Building resilience: Impact of pesticide reduction strategies on food security

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Introduction

Plant pests and diseases can significantly reduce crop yields, threatening food security. Pesticides are widely used to manage these threats and play a vital role in ensuring food security. However, their use also has negative impacts on the environment, such as water pollution and biodiversity loss, and on human health.

The goal of reducing the overall use and risk of chemical pesticides and the use of more hazardous pesticides by 50% by 2030 is highlighted in the EU's Farm to Fork and Biodiversity Strategies. Reducing pesticides requires a comprehensive policy framework that considers the full range of efficiency, substitution and transformation options and involves all actors in the agri-food value chain.

There is a need to explore innovative approaches that combine traditional changes in farming practices with the adoption of precision farming techniques, and intercropping as well as other forms of intervention.

Several studies have assessed the impact of fertiliser taxation and the level of taxation required to achieve specific pesticide reduction targets, as well as the role of new technologies and precision farming techniques, the cultivation of crops with higher disease resistance and low-input crop management systems and their impact on yields. In addition, recent studies assess the impact of pesticide use on biodiversity. Of particular interest are the effects of reduced pesticide use on the recovery of biodiversity and the associated social and environmental benefits from ecosystem services such as pollination, which in turn may help to stabilise or even increase yields, thus (partially) offsetting the potential yield losses due to reduced pesticide use.

According to Finger (2024), these changes in agricultural practices, land use and production systems have costs and benefits. While the impacts on farmers include changes in yields, costs, labour requirements, profits and risks, society benefits from changes in health but is affected by changes in e.g., food prices and self-sufficiency. In addition, international trade in agricultural and food commodities affects other countries in terms of, for example, standards, prices, trade patterns, leakage and food security (Finger, 2024, Wesseler, 2022, Barreiro-Hurle et al. 2021, Beckman et al. 2020).

According to Finger (2024), however, the impacts of new business models to reduce pesticide use in terms of costs, risks and yields are still highly uncertain. Achieving lower pesticide use, for example by transitioning to new 'low pesticide' production systems, and their impacts on the environment, climatic conditions and biodiversity need to be better quantified. Furthermore, the feedback loops through markets, including trade dynamics, and the resulting impacts on the supply and demand of agri-food commodities and thus on food security are not well understood.

Against this background, the main objective of this study is to assess the impacts of different more sustainable production practices leading to reduced pesticide use on agricultural production, farm income and food security. Specifically, this study addresses the following research questions

- How do different pesticide reduction strategies affect agricultural yields, production and land use?
- How does the transition to low pesticide production systems affect trade patterns/dynamics? Especially if only one group of countries implements this.
- What are the implications for world food prices and food security?

The article is structured as follows. The next section provides an overview about the impacts of pesticide use on plant yields and strategies for reducing pesticide use to transform production systems. After describing the applied model and underlying database this article develops different scenarios to simulate possible impacts of pesticide reduction strategies on food security in the short and long run. The last sections then present and discuss the results, limitations and final conclusions.

Literature review

We conduct a thorough literature review to identify and extract the range of possible impacts of different sustainable production practices leading to reduced pesticide use on yields and yield stability, but also on biodiversity and related ecosystem services and their associated impacts on crop production and yields (second-round yield effects, e.g., less pesticides can lead to more biodiversity, and more pollinators can lead to higher yields).

Method and experiment design

Model and database

For the quantitative analysis, we use the GTAP database version 11 with base year 2017 (Aguiar et al. 2023), covering 141 countries and regions and 65 sectors. Our aggregation represents major agricultural producers such as the EU, US, Brazil and China as well as regional aggregates according to food security criteria. We take into account the granularity of the agricultural and food sectors, while other primary, industrial and service sectors are broadly aggregated.

Scenario design

The results of the literature review are used to inform what-if scenarios to simulate the full range of likely impacts of sustainable production practices and reduced pesticide use on agricultural yields in the context of a sustainable transformation of agri-food systems, such as promoted under the currently pending EU Sustainable Use Regulation.

These scenarios will be implemented in an extended version of the comparative-static, multi-regional and multi-sectoral Global Trade Analysis Project Model (GTAP) model (Corong et al. 2017), which includes a detailed land representation based on 18 AEZs, separated into pasture and cropland, as well as a nutrition module to show impacts on food and nutrition security.

Results

The literature review sheds light on the impact of different sustainable production techniques and the resulting reduction in pesticide use, but with mixed effects on crop yields. In addition, the impact of reduced pesticide use are assessed in terms of its effect on biodiversity, which in turn may have a positive effect on crop production and yields. The simulations assess the impact of such pesticide reduction strategies and the resulting impact on crop yields on agricultural

production, agri-food markets and food security. Specifically, we assess the impacts on farm income, production decisions, factor use and agri-food supply, as well as changes in trade dynamics and agri-food prices. This provides information on food security in terms of affordability and availability of food. Linking nutrition data to the GTAP modelling framework allows us to assess the impact on energy intake and diet composition and quality. In particular, we expect that in the short-term yields and agricultural production will decline, leading to higher food prices and increased food insecurity, while in the long-term increased biodiversity will at least partially offset the negative effects. What-if scenarios allow us to explore the impact of the range of possible yield changes, based on the scientific literature, to understand the likely implications for food and nutrition security.

Discussion and Conclusion

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