disciplines. Work-package meetings, the Digital Connection group, the two Standards and Metadata Expertise (SAME) groups and regular user-group meetings offered further opportunities to share methods, connect datasets, and identify common research questions. Work also began on the rollout of an intranet to provide researchers and partners with easy access to work procedures and other shared resources. The intranet is scheduled to launch by the end of March 2027.

Happy winners during a Young CropXR event

The second edition of the CropXR Conference, held in October 2025 in Soesterberg, the Netherlands, provided another opportunity for researchers and partners to connect and exchange ideas. The programme featured talks, poster presentations, and workshops. Kathy Roberts Munkvold, Scientific Program Director for Next Generation Crops at FFAR, delivered the keynote *Future-Ready Agriculture: Innovating Tools, Traits, and Training for Complex Systems*. Researchers from different disciplines and technology partners presented their work on crop resilience, data-driven breeding, knowledge graphs, and comparative genomics. Participants also learned about the new EduXR minor.

Beyond the scientific content, the conference invited participants to take a closer look at CropXR's identity and shared values. In the workshop *Connecting the Community: CropXR Values*, participants discussed what defines CropXR and how its members work together. CropXR's four values—Pioneer Spirit, Moral Courage, Connect the Coalition, and Passion and Perseverance—reflect a shared commitment to exploring new ideas, working openly, valuing different perspectives and pursuing common goals. This commitment is central to CropXR's ambition to build a lasting network of researchers and organisations whose connections and collaborations continue well beyond 2033.

2.4 Outreach and external engagement

Stakeholder engagement and events

On 11 July 2025, a seminar for all Principal Investigators (PIs) connected to CropXR was organised in Ede to ensure a shared understanding of the programme and to stimulate collaboration and a sense of community.

In April 2026, CropXR organised the event titled *Data-Driven Breeding: From Research to Resilient Crops* in Utrecht, where researchers, students, plant breeders, growers, policymakers and other stakeholders gathered to explore the future of data-driven breeding. The programme addressed challenges in breeding for complex resilience traits and explored how data- and knowledge-driven design, New Genomic Techniques (NGTs) and AI could contribute to the development of climate-resilient crops. Discussions also addressed the evolving EU regulatory framework for NGTs and its implications for plant breeding, as well as data management and cooperation across research and industry.

In June 2026, CropXR welcomed the Advisory Committee of the Dutch National Growth Fund. The visit provided valuable insights into the role CropXR can play in strengthening the Dutch innovation ecosystem and contributing to future food security.

That same month, CropXR hosted a visit for key funders, government representatives, and potato sector partners to the CropXR potato trial fields at AIKC Rusthoeve in Zeeland.

Participation in external conferences and events

The CropXR Board of Directors contributed actively to external events to inform the wider circle of stakeholders about CropXR, its mission, and its progress. Examples include:

- Presentation at the Potato Europe Symposium in Lelystad – 3 September 2025
- Participation in the Innovation Mission to Brasil – September 28 – 3 October 2025
- Visits/presentations at TSIPS Institute & Academia Sinica in Taiwan – 14-15 October 2025
- Presentation at Naktuinbouw 'kennispodium' – 30 October 2025
- Contribution to the 23rd Erasmus Descartes Conference on Food Sovereignty in Rotterdam – 27 November 2025
- Visit by the Dutch Ministry of Agriculture, Fisheries, Food Security and Nature (LVVN) group of agricultural counsellors to Utrecht Future Food – 3 June 2026

Furthermore, CropXR members presented their work at national and international conferences, workshops and other events. An overview is provided in Annex B.

Media and communications

To strengthen communication within CropXR and with external audiences, a communications advisor joined the team during the reporting period. A few highlights were:

Newsletters

Five newsletters were produced and distributed to nearly 400 email addresses, featuring research updates, events, and developments across the consortium.

LinkedIn

CropXR's LinkedIn page was regularly updated and attracted a worldwide following by almost 5,500 people.

Dutch television

One of the media highlights of CropXR's third year was the appearance of its potato research on Dutch national television in an episode of the science programme *Focus*, titled *Super Plant – Is the Secret to Food Security Hidden in the Soil?* The episode explored the role of soil and microbiomes in food security and brought CropXR's research to a wider public audience.

Podcast Eten is Weten (Food for Thought)

Our Managing Director, Hedwich Teunissen, was a guest on the Dutch podcast **Eten is Weten**, to talk about the importance of crop resilience and what makes CropXR unique.

Prophyta - CropXR: Predict resilience through smart data

Predict **resilience** through smart data

Prophyta is a trade journal for breeders and producers of plant material. The spring edition featured a three-page article on CropXR's *Smart Data Breeding Concept*.

2.5 Publications

During the reporting period, four peer-reviewed research articles based partly or entirely on CropXR research were published. Other outputs included a research preprint and contributions to professional journals and online publications.

Peer-reviewed research articles

- Alonso Esteve, J., Aerts, N., van Wees, S. C. M., de Ridder, D., & van Dijk, A. D. J. (2026). Can deep learning predict inducibility of stress-responsive gene expression from DNA sequence in *Arabidopsis thaliana*? *in silico Plants, 8*(1), Article diag012. https://doi.org/10.1093/insilicoplants/diag012
- Beumer, K., & Roskam, A. (2026). Friends with benefits: What constitutes a 'benefit' in access and benefit sharing (ABS) for plant genetic resources? *Agriculture and Human Values, 43*(1), Article 38. https://doi.org/10.1007/s10460-026-10849-x
- Cosma, B.-M., & Abeel, T. (2026). A conserved bacterial signature characterizes plant microbiome responses to drought. *Frontiers in Microbiology, 17*, Article 1768028. https://doi.org/10.3389/fmicb.2026.1768028
- Noordijk, B., Reinders, M., van Dijk, A. D. J., & de Ridder, D. (2025). BADDADAN: Mechanistic modelling of time-series gene module expression. *Quantitative Plant Biology, 6*, Article e31. https://doi.org/10.1017/qpb.2025.10017

Research preprint

- van Eijnatten, A. L., Keijzer, J. J., Trenner, J., Delker, C., Quint, M., van Zanten, M., & Snoek, L. B. (2026). EcoCore: An ecologically diverse panel of *Arabidopsis thaliana* accessions for studying plant–environment interactions [Preprint]. *bioRxiv*. https://doi.org/10.64898/2026.04.17.719158

Professional and online publications

- Berendsen, R. (2025, July 7). Groei van aardappels voorspellen. *Onderzoek*, (18). https://www.nwo.nl/onderzoek-op-ongekende-schaal

- Betriu Yáñez, V. (2026, January 15). Is a Derridean critique of generative AI possible? Writing machines and logocentrism without subject. *The OLR Supplement*. https://olrsupplement.com/2026/01/15/is-a-derridean-critique-of-generative-ai-possiblewriting-machines-and-logocentrism-without-subject/
- Bourke, P. M. (2026). Breeding for diversified cropping systems. *Gewasbescherming, 57*(3), 106–107. https://www.knpv.org/db/upload/documents/Gewasbescherming/2026gb57nr3.pdf

2.6 Monitoring progress and impact

In addition to what is shared here in the narrative report, progress in the CropXR programme is evaluated against the indicators and targets set out in the Milestone and Key Performance Indicator (KPI) tables below. Furthermore, an updated version of the CropXR Theory of Change (ToC) has been finalised together with Berenschot, NGF, and LVVN. These documents provide guidance for steering the programme towards impact. The latest version of the Theory of Change is presented in Annex C.

Overall, progress on the milestones and KPIs is largely in line with the timelines, although parts of the research programme have been delayed due to a longer starting phase combined with experimental challenges arising from the complexity of large-scale experiments. Most outputs from the fundamental research (PlantXR and AgroXR) are expected to be delivered in years 4 and 5 of the programme, in particular publications, inventions, and PhD graduations (doctorates). The strength of the programme lies in the pre-competitive development of knowledge, tools, and methods. IP protection is expected for only a limited number of inventions and ideas.

Some achievements in DataXR and EduXR have been realised earlier and more extensively than originally anticipated. More students have been involved in the minor and applied research projects and, for the Resilience Hub, the number of users and AI/modelling methods deposited is ahead of the anticipated trajectory towards the 2032 targets.

Table 2: Milestones for phases 0 and 1 of CropXR as established with the NGF before the start of the programme and their status as of 30 June 2026

Programme line	Milestone	Target date	Status as of 30 June 2026
CropXR (overarching programme organisation)	Virtual institute launched, with governance and organisation set up and operational	Q1 2023	**Achieved**
PlantXR	Proof of concept (Arabidopsis) plant model in demonstrator (WP-C1)	Q1 2025	**Delayed; partially achieved.** Large experiments have been successfully conducted with a delay of 19-24 months. The collected data are currently being used to generate the proof of concept. Sub-models have been generated.
PlantXR	Smart datasets generated for identifying complex resilience traits (WP-C2–WP-C6)	Q4 2025	**Delayed; partially achieved.** Many large-scale experiments have already been conducted, and others will be executed in 2026-2027 with a delay of 7-12 months. These experiments provide the foundation for identifying complex resilience traits.
PlantXR	Insight generated into systemic barriers and societal needs and concerns (WP-C7)	Q4 2027	**On schedule**
PlantXR	Knowledge and insight into resilience mechanisms for translation into crops (WP-C2 to WP-C6 and WP-T)	Q4 2027	**On schedule.** Translation to crops is in progress. The proof of concept (WP-C1) is required to achieve the translation of models to crops.

Table 2 continues on the next page.

Programme line	Milestone	Target date	Status as of 30 June 2026
DataXR	Data management plan and inventory of needs for data infrastructure	Q2 2023	**Achieved**
DataXR	First version analysis platform (also PlantXR WP-D)	Q1 2025	**Achieved,** with the implementation of an RNA sequencing pipeline and available compute
AgroXR	Insight into scenarios for achieving resilient production systems	Q4 2024	**Achieved**
AgroXR	Methods developed to identify crop traits relevant to cultivation	Q4 2025	**Delayed.** Research on strip cultivation and mix cultivation has started with a delay of 19-24 months.
AgroXR	Methods to measure crop stress tolerance and resilience in the Netherlands Plant Eco-phenotyping Centre (NPEC) facilities	Q2 2024	**Achieved**
EduXR	Applied research at universities of applied sciences (HBO) and universities (WO) started in phase 1	Q1 2024	**Achieved**
EduXR	Inventory of relevant existing education and a plan to strengthen it	Q4 2024	**Achieved**

WP = work package, Q1-4 = quarters 1-4

Table 3: KPIs as agreed with the NGF and their status as of 30 June 2026

KPI	Target value for 2032	Status as of 30 June 2026
Publications in peer-reviewed scientific journals	~160	12: a) 2 in year 1 b) 4 in year 2 c) 6 in year 3
Invention disclosures	5-20	0
Patent applications	2-5	0
Start-ups (spin-offs based on CropXR outcomes)	1-4	0. 2 potential spin-offs are under development: a) MetaBuddy b) Decision-support system for potato farmers
Doctorates (a high percentage of PhD graduates are expected to find a job at participating companies)	40-50	0
New AI/modelling methods (number of software modules and manuals)	5-10	5: a) MetaBuddy b) Metaseed c) AI-based automated phenotyping of roots d) Baddadan: A custom mechanistic modelling tool to simulate time-series gene module expression and help reconstruct gene regulatory networks from experimental data e) Mechanistic model of temperature and drought responses
Number of individual users of the models/applications (downloads, registered users on the DataXR platform)	100-200	40 active users of the Resilience Hub as of 30 June 2026
Minor programme (number of new/adapted courses)	2-8	1 course at WUR

Table 3 continues on the next page.

KPI	Target value for 2032	Status as of 30 June 2026
Number of students who have participated in new minors/courses (~15 per minor)	30-120	132: a) 10 students participated in the minor at WUR b) 116 students have been involved in applied research projects (in 5 project periods, spread over 40 different projects) c) 6 additional students have been involved in the Learning Community events
New application projects	6-12	2: a) Flagship project on tropical cauliflower b) AgroXR project on potato Other new application projects are foreseen in phase 2.
International collaboration projects in which the consortium works with one or more international partners	2-6	2: a) CropXR and the TD is actively involved in the ELIXIR network and collaborating on standards and research data management b) Collaboration project on metadata management with VIB and IPK Gatersleben
Number of new participating companies and organisations (including new PlantXR satellite participants, data support companies, TransferXR projects)	10-15	3: Both Radboud University Nijmegen and Erasmus University Rotterdam joined PlantXR, while a new company (Agrico) joined HIP and, through this, CropXR.
Number of resilience traits in crops, based on the PlantXR methodology, incorporated into the breeding programmes of participating companies	3-10	0

3. Looking ahead: plans for the fourth year

CropXR will harvest the findings, developed tools, and discoveries from what was sown and grown over the three previous years, as well as prepare for the mid-term review and planning of phase 2.

3.1 Plans across the programme lines

DataXR aims for the Resilience Hub to be fully used within CropXR, with at least one dataset from each work package deposited in the Hub and up to 100 researchers actively using it for storage by the end of the fourth reporting period. Planned milestones include an operational data catalogue, knowledge graphs available through the Hub, a first version of a gene-expression browser and at least one operational data-processing pipeline. A first computing pilot will explore a use case such as root-image recognition. Furthermore, the team will organise two Data Harvest Days per year to help researchers document and deposit their data. Work will continue to improve the Resilience Hub, data-sharing guidance, and MetaBuddy. As part of this work, a pilot in the medical field will help refine MetaBuddy and explore its potential beyond plant science.

Working closely with DataXR, **work package D** will evaluate MetaBuddy and explore semi-automated metadata extraction from electronic lab notebooks and transcripts of data conversations. Researchers will benchmark bioinformatics annotation pipelines and evaluate the robustness and generalisability of machine-learning models across plant species, environments, and molecular data types. They will also investigate methods for model interpretation and biological knowledge extraction and assess batch-correction strategies for integrating biological datasets.

In **work package C1**, researchers will identify and validate candidate genes involved in stress resilience through life-cycle experiments that include post-stress recovery. Phenotyping, genome-wide association, and RNA sequencing analyses will help link growth responses with their underlying mechanisms. Modelling will integrate circadian-clock regulation with shoot and root growth and combine mechanistic modelling with machine learning. Model predictions will guide further experiments, while experimental results will in turn help fine-tune the models.

Work package C2 will analyse experiments combining elevated temperature with hormones and molecular patterns to improve gene regulatory networks and mechanistic metabolic models and explore connections between them. Experiments with pathogens and thrips will test selected mutants and investigate the role of specific glucosinolates in pest and pathogen resistance under elevated temperature.

Work package C3 will complete genome-wide association analyses of approximately 175 Arabidopsis accessions to identify genetic factors involved in root architecture and drought responses. Researchers will also conduct follow-up experiments to validate selected phenotypes. Machine-learning pipelines will support root and shoot trait extraction, while models will be extended to incorporate water transport, carbon allocation and signalling.

In **work package C4**, proteomics and proximity-labelling experiments will investigate whether BAP/D module components form protein complexes. RNA sequencing and analysis of an Arabidopsis mutant population will help identify regulators of growth-resilience trade-offs and link genetic variation with growth responses.

In **work package C5**, researchers will identify genes involved in flowering time, pollen vitality, seed dormancy, and germination under heat and drought, and test selected candidate genes. Single-nucleus RNA sequencing and seed RNA tomography will examine gene expression, and the biology-constrained neural-network methodology will be applied to the generated data.

Work package C6 will investigate potato drought recovery and early responses to nitrogen deprivation through tunnel and greenhouse experiments. Onion experiments will examine drought before and after bulb initiation. Transcriptomic, metabolomic, physiological, and plant-trait data will be integrated to better understand these responses.

Work package C7 will deliver training for CropXR PhD candidates and postdoctoral researchers on the ethical, legal and societal dimensions of smart-data breeding. Research and publications will address responsiveness, access and benefit sharing, digital genetic information, resilience, and transdisciplinary collaboration. A postdoctoral researcher will be recruited to study innovation dynamics. Two stakeholder meetings are also planned, alongside outreach activities aimed at wider audiences.

Work package T will complete expression and phenotypic datasets for potato, lettuce, tomato, and cauliflower and establish protocols for carrot, onion, and chrysanthemum. Researchers will develop methods and guidelines for comparing gene expression across species, approaches for translating Arabidopsis models to crops, models of Arabidopsis seedling development and potato growth, and a user-friendly software toolbox.

In **work package S1**, researchers will analyse potato tuber yield, size distribution, and quality and improve crop-growth models through a tunnel experiment with the Fontane variety. Microbiome studies will produce and validate predictive models, investigate genetic factors influencing microbiome-supported potato growth, and extend findings to tetraploid cultivars. Researchers will also apply the Bayesian framework to field data and explore its integration with genomic prediction.

The **Cauliflower Flagship** will select founder lines and determine its breeding-population design using genetic analyses, simulations, and breeder expertise. First crosses are planned at Wageningen University & Research in spring 2027, followed by further crossing and population development by the companies. Researchers will continue developing knowledge graphs and investigate whether information derived from them can improve genomic prediction.

AgroXR will analyse data from the field experiments, present preliminary results, and use the findings to plan experiments for the following growing season. Researchers will complete the quantitative-genetic modelling framework for genotype mixtures and simulate breeding strategies for genotype mixtures.

EduXR will deliver the second edition of the minor *Resilient Crops: Interdisciplinary Approaches* at Wageningen University & Research. Moreover, modules from the minor will be made available as open educational modules through a first version of the CropXR Education Hub, together

with short explanatory videos (knowledge clips) on topics relevant to the CropXR community. A lifelong-learning pilot with industry partners will combine access to these modules with an in-person training day. In parallel, crop teams will review progress towards their crop visions, continue applied research and student projects, and contribute to phase 2 plans for education and applied research.

3.2 Programme-wide priorities

CropXR will prepare for the mid-term review required by NWO and NGF and develop plans for phase 2, including a more detailed research proposal. Industrial partners will play a key role in defining the phase 2 satellite projects within PlantXR. Strengthening their involvement and commitment will remain a priority as CropXR prepares for its next phase. Phase 2 planning will also cover AgroXR, DataXR, EduXR, and TransferXR, a new programme line focused on knowledge valorisation. Preparations will include developing a financial plan for phase 2, exploring additional funding opportunities to strengthen the scientific programme, and securing renewed commitments from consortium partners. As part of this process, CropXR will also review its KPIs and milestones, proposing adjustments where needed.

Alongside these preparations, CropXR expects to finalise its consortium agreement and the corresponding adjustments to the PlantXR consortium agreement in the first months of the next reporting period. These agreements will provide a framework for governance, data access, decision-making, partner roles, and intellectual property. Efforts will also focus on formalising the updated governance arrangements to reflect collaboration between public and private partners across all programme lines, clarifying responsibilities, and making relevant information and procedures easier for CropXR researchers and partners to find and use.

In parallel, workshops, hackathons and company visits will bring experimental researchers, computational researchers, and industrial representatives closer together. These exchanges will help align experiments and data collection more closely with modelling needs and support the application of data-driven design across the programme.

Looking outwards, CropXR will seek to identify potential national and international collaborations that could further strengthen the consortium. It will continue exploring connections with national and European data infrastructures and research initiatives, including ELIXIR and SURF, and other NGF-funded programmes, such as Holomicrobiome. These connections offer opportunities to build on existing expertise, standards and services, avoid reinventing the wheel, and align the continued development of CropXR's data infrastructure with the wider research-data ecosystem.

Ultimately, these efforts will help CropXR build on its scientific progress, strengthen its community, and move closer to its goal of developing more resilient crops through data-driven design.

Annex A: Founders, partners, funders, governance

Founders

Utrecht University

WAGENINGEN UNIVERSITY & RESEARCH

TU Delft

University of Amsterdam

Plantum

Academic Executing Parties

Erasmus University Rotterdam

Radboud Universiteit

Technologie companies

genetwister

KeyGene

Vegetable breeding companies

bejo

ENZA ZADEN

RIJK ZWAAN

EAST-WEST SEED

農友種苗 KNOWN-YOU SEED

Limagrain de la terre à la vie

SAKATA®

TAKII

Ornamental breeding companies

Dekker chrysanten

DELIFLOR Chrysanten

DÜMMEN ORANGE

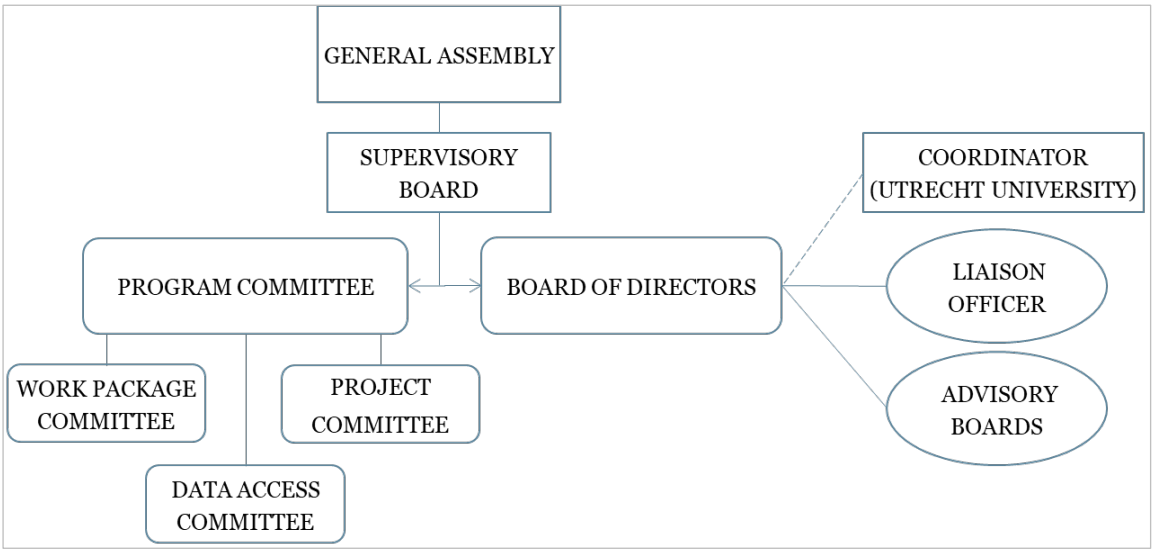
Royal Van Zanten

Potato breeding and processing industry

Education Partners

Funders

Governance



General Assembly

High-level representatives of the academic and industrial partners.

Programme Committee

Members:

Agnieszka Doroszuk-Van der Wurff (Rijk Zwaan)
Jeroen Rouppe van der Voort (Enza Zaden)
Johan Hopman (McCain / HIP Consortium)
Saskia van Wees (Utrecht University)
Laurens Kroon (Bejo Zaden)
Marcel Reinders (TU Delft)
Marcel van Verk (KeyGene)
Aike Post (Ornamentals)
Nikkie van Bers (Genetwister)
Ab Kragtwijk (Universities of Applied Sciences)
Petra Bleeker (University of Amsterdam)
Richard Immink (WUR)

Observers:

Bea Pauw, Dieuwertje van der Does (NWO)
Maita Latijnhouwers (Min. of LVVN)
Kathy Munkvold, Magda Galindo (FFAR)
Henk Huits (liaison officer vegetables)
Bernard de Geus (liaison officer potato)

Supervisory Board

Martin Kropff (*Chair*, formerly CGIAR)
Karin Metzlaff (European Plant Science Organisation)
Geert-Jan Houben (TU Delft)
Dirk Inzé (VIB)
Nelleke Kreike (Hogeschool Inholland)
An Michiels (AgKnowledge Partnering)
Observer: Susanne Sütterlin (LVVN)

Board of Directors

Auke Damstra, Technology Director
Hedwich Teunissen, Managing Director
Guido van den Ackerveken, Scientific Director

Education Director

Christa Testerink, Education Director

Liaison Officers

Bernard de Geus (Potato)
Hedwich Teunissen (Ornamentals)
Henk Huits (Vegetables)

Stakeholder Advisory Board

André Hoogendijk (BO Akkerbouw)
Eefje Cuppen (Rathenau Institute)
Jim Woodhill (Environmental Change Institute, University of Oxford)
Maaike Raaijmakers (Bionext)
Mirka Macel (Aeres Hogeschool)
Monique Lukassen (Plantum)
Sheila Obim (Alliance for Science)

Scientific Advisory Board

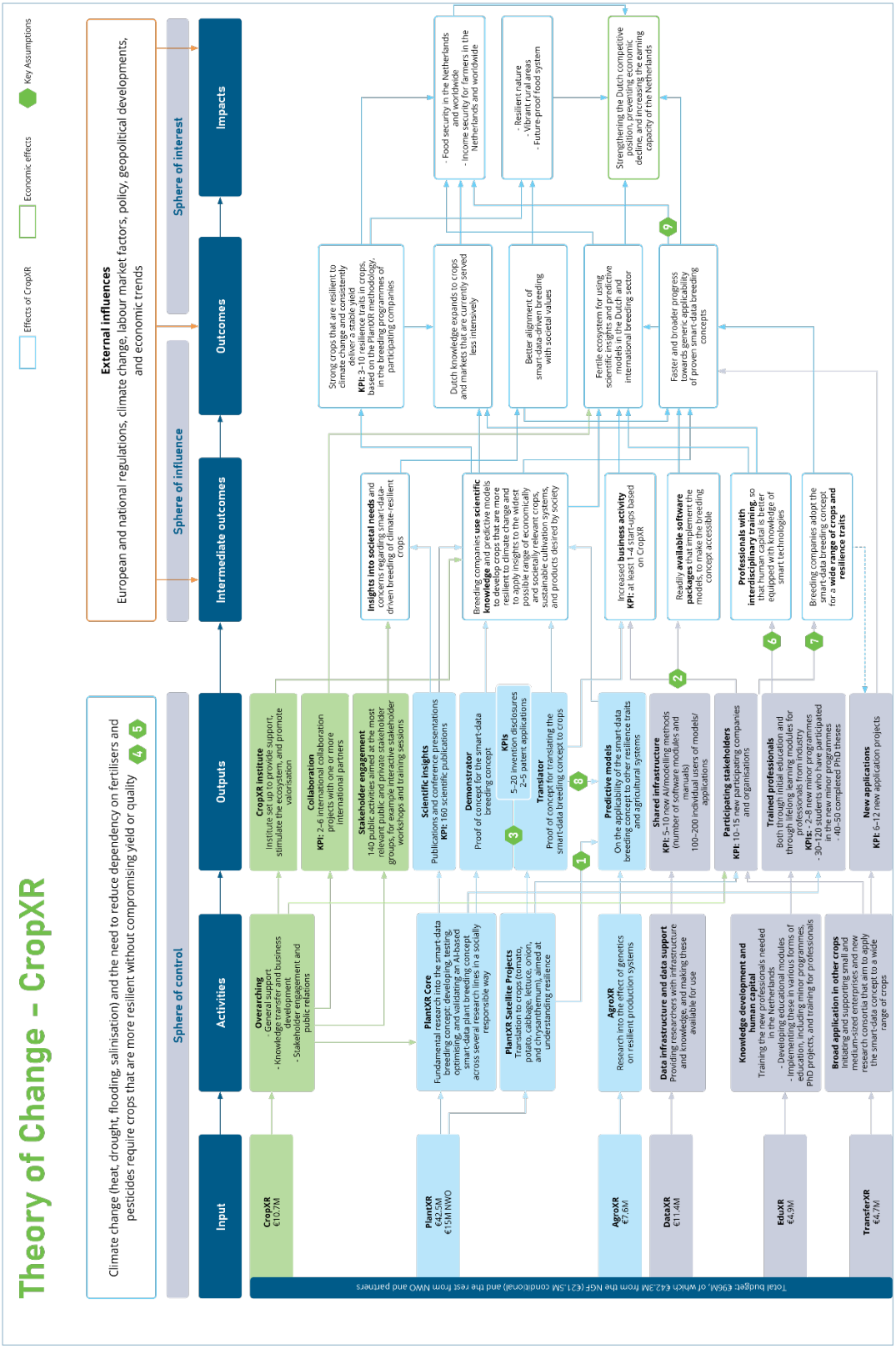
Diana Horvath (2Blades Foundation)
Julia Bailey-Serres (UC Riverside)
Klaas Vandepoele (VIB, Ghent University)
Vacancy (AI-related topics)

Annex B: Participation in external conferences, workshops, and events

During the reporting period, CropXR members participated in or presented their work at national and international conferences, workshops, and other events. An overview of these contributions is provided below.

1. Aalt van Dijk, EMBL Conference on AI in Biology, April 2026, *CropXR develops smart data breeding methodology to manage plant disease in a changing climate* (presentation).
2. Aalt van Dijk, CropIB, Germany, *Machine learning in plant breeding* (lecture).
3. Aisha So-Last, guest lecture for first-year MSc Plant Sciences students, Wageningen, *The politics behind plant breeding* (guest lecture).
4. Aisha So-Last, guest lecture for third-year BSc Biology students, Utrecht, *Responsibility in (biological) science* (guest lecture).
5. Aisha So-Last, Artemis project, Tanzania, two presentations on interdisciplinary research into plant breeding (presentations).
6. Aisha So-Last, WTMC workshop on interdisciplinary collaboration, presentation of the results of the first study (workshop).
7. Aisha So-Last, National Conference of Science & Technology Studies (STSNL), presentation of the results of the second study (conference presentation).
8. Aisha So-Last and Koen Beumer, National Conference of Science & Technology Studies (STSNL), organisation of a track on comparing theoretical frameworks for science-society interactions (conference organisation).
9. Corné Verburg, EUCARPIA Biometrics in Plant Breeding 2026, January 2026, *Bridging Genomic Prediction and Crop Growth Modeling with System Identification for Nonlinear Dynamics (SINDy)* (conference presentation).
10. DataXR team, Plant Open DataHub, Maastricht University, presentation at the strategy meeting on collaboration opportunities in data infrastructures for plant scientists.
11. DataXR team, Data Spaces Symposium 2026, January 2026, Madrid, Spain (participation in networking, visibility, and knowledge exchange).
12. Elena Sánchez-Brunete Guillermo, UK–Netherlands Brokerage Event: Horizon Europe Cluster 6 2026–2027 Work Programme, November 2025, Utrecht, the Netherlands (participation and networking).
13. Elsenoor Wijlhuizen, Green Trade Lab, presentation of research work (presentation).
14. Elsenoor Wijlhuizen, Bio-economy Research Group, University of Cape Town, presentation of the results of the first study (presentation).
15. Elsenoor Wijlhuizen, Earth System Governance Conference, presentation of the results of the first study (conference presentation).
16. Eva Eleonora Ferradosa, NFDI4LS 2026, January 2026, *Metadata Extraction from Electronic Lab Notebooks: Designing and Evaluating a Multi-Agent System for ISA-Compliant Research Data* (presentation).

17. Eva Eleonora Ferradosa, WomENcourage '26, January 2026, *Rethinking Metadata Documentation: From Technical Solutions to Sociotechnical Support for Sustainable Research Data Management* (presentation).
18. Eva Eleonora Ferradosa, Flower Workshop, June 2026, *Rethinking Metadata Documentation: From Technical Solutions to Sociotechnical Support for Sustainable Research Data Management* (presentation).
19. Guido van den Ackerveken, Academia Sinica, October 2025, Taiwan, *CropXR: integrating experimental and computational biology to understand plant resilience and enable data-driven breeding for sustainable, climate-adapted agriculture* (presentation).
20. Guido van den Ackerveken, Cell Symposium: Towards Sustainable Agriculture: Genomics, Bioengineering, and Smart Technologies, October 2025, Hainan, China, *CropXR: integrating experimental and computational biology to understand plant resilience and enable data-driven breeding for sustainable, climate-adapted agriculture* (presentation).
21. Guusje Bonnema, Gewasdiversiteit Bijeenkomst, BO Akkerbouw, February 2026, De Brielse Boer, Zwartewaal, *Plantenveredeling voor diverse gewassystemen* (presentation).
22. Hazel van Waijjen, EPS Get-together, April 2026 (poster presentation).
23. Hazel van Waijjen, Flower Workshop, June 2026, France, research into flowering (poster presentation).
24. Janne Bibbe, EPS Annual Meeting, March 2026, Hotel Zuiderduin, Egmond aan Zee, *Most duplicate genes in flowering plants diverge their expression by tissue-specific subfunctionalization* (poster presentation).
25. Janne Bibbe, Netherlands Society for Evolutionary Biology Meeting, April 2026, Akoesticum, Ede, *Most duplicate genes in flowering plants diverge their expression by tissue-specific subfunctionalization* (poster presentation).
26. Jelle Keijzer, EPS Conference, March 2026, *Assessing natural variation in Arabidopsis thaliana acclimation strategies to combined high temperature and drought conditions* (poster presentation).
27. Jielin Wang, EPS Workshop “Transcription Factors and Transcriptional Regulation”, December 2025, *The role of root plasticity in drought resilience* (poster presentation).
28. Jordan Earle, UvA Deep Tech Day 2026, January 2026, Amsterdam, current research technology demonstrated to companies (demonstration).
29. Jordan Earle and Anna Neefjes, Benelux Metabolomics Seminar, June 2026, *Modeling of glucosinolate biosynthesis during biotic stress as a function of mRNA* (online seminar presentation).
30. Julia Ruiz Capella, EPS Annual Meeting, March 2026, Egmond aan Zee, the Netherlands, recent findings in Environmental Plant Sciences (poster presentation).
31. Koen Beumer, Department of Biology, Utrecht University, guest lectures in four different courses (guest lectures).
32. Koen Beumer, Conference on Technological Refusal, Maastricht University, and workshop on agriculture and labour, Wageningen University, presentations of CropXR-related research (conference and workshop presentations).
33. Kyran Wissink, BioSB Conference 2026, May 2026, *Biology Constrained Neural Networks* (poster presentation).

34. Lotte van der Krabben, EPS Annual Meeting, March 2026, *Reannotation of publicly available data from the literature* (poster presentation).
35. Lotte van der Krabben, COST Action CA22157 RECROP, June 2026, Brno, Czech Republic, *Epigenetic and Post-Transcriptional Gene Regulation for Stress Response and Memory During Plant Reproduction* (poster presentation).
36. Max Wellens, Minor in Plant Resilience, 20 April 2026, Aeres University of Applied Sciences, Almere, *Rassenmengsels voor een weerbare teelt* (guest lecture).
37. Max Wellens, Growers' Meeting on Crop Diversification, May 2026, Aeres University of Applied Sciences, Dronten, *Rassenmengsels voor een weerbare teelt* (presentation).
38. Michela Recchia, Workshop on the Molecular Mechanisms Controlling Flowering, June 2026, ENS de Lyon, France, *Molecular Regulation of Abiotic Stress-Mediated Flowering in Plants* (poster presentation).
39. Monica Garcia Gomez, PAG, San Diego, USA, January 2026, *Scientific Machine Learning for Plant Systems Biology* (workshop).
40. Peter Bourke, 6th International PLANTCOM Meeting, November 2025, INRAE Centre de Dijon, Dijon, France, *Breeding for diversified cropping systems* (keynote presentation).
41. Peter Bourke and Benedikt Haug, PE&RC course "Advances in Intercropping and Strip Cropping", 15 January 2026, Hotel De Bosrand, Ede, *Breeding for diversity* and *Optimal plant trait combinations in intercropping – an experimental approach* (guest lectures).
42. Peter Bourke, StudieKring voor Plantenveredeling meeting, January 2026, Hotel De Nieuwe Wereld, Wageningen, *Breeding for diversified cropping systems, with some examples from the Netherlands* (presentation).
43. Samara Almeida Landman, EPS Annual Meeting, March 2026, Egmond aan Zee, the Netherlands, the setup of a large RNA-sequencing experiment (poster presentation).
44. Saskia van Wees and group, University Museum Utrecht, co-development of the educational tour *Mysterious plant stories*.
45. Thijs Stegmann, International Conference on Root Development, May 2026, Italy, *Root system adaptation to mild drought in Arabidopsis thaliana* (poster presentation).
46. Victor Betriu Yanez, 4TU.Ethics PhD Day, organisation of a conference day on the well-being of philosophy PhD candidates at Dutch technical universities, focusing on the neoliberalisation of the university (conference organisation).
47. Work package C4, Open Days and Fascination of Plants Day, showcasing the CropXR consortium (outreach activities).
48. Work packages C6 and S1, 3rd International Crop Modelling Symposium, February 2026, Florence, Italy (poster presentations).
49. Work packages C6 and S1, GRC Salt and Water Stress in Plants 2026, May 2026, Les Diablerets, Switzerland (poster presentations).

Annex C: CropXR's Theory of Change