D3.3: Report on user orientation towards EMPHASIS services

Michela Janni, Silvana Moscatelli, Francesco Loreto| 31 May 2021

Document information

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Authors (Partner)				
Responsible author	**Name**	Michela Janni	**Email**	michela.janni@ibbr.cnr.it

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Contents

Documents used in the preparation of this deliverable:

Global Plant Phenotyping Survey 2020/21 Dataset.
https://zenodo.org/badge/DOI/10.5281/zenodo.4723409.svg

EMPHASIS-PREP Deliverable 2.5: Report on current and future user demands
https://zenodo.org/badge/DOI/10.5281/zenodo.4544533.svg

Executive Summary

Scope of this deliverable

This deliverable aims at describing the user orientation towards EMPHASIS pilot services. This document provides a summary of the results of the Global Plant Phenotyping Survey (GPPS) launched in November 2020 and concluded in March 2021. GPPS was performed in collaboration with the International Plant Phenotyping Network (IPPN).

The plant phenotyping community was interrogated both on general issues and on a set of specific questions to further evaluate EMPHASIS pilot services, which were developed on the basis of the user demand identified by the past two surveys (2017 and 2018). Data collected are a picture of the recent trends in plant phenotyping in Europe and can serve as valuable tools for further analyses to help shaping and supporting the future of plant phenotyping.

The database originated from the survey has been delivered to the phenotyping community.

Main results of the deliverable

The reported data represent an update on the orientation and demand of the plant phenotyping user community and describe the user response to the following EMPHASIS pilot services:

- Field phenotyping
- Innovation
- Harmonisation
- Data management
- Modelling
- Training

This report highlights that stakeholder engagement increased during the EMPHASIS-Prep project. The GPPS was filled by almost 400 participants and, perhaps more importantly, yielded a good correspondence between user orientation and EMPHASIS service portfolio.

Introduction

With the increasing demand on the use of plant phenotyping in recent and upcoming years (D2.5, https://zenodo.org/badge/DOI/10.5281/zenodo.4544533.svg), understanding user orientation in plant phenotyping is key to fine-tuning EMPHASIS service portfolio and activities in the implementation phase and in preparation of the operational phase.

The year 2021 is marking the transition between EMPHASIS preparatory and implementation phases. This is led by the recently constituted Interim General Assembly (IGA) with the objective to pave the road for the full operational phase of EMPHASIS from 2022 on. With the aim to deliver early benefits to the community in specific areas, while testing and learning from pan-European requirements and provisions, a series of pilot services have been structured. The defined pilot services are aimed to help turn the EMPHASIS strategy into reality and bridge the preparation of EMPHASIS to full operation.

In the past years, EMPHASIS, has carried out a series of "Plant Phenotyping Surveys" covering basic and advanced questions related to plant phenotyping, for the purpose of assessing the status of global plant phenotyping and its demand, the presence of emerging fields where plant phenotyping will be profitably used. The surveys addressed participants coming from all geographic regions and all professional disciplines related to plant phenotyping.

These data provided the primary source of information for our plant phenotyping knowledge base, informing us about range and diversity of topics and issues of value and importance to the international and regional (sub-)communities, and to academia, industry, and general users. This also helped both in the identification of potential gaps and in improving understanding of the demands of the community in terms of required services and tools.

To finally streamline the user orientation toward plant phenotyping and EMPHASIS pilot services, making advantage of lessons and results of earlier surveys, an ultimate international **Global Plant Phenotyping Survey (GPPS)** was carried out via a joint collaboration between EMPHASIS and the International Plant Phenotyping Network (IPPN).

A total of 49 questions were presented to a group of potential **EMPHASIS stakeholders**.
The GPPS was disseminated through IPPN and EMPHASIS newsletters and through fully operational IPPN and EMPHASIS social networks.
We collected data from European and international sources and here we report on those coming from European participants only representing 57% of the whole respondents (690 people, Fig. 1).

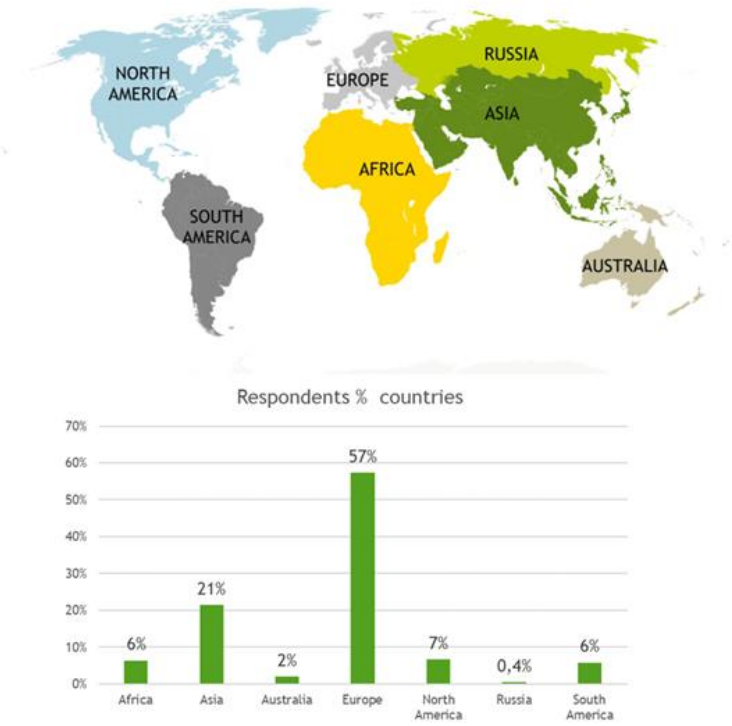

Fig.1 Geographical representation of Global Plant Phenotyping Survey (GPPS) respondents https://doi.org/10.5281/zenodo.4723409)

However, a full analysis of the data collected at international level is ongoing and will be useful to perform comparisons of needs, demands and orientations at global level.

1. The global plant phenotyping user community

Description of plant phenotyping users, and engagement with Global Plant Phenotyping Survey

1.1 Who and how many responded to the survey?

This deliverable includes data of 396 European respondents belonging to academia (80%) and industries (20%). Among them, **phenotyping users** were the main represented category (60% in academia, 50% in industry), followed by **technology developers** mainly coming from the industry sector (37%). Most of the facility providers, as expected, work in public institutions (21% academia, 13% industry, Table 1). The survey showed a prominent interest toward **applied research** since 62% of respondents focus its activity on it, with only 36% of respondents interested on **fundamental research** (36%).

Table 1. User category of the GPPS

	Academia	Industry
Phenotyping user	60%	50%
Technology developer	19%	37%
Facility provider	21%	13%

1.2 What are respondents interested to?

Above ground traits are the area of interest of 75% of participants, while 25% works on below ground traits.

Mature applications for plant phenotyping are screening for abiotic (25%) and biotic (17%) stresses, plant breeding (18%) and plant physiology (16%). Emerging applications are agrochemical development (5%), resource use efficiency and sensor development (7%), optimization of growth conditions (2%).

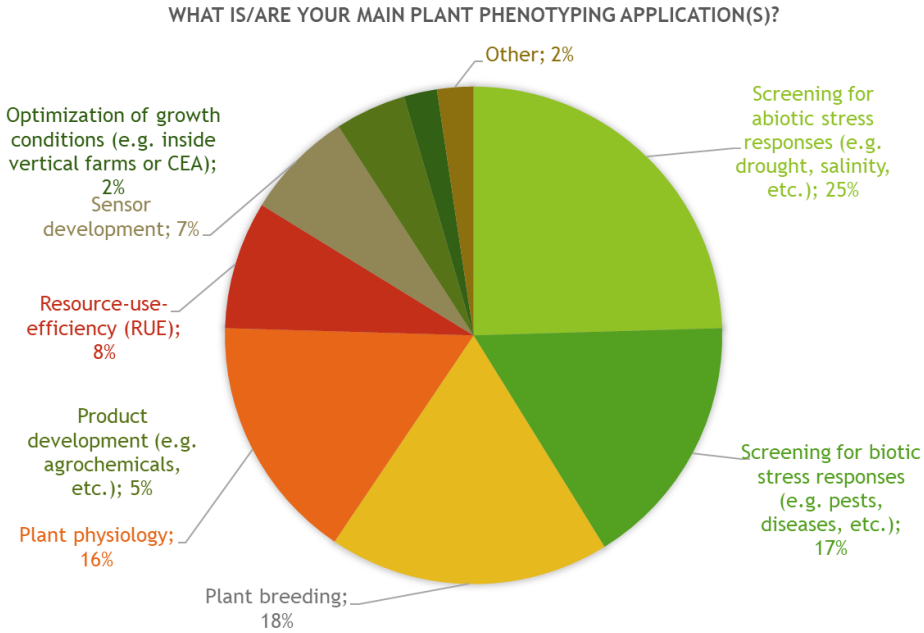

Fig. 2 Main application fields of plant phenotyping (multiple answers allowed)

Top plants analyzed with phenotyping techniques are cereals (27%), and vegetable crops (19%), followed by model species and legumes (12 and 11%, respectively). Fruit and woody species and grasses shared the interest of the remaining 22% of respondents.

1.3 Environment of plant phenotyping

Respondents confirmed an increasing interest with respect to the previous survey in field plant phenotyping and its applications (36%). However, controlled conditions phenotyping still plays a pivotal role, as 45% of the users applied plant phenotyping in greenhouses and controlled the environment (25% and 20% respectively). Only 18% of the respondents use plant phenotyping within the laboratory.

EMPHASIS is becoming a reference for the plant phenotyping community. Out of the 396 respondents 41% were familiar with EMPHASIS and its services (Fig. 3). The remaining 57% (214) are new followers of EMPHASIS activities.

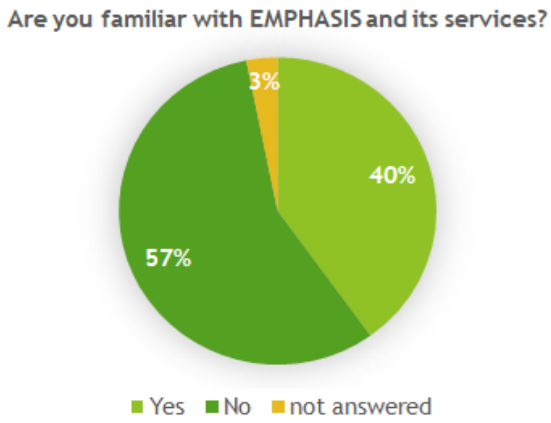

Fig.3 EMPHASIS stakeholder engagement

2. The user orientation and EMPHASIS pilot services

The EMPHASIS pilot services have been identified as relevant for the phenotyping community by the last performed survey (2017-2018).

The definition of the pilot services involved also the EMPHASIS Support Group, consisting of representatives of twenty-four national communities, that provided valuable inputs and advices on the pilot service conceptualisation.

Further details on the work plan of each pilot services and the related key performance indicators (KPIs) are reported in **Deliverable 6.3** (not yet released).

Aim of the GPPS was to verify the consistency of the proposed pilot services with up-to-date user orientation and demands, to further develop a participatory process taking into consideration the evolution of real needs expressed from the users and producing immediate benefits all communities involved in plant phenotyping, from researchers and technologists to end-users. A synthesis of the main results of the GPPS about the single pilots follows.

2.1 Field Pilot

Multi-site field phenotyping experiments are key to perform plant phenotyping in applied crop science and plant breeding as it allows testing genotypes of important crops in different climatic conditions in agriculturally relevant settings. Breeding programs often rely on multi-site field trials to determine new variety performance under different environments and/or regions targeted.

During the EMPHASIS implementation phase, the purpose of the field pilot was to prepare and test multi-site field phenotyping services. In collaboration with an EMPHASIS field expert group, EMPHASIS is developing multi-site field phenotyping pilot service which will be carried out during the one-year implementation phase of the project (https://emphasis.plant-phenotyping.eu/field_pilot).

79% of EMPHASIS community expressed a broad consensus on the key importance of multi-site experiments in field phenotyping experiments and 46% of respondents already performed multi-site experiments (Fig. 4).

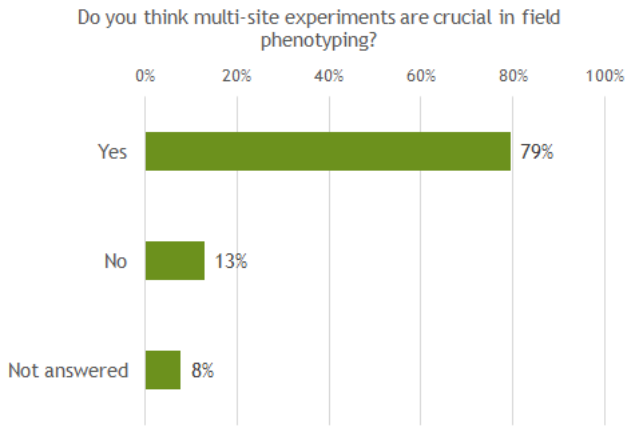

Fig.4 Importance of multi-site experiments in field phenotyping

A critical point in performing field phenotyping is the identification of multi-site fields available and suitable for the specific trial. This is so far based largely on existing research networks (33%) and personal contacts (32%). The rest of the respondents identified the field network via university (17%), through the establishment of a research consortium (16%) and only a little percentage (2%) was not able to identify any multi-site field. This result highlights the needs for creation and rapid expansion of an organized network of field trials at European level.

Regarding the EMPHASIS contribution to improve field phenotyping, users would like to have support to access field phenotyping equipment of third parties (26%), find accessible field sites (25%), reduce logistic and administrative problems that come with multi-site field experiments (19,9%), being trained in field phenotyping (e.g. methods) (19,9%), having services level contracts that are binding through EMPHASIS (legal support) (7,6%) (Fig.5).

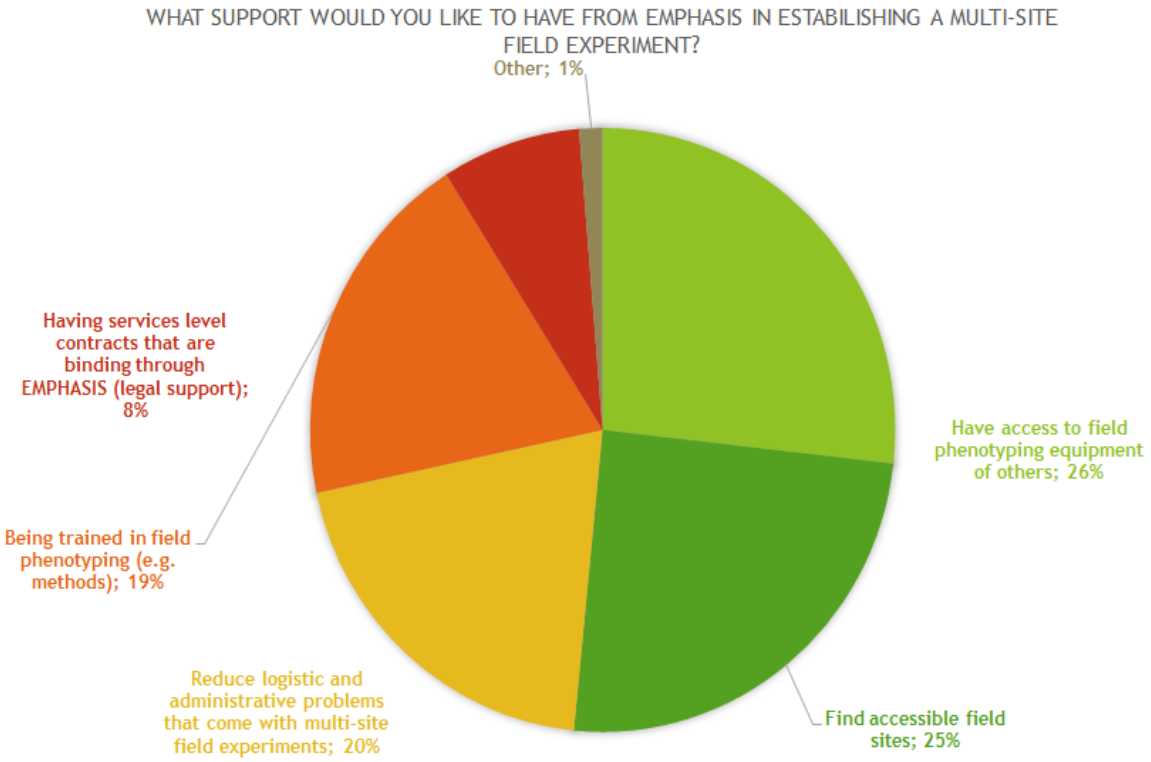

Fig 5. Support of EMPHASIS in establishing multi-site field experiments

To facilitate multi-climate, multi-site field phenotyping, EMPHASIS also developed a map of the existing and upcoming field phenotyping sites in Europe (Fig. 6, https://emphasis.plant-phenotyping.eu/emphasis_infrastructure_map)

Fig.6 Intensive and Lean Field map from the EMPHASIS infrastructure map

2.2. Innovation Pilot

EMPHASIS aims at fostering innovation in plant phenotyping technologies, tools and methods. This will ensure the long-term sustainable excellence of the infrastructure. One of EMPHASIS purposes is to accelerate interactions between plant phenotyping infrastructure operators/users and technology developers/suppliers.

GPPS revealed a still poor innovation orientation of plant phenotyping users. 29% of the respondents exclusively use commercial facilities/equipment for plant phenotyping while 44% prefer commercial facilities/equipment but occasionally develops customized solutions to solve specific problems when phenotyping. Only 23% of the EMPHASIS users develops routinely new solutions and new facilities for plant phenotyping.

When trying to understand the reason of such orientation, 57% of respondents explained that limits to the use of phenotyping technology are due to the **high cost of these technologies**. 32% of respondents are indeed limited in performing plant phenotyping by the cost of the acquisition of new instruments, and 25% prefers to use affordable tools and instruments to perform experiments. 12% of researchers shares equipment within their own research institutions and only 10% has funds to cover development of new technological innovation in plant phenotyping, and 3% uses instruments for plant phenotyping from colleagues, often under the umbrella of scientific collaborations. Indeed, new approaches to allow a wider use of phenotyping techniques should be considered in the next future of field phenotyping.

EMPHASIS also fosters the interaction between innovation industries and users by creating a database of industries. The EMPHASIS Directory provides an open platform for plant phenotyping related companies in Europe (https://emphasis.plant-phenotyping.eu/Industry_List).

2.3 Harmonization Pilot

Good phenotyping practises have an increasing role in the phenotyping community and allow for the exchange and sharing of phenotyping datasets. The application of harmonized protocols increases reproducibility of data by phenotyping platforms and facilitates the transfer of information from controlled-conditions platforms towards field conditions.

In this frame, the EMPHASIS harmonisation pilot service aims at establishing a central point of information on good phenotyping practices, in close collaboration with the phenotyping community and based on state-of-the-art procedures (https://emphasis.plant-phenotyping.eu/harmonisation_pilot).

The GPPS confirmed the urgent need of harmonizing protocols for data acquisition and management. In fact, 28% of the GPPS respondents perform plan phenotyping experiments based on their experience, 29% consulting literature and 21% asking colleagues. Infrastructure providers and operators play a certain role in orienting the experimental plan (12%), but only 7% of respondents consults repository portals for protocol identification (Fig.7).

52% of the GPPS respondents demand for the use of standardized and harmonized methods to increase the impact and the quality of phenotyping data and for publication of better and Findable, Accessible, Interoperable and Reusable (FAIR) data-sets in peer review journals.

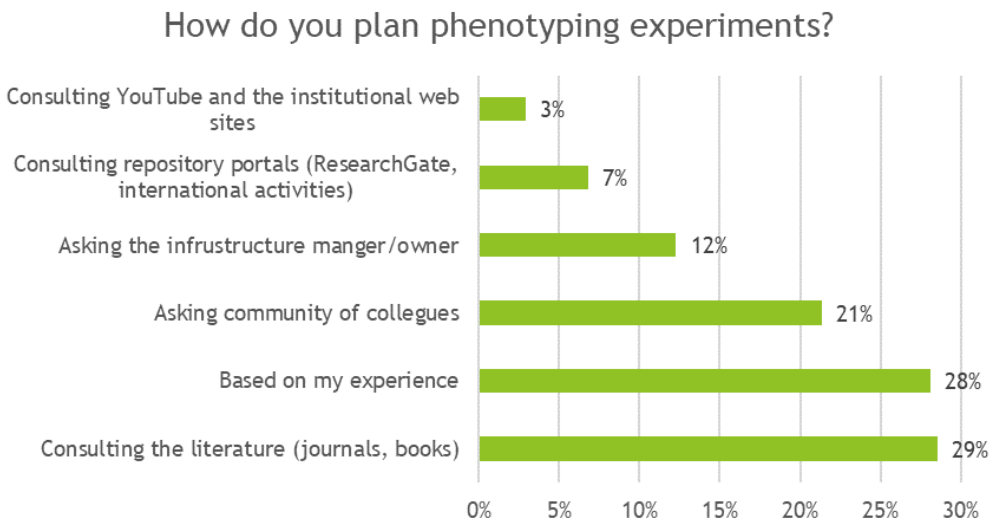

Fig.7 Harmonization methods: how do you plan phenotyping experiments?

2.4 Data management Pilot

Datasets collected in EMPHASIS installations are costly, labour intensive in absence of consensus protocols can be difficult to be reproduced. However, it is essential that datasets be re-analysed by a wide scientific community, and by users themselves, when needed. “Open science” and “open access” are nowadays required by most journals, public research and funding institutions, and data must be collected following the FAIR principles (https://emphasis.plant-phenotyping.eu/data_services).

EMPHASIS aims at fostering open access to all phenotyping data and to promote the sharing of phenotypic data. This is a new paradigm, as 77% of the respondents has never used open access phenotyping data present in public databases, while only 22% did.

From the sharing point of view 40% of respondents shared their phenotyping data, mainly attached to publication (40%), in open repository (15%), and upon request (15%). A key point is that 27% of respondents (92 respondents) did not answer the question.

The above percentages highlight the need of a coordinated and user-friendly information system to provide best framework of use of open science.

EMPHASIS is working closely with the infrastructures ELIXIR (genomics, via the MIAPPE working group) and AGMIP (modelling), to use datasets for different purposes by different scientific communities.

To sensibilize users toward FAIR data and open science, EMPHASIS produced an infographic video that easily explained the background and importance of FAIR (https://youtu.be/rXKBy7DOPrY).

2.5 Modelling Pilot

Data from phenotyping experiments can be greatly complemented by mathematical plant modelling. Modelling, for example, allows computation of novel traits that are not directly accessible to available sensors. Modelling also helps focus on significance of observed phenomics data to predict integrated (e.g. yield) or functional traits (e.g. plant root system architecture) for new genotypes across a wide range of target environments or management practices (https://emphasis.plant-phenotyping.eu/modelling_pilot). GPPS community clearly expressed interest toward modelling. Modelling is currently used by 31% of respondents although 39% would like to use modelling but needs help in approaching this new tool, and 26% still do not use modelling (Fig. 8).

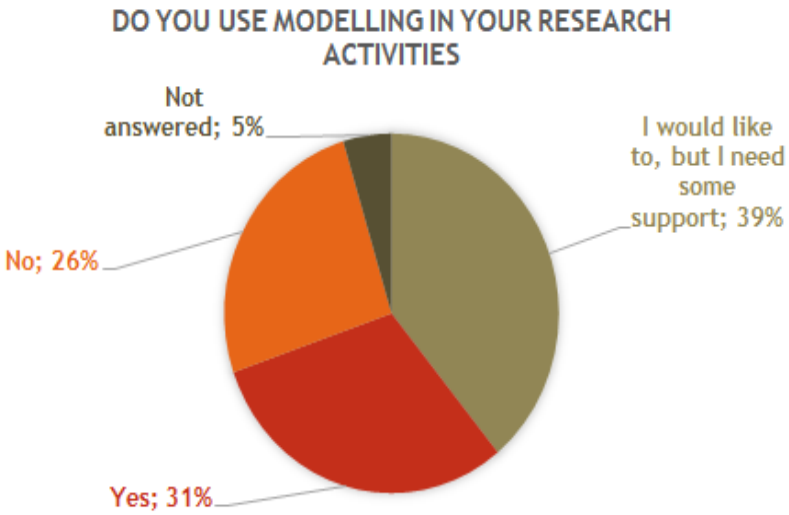

Fig. 8 Modelling user orientation

2.6 Training Pilot

EMPHASIS will coordinate and support training activities in plant phenotyping taking advantage of knowledge about needs and expectations of the plant phenotyping community as acquired during the preparatory phase (EMPHASIS-PREP, https://emphasis.plant-phenotyping.eu/training_pilot).

Training was already highlighted by the previous surveys as the activity in which EMPHASIS is most urgently required to act (deliverable 2.5), thus the establishment of a training pilot should be planned and performed during the implementation phase.

EMPHASIS can significantly transfer knowledge by means of training (Fig. 9). Users require training mainly in methods (36%), specific research topics (33%), basic introduction (20%), career opportunity (11%).

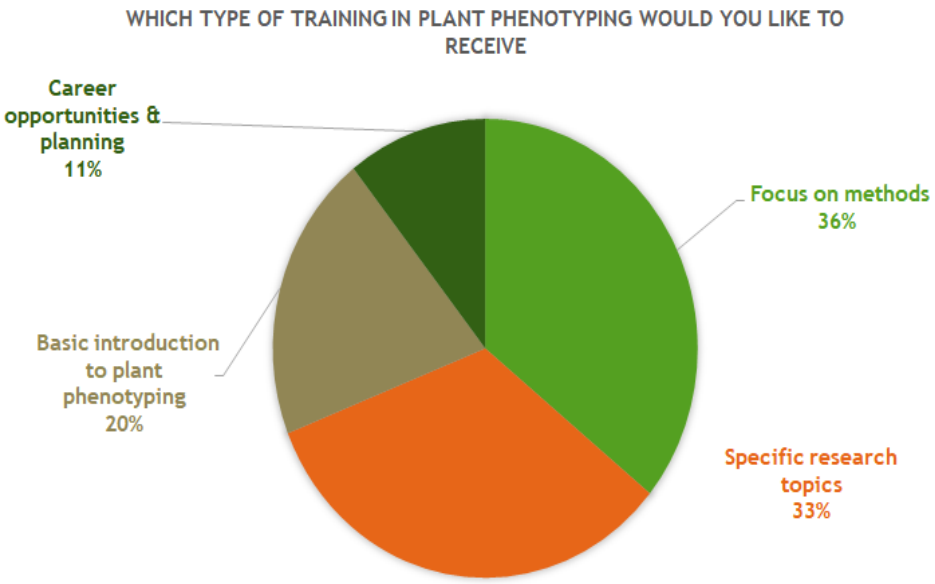

Fig.9 User orientation toward training

The recent Covid-19 pandemic situation deeply changed the way training can be provided. These changes may not temporary, and we may need to consider them also in the future, providing attractive and efficient while innovative and remotely held training sessions, in particular on topics that involve rapid technology innovation without hands-on needs.

Webinar (27%), tutorial video (24%), interactive workshops (digital, 24%), face-to-face workshops (24%) are the channels perceived by the GPPS respondents as most suitable to deliver and receive training.

3. Conclusion

The GPPS data analyses described a European plant phenotyping community that is rapidly evolving and is aware and generally sufficiently knowledgeable about plant phenotyping. This community is represented by both academia and industry actors, with academia playing a pivotal role in applying plant phenotyping.

A detailed strategy is needed and somehow already ongoing to further increase interest and engagement of the private sector.

The designed EMPHASIS pilot services are clearly going in the direction of addressing the developing user needs toward plant phenotyping. Making operative the selected pilot services is expected to deliver concrete benefits to the plant phenotyping community, increasing EMPHASIS efficacy and visibility, and helping to produce solid, usable and sharable data sets, further building trust in the EMPHASIS stakeholders.

Annex 1: Check list

Deliverable Check list (to be checked by the "Deliverable leader")

	Check list		Comments
B e f o r e	I have checked the due date and have planned completion in due time		*Please inform Management Team of any foreseen delays*
	The title corresponds to the title in the DOW		
	The dissemination level corresponds to that indicated in the DOW		*If not please inform the Management Team with justification*
	The contributors (authors) correspond to those indicated in the DOW		
	The Table of Contents has been validated with the Activity Leader		*Please validate the Table of Content with your Activity Leader before drafting the deliverable*
	I am using the EMPHASIS deliverable template (title page, styles etc.)		*Available in "New EMPHASIS Logo, Templates, CI" on the collaborative workspace*
The draft is ready			
A f t e r	I have written a good summary at the beginning of the Deliverable		*A 1-2 pages max. summary is mandatory (not formal but really informative on the content of the Deliverable)*
	The deliverable has been reviewed by all contributors (authors)		*Make sure all contributors have reviewed and approved the final version of the deliverable. You should leave sufficient time for this validation.*
	I have done a spell check and verified the English		
	I have sent the final version to the WP Leader and to the Project coordinator (cc to the project manager) for approval		*Send the final draft to your WPLeader and the coordinator with cc to the project manager on the 1st day of the due month and leave 2 weeks for feedback. Inform the reviewer of the changes (if any) you have made to address their comments. Once validated by the 2 reviewers and the coordinator, send the final version to the Project Manager who will then submit it to the EC.*

Annex 2: List of Global Plant Phenotyping Survey (GPPS) questions

Page 01

1. In which geographical region are you working?

Africa

Asia

Australia

Europe

North America

Russia

South America

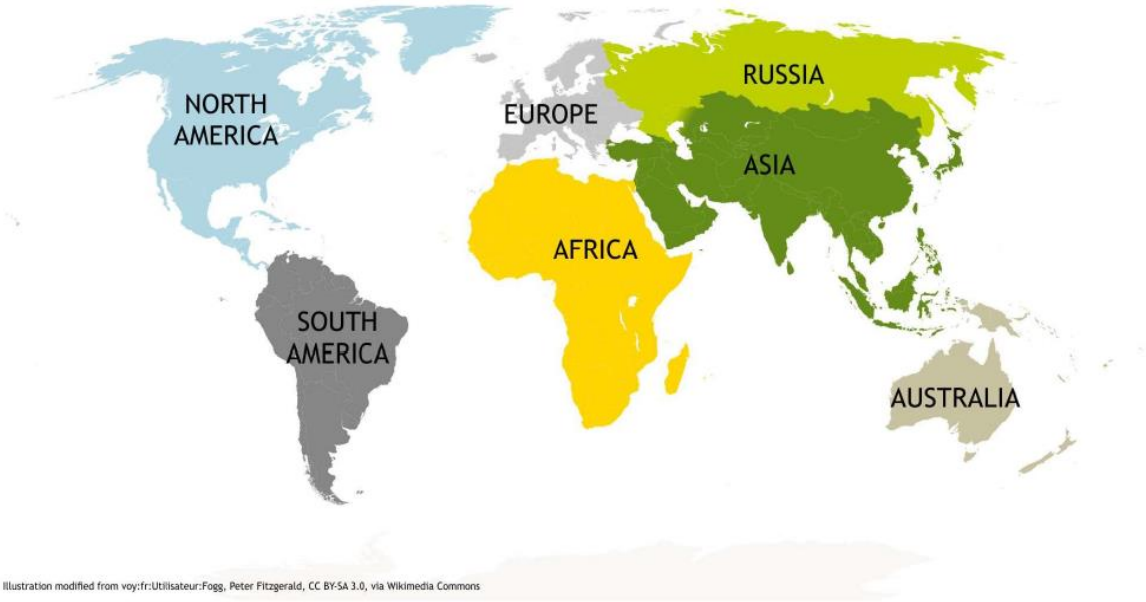

Illustration modified from voy:fr:Utilisateur:Fogg, Peter Fitzgerald, CC BY-SA 3.0, via Wikimedia Commons

2. How long are you working in your field (connected to plant phenotyping)?

0 - 5 years

5 - 10 years

10+ years

3. Are you working in industry or academia?

Industry (private/commercial company)

Academia (public institution/research centre)

4. What is your current job title/occupation?

5. Is your research basic/fundamental or applied?

You can select multiple options.

- Applied research
- Fundamental research
- Neither one

6. Are you a phenotyping user (e.g. someone who applies phenotyping), a technology developer (e.g. working for a company developing instrumentation) or a provider of phenotyping infrastructure (e.g. facility host, public institution, research centre)?

You can select multiple options.

- Phenotyping user
- Technology developer
- Facility provider

7. Do you mainly focus on above- or belowground traits in your work?

You can select one or both.

- Aboveground traits
- Belowground traits

8. In which environment(s) do you apply plant phenotyping mostly?

- Field
- Laboratory
- Climate chamber
- Controlled greenhouse
- Other:

9. What is/are your main plant phenotyping application(s)?

The context of your work involving plant phenotyping

- Sensor development
- Screening for biotic stress responses (e.g. pests, diseases, etc.)
- Screening for abiotic stress responses (e.g. drought, salinity, etc.)
- Product development (e.g. agrochemicals, etc.)
- Plant breeding
- Plant physiology
- Resource-use-efficiency (RUE)
- Optimization of growth conditions (e.g. inside vertical farms or CEA)
- Other:

10. Which type of phenotyping system do you mainly use or prefer?

- Cheap/affordable phenotyping tools (e.g. mobile phones, webcam, etc.)
- Gantry-based systems
- Conveyor-based systems
- Portable devices
- Unmanned Arial Vehicles (UAVs)
- Unmanned Ground Vehicles (UGVs)
- Deep Phenotyping Systems (e.g. CT, NMR, etc.)
- Other:

11. Which plant species groups are you focusing on?

Multiple selections are possible.

Feel free to specify the exact species in the field “Other”.

- Model species (e.g. Arabidopsis spec)
- Vegetable crops (e.g. Brassicaceae)
- Fruit crops (e.g. banana)
- Cereal crops (e.g. wheat, corn, etc.)
- Legumes (e.g. soy)
- Woody species (e.g. shrubs, trees, etc.)
- Grasses (e.g. Poaceae)
- Other:

12. Which plant traits are of particular interest to you?

Feel free to further specify the exact trait(s) you are working with in the field “Other”.

- Biomass
- Growth
- Flower traits
- Architecture
- Yield (& yield components)
- Cellular/tissue traits
- Leaf traits
- Physiological traits (e.g. transpiration rate)
- Agronomical traits
- Post-harvest traits (e.g. shelf-life, etc.)
- Other:

13. At which (observer) scale are you normally phenotyping?

- Nanometer (nm)
- Micrometer (µm)
- Millimeter (mm)
- Centimetre (cm)
- Meter (m)
- Kilometre (km)
- Other:

14. How do you currently access plant phenotyping facilities/infrastructures?

Facilities in my institution

Facilities or infrastructures in your country

Facilities outside the country through international calls (e.g. EPPN2020)

Through connections within research projects

bilateral agreement

Through service

I don't have access

15. How would you like to access phenotyping facilities/infrastructures?

Only for free (no funds available)

Through international calls (EPPN)

Through research projects

Bilateral agreement

As paid services

16. Are you familiar with EMPHASIS and its services?

Yes

No

17. How do you plan phenotyping experiments?

Based on my experience

Consulting the literature (journals, books)

Consulting repository portals (ResearchGate, international activities)

Consulting YouTube and the institutional web sites

Asking community of collegues

Asking the infrustructure manger/owner

18. Do you think the use of standardized and harmonised plant phenotyping methods should be considered in the evaluation of manuscripts for publication?

Yes.

No, this complicates the experimental plan a lot.

No, I prefer to follow article protocols.

I don't know.

19. Do you develop custom devices or sensors for your specific research or do you prefer to use commercial equipment?

My group develops new solutions for phenotyping in my area of research.

I use commercial solutions, but occasionally I develop customised solutions.

No, I buy if possible.

20. Is your application of advanced phenotyping technologies limited by high costs?

Yes, I cannot afford to buy advanced phenotyping instruments

Yes, I use affordable phenotyping tools to conduct my experiments

Yes, I cannot afford to hire additional personnel

No, I have funds to buy the technology needed

No, I usually ask for the use of instruments in kind

No, in my institution we share the instruments

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21. Have you ever used open access phenotyping data from public databases?

Yes

No

22. How do you share your data?

Attached to publication

In an open repository

Upon request

I don't share the data

23. How do you manage your phenotyping data?

Ontology-driven data base

Hard drive file system

Cloud

Personal database

Information system (PIPPA, PHENOMIS, PHIS)

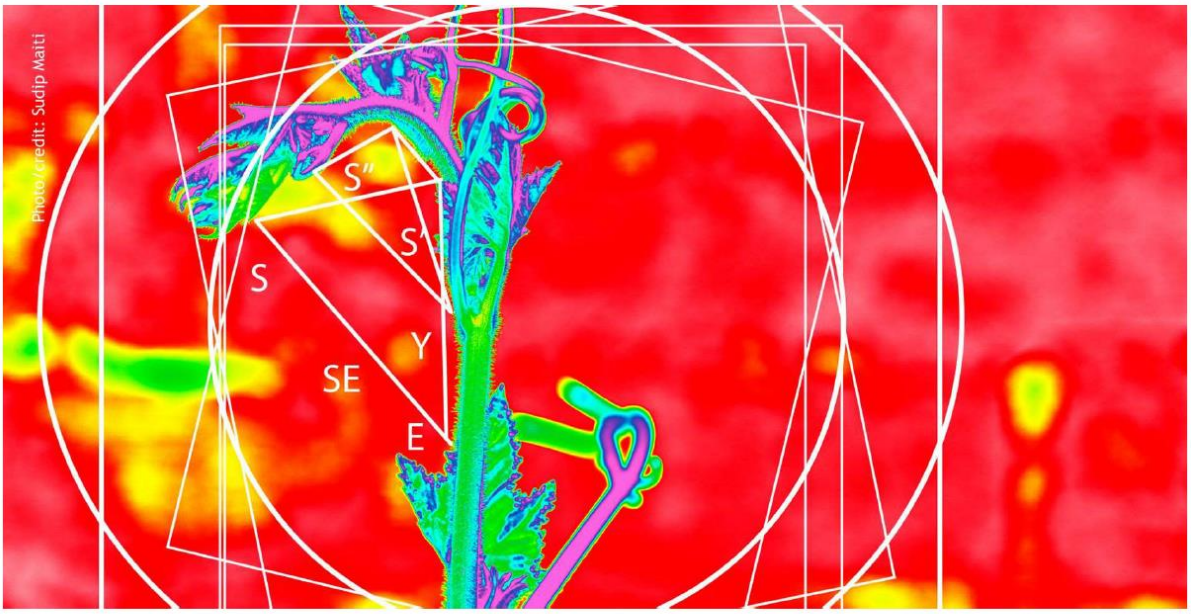
"Self-made"

24. Do you use modelling in your research activities?

Yes

No

I would like to, but I need some support.



25. What kind of model do you use in your research?

Agronomical model

Physiological model

Root model

Ecosystem model

Economic model

Climate model

I don't know.

Other

26. Do you currently use field trials in your research projects?

Yes

No

27. Do you think multi-site experiments are crucial in field phenotyping?

Multi-site field experiments involve at least two fields in different climatic conditions/regions.

Yes, I often performed multi-site filed trials.

Yes, I will use multi-site field trial in the future.

No, I don't think such experiments are always necessary.

28. How do you identify accessible field sites for your experiments?

Through existing research networks

Through personal contacts

Through the establishment of a research consortium

I need them, but I don't know how to find them.

Via my institute /university

29. Do you think that a map of the available field infrastructures (phenotyping equipment available, environmental conditions) would be useful to plan your experiments?

Yes

No

30. What support would you like to have from EMPHASIS in estabilishing a multi-site field experiment?

Find accessible field sites

Have access to field phenotyping equipment of others

Reduce logistic and administrative problems that come with multi-site field experiments

Having services level contracts that are binding through EMPHASIS (legal support)

Being trained in field phenotyping (e.g. methods)

Other:

31. Which access mode do you use to perform your field trials?

I perform the experiments on the premises of my institution

I take advantage of the collaboration with private companies who have sites in multiple locations

I have collaborations with other institutions

I rent from local farmers

Contract with cooperatives

Other

32. How do you finance your field trials?

Through funded research projects

In kind

Access through international initiatives

I am part of a field network consortium

Through national access

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jump3

33. Are you responsible for a phenotyping installation?

Are you responsible of e.g. planning of service, maintenance, life-cycle plan & proper use of a phenotyping system.

Yes

No

34. Please provide the name of your installation

35. Has your installation been updated or upgraded since it was built?

Update: No functional additions but newer version of existing software working in the same way as before.

Upgrade: Functional additions have been added (e.g. extra sensor or additional software).

Maintenance: Regular service of hard- or software parts to sustain proper functionality.

- Yes, in the software (updates)
- Yes, hardware parts have been upgraded (e.g. new or better components)
- Yes, new hardware has been added
- Only regular maintenance
- Other

36. How many years has your phenotyping system been cutting-edge (enabling you to do latest research) before upgrade/replacement was needed?

Please indicate the number of years.

- Upgrade/replacement after ... years
- So far my system did not need to be upgraded to sustain state-of-art research

37. Please provide some details about upgrades of your phenotyping system. Which parts needed to be upgraded to continue performing cutting-edge research?

You can specify which parts exactly needed to be upgraded.

- Software upgrade
- Sensor upgrade to new
- Sensor replacement
- Automation upgrade (e.g. sensor carrier or conveyor belt)
- Only regular maintenance works have been done
- Details on upgraded part(s):

38. What is the estimated lifespan of your installation (in years) from successful site-acceptance until decommissioning?

Site-acceptance: First successful, fully functional operation of the system on-site.

How many years?

39. Has there been an upgrade plan already included in the system's costs before the initial purchase order?

Yes, the upgrade plan was made for the duration of ... years

For example: An upgrade is planned every 5 years.

No, this has been done subsequently (e.g. after some time)

No upgrade plans were made at all

40. Would you be open for an interview about life cycle assessment of your installation?

Yes (please contact emphasis@fz-juelich.de)

No

41. Which type of training in plant phenotyping would you like to receive?

Basic introduction to plant phenotyping

Specific research topics

Focus on methods

Career opportunities & planning

42. How would you like to receive the training?

Tutorial video

Webinar

Interactive workshop (digital)

Face-to-face workshop

43. How can national, regional or global plant phenotyping networks best support your activities?

Training & education

Networking

Access to phenotyping installations/-platforms

Innovation support

Data access

Funding

Benchmark technologies

Support marketing

News & information

Launch dedicated workshops and/or conferences

Other:

44. Where do you see a major bottleneck for plant phenotyping at the moment?

Platform construction

Image analysis

Data management & usage

Hardware maintenance

Software

Qualified personal

Inter-connection to other disciplines

Funding

Throughput

Flexibility of use (e.g. in different locations)

Other

45. How did you learn about this survey?

- Twitter
- LinkedIn
- Facebook
- EMPHASIS Newsletter
- IPPN Newsletter
- Websites
- Other:

46. Which is your preferred channel to get information on plant phenotyping research, events and new technology?

- Scientific journals
- Websites
- Social media
- Newsletters
- Webinars
- Email

47. Which social media channels do you prefer to get information on plant phenotyping?

- Facebook
- Twitter
- LinkedIn
- Other
- None

48. Is there any service that you would recommend to be provided by plant phenotyping initiatives (e.g. EMPHASIS, IPPN, etc.), which is not yet in place?

49. Feel free to express any further recommendations, constructive criticism, remarks, hints, etc. you would like to address: