

**Editor's Introduction:**

## **The Future of Agricultural Biotechnology: Creative Destruction, Adoption, or Irrelevance?—In Honor of Prof. Vittorio Santaniello**

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With the death of Prof. Vittorio Santaniello in the summer of 2007, the International Consortium for Agricultural Biotechnology Research (ICABR) lost one of its most enthusiastic founders and most important contributors. This special issue celebrates Prof. Santaniello's commitment to the establishment of an independent forum of discussion for agricultural biotechnology issues by collecting high-quality, peer-reviewed scientific contributions to the ICABR Conference held June 12-14, 2008 in Ravello, Italy. The conference theme, *The Future of Agricultural Biotechnology: Creative Destruction, Adoption, or Irrelevance? in Honor of Vittorio Santaniello*, was an invitation to look at the current status of scientific knowledge in agricultural biotechnology and to the new challenges ahead. Participants from around the world found their way to the Amalfi Coast to present their contributions and begin to pave the road ahead. Their efforts were framed by seven excellent plenary sessions.

Thirteen scientific articles have been selected for this special issue. Pasquale Lucio Scandizzo, David Zilberman, and Carl Pray open by commemorating Prof. Santaniello in "Vittorio Santaniello: Founder of the International Consortium on Agricultural Biotechnology Research (ICABR): A Personal Memorial," which highlights the life of their long-time friend and colleague.

Justus Wesseler remembers Santaniello's contributions to issues of irreversibility and uncertainty in agriculture and summarizes them in "The *Santaniello* Theorem of Irreversible Benefits." This theorem states that *irreversible benefits do justify the immediate introduction of transgenic crops, even if future uncertainty about reversible benefits include negative benefits and traditional cost-benefit-analysis treating all benefits and costs as reversible would reject the introduction*. The theorem of irreversible benefits points out the non-trivial issue of properly weighting reversible and irreversible impacts in cost-benefit analysis. In a time at which some researchers and policy makers celebrate precau-

tion by favoring delays, this theorem shows that this choice foregoes immediate benefits that maybe irreversible. In this context, immediate action may prove to be the most precautionary socially optimal choice. In the discourse on the economics of agricultural biotechnology, scientific contributions such as Santaniello's Theorem of Irreversible Benefits meet existing narratives often originating from culture, beliefs, and perceptions instead of pure science.

Nevertheless these narratives play a crucial role in the diffusion and perception of agricultural biotechnology innovations around the world, as illustrated in the contribution by Ronald Herring in "Persistent Narratives: Why is the 'Failure of Bt Cotton in India' Story Still With Us?" Pasquale Lucio Scandizzo, in his contribution "Science and Technology in World Agriculture: Narratives and Discourses," highlights contrasting narratives originating from the analysis of past experiences and future tendencies. Subjective recount of successes and failures of agricultural research influence the choice of paradigm used to organize such knowledge. Two contrasting paradigms arise. The conservative paradigm believes that agricultural progress has taken the right direction, yielding a long chain of success stories. The radical paradigm, in contrast, criticizes the direction taken by agricultural progress due to its negative impact on small farms. Deeply contrasting paradigms create extremely different narratives on the successes and failures of agricultural biotechnology, yielding a confused interpretation of facts and biased beliefs in the neutral observer. International organizations such as the World Bank may help restore objectivity by offering their "own narratives, stylized truths, and balanced interpretations." The World Bank's role in restoring balance is a very important one because individuals' risk perceptions are formed from current narratives and discourses, and the same perceptions shape policy makers' choices of ex-ante rules and regulations.

This is further emphasized by Greg Graff, Gal Hochman, and David Zilberman in “The Political Economy of Agricultural Biotechnology Policies.” The regulatory environment in the European Union can be explained by the interest of the European chemical industry to slow down the introduction of transgenic crops in Europe in combination with the interests of environmental pressure groups to stop the technology, resulting in no or delayed approval. The political economy of biotechnology also resulted in delayed approval in Argentina, Canada, and the United States, further increasing the foregone irreversible benefits. What coping with ex-ante regulations for farmers means is shown in the contributions by Nicola Consmüller, Volker Beckmann, and Christian Schleyer and Theodoros Skevas, Pedro Fevereiro, and Justus Wesseler. In the Brandenburg, Germany, case study, eight Bt-corn growing farmers and six adjacent neighbors were interviewed, revealing that Bt-corn growing farmers organize compliance with coexistence regulations by intra-farm coordination. The large farm size—with an average of more than 690ha of arable land—allows those farms to internalize the coexistence regulations at almost no additional costs. The German coexistence regulations increase the comparative advantage of larger farms over smaller ones. Interviews with 37 Bt-maize farmers and 66 conventional farmers in Portugal reveal that most farmers think of ex-ante regulations as rigid and difficult to apply, and for 29 farmers, the complexity of coexistence rules was a determining factor in their choice not to plant Bt-maize. Despite the challenging social and political context, researchers continue to collect information on the socio-economic and environmental performance of transgenic crops in developed and developing countries.

Haruko Okusu reports about agricultural biotechnology research activities among the CGIAR centers. More than 15 crops are currently being tested using transgenic methods. The main aim is developing abiotic stress-tolerant—particularly drought tolerance—improved crop varieties and to breed staple foods biofortified in micronutrients, such as vitamin A, zinc, and iron. The centers also provide assistance to countries in developing biosafety regulations.

In another article, Marnus Gouse, Jenifer Piesse, Colin Thirtle, and Colin Poulton investigate the economic performance of herbicide-resistant (RR) maize in KwaZulu-Natal, South Africa for the 2006/07 maize production season, finding little impact on efficiency for small-scale farmers. The authors warn against generalizing findings from the analysis of a single season and call for caution in the interpretation of these results. Such a

warning is important because socio-economic aspects of agricultural biotechnology are gaining attention within the debate about conservation of biological diversity.

José B. Falck Zepeda discusses the inclusion of socio-economic considerations into biosafety assessment procedures. The major problem he identifies is having another reason for delaying the introduction of a safe transgenic crop. A clear description of the requirements for a socio-economic assessment as part of the approval process would therefore be indispensable.

Clearly defined regulatory requirements are important to avoid misallocation of investments. David Castle, Kira Kumagai, Celine Berard, Martin Cloutier, and Richard Gold demonstrate that by employing a system-dynamics model, plant-derived vaccines to control hepatitis B can provide enormous welfare benefits in India. Differences in the regulatory regime for producing the vaccine can generate substantial irreversible benefits by saving more than 2 million lives over a 40-year period.

Koen Dillen, Matty Demont, and Eric Tollens, in their contribution “Global Welfare Effects of GM Sugar Beet under Changing EU Sugar Policies,” show the potential economic value of herbicide-tolerant (HT) sugar beet in the global sugar sector under both the former and the actual European Common Market Organization (CMO) for sugar. The authors estimate a €15.4 billion value for HT sugar beet for society over the course of the period 1996-2014; 29% of this is captured by EU farmers, 31% by farmers and consumers in the rest of the world, and 39% by the seed sector.

As suggested by Vittorio Santaniello and highlighted in Justus Wesseler’s own contribution to this special issue, however, delays in the acceptance of this technology cause an immediate irreversible loss of part of this value. To avoid the seasonality problems mentioned in the Gouse et al. article, the model is calibrated based on production data of HT sugar beet from 1996 to 2006. Dillen et al.’s model interestingly shows a small negative impact of the technology on profits of seed producers. This effect is due to the fact that yield-enhancing technologies introduced in highly protected sectors negatively affect their own demand, as farmers who are non-responsive to world prices will decrease their land allocated to the crop, lowering the derived demand for enhanced seed.

The importance of the European Common Agriculture Policy (CAP) in this respect cannot be stressed enough. Steven Sexton, Gal Hochman, Deepak Rajagopal, and David Zilberman illustrate the relevance of biotechnology in the biofuels and food sectors. The recent increase in food prices can be explained also by an

increase in biofuel production, particularly harming global food consumers. Investment in biotechnology provides the potential to easily double biofuel production by making use of cellulosic plants such as switch grass or *Miscanthus*. Full use of biotechnology for food and biofuel production can reduce the risk of a sudden increase in food prices, but this requires an increase in the investment in R&D, a topic Rupa Deshmukh and Carl E. Pray investigate in their contribution. Their findings suggest policies can play an important role in the innovative activity of private firms, whether it is financial grants for R&D or subsidies for production, but they can also work against each other. Support for R&D and

pilot plants stimulated more R&D, while subsidies on ethanol production had a negative impact on R&D. Funds for research in new biofuel technologies stimulate innovation, while subsidies on production do not, an important result for R&D policies.

In summary, the articles selected for this special issue cover a variety of important current and future socio-economic issues in agricultural biotechnology. The range of topics with contributions of established researchers as well as young scholars from all over the world reflects the spirit of the ICABR conference and of Prof. Vittorio Santaniello.