Veille citoyenne d'information sur les OGM et les semences

GMOs are not the answer to the climate crisis

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Two economics researchers from Peking University, Kaixing Huang and Yaxuan You, have published a paper comparing greenhouse gas (GHG) emissions between countries that have grown genetically modified (GM) crops and those that have not. Their conclusion is unequivocal. They assert that genetically modified maize, soya, cotton and rapeseed increase greenhouse gas emissions from agriculture. However, this study has significant limitations: based on international statistics, it adopts an ‘accounting’ approach and does not challenge either globalised agriculture or genetically modified crops. Inf’OGM has nevertheless chosen to analyse it, as the subject is poorly documented and the study helps to shed light on its complexity. This article is intended as a contribution to the dossier on the impact of GMOs on the climate and, more specifically, on GHG emissions.

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A recurring question regarding GMOs is that of their impact on climate change. GMOs are plants used in industrial agriculture, which is itself widely criticised for its negative impact on the climate[1]. Two researchers from Peking University, Kaixing Huang and Yaxuan You, therefore studied[2] the impact of genetically modified crops on emissions of various greenhouse gases (GHGs) — methane, nitrous oxide and CO? — in agriculture across 145 countries between 1985 and 2018[3][3].

What method was used?

These researchers decided to ‘work’ at country level: they compared the GHG emission trajectories of countries that adopted GM crops (maize, soya, cotton, rapeseed) with those of countries that did not adopt them, or that adopted them later. In their ‘*difference-in-differences*’ (DID)[4] econometric models, they include country-specific characteristics that remain constant (soil, agricultural structure), characteristics common to each year (global trends, world prices) and a set of climatic variables. In this way, they aim to avoid confusing the effect of GMOs with structural differences between countries or with general trends in the climate and the global economy.

To put it another way, they do not directly compare ‘*GM maize versus non-GM maize*’ at plot level, but seek to determine how, overall, GHG emissions are changing in agricultural systems that do or do not incorporate these genetically modified crops.

To measure this impact, they examine greenhouse gas emissions from two perspectives. On the one hand, they analyse GHG emissions linked to crops as a whole, which the FAO refers to as ‘agricultural soil emissions’: emissions from fields linked to synthetic nitrogen fertilisers, organic inputs (manure, crop residues), the conversion of organic soils (notably peatlands) to cropland, as well as CO? emissions from fuel used by agricultural machinery. The researchers do not take into account GHG emissions linked to the production[5] of nitrogen fertilisers, nor do they mention the mineralisation caused by the intensive use of these fertilisers, or the soil degradation they entail[6]. This would further increase the negative impact of GMOs on the climate.

On the other hand, they take into account emissions from the agricultural sector as a whole, which includes emissions from crops, livestock (enteric fermentation, manure management, grazing) and certain aspects of land-use change, notably the loss of tree cover and the conversion of previously forested or grassed land to cropland. In both cases, they use FAO inventories compiled in accordance with the IPCC’s standard methodology, converting methane, nitrous oxide and CO? into CO? equivalents – a conversion that is, by its very nature, imperfect[7].

GMOs increase carbon intensity

Firstly, ‘carbon intensity’ refers to the quantity of GHGs emitted per hectare of cultivated land or per tonne produced: the higher this ratio, the more ‘carbon-intensive’ a unit of land area or agricultural production is, even if total production increases.

Drawing in particular on the controversial study by Klümper & Qaim (2014)[8], the researchers assume that the adoption of genetically modified varieties of maize, soya, cotton and rapeseed is associated, on average, with a rise in yields of around 13–14 per cent and an increase in the area under cultivation of around 15 per cent for these crops. This increase is far from universally accepted. Inf'OGM, citing a USDA report, stated that '*the empirical evidence regarding [their] effects on yields is mixed*'?[9]. In other words, it has not been established that GMOs systematically improve yields in all contexts. If, in at least some situations, yields do not increase, this means that the rise in GHG emissions estimated in this article is all the greater, which would reinforce the significance of their findings.

This increase in yields (itself a matter of debate) and in the area under cultivation inevitably entails more inputs, more fertiliser and more mechanical labour. But the authors go further: they show that GHG emissions per hectare and per tonne are increasing. They question whether this rise is not simply a reflection of increased production: if GHG emissions are rising at the same rate as productivity, it could be argued that GMOs have no impact on GHG emissions per unit produced, even if the total emissions are increasing.

On average, per hectare, countries that adopt GMOs do not simply 'produce more with the same amount of inputs': they use more fertiliser, irrigate more, increase the number of crop cycles and bring lower-quality land into production, the authors state. The authors also highlight a long-term negative effect on the quantities of pesticides used: the initial decline (particularly for Bt crops, which produce an insecticide) was fairly quickly offset by an increase linked to the emergence of resistant weeds or pests, or secondary pests that were not targeted by the Bt crops. It is this intensification of input use and the expansion into less favourable land that explains why GHG emissions per hectare are rising. Under these conditions, the increase in yield is not sufficient to offset the rise in inputs and the deterioration in soil quality: emissions per hectare are rising faster than yields. Consequently, emissions per tonne of maize or soya produced are also rising, which the authors quantify as an increase in the carbon intensity of these crops of between 9 and 11 per cent.

GMOs are altering the agricultural landscape and may increase GHG emissions

In practical terms, by cross-referencing FAO statistics on inputs and land area with GAEZ[10] data on soil quality, the authors show that following the adoption of GMOs, nitrogen fertiliser use per hectare increased by an average of just over 20 per cent, energy consumption (fuel and irrigation) per hectare rose by around 8 per cent, the total agricultural area expands by around 3.5 per cent, the harvested area increases by nearly 6.8 per cent – a sign of more frequent multiple cropping (for example, in Brazil[11]) and reduced fallow land – and tree cover declines by an average of around 0.9 per cent in countries adopting GM crops. More specifically, they note that the expansion of GM maize and soya between 2000 and 2010 took place on land of lower agronomic quality, with an increase in the proportion of land classified as 'low quality' and a decline in 'high-quality' land, which requires more fertiliser and energy per tonne produced. The study does not take into account GHG emissions linked to land-use changes, for example when forests are converted into soya fields, as is the case in Brazil[12].

Indeed, they write, more profitable genetically modified crops (maize, soya, cotton, rapeseed) are gradually gaining ground at the expense of other non-GM crops, which is leading to a reorganisation of crop rotations. The authors show that, when GM crops are adopted, the areas devoted to non-GM crops of the same type (cereals, comparable oilseeds) decrease. However, they start from the assumption that, prior to the arrival of GM crops, each monoculture was located on the land best suited to it. The authors do not consider other types of agriculture: they simply observe what is happening. However, they could also have pointed out that high levels of efficiency in terms of overall yield per hectare and employment result from the complementarities between arable and livestock farming within the same area, from crop rotations, intercropping or even agroforestry. These practices are described in the literature[13] as being far more efficient in terms of yield per hectare and less polluting and damaging to the land than monocultures.

GMOs fuelling greenhouse gas-intensive intensive livestock farming

Another important piece of the puzzle is the indirect effects on livestock farming. A significant proportion of GM maize and soya is consumed domestically – particularly as animal feed in intensive livestock farms that emit high levels of greenhouse gases – rather than being exported. The authors estimate that this has ‘boosted’ this type of livestock farming and that, as a result, emissions linked to livestock farming are increasing by an average of around 12 per cent.

Initially, on average, countries that grow GM crops have a lower carbon intensity per tonne of crop than non-GM countries (they emit fewer GHGs per tonne produced). The study does not dispute this starting point; it focuses on what happens next: it shows that, following the adoption of GM crops, total emissions and carbon intensity per hectare and per tonne increase more rapidly than in countries that do not adopt GM crops.

In this theoretical scenario, the authors consider emissions linked to agricultural production itself (the carbon intensity of crops). They assume that growing GM crops in countries with lower carbon intensity and then exporting them to countries with higher carbon intensity reduces the emissions associated with the production of these crops, even though this does not take into account CO? emissions from cargo ships and lorries. However, as a large proportion of GMO production is still used domestically to feed intensive livestock farming, this potential benefit is largely offset. And, once again, the authors are operating within the framework of globalised agriculture, which they do not question.

Admittedly, it is likely that a few mixed-farming holdings still exist, but this is not the dominant model in countries that grow GM crops on a massive scale. Natural grasslands used for small-scale and extensive livestock farming are often regarded as the agrosystems that store the most carbon, by recycling animal manure into the soil and enriching microbial life. They can largely, and sometimes even entirely, offset methane emissions from ruminants, and pastoralism plays a crucial role in preventing forest fires. This is not the case with ‘off-land’ livestock farming, which relies on maize and soya monocultures, widely adopted through the use of GMOs.

Ultimately, what the article documents is the establishment of an agricultural system that uses more land, more fertiliser and more energy, leads to more livestock farming and less tree cover. It is this combination that explains why total GHG emissions are rising in countries that adopt these GM crops.

How can GM crops be made less harmful in terms of GHG emissions?

The authors assume that GM crops are beneficial in terms of production and farmers' incomes. This assumption is widely contested. Inf'OGM has often set this out in detail. They therefore propose two approaches to improve the use of GM crops. The first is to restrict GM crops to the most suitable land to prevent the conversion of marginal land, which drives up carbon intensity. The second is to encourage the export of crops produced in low-carbon-intensity countries (which use GMOs) to countries where carbon intensity is higher (such as those that do not use GMOs), rather than using almost all of the additional production for domestic livestock farming in intensive systems. This proposal is based purely on the accounting logic of GHG emissions, without taking into account the devastating effects of this approach on the food sovereignty of importing countries.

To sum up, this article is an attempt to present GMOs in a more positive light, but at the same time – and this is the paradox – it also shows why this technology is not sustainable. This paradox is perfectly illustrated by the 'solutions' proposed, which are unrealistic given the history of the deployment of GMOs around the world over the past 25 years.

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- + Huang, K. & al. (2024), MPRA paper, https://mpra.ub.uni-muenchen.de/122650/1/MPRA_paper_122650.pdf. This article was published on a repository for economic research papers, namely the Munich Personal RePEc Archive. It is not a peer-reviewed journal.
- + The researchers chose the period 1985–2018 in order, on the one hand, to have a long reference period without GMOs for estimating trends and DID models, and, on the other hand, to avoid disruptions linked to Covid-19. The first commercial cultivation of GM crops dates back to the late 1990s.
- + We look at the development of one country between two dates – before and after a policy was introduced – and that of another country which does not have that policy over the same period. The DID is the difference between these two differences.
- + Emissions associated with the industrial manufacture of fertilisers (the Haber–Bosch process for ammonia, the production of urea and nitric acid, the transport of fertilisers to the country, etc.) are generally classified under the 'industry/energy' sector, rather than the 'agriculture' sector, in GHG inventories.
- + Intensive nitrogen fertilisation, particularly in the form of synthetic fertilisers, increases the risk of losses in the form of leached nitrates, volatilised ammonia and nitrous oxide (N?O) resulting from denitrification, which exacerbates the climate impact and water pollution. And if this fertilisation is not offset by organic inputs (manure, crop residues, etc.), as is the case with small-scale mixed farming, it gradually leads to a depletion of humus and a deterioration in soil quality.
- + One example of the inherent limitations of this model is the arbitrary choice of time horizon (often 100 years). Thus, over a 20-year period, 1 kg of methane has the same warming effect as ~80–84 kg of CO?. Over 100 years, this is reduced to around 28–30 kg of CO?.
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- + Inf'OGM (2014), De meilleurs rendements agricoles avec les PGM ?, https://infogm.org/de-meilleurs-rendements-agricoles-avec-les-pgm/
- + GAEZ = Global Agro-Ecological Zones. This is a system developed by the FAO and IIASA to map agricultural zones and their agricultural production potential on a global scale. https://data.apps.fao.org/gaez/
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