Reflexive biotechnology development

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Summary

Agriculture and food production are of ongoing high priority in international development debates, focused on the alleviation of extreme poverty and the eradication of hunger. One of the many ways of contributing to agricultural development for the resource poor is the development of new crop varieties that are more resistant to disease and pests, and that produce more in unfavourable circumstances such as drought or on poor soils. The contemporary revolutionary pace of innovation in genomics, marker assisted breeding and biotechnology creates a background in which there is a lot of scope for improving existing crop varieties, and addressing some of the most pressing problems that farmers are coping with. However, while the technical potential to improve crop varieties may be increasing, that does not automatically mean that we are actually able to solve problems in agricultural production. New technologies may never reach farmers, may be prohibitively expensive, or may solve only a very limited part of the problem that farmers are facing in practice. These observations have led to an interesting debate on how to make sure that the potential of modern genetic technologies can actually contribute to solving the problems of resource poor farmers in agricultural production.

In this debate it is commonly recognized that not any technology that is successful in a western production system, can simply be parachuted into a farming system in a developing country, and be expected to work. Instead, a notion of 'appropriate technology development' has become crucial in international development debates, drawing attention to the fact that technologies and development projects need to be adapted to the specific problems at hand, and the circumstances in which a technology has to work. However, this notion of 'appropriate technology' is far from being self-evident or straightforward, and no concrete recipe exists for defining what constitutes appropriate technology in a given set of circumstances. For that reason, the question emerges how this notion of 'appropriateness' is being operationalized by different project in practice.

This thesis engages with the debate on appropriate technology development by moving beyond a technical perspective on what constitutes 'appropriate technology' and by focusing on how different approaches to agro-technological development create different social roles for technology developers and farmers in innovation processes and production systems. This leads to a genealogy of strategies for agro-technological development in which farmers may be treated as 'recipients of technology', or may be involved as 'co-innovators', and in which technology developers may present themselves as 'solution providers' or 'service providers'. Insight in those different approaches can contribute to a clearer debate on the potential role of biotechnology in agricultural development and the reduction of poverty.

The first chapter of the thesis introduces the field of international agricultural development, and the role that genetic technologies can play in that context. The Green Revolution is introduced and discussed as an important previous experience in the large scale, planned modernisation of agriculture in the developing world. The question whether the Green Revolution was a success is still being answered in very different ways. This illustrates that the success of a technology can only be measured with respect to a specific perspective on agricultural development, and the question what exactly a new technology is for: an increase in productivity or the alleviation of poverty. The chapter also introduces the notion of reflexive development, which focuses on the learning dynamic in development projects, and the capacity to take comments, criticisms and concerns regarding agricultural development on board in innovation processes. Such reflexivity seems essential in order to answer the question what new technologies are for, and how it relates to a specific perspective on agricultural development. However, the way in which such reflexivity takes shape in practice will strongly depend on institutional and political factors. This is illustrated by a comparison of the historical backgrounds of the Green Revolution and the more recent 'Gene Revolution', which demonstrates that both processes are determined by entirely different dynamics, ideologies and (commercial) interests. This provides a starting point for this study, which investigates how contemporary projects use genetics and biotechnology for agricultural development, and tries to understand how technologies are made appropriate for resource poor farmers in developing countries.

Chapter 2 describes the research design of this study. It introduces the aim of the study, its main research questions, the three case studies and the methodology for data collection. In addition it reflects upon the suitability of the methodology to answer the research questions posed, and discusses the validity of the conclusions that are drawn based upon this explorative study.

Chapter 3 provides a more extensive conceptual background, deepening the discussion started in the first introductory chapter. Agricultural development is discussed in terms of modernisation and industrialisation processes which are argued to both contribute to a relatively homogeneous approach to agricultural development, and to the externalization of many aspects of farming practice like breeding and seed management. While this may have been a highly successful model of agricultural development in some parts of the world, its appropriateness for resource poor farmers is challenged. Agriculture in developing countries is often small-scale and characterised by a high degree of variability and localized adaptation. The question is whether an alternative model of agricultural development is possible in which genetic breeding technologies are used, but without necessarily externalizing agricultural innovation to specialized breeding institutes or companies. The expectation is that farmers in some areas are likely to require a more open-ended approach to agro-technological development in which they are empowered in their own on-farm experimentation with new crop varieties. The questions is what such an approach to innovation would look like, and whether elements of such an approach can be witnessed in the case studies. Finally, the

question is raised what such an approach would mean in practice for the material design of new technologies or crop varieties.

Chapter 4, 5 and 6 present three case studies of projects in which plant breeding and genetic technologies are used to develop new crop varieties with interesting traits for resource poor farmers in developing countries.

Chapter 4 presents the case of the Collaboration on Insect Management for Brassicas in Asia and Africa (CIMBAA); a public private consortium in India which aims to develop a cabbage variety which is resistant against the diamondback moth. This insect is currently causing big losses in cabbage cultivation in India, and the CIMBAA consortium hopes to address this problem by engineering Bt insect resistance into a cabbage variety. The case study touches upon several dimension and aspects of making genetic technology appropriate for resource poor farmers, including the technical design of the gene construct that is used, the structuring role of intellectual property in the consortium, and the scope of stakeholder involvement in this project. The case is taken as a main illustration of how extensive efforts to reach resource poor farmers remain within the limits of an already existing industrial production system, in which the role of an external seed supplier is legitimized and consolidated. The innovation process in this case is characterised by its treatment of farmers as recipients of technology, and by their indirect representation in the project, rather than by their direct involvement.

Chapter 5 presents a set of initiatives of the International Potato Centre in Peru (CIP). The Peruvian Andes are the centre of origin of potato, and local traditional potato production is characterised by the use of a wide diversity of landraces. The use of modern improved potato varieties may boost productivity for farmers, but is feared to lead to the replacement of these native potato varieties, which are an important resource of genetic diversity for future plant breeding, as well as an important culinary and cultural resource for Andean potato farmers. For this reason, CIP is experimenting with participatory breeding programmes, the repatriation of native potato varieties, and the marketing of traditional potato varieties. These initiatives are argued to challenge the common bias in agricultural modernisation towards a narrowing genetic base, and the specialization on the cultivation of a very limited number of crop varieties. In addition, the centre is experimenting with virus resistance kits, which may significantly slow down the degradation of potatoes because of virus infestation. The combination of improved virus resistance of potatoes, diagnostic techniques and improved virus management practices may allow farmers to sustainably produce their own seed potatoes, providing them with a reasonable alternative to commercially available seed potatoes. The case study discusses the extent to which the technological interventions by CIP are capable of challenging ongoing trends towards an industrialisation of potato production, and capable of empowering farmers in their own on-farm seed potato production. Finally, the case represents an example of how farmers can be involved in agricultural development as co-innovators with specific valuable and complementary knowledge and expertise.

Chapter 6 presents the work of the Generation Challenge Programme (GCP), which is committed to the use of upstream comparative genomics research for the development of drought resistance traits in crops of interest to resource poor farmers. The chapter evaluates the priority setting exercise conducted by GCP and the way in which the programme tries to make sure that its research outputs are actually taken up by downstream research partners. The chapter discusses some of the potential difficulties in this process and explores the potential of 'complementary innovation systems' in order to meaningfully link upstream science-led genomics research and downstream bottom-up breeding programmes. The Genotyping Support Service (GSS) is expected to play an important role in that respect. The GSS is a very accessible service which allows the outsourcing of molecular analyses to specialized institutes for a variety of projects. This initiative is taken as a potentially very interesting approach to agro-technological development that shifts focus from the development of a technical solution, to the provision of a technical service. The GSS may as such constitute a technical interface between upstream genomics research and downstream variety development. The case also is a clear example of treating local research partners and farmers as co-innovators in agricultural development.

Chapter 7 brings together the analyses of the three case studies and evaluates how the different projects have practically operationalized the objective to develop 'appropriate technology' for the agricultural development of resource poor farmers. This leads to an extensive discussion on the different dimensions in which appropriateness of technological innovation is interpreted and reconsidered, and to the formulation of a contemporary understanding of what appropriateness means in practice. The multi-dimensional understanding of appropriateness that emerges from this analysis is taken as an argument for 'reflexive biotechnology development' as an approach to agro-technological innovation. The chapter further reflects upon the extent to which the material design of the various genetic technologies in the case studies is related to specific structures of production or innovation systems, and the extent to which the use of genetic technologies in plant breeding necessarily leads to an externalization of the innovation process. Some practical implications of the study for contemporary innovation policy are discussed and new questions for future research are formulated. This leads to the formulation of the following practical recommendations for policy makers or research managers in the field of agro-technology development:

- Encourage reflection upon the alignment between research approaches and the model of agricultural development that may be most appropriate for the intended beneficiaries, especially in terms of the production system and innovation system that is created or supported.
- Encourage the experimentation with breeding strategies that focus on the release of a wider set of new varieties and that aim to complement the cultivation of traditional varieties, rather than replace it. In addition, encourage the experimentation with crop varieties that allow farmers to be involved in their on farm seed production and hence may be instrumental in the strengthening of the informal seed sector. These strategies may not be

appropriate for all farmers in all regions, but they provide a potentially valuable alternative to the trends of an externalization of the means of production and the decrease of local innovation capacity, and may as such be highly appropriate for farmers in regions that have so far been left behind in attempts of agricultural development.

- Make optimal use of the complementarities between a genetic perspective on plant breeding and the capacities of farmers in variety selection, in order to maximize the relevance of new crop varieties.
- Invest in institutional learning processes and develop methods to measure research impacts along those lines.
- Encourage public private partnerships for the potential complementarity in capacities and the access to proprietary IP, but be careful in the kind of production system that is supported and the interests of the private partners to play a future role as technology provider. The model of agricultural modernisation that is interesting for the private partner may not always be the most appropriate model for resource poor farmers.
- Encourage stakeholder involvement and interactive research processes, but don't blindly extend this effort to upstream genomics research. In that domain, it makes much more sense to reflect on the way in which complementarities with different downstream partners can be exploited, and how new technologies and methodologies can be made available as a service, rather than as a concrete artefact.