No Water: No Food?

Price 40p

Plants as solar driven pumps

All plant life requires sunshine, nutrients and water. Plants act like solar driven pumps. Water containing nutrients from the soil rises by capillary action into the plant and is drawn through by evaporation from pores in the leaves. Meanwhile light falling on the green parts of the plant, which contains chlorophyll, generates a chemical reaction whereby carbon dioxide is absorbed from the air, oxygen released and sugars formed from the carbon dioxide combining with water in the plant. We consume the sugar (and nutrients) either directly from vegetables and fruit, or indirectly through meat and fish, and gain energy to drive our living processes.

With plentiful water it is the amount of light (given certain temperatures which vary with different plants) which determines the rate of growth. All other things being equal, plants could grow 5 times as fast on the Equator as in the UK, due to the extra light energy available.

Primitive irrigation in Dogon country, Mali. The cost of transporting water to good land is high so, instead, the soil is brought to the water and laid in small walled bays where small pumps can get water to it. The crop is of shallots

Rainfall

The sun itself acts as a huge desalination plant drawing pure water as vapour into the atmosphere where, if dense enough, it will be seen as clouds. Winds move this moist air around the globe. The quantity of moisture the atmosphere can hold increases with rising temperature but there comes a point where it is saturated and falls as rain, commonly on mountains where the moist air cools as it is forced upwards or where warm moist air meets a cold 'front'. Rainfall (and hence the amount of water available to grow food) varies hugely by location. Also, because wind at all elevations in the atmosphere changes direction, it varies widely from season to season and year by year. Few people recognise that the UK, being surrounded by ocean and at the crossroads of about 6 different weather systems, is blessed by the advantage of *regular* and *reliable* rainfall. Much UK food is grown without need for irrigation, our landscape remains green most of most years, and our rivers flow throughout the year sustaining aquatic life and navigation as well as providing water for people and industry.

How much water?

Water covers about 70% of the planet's surface. Figures vary on the exact percentages but the vast majority, around 97%, lies in the oceans. Over 2% is locked up in ice caps and less than 1% in rivers, freshwater lakes and underground. The sun lifts almost a metre depth of water from the oceans in a year and although much of this falls fall back to the sea a huge quantity, perhaps over 100,000 cubic kilometres or around 75 centimetres depth over the Earth's whole land mass, falls on land. Much falls where it has no value. Some runs directly to rivers and straight to the sea but other rain travels long distances by river or recharges inland lakes or seeps into the soil or rock below. In global terms there is no shortage of water and global warming will increase not reduce the quantity available. Any water 'stress' arises from uneven distribution.

The significance of evaporation

The rain that falls however is only one factor to be taken into consideration. The other is the amount of evaporation. Around the Equator the sun is capable of evaporating 2.5 metres or more depth of water from a lake in a year. In the UK it is barely 0.5 metre. Rainfall, even in the dry SE of England, averages about 0.75 metres (more, sometimes much more, as one goes NW). The UK has a surplus of rain overall, though deficits in some months in some places, particularly East Anglia. A country nearer the Equator may have the *same* rainfall as the UK's but 5 times as much evaporation and end up with a severe deficit. Its rivers will run sporadically and reach the sea intermittently or not at all. Whereas the UK's food production is limited by lack of sunshine, further south the limit is usually water.

Dry lands and deserts

The Earth is tilted on its axis so that over a year the sun

This briefing note has been written by Richard Balmer and the opinions expressed are his own. However it should be technically accurate. If you see errors or have comments, please email him at richard_balmer@blueyonder.co.uk

appears to move between the Tropics of Cancer and Capricorn on latitudes of about 23° N and S of the Equator. The sun's position overhead generates winds so that rains tend to follow the sun. The consequence is that there are bands of dryness associated with both Tropic lines where the sun 'stalls' as it were, notably the Sahara, Middle East and Sind desert in the north and the Kalahari and the Australian deserts in the south. These areas not only suffer from weak rain generating winds but high rates of evaporation. Though other wind influencing factors are at play elsewhere it is not surprising that much land at these latitudes, and land a long way from the oceans such as parts of Russia, the 'Stans', Canada and China, experience great water stress along with quirky coastal areas in Chile and Namibia.

Bringing water to crops

In early days (and in many places still today) farmers planted cereal crops after any rains and relied on the harvest to see them through the year with a few carefully tended vegetables and whatever meat or fish came their way. Elsewhere people relied on rivers. Early civilisations first prospered in the valleys of the Nile and Tigris and Euphrates where there was ample sunshine and the rivers brought water. In Persia early engineers constructed qanats (small tunnels) to convey water from distant hills to fertile land. Seed quality and farming practices needed to improve of course but, because even simple irrigation requires the technology of diverting and lifting water and the politics of sharing and financing it, it was food production that caused the first 'civilisations' to arise and subsequently develop both power structures and rituals.

Rivers may deliver water but rarely can they match the volume provided by decent rain. From the air Egypt, for example, looks like a thin green snake perhaps 2 kilometres wide. On either side it is brown, barren desert. Nonetheless large populations are supported not only by the Nile but the Niger, which runs a long distance along the south of the Sahara, the Indus in Pakistan, and so on.

In the last 150 years, as populations have grown rapidly a further step has been taken, that is to dam rivers to store surplus winter or rainy season water for use later. That the same water can be used to generate electricity (c. 15% of all global electricity comes from hydro) and help finance the works makes dams attractive. The reservoirs created, however, especially large ones, risk conflict. They flood valley land which is often the most fertile and densely inhabited. Farmers are dispossessed and social upheaval caused. The huge 3 Gorges dam in China has created a lake 600 kilometres long and dispossessed over 1 million people. Archaeological remains may be flooded. The Aswan Dam flooded Egyptian temples (though the Abu Simbel temple was moved) and the Ilisu Dam in Turkey, if built, will both dispossess farmers and flood historic sites.

International disputes; 'pinch' points

The Ilisu Dam on the Tigris provides a good example of another problem: that many rivers, especially large ones, cross international boundaries. The Tigris runs from Turkey into Syria and then Iraq and, in 2009, Iraqi farmers suffered when Turkey held back supplies for itself. The Nile rises in Uganda and Ethiopia and flows through Sudan to Egypt. Actually the White Nile is fed from Lake Victoria which is bordered not only by Uganda but Tanzania and Kenya. In 2004 the Guardian reported that Tanzania was proposing to pinch more than its agreed share of water until deterred by Kenya and others. At much the same time Uganda was actually drawing more water through the dams at the Owen Falls than allowed to generate electricity, so lowering the whole lake, until stopped. The tributaries of the Indus rise in Kashmir before running through Pakistan. The Brahmaputra rises in Tibet before flowing through India and Bangladesh. Water taken for irrigation in one country is obviously lost to countries downstream.

Perhaps the most critical example of all is in the Middle East. The River Jordan rises in the disputed Syrian/ Israeli territory of the Golan Heights. Following the 1967 war the Israelis secured control of the majority of the river water and the aquifers which lie under the West Bank and Gaza Strip, ignoring prior agreed allocations with the Palestinians. The average Israeli now has 292 m^3 of water a year for all purposes including irrigation compared to 61 m^3 for each Palestinian.

Water stress is not necessarily caused by international pressure. The level of the Aral Sea fell by 16 m in 32 years because the Soviets needed to grow cotton and took the waters flowing mostly through Uzbekistan for it. (Indeed if Afghan farmers are diverted from poppies to food more water will be needed from the headwaters of those rivers). The Yellow River ran dry for 226 days in 1997. The Colorado River in USA is so heavily used for irrigation it is a salt swamp in its lower reaches. In Australia, despite the visionary Snowy Mountain scheme which diverts a huge quantity of water from the Snowy River to the better agricultural lands of the Murray/ Murrumbidgee river basins, farmers were in terrible trouble in 2007 at the end of several years drought.

So 'pinch points' are apparent but, despite the facts that agriculture uses about 70% of all water; that 40% of food production is dependent on irrigation; that more water is required nowadays for domestic use and industry; and that global population is rising (slowing the birth rate, especially in poorer countries, would have great benefit) there are things that can still be done.

What can be done?

First more rivers can be diverted and more dams built though with more sensitivity than in the past. We can desalinate water and, although this is expensive, the

Israelis are doing it. We can 'seed' clouds to make rain fall in a few favourable places.

Second water can be used more efficiently. When the first farmers irrigated they simply installed a pump to abstract water from the nearest river or aquifer. Growing pressure created a need for licensing to control abstractions but in most cases the farmer had a 'right' to take water which could not lightly be removed. Many licences were issued on a 'use it or lose it' basis, with charges heavily subsidized. 'Buying out' a right was expensive and more efficient use slow to arrive.

Third there is potential to change the mode of irrigation. There are 3 basic methods which can be described as flood, spray and drip. With flood irrigation land is typically divided into flat squares with low earth walls (bunds) about 20 cm high with water channels running along one side. The bund is breached, water floods in, the bund repaired, the next square flooded, and so on. The same basic method is used on terraces. Volume control is obviously rudimentary and efficiency normally quoted at 50% or less.

In the UK we are most likely to see spray irrigation. Lightweight pipes are run across fields, and water pumped through them at perhaps 3 bar pressure to rotating spray 'guns'. Alternatively long lines of spray guns can be towed by pairs of tractors across a field or pulled round from a centre pivot. Volume control is better, efficiency being around 70%, but water is lost through wind drift, evaporation from wet leaves and soil, and the coverage may not be even. Spray irrigation requires capital investment and consumes energy but could replace at least some flood irrigation.

Drip irrigation brings water directly to the roots of each plant. The pipe network is obviously more complicated and expensive and the small outlets more numerous. It is clearly very efficient but can only really be used for permanent crops, for example orchards or bush crops such as raspberries not, for example, fields of wheat. Even so upgrading from spray to drip is also possible.

A problem with all irrigation is that river or borehole water contains a little salt. Some is left in the soil with each application, builds up and eventually 'poisons' the soil. There is a theory that the advanced Babylonian civilisation came to an end because it failed to recognise this problem. Additional water has to be used to 'wash' the salt through the soil. Where water is cheap, farmers are motivated to err on the side of caution and use more water than is strictly necessary.

Raising productivity

The third option, and the one with the greatest potential is to raise productivity. This means obtaining more food from the same area of land by more 'intensive' farming, a strategy often bitterly opposed. It was noted at the beginning that plants require light, water and nutrients. For nutrients, read fertilizer. Great gains in productivity have occurred since plant physiology has been understood and the importance of fertilizer, especially nitrogen, phosphate and potassium (NPK) recognised. Unhappily fertilizer production needs a lot of energy. Nor are global reserves of either phosphate or potash inexhaustible.

The second route is by defending crops against attack, but this means more pesticide, herbicide and fungicide use. The third is to develop higher yielding seed varieties or seeds which can flourish in marginal conditions. GM technology is one means to do this but again is widely opposed, at least in Europe. The fourth is to promote more efficient farm management. This means creating bigger farms employing more capital including machinery, which offends the 'small is beautiful' adherents, though its growth in Africa is thought to be capable of doubling output or even more. Productivity can be increased but all, except the use of GM, require extra energy and can have both environmental and social downsides.

Urban competition

One last problem needs mention, that is growing competition for water from urban areas. Some major cities, for example Chennai in India and Sanaa in Yemen have drawn down local sources so that water is available for only a few hours a day. Imports will necessarily compete with agriculture.

Conclusion

Ever since humans stopped living off the animals and fish they could catch and the fruits they gathered from the land and began 'farming' agricultural scientists and engineers have been seeking ways to increase production to feed growing populations. Better crops and farming methods have come and water brought from near and far. Farming has *necessarily* become more intensive but there have been more undesirable side effects: loss of habitat; displacement of people; use of energy (with CO_2 emissions) and use of synthetic chemicals.

The world is not generally 'running out of water' and need not go short of food. There remains great potential to raise productivity in all countries especially developing ones and some, for example in the Middle East, are rich enough to buy from elsewhere or even produce water from the sea. The real issue is that the *pressure* on water and land is increasing all the time.

There are many 'pinch points' in different places at different times but the real concern lies in some of the African countries on the Saharan fringe such as Chad, Darfur in Sudan, Ethiopia and others. All have high birth rates. None has competent government. Much more needs to be done to raise agricultural productivity and extend family planning than merely reacting with famine relief.