Science AMA Series: I'm Christine Raines, a Professor of Plant Molecular Physiology at the University of Essex. I do research on increasing the efficiency of photosynthesis in wheat. AMA!

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Abstract

Hi reddit! In order to feed a growing population, estimates suggest that world food production must increase by 70% by 2050. Wheat is a major crop grown worldwide and increasing its yields provides an opportunity to meet this demand. My colleagues and I at the University of Essex have worked closely with researchers at Lancaster University and Rothamsted Research to increase wheat yields by improving the efficiency of photosynthesis, where light energy is converted into biomass. We've done this by increasing the expression of an enzyme in the photosynthetic process. We will soon begin field trails at Rothamsted to evaluate the performance of the GM wheat in real world conditions. I'm part of the Sense about Science Plant Science Panel, an online group of over 50 independent plant science researchers. You can ask them any questions to do with plants, food or the environment on Twitter (@senseaboutsci #plantsci) Facebook or via the website. Answers are sent back within a couple of days and posted online. The Panel has answered close to 400 questions over the last three years and it's a great way to cut through the noise around what can often be very polarised debates. I'll be back at noon EST to answer your questions, AMA!

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CHRISTINE_RAINES R/SCIENCE

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What are some common misunderstandings about GMOs that you see as part of the Sense about Science Plant Science Panel? What do you wish the public better understood about your work?

firedrops

GM is a technology that has the potential to enable the introduction of new and beneficial traits that can be used for the production of new crop varieties. I think there is a tendency to talk about all work making use of this technology as though it is aimed at the same traits (characteristic) - this is not the case. e.g. our work is about improving a photosynthesis and is not at all related to work on introducing herbicide or pest resistance to plants.

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Will your research lead to a greater production of wheat/wheat based produce? Or are you observing?

Queentoad1

Our aim is to increase the yield of wheat, that is the amount of grain produced per unit area of land - so yes it is about a greater production of wheat. We do not know at this point if we will achieve this and that is why we are going to carry out the field trial.

Does this improvement in efficiency have any effect on the plant's consumption or production of CO2 or O2?

rslake

Our aim is to improve the process of photosynthesis involved in uptake of CO2 therefore we would expect to see an increase in uptake of CO2, concomitant with this a higher level of O2 is likely to be released. It is possible that respiration in the dark may be increased which could result in a greater release of CO2 but this has not been evident to date in our plants.

I have heard of similar efforts to improve photosynthetic efficiency in other species that focused on different types of modifications, such as transferring a more efficient version of a key enzyme from another plant or from algae or bacteria. Could you give non-plant scientist-friendly explanation of the function of the enzyme you work on, and why increasing its expression helps make the plant more efficient?

neurobeegirl

The enzyme I work on is called sedoheptulose-1,7-bisphosphatase and catalyses a reaction in the part of photosynthesis that takes CO2 from the atmosphere and converts into sugars. Increasing the level of this enzyme (and therefore its activity) has been shown in the greenhouse to increase the rate of CO2 fixation and growth of the plant.

Dear Prof. Raines

I would like to know what role Analytical chemistry plays in your research group? I can imagine in a field such as yours, alot of time goes into sample preparation.

How do you view the chemical characterization tools available? Are they sufficient for your purposes? How do you deal with the uncertainty from these complex analysis machines and methods? And any other interesting insights you would be willing to share!

With best regards!

Rikkid6

Currently there has been no application of analytical chemistry in this particular project. We do use some these approaches in other work in my lab but I am not an expert in this area.

What are the expected downsides to the improved efficiency? (nothing's free in this life!) Will the crop need more water/fertiliser or other inputs?

CharlieKennedy

We have not carried out sufficient studies to be able to answer this question, therefore I cannot rule out the possibility that more inputs may be needed to sustain the extra growth and higher yields. But our goal is to achieve higher yields from the same area of land with no increase in input.

Have you utilized any remote sensing techniques with hyperspectral imagery to look at some of some of the physiological variables on a landscape scale?

Trailbear

Not yet but this would be an option with our field trial this summer.

I read an article recently that said the biggest environmental impact from a loaf of bread comes from the wheat growing process; namely, the application of pesticides. Are you and/or your colleagues doing anything to reduce pesticide use?

When it comes to your upcoming field trials, what hurdles do you expect to face, if any?

marypoppycock

We are not working on pesticide use, clearly it is desirable to have less application of chemicals but our focus for now is on increasing yield.

I am not sure what type of hurdles you mean but at present our concern is likely for favourable weather conditions (e.g. no unseasonal winds or excessive rain) so that our experiment will provide us a good insight into the likely success of our approach.

Are you familiar with "Darwinian Agriculture" by RF Denison? He argues that simple biotech interventions like overexpression of specific enzymes or constitutive expression of defense mechanisms are likely to come with significant energy trade-offs for the plant, because evolution and natural selection try this simple variations all the time. On the other hand, this might be a trade off that makes the plant worse-off fitness-wise, but actually gives us an advantage in agricultural fields, so it might be a trade-off we want.

So, the question is: why do you think this relatively low hanging fruit like the overexpression of an enzyme in the Calvin Cycle was not selected for naturally or by traditional breeding? Do you expect any trade-offs that would make this change untenable in a wild environment?

Thanks to for doing this AMA and to all Sense About Science for the wonderful work they do.

Prosopopea

Yes this question is valid and pops up regularly - my answer has to be that there is a difference between survival in the natural environment and productivity under agricultural conditions. It is likely that over expression of SBPase as in our experiment may well not confer an advantage in the natural environment where there are pests and water shortage.

Are you also investigating controlling environmental factors, by looking indoor farms, where temp., humidity, and intensity of specific wavelengths of light, to improve efficiency?

CurlyHairedFuk

The initial work that has led to this field trial was carried out in controlled environment conditions , but to date we have not manipulated specifically individual environmental parameters.

With the threat posed by climate change, I'm not sure increasing world food production will have any meaningful effect once the climate starts killing large numbers of people. Are there any groups focused on GMO farming to increase carbon sequestration, i.e. high-carbon plants?

NeverEnufWTF

Planting of deforested or unused land could provide an opportunity to increase the carbon sequestration

There were protests at a GM trial in the UK a few years back. Are you expecting similar backlash this time? What have you done to engage with locals/wider public?

CharlieKennedy

We have been completely open about our field trial and how we have made the transgenic plants . We presented this at an open meeting with the press and have been answering questions posed by the media and the public in order to provide as much information as possible. I believe and hope that this will help to allay concerns of many if not all of this opposed to GM.

I imagine that this AMA will be flooded with anti-GMO trolls, so let's get this out of the way: Do you see any potential downside of this research....e.g. superweeds, poisoning the food supply, Triffids???

Nano_Burger

The work we are doing will not result in superweeds nor will it poison the food supply. Our focus is on increasing photosynthesis to increase the production of sugars and grain yield. This is a natural process and the enzyme were are introducing is present in all plants including wheat, all we are doing is increasing the level of this naturally occurring enzyme and hence its activity.

Hello Professor Raines, I would like to ask if the enzyme you propose to overexpress in wheat is related to the recent discovery of possible C4 photosynthesis in this species.

xicocookies

No the enzyme we are over expressing is in the C3 pathway (it is of course also present in C4 plants).

Arable land may become a scarce resource in the future. Could this modified wheat be grown in a hydroponics or aeroponics set-up?

Aximill

Our aim is to be able to use existing arable land so would not be looking to expand the area for wheat

cultivation. it is likely possible to grow wheat hydroponically but I think this would be expensive and not likely as productive as growth in soil.

What does increasing the efficiency of photosynthesis in wheat do to the wheat? Does it increase the yield? Does it develop more resistance to weeds or insects?

EAsham

Increasing photosynthesis is aimed at increase the productivity and yield of grain. This approach will not lead to more resistant plants

I'm an undergraduate who works in a lab dedicated to the study of phytochromes. As they are the sensory molecules that regulate photosynthesis associated gene expression, what role if any do Phytochromes play in your research?

Thanks for taking the time to answer questions and share your work! :)

zultdush

Phytochromes do have a role in light regulated photosynthetic gene expression but we are not working on this aspect.

What's the strategy? C4 wheat?

rudesasquatch

No our strategy is not to introduce the C4 pathway into wheat, although I believe others have this on the agenda. We are increasing the level of one enzyme in the C3 pathway, sedoheptulose-1,7-biphosphatase (SBPase) which we have shown to be limiting for photosynthetic CO2 uptake.

Would it be easier to improve our farming habits- more greenhouses and less open air farming - in order to improve crop output? I imagine that greenhouses could be more water effiencient and in less need of pesticides and herbicides, with the only shortcoming being energy waste.

anglegij

Not sure more greenhouses is the way to go, think of the areas of the world that would need to covered in these buildings. I think GM approaches are only one technology to help with crop production, improvement of farming practises will also play a role, particularly int he developing world.

Is photosynthetic efficiency the rate-limiting factor of grain growth and production? I have heard of plant hormones (eg, gibberelic acid) being used to speed up plant growth, so why not use a"chemical" approach rather than a genetic one?

Hydropos

The first green revolution was entirely dependent on chemical application and although this still has a role to play our focus is on increasing the potential yield of the plant and improvement of photosynthesis is the route to the goal.

Hi,

I am wondering do you think investments into GMO agriculture may result in us reaching a point where we are sufficiently locked into this sort of food production? As a result, would this limit our ability to adapt and implement different methods of agriculture say agroforestry? Finally, what is your opinion on the resilience of GMO crops to external risks such as pathogens and long-term climate change?

AdamBermingham2916

GMO's are only one technology for improving our crops and therefore I do not see us being locked into this technology. I think we need to be careful when we talk about GMO's this is a technology to introduce new traits into plants in a highly specific manner. There is no reason why this technology should impact on the resilience of these plans to pathogens or long term climate change any more that for plants being bred through other approaches.

I see several vocal supporters of agricultural technology getting routinely harassed by activists, activist organizations, and popular charlatans.

Reddit even provides a platform and tools for harassment/propaganda/trashing of scientists, pro ag tech activists, journalists, and plant breeding companies. Mods set up the sites, and ban all dissent through the ban features given to them.

Have you ever been harassed or trolled by anti ag tech folks, and do you feel threatened by them?

factbasedorGTFO

No I have never been threatened or harassed.

Hello Prof. Raines. What is the biggest negative about GMO's? (In this instance crops)

DdeathK

I do not think there is a big negative with GMO's per se.

Is the consumption of a GMO crop connected to any known, even the slighest, dangers at all?

DdeathK

The transgenic wheat from the experiment has not and will not be used for human consumption. I cannot see how this particular manipulation would be dangerous as the plants are already contain this particular enzyme, all we are doing is increasing the amount.