Received: 15 May 2025 | Accepted: 17 October 2025

DOI: 10.1002/ppj2.70048

The Plant Phenome Journal OPEN ACCESS

COMMENTARY

Special Section: International Plant Phenotyping Symposium 8

The future role of regional research infrastructures and networks toward the global plant phenotyping community

Stijn Dhondt[1] | **Richard Dickmann**[2] | **Sven Fahrner**[3] | **Roland Pieruschka**[3] | **Valerio Hoyos-Villegas**[4] | **Susie Robinson**[5] | **Philipp von Gillhaussen**[6]

[1]VIB Agro-incubator, VIB, Deinze, Belgium

[2]Australian Plant Phenomics Network, University of Adelaide, Adelaide, Australia

[3]Plant Sciences, Institute of Bio- and Geosciences 2 (IBG-2), Jülich Research Centre, Jülich, Germany

[4]Department of Plant, Soil and Microbial Sciences, Michigan State University, East Lansing, Michigan, USA

[5]Independent Consultant, Cambridge, UK

[6]International Plant Phenotyping Network e. V. (IPPN), Jülich, Germany

Correspondence
Sven Fahrner, Plant Sciences, Institute of Bio- and Geosciences 2 (IBG-2), Jülich Research Centre, Jülich, Germany.
Email: s.fahrner@fz-juelich.de

Assigned to Associate Editor Francisco Pinto.

Abstract

Regional plant phenotyping research infrastructures and networks provide key services fostering research excellence and community growth for their stakeholders. Globally, we see an underdeveloped niche for stronger collaboration among them to better serve the global community of plant phenotyping. We propose the concept of a "global collaborative space" and identify potential benefits, areas for collaboration, challenges, and concrete next steps.

Plain Language Summary

Regional plant phenotyping research infrastructures and networks support researchers in their respective regions by providing technologies, competencies, and knowledge they would not get otherwise, and help them to collaborate with others in their field of expertise. However, going beyond regions toward a global level, such support activities are still underdeveloped. Thus, we provide our thoughts here on how such global cooperation among regional research infrastructures and networks could work and what benefits it would generate. We also describe the challenges ahead and concrete next steps.

1 | INTRODUCTION

Plant phenotyping (PP) research infrastructures (RIs) and facilities provide a key foundation for research excellence toward providing solutions to global challenges, including food security, soil health, and sustainable agriculture, as outlined by the UN Sustainable Development Goals and further international and regional high-level policies (e.g. European Green Deal). The relevance of RIs for tackling such challenges has been stressed by many recent high-level strategic policy documents. For example, the latest "Brisbane Statement 2024" acknowledges the urgent priority of "Feeding the Planet" and the unique contributions of RIs to "understanding how the Earth's biodiversity and climate impact future agricultural systems."

This commentary has been developed based on a discussion during the "Plant Phenotyping Research Infrastructures Globally" session, which was organized as a satellite meeting of IPPS24. The commentary provides a first conceptual approach on how globally networked regional RIs, building on the expertise of local and national PP facilities while directly responding to the demands of their community, could jointly work toward establishing global collaborative space. This space would serve the demands of a global community of plant phenotyping experts, practitioners, RI investors, and administrators. The commentary concludes by identifying potential areas of collaboration, challenges, and next concrete steps.

2 | CURRENT LANDSCAPE

Regional plant phenotyping RIs and networks have been developing and operating for more than a decade. In Europe, a pan-European RI, EMPHASIS, has successfully established its position on the ESFRI roadmap since 2016 and undertaken significant preparations toward full implementation. North America saw the foundation of the North American Plant Phenotyping Network in 2015, fostering collaboration across disciplinary and national boundaries since then. In Australia, the Australian Plant Phenomics Network, which was founded as a national infrastructure in 2009, and was expanded substantially in 2024, seeks to address production and environment challenges greatly accelerated by climate change. The International Plant Phenotyping Network (IPPN), formed loosely in 2009 and officially founded as an association in 2016, operates as the global network for PP institutions, fostering cooperation and facilitating interdisciplinary training and industry–academia cooperation.

While the development of different geographical regions for applying PP methods and sustaining active research communities is heterogenous, some regions have seen initial momentum toward integration across national communities: for example, in Latin America and Asia, PP facilities and national RIs have been established, but cross-border integration is still relatively weak in these regions—while other regions have only more recently begun to consider PP as an emerging research field.

The example of Africa is interesting, where PP is vital for food security and climate resilience, yet Africa faces major hurdles due to limited infrastructure, expertise, and methods tailored to local crops and environments (Cudjoe et al., 2023; Ghanem et al., 2023; Yang et al., 2020;). Nonetheless, modern phenotyping practices are already undertaken by CGIAR centers, and new initiatives—including regional networks (e.g., PhenoSA), high-throughput platforms (e.g. Stellenbosch University, UM6P, University of Pretoria), and global partnerships through the IPPN—are rapidly advancing capacity and integration, with Africa set to host the International Plant Phenotyping Symposium in 2026.

The global disparities in infrastructure and concentration of PP activity are demonstrated in Figure 1.

The global RIs and networks operate user-driven services to the benefit of their respective user communities, fostering tangible outputs (e.g., publications, research projects, patents, licenses, standard operating procedures, research data, industry collaborations).

These services aim to alleviate the field's known bottlenecks, such as the high costs connected with PP hardware (Gill et al., 2022; Poorter et al., 2023). The IPPN Affordable Plant Phenotyping Working Group (since 2016) supports the self-builder community with open protocols and methods to cut hardware and software costs and to help democratize PP application in regions with low investment capacity, and PhenomUK's "Access to Facilities" pilot supported the development and replicability of affordable custom phenomics equipment (https://phenomuk.org/strands/access-to-facilities/low-cost-custom-phenomics/).

Core Ideas

- Regional plant phenotyping research infrastructures and networks hold unique positions.
- Stronger collaboration between them can provide added benefits to a global community.
- A concept for a "global collaborative space" is proposed.
- Challenges, potential benefits, and concrete next steps are identified.

Further, the PHENET project brings together European plant phenotyping, environmental, and data-focused research infrastructures with global innovators to deliver cross-RI services using low-cost, low-energy AI-enabled sensors, Earth Observation, IoT, FAIR data/semantic web, digital twins, and training (https://www.phenet.eu/en).

At the global level, however, we still see an underdeveloped niche for collaboration among RIs and networks, with all the potential benefits of stronger integration across the global PP community.

2.1 | European infrastructure EMPHASIS

EMPHASIS is in the process of formally integrating the national European infrastructures by establishing an international legal entity, known as a "European Research Infrastructure Consortium" for approval by the European Commission in 2026. EMPHASIS, with its central Coordination Office located in Belgium, has its operating model built on a solid "backbone" of national nodes, each representing local constellations of phenotyping installations, dedicated scientific expertise, and engaged national communities. EMPHASIS supports open access to over 200 plant phenotyping facilities across Europe, along with local services and expertise. It covers installations in controlled conditions, in "intensive fields" able to accurately monitor crops at highly equipped installations, and in "lean fields" through deployment of temporary, portable phenotyping equipment. EMPHASIS fosters good data management practices across these multi-scale facilities

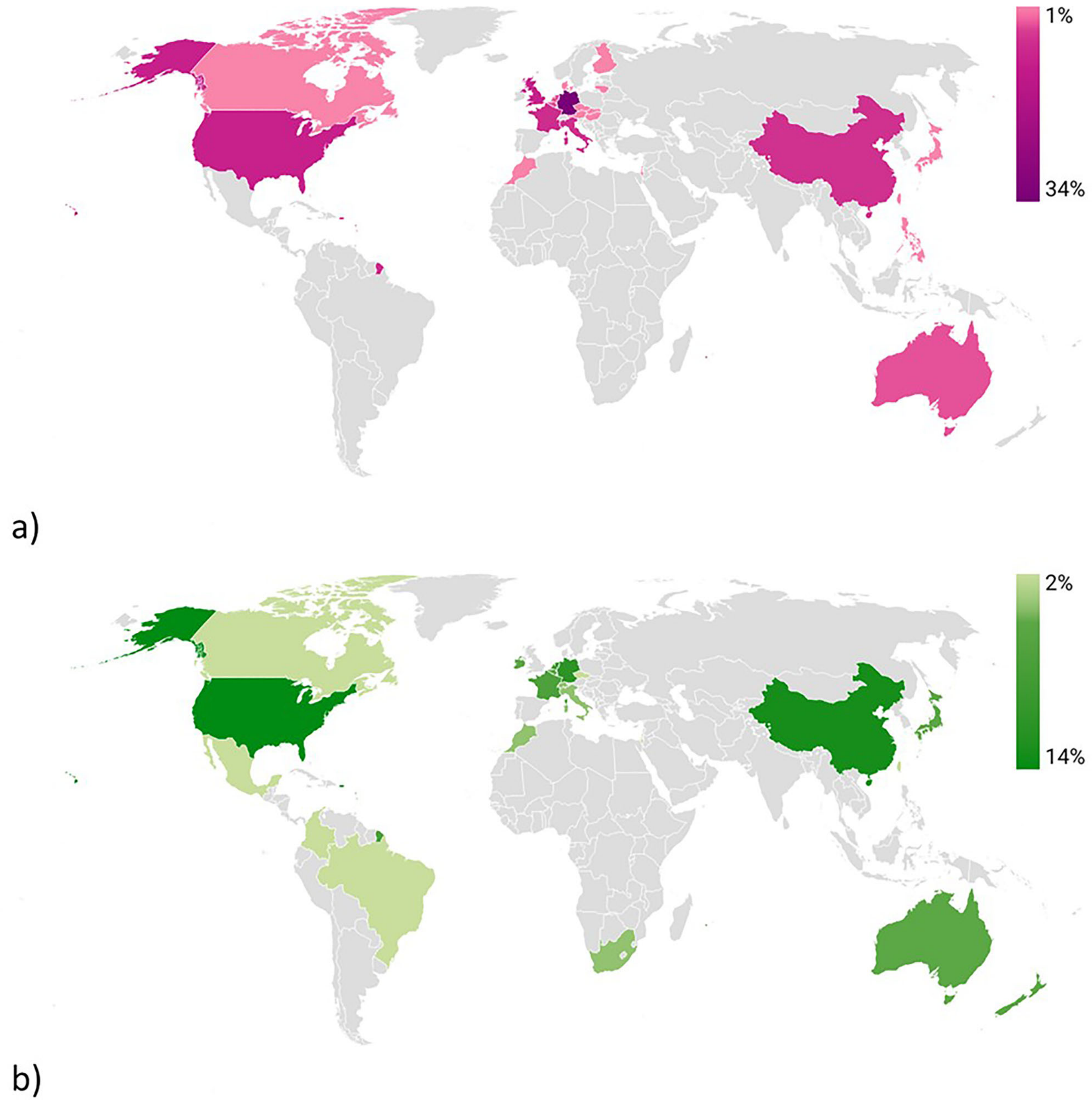

FIGURE 1 Global distribution of plant phenotyping research infrastructures, and International Plant Phenotyping Network e. V. (IPPN) members. Map derived from (a) the publicly accessible Global Infrastructures Database on the IPPN website (https://www.plant-phenotyping.org/infrastructure_map) with pink color gradation derived from percentage values. (b) Map derived from IPPN membership data from the years 2024/2025, with green color gradation showing percentage values.

and FAIR data sharing with the broader scientific community. Additionally, the RI coordinates the development of new methods and tools for phenotyping workflows and commits to the education and training of future phenotyping scientists.

In parallel to the establishment of EMPHASIS as a legal entity, a number of EU funded projects have provided access services and fostered the integration of the European community (i.e., among others EPPN2020, AI4Life, AgroServ, Microbes-4-Climate, PHENET).

2.2 | Australian Plant Phenomics Network

Established in 2009 via core funding from the National Collaborative Research Infrastructure Strategy of the Federal Department of Education, the Australian Plant Phenomics Network (APPN) seeks to address production and environment challenges greatly accelerated by climate change. In 2024, APPN gained additional state government, university, and industry funding to expand from three Nodes to a truly national footprint of nine academic and government Nodes. Key elements of the new configuration include the following:

- Seven Controlled Environment Nodes addressing various industries and environmental challenges, including vertical horticulture, medicinal agriculture, future pastures as well as whole tree and root phenotyping.
- A coordinated suite of five Fixed Field sites, offering accelerated field validation of early science in real world conditions.
- Six "Mobile Phenotyping units" equipped with identical advanced ground and drone-based phenotyping sensors and deployed across Australia.
- A national network of trial environment monitoring sensors.
- An underpinning FAIR and open data network, which will include common data standards, as well as shared processing and storage.

APPN's overarching aim is to provide open access to state-of-the art plant phenotyping technologies that drive research excellence and innovation aimed at developing improved crops that are better adapted to changing climates/environments.

2.3 | The North American Plant Phenotyping Network

The North American Plant Phenotyping Network (NAPPN) aims to be a globally renowned, scientific organization that is self-sufficient and serves both its members and the public. NAPPN recognizes these goals as part of its core mission and 2025–2030 strategic plan: advocacy to public and private sector decisionmakers, community building, community communication, professional development and education, and NAPPN sustainability. It also facilitates collaboration and utilization of its facilities, with some examples as follows: the TERRA-REF gantry system in Maricopa, Arizona (Zhang et al., 2022); the Bellwether Facility in St. Louis, Missouri (Fahlgren et al., 2015); and the Boyce Thompson Institute Plant Phenotyping Facility in Ithaca, New York (Yu et al., 2024). A recent review on the topic of affordability outlines some of the efforts being undertaken to expand utilization and cost of access of phenomics facilities (Hoyos-Villegas et al., 2025).

2.4 | International Plant Phenotyping Network

The International Plant Phenotyping Network e. V. (IPPN) is a nonprofit organization currently uniting 60 major global plant phenotyping institutions and industries. Founded in 2016, the IPPN aims to advance phenomics and plant phenotyping research by fostering international collaboration among researchers, industry, and policymakers to address food security and climate change, while supporting broader plant sciences through advanced phenotyping. IPPN sustains a global network, promotes stakeholder communication, increases the visibility of plant phenotyping, and supports interdisciplinary training and early career education.

In addition, the IPPN organizes the biennial International Plant Phenotyping Symposium (IPPS) to showcase advancements in science and industry and fosters international collaboration. The IPPN is linked to most national and regional phenomics networks (see https://www.plant-phenotyping.org/Partnership), including regular exchange of information and dissemination of news items, vacancies, and publications. Currently, the IPPN plays a key role in interconnecting globally fragmented national and regional communities functioning as a global hub for plant phenotyping research and its applications.

2.5 | Concrete collaboration efforts underway, building insights, and connections

A number of integrative efforts toward inter-network collaboration are underway. For example, since 2016, the IPPN has established several Working Groups (https://www.plant-phenotyping.org/IPPN_Working_Groups) in different topics related to plant phenomics. Currently, there are nine working groups active, all including multi-national teams with outputs across 2019–2024:

- 10 special issues initiated in international peer-reviewed journals
- 30+ webinars
- 30 travel grants to early career professionals to attend plant science conferences
- 20 on-site workshops at international plant science or phenomics conferences

In 2023, the APPN and EMPHASIS signed a Memorandum of Understanding to enhance cooperation in plant phenotyping, with the aim of increasing research efficiency, fostering data standardization, and avoiding research duplication, identifying shared challenges and opportunities, for example, addressing common approaches to bridging scales from remote sensing to ground truthing.

Through involvement in the RI-VIS initiative (increasing the visibility of global research infrastructures to new communities, https://ri-vis.eu/network/rivis/white-papers), EMPHASIS has developed perspectives on the potential of collaboration with different regions (Australia, Latin

America, and Africa) and developed recommendations on future improvements which it will take forward into global engagement roadmaps.

The IPPN Advanced Sensor Applications Working Group meets regularly (online and on-site, e.g., EPPS2025), on the topic of data management, with the aim to synchronize data management practices and to avoid redundancy among globally dispersed communities, with active participants from various regional networks, like EMPHASIS (Belgium, The Netherlands, Austria), APPN (Australia), and IPPN (Germany).

One of the most recent examples of inter-network collaboration is the establishment of the "Early Career Professionals Network", a new initiative launched by several national and international networks and projects (IPPN, EMPHASIS, PhenomUK, Global Wheat Datasets, ELIXIR, PHENET, and DPPN) to provide a continuous, global platform run by and for early-career researchers and industry professionals in plant phenomics to foster collaboration, exchange knowledge, provide access to training, and advance professional development.

3 | A CONCEPTUAL APPROACH TOWARD A "GLOBAL COLLABORATIVE SPACE"

Drawing on their insights and experiences as current and former leaders and representatives of pan-continental plant phenomics RIs and large-scale regional or global networks, the authors see a significant potential to further amplify impact across the global community by stronger collaboration. Here, we identify potential areas of collaboration between the regional RIs and networks, challenges for realizing such collaboration, and concrete next steps and approaches to overcome the challenges. This initial conceptualization of a "global collaborative space" (Figure 2) is intended to act as an opening proposal for further and more detailed framing and implementation in the future.

We have identified the following potential benefits to be generated by a more strategic and intensified global-scale cooperation:

- Facilitate the exchange of technical and management experts to improve service quality and efficiency by "solving problems once, for all."
- Enhance the mobility of researchers and technicians at all career levels, opening new career paths and strengthening knowledge exchange.
- Promote dialogue and alignment on scientific goals to foster research cross-pollination and incentivize new projects, leading to novel outputs.
- Increase the visibility of plant phenotyping's potential to attract new talent and further increase societal support.
- Foster global data harmonization and FAIR data availability to generate high-quality datasets and create new scientific consortia for data analysis and modeling.
- Develop algorithms to extract higher level traits from foundational phenotypic data across scales and different technological concepts.
- Identify new innovation and market opportunities through global interconnectedness, strengthening industry engagement and economic impact.
- Advocate for the criticality of plant phenotyping to policymakers and funders to increase capital and operational investments. In that line, develop harmonized concepts for scientific and socioeconomic impact measurements.

We have further identified numerous challenges, which need to be tackled to strengthen the cooperation among regional RIs and networks:

- Differing strategic planning and investment cycles among regional infrastructures and networks.
- Local focuses of regional infrastructures, which are designed to meet the specific needs of their communities.
- Need to balance community-driven demands with top-down strategic plans.
- Interdisciplinary nature of plant phenotyping, which requires accommodating diverse and potentially diverging community demands.
- Funding constraints and competition with other sectors, highlighting the need for a strong, unified voice advocating for scientific, economic, and social benefits of plant phenotyping.
- Absence of shared frameworks to standardize facility specifications and minimize errors across different locations.

We propose the following next steps and general approaches for regional PP RIs and networks to overcome challenges and realize the benefits of a "global collaboration space":

- Refine the concept with direct feedback and broader perspectives from local and national plant phenotyping facilities and communities.
- Adopt agile mindsets to allow for flexibility in adapting long-term strategies, with the primary goal of strengthening cooperation.
- Establish regular, ongoing "touchpoints" for the global community as part of a formal timeline of activities.
- Initiate joint advocacy for funding and allocate a portion of individual budgets to global collaboration, supported by compelling business cases.

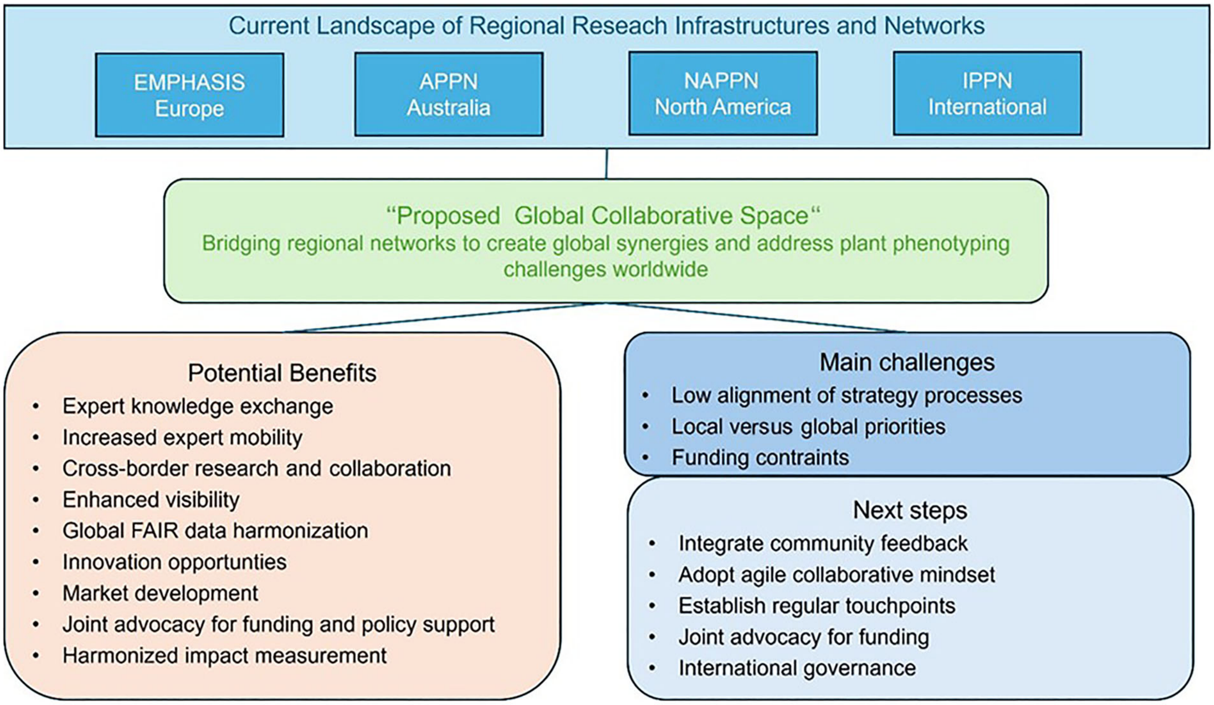

FIGURE 2 Summary of the initial conceptualization of a "global collaborative space." APNN, Australian Plant Phenomics Network; IPPN, International Plant Phenotyping Network e. V.; NAPPN, North American Plant Phenotyping Network.

- Integrate international expertise and perspectives into governance bodies to align regional strategies with global collaboration goals.
- Elevate the profile of phenomics through its recognition as a unique scientific discipline and its introduction into commercial and policymaking spheres to guide funding strategies toward global collaboration.
- Recognize that building global collaborations requires risk management, flexibility, and adaptation due to the complex political and scientific landscape.

4 | CONCLUSION

In this commentary, we introduced the conceptual framework for a "global collaborative space" in PP, drawing on the collective experience of leaders from pan-continental RIs and networks. We have identified key benefits of intensified global collaboration, including enhanced technical competencies, increased mobility, and improved data harmonization, all of which are critical for advancing research and maximizing societal impact. We also acknowledge significant challenges, such as misaligned strategic planning and the need for sustainable international funding models. To move forward, we propose concrete next steps, emphasizing an agile approach, community-driven development, and joint advocacy to secure the necessary support. This study is intended to be a starting point for the broader PP community to engage in a more detailed discussion and future implementation of this framework.

AUTHOR CONTRIBUTIONS

Stijn Dhondt: Conceptualization; methodology; writing—original draft; writing—review and editing. **Richard Dickmann**: Conceptualization; methodology; writing—original draft; writing—review and editing. **Sven Fahrner**: Conceptualization; methodology; project administration; writing—original draft; writing—review and editing. **Valerio Hoyos-Villegas**: Conceptualization; methodology; writing—original draft; writing—review and editing. **Roland Pieruschka**: Conceptualization; methodology; writing—original draft; writing—review and editing. **Susie Robinson**: Conceptualization; methodology; writing—original draft; writing—review and editing. **Philipp von Gillhaussen**: Conceptualization; methodology; writing—original draft; writing—review and editing.

ACKNOWLEDGMENTS

The authors would like to thank the organizers of the IPPS24 for enabling us to run a satellite meeting at the conference.

Open access funding enabled and organized by Projekt DEAL.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ORCID

Sven Fahrner https://orcid.org/0000-0001-6240-9678
Philipp von Gillhaussen https://orcid.org/0009-0001-7466-696X

REFERENCES

Cudjoe, D. K., Virlet, N., Castle, M., Riche, A. B., Mhada, M., Waine, T. W., Mohareb, F., & Hawkesford, M. J. (2023). Field phenotyping for African crops: Overview and perspectives. *Frontiers in Plant Science*, *14*, 1219673. https://doi.org/10.3389/fpls.2023.1219673

Fahlgren, N., Feldman, M., Gehan, M. A., Wilson, M. S., Shyu, C., Bryant, D. W., Hill, S. T., Mcentee, C. J., Warnasooriya, S. N., Kumar, I., Ficor, T., Turnipseed, S., Gilbert, K. B., Brutnell, T. P., Carrington, J. C., Mockler, T. C., & Baxter, I. (2015). A versatile phenotyping system and analytics platform reveals diverse temporal responses to water availability in Setaria. *Molecular Plant*, *8*(10), 1520–1535. https://doi.org/10.1016/j.molp.2015.06.005

Ghanem, M. E., Amri, M., Audebert, A., Fernandez, R., Comar, A., & Pradal, C. (2023, October 23–26). *Advancing crop phenotyping in Africa: Exploring boundaries and horizons* [Conference presentation]. African Plant Breeders Association Conference 2023, Morocco.

Gill, T., Gill, S. K., Saini, D. K., Chopra, Y., de Koff, J. P., & Sandhu, K. S. (2022). A comprehensive review of high throughput phenotyping and machine learning for plant stress phenotyping. *Phenomics*, *2*(3), 156–183. https://doi.org/10.1007/s43657-022-00048-z

Hoyos-Villegas, V., Jackson, M., Vargas-Cedeño, M., Farmer, E. E., Hanneman, M., Mazis, A., Singh, K. D., Sangjan, W., Mcnair, M., Sankaran, S., Tirado Tolosa, S., Gore, M. A., & Rife, T. W. (2025). Affordable phenomics: Expanding access to enhancing genetic gain in plant breeding. *The Plant Phenome Journal*, *8*, e70034. https://doi.org/10.1002/ppj2.70034

Poorter, H., Hummel, G. M., Nagel, K. A., Fiorani, F., von Gillhaussen, P., Virnich, O., Schurr, U., Postma, J. A., van de Zedde, R., & Wiese-Klinkenberg, A. (2023). Pitfalls and potential of high-throughput plant phenotyping platforms. *Frontiers in Plant Science*, *14*, 1233794. https://doi.org/10.3389/fpls.2023.1233794

Yang, W., Feng, H., Zhang, X., Zhang, J., Doonan, J. H., Batchelor, W. D., Xiong, L., & Yan, J. (2020). Crop phenomics and high-throughput phenotyping: Past decades, current challenges, and future perspectives. *Molecular Plant*, *13*, 187–214. https://doi.org/10.1016/j.molp.2020.01.008

Yu, L., Sussman, H., Khmelnitsky, O., Rahmati Ishka, M., Srinivasan, A., Nelson, A. D. L., & Julkowska, M. M. (2024). Development of a mobile, high-throughput, and low-cost image-based plant growth phenotyping system. *Plant Physiology*, *196*(2), 810–829. https://doi.org/10.1093/plphys/kiae237

Zhang, Z., Pope, M., Shakoor, N., Pless, R., Mockler, T. C., & Stylianou, A. (2022). Comparing deep learning approaches for understanding genotype × phenotype interactions in biomass sorghum. *Frontiers in Artificial Intelligence*, *5*, 872858. https://doi.org/10.3389/frai.2022.872858

How to cite this article: Dhondt, S., Dickmann, R., Fahrner, S., Pieruschka, R., Hoyos-Villegas, V., Robinson, S., & von Gillhaussen, P. (2025). The future role of regional research infrastructures and networks toward the global plant phenotyping community. *The Plant Phenome Journal*, *8*, e70048. https://doi.org/10.1002/ppj2.70048