This report presents a highly economical and accessible approach to generate a stable discrete relative humidity gradient in a modified multi-well plate for humidity assay of plant-pathogen interactions with good throughput. The device consisted of a freeway channel in the top layer, multiple compartmented wells in the bottom layer, a water source, and a drying agent source. The combinational effects of evaporation, diffusion, and convection were synergized to establish the stable discrete humidity gradient. The device was employed to study visible and molecular disease phenotypes of soybean responding to infection by Phytophthora sojae, an oomycete pathogen, under a set of humidity conditions, with two near-isogenic soybean lines, Williams and Williams 82, which differ for a Phytophthora resistance gene (Rps1-k). The result showed that at 63 % relative humidity, the transcript level of the defense gene GmPR1 was at minimum in the susceptible soybean line Williams and at maximal level in the resistant line Williams 82 following P. sojae CC5C infection. Since the device can be easily made, modified, and operated, it will benefit many laboratories in the areas of seed science, plant pathology, and plant-microbe biology, where humidity is an important factor that influences plant disease infection, establishment, and development.

Also, a high-throughput microfluidic microalgal bioreactor to culture and screen microalge strains growth under different CO2 concentration conditions is reported. This bioreactor consists of a microfluidic microalgae culture platform, a CO2 concentration gradient generator and an optical screening moving stage. A CO2 semipermeable membrane was placed in the middle of two PMMA chips to control mass transport of CO2 and to build a uniform CO2 distribution. To validate the workability of this system, C. reinhardtii strains CC620 were cultured in the developed bioreactor and were screened the increasing rate difference of cell densities under different CO2 concentrations. The system allows for a colorimetric detection as well as transmission measurement. The bioreactor can be extended to multi-application by simply modification. This work showed a promising microfluidic bioreactor for on-line screening based on microalgal culture under different CO2 concentrations. It is believed to have great potential to accelerate the investigation of biorenewable energy.

Furthermore, this report presents an electrophoresis based microfluidic ion nutrient sensor for the detection of anions in soil solution samples. The sensor offers a new capability to analyze concentration of various anions in extracted soil solutions with both high specificity and sensitivity. The electrophoretic microchip integrates a pair of in-plane conductivity detection microelectrodes. A programmable high voltage power supply unit was designed to achieve precise control over voltage potentials needed for sample and buffer injection and ion separation. An electrical conductivity detector was designed to extract and process detection signals for further analysis. Soil solutions were analyzed for ions to evaluate feasibility of using this microfluidic sensor to measure nitrate ion concentration. The occurrence time and magnitude of the detection peaks was also confirmed in simulation. It should be a powerful tool for optimizing nutrient management and for soil health monitoring.