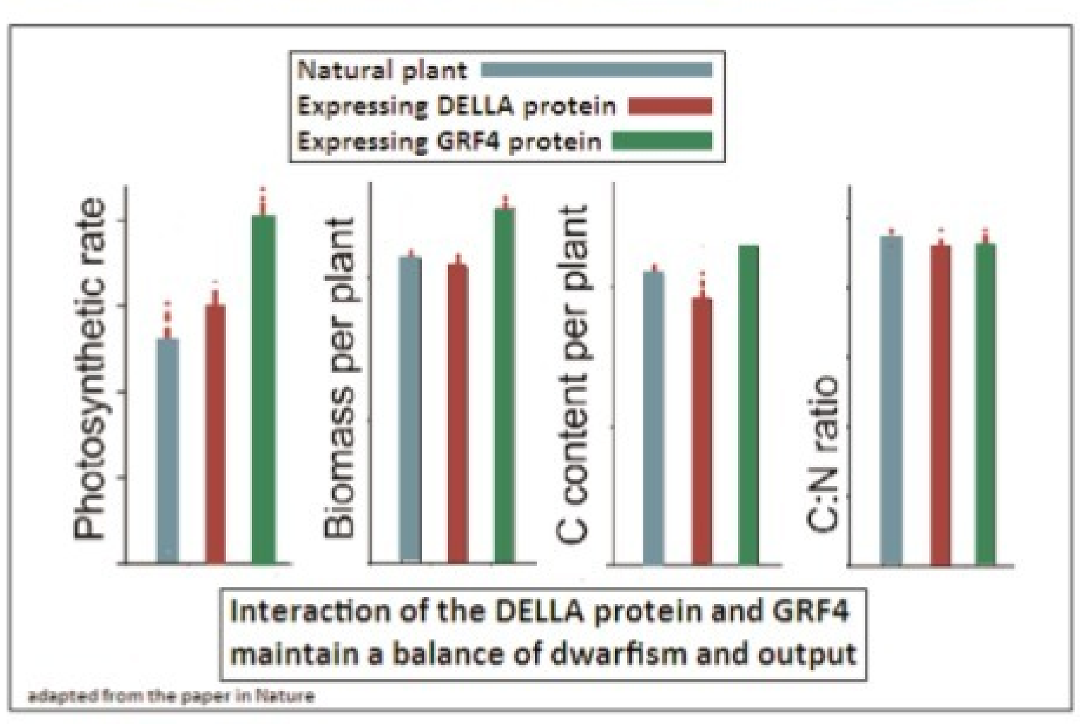
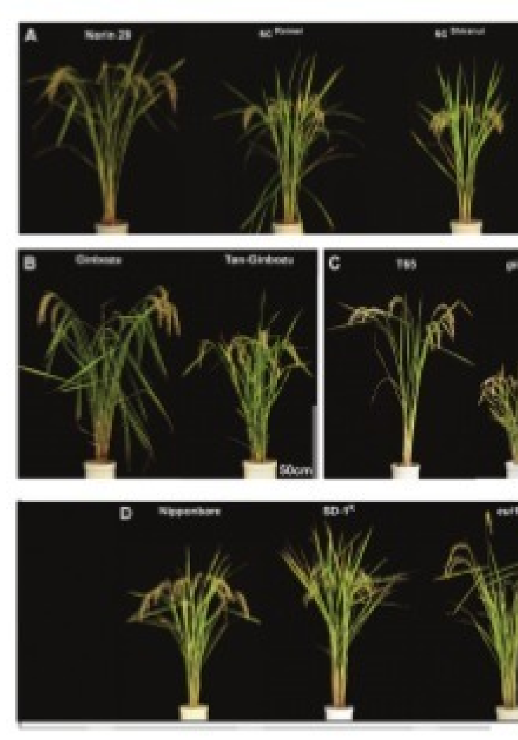
Short and frugal

The changes that helped grow more food led to excessive use of fertilisers but new research could provide a way around the problem





S ANANTHANARAYANAN

Modern ways of agriculture held out a promise of unlimited food to feed growing populations. The boom in produce was mainly through high-yielding varieties of crops and massive input of artificial fertilisers. Of fertilisers, however, both production and the run-off, from fields, are proving an environmental hazard, which would negate the value of the food produced.

Shan Li, Yonghang Tian, Kun Wu, Yafeng Ye, Jianping Yu, Jianqing Zhang, Qian Liu, Mengyun Hu, Hui Li, Yiping Tong, Nicholas P Harberd and Xiangdong Fu, from the Chinese Academy of Sciences, Beijing, Hebei Academy of Agriculture and Forestry Sciences, Shijashuang, China and the University of Oxford, report in the journal, Nature, that there is a relationship between the genetic factors that help a food plant stay short in stature, which helps stability of the plant and its output, and how efficiently the plant assimilates nitrogen from fertiliser. Tinkering with the genetic factors then enables plants to stay short in stature, but still use fertiliser efficiently.

"The Green Revolution of the 1960s boosted crop yields, and was partly driven by widespread adoption of semi-dwarf Green Revolution varieties of cereals", the Nature paper says. The paper explains that semi-dwarfism reduces the flattening of plants by wind and rain, an effect called "lodging", which reduces the grain yield of plants. Semi-dwarfism in plants is because of the growth suppressing protein, Della. As plants need to grow, normal plants have a factor, GA, which suppresses Della. In semi-dwarf and high yielding plants, Della is either resistant to GA or there is low production of GA, the paper says. In both cases, Della is able to accumulate and the plant stays short.

Keeping the height of the plant low is also helped by the plant being relatively insensitive to nitrogen. Della has the effect of reducing the plants' growth response to nitrogen. However, "nitrogen allocation to grain continues," the paper says.

With low nitrogen intake in hybrid plants, there is a need to increase the quantity of fertiliser use, so that supply of nitrogen for grain production is not affected. Fertiliser use, however, damages the environment. The production, both in the form of ammonium salts, which are used in anaerobic crops, like rice, or nitrites, which are used with aerobic crops, like wheat, need huge energy for production.

That is because ordinary nitrogen, which is abundant in the atmosphere, is of no use for vegetation. Ordinary nitrogen is the molecular form, which is exceedingly stable, a leader among inert substances and difficult for plants to use. Useful nitrogen, which is found in fertilisers, is the reactive, "active" kind and it takes energy to prise the nitrogen molecule apart. This apart, most of the fertiliser that is used, is not absorbed by the plant and waste irrigation water contaminates water bodies.

"Development of new Green Revolution varieties that combine high yields with reduced nitrogen supply is thus an urgent goal for global sustainable agriculture," authors of the paper say. They hence set out to analyse how these plants integrated the priorities — low stature, plentiful grain production and low nitrogen inputs.

A survey of different existing and cross-bred rice varieties and analyses of their genetic composition revealed that the intake of the nitrogen-rich ammonium ion, as well as growth, in response to nitrogen supply, was regulated by the protein, GRF4. GRF4 thus counteracts the growth-repressive effect of the Della protein.

Significantly, it was found that GRF4 abundance itself was dependent on low levels of nitrogen. As increasing GRF4 abundance leads to an increase in nitrogen uptake too, this creates a feedback loop — where low levels nitrogen increase GRF4 levels, which increases the nitrogen level, which then restricts the growth of GRF4, leading to a drop in nitrogen levels. A case of "homeostatic coordination of plant nitrogen metabolism", the paper says, "GRF4 is a nitrogen-responsive regulator promoting both ammonia ion uptake and growth in response to nitrogen supply, and counteracting the inhibitory effects of the Della protein."

The group next examined the way that the GRF4-Della protein interaction affected the food producing mechanism — of plants fixing carbon from the air in the presence of sunlight. While GRF4 was found to promote the genes that help photosynthesis, and the Della protein restrained them, it was seen that semi-dwarf, Green Revolution varieties did have higher rates of photosynthesis. The effect of Della to suppress growth was reversed, and more, in varieties with GFR4, while keeping the uptake of carbon and nitrogen in the same balance. And finally, it was seen that GFR4 had the effect of increasing grain yield and the efficiency of nitrogen use.

"Although long thought to exist," the paper says, the study has shown the working of GRF4, which regulates multiple nitrogen metabolism genes, with a self-regulating, nitrogen sensitive, feedback mechanism. With an antagonistic relationship with Della, a growth repressor, there comes into being a coordinated regulation of plant growth and metabolism, the paper says. And then, "increasing the abundance of GRF4 in Green Revolution varieties tips the GRF4-Della balance to favour GRF4, conferring increases in carbon and nitrogen assimilation, biomass, leaf and stem width, but having little effect on plant height. The practical plant breeding consequence of this is that it enables plants to assimilate nutrients without the loss of the beneficial semi-dwarfism conferred by Della accumulation. Nitrogen use economy can thus be improved, without the yield penalties of increased lodging," the paper says.

In the matter of environmental damage, the Stockholm Resilience Centre names phosphorus and nitrogen flows as planetary boundaries that have already been breached. Methods to keep grain production at the levels that we need for the growing world population, without aggravating nitrogen use in agriculture, is a priority.

The writer can be contacted at response@simplescience.in

PLUS POINTS

Not that special

The Earth is "pretty normal" as far as the universe goes and there could be many more planets like our own than we ever realised, according to a new study. The building blocks that helped create our own planet are spread across the universe, the researchers discovered. As such, other planets like our own are probably out there "just waiting to be found", said researchers.

The study is one of the biggest investigations into how other planetary systems are formed and what materials are used, as well as looking at what that might mean for other Earth-like planets elsewhere in the galaxy. Looking for such planets and trying to understand their makeup is difficult because any signals from them are usually completely drowned out by the stars that are near them, the researchers said. So they looked into other ways of examining those planets and examining their composition.

"Most of the building blocks we have looked at in other planetary systems have a composition broadly similar to that of the Earth," said researcher Siyi Xu of the Gemini Observatory in Hawaii. The discovery was made by looking at white dwarfs, stars that have shrunk down to be very small and dense, a fate that awaits our own star in just five billion years.

As they get so small, they pull in other material from nearby. That can then be seen as it moves closer to the star, allowing scientists to explore what the planets that surround it are made of. "White dwarfs' atmospheres are composed of either hydrogen or helium, which give out a pretty clear and clean spectroscopic signal," said Xu, "However, as the star cools, it begins to pull in material from the planets, asteroids, comets and so on, which had been orbiting it, with some forming a dust disk, a little like the rings of Saturn."

Looking through those measurements, scientists found that most of the planets were made up of the same materials that are beneath our feet.

The independent

'Silent epidemic'

Pioneering research, which will help thousands of people across the globe at risk of losing their sight to a "silent epidemic" of eye infections, has been launched at the University of Sheffield.

A multidisciplinary team of scientists and clinicians from the University of Sheffield are working with colleagues at the LV Prasad Eye Institute in Hyderabad to develop a new treatment for eye infections that does not rely on conventional antibiotics — to which many microbes are becoming rapidly resistant.

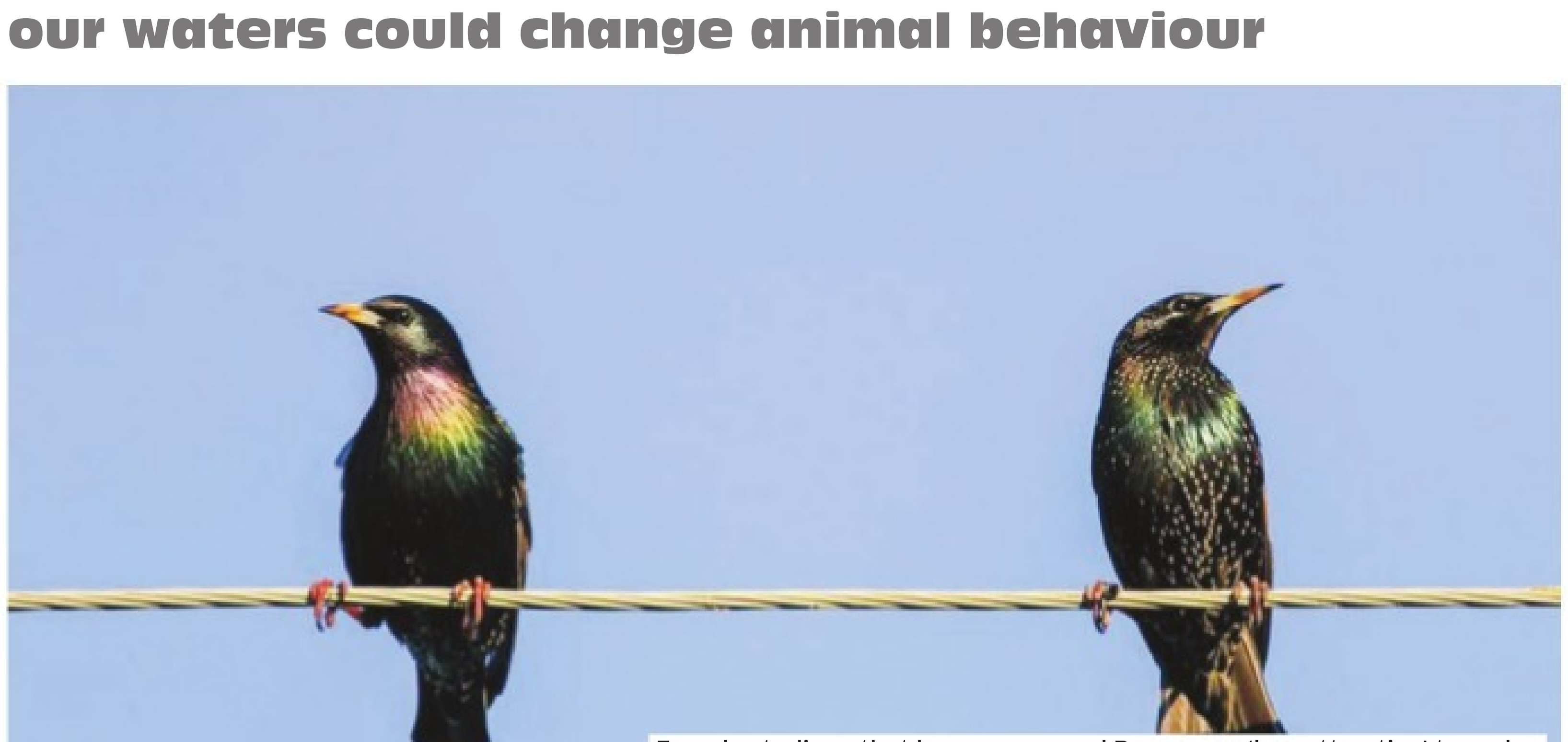
Eye infections can be very serious and lead to the loss of sight. However, in the UK and throughout the developed world, these are readily diagnosed and treated effectively by well-established healthcare systems. In less developed countries such as India, there is both a higher incidence of infections caused by different types of microbes and a critical lack of access to organised care.

Pete Monk from the University of Sheffield's department of infection, immunity and cardiovascular disease, is leading the revolutionary research that has been awarded grants of almost £1.4 million from the Medical Research Council.

"Infections are often treated incorrectly, if at all. This increases sight loss, frequently in men and women in their working years," said Monk, "This 'silent epidemic' affects 840,000 people a year in India. We have identified a way of preventing infections from establishing a foothold on the surface of the eye. The treatment can be applied safely without needing time-consuming and expensive identification of the bacterial or fungal pathogen, allowing it to be used as early as possible in remote rural locations."

Turning to technology

With mental health problems on the rise, more medications are finding their way into rivers and estuaries. Here's how the antidepressants polluting our waters could change animal behaviour



Female starlings that have consumed Prozac are 'less attractive' to males

ALEX FORD

Antidepressants don't just affect human libidos. New research shows that female starlings fed food spiked with the antidepressant fluoxetine (Prozac), were less "attractive" to males and so less likely to mate. This is the latest evidence highlighting the potential harm of the drugs that we are releasing into the environment.

Like many drugs we consume, antidepressants that don't get fully broken down in our bodies are excreted through our urine, from where they find their way to wastewater treatment plants. These facilities don't have the ability to break down the drugs, which then enter our rivers and estuaries, and come into contact with and build up in our wildlife.

With the numbers of young and old people with mental health problems on the rise, and rapid increases in prescriptions of antidepressants and anti-anxiety medications, these problems of water contamination are set to get worse.

We already know quite a lot about the effects of pollution on animal behaviour. We know that chemicals can alter wildlife's aggression, ability to smell, courtship and reaction to stimuli such as light. All these behaviours are critical for animals escaping from predators, finding food and mates, or defending territories.

But most of this data comes from studies in labs. And an animal's behaviour is often very sensitive to its surroundings. So to work out exactly how drug pollution is affecting animals in the wild, my colleagues and I have turned to technology to track, measure and analyse their behaviour.

One of the difficulties with this is that animal behaviour often changes quickly and is hard to record without disturbing the specimens you're trying to monitor, especially in something like a murky river. To take humans as an example, an individual might not be aggressive or anxious all the time. Their behaviour might alter depending on whether they were in a large or contained space, or the time of day.

If you wanted to measure the "feminising effect" of sewage effluent on fish, you could collect some fish upstream and downstream of sewage facility and dissect them. Or you could take blood samples that give you a snapshot of their physiology over time. Alternatively, you could cage an animal downstream of a sewage treatment plant and take similar measurements. But when trying to measure fish behaviour, there is no easy blood test or tissue sample that gives you a snapshot of abnormal behaviour. Caging animals naturally alters their behaviour. This is where technology can help.

For example, tagging animals with GPS markers and following them with satellites has enabled scientists to study the movement of giant blue whales in response to noise, as well as diving in turtles and the migration of birds. These technologies have enabled scientists to determine the new parts of the life histories of remote and endangered species, such as previously unknown migration routes, and how they respond to food, predators and even human disturbances such as shipping.

Previous research in my own lab has shown that crustaceans exposed to antidepressants spend five times more time in the light compared to animals not given drugs. Using infrared cameras and tracking software, we are now optimising our experiments so that we can measure their behaviour in the dark.

The software has enabled us to automatically measure many aspects of the crustaceans' behaviour, such as what activities they undertake, the distance and speed of their movements and the speed and angles of their turns. Before, we would have had to painstakingly watch hours of boring videos of their movements and manually record their specific actions.

Newer software systems now include behaviour-recognition software. For example, if we were studying a rat or mouse, the software would automatically record the time the animal spent grooming, sniffing or eating, to name just a few types of behaviour.

The challenges to come will involve using machine learning algorithms (a form of artificial intelligence) that enable the computer to identify patterns of behaviour we didn't know existed and very subtle behaviours not recognisable to humans. This will help researchers discover unusual types of behaviour caused by pollution.

Our next goal is also to determine whether the effects of antidepressant pollution recording in the lab are also occurring in the wild. Researchers in Sweden have been addressing this very question using sound recordings to track the behaviour of fish exposed to anti-anxiety medication (oxazepam) in a whole lake.

The fish were fitted with acoustic transmitters whose signals were picked up by receivers around the lake that could accurately triangulate the positions of the fish. Interestingly, fish exposed to oxazepam were more bold and ventured further from the edges of the lake, had larger territories and were generally more active. These field results mirrored those gathered in the lab, giving some degree of confidence that lab-based experiments may be providing good information about the effects of drugs in the wild.

In future, we hope the hardware used to track animals will become even smaller so that even tiny invertebrates such as shrimp and snails can have their behaviour monitored. But even now, this technology is already giving us great insight into the behaviour of our wildlife, and providing a worrying indication of the impact of drugs on the environment.

The writer is a professor of biology at the University of Portsmouth, UK. This article first appeared on www.theconversation.com