IPK's PhenoSphere brings functional plant science much closer to real field environments

Press Release

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Gatersleben, 19.09.2023 **In research of molecular mechanisms in plants, the suboptimal match of growing conditions hampers the transfer of knowledge gained in controlled environments in glasshouses or climate chambers to field environments. The PhenoSphere, a unique plant cultivation facility at IPK Leibniz Institute designed to simulate field-like environments in a reproducible manner, enables scientists to overcome these limitations. In a first step, IPK researchers compared the effects on plant growth of weather conditions of a single maize growing season and of an averaged season over three years to those of a glasshouse and of four years of field trials. And indeed, in the single season simulation growth and development progression are very similar to that observed in the field. The results have been published in the journal "Nature Communications".**

For fundamental and for application-oriented research there is a need to expose crop plants to relevant field-like conditions in a reproducible manner. "We present IPK's PhenoSphere to the plant science community as a novel tool to study the plant's response to variation in weather variables and other environmental conditions", says Prof. Dr. Thomas Altmann, head of IPK's department "Molecular Genetics". The PhenoSphere enables detailed analyses of performance-related trait expression and causal biological mechanisms in plant populations exposed to weather conditions of current and anticipated future climate scenarios - such as greater drought, higher temperatures and increased CO_2 concentration.

Its technical capabilities overcome several limitations of typical growth chambers and glasshouses. Here, deliberate temperature profiles can be realized with an hourly resolution, light quality and quantity can be manipulated on a minute resolution scale. Clouds can also be simulated via the sophisticated lighting system as well as wind speed and direction can be changed on the sub-hour scale, atmospheric CO_2 levels can be increased. Water and fertilization can be automatically applied daily, and the large-volume containers allow the use of different soil types and compositions and the modulation of the soil temperature. "This will support systems biology analyzes carried out to elucidate molecular mechanisms underlying the expression of agronomically relevant traits. It furthermore enables testing hypotheses derived from different approaches such as network analysis and modelling", says Prof. Dr. Thomas Altmann.

The first results are very promising. Simulating a single maize growing season within the PhenoSphere and using large-volume soil containers resulted in plant growth and development progression that matched the rates that the same population exhibited upon

cultivation in the corresponding field season. “Field grown plants and plants inside the experiment required the same amount of time to reach peak growth speed, maturity of leaves, and tasselling” says Dr. Marc Heuermann, first author of the study. “The correlation between the weather simulation and the outdoor environment concerning temperature, thermal time, and VPD profiles over the cultivation periods was highest when using real days as templates in the single season simulation“, explains Dr. Marc Heuermann. And in any case the single season simulation proved superior to the glasshouse and the averaged season in the PhenoSphere.

The PhenoSphere thus fills the gap between hitherto established controlled-environment phenotyping systems and field phenotyping trials. “The ability of eliciting field-like growth and development in the dynamic but controlled environment of the PhenoSphere is a very substantial and important advance and goes far beyond previous improvements in standard climatized glasshouses cultivation procedures”, says Prof. Dr. Thomas Altmann.

The optimized and validated field-like environment simulation programs can now be used to perform also (seed) yield trials, which require a specific experimental setup and designs fundamentally different from the benchmarking experiments of this study.

Original publication:

Heuermann *et al.* (2023): Natural plant growth and development achieved in the IPK PhenoSphere by dynamic environment simulation. Nature Communications.
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Photo/ Graphic (for free use):

https://ipk-cloud.ipk-gatersleben.de/s/8WbmWwkCqsXWdHK

Field-like environmental conditions can be simulated reproducibly in the IPK PhenoSphere (photo above). For the current study, Marc Heuermann and Gunda Wehrstedt documented the development of the plants (photo below). Photos: IPK Leibniz Institute/ J. Bergstein