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3.3 The Green Revolution

Graham P. Chapman

Thomas Malthus observed two centuries ago that population had the capacity to increase by compounding numbers (i.e. exponentially), while all his experience of 'the qualities of soil' of 'this Island' (Britain) did not allow him to imagine that agricultural produce could increase more than in arithmetic ratio – i.e. in a constant linear manner. His conclusions from these two 'facts' were that, unless preventive measures were taken, such as late marriage and celibacy, human populations would increase until 'positive checks' halted their growth. These checks were those that came to be associated with the eponymous adjective Malthusian – 'all unwholesome occupations, severe labour and exposure to the seasons, extreme poverty, bad nursing of children, great towns, excesses of all kinds, the whole train of common diseases and epidemics, wars, plague and famine' (Flew, 1970: 23).

In the 200 years since Malthus wrote, there have indeed been famines and plagues, but the human population of the planet as a whole has increased exponentially, and on average is better fed and lives longer than ever before – even if there remain far too many people who are malnourished and in dire poverty. This 'success' has proved possible for two reasons: first because more land has been taken under cultivation – in the American prairies for example – as modern transport allows the carriage of bulk commodities like wheat over intercontinental distances; second, because there have been major increases in the productivity of agriculture. Increases in productivity in agriculture often occur in step-like functions as a result of changes in the agricultural system; for example, the change from broadcast rice to transplanted rice, new animal–crop rotations, or the adoption of new fertilizer-responsive varieties. Since both colonization of new land and adoption of new techniques happens incrementally in time, the output of world agriculture seems to increase fairly smoothly and exponentially. However, much of the agricultural experimentation and improvement of the last 200 years has taken place in temperate lands, and that is where in the last century most of the gains in productivity were made.

At a disaggregated level the picture is not always so encouraging. The twentieth century saw several major famines in Asia and Africa, though more often than not it was war or political turmoil that was the cause rather than the result of famine. In the eyes of the industrial world the Malthusian spectre seemed still to threaten. During the Cold War the two ideologies of capitalism and socialism fought for the allegiance of many developing countries, each promising the populace release from poverty and hunger by following their respective political-economic models.

The solutions to these problems were seen differently by the two sides. The socialist camp thought that the problem lay in the relations of production, and that abolition of landlordism and its replacement by collective farming would solve food problems – as enforced in China. Other states believed in the redistribution of land to poor people, though not outright collectivization of land. The developed countries of the West sought to promote growth in agricultural productivity and hence rural incomes by technical means. The Rockefeller Foundation financed the Co-operative Mexican Agricultural Program in Mexico, the forerunner of CIMMYT – Centro Internacional de Mejoramiento de Maiz y Trigo (the International Centre for the Improvement of Maize and Wheat), indelibly linked with the name of Dr Norman Borlaug, who worked there from 1944–60. He was awarded the Nobel Peace Prize in 1970 for his success.

Borlaug was a plant breeder who used hybridization and back-crossing, which over seven or ten generations might produce a new variety with stable and desirable traits. The main strategy adopted was to breed new dwarf varieties that were responsive to artificial fertilizer, particularly nitrogen. The short height of the plants had two advantages: with less leverage from the head acting on the stem, the head could be heavier without causing the stem to bend over and fail ('lodging'), therefore allowing the use of higher doses of fertilizer; and proportionately more of the plant mass would be in grain, and less in unwanted by-products such as the stalk. In breeding selectively for these traits, other unwanted traits emerged. These included a heightened susceptibility to diseases and pests in the early new varieties, so increased use of pesticides and fungicides became part of the revolution. In part the problem resulted from the fact that there were few of the new varieties, and hence rotation of varieties with different disease and pest resistance was difficult. The new monocultural landscapes therefore became good breeding grounds for pests and diseases. Another difference compared with 'traditional' farming systems in which canopy heights are ragged, was that in seeking to help mechanization the canopy height was now kept as constant as possible. This created a different micro-climate, better suited to disease transmission between plant heads which were closer together. A further demand was for water. If inorganic fertilizer is used in dry conditions it competes with the plants for available soil moisture, and can in fact 'burn' the crop. So controlled irrigation became another necessity. In the case of high-yielding varieties (HYV) of rice developed in the Philippines, the economic value did not necessarily increase in line with yield, as the quality of the grain was often inferior, being less savoury and more glutinous, and commanding a lower market price.

In sum the new agriculture required considerable expenditure, and was in a sense not so well adapted to local environments. Thus the more recent name for this agriculture – high external input agriculture – is perhaps more accurate than the evocative label 'the Green Revolution' that was applied to it in the 1960s–90s. The increases in yields obtained pushed production dramatically upwards. Wheat production in Mexico multiplied threefold in the time that Borlaug worked with the Mexican government; and 'dwarf' wheat imported in the mid-1960s was responsible for a massive increase in wheat harvests in Pakistan and India. In 1961 wheat production in India was

11m tonnes, and in 1991 55 m tonnes. From 1967 to 1990 average wheat yields increased by 3.14 per cent compound annually (Bhalla, 1994: 143, 146).

Different aid agencies and foundations started many different agricultural centres to advance the new technologies. In 1971 the CGIAR (Consultative Group for International Agricultural Research) was established as an informal association of 58 public- and private-sector institutions to support a network of 16 international agricultural research centres.[1] CIMMYT and the International Rice Research Institute in the Philippines, which replicated Borlaug's work on wheat by producing in the 1960s (and ever since) new HYVs of rice, came under the CGIAR umbrella, substantially funded now through the World Bank, the Food and Agricultural Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the United Nations Environment Programme (UNEP).

In most developing countries the arguments about the desirability of the new technology and the problems with its side-effects got short shrift from hard-pressed governments. In the first two decades after Independence in India population grew at more than 2 per cent per annum, almost the same rate as food production. Food availability per capita hardly changed, and a bad or failed monsoon could easily threaten food security. In India, in 1965 and 1966, famine, supposedly impossible after Independence, again stalked the land. In a country where more than 70 per cent of workers were engaged in agriculture, at the peak of the emergency 10 per cent of available food was imported from the USA on concessional terms. The government response was to embrace the new technology with determination. It particularly pushed irrigation and fertilizer use with the new seeds. It adapted the new seeds on its own agricultural stations, developing new crosses with local improved varieties (LIVs), striving for better adaptation to local conditions. In the short term the success has been outstanding. In many countries in Asia and Latin America for the last quarter of the twentieth century growth in food output exceeded growth in population – the compound rate of the former going up, and the compound rate of the latter falling, for a variety of reasons, one of which may have been increasing food security and wealth. Average rice yields in South and Southeast Asia in 1991–93 were 83 per cent higher than those in 1964–66, the 3 years immediately preceding the introduction of the first modern, high-yielding variety. Total production rose by 120 per cent, ahead of an 85 per cent growth in population. The land planted to rice increased by only 21 per cent. In effect yields have been doubled.

SOCIAL AND ENVIRONMENTAL EFFECTS

Socially the new technology proved divisive, as in the early days the costs of investment meant the new technology was better suited to bigger and richer farms. If the output of large farmers caused prices to fall (but their income terms of trade could still improve because output had grown so much) then poorer small farmers who had not increased their output suffered. Share-croppers and others in limited tenancy were evicted as potential profits grew. But as the wealth of the countryside grew, so did other rural job opportunities, and so did the demand for labour. New seasonal migration streams became established between regions. In the current decade the effects are thought to be more scale neutral, and small farmers have also benefited, particularly with changes in irrigation technology. Environmentally the costs include: the loss of indigenous varieties (particularly of wheat);[2] a purported addiction of some soils to fertilizer, which means that increasing doses have to be applied; persistent pesticides in the environment, which are particularly harmful where rice and fish are cultivated together; a reduced output of straw, which means that animal fodder has to be found from new sources; in some areas rising water tables, which cause salinization of the soil if they reach the surface, and in other areas which are over-pumped a rapid fall in water tables. This again is more likely to impact on poor people, who use traditionally dug open wells, than the rich, who have tube wells drilled in their land. The environmental concerns have given rise to a search for an integration between new and old methods, in particular a quest for a Low External Input Agriculture. This agriculture seeks for more disease-resistant varieties, and integrated pest management, in which natural biological predators are encouraged. It is in some senses moving parallel to the organic farming of the developed countries. It also uses social technologies, to make the sharing and use of water more equitable and more efficient, for example. Other new (or rediscovered) ideas include agroforestry, using trees to draw on nitrogen-rich groundwater, returning leaves of value for fodder and compost. In general, the movement is towards making the new systems sensitive to local environments, rather than independent of them.

A PATCHY RECORD

The Green Revolution provided an increase in agricultural production which undoubtedly has given many governments a breathing space. In comparison with wheat, maize, rice and potatoes, much less has been done for subsistence crops like cassava in Africa or millet in India. Indeed much of African peasant agriculture seems to have been left behind. The number of food-insecure people in sub-Saharan Africa may increase in the next 20 years – the only world region where this is forecast. Equally, the programmes for rain-fed agriculture have lagged behind those for irrigated agriculture, though the situation is changing. For India and China the breathing space has been essential. Rates of population increase continue to fall, but absolute numbers will continue to increase as young populations achieve adulthood and reproduce. By 2050 India and China alone will have added another 800 million people – or an increment equal to three times the current population of the USA. The colonization of new land has essentially ended (apart from the contentious cases of tropical rainforests in Latin America, Indonesia and Africa). And, as with increasing incomes people will seek more dairy products and more meat, the arable output of agriculture will have to increase far faster than population growth. International trade will grow. Russia and East Europe may again emerge as major exporters alongside the USA – a position Russia held before both the First World War and the Revolution.

Technological optimists believe that the age of biotechnology and direct gene manipulation will solve these problems. The slow system of crossing and selecting that Borlaug worked with can be replaced by tailoring new genes to new demands, even transgenically – introducing fish genes into tomatoes to make them withstand freezing, for example. This is one of the big current debates – about Genetically Modified Organisms (GMOs). The big hopes are that plants can be made more disease and pest resistant, so that chemicals need not be used; that the symbiotic bacteria which fixate atmospheric nitrogen on the roots of legumes (enabling beans and peas to create their own fertilizer) can be engineered to grow on the roots of cereal plants; and that plants develop better drought tolerance. Intriguingly, drought tolerance is higher in an atmosphere with heightened CO_2. But even with enhanced drought tolerance, there is no doubt that much of the needed increase in production will come from irrigated areas – and conflict over water will become increasingly tense, particularly as growing urban centres pre-empt more of the supply.

CGIAR still exists and grows, and is still influential. It has added some social science centres to its technical core. But the vanguard of the new technology is no longer with CGIAR. Now it is with the First World big corporations who have invested most in GMOs. The pessimists fear that the rewards will go to the big corporations, and that the small and poor of the third world will be passed by, or forced to pay excessive prices for the new seeds that will undoubtedly be needed. The critics say that big business is interested first in GMOs that increase their profits, and then either not at all, or least and last, in farmers and consumers. They also fear unpredictable consequences as new genes enter the environment. What is clear is that at all stages of human history social revolution has driven changes in agricultural technology, and changes in agricultural technology have driven social changes. As the developing world rapidly urbanizes, new opportunities will arise for new technologies to increase food output. Hopefully these changes will increasingly incorporate Africa; hopefully their impact upon the environment will be increasingly benign. What we do know is that there will be no 'final equilibrium', only a process of constant adaptation and change, leading to a future where, one hopes, all human beings are well fed, and the spectre of Malthus no longer hovers at the table.

NOTES

1. Visit the CGIAR website for more details on centres.
2. In China in 1949, 10,000 wheat varieties were known: by 1970 there were only 1,000 (Shand, 1997).

GUIDE TO FURTHER READING AND REFERENCES

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3.4 Food security

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INTRODUCTION

The concept of food security has been seminal in developing policies to end hunger and malnutrition during the last 25 years. Yet, when planet earth entered the twenty-first century, it did so with more than 800 million hungry people on board. The reason most people are hungry today is not because enough food cannot be produced, but because it does not get distributed fairly and because some people are too poor to buy it. The concept has evolved with full realization that increasing per capita food production alone would not significantly reduce hunger and malnutrition.