THIRD WORLD RESURGENCE

Feeding the world sustainably

In the following article, *Clare Westwood* highlights findings by University of Copenhagen researchers on the best strategy to feed a fast-growing global population. The findings show that agrobiodiversity, rather than genetic engineering, offers us a more appropriate option.

CLOSE to a billion people go hungry in the world every day, with 10 children dying of starvation every minute (Pinstrup-Andersen 2010a, 2010b). A further 2 billion people suffer from one or more micronutrient deficiencies (Alnwick 1996). The world has yet to figure out a way to produce enough food for its growing population, which is expected to exceed 9 billion by 2050, with less input while safeguarding biodiversity, arable land and ecosystem resilience. Agricultural sustainability is therefore no longer optional, but mandatory. There are two major and opposing schools of thought with regard to this question: one favours genetically modified (GM) [also called genetically engineered (GE)] crops while the other focuses on the potential of agricultural diversity.

A team from the University of Copenhagen (Jacobsen et al. 2013) has tackled this burning issue of how to best ensure sustainable and adequate food production by analysing the benefits and disadvantages of the development of plant breeding based on the use of existing agrobiodiversity compared with the use of GM technology. Their review covers the performance and economics of GM crops, the potential of agrobiodiversity, and research funding for both streams. This article highlights the key elements of this review with some additional discussion and references, along with the researchers' conclusions and recommendations on the more sustainable route, based on the evidence.

The status of GM crops in the world

The main question surrounding GM crops now is whether they are the best option to feed the growing population. Around 17 million farmers in 28 countries around the world grow GM crops over a total area of about 170 million hectares (ISAAA 2012), with the US, Brazil, Argentina, Canada and India having the most acreage under GM. The main commercial GM crops are soybean (81%), cotton (81%), maize (35%) and canola (30%) (ISAAA 2012). Herbicide-resistant (HR) GM crops make up around 85% of the global acreage while insect-resistant GM crops comprise around 41%; 26% have both traits (ISAAA 2011, 2012; Figure 1). Most of the HR crops are biotech company Monsanto's Roundup Ready (RR) varieties resistant to glyphosate, which is also sold by Monsanto under the brand name Roundup, while most of the insect-resistant crops are Bt varieties made resistant to selected insects using a gene from the bacterium Bacillus thuringiensis. While the adoption of GM crops has been rapid in the US, it has been the reverse in Europe due to strong public opposition.

GM crop performance

Jacobsen et al. (2013) highlight several issues regarding GM crop performance that question the claimed benefits of GM crops.

Bt cotton

Bt cotton is grown extensively in India and China. Although not a food crop, it is the most widely and longest grown Bt crop in the world and thus, Jacobsen et al. (2013) analyse its performance as a base to illustrate the issues surrounding Bt crops in general.

Monsanto controls over 95% of the Indian cotton seed market. In India, about 250,000 cotton farmers have committed suicide over the last 15 years. This has been mainly attributed by various civil society sectors to the farmer indebtedness due to loans taken out to buy the expensive Bt seeds and the subsequent failure of Bt cotton to meet promised yield levels.

In fact after 10 years of Bt cotton cultivation in the country, the Indian Parliamentary Standing Committee on Agriculture released a report in August 2012 stating that 'There have been no significant socio-economic benefits to the farmers because of the introduction of Bt cotton. On the contrary, being a capital-intensive agricultural practice, investments of the farmers have increased manifold, thus exposing them to far greater risks due to massive indebtedness, which a vast majority of them can ill afford. .The experience of the last decade has conclusively shown that while [GE agriculture] has extensively benefited the industry, as far as the lot of poor farmers is concerned, even the trickle down is not visible' (Indian Parliamentary Standing Committee on Agriculture 2012).

In China, although Bt cotton has managed to control the bollworm pest, field data collected in 2004 has demonstrated that this benefit has been offset by the increased use of pesticides to deal with secondary pests, so the average expenditure on pesticides of Bt and non-Bt cotton farmers was about the same (Wang et al. 2006, 2008). In addition, Bt cotton seeds cost three times more than non-Bt seeds and Bt farmers made less money than their non-Bt counterparts (Wang et al. 2006).

Yield lag

GM proponents claim that new varieties can be developed faster than in traditional plant breeding. However, as GM cultivars need several years of backcrossing trials to ensure the inserted traits will express as expected in local environments, there is little difference currently in this aspect between GM and traditional breeding methods. In fact, the yield lag of RR soya was reflected in the flat overall soybean yields from 1995 to 2003, the very years in which GM soya increased from nil to 81% of US soybean acreage. Stagnating soybean yields in the US are estimated to have cost soybean farmers $1.28 billion in lost revenues from 1995 to 2003 (Eliason and Jones 2004).

Impact on biodiversity

Another argument in favour of GM crops is what is called a beneficial trade-off between low-yielding extensive agricultural systems with traditional crops, which require more land, and high-yielding intensive systems, which require less land, leaving more uncultivated land free from interference to its biodiversity. However, there are many benefits associated with the former, such as increased sustainability and higher resilience to drought, pests and disease compared to intensive GM systems which require high chemical inputs. Agroecological farms in fact contain a high level of biodiversity and are self-supporting systems in harmony with their environment (Altieri 2008).

The economics of GM crops

Herbicide-resistant and insect-resistant GM crops were created to reduce labour required to control weeds and insect pests, respectively. However, in developing countries, labour is not an issue compared to developed countries. In an analysis of 168 datasets comparing yields of GM and conventional crops, 124 showed increased yields for adopters, 32 indicated no difference and the rest were negative (Carpenter 2010). Nevertheless, the Union of Concerned Scientists concluded in 2009 that GM crops had contributed only modestly to increased yields in the US (Gurian-Sherman 2009).

Increased yields and reduced insecticide use (in the case of Bt crops) do not necessarily translate to higher profits for farmers, as highlighted by Jacobsen et al. (2013). Higher production costs including from the high costs of GM seeds often result in the reverse. Patents over GM seeds drive up seed costs, restrict farmer innovation, inhibit seed saving and exchange, and undermine local cultivation practices for food security. In addition, there is the 'hidden' coexistence cost of GM crops which is defined as the cost that may occur to ensure that both GM and conventional crops can be cultivated next to each other and to ensure traceability in the supply chain without contamination. Such costs would for instance cover the cleaning of machinery, buying insurance to cover for the risk of contamination, and having to separate GM from non-GM crops in the field and supply chain by having a buffer zone. Such costs vary according to crop and location. A comparison of GM crops grown in Denmark showed that it was possible to gain a net benefit from growing GM sugar beet and potatoes, but for maize, the net benefit was negative due to high coexistence costs (DMFAF 2009).

Research funding

Jacobsen et al. (2013) point out that current research funding is clearly in favour of GM technologies over traditional and agroecological methods. For instance, in Denmark, GM research received 20 million euros in recent years from the Danish Research Council while conventional crop research received only 4 million euros. This increased specialisation and intensification of agricultural production has led to a loss in crop and livestock biodiversity and worsened genetic erosion and vulnerability (Gepts 2006; FAO 2007).

Research on traditional breeding and projects combining traditional knowledge and biotechnology tools has shown much promise. Some examples of this include work done in developing drought tolerance in maize by conventional breeding. A further example of successful utilisation of traditional knowledge and modern science would be the push-pull system in Kenya (illustrated in Figure 2) developed jointly by scientists and local farmers. Corn is intercropped with Desmodium, which repels the borer moth (push), and Napier grass, which attracts it (pull). Chemicals secreted by the Desmodium control the extremely damaging Striga weed and deplete the Striga seed bank in the soil while Desmodium roots fix atmospheric nitrogen in the soil. The push-pull system produces multiple benefits: combatting the main corn pest, the corn stem borer, and the problematic Striga weed, as well as providing a supply of rich fodder (Napier grass) for cattle which produce more milk, improving farmers' livelihoods as a result.

While the benefits of agrobiotechnology for developing countries remain dubious, large sums of money continue to be channelled in this direction away from options such as the push-pull system which have proven to be more sustainable and beneficial for small farmers and the environment.

Tapping the potential of agrobiodiversity

Jacobsen et al. (2013) argue that crop productivity can be best understood and increased by analysing yield as a product of genotype, environment and management and their interactions. They also stress that existing biodiversity is sufficient to satisfy future global food demand while it is risky and unviable to depend on a few major crops to do so. Modern-day simplified agrosystems with low biodiversity offer low-diverse diets which in turn lead to high incidence of lifestyle illnesses such as obesity, Type II diabetes, heart diseases and cancer (Frison 2009). In other words, as declared at the UN Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, the world's food supply and nutrition are most secure if based on the broadest range of crops available.

About 400 million peasant farmers feed about 70% of the world's population. Small farms are typically characterised by a high level of biodiversity, low dependence on external inputs, high efficiency and diversified cropping systems (Altieri 2008). The nutritional value of many traditional crops is generally high with micronutrients, antioxidants and essential amino acids, while many traditional crop varieties have high tolerance to drought, salinity or floods, which carries great importance in the face of climate change. Local varieties of African and Asian cereals like rice, millets and sorghum, Andean roots and tubers, and all types of leafy vegetables and fruits are essential in ensuring food security at the local level.

A further advantage of local crops over GM crops is that they are adapted to the local environment over a long period of time. Many of these crops however are ignored by researchers and policy-makers and endangered due to unfair competition from industrially produced food and their local image as 'poor people's food'.

Diversified farming is a fundamental component in improving the health and livelihoods of grassroot communities as well as building community adaptation and resilience to climate change. One study of mixed cropping found that plots grown with 16 species produced 2.7 times more biomass than monocultures (Tilman et al. 2001). Meadows and grasslands with different species also produced more hay than their low-diversity counterparts (Bullock et al. 2007; Hector and Loreau 2005). Home gardens in particular are some of the most diverse and productive food systems in the world. A report commissioned by the Hunger Alliance in 2012 found that the single most important thing that governments can do to meet the UN Secretary-General's Zero Hunger Challenge is to help the millions of poor women in developing countries grow more food in their tiny plots of land in and around their homes and to give them complementary support in nutrition, sanitation and health (UK Hunger Alliance 2013).

Agriculture's most direct negative impact on biodiversity is the loss of natural habitats which happens when natural ecosystems are converted into farms. The burning question is how to increase productivity without increasing land use area. Several studies have shown that organic production can match and even out-yield conventional systems without the same damage to the environment as the latter. Three are cited here.

A study by Pretty and Hine (2001) found that for 89 projects, sustainable farming practices resulted in yield increases of 50-150% for rainfed crops and average food production per household rose by 1.7 tonnes per year (an increase of 73%) for 4.42 million small farmers growing cereals and roots on 3.6 million hectares. This study led to a meta-analysis of 286 projects in 57 countries which found that 'resource-conserving' or sustainable agricultural practices increased agricultural productivity by 79% (Pretty et al. 2006). Another study by the University of Michigan examined a dataset of 293 samples and found that on average, in developed countries, organic systems could produce 92% of the yield produced by conventional systems while in developing countries, organic farms produced 80% more than their conventional counterparts (Badgley et al. 2007).

Conclusions and recommendations

This article addresses the ongoing debate on what the best strategy to feed a fast-growing global population sustainably is. It draws upon a major review of two major schools of thought on this question done by a team from the University of Copenhagen (Jacobsen et al. 2013). The team analysed the advantages and disadvantages of the development of plant breeding based on the use of existing agrobiodiversity compared with the use of GM technology. They came to the conclusion that the available evidence supports a focus on agrobiodiversity as the more appropriate technology to ensure food production in sufficient quantity and quality in the years to come, and placed GM crops far down the list of potential solutions for food security.

The study team reports that there are two obstacles preventing the development of sustainable agriculture solutions. The first is the claim that GM crops are necessary to secure food production for the future. The study team finds that this claim has no scientific support, but is more a reflection of agri-corporate interests, supported by the career interests of GM researchers. Based on its review of the performance and impacts of commercially grown GM crops, Jacobsen et al. state that the GM technologies will not help most of the world's farmers, but instead are expensive, increase the dependency of farmers on external inputs, produce stagnating yields in many instances, and have a negative impact on income distributions. This is similar to the conclusion by the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD 2009) that GM crops are unlikely to play a substantial role in addressing poor farmers' needs.

The second obstacle is the lack of research funding for agrobiodiversity solutions in comparison with funds available for research on GM crops, a situation which has greatly reduced crop and livestock biodiversity and increased genetic vulnerability. The team suggests that much of the research funding currently available for the development of GM crops would be much better spent on other research areas of plant science like nutrition, policy research, governance, and solutions suited to local market conditions to ensure sustainable food production. It opines that biotechnology's best contribution to reducing malnutrition would be to find ways to reduce the cost of producing food.

Jacobsen et al. warn that the expansion of GM crops will reduce the nutritional value and yield reliability of the food chain and lead to a dangerous loss of biodiversity. They strongly maintain that the best way to eliminate global under-nutrition is through the increased consumption of a diverse range of nutritious non-staple foods made available through agroecological farms and traditional breeding methods. Agroecological farms contain a high level of biodiversity, are self-supporting systems in harmony with their environment, and offer many benefits such as increased sustainability, nutritional diversity, and higher resilience to climate change, pests and disease compared to intensive GM systems.

The review team recommends that research should focus on: (1) improved agricultural practices in hunger-prone developing countries, (2) the development of agrobiodiversity resources through plant breeding, and (3) more sustainable consumption as well as production of foodstuffs.

Clare Westwood is a researcher on food and agriculture issues with the Third World Network. This article is based largely on the full review by Jacobsen et al. (2013), which can be viewed at http://link.springer.com/article/10.1007/s13593-013-0138-9. Some supporting evidence has been added.

References

Alnwick D. 1996. Significance of micronutrient deficiencies in developing and industrialized countries. In: Combs GF, Welch RM, Duxbury JM, Uphoff NT, Nesheim MC (eds) Food-based approaches to preventing micronutrient malnutrition. An international research agenda. Cornell University, Ithaca, NY, USA.

Altieri M. 2008. Small farms as a planetary ecological asset: Five key reasons why we should support the revitalisation of small farms in the Global South. Third World Network. Malaysia.

Badgley C; Moghtader J; Quintero E; Zakem E; Jahi Chappell M; Avil,s-V zquez K; Samulon A; and Perfecto I. 2007. Organic agriculture and the global food supply. Renewable Agriculture and Food Systems, 22:86-108. doi:10.1017/S1742170507001640.

Bullock JM; Pywell RF; and Walker KJ. 2007. Long-term enhancement of agricultural production by restoration of biodiversity. J Appl Ecol, 44:6-12.

Carpenter JE. 2010. Peer-reviewed surveys indicate positive impact of commercialized GM crops. Nat Biotechnol, 28(4):319-321.

DMFAF (Danish Ministry of Food, Agriculture and Fisheries). 2009. GM crops - what can it be used for? [in Danish: Fodevareministeriet GMO - Hvad kan vi bruge det til?], Fodevareministeriet. September.

Eliason R and Jones L. 2004. Stagnating National Bean Yields. Presentation in Midwest Soybean Conference, Des Moines, Iowa, August.

FAO (Food and Agriculture Organisation). 2007. The state of food and agriculture. Rome.

Frison E. 2009. Director General calls for investment in true food security. Biodiversity news. http://www.bioversityinternational.org/news_and_events/news/news/article.

Gepts P. 2006. Plant genetic resources conservation and utilization: the accomplishments and future of a societal insurance policy. Crop Sci, 46:2278-2292.

Gurian-Sherman D. 2009. Failure to yield - evaluating the performance of genetically engineered crops. Union of Concerned Scientists.

Hector A and Loreau M. 2005. Relationships between biodiversity and production in grasslands at local and regional scales. In: McGilloway DA (ed) Grassland: a global resource. Wageningen Academic, Wageningen, The Netherlands, pp 295-304.

IAASTD (International Assessment of Agricultural Knowledge, Science and Technology for Development). 2009. Agriculture at a Crossroads. Synthesis Report. http://www.unep.org/dewa/agassessment/reports/IAASTD/EN/Agriculture%20at%20a%20C

rossroads_Synthesis%20Report%

20%28English%29.pdf.

Indian Parliamentary Standing Committee on Agriculture. 2012. Cultivation of Genetically

Modified Food Crops - Prospects and Effects. 164.100.47.134/lsscommittee/Agriculture/GM_Report.pdf

ISAAA (International Service for the Acquisition of Agri-biotech Applications). 2011. Global Status of Commercialized Biotech/GM Crops: 2011. Executive Summary, ISAAA Brief 43-2011. See section entitled 'Adoption by trait - herbicide tolerance remains the dominant trait.' http://www.isaaa.org/resources/publications/briefs/43/executivesummary/default.asp

ISAAA (International Service for the Acquisition of Agri-biotech Applications). 2012. Global Status of Commercialized Biotech/GM Crops: 2012. Executive Summary, ISAAA Brief 44-2012. http://www.isaaa.org/resources/publications/briefs/44/executivesummary/default.asp

Jacobsen S; Sorensen M; Soren MP; and Weiner J. 2013. Feeding the world: genetically modified crops versus agricultural biodiversity. Agron. Sustain. Dev. doi: 10.1007/s13593-013-0138-9. http://link.springer.com/article/10.1007/s13593-013-0138-9.

Pinstrup-Andersen P. 2010a. Ny viden er farlig for en ideologi, somhar spillet fallit. Jord og Viden, 4:8-10. In Danish.

Pinstrup-Andersen P. 2010b. The advantages of genetic engineering in agriculture include increased food production and reduced hunger - benefits for hungry and malnourished in developing countries outweigh disadvantages. http://www.monsanto.com/biotech-GM/asp/experts.asp?id=P

instrupAndersen#mid.

Pretty JN and Hine RE. 2001. Reducing food poverty with sustainable agriculture: A summary of new evidence. University of Essex Centre for Environment and Society. UK.

Pretty JN; Noble AD; Bossio D; Dixon J; Hine RE; Penning de Vries FWT; and Morison JIL. 2006. Resource-conserving agriculture increases yields in developing countries. Environmental Science and Technology (Policy Analysis), 40(4):1114-1119.

Tilman D; Reich PB; Knops J; Wedin D; Mielke T; and Lehman C. 2001. Diversity and productivity in a long-term grassland experiment. Science, 294:843-845.

UK Hunger Alliance. 2013. Small Scale - Big Impact: Smallholder agriculture's contribution to better nutrition. A briefing paper by the UK Hunger Alliance. https://www.concern.net/.../hunger_alliance-_small_scale_big

_impact.pdf.

Wang S; Just DR; and Pinstrup-Andersen P. 2006. Tarnishing Silver Bullets: Bt technology adoption, bounded rationality and the outbreak of secondary pest infestations in China. Paper presented at American Agricultural Economics Association annual meeting, Long Beach, CA, 22-26 July.

Wang S; Just DR; and Pinstrup-Andersen P. 2008. Bt cotton and secondary pests. Int J

Biotechnol, 10:113-120.

Third World Resurgence No. 283/284, Mar/Apr 2014, pp 8-12
