Zurich-Basel Plant Science Center

PhD Program in Plant Sciences: Crop Phenotyping

Lecturers: Andreas, Hund, Lukas Roth, Jonas Anderegg, Achim Walter, Jörg Leipner
Location: Eschikon Field Station**,** FMG B17.2; vvz.ethz.ch/Vorlesungsverzeichnis
Dates: every Friday in Semester**:**
in person: 23.02.*; 29.02.*; 31.05.2024*
Online: 01.03.; 08.03.; 15.03.; 22.03.; 05.04.; 12.04.; 19.04.; 26.04.; 03.05.; 17.05.; 24.05.2024
Field Day: 21.06.2024*
Time : 08:00 – 12:00
Credit Points: 2 ECTS

Course Description

Crops are exposed to different abiotic stress factors during their development. Adaptation of crops to extreme environmental conditions during the course of the growing season (e.g. cold and heat stress; water-saturated or dry soils) has been achieved by plant breeding in the last century. However, there is enormous potential for optimization by means of modern crop phenotyping. In this course, the most important mechanisms of plant adjustment towards stress will be explained, as well as critical stages identified in which stress affects yield most severely. We will dissect growth and development into three main trait categories which can be related to ideotype concepts:

1. Timing of key stages:
Turning points in the dynamics of numeric measurements which may be related to phenology; e.g., beginning of stem elongation, time point of canopy closure, or the onset of senescence.

2. Quantities at defined time points or periods:
Traits based on numeric measurements; either at a steady state; e.g., canopy temperature between flowering and beginning of senescence; or at well-defined time points; e.g., number of tillers at beginning of stem elongation.

3. Dose-response curves:
Traits that describe developmental responses in dependence of environmental covariates between clearly defined boundary key stages. Dose-response experiments are classically conducted under controlled condition, e.g., the response of leaves to temperature, but may also be conducted in the field, e.g., the response of stem elongation to temperature.
The course will provide a step-by-step training of the most important necessary components of a successful crop phenotyping experiment. It will take place in the field phenotyping platform FIP (kp.ethz.ch/FIP) of the ETH research station in Eschikon. The course will provide basic knowledge in physiology, breeding and management of major crops like wheat and soybean combined with concepts of inheritance, experimental design, crop modelling and the tolerance to abiotic stress. In a combination of lectures, discussions, team-work and hands-on experiments, you will learn to evaluate the performance of different genotypes by means of repeated measurements using a range of different sensors.

The lecture will put a strong focus on hands-on experience for both the handling of plants and sensors as well as coding in R and Python. You will learn how to use passive imaging sensors, like thermal, hyperspectral or RGB cameras but also active sensors like laser scanners and chlorophyll fluorometers. You will set up your own R and Python environment and work on different aspects of the whole crop phenotyping workflow in small expert-teams. Each team will contribute a piece of information to the common phenotyping experiment which will be presented jointly at the final field day in June. At this day, different experts from ETH, Agroscope and Syngenta will provide hands-on experience in the field.

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Course Program / Learning Objectives

- The course aims to get you acquainted with different aspects of crop phenotyping.
- Hands-on-practice: Learn how crops develop throughout the season using wheat as an example. Learn how to apply different sensing technologies to monitor crop development ranging from your own eyes over multi-view imaging to thermal imaging, chlorophyll fluorescence, hyperspectral sensing and laser scanning.
- Basics in agronomy, physiology and plant breeding: Acquire a basic understanding about the major factors affecting the genetic gain for yield and quality parameters.
- Carriers and sensors: Acquire the ability to select the appropriate combination of sensor and carrier system given the targeted traits.
- Feature extraction: Acquire a basic understanding about methods to extract features from images or hyperspectral data.
- Data handling: Know the basics about how to organize measurements and data.
- Statistical processing: Know how use the Breeders' equation and calculate heritability to judge the benefit of modern phenotyping techniques. Know how to generate sophisticated experimental designs and analyze them to improve the heritability of a trait.
- Dynamical modelling: Know how to model the dynamics of growth to characterize the development.
- Modelling dependence on environmental gradients: Know how to link growth and development with environmental factors to determine a crop-specific response pattern.
- Target trait prediction: Get a basic understanding how to use all above inputs to improve the prediction of yield and quality.

Prior Knowledge in plant breeding and the programming language R is a plus.

Number of Participants: 5 PhD students

Individual Performance and Assessment: PhD students will take part in the MSc course 751-4106-00 G Crop Phenotyping. A reduced workload will allow to acquire 2 instead of the 4 ECTS points: Participants enrolled in the PSC are required to i) give a presentation, ii) participate in the group work carried out during the season, and iii) submit one of 5 exercises.