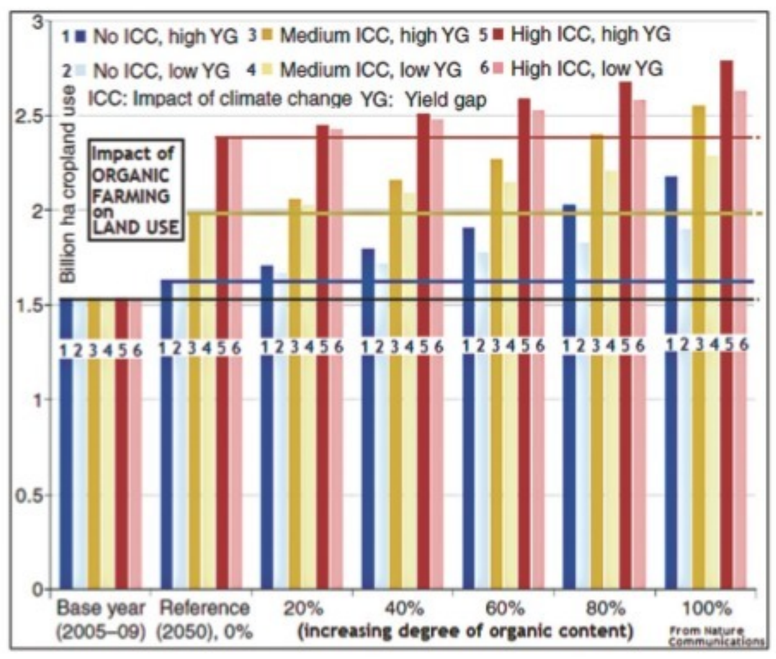
Making the route practical



S ANANTHANARAYANAN

While it is the use of chemical fertiliser and insecticides that has helped agriculture meet demands of rising populations, it is now proving the block to ensuring sufficient food in coming decades. An alternative is to switch to farming without the use of chemicals and relying on natural fertilisers and pest control. Measures like this, however, would call for more land, including land where fodder for livestock is grown, to be brought under cultivation of food grain. And organic farming may still fall short of the quantity of food grain required.

Adrian Muller, Christian Schader, Nadia El-Hage Scialabba, Judith Brüggemann, Anne Isensee, Karl-Heinz Erb, Pete Smith, Peter Klocke, Florian Leiber, Matthias Stolze and Urs Niggli, from institutes of research in agriculture, ecology and environment in Switzerland, Austria, Aber-deen and Potsdam, and the Food and Agriculture Organisation of the United Nations in Rome report in the journal, *Nature Communications*, a comprehensive study of the economy of implementing rising levels of organic farming. While going organic is the way to escape chemical poisoning that conventional farming involves, the paper proposes a strategy to make the organic route practical.

In 1798, Thomas Malthus said that the growth of population was so fast that food production would not keep up with the demand for food. The prediction of food scarcity did not come about, however, because synthetic fertilisers, insecticides and irrigation helped multiply agricultural produce. The world's production of rice and wheat grew ten-fold since 1800 and by a factor of 2.5 since 1950. And the growth of world population, from 1 billion in 1800, to the present 7.6 billion, has been slower than what Malthus feared. But population is expected to rise to 9.6 billion by 2050, and with consumption of food having risen faster than production, whether there would be enough food in the coming decades is still in question.

The problem is that al-though the land under crops has increased, the real driver of high production has been the greater output possible with synthetic fertilisers. In traditional farming, plants convert the sun's energy into food, but only with the help of trace but essential traces, of phosphates, active nitrogen and some others. These agents enable plants to grow naturally in soil through breakdown of organic matter or from the plentiful, inactive nitrogen in the atmosphere by the action of microbes or energetic events like lightning.

As agriculture depletes the soil, these nutrients need to be replenished. This can be done by leaving the land fallow, to regenerate, or by alternating crops or adding manure. Manure, by composting organic matter or the excreta of animals, is rich in active nitrogen and has been a traditional fertiliser. A far richer source of active nitrogen, however, is in the form of chemicals like ammonium phosphate, urea or superphosphate. The content of plant nutrients in these compounds can be 30 per cent by weight, against only 4 per cent in the case of natural fertilisers.

Manufacture of chemical fertiliser became a major industry in the early 20th century and agricultural production rocketed. With the use of fertilisers rose large farms of one sole crop. This prevented natural pest control by a mix of species gro-wing together and created the industry of chemical insecticides. It was only later in that the spotlight turn-ed on the damage done by chemicals in the soil, apart from the coal burned to power factories.

Avoiding waste and changes in dietary habits may pave the way for organic farming becoming a feasible solution

The downside of chemical fertilisers is that they are toxic if not used with plenty of water. And then the run-off water carries excess chemicals to poison ponds, waterways or fresh water sources. The high rate of production also creates imbalance in soil nutrients, calling for a cycle of additives. The Stockholm Resilience Centre has placed biochemical poisoning as one of the nine boundaries of pollution, which the Earth should not cross, and a boundary that active nitrogen discharge has crossed.

The general solutions that are considered are switching to organic farming, releasing land from cultivation of fodder for livestock and avoiding waste or loss of food, which the FAO has found to be 30 to 40 per cent. With urban settlements pressing for expansion and encroachments of forests, finding land for agriculture is a challenge. Change in land use, in fact, is another of the nine planetary boundaries identified by the Stockholm Centre. Studies in the field, however, the *Nature Communications* paper says, have not followed a de-tailed food systems app-roach that accounts for the interplay of the three strategies along the way to assuring a certain calorie intake for the world population. Nor, the paper says, have they "captured the main agronomic characteristics of organic agriculture in a systematic way".

The current study steps in with a software model, which is able to remedy this shortfall by considering the different factors involved in a mix of strategies and evaluating the land use needed to assure sufficient food calories, at different levels of organic farming. The model hence simulates changes in each of the different factors, to picture what happens in different conditions.

The first result is a formal assessment of the land use involved if we were to shift to degrees of organic farming from 20 to 100 per cent. Against the present (2005-2009) land use, at 1.5 billion hectares, the projection for 2050, with no changes in the manner of farming — is an increase to 1.7, 2.0 and 2.3 billion hectares depending on climate change with low, medium or high impact. And then, for higher levels of organic farming, the land use rises to 2.75 billion hectares with 100 organic farming and high climate impact.

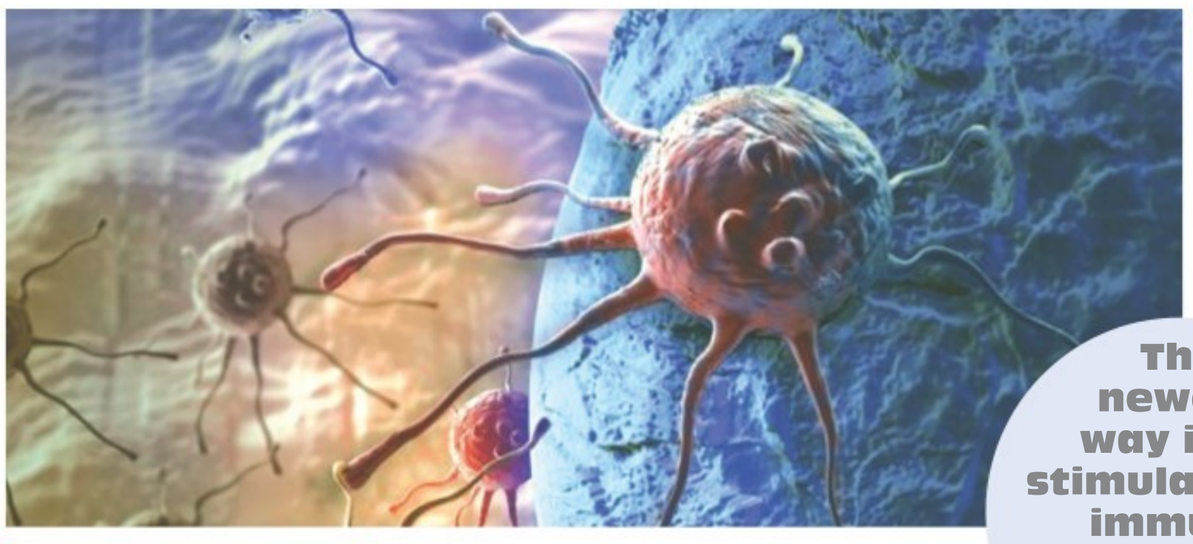
The simulation examined how land use was affected by levels of saving land for livestock fodder for agriculture and by steps to contain waste or loss. The results are displayed in the figure. Under conditions of zero per cent, 25 per cent and 50 per cent waste reduction, and then zero per cent, 50 per cent and 100 per cent reduction of land used for fodder, the percentage change in land required for crops are shown, under different levels of organic farming, according to less and greater impact of climate change.

The boxes with negative figures represent conditions where the land use is less than the reference level. We can see that even 100 per cent organic farming becomes feasible under conditions of medium impact of climate change, 50 per cent reduction of waste and 100 per cent reduction of use for fodder.

As greater organic farming implies improvement first in pollution by active nitrogen and then of the consumption of power and water, this study allows planning for the level of organic farming that is feasible or desirable, while considering the extent of limiting waste or reducing competing demands for use of land. The separate targets, organic yield and production, reducing animal numbers and consumption of animal products and then waste and loss, could hence be implemented in part and in combination, in place of being maximised in isolation, the study says, to help increase the sustainability of the global food system.

The writer can be contacted at *response@simplescience.in*

Beyond traditional cures



TAPAN KUMAR MAITRA

Anyone familiar with the events occurring inside living cells must feel a sense of awe at the complexities involved. Given the vast number of activities that need to be coordinated in every cell, it is not surprising that malfunctions occasionally arise.

Cancer is a prominent example of a disease that arises from such abnormalities in cell function. If current trends continue, almost half the population of the US will eventually develop cancer, making it the second-leading cause of death after cardiovascular disease. Although our understanding of the molecular and genetic defects that lead to cancer is not yet complete, enormous progress has been made in recent years and there is reason to believe that our growing understanding of this dreaded disease will eventually allow it to be brought under control.

People diagnosed with cancer have various treatment options that depend both on the type of cancer involved and how far it has spread. The most common approach involves surgery to remove the primary tumour followed (if necessary) by radiation therapy and/or chemotherapy to destroy any remaining cancer cells.

One problem with drugs and radiation therapy is that they are toxic to normal dividing cells as well as to cancer cells. When cancer arises in a tissue whose growth requires a specific hormone, it may be treated in a less toxic fashion using drugs that block the action of that particular hormone. For example, many breast cancers require estrogen for their growth. Estrogens exert their effects by binding to nuclear receptor proteins that activate the expression of specific genes. The drug tamoxifen, a common treatment for breast cancer, binds to estrogen receptors in place of estrogen and prevents the receptors from being activated.

The use of surgery, radiation, or chemotherapy — either in isolation or in various combinations — can cure or significantly prolong survival times for many types of cancer, especially when the disease is diagnosed early. However, some of the more aggressive cancers (such as those involving the lung, pancreas or liver) are difficult to control in these ways, and current approaches are not very successful with cancers diagnosed in their advanced stages. In trying to find more effective ways to treat such cancers, scientists have been looking for "magic bullets" that selectively seek out and destroy cancer cells without damaging normal cells in the process.

One strategy for introducing such selectivity into cancer treatment is to exploit the ability of the immune system to recognise cancer cells. This approach, called immunotherapy, was first proposed in the 1800s after doctors noticed that tumours occasionally regress in people who develop bacterial infections. Since infections trigger an immune response, subsequent attempts were made to build on this observation by utilising live or dead bacteria to provoke the immune system of cancer patients. Although the approach has not worked as well as initially hoped, some success has been seen with Bacillus Calmette-Guerin — a bacterial strain that does not cause disease but elicits a strong immune response at the site where it is introduced into the body. BCG is useful in treating early stage bladder cancers that are localised to the bladder wall. After the primary tumour has been surgically removed, inserting BCG into the bladder elicits a prolonged activation of immune cells that in turn leads to lower rates of cancer recurrence.

The newest way is to stimulate the immune system to fight cancer

While it demonstrates the potential usefulness of immune stimulation, BCG must be administered directly into the bladder to provoke an immune response at the primary tumour site. To treat cancers that have already metastasised to unknown locations, an immune response must be stimulated wherever cancer cells might have travelled. Normal proteins that the body produces to stimulate the immune system are sometimes useful for this purpose. Interferon alpha and interleukin-2 (IL-2) are two such proteins that have been successfully used as drugs for treating certain types of cancer. Attempts are also underway to develop vaccines that introduce cancer-cell antigens into patients to stimulate the immune system to attack cancer cells.

Another way of using the immune system to fight cancer is with antibodies, which are proteins whose ability to recognise and bind to target molecules with extraordinary specificity makes them ideally suited to serve as agents that selectively attack cancer cells.

Until the early 1980s, the development of new cancer drugs focused largely on agents that disrupt DNA and interfere with cell division. While such drugs are useful in treating cancer, their effectiveness is often limited by toxic effects on normal dividing cells. In the last two decades, the identification of individual genes that are mutated or abnormally expressed in cancer cells has created a new possibility-molecular targeting-in which drugs are designed to specifically target those proteins that are critical to the cancer cell.

One approach for molecular targeting involves the use of monoclonal (pure) antibodies that bind to proteins involved in the signalling pathways that drive cancer cell proliferation. The first antibody to be approved for use in cancer patients, called herceptin, binds to and inactivates the growth factor receptor produced by the ERBB2 gene. About 25 per cent of all breast and ovarian cancers have amplified ERBB2 genes that produce excessive amounts of this receptor. When individuals with such cancers are treated with herceptin, the herceptin antibody binds to the receptor and inhibits its ability to stimulate cell proliferation, thereby slowing or stopping tumour growth.

An alternative way of targeting molecules for inactivation, called rational drug design, involves the laboratory synthesis of small molecule inhibitors that are designed to inactivate specific target proteins. One of the first anti-cancer drugs to be developed in this way was gleevec. It is a small molecule that binds to and inhibits an abnormal tyrosine kinase produced by the BCR-ABL oncogene, which arises from the fusion of two unrelated genes and produces a structurally abnormal tyrosine kinase that represents an ideal drug target because it is produced only by cancer cells. The effectiveness of gleevec as a treatment for early stage myelogenous leukemia is quite striking. More than half of the patients treated with gleevec have no signs of the cancer six months after treatment, a response rate that is 10 times better than that observed with earlier treatments.

Based on the encouraging results obtained with herceptin and gleevec, dozens of other drugs that utilise the principle of molecular targeting are currently under development. Tyrosine kinases and growth factor receptors (the targets for gleevec and herceptin) are just two of many potential targets for such drugs.

The writer is associate professor, head, department of botany, Ananda Mohan College, Kolkata, and also fellow, Botanical Society of Bengal, and can be contacted at *tapanmaitra59@yahoo.co.in*

PLUS POINTS

Healing with sugar

Academics from the University of Sheffield and COMSATS Institute of Information Technology, Lahore, Pakistan have discovered that sugar can, in fact be good for you following breakthrough research.

The research, conducted by the department of materials science and engineering and the School of Clinical Dentistry at the University of Sheffield and the Interdisciplinary Research Centre in Biomedical Materials Research at COMSATS Institute of Information Technology, Lahore, found that sugar can help aid new blood vessel formation, also known as angiogenesis. New blood vessel formation is crucial for wound healing as they carry blood, which ultimately supplies the body with oxygen and nutrients.

The new way of stimulating blood vessel formation with sugar uses a combination of simple and inexpensive sugar added to a hydrogel bandage. This successful method is much more simple and cost-effective than more traditional methods such as adding in expensive short-lived growth factors. The new technique conceived and developed by the collaborative research group, works because a specific group of sugars can stimulate skin healing.

Professor Sheila MacNeil from the department of materials science and engineering at the University of Sheffield said, "Throughout the world, people are living longer and unfortunately experiencing more non-healing skin wounds associated with age, poor blood supply and diabetes. These are often difficult to treat and are very expensive for healthcare systems to manage."

The research has been published in Materials Today Communications in a paper entitled, "Deoxy-sugar releasing biodegradable hydrogels promote angiogenesis and stimulate wound healing" by Muhammad Yar, Lubna Shahzadi, Azra Mehmood, Muhammad Imran Raheem, Sabinian Roman, Aqif Anwar Chaudhry, Ihtesham ur Rehman, CW Ian Douglas and professor Sheila MacNeil.

Did they write them?

Newly-excavated skeletons at a 2,000-year-old site in the West Bank could give clues as to who wrote the Dead Sea Scrolls.

Anthropologist Yossi Nagar, of the Israel Antiquities Authority, said analysis of 33 newly-excavated skeletons buried at Qumran, were in line with a theory that the community consisted of a religious sect of men.

In the past it has been theorised that a community of celibate men lived there at the time the scrolls were placed in the caves near an ancient settlement. It has also been suggested that they may have written or guarded the scrolls, a collection of nearly 1,000 manuscripts, which are the oldest-surviving copies of biblical text.

Around 30 of the skeletons, excavated in 2016, were definitely or most likely males, aged between 20 and 50 — or possibly older — when they died. The skeletons are thought to be approximately 2,200 years old, according to radiocarbon dating, which is around the same age as the scrolls.

"I don't know if these were the people who produced the Qumran region's Dead Sea Scrolls," Nagar said at the annual meeting of the American Schools of Oriental Research, according to Science News, which originally reported the story. "But the high concentration of adult males of various ages buried at Qumran is similar to what has been found at cemeteries connected to Byzantine monasteries," he said.

The scrolls are written in a variety of languages, mostly Hebrew, but also Aramaic, the ancient language believed to be spoken by Jesus Christ.

The Independent

Corrigendum

The map published in last week's Science page with S Ananthanarayanan's article "Unflattering first place" was incorrect. The error is regretted.-

Ed. S.