C4 bioenergy grass: Working towards higher productivity under fluctuating light

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C3 and C4 Gas Exchange. Credit: Moonsub Lee/University of Illinois

One of the major challenges the world faces is how to provide

sustainable sources of energy that meet societal needs as the global population continues to grow. Bioenergy crops have garnered increasing attention as a renewable energy source, but their productivity has not yet been fully realized.

In a recent study, published in *GCB Bioenergy*, a team from the University of Illinois evaluated limitations to photosynthetic efficiency of bioenergy grass species during fluctuating light.

Photosynthesis is the natural process that plants use to convert sunlight into energy. Plants fall under two main types of photosynthesis, C3 and C4. The difference between the two types is that C4 plants operate a carbon concentration mechanism (CCM), which increases the CO_2 concentration around the enzyme Rubisco. Because of this CCM, C4 plants tend to have greater water and nitrogen-use efficiency. While it is known that photosynthetic efficiency is reduced during fluctuating light, it remains unknown if C4 plants face greater reductions in efficiency compared to C3 plants.

"We want to know about the response of C3 and C4 plants to fluctuating light because one of the limiting factors field crops experience is changing light due to shading from overlapping leaves, wind or passing clouds, and the sun's changing angle throughout the day," said Moonsub Lee, a postdoctoral researcher at Illinois, who led this work for a research project called Renewable Oil Generated with Ultra-productive Energycane (ROGUE).

ROGUE, which is led by the University of Illinois Urbana-Champaign, is engineering two of the most productive American crops— energycane and Miscanthus—to create an abundant and sustainable supply of oil that can be used to produce biodiesel, biojet fuel, and bioproducts. ROGUE is supported by the Office of Biological and Environmental Research and the U.S. Department of Energy.

The researchers for this project aimed to evaluate the photosynthetic performance of both C3 and C4 bioenergy grass species under steady state and fluctuating light conditions by examining its leaf gas exchange. They studied 12 different bioenergy grass species, six being C3 species and the other six being C4.

"Overall, the C4 species assimilated more carbon than the C3 species during fluctuating light, with both types assimilating about 16% less carbon than expected based on steady state measurements," said Ryan Boyd, a postdoctoral researcher at Illinois for the Realizing Increased Photosynthetic Efficiency (RIPE) project, who also worked on this study for ROGUE. "There was a lot of variability and natural diversity in C4 response to fluctuating light, providing evidence that photosynthetic efficiency in response to fluctuating light could be targeted to increase C4 bioenergy grass productivity."

While there have not been many studies conducted surrounding the topic of C3 and C4 species under changing light conditions, the variations that were found in the results of this study can be used in future plant breeding programs. This leads to the optimism that we can target certain traits in bioenergy grass species, as well as other crops, to improve yields and reduce our nation's dependence on fossil fuels.

"The ultimate goal of the ROGUE project is to engineer these bioenergy grasses to accumulate energy dense fuel molecules and this work is a roadmap for producing the extra photosynthetic energy needed to accomplish that goal," said Don Ort, Robert Emerson Professor in Plant Biology and Crop Sciences, and ROGUE professor and RIPE Deputy Director.

More information: Moon-Sub Lee et al, The photosynthetic response of C 3 and C 4 bioenergy grass species to fluctuating light, *GCB Bioenergy* (2021). DOI: 10.1111/gcbb.12899