



High-throughput plant phenotyping –  
new challenges in data generation

Selecting the right personnel for each task

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## **INTRODUCTION**

Changing from manual phenotyping to automated phenotyping under high-throughput conditions in greenhouses and growth chambers offers many new opportunities to generate data in an amount and quality that until recently seemed impossible. But the implementation of a new technology also poses new challenges and makes demands on the employees handling these systems. The following text will highlight some important topics which should be considered when allocating personnel to new high-throughput phenotyping facilities.

## **QUALIFICATIONS NEEDED**

Here is a list of the qualifications needed for high-throughput phenotyping

1. **Plant logistics:** High-throughput implies large numbers of plants to be seeded, potted, grown, supplied with nutrients and discarded at the end of tests. In many cases plant numbers or pot sizes may increase significantly when high-throughput facilities are implemented. For this reason it must be considered carefully and quantitatively what and who will be necessary to manage and keep the logistics of the facility running. The process may often look much more like agriculture or commercial gardening than like scientific growth of small plant numbers. (Filling 500 pots with 20 kg of soil finally makes 10 tons that need to be handled!) At this point scientific reproducibility and precision meet the almost industrial handling of large plant numbers, and personnel trained in large scale gardening is usually well prepared for such tasks.
2. **Running HTS-screening systems:** While the core of all HTS-systems is the image processing for data acquisition, the Scanalyzer 3-D systems including the control software are mainly big, highly automated machines with many different technical modules (watering unit, conveyor belts, illumination, cameras etc.). All complex technical systems need someone who is in charge of keeping such machinery running. While troubleshooting is the smaller part of the work, a deep insight into the technical functions and the ability to handle the LemnaTec software are necessary to assist the scientists in parameterising the Scanalyzer for their needs. Long-term experience with LemnaTec machines and extended experience with measurement facilities at the particle accelerator at CERN in Geneva have shown that people who know their machines well and work with them continuously over longer periods may more efficiently assist the frequently rotating scientists. The person best trained in the

technical sector needs to enjoy practical work with complex automation technology and also to communicate with the scientists about what they need. Based on these requirements the person responsible will parameterise the system (cameras, watering unit, configurations, etc.), either based on preset configurations or in adjustment to existing configurations, using the convenient LemnaTec configuration wizards. Whenever necessary and implemented, the operator may also develop new configurations, using the expert mode for parameterisation. It is not necessary to be qualified in image analysis programming or data management to fulfill this role.

An employee such as this, answering the questions of daily maintenance and assistance, is also the perfect complementary helper to a LemnaTec hardware service contract, fixing the big and highly specialised issues.

3. **Doing the daily work:** Depending on the size of the system and the integration of conveyor belts, at least one employee may be needed to bring plants to the Scanalyzer, put plants into the system and bring them back to the greenhouses or growth chambers again later. Staff doing this work may come in many cases from the gardening sector. They will surely need training in machine handling and should feel secure when working with computers and technical systems. Nevertheless they do not need in-depth knowledge of mechanics, databases and image analysis as they will work only with predefined and completed configurations I
4. **Image processing and image analysis:** Image analysis is a key aspect of plant phenotyping. To have someone in place with basic knowledge about image processing or who is at least very interested to learn more about it, cannot be wrong. Nevertheless, it is only of minor importance that this member of staff is able to use programming languages to create new image processing algorithms. For customers with the full version, the LemnaLauncher includes a huge toolbox to built up complex image analysis algorithms based on a constantly increasing number of drag and drop tools. The graphic interface does need no programming skills, but a good intellectual understanding of what image analysis can do. However, this part of the work process may relatively easy be outsourced to LemnaTec via service contracts, as new analysis schemes can be quickly developed and tested by a remote service, based on customer-defined analysis targets. Thus it is no basic requirement to have staff with good programming and image analysis skills on location. From the LemnaTec point of view, in high-throughput phenotyping image analysis is a tool, but never the aim of the biological sciences.
5. **Data management:** LemnaTec high-throughput phenotyping systems can generate several terabytes of data per year. To handle, manage and secure such a huge amount of data properly, it is always a great advantage to have a member of staff who takes care for it and assumes responsibility for the valuable electronic information.



Nevertheless, LemnaTec service contracts provide a comprehensive remote service if remote access is possible. But even with LemnaTec doing the software service, it is still important to have someone on site who manages the service requests and is in charge of the required locally set-up hard-and software, e. g. for backups, networks or access questions.

6. **Data analysis:** Often underestimated is the extremely important role of those staff members that have the skills and tools for interpreting the data created by LemnaTec high-throughput systems. While image analysis is mostly intended not only to provide raw data, but also ultimate "meaning", experience has shown that employing a powerful statistical and functional data analysis is in the majority of cases far more efficient in extracting important biological information than further investing in more detailed image analysis. While the LemnaMiner offers various efficient tools for data preprocessing and visualisation, the final data analysis remains the biggest challenge for the scientific biological user. To perform this task, specially trained bioinformation scientists or scientists with similar interests and capabilities are extremely important. These scientists should be skillful in multi-parameter statistical analysis as well as able to communicate with the biological scientists and interested in all parts and stages of data production, from test design and data acquisition to the transformation of biologically important data. Data extraction is a complex scientific task being performed right at the heart of the specific scientific aims of research. Therefore the focus of this work is always on the user side, with LemnaTec assisting by offering general advice.