Scientists Want to Improve Photosynthesis, but is That a Good Idea?

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"Photosynthesis is the basis for almost all life on Earth, yet it has the potential to use the Sun's energy so much more efficiently," Jackie Hunter, the Chief Executive of the Biotechnology and Biological Sciences Research Council (BBSRC), said in a recent statement. And that's exactly why the BBSRC and the US National Science Foundation funded researchers from Rothamsted Research and Cornell University, respectively, to look into improving this efficiency.

Now, a study recently published in the reputable journal*Nature* details how this collaborative effort has successfully achieved the first stage of improving the life process in a land-based plant.

Photosynthesis is one of the earliest forms of energy production, arising and most likely prompting a key moment in Earth's primordial history called the Great Oxidation Event (GOE) more than two billion years ago.

However, it wasn't complex plant life that prompted the GOE. It has long been suspected that cyanobacteria, the same blue-green algae we see in our oceans today, were the first to get the GOE rolling by belching out dioxide (O2) as they used sunlight and carbon dioxide (CO2) to make energy. And like any great classic, the photosynthetic process of blue-green algae appears to be better than any later versions adapted by plants on land.

That's apparently why scientists have been struggling to slip the cyanobacteria's more efficient photosynthetic mechanisms into the world's most important crops. And according to the new study, they've succeeded. "It was essential to carefully engineer the cyanobacterial genes so that they would be expressed at sufficient levels to support photosynthesis," explained Myat Lin, a researcher at Cornell University.

Lin and his colleagues reportedly used recombinant DNA methods to connect the bacterial DNA to plant DNA sequences. The result allowed bacterial proteins to be produced in plant chloroplasts and successfully assemble into a functional Rubisco enzyme.

The study details how this altered enzyme - which is involved in the first major steps of photosynthesis - works significantly faster to convert CO2 into glucose (energy),

compared to a plant's traditional Rubisco enzyme. And faster energy conversion means greater production and yield.

All The Wheat You Can Eat

That's exactly what the researchers saw in their first crop of genetically enhanced tobacco plants - a proof-of-concept for further work on major crops like corn and wheat.

"We are truly excited about the findings of this study. Wheat yields in the UK in recent years have reached a plateau. In order to increase wheat yields in a sustainable manner in the future, we are looking at a variety of approaches," said Martin Parry, the lead Rothamsted researcher. "The present study has been undertaken in a model plant species and it represents a major milestone. Now we have acquired important knowledge and we can start taking further steps towards our goal of *turbo-charging* photosynthesis in major crops like wheat."

But while a high yield "super-crop" sounds like a boon for wheat farmers, is it really necessary?

Despite its plateau in the United Kingdom (UK), wheat production doesn't appear to be getting outpaced by demand. According to the US Department of Agriculture's (USDA) World Agriculture Outlook Board, consumption of wheat for 2014/2015 has increased by only 3.2 million tons, while overall world production has risen by 3.9 million tons within the same window of time. This is despite the fact that drying in some regions like Australia and the United States has led to a notable drop in production this growing season.

Additionally, researchers recently determined that the Earth's maximum plant production is "roughly two orders of magnitude higher than the productivity of most current managed or natural ecosystems," meaning we have a ways to go before the entire potential for growth maxes out.

That is, at least according to Evan DeLucia, who led an analysis of the "theoretical limit of terrestrial plant productivity," which was recently published in the journal *Environmental Science and Technology.*

Interestingly, the researcher conducted his assessment with both predicted climate change factors and the theoretical maximum potential of photosynthesis in mind. That means that to reach this ideal productivity, the world's plants would all have to have achieved their peak potential through natural selection, or - more likely - genetic editing.

Imagine what his numbers would have been had he taken into account Parry's "turbo-charged" photosynthesis! Global starvation suddenly seems a near-impossibility.

"I don't want to be the guy that says science is going to save the planet and we shouldn't worry about the environmental consequences of agriculture, we shouldn't worry about runaway population growth," DeLucia said in a statement "All I'm saying is that we're underestimating the productive capacity of plants in managed ecosystems."

If it Ain't Broke...

But while some tamer genetically modified organisms (GMO) and genetic editing strategies may be accepted by the scientific community as safe and effective, they might not say so of "turbo-charged" plants.

"Upgrading photosynthesis is a different story," writes Micheal Le Page, an editorial writer for *New Scientist* magazine. "If biologists succeed in boosting it by 25 percent or more, the upgraded plants are going to have a big advantage over their unmodified cousins. And that could spell trouble."

The science journalist argues that while many of the strange traits selected for in GMO crops - like resistance to herbicides - are unlikely to make them a successful invader in the natural environment, supercharging photosynthesis would be like giving steroids to only one team in an entire football league.

If supercharged plants, like the model tobacco plant mentioned above, were to ever accidentally escape from a controlled environment into the wild, they would wreak havoc on ecosystems, out competing even the strongest of natural flora simply because of their remarkable efficiency.

Improved photosynthesis would make these plants more resistant to climate change, too. In drought environments, which are becoming more prevalent in the Northern Hemisphere, they would flourish, as any plant with adequate energy reserved doesn't have to open its pores as much, meaning it can better retain moisture.

Interestingly, Le Page does not seem entirely set against letting improved plants run wild, despite the fact that it would radically alter the natural world.

"This may seem like a shocking idea. But the reality is that we are way, way past the point where we can preserve Earth the way it was before we came to the fore," he writes. "If we are going to reshape plants so that they can make more food, why not do it in a way that benefits most life on Earth, not just us humans?"

It's a novel idea, leveling the playing field by improving all plants, or at least those carefully selected by humanity, but implementing it seems a lot like fantasy, at least for now.