



Ten Lessons from Biotechnology Experiences in Crops, Livestock and Fish for Smallholders in Developing Countries

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Abstract: : FAO recently commissioned a unique series of 19 case studies where agricultural biotechnologies were used to serve the needs of smallholders in developing countries. Most involved a single crop, livestock or fish species and a single biotechnology. The biotechnologies covered include some that are considered quite traditional, such as artificial insemination and fermentation, as well as other more modern ones, such as the use of DNA-based approaches to detect pathogens, but not genetic modification. From the case studies, we have drawn ten general and interrelated lessons which can be used to inform and assist policy-makers when deciding on potential interventions involving biotechnologies for smallholders in developing countries. These include: the absolute necessity for government commitment and backing from donors and international agencies, and of partnerships, both nationally and internationally, and also with the farmers themselves in the planning and implementation of programmes while bearing in mind also the need to retain flexibility in order to respond appropriately to evolving circumstances; and the recognition that while long-term investments in science and technology are critical, the successful use of biotechnologies also requires their appropriate integration with other sources of science-based and traditional knowledge. For the 19 case studies, there were no indications that intellectual property issues, access to genetic resources or specific regulatory mechanisms constrained use of any of the biotechnologies or their products. It was also concluded that planning, monitoring and evaluation of biotechnology applications was weak and should be strengthened.

Key words: Biotechnology, crop, livestock, fish, smallholders, developing countries

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Introduction

The latest State of Food Insecurity in the World report (FAO, IFAD and WFP 2013) indicates that although further progress had been made in reducing hunger, over 840 million people still suffered from chronic hunger in 2011-2013 and did not have enough food for an active and healthy life. The vast majority of hungry people live in rural areas in developing countries. While the current global food security situation is, therefore, quite critical, the future also promises very serious challenges which can exacerbate it considerably. The demand for food is expected to increase while the agriculture sectors, including forestry and fisheries, are expected to produce more non-food products, especially for energy and feed. At the same time, the natural resources needed for agriculture, such as available land, water and fertile soil, are threatened by numerous factors, including environmental degradation, climate change, urbanisation and loss of biodiversity and ecosystem services (Place and Meybeck 2013).

Research systems have to try to provide solutions to these major complex long-term problems, including how best to achieve 'sustainable intensification', whereby food production is increased in a sustainable way from existing farmlands (Garnett *et al.* 2013). It is widely held that agricultural innovation, encompassing the use of new processes, products and technologies, can play a key role in helping developing countries to face these future challenges (World Bank 2011). Agricultural biotechnology offers a suite of innovations whose potential contribution in this context has often been highlighted - see FAO (2011) or Ruane and Sonnino (2011) for further details.

In order to provide useful information for future interventions involving agricultural biotechnologies, we present here a summary of lessons learned from a Food and Agriculture Organisation of the UN (FAO) study of 19 cases describing the practical realities and experiences of applying biotechnologies for smallholders in different parts of the developing world (Ruane *et al.* 2013). They were chosen after a widely disseminated open call for proposals of case studies in which biotechnologies were applied to serve the needs of smallholders in developing countries (i.e. where they had progressed past the research or laboratory stage and were actually used in the field). The case studies were prepared by scientists and researchers directly

involved in the initiatives who were asked to describe the background, achievements, obstacles/challenges encountered, factors for success (or failure), impacts and lessons learned from their case study.

Case Studies

The cases covered different world regions, production systems, species and underlying socio-economic conditions in the crop (seven case studies), livestock (seven) and aquaculture/fisheries (five) sectors. Apart from one on West Africa, the studies focused on a specific initiative within a single country. Four were from India, two from China and one each from Argentina, Bangladesh, Brazil, Cameroon, Colombia, Cuba, Ghana, Nigeria, South Africa, Sri Lanka, Tanzania and Thailand. More details on the different case studies are provided in Ruane *et al.* (2013).

A wide range of biotechnologies was used in the case studies, including some of the oldest or “traditional” methods, such as fermentation and artificial insemination, as well as several now at the forefront of “modern” science involving sophisticated DNA and genetic analyses, although not including genetic modification. GMO applications were not included because of the highly polarised debate they normally engender in discussions regarding agricultural biotechnologies, even when the term is defined in a very broad sense as here. By dominating the debate, this has prevented serious consideration to be given to the potential contributions that the many non-GMO biotechnologies can make to sustainable development and food security (Ruane and Sonnino 2011). To avoid this problem, we chose not to include them here and to instead dedicate other work activities exclusively to GMOs (e.g. Ruane 2013).

Most of the case studies involved application of a single biotechnology in a single crop, livestock or fish species. They included applications of biotechnologies to overcome biological and technological constraints to increase productivity, improve people’s livelihoods, tackle diseases and pests, expand market opportunities through diversification and value addition, and to conserve genetic resources.

The case studies yielded many varied and valuable outputs, in terms of the scientific and technical knowledge, capacities and products that were generated. Collectively, these outputs had great potential for improving

on-farm productivity, market access and livelihoods. While evidence of significant outcomes (i.e. widespread adoption or use of the products by farmers and supporting partners) was not convincing in all cases, some biotechnologies, particularly in relation to seed crops and fish, were certainly adopted on a large scale.

For example, two case studies described the use of molecular markers to assist genetic selection (i.e. 'marker-assisted selection') in pearl millet and rice for smallholders in India. In pearl millet, a new hybrid called HHB 67 Improved, developed in partnership by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Indian agricultural universities and British research institutes, was released by the Indian government for cultivation in 2005. By 2011, cultivation of this high yielding and downy mildew resistant variety had spread to almost 900,000 ha of land in northern India and it was estimated to have brought greater food security to about two million people.

In rice, partnerships between the International Rice Research Institute (IRRI) and Indian research institutes led to the commercial release of the Swarna-Sub1 variety in 2009. It is highly tolerant to submergence and lodging and, in flood-affected areas, was able to produce 1-3 tonnes of more rice per hectare than other varieties previously grown in rainfed lowlands. Around 38,000 tonnes of Swarna-Sub1 seed were produced in 2011, reaching over three million farmers and covering over one million ha of land during the 2012 wet season.

In aquaculture, a case study from China was dedicated to the Jian carp, developed by within-family genetic selection and gynogenesis (a reproductive technology resulting in all-female carp offspring which have received genetic material only from their mothers). The high-yielding fish is now grown on about 160,000 farms and is responsible for over 50 per cent of the total common carp production in the country.

In other areas, such as livestock and vegetatively propagated crops, the rate of adoption indicated in the case studies was less spectacular but nonetheless meaningful to the farming communities concerned. For example, in Bangladesh, one case study described a community-based foundation that provides production-related veterinary services, including artificial insemination, to around 3,000 smallholder dairy cattle farmers.

The initiative increased milk production and farmers' income and generated employment in a country where rural unemployment is a major problem.

Lessons Learned

From all the case studies, we have drawn ten general and interrelated lessons which can be used to inform and assist policy-makers when deciding on potential interventions involving biotechnologies for smallholders in developing countries. These are:

1. Commitment by national and/or state governments was critical for improving the productivity of smallholder enterprises and the livelihoods of smallholder farmers.
2. Financial support from bilateral and multilateral donors and international agencies was indispensable for supplementing national efforts.
3. International and national partnerships were vital for achieving results, particularly for translating research outputs into field outcomes and impacts. The case studies provided numerous examples of successful partnerships both within the public sector and involving international and national collaboration; between public and private sector entities; and involving NGOs and community-based approaches.
4. Long-term national investments in both human capital and infrastructure for science and technology were critical components of the recipe. The case studies involved continuous agricultural research efforts that extended over 15 to 40 years.
5. Biotechnology approaches did not work in a vacuum, but instead were introduced into both the research mix and farmers' fields through appropriate integration with other sources of science-based and traditional knowledge. For example, in the case studies using molecular markers, sound knowledge was also required of how to select parents, make crosses and backcrosses. All the biotechnologies required a good understanding of traditional procedures for plant, livestock and fish selection and breeding. Also, the accomplishments described would not have been possible without the knowledge, skills and support of the smallholder farmers themselves.

6. The diffusion of genetic resources, techniques and know-how across national and continental boundaries was an essential ingredient of most case studies. The case studies described significant transfer of germplasm across continents and individual countries (e.g. of cassava plantlets from Colombia to Nigeria). There were, however, no indications of difficulties regarding access to, and the use of, genetic resources in the 19 case studies considered in the publication.
7. Intellectual property issues did not constrain research or the production or use of biotechnology innovations in the case studies examined here. The issue of intellectual property rights (IPRs) was rarely mentioned suggesting that it did not hinder use of the biotechnologies. Note, however, that by definition all of the case studies chosen involved actual application of the biotechnologies in the field, and so represented a positive statistical sample. We cannot, therefore, exclude that IPRs might represent a barrier in some other projects, either preventing their initiation or their arrival to the application phase.
8. Products generated through the biotechnologies described did not need to conform to new biosafety or food safety regulations or standards. None of the case studies indicated that the processes and products from the biotechnologies required new national laws and regulations covering R&D, human, animal or plant sanitary issues or labelling. Without entering into the merits of such regulatory issues, this clearly represents an advantage for the development and use of products from the biotechnologies described in these case studies over those developed using genetic modification.
9. Over time, the “goalposts” sometimes moved, requiring both foresight and flexibility. Some case studies demonstrated clearly that development projects involving smallholder farm production systems can be dynamic and risk-prone and that stakeholders need to be aware, and anticipate, that the system may evolve quickly because of issues like changes in plant or animal disease dynamics or changes in farmer and consumer preferences. For example, in one case study, the breeding programme to improve the reproductive performance of the Deccani sheep in Maharashtra state in India had to be modified underway as farmers developed a preference for larger sheep of another breed.

10. Planning, monitoring and evaluation of biotechnology applications were weak and should be strengthened. Most of the studies provided no information concerning the costs or benefits (in terms of production, productivity or financial returns) or changes in livelihoods. To improve both the planning and management of future projects, these aspects should be given much higher priority by countries and their institutions.

Conclusion

In 2010, FAO organised an international technical conference on agricultural biotechnologies in developing countries (FAO 2011; Ruane and Sonnino 2011). At the end of the conference, the Member Nations reached a number of key conclusions. Among these, they acknowledged that agricultural biotechnologies can help to alleviate hunger and poverty; assist in adaptation to climate change and in maintaining the natural resource base; that agricultural biotechnologies have not been widely used in many developing countries, and have not sufficiently benefited smallholder farmers and producers and consumers; and that more R&D of agricultural biotechnologies should be focused on the needs of smallholder farmers and producers. The case studies in Ruane *et al.* (2013) demonstrate that despite the complexities of small holder farmer production systems, agricultural biotechnologies can indeed represent powerful tools to benefit smallholder farmers given the appropriate conditions and enabling environment. We hope that the case studies and the lessons learned from these studies may provide guidance and inspiration for policy-makers in the future.

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