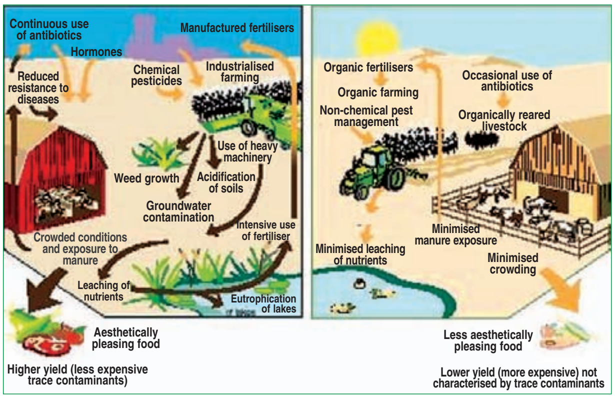
Green light for going green

Farming without ravaging the environment is found to be feasible, says s ananthanarayanan

THE Malthusian prophesy that the population would outstrip food production was "proved wrong" by strides in agriculture through technology. The steam engine, the tractor and, finally, the chemical fertiliser helped create so much food that the problem is now of storage and distribution. But the wheel has come full circle and it is pollution from agriculture that is threatening the atmosphere, the land and water — the demand for food is proving more than the earth can support.

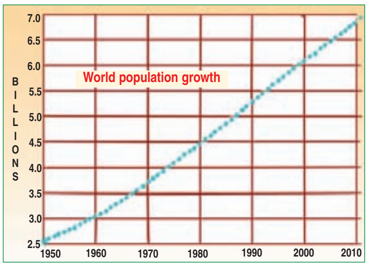
An alternative is farming without the use of chemical fertiliser and pesticides. This practice nurtures the micro-organisms in the soil and conserves water. It also saves the use of petroleum and energy in production of fertilisers. But the yield is not impressive, as with assisted farming, and for this reason it has been feared that such "organic farming" will bring too many hectares under cultivation to provide food for the world's people, and food for livestock. The journal *Nature* last week carried a study that shows organic farming can be almost as productive as the chemically supported kind.



Intensively managed agriculture (left) compared with organic farming (right).

Green revolution

The population explosion of the last century challenged scientists to find new ways to multiply agriculture yield and "eradicate starvation". The response was high-yielding varieties, mechanised farming and massive use of fertilisers. The world population has increased by over four billion since 1950 and without doubt there would have been political and demographic mayhem but for the rise in food production in the same period.



Paul R Ehrlich, in his 1968 book, *The Population Bomb*, has said that "India couldn't possibly feed 200 million more people by 1980" and "hundreds of millions of people will starve to death in spite of any crash programmes". But India managed, because its wheat production rose from 10 million tonnes in the 1960s to 73 million tonnes in 2006. The world grain production rose by 250 per cent between 1950 and 1984 and the average person in the developing world is stated to consume 25 per cent more calories now than before the green revolution.

High-yielding varieties of grain produce more grain per hectare, but they also make great demands on the soil, in the form of nutrients. This has to be provided and sustained through chemical fertiliser — the natural, organic fertiliser, or manure, is too little and not so rich in nitrogen — potassium and other essential elements for plant growth, as the synthetic ammonium or potassium nitrates, "urea", "superphosphate". The synthetic fertilisers contain some 30 per cent by weight of plant nutrients, against only four per cent in the case of natural manures.

Planting high yielding varieties also calls for large surfaces under the same plants — or *monocropping*. This reduces the *biodiversity*, which has a powerful effect of controlling pests and vermin in the region. The same strain planted over a vast tract is then freely attacked by a variety of pathogens and it needs large doses of powerful chemical pesticides. Many secondary plant species, which have been important dietary supplements for the local populace, get wiped out. There is the possibility of pesticide-resistant organisms gaining hold and, again, of the permanent loss, by selection, of valuable traits for nutrition or for survival of the food plants that have evolved over centuries. But the main effect of the fertilisers and pesticides is that the soil rapidly degenerates to simply a holder for the plant, with sunlight, to convert chemical fertiliser into food under the surveillance of chemical pesticides. Another effect is that of pesticides remaining with the seed, if not denaturing the seed, to poison consumers. The runoff of water, rich in chemical fertiliser and pesticide, again pollutes rivers and groundwater.

Organic farming

The reaction to the different side effects of the revolution in assisted grain productivity has been the culture of nurturing native strains, in pockets, with the use of only organic manure and no chemical pesticides. There is an immediate drop in yield, of course, but the practitioners of organic farming are usually idealists and the higher cost of "organic food" is considered a sort of merit, by itself, apart from the evident environmental benefit. The "organicists" also claim better flavour and nutrition features for organic food. This, of course, is without basis — native strains would have a different flavour but not using synthetic fertilisers or pesticides does not make the grain, or fruit, any different in content or nutritional value. But "organic food" has its following and for its kindness to the environment alone it continues to be proposed as a way to go. Organic farming is also kind to the farmer, as it allows small holdings, less investment and, maybe, better prices.

But as it uses up more land for the same output, it is feared that organic farming will be uneconomical and lead to deforestation and consequent loss of biodiversity, which would undermine the very benefits for which it is proposed. Ironically, the root of the problem is that there are so many consumers, or the growing population is not seen as the problem, and it is the solution that is being analysed. And as organic farming is seen to cause environmental damage too, there are many interests that feel there is yet no alternative to farming with chemicals. It is in this context that the report in *Nature*, that organic farming could also have almost as good an output as chemically supported farming, is of interest.

The *Nature* study

A first study of comparative yields of organic and conventional (ie, chemically supported) farming in 2007, reported in the journal, *Renewable Agriculture and Food Systems (formerly, American Journal of Alternative Agriculture*, found that, yes, organic farming was comparable, even superior, to conventional farming. But the study was contested, as having used data from sources that could not qualify as fully organic and also that comparisons made were inappropriate. The study now reported, by Verena Seufert and Navin Ramankutty of McGill University, Montreal, and Jonathan A Foley of the University of Minnesota, has used formal techniques of data analysis, which is appropriate because the data comes from different studies. Accepted standards of organic farming, as defined by certifying bodies, were applied to classify methods of farming and care was taken that comparisons were made within similar conditions of time and place. A survey of studies available worldwide resulted in 66 studies conforming to these criteria. The studies represent 62 study sites and report 316 organic-to-conventional yield comparisons on 34 different crop species.

The results of comparisons are that the organic to conventional yield ratio is 0.75 — ie, that overall organic farming yields are 75 per cent of conventional yields. This average of 75 per cent, however, comes from data that swings from 66 per cent for wheat to 85-95 per cent in the case of maize or soya bean. The ratio goes beyond 100 per cent in cases of legumes and perennials and fruits and oilseeds! One finding of why the ratio varies is that organic farm output depends on, and improves with, the availability of nitrogen during the peak growing period, which is not high with compost or animal manure. The high performance of legumes and perennials is largely due to non-dependence on external nitrogen sources and extended root systems. Another finding is that organic farming does better in weakly acidic or alkaline soils. This may be because stronger acidic or alkaline conditions reduce the availability of phosphorus to the plant, unless supplemented by fertilisers.

The analysis brings out that "organic" and "non-organic" are not exclusive alternatives, but organic farming can do much better when deployed under the best conditions. Another factor affecting yield was found to be the use of "best farming practices". Conventional farming was largely unaffected, but organic farming responded to better management. "Nutrient and pest management in organic systems rely on biological processes to deliver plant nutrients and to control weed and herbivore populations. Organic yields thus depend more on knowledge and good management practices than conventional yields," says the report. The study also finds that in organic farming the yield improves after the first few years — as soil fertility rises and management skills increase.

"...today's organic systems may nearly rival conventional yields in some cases — with particular crop types, growing conditions and management practices… Improvements in management techniques that address factors limiting yields in organic systems and/or the adoption of organic agriculture under those agro-ecological conditions where it performs best may be able to close the gap between organic and conventional yields," the study concludes.

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Enduring extremes for a purpose

sanchez manning reports on 14 researchers who are undergoing four months of freezing darkness ~ all in aid of space travel

LAST Saturday night, Alexander Kumar watched the sun set over Antarctica's dazzling white horizon. The next time he will see it will be in August. The accident and emergency doctor will spend the next four months without as much as a glimmer of natural light in the most inhospitable environment on earth, braving temperatures of -80° Celsius as part of a 14-strong European Space Agency mission that is conducting scientific investigations in preparation for the first manned mission to Mars.

He and his mainly French and Italian colleagues have committed to pushing themselves to the limit of human endurance by remaining on the Concordia Research Station, high on a plateau of Antarctica, for eight months. Shortly before their blackout, Dr Kumar spoke to Jon Spooner, from Unlimited Space Agency. "We're away from friends, family, McDonald's Happy Meals and life as you know it," a heavily bearded Dr Kumar explained via satellite phone. "It really is like living life on Planet Concordia. We suffer from low oxygen levels as well as isolation.

"We're about to enter into the harshest winter the world has to offer. It's an Antarctic winter and temperatures will drop below -80° Celsius — not that it makes that much difference below -20° Celsius for me. On top of that, we have four months of complete darkness."

The extreme conditions being experienced in the name of science by the medic and his crew are said to be the closest human beings have come to living on another planet. As the southernmost point on the globe, Antarctica has no indigenous population and there are few natural resources aside from ice.

Dr Kumar admitted that the impact of the harsh environment on the Concordia researchers' minds and bodies has already been considerable. "Your life cycle that you would have back in England changes," he said. "The second thing is your immune system drops. You're more susceptible to infections."

If Alexander Kumar and his colleagues can cope with winter in Antarctica, it will tell scientists more about whether people can be sent to Mars.

On a personal level, the 28-year-old said he missed the most simple things such as cut grass and more poignant events like family birthdays. But he is still certain that the hardships are more than worth it if their research paves the way to sending people to Mars. "More important is that we've shown that humans can live in such extreme environments," he said. "I hope this shows we can make it to Mars one day."

Dr Kumar, who works in the A&E department at Oxford's John Radcliffe Hospital and specialises in anaesthetics, left for Antarctica in January this year. A seasoned explorer, he cited Captain Scott and Edward Wilson as figures of inspiration. Such is his appetite for adventure, he said, there have been times when his commitment to medicine had been questioned.

"Working at the John Radcliffe emergency department, before I came away, people questioned whether I'm a doctor with the amount of time I spend exploring and adventuring across the world and abroad. Certainly, I have a curiosity and interest in the natural world — but not just the natural world, also the different cultures that exist around the world. I've never had a better time than a day spent with the Inuit in the Arctic," he said.

Asked if he had any advice for adventurers such as himself, he replied, "Never stop dreaming, and never stop believing in your dreams, because dreams have pushed mankind as far as we've gone — whether they've been through the interior of Africa, like Livingstone, or into space, like Neil Armstrong, and on to the surface of the moon."

The Independent, London

The marvel of cell differentiation

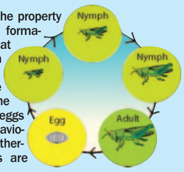
tapan kumar maitra explains the importance of cytoplasmic localisation in development

HOW do the first differences appear between the cells of an early embryo? The cytoplasm of oocytes and other cells contains molecules that influence the activity of the nucleus. Eggs have such substances in their cytoplasm and, in some cases, these are localised in specific regions of the egg. As development proceeds, these substances, called determinants of development, unequally distributed in the cytoplasm of certain groups of cells, then become committed to a particular type of cell differentiation.

Eggs are generally very large cells that stockpile many of the molecules required for early development. For example, a *Xenopus* egg contains about 100,00 times more RNA polymerases, histones, mitochondria and ribosomes than does a normal adult Xenopus somatic cell. One reason for accumulating these readymade materials rather than making them *de novo* during early embryogenesis is that cell division is extraordinarily rapid during cleavage. At the mid-blastula stage, one of the first stages of development, *Xenopus* replicates its DNA every 10 minutes, a process that takes 19 hours in the somatic cells of adults. Similarly, *Drosophila* blastulae double their DNA content in 3.4 minutes.

This rapid pace allows little time for new RNA and protein synthesis, but it is during this period that the first differences between nuclei are established. At least in some cases, these differences result from the presence of the determinants mentioned above. The best example of determinants in development is provided by the germ plasm. Amphibian cells contain in their so-called vegetal (yolky) pole a specialised region of cytoplasm which can be recognised morphologically by the presence of special granules.

This cytoplasm has the property of inducing germ cell formation; ie, those cells that contain the germ plasm will eventually become the germs cells of the new organism. When the posterior poles of the eggs are irradiated with ultraviolet light, sterile (but otherwise normal) animals are obtained. The effect of ultraviolet treatment can be reversed or rescued by injecting cytoplasm containing pole plasm determinants into irradiated eggs.



During nerve cell differentiation in grasshoppers, some divisions result in the formation of a neuron (ganglion cell) and a stem cell (neuroblast) which are always in the same position and morphologically recognisable.

Although determinants are undoubtedly very important in establishing early differences between cells, they cannot entirely explain development. For example, there is no evidence of cytoplasmic localisation in mammalian eggs. Furthermore, as development advances, cell interactions become increasingly important. At the stage of *gastrulation*, extensive cell movements and migrations occur and different types of cells interact with each other in the phenomenon known as *embryonic induction*. Notochord tissue and the optic vesicles (an outgrowth of the brain) induce nearby ectoderm to become the eye lens. These inductions are mediated attempts to isolate them but their chemical nature remains unknown.

It is possible that the same principles involved in the action of egg determinants could also apply to adult cells. At the beginning, we saw that cells contain in their cytoplasm molecules that can reprogramme gene expression. Cells continually exchange information between the nucleus and cytoplasm so that gene products accumulated in the cytoplasm can subsequently modify nuclear activity. If these substances are localised in certain regions of the cytoplasm, upon cell division they can become unequally distributed between daughter cells, giving rise to two different cell types.

How might this occur in adult and embryonic cells? In the differentiation of adult tissues it is frequently observed that only one of the daughter cells becomes specialised; the other remains as a stem cell that is able to divide again. This occurs in red blood cell differentiation and could occur in skin and intestinal epithelium, in which the dividing cells are located in certain regions of the tissue (attached to the basal membrane or at the bottom of the intestinal crypts).

The hypothetical mechanism is supported by experimental evidence. During nerve cell differentiation in grasshoppers, some divisions result in the formation of a neuron (ganglion cell) and a stem cell (neuroblast) which are always in the same position and morphologically recognisable. By introducing a needle at mitosis in one experiment, it was possible to rotate the spindle and chromosomes by 180 degrees, but in spite of this manipulation the resulting daughter cells had the neuron and stem cell in the normal position. This shows that the ability to become a neuron does not depend on a particular chromosome set but rather on the type of cytoplasm inherited by the daughter cell.

The idea that the cytoplasm contains determinants that can become unequally distributed in the daughter cells and affect nuclear activity is by no means new. In the 1896 edition of his classic book, *The Cell in Development and Heredity*, EB Wilson viewed development as follows: If chromatin be the idioplasm (ie, an old term referring to the genes) in which there is the sum total of hereditary forces, and if it be equally distributed at every cell division, how can its mode of action so vary in different cells as to cause diversity of structure (ie, differentiation)? Through the influence of this idioplasm (ie, the genes) the cytoplasm of the egg, or of the blastomeres derived from it, undergoes specific and progressive changes, each change reacting upon the nucleus and thus inciting a new change. These changes differ in different regions of the egg because of pre-existing differences, chemical and physical, in the cytoplasmic structure; and these form the conditions under which the nucleus operates.

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