IPPN Workshop on Affordable Phenotyping

The high entry-level and maintenance expenses of new sensors and infrastructures are two of the current problems in plant phenotyping, which prevent many research organizations from implementing urgently needed approaches due to lack of investment budget and technical personnel. Therefore, affordable phenotyping concepts and methods need to be disseminated to the wider plant-science and breeding community by identifying demands, increasing awareness, and collecting and sharing available knowledge on suitable solutions.

The IPPN Workshop on Affordable Phenotyping attracted more than forty-five participants and mainly addressed experimental biologists interested in alternative low-cost approaches in different fields of plant phenotyping encompassing controlled environment and field research. Companies also contributed with highlights of products and services related to this field. The workshop included lectures, demonstrations, hands-on activities, and discussions on different topics, including smartphone applications and programming, imaging, multispectral imaging, and field phenotyping methods for roots and shoot. Additionally, there was a breakout discussion with participants about different aspects of the workshop as well as affordable phenotyping approaches and the role of IPPN in promoting further activities in this area.

Summary of the breakout group discussion

1. What was useful and what could be addressed better in future meetings?

- The workshop exposed many participants to new ideas and to considering the value of new types of instrumentation and imaging approaches that can be used in controlled-environment facilities and field conditions.
- The workshop structure included presentations to introduce specific topics and hands-on training to explore selected low cost sensors practically. In general, the participants found the hands-on training very valuable and even more in depth sessions may allow the participants to go into detailed discussion. Additionally, demand for training in data analysis was expressed.
- Due to the diverse background of the participants, more general presentations with detailed background information on different approaches may further help the biologists to understand the technical background (e.g., sensors) and the engineers to appreciate in more detail the research questions of biologists.
- Finally, the workshop gave participants a better understanding of IPPN as an association that aims to link different plant phenotyping aspects and experts from both academia and industry.

2. What can be considered 'affordable phenotyping'?

- A number of definitions for 'affordable phenotyping' addressing aspects of cost-effective and cost-efficient approaches were proposed and discussed by participants:
  - Affordable phenotyping applies to cost-effective methods and tools that allow an increase in access to phenotyping.
  - Affordable vs. accessible is relevant – not only using phenotyping tools but also answering biological questions. In this respect, enabling access to existing platforms can be considered a cost-effective approach.
  - Costs considerations ought to include not only the initial investment but also the desired throughput, measurement quality, data evaluation, and data consumption, that is, the entire pipeline from measurements to data analysis must be taken into account.
  - Focus on relevant measurements and data is a cost-effective approach because not every measurement or data point may be relevant.

3. Future demand and challenges?

- Approaches for root phenotyping or field phenotyping represent a substantial challenge.
- Decision making (decision support systems), particularly in breeding, was regarded as an important practical outcome of phenotyping approaches that must still be developed. Therefore, close interaction between developer and user is important.
- The effective utilization of phenotyping platforms require both researchers and service providers.
- There is competition between researchers and developers for cost-effective ideas and solutions.
- The quality of affordable sensors requires benchmarking these approaches, which is often missing for plant-research purposes.
- There is a demand for the further development of smartphone-based approaches for different purposes, including but not limited to training and education as well as use in inaccessible field scenarios.
- A number of low-cost approaches is widely available, and sharing the experience within the community would help and prevent 'reinventing the wheel'. An online tool to categorize experts and phenotyping methods was considered useful by some participants.
- Interaction with the industry may be useful to identify the requirements of the community and bringing new developments to the market. Additionally, academic users may become testers of new equipment.

- Cost consideration represents a challenge to engineers and programmers in developing new approaches.
- Platforms that address affordable tools:
    - GOSH, Gathering for Open Science Hardware. http://openhardware.science/
    - PhotosynQ as a possible successful platform for bringing new hardware to community. https://photosynq.org/

4. What can IPPN do?

IPPN can support the development within the plant phenotyping community and in particular with respect to affordable phenotyping by:

- increasing interaction between experts from different countries with different and complementary expertise;
- becoming a common platform to share new developments and ideas;
- establishing a platform for reviews of technology, (software, hardware) by experts and users;
- giving an award for the 'phenotyping platform of the year' to encourage development and dissemination;
- continuing to organize networking events such as symposia, workshops, travel awards organized via the existing working group.