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ISHS

Bridging the World through Horticulture

WORKSHOP: PHENOTYPING FOR HORTICULTURAL CROPS

AUGUST 14, TUESDAY - 14:00-15:30

Phenotypes provide the essential link between genetic information and biological structure and function of a plant dynamically responding to a fluctuating environment. Understanding the plant environment interaction and quantitative assessment of plant phenotype in different environmental scenarios under controlled and field environment is important in basic plant science, in breeding as well as in production measures such as irrigation and fertigation. Within the last decade, genomic data has been becoming easily accessible and a number of crops has been sequenced, yet the phenotypic information is not keeping pace with the explosion in available genomic information. The lack of reliable and available phenotypic data may limit the use of methods needed to identify the associations between phenotypic and genotypic data. This phenotypic gap is a major challenge in biological understanding of plant processes and their translation into practical application. A coordinated effort is required to effectively address this gap by: i) fostering a standardization of phenotyping protocols, ii) establishment of complementary phenotyping facilities that are available for access to the user community, iii) development of data standards to facilitate database searches, data comparisons, and extrapolations.

In this workshop we are aiming at starting a close discussion between phenotyping experts and users from horticulture to learn about the opportunities of plant phenotyping and discuss the needs and requirements of the horticultural community, specifically within the framework of the ESFRI listed project EMPHASIS that aims at developing a pan-European plant phenotyping infrastructure, H2020 funded project EPPN2020 that provides access to plant phenotyping facilities and IPPN as a non-profit association linking plat phenotyping on a global scale. The workshop includes i) presentations about the current status of plant phenotyping and case studies from the horticultural community ii) a discussion how plant phenotyping can contribute to advance horticulture

Program:

- **Key lecture: Plant Phenotyping – technologies, concepts and integration**
  Ulrich Schurr, Jülich, Germany
- **Multi-scale high-throughput phenotyping of an apple tree core collection under water stress condition**
  Jean-Luc Regnard, Montpellier, France
- **Screening Tomato Genotypes Under Combined Water and Nitrogen Stress**
  Joana Machado, Porto, Portugal
- **Discussion about plant phenotyping in horticulture**
  Moderated by Ulrich Schurr, Roland Pieruschka, Jülich, Germany

EMPHASIS

European Plant Phenotyping Network EPPN 2020

International Plant Phenotyping Network IPPN

ABSTRACTS

Key lecture: Plant Phenotyping – technologies, concepts and integration

Ulrich Schurr[1], Sven Fahrner[1], Roland Pieruschka[1]

[1]Forschungszentrum Jülich, Institute for Bio- and Geosciences (IBG), IBG-2: Plant Sciences, Jülich Germany

Plant phenotyping is an essential tool for many applications ranging from functional genomics, to (pre-)breeding, breeding for cultivated plants and analysis of biodiversity. It has developed rapidly into a bottleneck for progress in basic and applied research. Lack of adequate solutions for quantitative analysis of plant architecture and function as well as their interaction with the dynamic and heterogeneous environment hampers progress in basic sciences as well as in breeding-related research. In recent years, significant interdisciplinary approaches have been started to overcome this "phenotyping bottleneck". Techniques were developed to quantify the dynamics and the heterogeneity of plant structure and function as well as of environmental cues. In this presentation we will explain recent results from the phenotyping chain approach specifically focusing on horticultural crops, by which we study the relevance of phenotyping technologies at various scales from the lab to the field in direct experimental approaches and from meta-analysis. The integration of different scales is also a central element of EMPHASIS: the pan-European for Multi-Site Plant Phenotyping And Simulation for Food Security in a Changing Climate, which is developing on the basis of the portfolio of existing national plant phenotyping centers in Europe. Here we will discuss the recent developments since EMPHASIS has been established as a ESFRI project and address the related I3 project EPPN2020 and the international association IPPN.

Key words: Plant phenotyping, phenotyping technology and concepts, EMPHASIS, EPPN2020, IPPN

Multi-scale high-throughput phenotyping of an apple tree core collection under water stress condition

Benoît Pallas[1], Magalie Delalande[1], Aude Coupel-Ledru[1], Frédéric Boudon[12], Jérôme Ngao[3], Sébastien Martinez[1], Sylvie Bluy[1], Evelyne Costes[1], Jean-Luc Regnard[1]

[1]UMR AGAP, Univ. Montpellier, CIRAD, INRA, Montpellier SupAgro, Montpellier, France

[2]CIRAD, UMR AGAP, F-34398 Montpellier, France.

[3] UMR PIAF, Univ. Clermont Auvergne, INRA, 63100 Clermont-Ferrand, France

Large genotypic variation in traits related to plant performance under contrasted environmental conditions has been reported but phenotyping them on large population remains a challenge for trees grown in orchards. We currently investigate or adapt new technologies for phenotyping developmental and adaptive traits in an apple tree core collection composed of more than 1000 individuals and grown under well watered and water stressed conditions. Targeted traits are associated with tree architecture which determines many traits of plant functioning such as light interception efficiency and transpiration, photosynthesis or water use efficiency. At the tree scale, T-LIDAR scans associated with new reconstruction algorithms are used for extracting variables related to the vegetative development (plant leaf area and its spatial distribution; number and length of axes). At the leaf scale, chlorophyll fluorescence has been measured on all the trees of the collection for determining a semi-empirical index (I_{pL} index) previously shown to be a good proxy of photosynthesis activity. Multi-spectral and thermal IR airborne imaging is also carried out in summer in order to compute spectral indices that reveal phenotypic features over the whole field assay. The validity of high-throughput indicators are being assessed at both tree and leaf scales, through in-planta measurements of plant functioning such as architecture digitizing and leaf gas exchanges. Most of the traits collected exhibit a large variability with highly significant effects of water stress and genotype suggesting that methods are relevant for genetic studies. In that context, GWAS analyses are undertaken to identify genomic regions associated to the trait variation. In forthcoming works some of the parameters quantified in this study will be used to complement functional structural plant models for in-silico exploring the interaction between tree architecture and functioning under contrasted environments.

Key words: architecture, photosynthesis, transpiration, T-LIDAR, chlorophyll fluorescence, multi-spectral airborne imaging

Screening Tomato Genotypes Under Combined Water and Nitrogen Stress

Joana Machado[1,2,4], Ep Heuvelink[2], Richard Finkers[3], Marta W. Vasconcelos[4], Susana M.P. Carvalho[1,2*]

[1]GreenUP/CITAB-UP, Faculdade de Ciências da Universidade do Porto, Campus Agrário de Vairão, Rua Padre Armando Quintas 7, 4485-661 Vairão, Portugal.

[2]Horticulture and Product Physiology, Wageningen University, Droevendaalsesteeg 1, 6708 PB Wageningen, The Netherlands

[3]Plant Breeding, Wageningen University, Droevendaalsesteeg 1, 6708 PB Wageningen, The Netherlands

[4]CBQF-Laboratório Associado do Estado, Centro de Biotecnologia e Química Fina, Escola Superior de Biotecnologia, Rua Arquiteto Lobão Vital 172, 4200-374 Porto, Portugal

Despite water and nitrogen (N) being two of the most important factors limiting tomato production, only a few studies have addressed the complex interactions between both abiotic stresses and new insights are required to improve their use efficiency. In this study, we aimed to screen the variation in water and N use efficiency (WUE and NUE) in tomatoes grown under combined stresses. To this end, a greenhouse experiment was conducted with 50 tomato genotypes (encompassing a range of genotypic and phenotypic variability that contains heritage varieties, hybrids, wild accessions, and cv. 'Moneymaker' and 'Microtom' as references). Two-weeks after germination, plants were transferred to pots with 0 to 1.5 mm grade vermiculite and were divided in two groups: (1) control plants that were irrigated to field capacity with complete nutrient solution; and (2) stressed plants that were irrigated to field capacity with an N deficient solution (20% N) and were further subjected to water stress. Control plants were re-watered daily (till substrate field capacity), whereas stressed plants received no more water following transplant. The experiment ended when the stressed plants from each genotype reached 50% of the substrate water capacity. At this time point several morphological and physiological parameters were accessed including: plant height, leaf area, dry weight, stomatal opening (porometer), photosynthetic efficiency (Fv/Fm), chlorophyll, flavonols, anthocyanins, and N indexes (dualex). Plant temperature (thermal camera), leaf curling and N deficiency symptoms were also evaluated. Shoot/root ratio, relative water content, proline and nutrient content were determined. From the final dry weights/N content and the known amounts of water/N supplied, WUE and NUE were estimated. WUE and NUE largely varied between genotypes, offering good prospects for plant breeding. Future work should focus on understanding the morphological, physiological and molecular basis of WUE and NUE.

Keywords: genotypic variation, Solanum lycopersicum, nitrogen use efficiency, water use efficiency