Smart farming can still do it

CORRECT METHODS ARE FOUND TO RAISE FOODGRAIN YIELDS WITHOUT POLLUTION COSTS, SAYS **S ANANTHANARAYAN**

The great increase in the world's food demands in the last 50 years has been met by technology in farming, but at huge environmental cost. The use of artificial fertilisers has multiplied farm produce and is certainly a good thing, but the trouble is that much of the fertiliser used does not go to the plant and runs off to pollute the land, rivers and groundwater. And the production of fertiliser consumes energy, which leads to emission of CO_2 and global warming.


Fusuo Zhang.

But there is growing consciousness that output comparable with that of aggressive fertiliser use is possible with better cultivation methods and less fertiliser. Fusuo Zhang, of the College of Resources and Environmental Sciences,

Beijing, with others from the same and other institutes in China and also from Stanford, report in the journal *Nature* the findings of a study, over four years (2009-2012) with nearly 20,000 farmers in more than 60 provinces in China. The study was of different farming methods that were implemented in experimental plots, with inputs and output scientifically monitored.

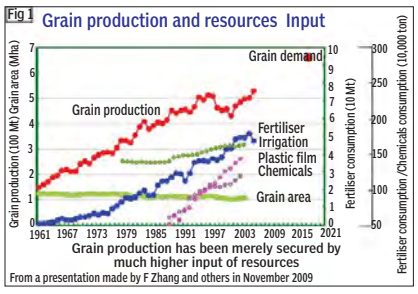
The results, of *Integrated Soil-crop System Management*, as a practical and effective farming technique is called, is found to be much better than traditional farming and almost as productive as resource-intensive farming, but without the environment cost.

What plants need to grow and produce grain is carbon, which is there as CO_2 in the air, water and sunlight, and traces of nitrogen and phosphorus. But these traces are vital. Now nitrogen is also abundantly there, in the air, but this is nitrogen gas, in molecules which are inert and do not take part in any chemical reaction. What is needed for the plant is *reactive nitrogen*, or a form where the two atoms in the stable nitrogen molecule have been pulled apart, through the use of energy, and where the atoms, in the energetic state, are combined with other elements and ready to react again to get to a lower energy level.

This kind of nitrogen is regularly created by energetic events like lightning in thunderstorms and, to a large extent, by microbes in the soil. Or chemicals that release reactive nitrogen can be manufactured through the energy-guzzling industrial process.

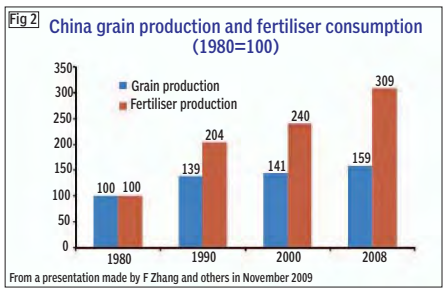
The rapid rise in world population in the middle of the last century created a huge demand for foodgrain, which was met partly by clearing forests to bring land under cultivation, irrigation, pesticides, but mostly by massive inputs of artificial fertiliser. While part of the fertiliser helped boost production, the bulk led to pollution of the land, loss of fish population, respiratory diseases and increased global warming by the release of nitrous oxide, which is worse than CO_2, into the atmosphere. Fig 1 indicates the rise in the use of fertiliser in China since 1960 and Fig 2 brings out the disproportionate rise in fertiliser use since 1980. We can see that for less than 60 per cent rise in food production, there was more than 200 per cent rise in fertiliser use. It was business as usual, while world population and food demand continued to rise in the current century, which was, hence, clearly not sustainable.

Fig 1 Grain production and resources Input



From a presentation made by F Zhang and others in November 2009

Fig 2 China grain production and fertiliser consumption (1980=100)



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High-yielding maize with ISSM practice.


High-yielding rice demonstration plot.

Fig.3 Results of the trials

Crops	Method	Yield tonnes/HA	Nitrogen used tonnes/HS	Rg of grain per kg of N	Nitrogen surplus
Rice	Current	7.2	181	41	58
	Improved	8.1	146	57	7
	Highyield	8.8	192	47	38
	ISSM	8.5	162	54	16
Wheat	Current	7.2	257	28	74
	Improved	8.3	192	44	-9
	Highyield	9.2	283	33	50
	ISSM	8.9	220	41	2
Maize	Current	10.5	266	40	72
	Improved	12.6	214	59	-8
	Highyield	14.4	402	37	140
	ISSM	14.2	256	56	8

Addressing the challenge

The paper in *Nature* describes the four-year-long trials to examine the need for large fertiliser inputs and place on a firm footing alternate farming practices that may be as productive but will cause less damage. The trials consisted of actually trying out four different farming procedures in large scale, realistic conditions with quantitative records, in the main agricultural belts in China in respect of rice, wheat and maize, which account for almost all the grain harvested worldwide. The procedures tested were:

- The normal practice of traditional farmers;
- Improved methods, where science and technology helps overcome limitations of traditional methods, like timing of the use of fertiliser and growing plants closer together to increase yield;
- Intensive farming, where the objective is to maximise yield without considering costs; and
- ISSM, where the use of nutrients, including fertiliser, and water were optimised so that yields could be the best with regard to the least environmental damage, based on the understanding of the relationship of the physiology of the plants and the ecology, the nutrient needs of high-yielding plants and the processes that affected the availability of nutrients to the plant, or their release into the environment.

Detailed surveys were professionally carried out of a vast number of farmers, selected and randomised to accurately reflect actual levels of fertiliser use and grain yield. All published sources were also surveyed, of measures of the proportion of nitrogen lost, including ammonia or nitrous oxide released into the atmosphere, to develop a model of how reactive nitrogen was released into the environment. All kinds of data were then collated, using the relationship between levels of nitrogen released in different ways and sources of nitrogen, and subjected to statistical analyses.

Nitrogen not used, or the *nitrogen surplus*, could be worked out from the difference between what was used and what appeared in the plant that grew. The data showed, the study says, that the release of ammonia into the atmosphere was proportionate to the use of fertiliser, but the nitrogen surplus, release of nitrous oxide into the atmosphere and loss of nitrogen to the land and water increased faster and faster with the increased use of fertiliser.

Based on these relationships arrived at from the field, the team was able to work out the quantity of reactive nitrogen lost to the environment as kilograms per hectare or as kilograms for every tonne of grain yield, for each of the four methods of cultivation considered. And in a similar way, the extent of greenhouse gases, that is CO_2, in the production of fertiliser and in transport, and methane, ammonia and nitrous oxide during plant fertilising and growth, leading to global warming potential per hectare, were also worked out. The findings, in respect of nitrogen use, is contained in Fig 3.

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PLUS POINTS

Proton beam therapy

What is this all about? Proton beam therapy is a form of radiotherapy treatment for cancer involving high-energy protons, which are hydrogen atoms stripped of their electrons. Proton particles penetrate the skin and release much of their energy at the site of the tumour, destroying the capacity of cancer cells to replicate.

What is the difference with conventional radiotherapy? Conventional "external beam" radiotherapy uses X-rays or gamma rays, which are essentially beams of photons rather than protons. The fast-moving and energetic photons

work in the same way as protons by causing breaks in the DNA molecule of cancer cells, which inhibits their ability to replicate. However, the big difference between the two forms of radiotherapy is that protons release about 80 per cent of their energy directly within a tumour, whereas conventional radiotherapy releases energy continually to the healthy tissues on both sides of the tumour.

What is the advantage of proton beam therapy? It all comes down to a part of physics called the "Bragg Peak". A phenomenon of protons is that they can be "programmed" to stop at a specific distance within the body, which is where they will release most of the energy — the Bragg Peak. Conventional radiotherapy beams made of photons continue to release energy before and after passing through the tumour, thereby damaging the healthy tissues of the body and causing more, worse side-effects.

STEVE CONNOR/THE INDEPENDENT

Solar ammonia

Low-energy ways to make ammonia — a vital constituent of fertiliser — could enable developing countries to manufacture their own fertiliser instead of importing it. One such technology published last month in *Science* produces the chemical directly from air, steam and sunlight and could offer an alternative to the conventional Haber-Bosch method. This relies on high temperatures and pressures, and so requires vast

amounts of energy: globally, it consumes more than one per cent of total energy generated each year.

The new method, developed by Stuart Licht of George Washington University in the USA and his colleagues, makes ammonia by bubbling steam into a cheap molten salt mixed with nanoscale iron particles and passing an electric current through. Core to the team's concept is "Solar Thermal Electrochemical Production", a process where sunlight is harvested and used to help power chemical reactions, reducing the need for energy input from other sources. Licht's team has also developed methods for making cement and treating water using Step.

Although their published ammonia production method uses mains electricity, solar energy can in principle provide both the electrical current and heat required. "Step ammonia does not need connection to the electrical grid and hence is suitable for poor and rural areas which have less developed infrastructure," Licht says. He adds that any Step process could be used on a small scale.

Paul Makepeace, a fertiliser specialist at the International Fertilizer Development Center in Nairobi, Kenya, says such an approach "is certainly of interest" in sub-Saharan Africa.

"This method's use and development will depend on its competitive advantage and the ability to deliver manufacturing capacity to African countries where fertiliser is a significant foreign exchange-spend," he says.

But he adds that the Step process "seems like it has a long way to go" to reach commercialisation. Licht concedes that his group is "not geared towards technology spin-out", and says he hopes industry or government will fill that role.

SCIDEV.NET

TICK-BORNE ENCEPHALITIS

TAPAN KUMAR MAITRA EXPLAINS THE GENESIS OF THE VIRUS AS ALSO THE METHODOLOGY OF ANALYSIS AND TREATMENT

The aetiological agent was discovered in 1937 by L Zilber and from a morphology point of view the virus is 25-45 nm in size and passes through bacterial filters. It occurs as inclusions within the nuclei of hippocampus cells. The virus is grown in tissue cultures, in the membranes of chick embryos, and in the body of white mice. The best method of cultivation is animal inoculation.

The aetiological agent of tick-borne encephalitis renders a cytopathogenic effect on the renal tissue cells of pig embryos and on some tissue subcultures. It causes cytoplasm degeneration, pyknosis and destruction of the nuclei.

An increase in RNA content, particularly within the degenerative cells, has been recorded.The glycogen content also increases, glycogen occurring in the form of large amorphous clusters. In the oxidation processes taking place in the cells, succino-dehydrogenase activity increases and cytochrome-oxidase activity decreases.

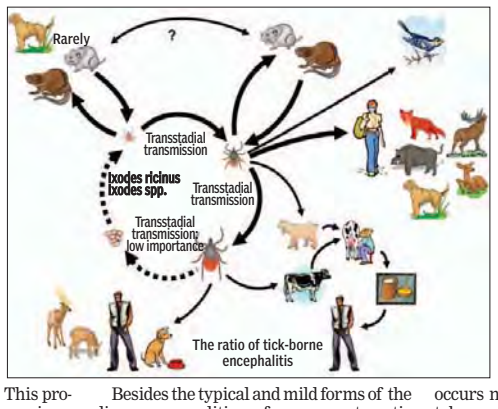
There are several varieties of the tick-borne encephalitis virus that are classed in genus *Flavivirus*. They are all identical in antigenic structure and produce cross immunity. In immunological properties, the virus of tick-borne encephalitis is similar to the Scotch encephalitis virus and other viruses.

As a result of serial passage in laboratories, the tick-borne encephalitis virus loses its pathogenicity to a considerable extent. This property is made use of in preparing vaccines. The virus survives for 70 days in 50 per cent glycerin. A temperature of 60-70° Celsius kills it in 10-15 minutes, a one per cent lysol solution in three minutes, a three per cent lysol solution in two minutes and ether and acetone in three days.

Chipmunks, rodents of the squirrel family, hares, thrushes, hazel-hens and numerous other wild animals and birds that do not contract the disease but are virus carriers of long duration constitute the natural reservoir of the virus. The vectors are the *Ixodes* ticks *(Ixodes persukatus, Ixodes ricinus)* that have been shown to be capable of transovarial transmission. Laboratory mice and monkeys are susceptible to experimental intracerebral, subcutaneous and intranasal inoculation.

Tick-borne encephalitis is a zoonotic disease that is transmitted from animals to man by a tick bite and by milk from virus-contaminated cows and goats. The aetiological agent invades the blood and displays a manifest tropism to the central nervous system (the brain stem nuclei and the anterior horns of the cervical part of the spinal cord). As a result, meningoencephalopoliomyelitis develops. Virusaemia is noted during the acute stage of the disease.

Tick-borne encephalitis is accompanied by fever, somnolence followed by insomnia, sensitivity and motor disturbances, and meningeal manifestations. Complications occur, such as atrophic paralysis of the shoulder and neck muscles. The disease is attended with the development of delayed allergy.



Besides the typical and mild forms of the disease, a condition of an asymptomatic infection leading to the production of immunity is quite often encountered among people. Tick-borne encephalitis patients do not transmit the disease either to people, animals or ticks.

Natural immunity in people is associated with the presence in their body of thermolabile inhibitors and the formation of interferon by the cells. Immunity may also be produced as a result of an asymptomatic infection; this occurs in endemic areas.

Laboratory diagnosis is made by isolating the virus from the blood, performing the neutralisation test on mice and by employing the complement-fixation reaction, the haemagglutination reaction, fluorescent antibodies test and allergic tests. Treatment is accomplished with anti-encephalitic serum that is injected intramuscularly. Specific gamma-globulin is also used.

The disease is characterised by natural nidality. Tick-borne encephalitis control includes early diagnosis, hospitalisation of patients and protection of people from tick bites. Tick extermination is necessary, particularly of those parasitic on domestic animals. Milk must be boiled. Specific prophylaxis is accomplished with a vaccine prepared from tick-borne encephalitis virus passaged on chick embryos or tissue cultures. A good effect is rendered by individual prophylaxis, ie, injection of anti-encephalitic gamma-globulin.

Moreover, what is Japanese Encephalitis virus? Its viral nature was demonstrated in 1934 by M Hayashi and the virus is 40-50 nm in size. In 1938 it was proven that Japanese encephalitis was transmitted by the bites of *Culex* and *Aedes* mosquitoes. Rats, various species of warm-blooded animals and birds of the sparrow family act as reservoirs of the virus. The disease occurs in Japan, Korea, China, Taiwan, the Philippines and the maritime territory of the Far East.

Japanese encephalitis is characterised by deep lesions in the central nervous system, particularly in the brain stem and basal nuclei of the brain. The death rate is very high. It reached 60 per cent in Japan and 25-53 per cent during outbreaks of epidemics in the Far East (maritime territory).

Recovery is followed by a high-grade immunity. No complications in the form of paralysis, which occur in tick-borne encephalitis, are encountered. It has been ascertained that Japanese encephalitis occurs not only in a severe form but may take a mild or asymptomatic course. In the latter case, infection is accompanied by the accumulation of antibodies in the blood of people living in endemic areas.

There is a continuous circulation of the virus among mosquitoes and animals in endemic foci. Mosquitoes are infected with the virus for life. A trans-ovarial mode of virus transmission has been proved. Large quantities of the virus accumulate in the mosquito body at a temperature of 27-30° Celsius. With each bite, the mosquito discharges about 100,000 lethal mouse doses.

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A vaccine for Ebola?

HUMAN TRIALS ARE UNDERWAY FOLLOWING THE SUCCESS OF ANIMAL TESTING BUT SUSTAINED PROTECTION IS COMPLEX, WRITES **ZACHARY DAVIES BOREN**

Scientists may have developed an effective vaccine for the Ebola virus after an experimental immunisation gave monkeys long-term protection from the deadly disease. Human trials for the experimental jab are underway at the National Institutes of Health in the USA, raising the prospect that the vaccine can be used to help resolve the current Ebola crisis in West Africa.

The NIH's monkey studies show that a single dose of the vaccine can trigger fast protection, but the effect waned unless the animals got a booster shot made a different way, according to research published last Sunday. It took the tested monkeys five weeks for the immunisation to take effect — which is in line with most other vaccines.

Partial protection was better than none, said Dr Anthony Fauci, director of the NIH's Allergy and Infectious Diseases division. But the goal was long-lasting protection, and so booster shots were also trialled. The vaccine is made with a chimpanzee cold virus, used as a delivery system for pieces of an Ebola gene. The researchers tried simply giving another dose as a booster two months later, but that didn't work well enough.

They then tried a different approach called "prime-boost". The first dose, to prime the immune system, was that original chimp virus-based Ebola vaccine. But for the booster two months later, they made vaccine a different way — placing the Ebola gene pieces inside a poxvirus that's used to make a vaccine against smallpox. This appears to have worked, with the monkeys staying protected 10 months later.

The World Health Organisation says more than 2,000 people have died of Ebola in the latest outbreak, and the crisis is rapidly deteriorating. It said it would fast-track experimental treatments and vaccines, with the aim of getting results from human trials in November. If the vaccine appears safe and triggers an immune reaction in people, the Who would look to supplying the shots to health workers in West Africa.

Small animal and human safety studies could not guarantee that experimental vaccines really worked in an outbreak, Fauci said. That's why he emphasises public health measures such as isolating the sick, quarantine and, especially for health workers, using personal protection equipment. "Make sure people do what works," he said.

The booster-shot findings illustrate an added complexity to speeding an experimental vaccine into the field. The initial first phase study results would shed light only on that "priming" vaccine made from the chimp cold virus, Fauci said. The poxvirus booster step would be tested later only if scientists decided the initial vaccine was promising enough.

Still, manufacturer GlaxoSmithKline has said it plans to begin manufacturing up to 10,000 doses of the initial NIH-developed vaccine. Canadian researchers created a similar Ebola vaccine that works in monkeys. Manufacturer NewLink Genetics of Ames, Iowa, said first-stage safety testing in healthy volunteers was set to begin in a few weeks.

THE INDEPENDENT