DEVELOPMENT ECONOMICS AND POLICY

Series edited by Franz Heidhues and Joachim von Braun

42

# Biotechnology and Value-added Traits in Food Crops

## Relevance for Developing Countries and Economic Analysis

Roukayatou Zimmermann

PETER LANG
Europäischer Verlag der Wissenschaften

# 6 Summary and Conclusions

Micronutrient deficiencies and infectious diseases constitute serious problems in the world, killing millions of children particularly in developing countries (DCs). Over one billion people, almost all in DCs, are suffering from the effects of micronutrient deficiencies, and another one billion are at risk of falling prey to them. In addition, more than 13 million children under the age of five die each year from infectious diseases – one in two deaths in DCs. Two million of those deaths could be prevented by vaccines already available.

*Micronutrient deficiencies* are due to the fact that cereals and other starchy staple foods often heavily dominate the diets of people in DCs. These staple foods are generally low in micronutrients. Animal products in particular, as well as fruits and vegetables, tend to be rich in bioavailable micronutrients, but poor people in DCs often cannot afford sufficient amounts of these expensive commodities. *Infectious diseases*, on the other hand, are due to the fact that in many DCs immunisations are non-existent, unreliable or too costly. Poor countries often lack financial resources, money as well as physical infrastructure, to transport and store the needed pharmaceutical compounds. Some vaccines, for instance, require constant cooling which often cannot be guaranteed. Consequently, diseases and epidemics break out that could actually be prevented, with concomitant human suffering, economic hardships for affected families and huge economy-wide costs.

Biotechnology, particularly genetic engineering, offers a cost-effective alternative to fight these problems. Staple food crops can be genetically modified (GM) to produce higher amounts of micronutrients or antigens as edible vaccines. Such new crop traits – enhancing the nutritional quality of the food product or extending its function – are called value-added traits (VATs). VATs promise nutritional and health benefits, particularly for those vulnerable groups who suffer from malnutrition and infectious diseases. The potential is particularly big for the poor, who cannot afford adequate health care and more nutritious diets, and for those who live in remote rural areas which are difficult to reach with conventional vaccines and micronutrient intervention programmes. Recently, for instance, researchers have managed to develop transgenic rice with higher provitamin A and iron content. Work on edible vaccines includes efforts to prevent diseases such as cholera, measles, diarrhoea and a number of viral infections. However, the role of biotechnology as a tool to eliminate nutritional and infectious problems should not be overestimated. The health and nutrition problems that DCs face are not only related to technological issues.

Moreover, crops with VATs are not ready for commercialisation yet. They are still at the stage of R&D. It will take a couple of years until promising

products are available in the market. Before the potentials can materialise, a number of technical, regulatory and public acceptance issues need to be resolved.

### *Methodological Innovation for the Economic Evaluation of VATs*

New agricultural crop technologies are usually evaluated by looking at changes in yield or cost of production. With the help of matching data, aggregate benefits can then be calculated by modelling a shift in the commodity supply curve. However, this approach is only suitable when the technology involves improved agronomic traits; that is, when the advantage unfolds at the level of agricultural production. Technologies that enhance the quality of commodities are often associated with benefits at the level of consumption. The primary goal of VATs considered here is to improve the health and nutritional status of food consumers. Generally, quality improvements would increase the consumers' willingness to pay, entailing an upward shift in the commodity demand curve. An increase in willingness to pay, however, presupposes that consumers recognise and appreciate the quality improvement. It is questionable whether this will be the case, particularly for crops containing higher amounts of micronutrients. Focus group discussions in the Philippines showed, for instance, that only a very small percentage of consumers would be willing to pay more for Golden Rice. Therefore, we propose a methodology from the health economics area which we adapted to our study. The approach is called disability adjusted life years (DALYs). We incorporate this methodology into our innovative analytical framework that simultaneously captures aspects of agricultural, nutritional and health economics. For illustrative purposes, the framework is outlined and used for the example of Golden Rice in the Philippines. To our knowledge, this is the first study that quantifies the nutritional and health effects of micronutrient-enriched staple food crops in an economic framework. In the future, this approach can be further refined and used for the evaluation of other VATs.

### *Economic Analysis of the Golden Rice Technology in the Philippines*

VAD is a severe problem in DCs, causing temporary and permanent eye impairments and increased mortality, especially among children and pregnant and lactating women. The analysis shows that the annual health costs in the Philippines are in a magnitude of 0.3 percent of the country's GNP. These costs could be reduced through GR. The scenario calculations demonstrate that GR will mitigate problems of blindness and premature death, with social benefits ranging between US$ 16 million and US$ 88 million per year.

Although these are remarkable gains, it must be clearly stated that GR alone will not eliminate VAD and related health costs. Micronutrient

deficiencies are caused by a complex set of economic, social and cultural factors, so that a technological approach cannot be considered a magic bullet. The purpose of developing GR is not to replace other interventions such as food fortification, supplementation or dietary education programmes. Rather, the technology should be seen as a complementary tool in the fight against VAD. GR is particularly promising for remote rural areas because, after the initial R&D investment, the cost and institutional effort in reaching the target population is much lower than for other interventions. The advantage is that GR can be reproduced and multiplied by farmers themselves. With appropriate information and dissemination campaigns during the early stages of adoption, diffusion could potentially be fast and widespread through an informal exchange of seed.

A preliminary cost-benefit analysis shows that R&D expenditure for GR is a highly profitable public investment. In the scenario calculations, IRRs range between 66 percent and 133 percent. These returns are higher than for many crop-breeding projects focusing on the improvement of agronomic traits. Of course, the benefits of agronomically improved crops and micronutrient-rich staple foods are different in nature. While the former show up in terms of increased real incomes for agricultural producers and consumers, the latter consist primarily in a reduced burden of disease for society in general and affected population groups in particular. These benefits might be less visible, but our analysis demonstrates their high economic significance. The breeding approach appears to be a promising and efficient way of reducing micronutrient deficiencies among the poor.

However, it has to be emphasised that there is still a large degree of uncertainty relating to the efficacy and coverage of the technology, which are key variables for the scenario calculations. Although the sensitivity analysis confirms the robustness of the general statements, more research and better data are needed before far-reaching conclusions can be drawn. Also, it should be pointed out that our analysis is only a first attempt to quantify the health impacts of micronutrient-enriched food crops within an economic framework. There is ample scope for refining and extending the methodology employed.