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Socioeconomic Impacts of Genetically Modified Crops can be Pro-Poor

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Introduction

Genetically modified (GM) crops have been grown commercially for more than 20 years in many parts of the world, including in developed and developing countries and by large and small farms. Most of the GM technologies used so far involve herbicide tolerance (HT) and insect resistance (IR) in crops like soybean, maize, cotton, canola, and a few others. In spite of the rapid and widespread adoption of GM crops by farmers in almost all parts of the world, public attitudes remain skeptical, especially in Europe but also elsewhere. Many believe that GM crops are risky for human health and the environment and bring no benefits for farmers and consumers. Numerous scientific studies have shown that GM crops are not more dangerous than conventionally bred crops. There is also a broad body of literature demonstrating sizeable economic and environmental benefits. The problem is that this scientific evidence has not really entered the public debate. Anti-biotech groups were much more successful in influencing public opinions through denying scientific results and spreading their own unsubstantiated narratives about risks and negative social impacts (Qaim 2016).

To be sure, results of scientific studies about GM crop impacts, which were carried out in different countries and with different data and methodologies, vary significantly. Depending on many factors, some studies show higher yield effects, while others show lower or no yield effects at all. Some point at reductions in the use of pesticides, while others point at increases in the use of pesticides and other chemical inputs. Hence, individual studies should not be generalized too widely. Results always depend on the particular context. But what can we learn from looking at the existing body of literature about GM crop impacts more systematically?

Results from a meta-analysis of GM crop impacts

A meta-analysis can help to draw some broader conclusions about mean effects at the global level, and also about reasons for deviations in particular situations. A recent meta-analysis, which we carried out, presents a clear picture: combining results from all scientific studies that compared the performance of GM and conventional crops reveals that GM technology has increased crop yields by 22% and reduced chemical pesticide use by 37% on average (Table 1). GM seeds are usually more expensive than conventional seeds, but the additional seed costs are compensated through savings in chemical pest control and higher revenues from sales. Average profit gains for GM crop-adopting farmers are 68% (Klümper and Qaim 2014).

Table 1. Mean impacts of GM crop adoption in % (meta-analysis results)

Outcome variable	**All GM crops**	**Insect-resistant crops**	**Herbicide-tolerant crops**
Yield	21.57***	24.85***	9.29**
Pesticide quantity	-36.93***	-41.67***	2.43

Pesticide cost

-39.15***

-43.43***

-25.29***

Total production cost

3.25

5.24**

-6.83

Farmer profit

68.21***

68.78***

64.29

***, *** statistically significant at 5% and 1% level, respectively.*

Source: Klümper and Qaim (2014).

A breakdown of GM crop impacts by type of technology reveals a few notable differences (Table 1). While significant reductions in pesticide costs are observed for both HT and IR crops, only IR crops lead to a consistent reduction in pesticide quantity (pesticides, as defined here, include insecticides, herbicides, fungicides, and all other chemical pest control agents). Such disparities are expected, because the two technologies are quite different. IR crops protect themselves against certain insect pests, so that spraying insecticides can be reduced. HT crops, on the other hand, are not protected against pests but against broad-spectrum chemical herbicides (mostly glyphosate), use of which facilitate weed control. While HT crops have reduced herbicide quantity in some situations, they have contributed to increases in the use of broad-spectrum herbicides elsewhere. The savings in pesticide costs for HT crops in spite of higher quantities can be explained by the fact that broad-spectrum herbicides are often much cheaper than the selective herbicides that were used before. Average yield effects are also higher for IR than for HT crops.

In the meta-analysis, we also differentiated between impacts in different countries, finding that farmers in developing countries benefit much more from GM crop adoption than their colleagues in developed countries. The reasons for significantly higher average yield and farmer profit gains in developing countries are twofold. First, farmers operating in tropical and subtropical climates often suffer from more considerable pest damage that can be reduced through GM crop adoption. Hence, effective yield gains tend to be higher than for farmers operating in temperate zones. Second, most GM crops are not patented in developing countries, so that GM seed prices are lower than in developed countries, where patent protection is much more common (Klümper and Qaim 2014).

Aggregate benefits at the global level

Aggregating the economic effects from micro-level impact studies to the total area currently cultivated with HT and IR GM crops results in global farmer benefits of over 20 billion US dollars per year (or more than 150 billion US dollars when using the cumulated adoption rates over the last 20 years). In addition, consumers benefit through lower prices that they pay for food and other agricultural commodities. A new technology with gains in farm productivity reduces market prices to levels lower than they would be without the technology. Hence, consumers also gain from productivity-increasing technology.

GM crops have also contributed to positive environmental effects. Reductions in the use chemical pesticides have led to benefits for biodiversity and ecosystem functions (Veettil et al. 2017). As mentioned, pesticide reductions are particularly relevant for IR crops. HT crops have facilitated the adoption of reduced-tillage practices, thus reducing erosion problems and greenhouse gas emissions from the soil. Finally, without the productivity gains from GM crops, around 25 million hectares of additional farmland would have to be cultivated globally, in order to maintain current agricultural production levels (Qaim 2016). As is well known, farmland expansion into natural habitats is an important contributing factor to biodiversity loss and climate change.

Effects for smallholder farmers in developing countries

GM crop adoption in developing countries has also led to social benefits. Especially IR cotton is widely grown by smallholder farmers in countries like China, India, Pakistan, Burkina Faso, and South Africa. With my research

group we have studied the situation in India over many years. More than 90% of the cotton growers in India have switched to GM technology. Higher yields and profits have contributed to significant welfare gains in smallholder households. Our estimates with panel data show that the adoption of IR cotton has raised household living standards by 18% on average (Kathage and Qaim 2012).

Higher family incomes through IR cotton adoption in India have also caused improvements in dietary quality and nutrition. Our data suggest that GM technology adoption has reduced food insecurity among Indian cotton growers by 15-20% (Qaim and Kouser 2013). Beyond the cotton growers themselves, other rural households benefit from growth in the cotton sector through additional employment (Subramanian and Qaim 2010). This is particularly relevant for poor landless families. Two-thirds of all rural income gains from GM cotton adoption in India accrue to poor people with incomes of less than 2 dollars a day.

Similar to these results from India, GM cotton has contributed to poverty reduction and other social benefits in the small farm sectors of China and Pakistan (Huang et al. 2010, Kouser et al. 2017). These positive effects of GM cotton have increased over time (Qaim 2016).

Future prospects

This evidence on impacts from around the world suggests that GM crops promote sustainable development in terms of all three sustainability dimensions, that is, economically, socially, and environmentally. With HT and IR traits introduced in only a handful of crops, the range of commercialized GM technologies is still limited. The main reasons for this narrow focus are public resistance against GM crops and overregulation, leading to long and unpredictable processes for technology approval. Many other promising GM technologies have been developed and successfully tested in various countries, so far without getting the commercial go-ahead. Cases in point are GM traits such as fungal and virus resistance, drought and salt tolerance, higher nitrogen use efficiency, and higher micronutrient contents in food crops such as rice, wheat, sorghum, cassava, potato, banana, and various vegetables. The potentials of such technologies to contribute to poverty reduction and food security in developing countries are large (Qaim 2016).

This does not mean that GM crops cannot also lead to undesirable effects under particular conditions. Every technology may cause certain problems if misused or not managed properly. For instance, GM crops have contributed to a rising concentration in biotech and seed industries. More efficient regulation could help to reduce or avoid issues of market power. Several weed species in North and South America have developed resistance to glyphosate, because the same HT crops were grown year after year. Reducing resistance development requires improved agronomy, especially better crop and herbicide rotations. These problems need to be addressed, but they hardly justify banning GM crops, as some anti-biotech groups call for. For comparison, we also observe market concentration in software and internet-based industries, without banning computers and the worldwide web. And we also observe the development of resistance to antibiotics in various human pathogens, without broadly prohibiting the use of antibiotics from all medical applications. In organic agriculture, the use of copper as a non-synthetic agent to control fungal diseases can cause serious environmental problems, without calls for banning organic farming practices altogether. When we are serious about sustainable development, we need to be more open-minded and stop judging technologies with very different standards.

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