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If India, why not Africa?

by MN.

AFRICA may be about to get the boost from agricultural technology that has transformed India. Despite abiding difficulties that drive economists and scientists to despair, recent research on some of Africa's crops is beginning to bear fruit.

India was a basket case 20 years ago; now it is self-sufficient in food grains. African food production per head has been falling for 15 years. The green revolution has passed Africa by, not just because of its depressingly well-documented political and administrative problems, nor simply because of economic policies that discriminate against its farmers. The land, the climate and the tardiness of its agricultural research efforts are also to blame.

Africa is, on average, the world's driest continent, but the unpredictability of the rains is as much of a problem as their paucity. Uncertain weather discourages farmers from pursuing green-revolutionary agriculture that requires expensive equipment and materials: better to minimise the investment and thus the risk. India enjoys more regular rainfall and widespread irrigation. Some 30% of its cultivated area is irrigated, compared with only around 5% of Africa's.

Much of sub-Saharan Africa has the red laterite soil that is found in large parts of the subcontinent. In Africa, though, the soil tends to be lower in nutrients, and sandier. Indian soils, which have more clay, retain water better; and India has more of the rich alluvial soil deposited by rivers.

The climate in most of Africa is too tough for rice and wheat. Yet those are the crops on which most of the research carried out in this century has concentrated. India, where wheat and rice grow well, has benefited from decades of background work, and a network of long-established research stations that helped to develop varieties which suit the subcontinent's conditions.

Africa's most successful high-yield crop, SR52 hybrid maize, was developed in Southern Rhodesia (now Zimbabwe) in 1952. Kenya's 600-series of hybrids was developed in 1963. Although, in both countries, the high-yielders were designed for the whites' huge commercial farms, they have spread to smallholdings: more than half of Kenya's smallholders now use hybrid seed and Kenya is exporting the stuff to its neighbours. Maize yields in East Africa now vary from 700 kilos a hectare with traditional varieties on poorly managed farms to 5,000 kilos with traditional varieties plus fertiliser, pesticide and good management, and to 8,000 kilos with well-cared-for hybrids.

Maize is a relatively sensitive plant. A spell of dry weather can finish off its seedlings. During the 1970s a run of good years pushed maize into marginal areas. Then farmers were hit by the droughts of the early 1980s, and are turning back to crops such as sorghum and millet, which give lower, but reasonably assured, yields.

Given the shortcomings of maize, since the mid-1970s researchers have concentrated on squeezing higher yields out of sub-Saharan Africa's main crops—sorghum, millet, and cassava in particular. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India has worked on high-yielding sorghum and millet for semi-arid parts of India, so researchers got to work and tried to introduce those hybrids to Africa.

Initial results were encouraging. Plenty of varieties performed well on research stations; but when they were given to farmers, lower inputs of labour, fertiliser and pesticide brought yields down by 40-60%. So, in 1980, the ICRISAT station in Upper Volta (now Burkina Faso) started a series of controlled trials on farms.

Millet, the African grain best suited to Africa's toughest region, the Sahel, has been a disaster. None of the 2,000 Indian successes did better than the local varieties, which have adapted themselves over centuries to severe weather.

Sorghum looks more promising. Three of the 5,000 Indian varieties tested have shown yield improvements on farms as well as on research stations. They are beginning to spread among farmers, and researchers are trying to produce hybrids of imported high-yielders and tough local varieties that combine the benefits of both.

Nigeria's International Institute for Tropical Agriculture (IITA) claims recent success with cassava. This whiteish root is a major subsistence crop: average consumption per head in Africa is more than 100 kilos a year. Like most African crops, it was introduced by foreigners and in Africa generally yields around two-thirds as much as it does in its native Latin America.

Since 1975 IITA has been trying to produce varieties that would grow well without fertilisers or pesticides. The institute has achieved yields of up to 18 times higher than the yields of traditional varieties. Even on farms, new varieties are doing well. According to a survey of Oyo district, cassava production tripled in 1980-85, partly thanks to IITA varieties.

New types of plants are not enough. As the figures show, good management, fertiliser and pesticides are needed if green-revolutionary varieties are to perform. Governments must provide the roads that make distribution and marketing possible. But the high-yielding varieties that researchers are beginning to come up with at least give Africa a chance to follow India along the road to agricultural prosperity.

Water jets

Unsavage cuts

IF YOU have been hit by a water cannon you will appreciate that water can be used as a tool. But you might be surprised to learn that water can cut three inches of steel or a foot of concrete. "Water-jet cutting" is a small but fast growing business that illustrates many of the features of a technology in the process of turning into an industry. Water jets are used to cut bridges, chocolate bars, aeroplane wings, glass, disposable nappies (diapers), steel, plastics and vegetables.

The technique was invented at the University of Indiana by Mr Norman Franz in 1969. He proved that a stream of water travelling at twice the speed of sound could cut like a knife. It can be made to travel that fast by pressurising it to 50,000 pounds per square inch and squirting it through a hole in a sapphire one-hundredth of an inch wide. By the early 1980s two companies had developed water jet machines reliable enough to sell to industry: Flow Systems of Kent, in Washington state and Ingersoll-Rand, based in Baxter Springs, Kansas. They are now battling to dominate a fast-growing world market.

A water jet unaided can cut only relatively thin or soft material, such as cardboard or a bar of chocolate. But mix into the water (downstream of the sapphire nozzle) a little abrasive material in the form of tiny garnets, and you get a jet that can erode as well as tear and so can eat its way through metal or a composite. It becomes a saw instead of a knife. Unlike saws, though, such abrasive water jets do not fray the edge of the material they cut. Unlike lasers, they do not heat it up. So materials that are hard to cut cleanly—like glass, titanium and especially DuPont's new composite called Kevlar (which is used, for example, in bullet-proof vests and which blunts saws and gives off toxic vapour when cut with lasers)—are natural targets for water jets. Similarly, onions cut with water jets do not make you cry.

The list of advantages goes on. Water jets do not throw up dust—and so can be used to cut asbestos safely—while, at the same time, they avoid wetting the material they cut. This is because they use only small quantities of water (up to a gallon a minute) and move fast enough to leave none behind. They are as dangerous as saws, meaning that they can cut off your fingers, but no more so. The two companies that developed water jets are busy marrying them with robots, so that they can be programmed and can manipulate the material they cut along many axes. This enables them to cut complicated shapes, such as electronic circuit boards.

Two things have slowed down the spread of this technology. One is the cost. Water jets start at about $25,000 and, depending on the frills, range up to $500,000 or more—at least ten times the cost of old-fashioned industrial cutters. This frightens off some conservative customers, such as food processors. But according to both the dominant firms, though, it is mostly ignorance that stands between them and $100m of sales a year. Many potential customers have not heard of water jets, and salesmen have to win over the incredulous with demonstrations.

Flow Systems is the IBM of water jets. It has installed 75% of the 1,300 or so water-jet systems so far working and 85% of those installed outside America. Ingersoll-Rand has built most of the rest, leaving half a dozen small companies, including Japanese, West German and British ones, with the crumbs of a market worth only about $35m a year, but growing at 30% a year. As Mr Matt Boylan of Ingersoll-Rand points out, this is practically the only part of the machine-tool industry where American manufacturers are not reeling from Japanese competition. Mr Dick Wenderborn of Ingersoll-Rand believes the two companies' lead, based on superior knowledge of high-pressure valves and joints, can be maintained. Mr Henry Massenberg, president of Flow Systems, is not so sure.

The biggest markets are in the car and aerospace industries. General Motors uses water jets to cut the wood-fibre substrate it uses on the insides of car doors. Cessna has used water jets to expand its business from its own aircraft to cutting Kevlar and titanium parts for other firms. Flow Systems looks to the food industry and electronics for many of its future customers, while Ingersoll-Rand concentrates on building materials (especially glass) and nappies.

The duopoly is healthily competitive. Ingersoll-Rand stresses quality. Mr Wenderborn believes its intensifiers (the pumps that maintain the pressure) last four times as long and that Flow Systems sells many more spare parts for its machines—which may be a bad sign. Flow Systems, on the other hand, stresses price. Mr Massenberg believes that automation of the production line has cut his production costs to well below those of Ingersoll-Rand. Both companies are investing heavily in research.

One of the ideas they are playing with is a portable water jet to replace the jack hammer or pneumatic drill. These can do as much damage to the surrounding concrete as they do to the ear drums and good temper of passers-by. Replacing the concrete on bridges—as many American states are now finding they must do—is made more difficult by the fact that the vibrations from jack hammers used in repairing bridges do the bridges further damage. A jet of water could cut concrete quietly and without vibrations. Admac, a small company in Seattle, already sells such concrete-cutting mobile water jets, running off engines as well as electric motors, but they are not easily portable.

. . . nor any drop to drink

Deep-sea diving

Dangers lurk

ASTRONAUTS and deep-sea divers are probably the only workers asked to suffer big physiological changes as part of their jobs. The main, and well-recognised, hazards of diving are "the bends" (which is caused when gases in the bloodstream turn into bubbles) and bone necrosis. It is usually possible to avoid "bending" divers by bringing them up from the depths slowly. Bone necrosis involves the death of portions of bone; nobody knows how it is caused. If it is diagnosed during a diver's annual check-up, he is prevented from diving before it gets bad enough to cause symptoms. Although damage to bones is easily spotted by X-ray, some doctors suspect that whatever causes it might also be damaging other tissues that are harder to inspect. This nagging worry turns out to be well-founded.

Last year, 21 North Sea divers had their brains scanned by nuclear-magnetic resonance-imaging equipment at Rogaland Hosscreens and a new, curved sort of keyboard, designed by Mr Sakamura, which he claims will double typing speeds. The systems will handle digital graphics as easily as text. Mr Sakamura complains that present systems are designed only for occidental character sets: TRON machines are happy with a character set 256 times larger.

Other TRONs are on the way. Central-TRON, a networking system for robots, work-stations and minicomputers, is being developed by NTT, Japan's telecoms giant. MTRON is a specification for networking many thousands of personal computers, and aims to end IBM's dominance of large-scale computing (at least in Japan) by eliminating the need for king-size mainframe computers. So far, MTRON exists only in Mr Sakamura's mind.

His specifications for the various TRONs say what each system ought to do and are supposed to guarantee its compatibility with the others. He holds the copyright for these specifications and licenses them out to TRON participants for free. The details of implementation (which are proprietary) are handled through the 18-month-old TRON Association. This has eight "core members" (all Japanese) and nearly 90 others, including IBM Japan and some other foreigners. The Japanese government is not involved.

Twice before in the 1980s Japan tried to develop a computer standard it could call its own. The attempts failed, probably because they were unambitious and did not win the support of the big companies. TRON has already brought them in. Under Mr Sakamura's guidance—as a university man, he is regarded as free of government or corporate affiliations—Japan's eight largest electronics firms have done what governments and the less forward-looking West could not: agreed to a common computer architecture.

Next they have to sell it. Office automation in Japan still lags behind what is happening in America and Europe, so a new system could make headway. It is hard to see TRON making much impact in America, which is too committed to its existing operating systems. But Mr Sakamura has such huge plans—TRON-controlled homes, offices, cars and more—that this might not matter. The eight companies that are developing TRON had combined sales last year of about ¥20 trillion ($150 billion). That gives them a bit of clout. ■

The Nile

A gasping serpent

by MN

CAIRO

WHEN Russian engineers put the final touches to the Aswan high dam in 1971, Egyptian officials claimed that it would shield the country for ever from the fickleness of mother nature. The vast reservoir behind the dam, Lake Nasser, would be Egypt's "everlasting source of prosperity", according to its eponym. Instead, it is drying up and may be Egypt's ruin.

Ethiopia's rainfall is unlikely to return to normal this year. Unless it does, the Blue Nile—which rises in the Ethiopian highlands—will not replenish Lake Nasser. Without enough water from the Nile, Egypt's ambitious desert-reclamation programme may peter out and Egyptian agriculture go into decline.

Egypt has long been complacent about the Nile. Only recently have the authorities realised the danger that drought elsewhere could pose for Lake Nasser, which regulates the Nile's flow through Egypt and generates up to 40% of the nation's power. Drought in the river's source regions is causing a drop in the river's rate of flow. And without an effective water-conservation programme in Egypt, the level of Lake Nasser has fallen sharply in recent years.

According to a report just submitted to the World Bank by a British engineering consultancy, Sir Murdoch Macdonald and Partners, things are more complex than they seemed last December, when the Egyptian government first admitted that Egypt was running out of water. Drought in the Ethiopian highlands and the resulting decline in flow of the Blue Nile is not the only problem. It is compounded by a decline in the flow rate of the White Nile out of Lake Victoria in East Africa, and overuse of the Nile's water to reclaim Egypt's desert.

From 1912 to the early 1960s the Blue Nile brought on average 54 billion cubic metres of water a year to the confluence of the two Niles at Khartoum. Over the same period the White Nile provided 26 billion cubic metres a year. By 1986 the flow from the Blue Nile had dropped to 46 billion cubic metres, while the White Nile's increased to 34 billion.

The Blue Nile's decline was balanced by the White Nile's increase. The level of Lake Nasser stayed roughly constant and Egypt's authorities were unconcerned. But the Macdonald study shows that there was no connection between the Blue Nile's rise and the White Nile's fall. It was simply a coincidence that Ethiopia suffered drought and the rains in Kenya and Uganda had been above normal—leading to a rise in Lake Victoria of about two metres above pre-1961 averages.

Lake Victoria is now back to its pre-1961 levels; the White Nile's compensatory flow into Lake Nasser has stopped; and the Blue Nile's flow is as low as ever. By the beginning of July the Aswan Dam turbines will be producing only half of their usual 1,000 gigawatt-hours per month. Unless substantial rains fall in Ethiopia during the July-August rainy season to refill Lake Nasser—and they have not yet done so in the 1980s—the outlook for Egypt is bleak at best. The study predicts that by the end of July the level of Lake Nasser will have fallen to its "dead" storage level—the point at which no more water can flow through the hydroelectric turbines.

The latest measurements suggest that there are only 6 billion cubic metres left of the 110 billion cubic metres of live storage water expected in a good year. And the lake's level is rapidly dwindling to the critical point, between live and dead storage levels, at which the turbines must switch off to avoid damage to the blades from sediments in the water.

Without power from Aswan, Egypt will either have to look elsewhere for up to 40% of its electricity or else go without. Power cuts are already fairly common, both in Cairo and in the countryside and provincial cities. The effect of a water shortage on Egypt's agriculture would be scarcely less damaging. If the Nile were to behave this year as it did last year, up to half of Egypt's agricultural production could be lost. The problem could be alleviated by using water in dead storage—but that would mean no electricity. Rice production has already been cut.

It is hard to see how Egypt's ambitious

Pharaoh's dreams are getting worse

desert-reclamation programme can continue. The country already has 6.5m acres under irrigation, using 49.5 billion cubic metres of water each year. The plan is to extend this by a further 1.5m acres by 1997, which would require an extra 8 billion cubic metres of water each year. The plan, which is partially sponsored by American aid and the United Nations Development Programme, is to provide some of this from ground-water resources and some from re-used irrigation water.

Unfortunately Egypt does not have enough water to supply its existing irrigated acreage. It has been exceeding—by 2 billion cubic metres—its agreement with Sudan to take a maximum of 55.5 billion cubic metres of water per year from the river for the programme.

According to officials in the ministry of public works and water resources, the government is trying to step up water conservation by making more use of ground water and drip-irrigation and using fewer hydroelectric turbines. Not before time, according to most experts. The drying out of the region may not be just part of a drought/flood cycle. Many argue—tentatively, since it cannot yet be proved—that it is the result of a gradual change in the world's climate, caused by the accumulation of carbon dioxide and other gases in the atmosphere—the so-called "greenhouse effect". This effect, the theory goes, may be exaggerating the temperature differentials between the northern and southern hemispheres, warming up southern oceans more.

This could lead to long-term changes in Africa's rainfall patterns. Some claim that the rainfall belt which should provide rain for the Sahel, in West Africa, is not penetrating as far north as it once did. If the greenhouse effect is playing a similar role in East Africa, the Ethiopian sources of the Blue Nile could be dry for a long time to come.

Artificial antibodies

Nothing to lose but their chains

PROTEIN engineering—the design of useful proteins in the laboratory—may have found its Henry Ford. Until now, it has been a makeshift business, using different tools for each product. A new system granted an American patent in November may usher in something like the assembly line. Unlike Ford's innovation, it will not do away with product diversity to win economies of scale. It should increase both.

At present, genetically engineered proteins are mostly hand-crafted. The gene which describes the protein is isolated; then cell cultures are coerced into producing it; then the protein is harvested. Antibodies and other large, complex proteins are particularly difficult. Because they are made up of more than one chain of amino acids, it takes more than one gene to describe them. To make sure that they are put together correctly, they have to be made in cultures of cells taken from mammals. These are much more finnicky than the simple bacteria used for other proteins.

A second problem with large proteins is that they tend to do more than one thing. What a protein can do depends on its shape, and large proteins have more complicated shapes, by and large, than smaller ones. If you want only one function, a genetically engineered copy of the whole thing is unnecessary. It may even cause trouble.

These two problems slow the development of new compounds, lengthen the time needed to take a product from laboratory to market, and drive up its cost. Genex, a biotechnology company in Gaithersburg, Maryland, seems to have a solution to some of the problems. Its scientists have devised a computer-assisted way to help write one-gene recipes for complex proteins.

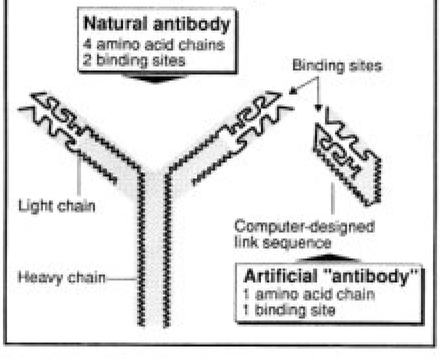
First researchers build computer models of the shapes of the parts of the protein they want. Then they scan databases to find amino-acid sequences that will join up the parts while leaving the modelled shapes intact. A gene to describe this new protein is then constructed.

The system can be used to convert any complex protein into a smaller, simpler molecule. But it is as a way to build single-chain antibodies—its original purpose—that it will bear its first fruits. Antibodies consist of four separate chains of amino acids, two "heavy" chains and two "light" ones. These allow the body to identify, isolate and destroy a wide range of threats—bacteria, viruses, parasites, cancers, even certain poisons. They circulate throughout the body, each one designed to bind to a target molecule. Each antibody has two binding sites—clefts between the ends of the heavy chains and the ends of the light ones—to allow it to recognise its target molecule (see diagram). Each site will bind to one target only.

A single-chain molecule that could substitute for an antibody would have many advantages. Used therapeutically, it could cause fewer side-effects. For one thing, single-chain antibodies would be much smaller than normal ones. They could be removed more easily and quickly from the body. Also, the computer could chose amino-acid sequences that would not evoke an immune response from a patient's body. At present, man-made "monoclonal" antibodies—ie, antibodies directed against a single target—still come from mouse, not human, cell cultures. The human immune system tends to dislike them. Single-chain antibodies can also be engineered to be more stable and bind more strongly to their target compounds.

These last two traits are especially useful for industry and research. In chemical purification, for example, single-chain antibodies can be used in devices called "affinity columns". When a liquid containing a desired compound runs down the antibody-covered column, the compound sticks to the antibodies and can then be collected. Single-chain proteins can grip more tenaciously to the column and to the compound than their complicated natural counterparts. Antibodies are used in a similar way in bio-sensors to monitor the level of substances in the environment. Better stability means that they can function in greater extremes of temperature, acidity and pressure.

Defence by design



Single-chain antibodies will be much cheaper to produce than natural ones. They could be made in the sort of large fermentation vats used to make everything from alcohol to penicillin. These vats rely on microbes that cannot make complicated molecules such as natural antibodies. They are equipped, however, to make single-chain antibodies. Fermentation can cope with all sorts of proteins, provided they are fairly short. Manufacturing a novel many-chained protein, by contrast, often calls for whole new production lines of mammalian cells.

Genex puts the total market for single-chain proteins at $1.5 billion today, and projects a $4 billion market by 1995. It hopes to test single-chain antibodies in some *in vitro* and *in vivo* applications within a year. But the company will not try to develop markets for products based on single-chain antibodies itself. It wants to supply the proteins to bigger companies that are more oriented to marketing.

One intriguing possibility is that Genex's method will be able to create alternative—perhaps better—versions of other genetically engineered products. So eventually any genetically engineered product on the market could be redesigned, resulting in a simple, easy-to-produce alternative. This would provide endless fun for patent lawyers.

the cell. Sandia claims record efficiencies of more than 14% for its hydrogen-treated silicon. It predicts that making a solar cell with the new technique will cost 60% less than using single-crystal silicon.

Diabetes

Curing the cure

Although diabetes does not now kill, it still causes much pain and suffering. The side-effects range from blindness to kidney failure. Scientists now think they have found a set of drugs to combat these side-effects.

Diabetics suffer from a shortage of the hormone insulin, which helps regulate the levels of glucose in the blood. The severity of the disease varies and those diabetics who make little or no insulin are usually put on low-sugar diets and give themselves daily injections of the hormone. It is these insulin-dependent diabetics who suffer the worst complications. They may lose their eyesight (51% of the 11m American diabetics have some form of visual impairment); their nervous systems may suffer, resulting in impotence or loss of sensation; and a third of them will die of kidney failure.

One theory is that these diabetic complications arise from the high concentration of a chemical called sorbitol, which has been produced from glucose by an enzyme known as aldose reductase. Sorbitol can accumulate within cells, causing them to swell and rupture, so that the tissue gradually erodes. Some diabetics do indeed seem to have too much sorbitol at their nerve endings.

The new drugs inhibit aldose reductase and so prevent the build-up of sorbitol. And they seem to prevent the appearance of complications in diabetic rats. But, as always, that does not prove that the drugs will work in human beings. Clinical trials on several hundred patients are now under way in the United States. The first results are expected this summer. A number of companies are developing the inhibitors but Pfizer's sorbinil and American Home Products' tolrestat are closest to market. Both companies expect to apply for approval of their drugs within two years.

Still there is no free lunch. The price for these anti-side-effect drugs is that they may have side-effects themselves. Sorbinil has already been shown to cause rashes, muscle ache or liver problems in 8-10% of patients.

The comeback of the camel

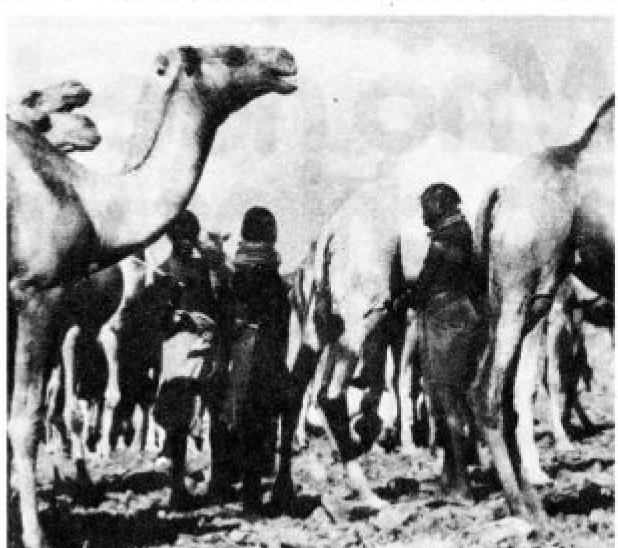
by M.N.

In August, 1984, Samburu tribesmen in northern Kenya faced an awful dilemma. Their only way to obtain food was to trade their skeletal cattle for maize, but those cattle were their livelihood. It is a decision that has been all too commonly faced by Africans in the past year. What made the Samburu case worse was that, in the same area, there were other tribesmen herding camels, who were still getting up to five litres of milk a day from each of their beasts.

All over the world's arid regions, a vast source of water and protein is being neglected: camel's milk. Dr Reuven Yagil of Israel's Ben Gurion University has put forward a big programme to encourage camel farming in dry areas, based on his own research at the camel research laboratory at Beersheba.

Take first the camel's obvious advantage over cattle. It can last for long periods without water and can feed on thorny and saline vegetation which cattle find indigestible. It can feed farther from watering holes and reach higher into trees, so that it makes fuller but less damaging use of ground vegetation.

Next consider the quality of the milk. Cow milk is higher in fats and lower in water and protein than camel milk. And, when deprived of drinking water, a camel responds by increasing the water content of the milk from 84% to 91%, while the fat content drops from 4% to 1%. The camel does this by transferring water from its blood to the milk (incidentally, water is stored not in the hump but in the bloodstream) in order to help its young survive in arid conditions. This milk is particularly well suited for people with no other source of nourishment and is ideal for small children. A well fed camel can yield 40 litres of milk a day—as much as a Friesian cow in Europe. (In the Saudi Arabian Royal Palace at Riyadh, there is a fully automated milking parlour for 40 camels.) Dr Yagil estimates that the milk from one camel can keep up to 20 children alive.


Food aid with a hump but no hitches

So why, if the camel's milk is so beneficial, has the camel been neglected? A camel costs much more than a cow, which makes camel owning a risky or inaccessible business for a poor person. But there is another, biological reason. Cattle breed faster. They start calving at a younger age, have calves more often and more of the calves survive. Therefore, in good times, you can get rich quicker by breeding cattle.

In seeking a way around this problem, Dr Yagil and his team began experimenting with hormone-based fertility drugs to try to increase the camel's breeding rate. The experiments seem to have worked—with coralled camels—and Dr Yagil's camels can now start breeding at the age of three instead of five or six, have calves every year instead of every other year and with a calf mortality rate of virtually zero.

In order to pass the results of the experiments on to those who can benefit from them, Dr Yagil now aims to set up this year a camel breeding station in an arid region, probably in southern Egypt or northern Sudan. He also plans to buy camels in areas where there are plenty and move them to drought-stricken areas—as a kind of bottomless well of food aid. But first the research team needs to find $2m, for which it has approached the Food and Agricultural Organisation and private bodies including the Rockefeller Foundation.

If this amount is to be raised, Dr Yagil will first have to find answers to critics of the scheme who claim that coralling camels would remove their advantages. Camels and their dependents are nomadic in nature. Once an area starts to run short of foodstuff and firewood, they move on to allow the area to recover. This practice will stop if camel breeding communities are encouraged to settle.