CAN GM CROPS PREVENT FAMINE?

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Introduction

A recent book by the former director-general of the International Food Policy Research Institute (IFPRI) and World Food Prize winner, Per Pinstrup-Andersen, opens with a story. The story is one of a 'skinny three year old girl' who 'lay dying on a mat, surrounded by crying relatives' in a village in south-western Zimbabwe during the summer of 1999 (Pinstrup Andersen and Schioler, 2001: 1). The imagery is powerful, the story familiar from media reports of famine in Africa, and the conclusion clear: if well harnessed, agricultural biotechnology can solve the problems of famine and hunger in the developing world.

The argument of that book and a growing array of publications from reputed and well networked organisations - whether the CGIAR (Consultative Group on International Agricultural Research) centres like IFPRI, national science academies, the OECD, the Rockefeller Foundation or the World Bank[1] - is simple. With growing populations and declines in yield growth of basic food crops in the post-Green Revolution era, increasing yield growth is essential to avoid famine. And new biotechnological applications, and in particular transgenics (GM crops), are an important part of the way forward. This is portrayed by some as perhaps the only feasible ethical standpoint for the international community. Pinstrup-Andersen again notes:

If technological development by-passes poor people, opportunities for reducing poverty, food insecurity, child malnutrition and natural resource degradation will be missed, and the productivity gap between developing and developed country agriculture will widen. Such an outcome would be unethical indeed (Pinstrup-Andersen and Cohen , 2000: 22).

This storyline is seen as particularly pertinent to Africa. For it is here that the potential gains of the Green Revolution have not been achieved, and trends in per capita agricultural productivity are, it seems, endlessly downwards. Poverty is growing, and all indicators of food insecurity appear to show a doomsday scenario. Everyone agrees that something must be done. The enthusiasts for GM crops in

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[1] See for example: World Bank, (Kendall et al., 1997); CGIAR (1999); OECD (2000); Royal Society, US National Academy of Sciences, Brazilian Academy of Science, Chinese Academy of Sciences, Indian National Science Academy, Mexican Academy of Sciences and the Third World Academy of Sciences (2000); Conway, G. (1999).

Africa offer a neat and hopeful scenario. Thus Florence Wambugu argues in her book 'Modifying Africa: How Biotechnology can Benefit the Poor and Hungry':

> Having missed the Green Revolution, African countries know they cannot afford to pass up another opportunity to stimulate overall economic development by developing their agriculture. Biotechnology gives us that opportunity – and we are determined to grasp it (Wambugu, 2001: 70).

Professor Jennifer Thompson from the University of Cape Town in South Africa is similarly strident in her book 'Genes for Africa' (Thompson, 2002). She sums up:

> Africa needs GM crops as part of its quest for sustainable agriculture and in order to feed its population… Europe has enough food and may not want GM technology, but this does not mean that the developing world should be forced to do without it (ibid, 2002: 170)

Both are clearly honest, heart-felt pleas; both appear to be based on logic and common sense. But do they stand up to scrutiny? Can the famines that continue to plague Africa – both new and old – be banished to history forever, with the application of science and the promotion of technology?

This chapter attempts to grapple with this question by asking some searching questions about the assumptions underlying the hopeful storylines told by the GM enthusiasts. This analysis seeks to situate the debate about technology – and GM crops in particular – in a wider understanding, looking at what types of technology are likely to be available, who will own and control them, and what consequences these will have for poor, marginal people, particularly in Africa. In critiquing the optimistic technology-driven scenario, the chapter also puts the counter-arguments under the microscope. To what degree are alternatives available? Are these realistic given the scope and scale of the challenge?

The chapter is, however, necessarily speculative in character. There are very few GM crops available in Africa, most of them under test. The only GM crop being grown by smallholder farmers in Africa is insect-resistant GM cotton (using the *Bacillus thuringensis* (Bt) gene) in South Africa. So, can GM crops help prevent famine? This chapter sets out to outline the contours of the debate, offering some tentative conclusions about how the debate needs to be reframed if technologies, such as GM, are to play a part in famine prevention strategies in Africa.

The chapter is organised as follows. The next section looks at the framing of the problem and how a GM solution arises from this. The following section examines the data and models that support such an assessment, and the limits of these. The next part of the chapter then looks at the assumptions used by pro-GM advocates and questions elements of these for the African context. In so doing it also examines the alternative scenarios offered for a non-GM future, and highlights the limitations of these arguments too. The concluding section then returns to the question posed in the title of the chapter and suggests that the answer to this is complex, contextdependent and uncertain. Rather than brave statements of faith for (or against) GM crops – as offered by Pinstrup-Andersen, Wambugu, Thompson and others opposing their stances – what is needed is a much more debate about the relationships between livelihood pathways and technology demands, located in particular settings – especially those where food insecurity and livelihood vulnerability is high – and, critically, involving those likely to be the users of technologies, rather than such self-appointed spokespersons.

The pro-GM narrative: food supply is the problem, technology is the solution

The core justification for the increasingly influential pro-GM position is essentially neo-Malthusian in character. Production (and to some extent nutritional improvement) is the key, the argument goes, and redistribution and access issues, while important, are infeasible to implement. For example, the highly influential Nuffield Council reports (Nuffield, 1999; 2004) reject the option of redistribution, and argue for a focused technological solution to create a pro-poor biotechnology:

> Political difficulties of redistribution within, let alone among, countries are huge. Logistical problems and costs of food distribution also militate against sole reliance on redistributing income (i.e. demand for food) to meet present, let alone future, needs arising from increasing populations in less developed countries. Hence we must stress the importance of any new options that will secure higher direct and indirect employment and cheap food in labour-surplus developing countries…. What is required is a major increase in support for GM crop research and outreach directed at employment-intensive production of food staples within developing countries (Nuffield, 1999).

In the same way the Hunger Task Force report (HTF, 20004) prepared for the Millennium Project is extraordinarily silent on issues of access and distribution. Instead it again focuses on an essentially technology-driven route to tackling hunger and meeting the Millennium Development Goal (MDG) targets.

For the biotech advocates population pressure is the core factor, the Green Revolution is the model solution, while a focused biotech 'Gene Revolution' is the ideal future. The FAO's biotech policy statement – echoed in the much criticised 2004 State of Food and Agriculture report (FAO, 2004)[2] - follows this now oft-repeated line:

> Agriculture is expected to feed an increasing human population, forecast to reach 8000 million by 2020, of whom 6700 million will be in the developing countries. Although the rate of population growth is steadily decreasing, the increase in absolute numbers of people to be fed may be such that the carrying capacity of agricultural lands could soon be reached given current technology. New technologies, such as biotechnologies, if properly focused,

[2] This report was highly criticised by NGOs and others for taking a pro-GM stance. This in turn prompted a response from the Director-General of FAO (see www.fao.org/newsroom/en/news/2004/46429/index.html)

> offer a responsible way to enhance agricultural productivity for now and the future… (FAO, 2000: para 1).

This argument is taken further by some, with analyses highlighting future prospects of scarcity-induced famines leading to political instability, conflict and resource-based wars (Homer-Dixon, 1999)[3]. Thus, encompassing this argument, boosts in agricultural yield and overall production are the solution not only to the 'old' famines, but also 'new' ones too.

The echoes and promise of the Asian Green Revolution remain remarkably potent in these narratives. The banishing of the scourge of famine in India for example is put down in large part to the widespread uptake of Green Revolution high-yielding variety rice and wheat varieties. From the late 1960s, these resulted in phenomenal yield growth, initially in the irrigated areas and then more broadly (Lipton and Longhurst, 1989), with the consequence that today India has significant stockpiles of food held at national level. The massive growth in production and productivity of course has not prevented hunger in Asia. The 'paradox of plenty' (Sharma, 2002) – with large central food surpluses yet localised pockets of dearth – is today's scenario in India.

But this is different to what is faced in large parts of Africa. Here national, sometimes regional, food supply deficits are faced, prompted by drought, war and conflict, political instability and a whole host of other factors discussed at length in other chapters of this book. Declining per capita agricultural productivity – created by the deadly combination of growth in crop yields being insufficient to offset increasing demands due to population growth – seems the obvious justification for a technology-led agricultural growth path, with new biotechnologies coming to the rescue just in time. But how rigorous is this justification? Where does it apply and where doesn't it? The following sections explore these questions in more depth.

Justifying a position: data, models and scenarios

The 'feeding a hungry world' narrative is reflected in the justifications for most policy positions on GM crops of mainstream international organisations (and in much biotech industry publicity material besides). These arguments are based on more than hunches. Increasingly sophisticated – but inevitably assumption-laden – models have been developed to make the case. For example, the influential IFPRI report on 'World Food Prospects' (Pinstrup Andersen et al, 1999) argues that, due to increasing populations, growing urbanisation, and rising incomes, there will be a 40% escalation of demand for cereals by 2020. A rising demand for meat is resulting in a 'livestock revolution' which will require increasing volumes of grain as fodder. In order to meet this demand, yield increases are essential, as cultivated areas are only expected to rise by a fifth. With trends in yield growth predicted to continue downwards this will require a doubling of imports of grains to the developing

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[3] This is now a highly influential argument, picked up by many media commentaries on Africa. However it has also been subjected to extensive critiques (e.g. Hartmann, 1998, among others).

world. Projected population increases are concentrated in Asia, with India and China accounting for a third of the estimated growth to 2020. In the model, China is forecast to account for a quarter of global increases in demand for cereals, and two-fifths of the increased demand for meat. Although population growth is not likely to be as significant in Africa (especially given the HIV/AIDS pandemic), and there remain opportunities for increasing production through expansions of cultivated area, sub-Saharan Africa is the region least able to deal with the consequences, according to the model. This is exacerbated by declining yield growth, declining world food prices and decreased availability of food aid.

Drawing on FAO data, and as an input to the MDG targets debate, another recent IFPRI report focused on Africa in particular (Benson 2004). This estimated there are now 200 million people who are undernourished in Africa, 160 million as a result of chronic conditions, and around 40 million each year suffering acute food insecurity. A third of pre-school children are stunted, with over 40% of these being in Nigeria, the Democratic Republic of Congo (DRC) and Ethiopia. Many, especially women and children, have specific nutrient deficiencies due to poor diets and other factors. Globally, iron deficiency anaemia affects an estimated 1.5bn to 2.1bn people, primarily women and children; over 200m people are considered to be vitamin A deficient; and iodine deficiency disorders affects between 740m and 1500m (Graham and Welch, 1996; Smith and Haddad, 2000).

What is particularly worrying are the trends in these statistics. According to FAO measures, undernourishment has increased in Africa at a continent level from around 110m in 1970 to 170m in 1990 to 200m in 2000. Overall population growth in Africa between 1990 and 2001 has been around 2.4% per annum, outstripping growth in the value of production, where all indicators lag behind. Poor agricultural growth is seen to be linked to low fertiliser use, averaging only 12.7 kg/ha in Africa compared to xxx in Asia, combined with low levels of irrigation coverage (4% compared to xx% in Asia), and a lack of response to new varieties, including poor uptake of hybrids. But, as the IFPRI report points out, these patterns are highly differentiated. Thus, major increases in food insecurity the last decade have been concentrated in the DRC, Tanzania, Burundi, Somalia, Madagascar and Zambia. Only three countries saw decreases in undernourishment figures in this period; namely Ghana, Nigeria and Malawi. The highest concentrations of undernourished people, according to these measures, are to be found in southern and northern Nigeria, southern and central Malawi, the Ethiopian highlands and Burundi, Rwanda and southern Uganda, particularly in rural areas.

In terms of agricultural productivity, again, patterns are far from uniform. Declines in continent-wide agricultural productivity occurred particularly between 1973 and 1985, coincident with major upheavals in a number of countries, but then stabilised, admittedly at a low level, into the 1990s (Masters et al, 1998). However, not everything is doom and gloom in Africa on the agricultural front. Since 1984 there have been significant output increases in cereals recorded, due to both yield growth and area expansion. This has been particularly dramatic in the Sahelian region, where good rainfall encouraged returning migrants and others to open up new areas of land, and invest in soil and water conservation measures and new varieties (Reij and Steeds, 2003; Gueye and Toulmin, 2003). Successes in maize production in east and southern Africa too have been seen in particular periods when the conditions were right. Thus the well-documented, smallholder-led post-independence maize boom in Zimbabwe was mirrored to some extent in Zambia (from 1970-89), Malawi (1983-93) and Kenya (1965-80) (Smale and Jayne, 2003). Declines since 1990 have however been evident across the region: not because the technology was absent, but for an array of other reasons. The growth of cassava production, prompted in part by the availability of Tropical Manioc Selection (TMS) cultivars, in west Africa, but also in east and southern Africa where it was not traditionally grown as a staple food crop, is another example of an unheralded success (Nweke, 2004). Although these more discrete successes have not been on the scale of the Asian Green Revolution, they should not be dismissed through a sole focus on gloomy aggregate statistics.

Thus, disaggregating the generalised statistics that drive the debate is a key challenge if a more nuanced picture is to emerge and responses to famines, new and old, be more focused, targeted and ultimately effective. Disaggregation encourages a focus on patterns of causation, and prompts us to think about contextual, historical and political economy factors as part of the picture. Thus, for example, the causal factors resulting in undernourishment in east and southern Africa are hugely different to those in the conflict-torn parts of central and western parts of the continent, and different again to those in the Horn. This may seem obvious to those who know the complexities and differences on the continent, but to those who engage in policy debates at global and continental levels these complexities get too regularly passed over in sweeping generalisations that mean little on the ground[4].

In the same way, the explicit and implicit parallels with Asia and the earlier Green Revolution need interrogating. The key agricultural production challenges in Africa are unlikely to be met simply by new high yielding varieties, of the sort that the breeding efforts of the 1960s delivered. Instead, African agronomic challenges are much more difficult. Soil moisture and nutrient deficits are a key issue, due to lack of irrigation and large expanses of poor, ancient soils. But these challenges are highly variable – between uplands and lowlands, between gardens and outfields, between heavy soil patches and sandy areas and so on (cf. Fairhead and Scoones, 2004; Scoones et al, 2001; Reij et al, 1996). Simple technological solutions, with wide spill-over benefits are unfortunately unlikely in Africa. The Green Revolution in Africa is going to take a very different form, requiring a very different type of research effort and set of technological solutions (Conway, 1997). The question is, can GM crops be part of this?

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[4] Even attempts at targeting – as in the draft Hunger Task Force report's identification of 'hot spots' for example (HTF, 2004) – are prone to similar problems. The 'hot spots' include such diverse circumstances and challenges (like the Ethiopian highlands) that simple, widely applicable solutions are going to be very difficult to find.

In coming to an assessment, though, we should be very wary of taking the statistics (even in disaggregated forms) that guide so much policy and so much of the current debate at face value. Most of the generalised prognoses that food security and famine policy relies on come from the national FAO statistics (including the well-used indicators of average household food energy availability). These are notoriously unreliable, particularly where national data collecting capacities are weak, a situation prevalent in most African countries (FAO, 2003; Smith, 1999). When particular indicators are tested against other comparable data from household expenditure surveys, both the ranking of incidence and the magnitude of estimates are found to wildly different (IFPRI, 2004). When several data points over time from different surveys are used – for example to look at stunting rates (Benson, 2004) – the trends are highly variable, often contradicting the trends suggested by the standard statistical sources. The reasons for the limitations of the FAO data (and household surveys and other instruments used on a wide national scale) are well known. Household expenditure surveys suggest that the FAO data give a significant underestimate of levels of undernourishment (IFPRI, 2004), while other observations suggest the opposite is true. For example, as discussed above, cassava is increasingly important for large numbers of people's food intake in Africa. Yet cassava, like other root crops and key staples like enset (false banana), central to food security in the southern highlands of Ethiopia, are usually systematically under-reported in food assessment surveys[5]. In the same way, wild foods – highly significant to the nutrition of the poor – are a 'hidden harvest' and not measured at all (Scoones et al, 1992; Campbell and Luckert, 2003). By taking the data at face value, the overall pattern of doom and gloom may therefore obscure other stories of success and survival which require a more complex understanding of what is going on in particular places for particular people.

There is little doubt, however, that in significant parts of Africa for large numbers of people undernourishment, whether of calories or nutrients, and often both, is a major problem requiring urgent action. This is not in dispute. But exactly what the scale of this is, where it occurs, to whom, and through what causes is far from certain. The neat maps identifying problem areas and hot spots for action are based on levels of uncertainty and conjecture that do not pass the test of close scrutiny. As a spur to action they may serve a useful political purpose, but as scientific data they are far from perfect. Should such information be used as the basis for designing ambitious action plans and committing significant investments in new technology? Or should we be a bit more circumspect, and bring our analysis to a more location-specific level, where guesswork and assumption-laden modelling is less the driver?

I will return to this dilemma later in the chapter, but for now, let us accept the main, and unquestioned, argument that food insecurity in Africa is a major problem (even if qualified by contextual insights). The question I want to turn to now is whether GM crops are the answer? And, if so, what assumptions are required to justify this. Will technological solutions deliver real benefits to the poor, and so eliminate hunger

[5] Although in advance of the Malawi famine of 2000, cassava production was overestimated (Devereux, 2002).

and famine? Is the science up to it? Are the political and economic conditions right? Are there enough public resources available? Will the private sector play ball? Are there other solutions that might deliver similar - or even better - returns to the undeniably important issue of raising agricultural production if given the support? These are just some of the questions I want to turn to in the next section which looks in more detail at the assumptions for a GM solution to famine prevention in the African context.

Testing assumptions: evidence from Africa

So what are the advocates of a pro-poor biotechnology assuming when they argue for the importance of seeing agricultural biotechnology as the solution to African famine problems? We need to identify the assumptions, and interrogate them, testing them against our knowledge of particular places, contexts and economic and policy trajectories. This section identifies a series of key assumptions.

Food and nutrient supply is the issue

As already discussed, one of the core arguments for GM crops is that yield growth declines or at least stagnation in major staple crops are such that demands, especially with growing populations, are outstripping supply. Technological innovation can help to increase yields, and these increases need to occur in magnitudes larger than available through conventional breeding techniques and agronomic management. GM crops, it is argued, are the solution to this dilemma. In addition, it is argued, GM crops can also help in meeting the 'hidden hunger' of nutritional insecurity by providing a supply of key nutrients through biotechnology assisted 'biofortification' of crops (Bouis, 2004).

The available data certainly does indicate at least a stagnation of yield levels in key staples in Africa, and population growth rates on aggregate, despite rising mortality levels due to AIDS, remain high. The supply argument is certainly convincing. But this also must be qualified. As discussed in the previous section, the reasons for food scarcity are highly variable across space and time. Failures of agricultural production and food supply are certainly part of the picture, but the simplistic neo-Malthusian scenario is an insufficient explanation.

According to various data sources – including the standard FAO data indicators – the places in Africa where food insecurity has grown in the past decade or so have been where there has been on-going political instability and conflict. This has undermined production patterns, market opportunity and institutions supporting agriculture and rural livelihoods. This includes the DRC, Burundi and Somalia in particular, but also other conflict areas such as Liberia and Sierra Leone. Other areas that have seen major increases in food insecurity are those where economic reform programmes have undermined the rural economy and increased vulnerabilities, such as Tanzania and Zambia. In each of these areas, it is not food supply per se that is the cause of undernourishment, but a host of other factors combining to affect safe and secure food supplies to households.

The major concentrations of food insecurity in Africa also include countries which have been relatively peaceful in the last decade, but have large populations. In Nigeria, for example, it is not a food supply issue only that is the cause. Nigeria of course is a resource rich country thanks to its significant oil resources, but poor governance, and lack of investment in agriculture has meant that its economy has failed to take off since the oil boom years of the 1970s. However, despite this general picture of agricultural decline in Nigeria, there are well-documented cases where intensification of agriculture has resulted in major boosts in output. These include dryland areas like the Kano Close Settled Zone (Mortimore and Adams, 1999; Mortimore and Harris, 2005) and areas of the middle belt in the higher potential areas of the country.

Cases where food supply is probably more of an immediate issue include central and southern Malawi and the southern and northern Ethiopian highlands. Here high population densities, farm subdivision and low levels of productivity mean that farmers are unable to produce enough food to meet their needs. But of course this has been a pattern for a long time, so why have food insecurity and livelihood vulnerability become more acute? Again a huge array of factors come into the picture. In Malawi, for example, the transition from a state-supported agricultural system to a liberalised one has not been smooth; the decline in wage labour opportunities on the commercial farms has hit hard; and the restrictions on regional labour migration to Zimbabwe, South Africa and Zambia have undermined Malawian livelihoods (see Carr, 1997; Dorward and Kydd, 2002; Devereux, 2002). In Ethiopia, conflict has plagued certain parts of the country over a long period; declining trading and migration opportunities both cross-border and within the country has had an impact on livelihoods; and the collapse of state farms as a source of seasonal employment has had a negative impact (Carswell et al, 1999; Sharp et al, 2003).

Some parts of Ethiopia and Malawi can perhaps be seen as classic Malthusian cases, where a supply-oriented, technology-driven response is the most likely way out of the bind. Certainly technology-oriented innovations have had some impact already. For example in Malawi, investment in integrated soil fertility management techniques for maize growing have shown success (Place et al, 2003; Snapp et al, 2002; Mekuria and Waddington), while in Ethiopia there have been some positive impacts from maize-fertilizer-credit packages in some higher productivity highland areas through the government and the SG 2000 programmes (Howard et al, 2003). In lower input more marginal areas, indigenous soil and water conservation efforts have seen significant returns, for instance in dryland Tigray (Mitiku Haile et al, 2001). But such responses, while important, have had impacts only at the margins in places like southern Malawi and highland Ethiopia. A more radical reappraisal of options for rural livelihoods may be necessary, recognising that agriculture, and its associated technologies, will only have an increasingly small part to play[6].

So where in Africa has technological investment in crop yield improvement had an impact on any scale? A number of cases have already been mentioned. These include the growth of cereal production in the Sahel (although much of this can be attributed to area expansion and improvements in rainfall); smallholder cotton production in both the Sahel and parts of southern Africa (Tefft, 2004); west and central African cassava production (Nweke, 2004); disease-free banana planting in east Africa (DeVries and Toenniessen, 2001); new rice varieties in West Africa (WARDA, 2004); and open pollinated at to a lesser extent hybrid maize production in east and southern Africa (Smale and Jayne, 2003; CIMMYT, 2004). All of these boosts in supply have been as a result of combination of factors, and not just the crop technology. Agronomic management – of soils and water in particular – have been especially important, as well as the institutional context - markets, input supply, extension support and so on (Haggblade, 2004; Dorward et al, 2004).

Therefore, technologies which can generate yield growth, especially in staples, and which also absorb labour and respond to the particular constraints faced by smallholder farmers are clearly in demand. The right ones will - as the examples listed above demonstrate - be taken up eagerly by many millions of farmers. But all the technologies in these success stories have been fairly basic – some elementary breeding, some work on pest resistance and management, some allied investments in soil and water management. None have resulted in the imagined – and perhaps needed – quantum jumps in productivity. Are transgenics then the answer?

Technologies – and transgenic biotechnologies in particular – are the answer

Those promoting biotechnology as a solution therefore argue that the powerful new techniques of transgenics, combined with the data processing and analysis of genomics and bioinformatics, can deliver the type of solutions to the key agricultural constraints affecting poor people, including resistance to pests and diseases, salt and drought tolerance and yield improvements in crops that have not responded to conventional breeding. These techniques in the longer term – with patience and the right type of support – will deliver the type of quantum leap returns that are needed to generate broad-based technology-led agricultural growth in Africa, along the lines seen before in Asia.

Most recognise, however, that it will have to be public research efforts that will deliver these types of gains, as the R and D effort will have to be focused on those crops and traits that the private sector will not touch. But is this pie-in-the-sky dreaming conjured up by public sector research scientists in need of big injections of

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[6] This argument is of course recognised in the 'deagrarianisation' (Bryceson and Jamal, 1997) and 'livelihood diversification' debates (Ellis, 1998; Ellis and Freeman, 2004). The big, usually unanswered, question, however, is in what way - even when livelihoods are diversified (which they usually are) - will agriculture contribute, and what sort of agriculture – with what technology requirements – will this be?

funding? Biotech scientists themselves (at least in private) are divided on the issue[7]. Many agree that the type of single magic-bullet breakthrough on a par with the dwarf wheat varieties in the 1960s is not likely. Others believe that the 'difficult' traits – like drought resistance and nutrient use efficiency – are exceptionally difficult to engineer. Many agree that transgenics will be only part of the picture, and that the genomics techniques combined with such approaches as Marker Assisted Selection (MAS) may in fact be more powerful.

Most early GM research, and all the currently available products, are based on easy, single gene traits where resistance to a certain pest or disease is conferred, at least temporarily. Thus the transgenic products being planted today include the Bt related products (insect resistance), now being produced by Monsanto, as well as a number of other companies, and Monsanto's Round-up Ready herbicide resistant trait. How useful are these first-generation products?

Bt cotton, for example, is now being planted in South Africa and is being tested widely elsewhere. Early results from South Africa suggest that the returns were good, exceeding those of conventional cotton (Thirtle et al, 2004). The reduction of pesticide use in cotton farming has many advantages. These chemicals are highly polluting and dangerous to humans who apply them without proper precautions. However, again, while early results on Bt cotton look promising, these are largely from sites where there is considerable back-up support, and farmers involved in experimenting with Bt cotton have tended to have more skills and are able to take the risk of the higher costs of seed. With only a few years of experience, pest resistance issues have yet to be faced, although everyone agrees these will arise, particularly as Bt use spreads from the controlled settings of early experimental areas where appropriate precautions (such as refugia etc.) are applied. And, of course, the Bt product is only effective against certain pests – notably the cotton bollworm. In some years other pests – such as jassids and aphids – may be more important, requiring continued spraying, even of Bt plants. A key factor in the success of Bt cotton, then, is the background variety that the Bt gene is inserted into. This has not always been the optimal one, and in some places non-Bt cotton outperforms Bt, not because the Bt does not have an effect, but that its background variety is poor or inappropriate.

The other much-hyped transgenic product that has been tested extensively in Kenya is virus-resistant sweet potato (Wambugu, 2001). This has seen less success. In part this is because sweet potato is a very different type of crop to cotton. Grown in small plots and gardens, it is often a 'women's crop' where the expectation of significant input costs is low. Cotton in contrast is grown often in settings with vertical integration of production and marketing and significant support supplied by a parastatal or private company. The type of virus-free planting material that the transgenic product offers can also be gained through cheap alternative means.

The type of complex trait products that can respond to drought or nutrient deficiencies are, however, some way off. These are very taxing genetic engineering

[7]Based on research interviews with scientists in India, Zimbabwe, Brazil, UK and the US.

tasks, beyond the scope of most public research labs. As the scientist who helped build up Monsanto's biotechnology capacity in the 1980s commented in relation to nitrogen fixation: "if I could put all the genes needed to create a nitrogen fixing plant in corn, I would probably end up with a plant that resembled soya" (quoted by Hodgson, 2000).

There may be cheaper and more robust responses to these sort of constraints available in the existing repertoires of African farmers. Soil moisture and nutrient stress is not a new phenomenon for African agriculture. Therefore various gardening techniques (mounding, digging etc.), manuring and mulching; micro-spot application of fertilisers; digging of infiltration pits, small tanks and ponds; the building of soil or rock bunds, lines and mini-dams; and the use and enhancement of natural wetland patches are all well-documented responses to these constraints (Scoones, 2001; Reij and Waters-Bayer, 2001). They are widely used, and where they are not, there are usually very good reasons. In places where soil and water conservation techniques have really taken off – for example in parts of the Sahel - the concomitant growth in agricultural output has been significant, far outstripping any gain that could be expected from breeding or genetic engineering.

The experience with GM crops so far suggests that GM is certainly only going to be a partial answer to the problems besetting African agriculture. It certainly has something to offer for simple trait problems (e.g. insect/disease resistance), but with some major provisos. What is probably more generally applicable is the suite of broader non-GM biotechnological techniques. Thus tissue culture can help with the generation of clean planting materials in vegetative propagated crops (e.g. banana, cassava, potato, sweet potato and yams) and Marker Assisted Selection work is improving identification and back-crossing of genes with local cultivars (e.g. for resistance to maize streak virus, yellow mottle virus in rice, and cassava mosaic virus) (DeVries and Toenniessen, 2001).

Some would argue that a non-GM strategy is not ambitious enough: the sky's potentially the limit with GM technology, they would argue. There are, it is argued, a huge range of exciting experiments going on in labs around the world, and particularly in the private sector (many of which are not even known about, or are just rumours on the scientific grapevine). There are some pipeline products which have real promise and these could revolutionise agriculture, including dealing with the challenges of recalcitrant crops and difficult traits. Overcoming these challenges requires vision and commitment, and, above all, resources, the argument goes. Carping just doesn't help: the Green Revolution happened in a welter of (social scientists') scepticism, but it delivered beyond even the architects' wildest dreams. Surely, the proponents argue, the GM revolution should be let to run its course, and be given the appropriate support.

Public research will deliver in partnership with the private sector

In the ideal world, a multi-tracked strategy – high-tech and low-tech; GM and non-GM and all variations in between - would of course be optimal. Try all avenues, and see what works where. But GM research is high cost. Equipping a lab (and keeping it going over say 20 years) for drought resistance GM research is not a small undertaking. The CGIAR system has US$300 million at its disposal for global public goods agricultural research annually, and African national agricultural research systems are notoriously under-resourced (ISNAR, 2000). Does it make sense to allocate a significant portion of this limited public money (or even new money which surely is required) to GM research? The way out of this dilemma is often seen to be to create partnerships with the private sector whose resource far outstrip those of the public sector[8]. But what are the prospects of this sort of arrangement delivering?

Public-private partnerships are thus the flavour of the month. These allow both funds and intellectual property to be shared for the public good, allowing the public and private sectors to do what they do best. Thus, for example, intellectual property issues can be dealt with through arrangements modelled on the Vitamin-A rice deal brokered by the Rockefeller Foundation. Private companies with proprietary rights over key genes or processes could in future give these up for public good research and development on 'orphan' crops and 'difficult' traits, with no strings attached. The African Agricultural Technology Foundation, for example, was set up by a consortium of government donor agencies, philanthropic organisations and private companies with the aim of facilitating such a process in Africa[9]

In parallel to this, the hope of the GM optimists is that the private sector will also independently deliver GM solutions to developing countries suited to local needs in areas where returns are guaranteed, just as they have done in other markets (such as hybrid seeds, fertilisers etc). This might include high value crops (e.g. horticulture), cash crops (e.g. cotton) and crops where hybrids are well established (e.g. maize). Indeed the aggressive support for GM crops by Monsanto in the main developing world markets – notably China, India and Brazil and to a lesser extent South Africa – is witness to this dynamic already underway. Others will follow (and are doing so, whether from China or from the US/European multinationals) and producers will benefit, it is argued. Studies on Bt cotton, for example, show (with some fairly heroic assumptions it must be admitted) that producers take a significant share of the benefits of the new biotech product, with the company taking only a minority share (Pingali and Traxler, 2002). The argument runs that the sort of liberalised, competitive global markets that a rules-based trading system is supposed to facilitate will encourage low prices and the best technology being delivered. An urgent necessity is therefore that African producers to engage successfully with these markets. This, it is argued, is as much a solution to food security as dealing with

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[8] The top ten life science companies have R and D resources in excess of $3 billion per annum. The largest national agricultural research systems are all outside Africa (Brazil, India and China) and amount to less than $500m per annum each (Pingali and Traxler, 2002).

[9] Eight problem areas have been determined as priority targets for AATF intervention: Striga control in cereals; insect resistance in maize; nutritional quality enhancement in maize and rice; cowpea productivity improvement; bananas and plantain productivity; mycotoxins in food grains; drought-tolerance in cereals; and cassava productivity increase (see www.aftechfound.org).

‘subsistence’ crops. The associated technology fees applied will not prevent smaller farmers reaping the benefits of the new globalised agri-food system it is argued. Indeed they must if they are to remain farmers at all.

But how realistic is this scenario of a private sector-led agricultural transformation in the food insecure regions of Africa that are the focus of this chapter? In certain sectors in certain places – such as in horticulture, floriculture, cotton, cocoa, some oil seeds etc. – it may be that under some conditions the global market beckons for the small-scale African producer. Low cost (in the face of Asian or subsidised European/US competition) and high quality (for demanding export markets and global standards) products are essential. Yet, implicitly or explicitly in such analyses, a very different type of farming future is being envisaged. The economics of production for such markets tends to dictate large, consolidated units, or at least contract farming, vertical input/output support systems often run by a corporate entity; strong, contracted links to agri-food value chains, and so on (Vorley, 2003).

This indeed may be the future for some areas and commodities. For example, the cotton successes in Mali can be in part attributed to the effectiveness of the parastatal CMDT, and in Zimbabwe to the now privatised Cottco. With the struggle to meet global market requirements, Bt cotton is increasingly likely to be part of picture (GRAIN, 2004). In the horticulture sector quality and the meeting of standards are essential, given the importance of supermarket supply chains (Dolan and Humphrey, 2004; Barrientos and Dolan, 2003) and GM varieties may help in creating uniformity and extending shelf life. In such settings R and D investment in GM crops by cotton companies or the horticulture industry pays back. The problems and crops are more amenable to genetic engineering (pests/diseases in cotton; shelf-life, size/quality in vegetables/fruits), and the similarity of enterprise (in terms of agronomic management, levels of inputs, scale economies) means too that spill-over technology is more likely from other commercial production systems in Europe, North America or Asia. These ‘smallholders’ may be so in the strict sense (having small farms), but in other respects are different to other smallholder producers, whose livelihoods are more diverse and complex. These are of course niche-specific enterprises with variable consequences for poverty reduction (e.g. labour conditions for women on horticulture enterprises; contract farming conditions etc.).

However, in the areas where undernourishment is growing or highly prevalent these conditions do not pertain either now oreven in the medium term. There are few if any nascent commercial or contract farming arrangements for cotton or export horticulture in the DRC, Burundi, or even large parts of Zambia, Tanzania, Nigeria or Ethiopia. Here non-export, largely locally consumed staple crops remain most significant. It is here where low-cost, labour-absorbing (although qualified by HIV/AIDS) crop technologies are required, which can produce on poor quality marginal, water deficit land with limited purchased inputs. These too are the areas where private sector returns are unlikely. There are not going to be large investments in these problems by the private sector now or in near-term future, and spill-over benefits are unlikely too. These are very different agricultural and livelihood systems, meaning different priorities and needs, and different technologies.

It is here that the much-touted public-private partnerships, and the reinvigorated public sector are supposed to deliver. But the track record to date is not encouraging. International - and national – public research has not made a massive impact on these marginal areas. The returns to public agricultural research effort has generally been seen to be highest in the well-resourced endowed areas, and among relatively richer farmers (Renkow, 2000). Although it can be argued that the potential marginal returns from such investments are higher in lower resource endowed areas (cf. Fan and Hazell, 2001 for India), with some exceptions this potential has not been realised with most research being focused on the irrigated areas, higher value crops and richer farmers. It is too early to tell whether the new public-private partnership initiatives will follow the same trend. The Vitamin A showcase example has yet to see wide application, and there may well be easier and cheaper ways of getting Vitamin A to poor people. Other initiatives discussed above have largely made use of high-end technology in the hope that they may become widely applicable. But other questions arise too. Does the private sector have appropriate technology and processes to share? Or is the fixation on the technology distorting our perspective on both the problem and potential solutions, which may lie in less glamorous and cheaper alternatives.

Regulatory issues will be dealt with

The regulation of GM crops has generated considerable controversy around the world, and is a significant part of the high real costs of GM crops. The Cartagena protocol on biosafety requires governments to set up national biosafety regulations, and develop capacity to monitor and assess imports, trials and commercial plantings of GM crops (MacKenzie, 2003). The assumptions of GM proponents, at least in the early days, was that food and biosafety issues would not be a major issue in the promotion of GM technology. It was assumed that transgenic products are essentially 'substantially equivalent' to other products, and in many cases the introduction of new crops will be a familiar process, not significantly different from traditional plant breeding. Regulatory issues would therefore be dealt with throughout the world by the transfer of regulations from the US or Europe, requiring often only adaptation of existing legislative provisions. International 'capacity building' efforts in developing standardised, harmonised regulations for the agricultural biotechnology sector would smooth this process, it was assumed, and the new regulations would in turn be enforced consistently and effectively throughout the developing world.

This of course has not come to pass. The advent of GM crops – for both good and bad reasons – has resulted in a storm of controversy and protest. The regulations have taken a long time to get in place and the capacity of national governments in the developing world is extremely limited. The imported regulations have equally proven inappropriate to local circumstances, and regulators, publics and scientists alike have been reluctant to take approvals in the US as an indicator that a product is safe in their own country. In Africa to date it is only Zimbabwe and South Africa that have biosafety legislation in place, with Kenya having draft regulations developed.

Other countries have been involved in discussions, but do not have the capacity to implement even rudimentary regulatory control.

Studies carried out in Kenya (Odame et al, 2003), South Africa and Zimbabwe (Keeley and Scoones, 2003), have looked at the implementation of biosafety regulations in Africa in practice. Many problems have been identified, issues increasingly highlighted by well-networked activist groups. For example, the regulatory frameworks offered by international organisations as templates have had in each case to be adapted significantly; the boards set up to oversee the regulations have in most cases not had the requisite resources to fulfil their mandate; regulators have not generated trust and legitimacy among a sceptical public, particularly in the face of protests by activist groups; illegal planting of GM crops has been suspected (via cross-border trade and illicit planting by companies), but not investigated and detected; and trade restrictions have been very difficult to implement. The food aid debacle in 2002 in southern Africa highlighted many of these problems at a regional level, highlighting in particular the intensely political nature of GM crops. The political pressure exerted by the US government to accept GM food aid was construed by many as an attempt to by-pass regulatory oversight by national governments and introduce GM maize into the region as a fait accompli (GRAIN, 2002).

Given the huge stakes at play, GM crops are far from a neutral technology. While in the right hands, used for the right purposes, and regulated through an effective, fair and transparent system, they may contribute to a multi-fronted response to famine and food insecurity in Africa, they are clearly only part of a more complex solution. The final section of the chapter, then, asks under what conditions might GM crops help prevent famine, and what processes are required to come to a sensible policy position on this issue.

Conclusion

In 1999, the Nuffield Council highlighted some of the constraints of a GM future:

> As GM crop research is organised at present, the following worst case scenario is all too likely: slow progress in those GM crops that enable poor countries to be self-sufficient in food; advances directed at crop quality or management rather than drought tolerance or yield enhancement; emphasis on innovations that save labour costs (for example, herbicide tolerance), rather than those which create productive employment; major yield-enhancing progress in developed countries to produce, or substitute for GM crops now imported (in conventional non-GM) form from poor countries (Nuffield, 1999: 4.23).

This assessment applies as much today as it did five years ago. The examination of the African context in this chapter echoes many of these concerns. Even if the science was up to it, a variety of other constraining factors are pointed to. Among these are the limited availability of public funds (and the low likelihood of a sudden flood arriving soon); the complications of intellectual property arrangements, and the aggressive insistence of the private sector majors in holding on to their proprietary rights; and constraints associated with the way the agri-food industry is increasingly organised around a limited number of multinational companies. The limited publicly supported, pro-poor GM technologies, it seems on current evidence, will largely be cast-offs and not make significant impacts on the problems of famine and food and nutrition insecurity in Africa, given where such problems are concentrated and the causes underlying these.

What is needed above all are some fundamental debates about these issues – not just assertions. Of the assumptions identified above, the answers are not clear for Africa or anywhere else for that matter. Unfortunately the GM debate has become exceptionally polarised, with positions becoming entrenched around both global and national struggles for positions (Stone, 2002). This scenario – provoked and reinforced by the fierce controversy particularly in Europe, and the advocacy positions of both corporates, governments, and NGOs – has perhaps undermined the quality and depth of the debate about what type of agricultural future is wanted in different (highly context specific) parts of the world, what type of agriculture improves livelihoods and reduces vulnerabilities, and what form of regulation responds to both scientific uncertainties and public disquiet.

There are, however, some experiments emerging which offer insights as to how a different type of policy deliberation might occur, where alternative perspectives and different framings of the debate have a place (Holmes and Scoones, 2000). In the few examples that have been convened in the developing world around biotechnology, there have been concerted and often heated debate about the assumptions listed above. For example, in citizen juries and participatory scenario workshops, poor rural producers have asked – drawing on their own experience and their own worldviews – many searching questions about the impacts of a GM revolution, as currently conceived, on livelihood choices and options (Pimbert and Wakeford, 2002). While inevitably imperfect and only experimental at this stage, such deliberative policy processes offer one route for encouraging a challenging of assumptions by those who are currently excluded from the mainstream policy debate.

By moving the debate about what to do about food insecurity and famine to the particular contexts where it is faced, and involving those affected directly, there is a chance of moving away from the generalised prognoses based on incomplete, sometimes inaccurate, data and assumption-laden models that dominate the debate today. Instead of attempting aggregate demand and supply models at regional, continental, even global, levels, different questions might be asked about interacting livelihood and technology scenarios for real settings. Such analyses must encompass the contextual complexity and multi-faceted causalities that underlie conditions of famine and food insecurity. While such approaches are less amenable to the target-oriented audit culture of our times, they are perhaps more realistic and recognise that contexts do matter, and that technology design and promotion cannot be dissociated from social, economic and ecological settings. So can GM crops help prevent famine? Well, of course, it depends. In some specific places, for some particular people, perhaps yes; in other places for other people, no. The challenge is to find out more about these settings and contexts, and avoid the inappropriate grandstanding that has dominated the debate so far.

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