

27. Advancing the cause in emerging economies

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1. Introduction and overview: The dialogue on the use of GM crops in emerging economies

The deficit model in teaching is out, science in developing countries shows growing valuable assets, and only dialogue and active listening will unearth mutual understanding between local science and local agriculture. Consequently, there is no room for corporate or environmental imperialism. GM crops have their real chance in developing countries in combination with the genomes of landraces

and local modern cultivars - provided those dialogue rules are respected and as a result collaborative breeding programs are implemented which meet the local needs of the farmers and give a chance to make use in African agriculture of top notch science as done by researchers of the University of Wageningen: (Slingerland et al., 2003; Slingerland et al., 2006) or in a collaboration between Germany and Namibia (Hoffmann et al., 2007). To search for a *combination* of the various agricultural approaches *adapted to regional and local needs* is the slogan, it's not about painting contrast by campaigning, teaching and preaching about its own convictions, as done by Marsden (Marsden, 2012).

The following sections 2-4 describe the premises for a realistic debate on successful bio-economical approaches: (2: science behind modern breeding, 3. high regulatory costs as a direct follow-up of the 'Genomic Misconception', 4. concepts of sustainability, from agro-ecology to bio-economy), section 5. will close with three success stories of modern agriculture in developing countries.

2. The science behind GM crop breeding: The 'Genomic Misconception': a major reason for the slowdown of regulation and commercialization of GM crops

The contrast between natural selection and transgenesis has been clearly overestimated

There is no difference between natural hybridization and genetic engineering on the level of the molecular processes, this has been emphasized and underpinned with sturdy science years ago (Arber, 1990, 1994; Arber, 2010; Arber W., 1990).

Arber notes: (Arber, 2002)

"Interestingly, naturally occurring molecular evolution, i.e. the spontaneous generation of genetic variants has been seen to follow exactly the same three strategies as those used in genetic engineering. These three strategies are:

- (a) small local changes in the nucleotide sequences,*
- (b) internal reshuffling of genomic DNA segments, and*
- (c) acquisition of usually rather small segments of DNA from another type of organism by horizontal gene transfer."*

However, on the breeding level differences are important and were helpful for the success of the new technologies: Arber continues:

*"However, there is a principal difference between the procedures of genetic engineering and those serving in nature for biological evolution. **While the genetic engineer pre-reflects his alteration and verifies its results, nature places its genetic variations more randomly and largely independent of an identified goal.** Under natural conditions, it is the pressure of natural selection which eventually determines, together with the available diversity of genetic variants, the direction taken by evolution. It is interesting to note that natural selection also plays its decisive role in genetic engineering, since indeed not all pre-reflected sequence alterations withstand the power of natural selection. Many investigators have experienced the effect of this natural force which does not allow functional disharmony in a mutated organism."*

Unfortunately, international biosafety protocols as the Cartagena Protocol and also the European biosafety legislation did not follow the *product-oriented regulation* as suggested by the majority of scientific authorities, rather it followed the regulatory path focusing on the *process* of transgenesis with all its negative aspects. Canada and other countries have chosen with great success the product oriented approach (Smyth & McHughen, 2008)

3. High regulatory costs as an indirect follow-up of the 'Genomic Misconception'

There are signals that biotechnology as a whole is a victim of growing anti-science campaigns (Miller et al., 2008). Many recent publications make a serious plea to lower the regulatory hurdles which are

the main cause for exorbitantly high developing costs of commodity crops (Giddings et al., 2012; Kuntz & Ricroch, 2012; Miller, 1994a, b; Potrykus, 2010; Tait & Barker, 2011; Twardowski & Malyska, 2012)

In a letter to the European regulatory specialists Public Regulation and Research Initiative (PRRI) has repeated the urgent plea to lower the regulatory hurdles imposed on a selection of GM plants (PRRI, 20120516). Important Swedish plant scientist launched an open letter for a revision of GM plant regulation, supported by some 500 British scientists: (Jansson Stefan et al., 20111006).

The delays of GM crop approvals go into years for certain traits, basically an intolerable situation (EuropaBio, 20120601). True, another reason for the grotesque delays can be seen in the obscure and too complex decision making structures of European regulatory system, as clearly diagnosed by independent experts (EPEC-SANCO, 2011).

As a result of the wrong focus on the process of transgenesis, opponents of GM crops and food claim lots of detailed critique, constructions of negative “facts” which do not hold critical reviewing and which are also contradicted by the evident success of GM crop planting worldwide. And worse: critical questions are often launched by non-specialists with no deep understanding of the specific science issues as David Schubert, a neurobiologist with flawed arguments, details in Bradford et al. (Bradford et al., 2005b) with their convincing and professional plea of reducing regulatory costs, the critique of Schubert (Schubert, 2005) and the rebuttal, answering properly point by point this critique (Bradford et al., 2005a).

Vested interests of important parties are heavily influencing the negotiations about changes in international regulatory legislation, since many have a clear interest to keep the pot cooking. See the overall analysis of the GM debate in (Arntzen et al., 2003):

“In the corpulent cafe societies of Europe, with their glut of good food, GM stands no chance of being accepted until there is an obvious benefit for consumers, but it is a crime for indifference and hostility to block the development of GM by and for the world’s poorest.” (Arntzen et al., 2003)

Influential and well funded activist groups (Apel, 2010) like the Norwegian GENOK¹ organize numerous biosafety classes in developing countries with detrimental effects for the perception of modern biotechnology in agriculture (Morris, 2011).

A comprehensive review of the regulatory system of GM crops of the United States has been published by McHughen & Smyth (McHughen & Smyth, 2008), a critical one on Europe by Morris & Spillane (Morris & Spillane, 2010). In a letter to the European regulatory specialists PRRI has repeated the urgent plea to lower the regulatory hurdles imposed on a selection of GM (PRRI, 20120516).

Investment in research and development is discouraged by this situation, and still clearly asymmetric between rich and poor countries, as diagnosed in 1998 by Alston et al. (Alston et al., 1998). More recent statistics from Africa show a good correlation between R&D investment and productivity due to technical progress, rather than due to the still lagging efficiency (Alene, 2010).

As a result (besides often missing research infrastructure), agricultural production in developed countries shows dramatic differences compared to emerging economies of Africa, as illustrated by

¹ GENOK, Center for Biosafety <http://www.genok.com/>

fig. 1.4 in the report of the Royal Society (Royal-Society, 2009): A lot of work remains to be done if we want to realistically ameliorate the situation. Innovative concepts need to be introduced, always with the focus on local conditions and human development, including both technological and socio-economic innovation.

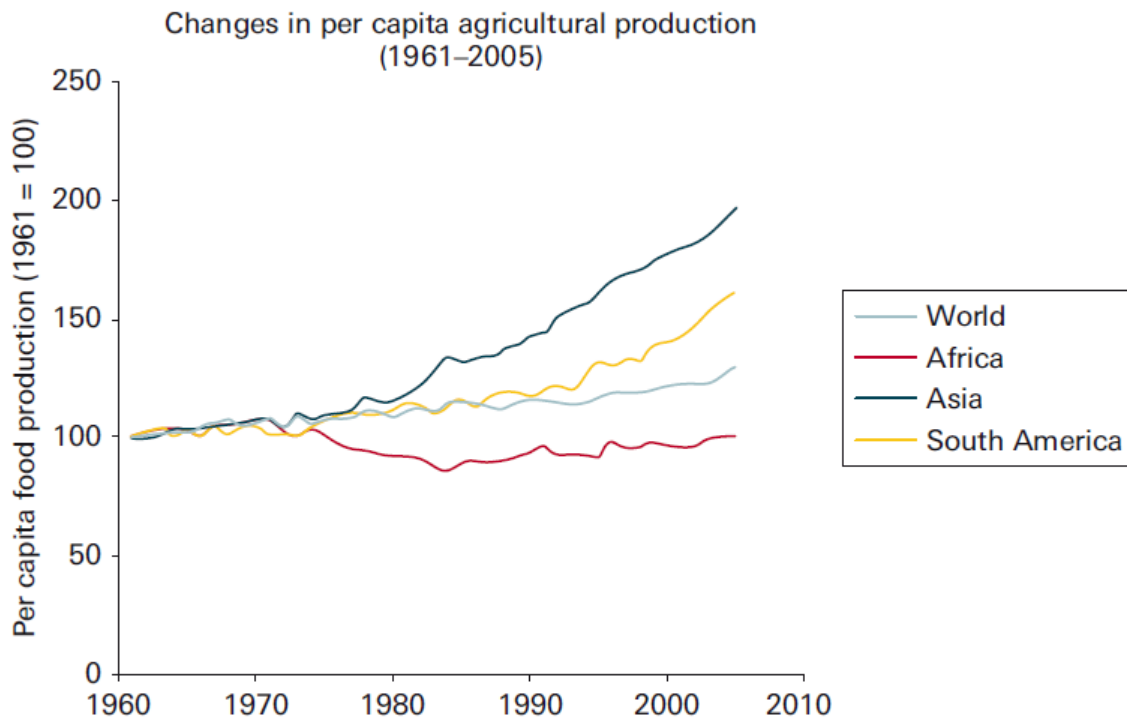


Fig. 1 Changes in per capita agricultural production from the (Royal-Society, 2009)

The trade policy of Europe is still going the wrong way of protectionism, which causes a lot of difficulties in developing countries: As Graff et al. (Graff & Zilberman, 2004) explain:

“European policies blocking genetically engineered crops are conventionally attributed to the concerns of European consumers, but they can be attributed to the self-interests of European industry and farmers as well. Biotech policies maintained in the name of consumer interests are helping European chemical firms to slow their losses in the global crop protection market and are helping European farmers differentiate their conventional crops on environmental and safety grounds, maintain their agricultural subsidies and win new non-tariff trade protections.”

In another paper Graff et al. (Graff et al., 2009) get even more explicit:

“The analysis suggests that in Europe and in some developing countries a “strange bedfellows” constellation of concentrated economic interests (including incumbent agrochemical manufacturers, certain farm groups, and environmental protest activists) act in rational self-interest to negatively characterize GM technology in the public arena and to seek regulations that block or slow its introduction.”

As early as 1997 Guasch et al. (Guasch & Hahn, 1997) described precisely the dilemma between high regulatory costs and the urgent need to enhance agricultural production in the developing world – but it did not help – on the contrary, it got worse.

More recent papers document the growing regulatory costs (Antle, 1999; Bernauer et al., 2011; Kalaitzandonakes et al., 2007), Bernauer documents also high protection costs against vandalism in a Swiss field experiment case of more than one million Francs. Kalaitzandonakes tables show regulation costs between 4 to 15 million dollars for well know transgenic traits in Maize and Soybeans. For major commodity crop estimates for global adoption go as high as 100 million dollars. The growing costs are clearly correlated to anti-science campaigns (Miller, 2009). Poorer nations turn to publicly developed crops, the expensive commodity crops of big seed companies are not popular (Cohen, 2005). Anyway most companies prefer fostering humanitarian projects in those countries (Miller-Wallstreet, 20120518).

4. Questions about Concepts of Sustainability from Agro-Ecology to Bio-Economy. Confusion can be reduced with a close Look at the Field Data with Meta Studies.

4.1. Concepts of Sustainable Agriculture

Concepts of sustainability are numerous, and often they are abused as defensive weapons to serve its own ideology. It is useful to study the original Brundtland Report (UN-Report-Common-Future, 1987), since it offers a remarkably broadminded view. Far from being exclusively defensive and retrospective, it explicitly adds the important elements of progress and search for innovation. Sustainable development has been defined in many ways, but the most frequently quoted definition is from *Our Common Future*, the Brundtland Report :

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs" (UN-Report-Common-Future, 1987).

Opponents of GM crops usually refer to the Brundtland report in their attempt to preserve traditional agro-ecology, but they forget the report also envisions a way forward – which asks not only for conservation, but also for the *development* and *management* of sustainable patterns of *production* and *consumption*. One should be aware of an extensive theoretical discussion on a “principle based approach for the evaluation of sustainability” as elaborated by (Hermans & Knippenberg, 2006). They propose, initiated by the Brundtland report, to extend the term sustainability beyond the environmental focus, an intricate philosophical map of intertwined factors of sustainability, where the main elements are justice and resilience.

A move forward to a more pragmatic, more concrete concept of sustainability is offered by the OECD with a focus on agriculture: The declaration of the OECD, authored by Yokoi (Yokoi, 2000) catalogues a range of concrete measures and rules in order to achieve a more sustainable agriculture. It is remarkable, that the proposed indicators do not distinguish between farming with or without transgenic crops. See in particular the Table 11.1 (Yokoi, 2000): it contains a comprehensive list of agricultural sustainability factors, many of them implemented in modern agriculture or ready to be implemented soon.

Agriculture is at the origin of renewable natural resources, including energy. Its worldwide recycling potential remains largely underexploited. Industrial agriculture is often still stuck in the petrochemical age, and organic agriculture panders too much to urban nostalgia and thus wastes its potential to contribute to the solution of the real problems on this planet in a more efficient way. The main goals of sustainable agriculture are indeed “to foster renewable resources, knowledge based agriculture (Trewavas, 2008).

The mistakes on the side of industrial agriculture have been already anticipated by one of the creators of the Green Revolution: Swaminathan (Swaminathan, 1968), cited from (Swaminathan, 2001) published early warnings on unwelcome developments related to the Green Revolution:

“The initiation of exploitive agriculture without a proper understanding of the various consequences of every one of the changes introduced into traditional agriculture, and without first building up a proper scientific and training base to sustain it, may only lead us, in the long run, into an era of agricultural disaster rather than one of agricultural prosperity.”

4.2. The Controversy about Agro-Ecology

The eco-imperialist attitude towards farmers in the developing world should be seen critically by (Paarlberg, 2000, 2006, 2008; Paarlberg, 2009a, b; Paarlberg, 2010). He, and many other authors cast doubts on the frequent claims (and this is supported by this author), that agro-ecology-based production strategies would be better for smallholder farmers than solutions including modern breeding, a claim which is not supported by data: The fact is, that some 80% of farmers from the developing world who have adopted GM crops are smallholder farmers making considerable economic profits with the technology (Brookes & Barfoot, 2007) and (Qaim & Stein, 2009a, b; Qaim et al., 2007)).

The numerous papers by Miguel Altieri (a selection: (Altieri, 1989, 1999, 2000a; Altieri, 2002; Altieri & Letourneau, 1982; Altieri et al., 1983; Altieri & Nicholls, 2003; Altieri & Rosset, 1999; Altieri & Toledo, 2011) offer tempting concepts on agro-ecology with some good elements and ideas, but they are not based on hard production data. Except for one publication (Altieri, 2000b) with focus on production but lacking sufficient details to allow verification, his concepts are more wishful thinking than agricultural reality. Other notorious and often cited examples of seemingly positive yield results by applying agro-ecological methods (even a doubling of yield is claimed) come from Jules Pretty: (Pretty et al., 2011; Pretty et al., 2005). They are efficiently debunked by (Phalan et al., 2006).

- a) *There is a strong selection bias towards successful projects.*
- b) *Methods used to measure changes in yields, water and pesticide use, and carbon sequestration are poorly explained, and therefore, hard to reproduce*
- c) *Crucially, the study lacks adequate controls, thereby failing to show that it is the introduction of resource-conserving practices which is responsible for reported increases in yield and sustainability.*
- d) *The extent to which these practices provide greater net benefits to farmers than conventional techniques is unclear.*

In the answers to the critique of Phalan, Pretty et al. (Pretty et al., 2006) basically admit the weakness of their study, but offer the excuse of unreasonably high costs to overcome the flaws in field data gathering. Nevertheless, Miguel Altieri seems to be 100% convinced that his way is the right one, otherwise it would be hard to understand why he helps fundamentalists to occupy research areas near Berkeley, hindering ag-biotech research with the false accusation, that it is supported by corporate money and he also supports the demonizing of biotech maize: (Brooks, 20120511).

Another sometimes cited paper from Africa, describing a comparative field research with maize cultivation, shows the seemingly positive effects of the push-pull technology, developed jointly by the International Center of Insect Physiology and Ecology (ICIPE, Nairobi) and Rothamsted Research (UK) - basically a fascinating idea to attract and trap pest insects with the weed *Desmodium*, but a careful study of the paper shows bias: (Hassanali et al., 2008). It compares a traditional inefficient maize with their own push and pull technology, getting thus a favorable result. If the team would have worked with a modern Bt maize, the result would most probably have been reversed.

More recent papers show better results as Khan Z.R. can demonstrate in (Khan et al., 2011):

Both companion plants provide high value animal fodder, facilitating milk production and diversifying farmers' income sources. The technology is appropriate to smallholder mixed cropping systems in Africa. It effectively addresses major production constraints, increases maize yields from below 1 to 3.5t/ha, and is economical as it is based on locally available plants, not expensive external inputs. Adopted by over 30,000 farmers to date in East Africa, key factors in its further up-scaling include effective technology dissemination, adaptability of companion plants for climate resilience, capacity building and multi-stakeholder collaboration, integration with livestock husbandry, improvement in input accessibility and creation of a supportive policy framework.

More papers from the same research group: (Khan et al., 2008a; Khan et al., 2008b; Khan et al., 2010; Khan et al., 2008c)

Clearly: the hard reality today is that we urgently need to produce more - on the basis of enhancing yield dramatically, the gaps are clear, and astonishingly enough those gaps are higher in Eastern and Central Europe than in Africa: (Hengsdijk & Langeveld, 2009) see fig. 3.5 p.14.

4.3. Organic Agriculture versus Biotech-based Agriculture

Organic farming generally gets a largely unjustified bonus especially in Europe, where the market for organic produce is booming, despite of higher prices and despite of the fact that local organic farming does not cover the market demands. This is why imports, even from overseas, are routine today and transport costs hardly influence retail prices. Organic is a buzz word, hardly contested in a fashionable world of wealthy western consumers.

A striking example of a nearly unbeatable positive image of organic food is the dangerous coliform outbreak in Northern Germany in 2011 which had only a low impact in the European press, despite the fact that the event caused more than 50 deaths and hundreds of patients suffering severe and permanent kidney damage. The outbreak is clearly related to organic farming. Nevertheless, it did not harm the organic boom at all. Highly virulent enterohaemorrhagic *Escherichia coli* (EHEC) strains originating from human feces introduced into organic cultures by liquid manure, in former cases it was liquid manure from cattle. In both cases it was the reason for dozens of uncontrollable outbreaks pointing to serious hygiene problems in organic cultivation. Dozens of papers clearly relate the presence of virulent EHEC to organic farming. In soil, its persistence for many months, if not years has been monitored with hard field data, including a summary of previous scientific results by (Islam et al., 2004a, 2005; Islam et al., 2004b). There are also many publications on recent field research: (Hathaway-Jenkins et al., 2011), (Ongeng et al., 2011a; Ongeng et al., 2011b; Ongeng et al., 2011c) supported by many other papers, they all demonstrate the connection between application of liquid manure and (mostly) organic farming. This tragic recent case in Germany, exacerbated by newly acquired multiple antibiotic resistance genes in the new strains only got

a minor echo in the press and the public in Europe. This does not mean that organic farming is dangerous in principle: for instance in Switzerland the hygienic rules are so strict that such deadly infection cases can be virtually excluded.

On the positive side of organic farming there is some pioneering work in developing recycling loops in organic agriculture (Albihn, 2001; Ernst, 2002; Granstedt, 2000a, b; Kirchmann et al., 2005; Korn, 1996; Risgaard et al., 2007; Srivastava et al., 2004) and on indirect effects resulting in better landscape management: (Belfrage et al., 2005; Boutin et al., 2008; Clemetsen & van Laar, 2000; Filser et al., 2002; Hadjigeorgiou et al., 2005; Hendriks et al., 2000; Holst, 2001; Jan Stobbelaar & van Mansvelt, 2000; Kuiper, 2000; MacNaedhe & Culleton, 2000; Norton et al., 2009; Potts et al., 2001; Rossi & Nota, 2000; Schellhorn et al., 2008; Skar et al., 2008; Stobbelaar et al., 2000).

There is no reason from a scientific point of view why organic methods of production should not go well together with some of the genetically improved plant varieties (Ammann, 2006, 2007, 2008; Ammann, 2009; Ammann & van Montagu, 2009; deRenobales-Scheifler, 2009; Ronald & Adamchak, 2008; Swaminathan, 2001).

The global success of biotech-based farming has been over well documented many years by International Service for the Acquisition of Agri-biotech Applications (ISAAA) (www.isaaa.org), with its centers in many countries and directed by Clive James. Downloading the latest reports (No. 43) provides a convincing picture that the success is continuing, with the exception of Europe: (James, 2011)

4.4. Comparison of Yield in Organic Farming and Biotech-based Agriculture

Organic agriculture in particular may be part of the solution but it is currently also part of the problem. The most widespread and notoriously negative sides in organic farming are the low yield, documented in many long term monitoring experiments (Mader et al., 2002; Mäder et al., 2002) etc. The paper by (Badgley et al., 2007), often cited by proponents of organic farming, claims high yields, but a closer look at the data reveals cherry picking of yield data and major statistic flaws: instead of averaging the yield data over some years, they simply added (cumulated) the results in some cases, see comments of Alex Avery (Avery, 2007).

The latest blow to the slogan of 'organic farming feeding the world' comes from a meta study published in Nature: (Seufert et al., 2012).

The main graph is convincing and does not need much comment:

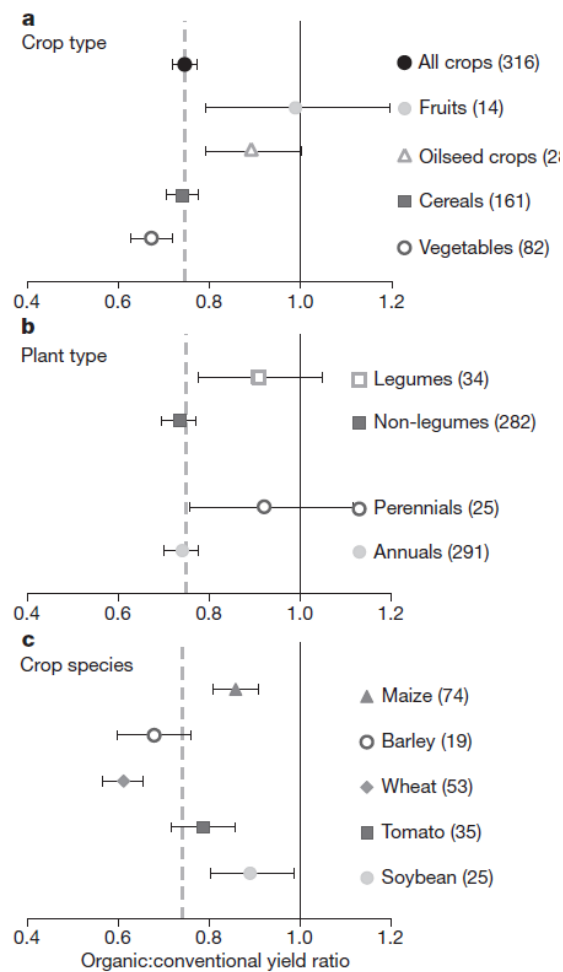
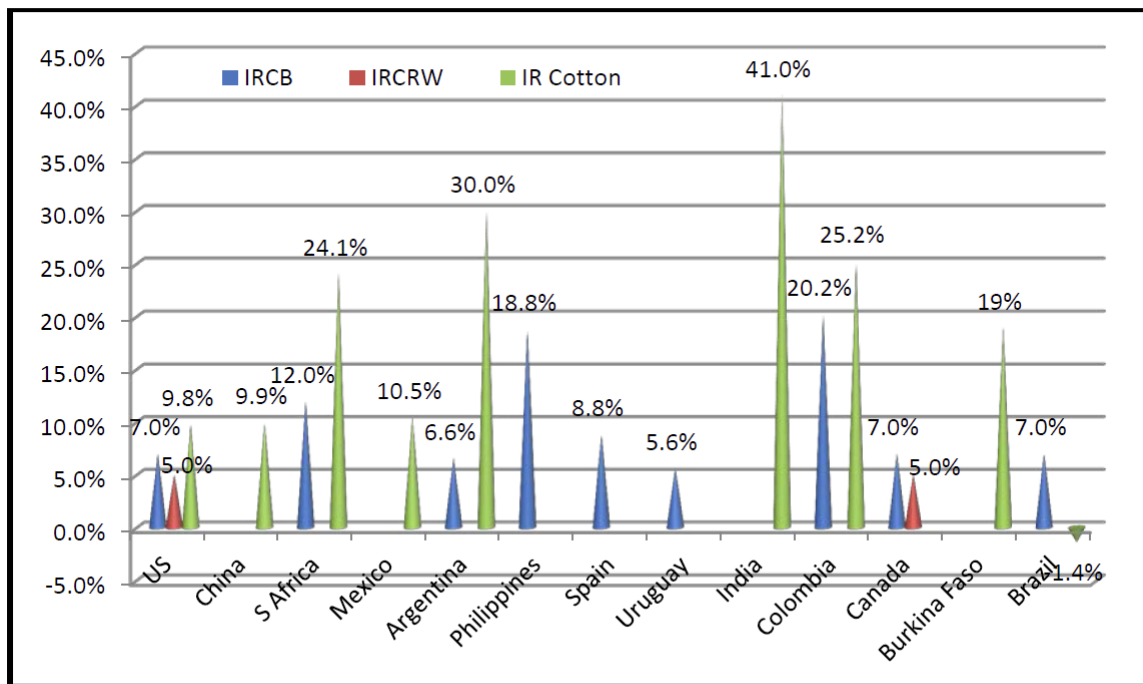


Fig. 2 Influence of different crop types, plant types and species on organic-to-conventional yield ratios. a–c, Influence of crop type (a), plant type (b) and crop species (c) on organic-to-conventional yield ratios. Only those crop types and crop species that were represented by at least ten observations and two studies are shown. Values are mean effect sizes with 95% confidence intervals. The number of observations in each class is shown in parentheses. The dotted line indicates the cumulative effect size across all classes. Fig. 1 from (Seufert et al., 2012)

The conclusions from (Seufert et al., 2012):

“The results of our meta-analysis differ dramatically from previous results (Badgley et al., 2007). Although our organic performance estimate is lower than previously reported in developed countries (220% compared to 28%), our results are markedly different in developing countries (- 43% compared to + 80%). This is because the previous analysis mainly included yield comparisons from conventional low-input subsistence systems, whereas our data set mainly includes data from high input systems for developing countries.” (Seufert et al., 2012)

Quite a different picture is given in a meta study about yield from GM crops, the example of insect resistant GM corn demonstrates a positive result globally:



Notes: IRCB = resistant to corn boring pests, IRCRW = resistant to corn rootworm

Fig. 3 Average yield impact of biotech Insect Resistant traits 1996-2010 by country and trait: The biotech IR traits, used in the corn and cotton sectors, have accounted for 98% of the additional corn production and 99.4% of the additional cotton production. Positive yield impacts from the use of this technology have occurred in all user countries (except GM IR cotton in Australia²) when compared to average yields derived from crops using conventional technology (such as application of insecticides and seed treatments). The average yield impact across the total area planted to these traits over the 15 year period since 1996 has been +9.6% for corn traits and +14.4% for cotton traits from Figure 17 in (Brookes & Barfoot, 2012)

A caveat about field trials and monitoring needs to be mentioned here: When you want to find out about the reality on yield and ecology by comparing agricultural strategies, you need to establish good contacts with the farmers and their work by doing intensive field work. Inevitably, there is one important factor which should also be taken into account: There is a possible learning effect and automatic amelioration of field practice when monitoring work by specialists starts. This effect could easily alter results in one of the other direction, independent of the agricultural strategy studied. A study on the complexity of the learning process in the wake of the Green Revolution offers some detailed insight (Foster & Rosenzweig, 1995).

4.5. Focus on Bio-Economics on the Search for the Way forward

Balancing local food production against global agricultural trade will be a challenge, since there will be increasing divergence between food demand and supply (which is stagnating due to insufficient investment in agricultural productivity). As a consequence, there will be pressure

² This reflects the levels of *Heliothis* pest control previously obtained with intensive insecticide use. The main benefit and reason for adoption of this technology in Australia has arisen from significant cost savings (on insecticides) and the associated environmental gains from reduced insecticide use (from

not just to enhance local food production but also to increase the share of food that is regionally and globally traded. After all, the food importing countries will be the ones that are most vulnerable to price shocks – and those price dynamics can be even correlated with political riots (Slavo Mac, 20110824).

The economic basis should be important, but local social networking and life need to be taken into account as well and protected from hidden protectionism under the false premise of import bans for GM crops.

It is shocking to discover, that according to (Peterson E. Wesley F. Author & Brink L. Reviewer, 2010) we spend a billion dollars a day on agricultural subsidies, in a very asymmetric way which results in a nearly perfect agricultural protectionism for the developed world.

Considering the complexity of the global challenges in sustainable food production, we should not rely on an ideological, rather than a pragmatic understanding of sustainable agriculture. Sustainable agriculture must be based on efficient resource-management that makes effective use of the new opportunities of the global knowledge economy and combines the best of system-oriented organic agriculture with the new tools in precision agriculture and biotechnology. From a scientific point of view there is no reason why organic methods of production should not go well together with genetically improved plant varieties (Ammann, 2006, 2007, 2008; Ammann, 2009; Ammann & van Montagu, 2009; deRenobales-Scheifler, 2009; Ronald & Adamchak, 2008; Swaminathan, 2001).

Even though the Green Revolution was a great success, there were also detrimental effects such as the upsurge of new pest insects, growing insect resistance against widely used pesticides and negative effects on the soil fertility and a rising number of herbicide resistant weeds. Swaminathan was one of the fathers of the Green Revolution who recognized its shortcomings. In his call for an Evergreen Revolution in 2006 (Kesavan & Swaminathan, 2008; Swaminathan, 2006) he argues, that ensuring continuous productivity increases requires a re-thinking of sustainable agriculture: a new emphasis on better infrastructure, crop rotation, sustainable management of natural resources as well as progressive enhancement of soil fertility and overall biodiversity. These are goals can only be achieved by combining traditional *and* high technology knowledge. Logically, detrimental effects like upcoming weed and pest resistance (new resistant species moving into a huge ecological niche) are also likely to become serious problems for large-scale farmers that adopt new high tech (GM)-crops. But these are well-known problems from experience with conventional and traditional agriculture as well (Weed Science, 2012), the only difference is that these resistance problems develop at a lower pace and can be addressed more quickly and more effectively with new technological means available (modern breeding measures, conservation tillage, crop rotation, mixed cropping etc., details are given in (Ammann, 2009)). It is obvious, that many opponents of GM crops want to take advantage of the negative news related to soybean farming in Brazil and Argentina, but those scare stories are based on flawed science and target in an unjustified way genetic engineering as a breeding method. All those negative arguments and the rebuttals, related to soybean farming, are summarized in (Ammann, 20120408).

A comprehensive overview of how sustainability could be organized, is offered by (Reed et al., 2006): The good thing about this scheme is that it is open ended and conceived as a learning process, thus having the near automatic capability of adaptation to local needs.

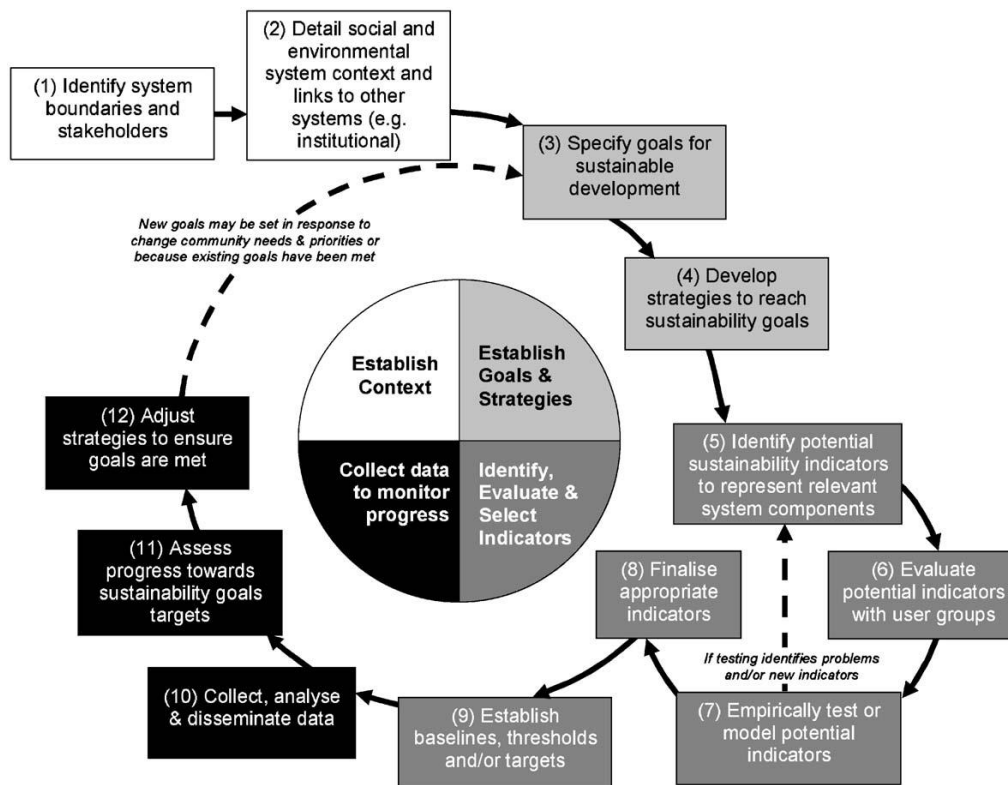


Fig. 4 Adaptive learning process for sustainability indicator development and application, from (Reed et al., 2006).

On a more theoretical level, but in a comparable process spirit (Phillis & Andriantiatsaholiniaina, 2001) have chosen the approach using fuzzy logic, followed by a recent publication within the same framework: (Phillis et al., 2010), giving a truly holistic picture including corporate structures.

“Many people believe that our society is at the crossroads today because of societal and environmental problems of scales ranging from the local to the global. Such problems as global warming, species extinction, overpopulation, poverty, drought, to name but a few, raise questions about the degree of sustainability of our society. To answer sustainability questions, one has to know the meaning of the concept and possess mechanisms to measure it. In this paper, we examine a number of approaches in the literature that do just that. Our focus is on analytical quantitative approaches. Since no universally accepted definition and measuring techniques exist, different approaches lead to different assessments. Despite such shortcomings, rough ideas and estimates about the sustainability of countries or regions can be obtained. One common characteristic of the models herein is their hierarchical nature that provides sustainability assessments for countries in a holistic way. Such models fall in the category of system of systems. Some of these models can be used to assess corporate sustainability.” From (Phillis et al., 2010)

5. Three Success Stories of GM Crop Growing and the Reasons Behind

5.1. The Worldwide Success of Herbicide Tolerant Soybean Cultivation.

There are many negative tales about South American soybean growing, most of them outright false or deeply flawed and not respecting basic rules in toxicology experimentation (Ammann, 20120408). Correct laboratory procedures reveal that there are no such problems. A new report by Williams et al. needs no further comments (Williams Amy Lavin et al., 2012), it is a comprehensive answer to all those allegations. From the summary:

“These data demonstrated extremely low human exposures as a result of normal application practices. Furthermore, the estimated exposure concentrations in humans are >500-fold less than the oral reference dose for glyphosate of 2 mg/kg/d set by the U.S. Environmental Protection Agency (U.S. EPA 1993). In conclusion, the available literature shows no solid evidence linking glyphosate exposure to adverse developmental or reproductive effects at environmentally realistic exposure concentrations.”(Williams Amy Lavin et al., 2012)

In a preprint, Jerry Green (Green, 2012) gives an overview on the success story of the herbicide tolerant soybean, the graphs do not need further comment. Compared to insect resistance and combined resistance the success of introduction of the GM soybeans has been overwhelming (James, 2011).

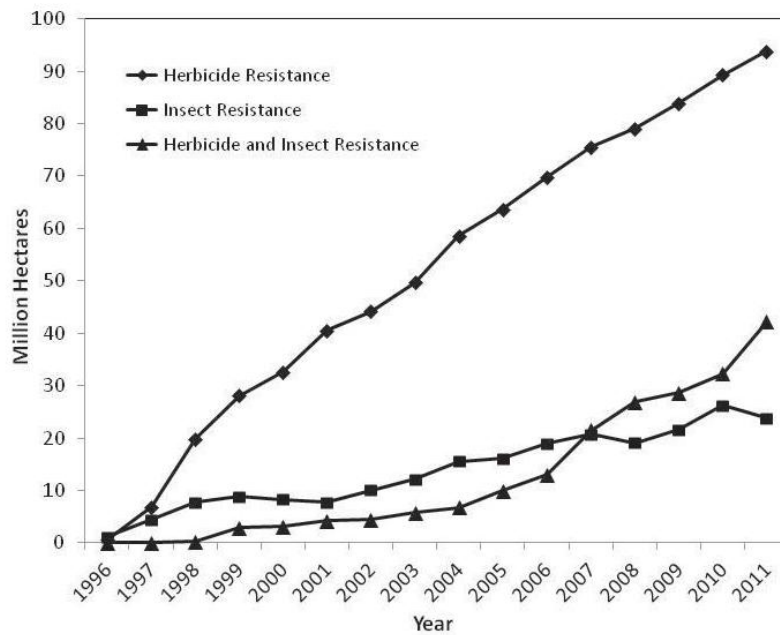


Fig. 5 Adoption of herbicide resistant and insect resistant crops globally from (James, 2011)

The environmental impact is overall clearly reduced due to conservation tilling and the low toxicity of Glyphosate a single graph of (Terrance Hurley M. et al., 2009)

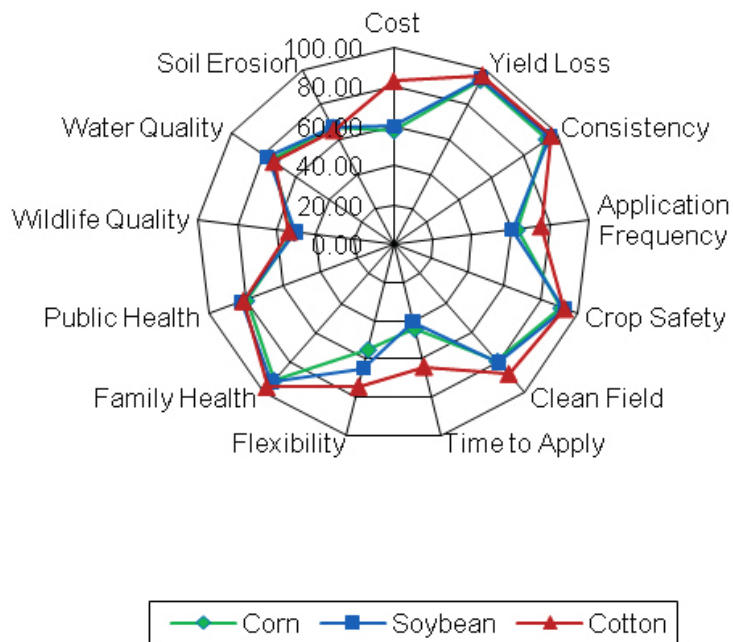


Fig. 6 Percent of of 1,176 corn, soybean and cotton growers reporting various glyphosate resistant crop characteristics that are very important, from (Terrance Hurley M. et al., 2009)

5.2. The introduction of a virus resistant GM bean in Brazil

Another recent knowledge source on the viral resistant bean has been published on the website of Biofortified by (De Souza, 20111018): It documents well an impressive success of Brazilian researchers with their own research and development and approval of a highly useful new virus resistant bean for domestic use.

“Why are virus-resistant beans so important:

Beans are highly nutritious and one of the most important legumes consumed by over 500 million people in Latin America and Africa. In Brazil it is regularly an indispensable item of the everyday diet, often combined with rice and eaten by all social classes in all parts of the nation. They are found in a great variety of types with different sizes, colors and tastes consumed throughout the country. Perhaps, the most typical Brazilian dish is the ‘feijoada’, a black beans stew. The local consumption is around 16 kg per person every year. Given its high protein (15 to 33%) content besides B vitamins and minerals as iron, calcium and phosphorus, beans provide a high nutritional value meal. Moreover, beans are the major source of protein for the economically disadvantaged.” (De Souza, 20111018).

AnBio,(AnBio Brazil, 2011) the Brazilian NGO dealing with biosafety including GE crops, has lots of activities running, among them a special website for highschools including a biology contest: <http://www.anbiojovem.org.br/obb/index.php?mod=home&ID=> . For more information about the multiple efforts in educating the public, see Traynor et al. (Traynor et al., 2007). Besides AnBio there is also an industry funded group active in biotechnology communication with the public <http://www.cib.org.br/index.php> under the direction of Alda Lerayer http://www.cib.org.br/sec_executiva.php called Conselho de Informações sobre Biotecnologia with numerous activities and providing scientific literature on the website.

Numerous local media covered the bean approval. It’s not only the anti-biotech groups communicating. Scientists, farmers, and even the Ministry of Agric CTNBio made important communication efforts, even using such modern communication tools as twitter <http://twitter.com/#!/CTNBio> to counterbalance the anti-propaganda.

For example from Xico Graziano, <http://www.xicograziano.com.br/> published in the newspaper Estado de Sao Paulo:

“The numbers do not lie, but liars produce numbers. The phrase, attributed to Itamar Franco, applies to the detractors of transgenics. Contrary to its release by CTNBio, the opponents advertise dangers that were never proven, tout to disbelieve in science. Invent reasons, shouting old discredited slogans against biotechnology.

In fact, the Brazilian transgenic crops developed by Embrapa broke the jaw of those who always accuse genetic engineering of serving the multinational large producers. They lost the easy ideological support of “neomarxist” discourse and its anticorporate stance.

Farmers in Brazil these days complain in newspaper interviews that they have to wait too long for the approval process of highly useful crops. See for example a newflash in Portugese on <http://www.youtube.com/watch?v=bl8RWHnZftY>.

5.3. The fast adoption of Bt cotton in India

The whole complex story has been recently summarized in general aspects by (Gatehouse et al., 2011; Sanahuja et al., 2011) and specifically for the economic benefits in India by (Sadashivappa & Qaim, 2009):

“On average, Bt-adopting farmers realize pesticide reductions of roughly 40%, and yield advantages of 30-40%. Profit gains are at a magnitude of US \$60 per acre. These benefits have been sustainable over time. Farmers’ satisfaction is reflected in a high willingness to pay for Bt seeds. Nonetheless, in 2006 Indian state governments decided to establish price caps at levels much lower than what companies had charged before. This intervention has further increased farmers’ profits, but the impact on aggregate Bt adoption was relatively small. Price controls might have negative long-term implications, as they can severely hamper private sector incentives to invest in new technology.” (Sadashivappa & Qaim, 2009)

At the end of the day the profitability of Bt cotton is now uncontested, see early comments of Müller-Jung Frankfurter Allgemeine: (Mueller-Jung, 2007)

The connection between suicides of Indian farmers and the introduction of GE cotton in India has been thoroughly falsified repeatedly (Gruere et al., 2008; Gruere & Sengupta, 2011). This does not hinder activists like Vandana Shiva from continuing with the same old and cheap propaganda linking GE crops with the sad tradition of farmer suicides in India, which started decades before the introduction of GE crops and beginning activities of multinational seed companies.

Although there are early warnings and incidences of pest resistance related to the widespread use of Bt cotton (Tabashnik et al., 2003; Tabashnik et al., 1994, 1995; Tabashnik et al., 2008), resistance management can be successful (Huang et al., 2011) and even beneficial halo effects have been demonstrated in regions with widespread use of Bt crops: Fields with non-Bt crops are indirectly protected by pest suppression through Bt crops, and biological control is indirectly supported (Wu et al., 2008) and (Lu et al., 2012; Wan et al., 2012)

A new perspective is open since 2006 for the production of cotton seed oil for human consumption and seed meal for feed), made possible thanks to the detoxification (gossypol) successfully done by modern breeding including genetic engineering (Sunilkumar et al., 2006), see the latest summary on the matter: (Choudhary & Gaur, 2011).

From ISAAA news and highlights 2012 (James, 2011) and (Brookes & Barfoot, 2012)

India celebrated the 10th anniversary of Bt cotton, with plantings exceeding 10 million hectares for the first time, reaching 10.6 million hectares, and occupying 88% of the record 12.1 million hectare cotton crop. The principal beneficiaries were 7 million small farmers growing, on average, 1.5 hectares of cotton. India enhanced farm income from Bt cotton by US\$9.4 billion in the period 2002 to 2010 and US\$2.5 billion in 2010 alone. Thus, Bt cotton has transformed cotton production in India by increasing yield substantially, decreasing insecticide applications by ~50%, and through welfare benefits, contributed to the alleviation of poverty of 7 million small resource-poor farmers and their families in 2011 alone.

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