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Ctarts a new Bulgarian center of excellence

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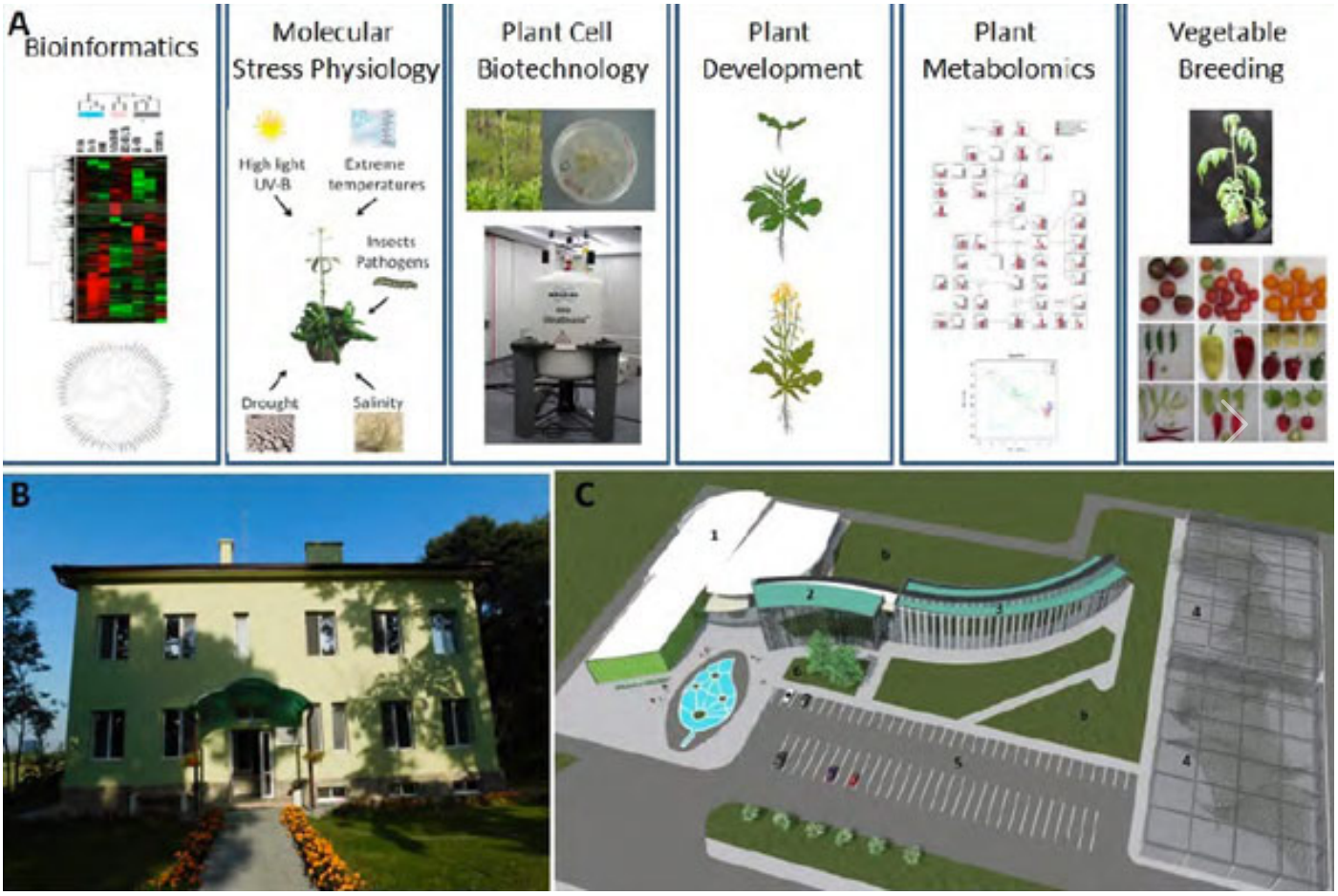

In issue 5/2021 of the journal "Plant Protection" we present the Center of Plant Systems Biology and Biotechnology (CPSBB). The focus is on scientific research in the field of plant systems biology and biotechnology with transformation into practical applications.

The Center of Plant Systems Biology and Biotechnology (CPSBB) is a new scientific organization for cutting-edge research in the field of plant biology. CPSBB combines classical physiological and genetic approaches with modern technologies for genomic and bioinformatics analysis in order to understand how plants respond as integral, complex systems.

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CPSBB was established in Plovdiv (Bulgaria) with the support of the PlantaSYST project under the „Teaming“ financial instrument of the EU Horizon 2020 Programme. The first phase of the project was implemented in 2015–2016 with the main objective to prepare a robust 10-year business plan for the development of CPSBB. During this period the Center was registered as a legal entity in the Plovdiv Court. The second phase of PlantaSYST started in March 2017 with a duration of seven years. The project consortium consists of six research organizations, with the newly established CPSBB acting as the coordinating institution.

The PlantaSYST Consortium

Center of Plant Systems Biology and Biotechnology (CPSBB) with coordinator Tsanko Gechev (Bulgaria).

Maritsa Vegetable Crops Research Institute (VCRI „Maritsa“) with coordinator Dimitrina Kostova (Bulgaria).

Stefan Angelov Institute of Microbiology with coordinator Milen Georgiev (Bulgaria).

Max Planck Institute of Molecular Plant Physiology with coordinator Alisdair Fernie (Germany).

University of Potsdam with coordinator Bernhard Müller-Röber (Germany).

Institute of Molecular Biology and Biotechnologies (IMBB) with coordinator Ivan Minkov (Bulgaria).

Of particular importance in Teaming projects is the support from the so-called advanced partners, in this case two German organizations, namely the University of Potsdam and the Max Planck Institute of Molecular Plant Physiology in Potsdam-Golm.

The grant funding of EUR 15 million provides for the remuneration of staff over the seven years of the PlantaSYST project, the implementation of specializations abroad, as well as the organization of events. At the same time, the Bulgarian government, through the Operational Programme „Science and Education for Smart Growth“ (OP „SESG“), committed additional funding of EUR 15.3 million for the construction of the new CPSBB complex in Plovdiv and for the purchase of state-of-the-art equipment. The co-financing agreement was signed by CPSBB and OP „SESG“ at the end of 2019. Equally important is that Plovdiv Municipality supported the project by providing a plot of 23.5 decares for the new CPSBB building within the city of Plovdiv.

Establishment of a research center

The implementation of the project idea began with the establishment of links between the already participating institutes, recognizing the need to develop a new research center that would catalyze the scientific and

socio-economic development of Plovdiv. The establishment of a new, fully autonomous research organization (administratively and financially) in practice meant enormous groundwork, including administrative work (the CPSBB Statute, basic rules and procedures in compliance with both Bulgarian and European legislation). Achieving autonomy, as one of the most important recommendations of the Teaming programme, was in itself not an easy task, as it does not coincide with the traditional situation in Bulgaria, where research organizations are under the umbrella of the Bulgarian Academy of Sciences or the Agricultural Academy. At the same time, the human capacity of CPSBB (administration, core research, technical and IT staff) had to be developed. For this purpose, the research departments of the Center were established as quickly as possible.

Infrastructure development

CPSBB received a building from the PlantaSYST partner VCRI "Maritsa" (Fig. 1B). This was an important step that enabled the rapid recruitment of research and technical staff and thereby accelerated research and development activities. At the same time, the Bulgarian government recognized CPSBB as a national facility of strategic importance and included it in the National Roadmap for Research Infrastructure (https://www.mon.bg/bg/53), which made it possible to purchase core equipment for the Center. Further infrastructure development is expected in the coming years, when the new CPSBB building will be constructed in the Trakia district of Plovdiv (Fig. 1B, Fig. 2). The building will have a modern administrative wing with offices, a large auditorium and seminar rooms, a laboratory complex, premises for specialized equipment and adjacent greenhouses. The groundbreaking ceremony for the new research complex took place in July 2020, attended by representatives of a number of local organizations and state institutions.

One of the first steps is the selection of human potential

The administrative staff is of primary importance for the management of the Center, as it is involved in establishing the basic rules and procedures, as well as in providing administrative services to the scientific staff. In turn, the scientific and technical staff contribute to the development of the infrastructure and scientific outputs (publications of high scientific value and new joint projects). Many young people work both in the administration and in the research departments.

Currently CPSBB has six research departments – *Bioinformatics and Mathematical Modelling, Molecular Stress Physiology, Plant Cell Biotechnology, Plant Development, Plant Metabolomics, Breeding of Vegetable Crops,* and two service departments – *Funding, Technology Transfer and Intellectual Property Management.* CPSBB is international, strives to recruit the best scientists from all over the world and plans to further expand its human resources after the construction of its new building.

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Scientific activities

The scientific departments of CPSBB conduct joint research with the partner institutions from PlantaSYST in several important areas of plant systems biology and biotechnology. The Bioinformatics and Mathematical Modelling Department provides support to the experimental departments in all major aspects related to the analysis of data sets from the so-called „omics“ approaches (including next-generation sequencing data, e.g. RNA sequencing, ChIP-seq or whole-genome sequencing; metabolomics data for constructing metabolic profiles of primary and secondary metabolites and others). In addition, the Center conducts its own research, e.g. comparative genomics of extremophile plants.

The Molecular Stress Physiology Department investigates how plants utilize their genetic potential to cope with abiotic and oxidative stress. One of CPSBB's research areas is deciphering the molecular mechanisms of tolerance to desiccation and long-term darkness in the resurrection plant Rhodope silivryak (*Haberlea rhodopensis*), using biochemical, physiological and „-omics" approaches (e.g. transcriptomics, metabolomics or lipidomics) (Durgud et al., 2018). Another research direction is the identification of a new gene specific to flowering plants, which plays an important role in the regulation of tolerance to abiotic and oxidative stress (Sujeeth et al., 2020). In collaboration with the Irish company BioAtlantis, scientists from CPSBB and Potsdam are developing an efficient, environmentally friendly technology for molecular priming, whereby a biostimulant derived from algae induces certain plant genes and metabolites with protective functions. The result of this innovative approach is enhanced stress tolerance (Kerchev et al., 2020; Omidbakhshfard et al., 2020). This technology has been successfully tested with model and crop plants [*Arabidopsis thaliana*, tomato (*Solanum lycopersicum*), pepper (*Capsicum annuum*)]. Cooperation with companies is of particular importance for CPSBB, as it links the Center with industry, enables rapid transfer of applied research to end-users (e.g. farmers) and ensures its long-term sustainability. Currently CPSBB has cooperation agreements with five companies. Particularly fruitful is the cooperation with BioAtlantis, which has resulted in several co-authored research papers and the establishment of a new project under the „Horizon 2020“ programme, coordinated by CPSBB.

The Plant Development Department focuses on the effect of adverse environmental conditions (in particular drought) on the development of vegetable crops (e.g. tomato). The emphasis is on the role of transcription factors and their gene regulatory networks, with the aim of unraveling the connections between individual signalling pathways (developmental, hormonal and stress-related).

The Breeding of Vegetable Crops Department, in cooperation with VCRI "Maritsa", works with the vast diversity of Bulgarian pepper and tomato varieties (Nankar et al., 2019). It cooperates with the Plant Metabolomics

Department, which also investigates diversity in tomatoes (Zhu et al., 2018), using spectrometric technologies (Alseekh et al., 2018), as well as with the Plant Cell Biotechnology Department, which has oriented its studies towards pepper (Scossa et al., 2018) and medicinal plants (Scossa et al., 2019).

The main scientific focus of the Plant Cell Biotechnology Department includes the biosynthesis of value-added molecules and the development of biotechnological approaches for their sustainable bioproduction, together with the application of new platforms for comprehensive metabolic profiling [e.g. nuclear magnetic resonance (NMR)-based metabolomics] and biochemometrics (chemometrics combined with anti-inflammatory, immunoregulatory and anti-obesity assays) (Chen et al., 2018; Joshi et al., 2020; Vasileva et al., 2018; Vasileva et al., 2020).

Interactions with the scientific community and with other consortia funded by „Horizon 2020“

CPSBB establishes and maintains fruitful cooperation with numerous partners worldwide. In particular, the leading scientists involved in the so-called International Scientific Advisory Board (ISAB) of the Center provide an independent, objective assessment of activities, which serves as guidance over the years and streamlines research. In addition, CPSBB scientists maintain links with more than fifty research organizations around the world, which is reflected in a number of joint scientific papers and research projects.

PlantaSYST is linked to the other phase 2 Teaming projects through the so-called „Teaming club“. The coordinators of the phase 2 Teaming consortia maintain regular contacts with each other to discuss existing challenges, potential solutions and future opportunities for the development of their research centers.

Two ongoing projects under the „Horizon 2020“ programme include CPSBB partners from PlantaSYST. TomGem, with the participation of VCRI Maritsa and the Max Planck Institute of Molecular Plant Physiology, is developing heat-tolerant tomato varieties and practices for their cultivation. RESIST, with the participation of CPSBB, the Max Planck Institute of Molecular Plant Physiology and the University of Potsdam, deciphers the genomes of drought-tolerant plants and the genetic basis, together with the molecular mechanisms, of drought tolerance in model and crop plants such as tomato and pepper.

Closer to the real world: Partnerships with industry and end-users

CPSBB and other partners in the PlantaSYST project maintain active cooperation with several European companies. Partnership with industry is part of the strategy to ensure the long-term sustainability of the Center and provides direct transformation of fundamental knowledge into practical applications. CPSBB has partnership

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agreements and/or contracts with BioAtlantis Ltd. (Ireland), Huvepharma (Bulgaria), SUBA Seeds (Italy), the Bulgarian Pepper Association and others. Equally important is the contact with end-users, such as vegetable producer associations and farmers, which ensures that the applied research carried out by the PlantaSYST partners meets public demand.

CPSBB already has a joint project under the Horizon 2020 programme with BioAtlantis (project RESIST) and is currently preparing three others in cooperation with companies. Additional opportunities for joint research with academic and industrial partners also exist under the new framework programme „Horizon Europe“, which promotes European and international partnerships. Sharing CPSBB's experience in this area will be beneficial to all other organizations that follow the same strategy.

CPSBB is extremely grateful to all partners in the PlantaSYST consortium for maintaining an excellent working atmosphere and for their assistance, as well as to the members of the International Scientific Advisory Board for their valuable guidance.

The dynamic development of research work at CPSBB is a result of the European funding obtained under the Horizon 2020 programme, project „Establishment of a Center of Plant Systems Biology and Biotechnology for Transfer of Fundamental Research into Sustainable Bio-based Technologies in Bulgaria – PlantaSYST“ (SGA-CSA No. 739582 under FPA No. 664620), Phase 2, as well as the support of the Bulgarian government under the Science and Education for Smart Growth Programme (OP SESG), project BG05M2OP001-1.003-001-C01 – complementary support for research organizations with approved projects under the Horizon 2020 Framework Programme, WIDESPREAD-TEAMING competition, Phase 2, funded by the European Regional Development Fund.