

Banned in Europe, allowed in imports. Can lower pesticide residue limits close the gap?

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Key messages

- Lowering Maximum Residue Levels (MRL) to the Limit of Quantification (LOQ) targets a subset of substances whose MRL is still above the LOQ. In 2019, these uses accounted for between 3 and 6.5% of the pesticide footprint of EU consumption of maize, soybean and wheat, and for 12% of pesticide spending on these crops in Mercosur and about 3% in other exporting regions.
- Many banned substances used on crops imported into the EU feature an MRL already at the LOQ, but they are still used. A maximum residue level does not contain the upstream use of phytosanitary products.
- The Omnibus proposal targets a subset of banned substances meeting the hazard cut-off criteria. Substances banned only for their acute toxicity or their harm to pollinators fall outside its scope.
- In our simulations, the measure has small effects on trade and raises EU consumer prices by at most 0.5% (for soybean; about 0.1% for maize and wheat). Larger effects arise only in a stress test in which the measure cuts the use of hard-to-replace substances by 90%. Exporters then use more of the other pesticides, and the pesticide footprint of EU consumption rises by 7 to 8% under the acute oral LD50 for mammals and the Harmonised Pesticide Load Indicator weights.
- At best, bringing MRLs to the LOQ has a modest impact on trade and on the footprint of these crops. At worst, when it does constrain application rates abroad, it comes at important inefficiency costs, increasing the use of non-targeted substances, potentially increasing the toxicity footprint it was meant to reduce. An instrument based on the overall pesticide load of imports would not face this trade-off (Gaigné et al., 2026).

Introduction

In its Vision for Agriculture and Food, published in February 2025, the European Commission stated that "the most hazardous pesticides banned in the EU for health and environmental reasons should not be allowed back to the EU through imported products" (European Commission, 2025a). The Commission's objective is to ensure a level playing field between EU farmers and producers in third countries who export to the EU.

The EU has long faced a tension between its domestic pesticide regulations and its trade policy. Active substances that fail to meet the EU's approval criteria are still used by farmers in third countries to grow agricultural products exported to the European market, provided that residue levels in those products do not exceed the applicable maximum residue levels (MRLs). As a result, products grown with pesticides that EU farmers are not allowed to use can still be sold on the EU market. To close this gap, the European Commission proposes to lower the MRLs for certain active substances not approved in the EU to what is often called a "technical zero": the limit of quantification (LOQ), the lowest concentration at which a laboratory can reliably measure a residue.¹

This research note presents the results of an analysis of how lowering MRLs to the LOQ would affect EU imports, agricultural production and consumer prices. Before presenting our results, it is worth noting that, as currently designed, the policy can be expected a priori to have limited effects, for three reasons.

First, an MRL regulates residues in products, not pesticide use at the place of production. Low MRLs do not necessarily imply low pesticide use, as there is no one-to-one relationship between the quantity applied in the field and the residue detected in the harvested product. Residue levels depend on application rates and timing, the substance's properties, crop characteristics, and the time elapsed between application and harvest. Consequently, products may comply with low MRLs despite substantial pesticide use.

Second, the set of targeted substances is restrictive. While the Commission's Vision for Agriculture and Food refers to the most hazardous pesticides banned "for health and environmental reasons", the Omnibus proposal (European Commission, 2025b) covers only non-approved substances meeting the hazard-based cut-off criteria of Regulation 1107/2009 (CMR substances, endocrine disruptors, persistent or bioaccumulative pollutants). Many substances banned in the EU only for other reasons, such as acute toxicity or risks to pollinators and groundwater, are therefore excluded. Indeed, according to the JRC (Barreiro-Hurle et al., 2026), of the 976 active substances not approved in the EU, only 80 meet the hazard criteria of the Omnibus proposal. Yet many non-approved substances remain widely authorised abroad. Among the 455 active substances approved in eight Latin American countries, 199 are not allowed in the EU (de Groot et al., 2026). Among Mercosur countries, Brazil has approved 115 active substances not allowed in the EU, followed by Argentina (106), Bolivia (87) and Uruguay

¹ The limit of quantification (LOQ) should not be confused with the limit of detection (LOD), which is the lowest concentration at which a residue can be shown to be present without being reliably measured. The LOQ is the lowest concentration that can be measured with validated precision. Confusingly, EU MRL legislation calls the LOQ the "limit of determination" and also abbreviates it LOD (Regulation (EC) No 396/2005, Art. 3(2)(f)), so that some sources refer to MRLs "above the LOD" when they mean above the LOQ.

(86).

Third, among the banned substances that still have MRLs above the LOQ, only a small number would be targeted. As of April 2026, PAN Europe identifies 88 active substances banned or severely restricted in the EU and listed under Regulation (EU) No 649/2012 that still have at least one MRL above the LOQ (PAN Europe, 2026). By comparison, only 22 substances meet the hazard criteria of the Omnibus proposal while still having MRLs above the LOQ (Barreiro-Hurle et al., 2026, data as of April 2026), and the JRC retains just 18 in its analysis. Substances banned in the EU because of their acute toxicity or their effects on pollinators would thus remain outside the scope of the measure.

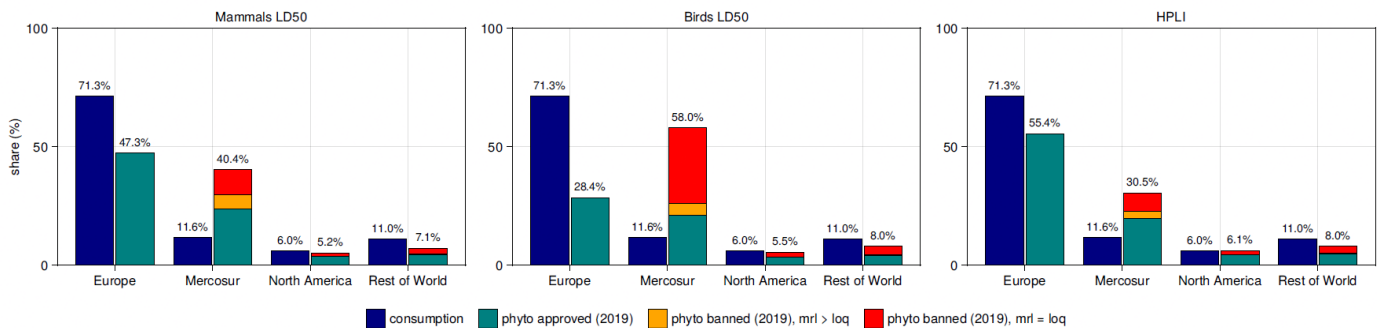
Our empirical analysis proceeds in two steps. We first document that the banned pesticides the measure can reach play only a minor role in EU imports. They account for a small share of the phytosanitary footprint of EU food consumption, so that most of the phytosanitary footprint of imports would remain unaffected even if exporters stopped using the targeted substances entirely. In other words, even after the MRLs for the targeted substances are lowered to the LOQ, the EU would continue to import products grown with other pesticides that are banned for EU farmers. These substances also account for a small share of pesticide spending in exporting countries, which suggests that exporters could adapt at low cost by switching to alternative substances or practices. The measure would therefore do little to restore a level playing field between EU farmers and their competitors in third countries.

We then simulate the effects of the measure using a model of trade and production covering three major crops (maize, soybeans and wheat). Our simulations vary two key parameters: how far an MRL at the LOQ forces exporters to cut their use of the targeted substances, and how easily these substances can be replaced by others. The first is uncertain because there is no stable relationship between the dose applied and the residue at harvest: a substance applied early in the season leaves little or no measurable residue, while the same substance used as a pre-harvest desiccant does. In most configurations, lowering MRLs to the LOQ has only small effects on EU imports, agricultural production and consumer prices. Significant effects arise only when the measure forces a large cut in the use of targeted substances that are difficult to replace. In that case, complying with an MRL set at the LOQ requires exporters to sharply reduce their use of the targeted substances, which raises production costs and reduces exports to the EU. This scenario, however, has a perverse effect: as exporters replace the targeted substances with alternatives, the phytosanitary footprint of EU consumption increases under the acute oral LD50 for mammals and HPLI weights. Large trade effects are therefore unlikely, and where they do occur, they would come at a significant environmental and public health cost for exporting countries.

I. The elusive extraterritorial reach of MRLs

I.a The footprint of EU consumption and how much of its banned part an MRL at the LOQ can reach

Figure 1: The footprint of EU consumption



Note: For each region of origin, the left bar gives its share of aggregate EU consumption of soybean, maize and wheat, measured in calorie equivalents, and the right bar its share of the pesticide footprint of that consumption. The footprint is the quantity of each active substance applied per tonne of output, weighted by its toxicity and attributed to EU final demand. Toxicity weights are the acute oral LD50 for mammals (panel a) and for birds (panel b), and the Harmonised Pesticide Load Indicator (HPLI; Vandevoorde et al., 2025) (panel c). Substances are approved if authorised in the EU under the 2019 rules and banned otherwise. The banned part is split by the EU maximum residue level (MRL) in force in 2019 for the substance and crop: at the limit of quantification (LOQ) and above the LOQ; uses with no specific EU MRL fall under the default limit of 0.01 mg/kg and are counted at the LOQ.

The phytosanitary footprint of EU consumption, following the methodology developed in Gagné et al. (2025), measures the pesticides used, directly and indirectly, to produce the agricultural goods consumed in the EU, wherever they are grown. It works like a carbon footprint, but for pesticide use. It is built in three steps. First, quantities of each active substance applied per crop and country (Kynetec) are divided by yields (FAO), which gives the pesticide use embodied in each tonne of output. Second, trade and input-output data (FABIO; Bruckner et al., 2019) trace the share of each country's output that ends up in EU final demand, directly or through processed and animal products. Third, each substance is weighted by its toxicity and expressed in glyphosate equivalents, so that one kilogram of a highly toxic substance counts for more than one kilogram of glyphosate.

There is no single measure of pesticide toxicity. Depending on what one wants to capture, different weights are appropriate, and this brief therefore reports results under three of them. The first is the acute oral LD50 for mammals, the dose that kills half of a test population, typically rats. It is the standard regulatory proxy for acute toxicity to humans and speaks mainly to the risks faced by farm workers and rural residents exposed at application. The second is the acute oral LD50 for birds. It captures harm to farmland wildlife and is thus closer to an ecological measure; it gives particular weight to insecticides, which are far more

toxic to birds than to mammals. Both LD50s measure acute effects only. The third weight, the Harmonised Pesticide Load Indicator (HPLI; Vandevoorde et al., 2025), is more comprehensive: it combines some twenty hazard metrics covering human health, including chronic effects, ecotoxicity and environmental fate, such as persistence in soil and water.² The three weights rank substances very differently, and results are therefore shown side by side.

The question this brief asks is how much of this footprint EU residue rules can reach. To answer it, each active substance is classified as banned if it was not approved in the EU on 31 December 2019, and matched, crop by crop, to the EU maximum residue level (MRL) in force on that date. Figure 1 shows the result by region of origin. Banned substances account for 20.8%, 42.8% and 15.5% of the footprint under the mammal, bird and HPLI weights, respectively, and most of this banned part (68 to 86%) originates in Mercosur.

An MRL affects farming practices abroad only if residues from a given use would exceed it, so that the shipment could be refused at the EU border. Lowering MRLs to the limit of quantification (LOQ) can therefore change behaviour only where the MRL currently sits above the LOQ. In 2019, this was rarely the case. Within the banned part of the footprint, 60, 74 and 68% (mammal, bird, HPLI) come from uses whose MRL is already at the LOQ, and another 9, 14 and 11% have no EU MRL or cannot be matched (these uses fall under the default limit of 0.01 mg/kg, i.e. at the LOQ). Only 31, 12 and 21% are above the LOQ, that is, 6.4, 5.1 and 3.2% of the total footprint.

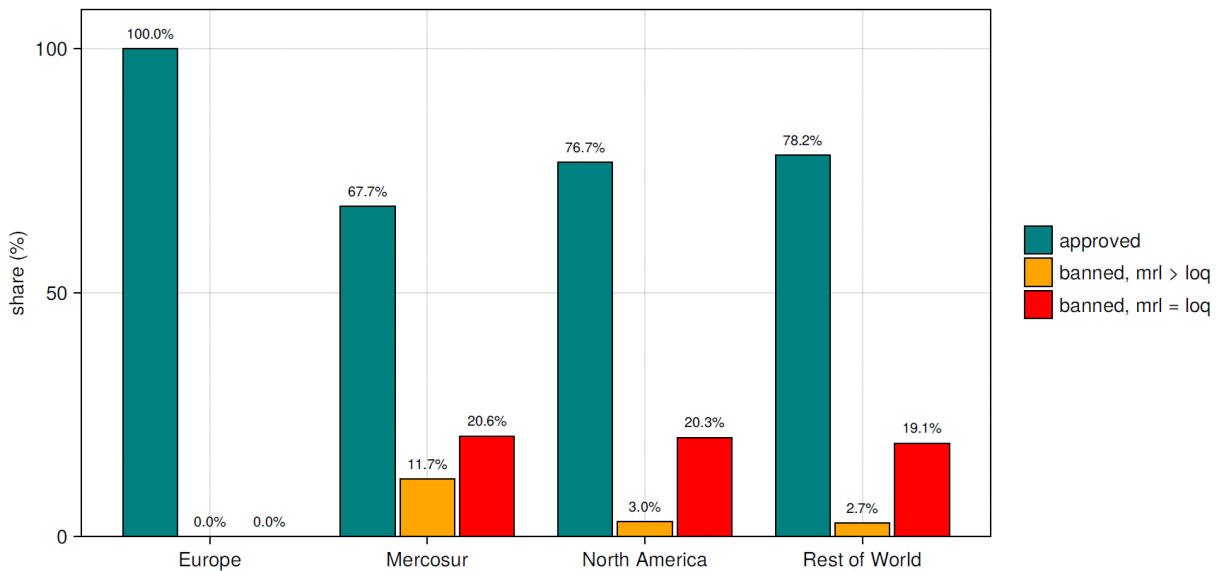
This above-LOQ share is concentrated in a few cases, mostly substances applied to Mercosur soybean that benefit from EU import tolerances, such as carbamates (methomyl), pyrethroids (bifenthrin) and organophosphates (acephate). Mercosur accounts for 87 to 96% of it. By contrast, paraquat, the largest banned contributor under the mammal and bird weights, already has an MRL at the LOQ, so lowering MRLs would not affect it. We return to the role of specific substances in Section I.b.

Applying the list of substances classified as banned in 2025 to the same 2019 quantities enlarges the banned part of the footprint but barely widens the room for the instrument (Appendix Figure A1). The banned share of the footprint rises to 35.4, 64.2 and 25.1%, but the above-LOQ share within it falls to 13, 8 and 16%: 4.6, 4.9 and 4.1% of the total footprint, against 6.4, 5.1 and 3.2% under the 2019 rules. Most substances banned after 2019 that weigh in the footprint, such as chlorpyrifos and imidacloprid, already have an MRL at the LOQ, and some older bans saw their MRLs lowered to the LOQ in the meantime (methomyl on soybean). Among recent bans, the main exception is cyproconazole, whose import tolerance on Mercosur soybean remains in force. Under the 2025 rules, lowering MRLs to the LOQ would therefore bite mainly on cyproconazole and on older bans with import

²Vandevoorde et al. (2025) report HPLI values only for substances authorised in the EU. For the remaining substances, we compute the indicator ourselves, following the authors' methodology as closely as possible. The replication is not exact, but it comes close: for authorised substances, where both the original and the replicated values are available, the correlation between the two is 0.90 (0.88 in ranks).

tolerances (bifenthrin and acephate) on Mercosur soybean.

Figure 2: Phytosanitary cost shares by region of origin



Note: For each region of origin, the bars give the share of pesticide spending on maize, soybean and wheat that goes to approved substances, to banned substances whose EU MRL is above the LOQ, and to banned substances whose EU MRL is at the LOQ. Approval status and MRLs are those in force on 31 December 2019, consistent with the 2019 quantities. The share of banned substances in Europe is zero by construction, since EU farmers could not use substances that were not approved on that date.

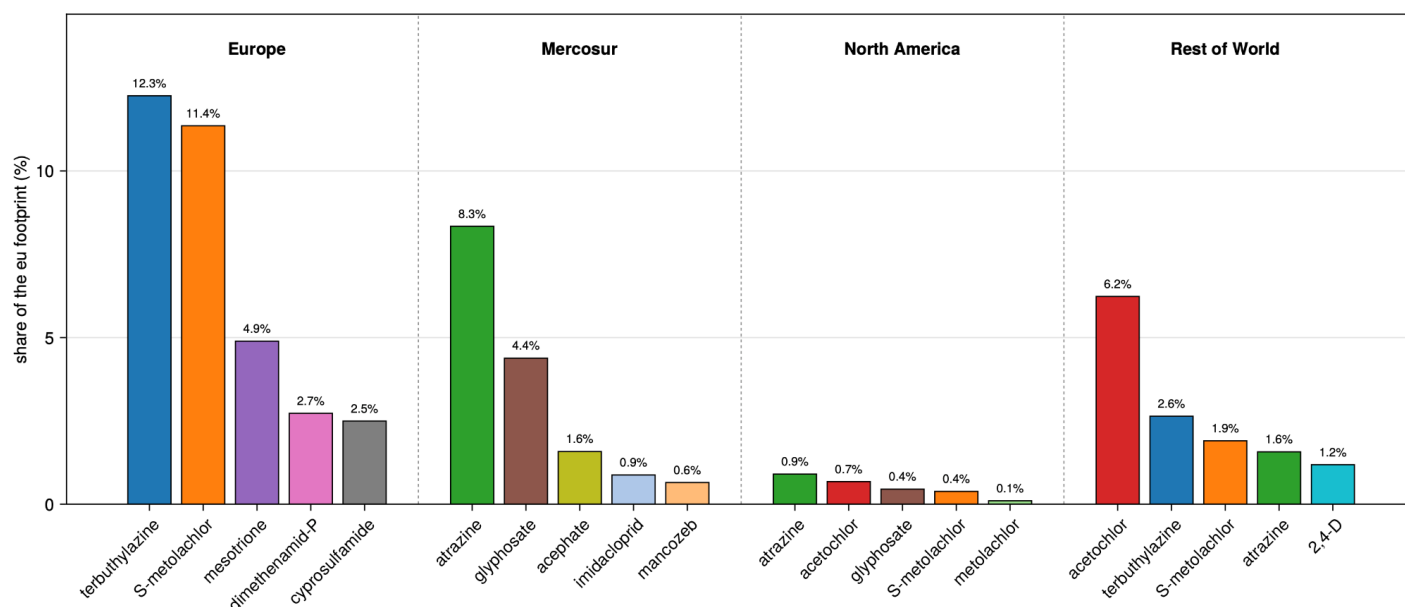
Figure 2 looks at the same question from the exporters' side: how pesticide spending on maize, soybean and wheat is split between approved and banned substances. Substances banned in the EU matter economically abroad: they account for 32% of pesticide spending in Mercosur, 23% in North America and 22% in the rest of the world. Most of this spending, however, goes to substances whose EU MRL is already at the LOQ (64%, 87% and 88%, respectively). These substances remain in widespread use on crops exported to the EU, which confirms that an MRL at the LOQ does not by itself stop their use. The substances that are targeted by lowering MRLs to the LOQ account for only a small share of pesticide spending in exporting countries: 12% in Mercosur, and 3% in North America and the rest of the world. This is an upper bound, since the Omnibus proposal targets only the subset of these substances that meet the hazard cut-off criteria. Because the cost of complying depends on the share of spending at stake, these shares anticipate the simulation results of Section II: the effects on production costs and prices are small everywhere, and largest for Mercosur.

I.b Which substances, where and which toxicity?

The histograms reported above hide significant heterogeneity across crops and substances. It leads to the question of which substances drive the footprint. The results depend on the toxicity metric retained. We focus on the HPLI, which encompasses various dimensions of harm to human health and the environment. We report, for each crop, the top 5 substances that contribute to the overall footprint in EU consumption by region.

The relative levels between the EU and the rest come from the relative importance of imports with regard to EU production. Hence, in the case of wheat (Appendix Figure A3), most of the footprint is unsurprisingly European. We also find, as expected, that the nature of the substances contributing to the footprint differs between the EU and other regions. For instance, the use of atrazine (banned in the EU) in Brazil alone accounts for 8.3% of the EU footprint associated with the consumption of maize (Figure 3). While the volume of maize imported from the US is low, we see that again atrazine is the largest contributor to the footprint. Glyphosate, which is approved in the EU, does not appear among the main contributors to the footprint of European production, but it is among the largest contributors for imports from Mercosur and North America. Importantly, large contributors such as atrazine are substances whose MRL is already set at the LOQ. Soybean (Appendix Figure A2) is the opposite case: the footprint is dominated by Mercosur, where glyphosate alone accounts for 21.5% of it and paraquat, banned in the EU and already at the LOQ, for 5.9%.

Figure 3: Top 5 active substances in the footprint of EU maize consumption, by region of origin (HPLI)



Note: For each region of origin, the bars give the five active substances that contribute most to the pesticide footprint of EU consumption of maize, as a percentage of that footprint. Toxicity weights are the Harmonised Pesticide Load Indicator (HPLI; Vandevorde et al., 2025). Quantities refer to 2019.

II. Simulations

Section I showed that lowering MRLs to the LOQ can reach only a small part of the banned footprint of EU consumption. First, this section starts with the parametrization of the reach of the MRL policy, i.e., how far these measures can curb the use of the corresponding plant protection products abroad, effectively acting as a (partial) mirror measure to the EU ban. Second, it assesses its economic impact on trade flows, EU commodity prices and the footprint of EU consumption.

The model is presented in detail in the Appendix.³ Two ingredients are key to interpreting the results.

Policy leverage depends on the timing of application. Lowering an MRL constrains foreign producers only insofar as the substance leaves residues at harvest. This depends less on how much is applied than on when: there is no stable relationship between the dose applied and the residue in the harvested product. Glufosinate illustrates the point. Applied early in the season, as in post-emergence weed control on herbicide-tolerant soybean and maize in North America, it leaves little residue, and a lower MRL would barely constrain its use. Used as a pre-harvest desiccant, as on Brazilian soybean, it would be constrained much more.

Because the link between residues and use cannot be pinned down substance by substance, we do not derive the required cut in use from a dose–residue relationship. We instead consider two polar cases, in which an MRL at the LOQ reduces the application rate of the targeted substances at the field level by 30% and by 90%. The JRC assessment (Barreiro-Hurle et al., 2026) proceeds differently. A trade flow is treated as exposed to the measure as soon as a targeted substance is authorised on the crop, whether or not it is actually used, and one of its scenarios considers the case in which exporters do not adapt, so that their trade with the EU stops (see Garnier and Dupré, 2026, for a discussion). Our data instead allow us to observe how much of each substance foreign farmers actually apply. These data rule out a full (100%) reduction: many substances banned in the EU whose MRLs are already set at the LOQ are still widely used abroad on crops exported to the EU (Figure 1). Residue monitoring points the same way: paraquat was found in two thirds of soya feed samples tested in Germany, mostly meals from Brazil and the United States, yet only about 5% exceeded the EU limit (Heydebreck, 2021). Two further mechanisms make it unlikely that exports fall to 0. Farms respond heterogeneously to the policy, and they can sort across export markets, depending on price differences, market opportunities and regulatory requirements. Our simulations account for this market segmentation.

Producers adapt by adjusting their input mix. Farmers can respond to the policy by changing their mix of plant protection products. How far they can do so is governed by the elasticity of substitution between active substances, κ , which we set to 0.5 or 1. In order to be

³ The simulations exclude soybean meal. No specific EU MRLs have been set for products used exclusively as feed, and there are no EU-harmonised processing factors to derive them from the MRL on soybeans (European Commission, 2021). Soybean meal is therefore not subject to the same MRL controls as whole soybeans (Heydebreck, 2021).

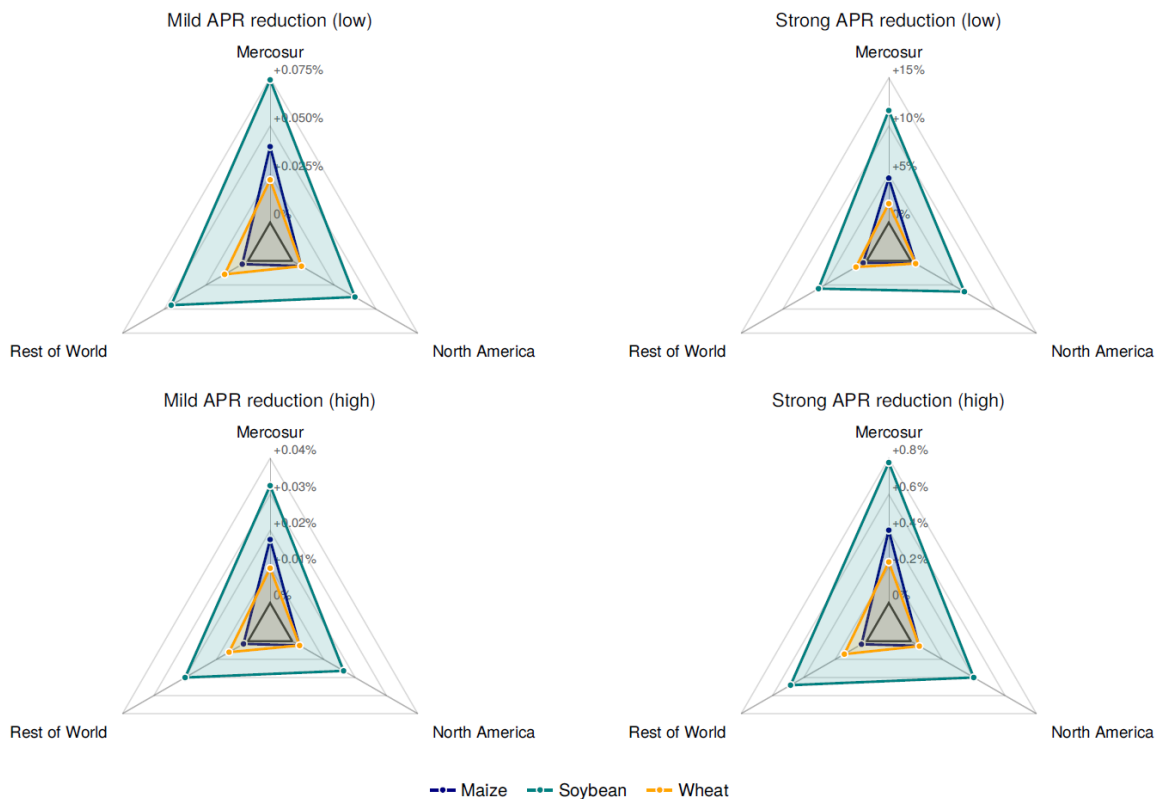
conservative, we rule out values above 1. Assuming instead that substances are substitutes ($\kappa > 1$), lowering MRLs and potentially thereby application rates would have lower effects on trade and raise the weight of allowed substances in the pesticide footprint of EU imports.

With low-substitutability every substance becomes essential in the sense that if the application rates of that substance were to drop by 100%, production would also drop by 100%. Thus, restricting the use of these substances is expected to have a large impact on production costs and thereby output and trade. Both parameter choices therefore lean towards overstating the effects of the measure.

Combining the two cuts in application rates with the two elasticities gives four scenarios. Three of them (a 30% cut with $\kappa = 0.5$ or $\kappa = 1$, and a 90% cut with $\kappa = 1$) span plausible combinations of the two parameters. The fourth, a 90% cut with $\kappa = 0.5$ ("Strong APR reduction (low)" in the figures), is better understood as a stress test. It is an admittedly extreme set of assumptions that amplifies the response of producers. We find it useful as a benchmark for two reasons: it states explicitly what it would take for the measure to have sizeable effects but it also allows us to gauge the efficacy of a policy which aims to mimic a mirror measure on an essential substance.

Outside the stress test, the effects on prices and trade are small (Figure 4). The largest increase in the producer price of EU-compliant output is 0.8%, for Mercosur soybean (0.9% for Brazil), and the consumer price of soybean in the EU rises by at most 0.5% (0.7% in the most affected Member State). Soybean is the most affected crop because the targeted substances, mainly mancozeb and cyproconazole in Brazil and glufosinate and metribuzin in North America, account for 6 to 8% of pesticide spending on EU-compliant soybean. Sizeable effects arise only in the stress test, where the measure forces a 90% cut in the use of substances that are hard to replace: the producer price of Mercosur soybean then rises by 11.6% and the EU consumer price of soybean by 6.8%.

Figure 4: Change in average unit price by non-EU region



Note: Each panel shows one scenario, with low and high substitutability ($\kappa = 0.5$ and 1.0) crossed with a mild (-30%) and a strong (-90%) cut in the use of targeted substances. Each spoke is a non-EU region (North America, Mercosur, Rest of World) and each line is a crop. Values are the % change in the producer price of EU-compliant output, weighted by each origin's exports of that crop to the EU. Each panel has its own scale, so compare shapes across panels rather than magnitudes. Prices do not depend on the toxicity index: they are the same under the mammal LD50, bird LD50 and HPLI weightings.

Figure 5 decomposes the change in the pesticide footprint of EU consumption into four channels (HPLI weights for toxicity). Three of them always reduce it. The scale effect: higher prices lower the demand for crops. The crop-mix effect: consumption shifts towards the crops whose price rises least. The sourcing (crop-country) effect: imports fall more from Mercosur, whose production is the most pesticide-intensive, than from other origins. The fourth channel, intensity, is the use of all pesticides per tonne of output, and it pushes the other way whenever the cut is large: when the use of the targeted substances is restricted, farmers use more of the other substances to protect yields. With a mild cut, it reduces the footprint under the HPLI and bird weights, because the targeted substances themselves weigh heavily in these indices; under the mammal weight, it is close to zero.

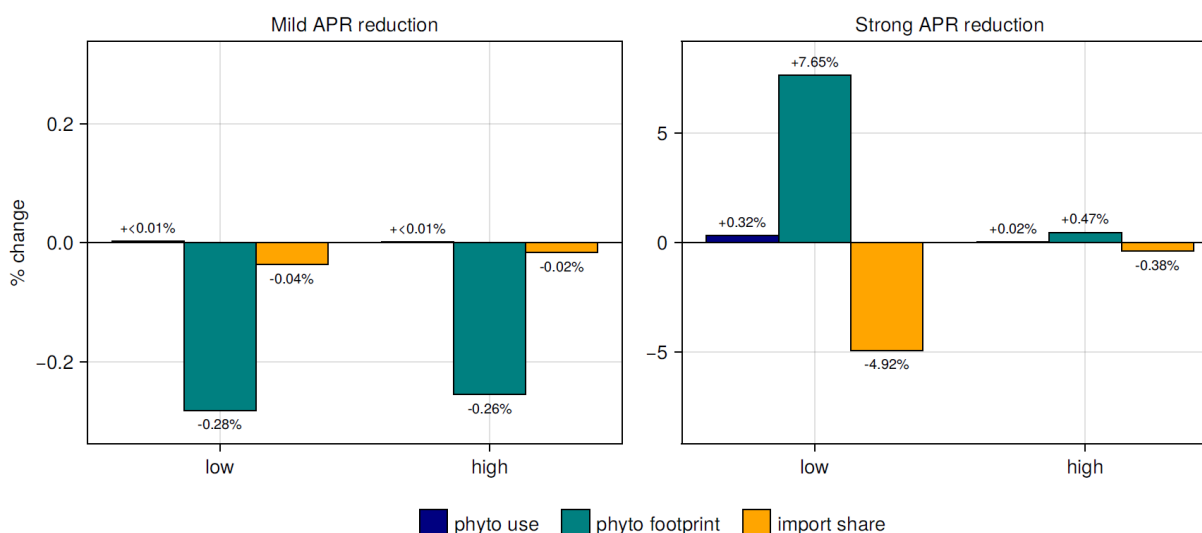
In the three main scenarios, all four channels are small, and the net change in the footprint is close to zero: -0.3% with a 30% cut and $\kappa = 0.5$, -0.3% with a 30% cut and $\kappa = 1$, and $+0.5\%$ with a 90% cut and $\kappa = 1$. Where the measure has the most bite (the 90% cut), it raises the footprint rather than reducing it. In the stress test, the intensity channel raises the footprint by

10.4%, against a combined reduction of 2.8% from scale (−1.1%), crop mix (−0.9%) and sourcing (−0.7%), so that the footprint of EU consumption rises by 7.7% (7.1% under the mammal weight, Appendix Figure A4). The scenario in which the measure has its largest effects on trade is thus the one in which exporters' production becomes most pesticide-intensive.⁴

The intensity effect grows with the size of the cut. For a 90% cut, it is much larger when substitution is difficult (+10.4% with $\kappa = 0.5$, against +0.7% with $\kappa = 1$): farmers must make up for a large loss of an input that other substances replace poorly. For a 30% cut, it is small and negative whatever the value of κ (about −0.25%): the cut in the targeted substances outweighs the extra use of the others.

These results rest on assumptions that are generous to the measure: MRLs are assumed to constrain use abroad, the targeted substances to be hard to replace, and the set of targeted substances on these crops is broader than the one assessed by the JRC. If close substitutes exist, exporters could switch at little cost. Moving from $\kappa = 0.5$ to $\kappa = 1$ under a 90% cut already reduces the scale effect from −1.1% to −0.1% and divides the intensity effect by about fifteen. With closer substitutes ($\kappa > 1$), both would shrink further: the measure would mostly change which substances are used, with little effect on trade or on the pesticide footprint of EU imports.

Figure 5: Change in the pesticide footprint of EU consumption and in trade flows



Note: Bars show the % change from the baseline in three EU outcomes: (i) phyto use: toxicity-weighted pesticide use by EU farmers; (ii) phyto footprint: toxicity-weighted pesticide use embodied in all crops consumed in the EU, whether grown domestically or imported; (iii) import share: the share of EU crop consumption sourced from outside the EU. The toxicity measured refers to HPLI.

⁴ Under the bird weights, the footprint of EU consumption instead falls slightly in the stress test (−0.62%; Appendix Figure A5). This stems from the fact that many active substances have no avian toxicity value and therefore carry no weight under this index, so that part of the shift towards other substances is not captured.

Conclusion

Overall, our analysis shows that bringing MRLs down to the LOQ is a weak instrument. Its scope is structurally limited, and it is poorly suited to achieving the stated objective. When the substances targeted have substitutes, trade flows and the pesticide footprint are barely impacted. Large impacts on trade flows can be obtained under a deliberately extreme combination of assumptions, namely that the targeted substances cannot be replaced and that their application rates must decrease by 90%. Even in that case, this policy pushes producers towards other substances and the EU footprint rises. This substitution towards other substances – a leakage effect – calls for a more ambitious policy indexed to the overall pesticide load, such as the border adjustment considered by Gagné et al. (2026).

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Appendix: Model and simulation design

The model

We use a general-equilibrium model of agricultural production and trade in the spirit of Farrokhi and Pellegrina (2023). Countries produce and trade maize, soybeans and wheat alongside a non-agricultural good. Farmers in each country allocate land across crops and production techniques according to the relative returns of each option. Consumers in each country choose between domestic and imported crops based on relative prices. Crop prices, trade flows, land use and incomes are all determined jointly, so a policy that changes production costs in one country affects prices and trade everywhere. The model is calibrated to observed production, trade and pesticide-use data, and results are reported as percentage changes from this baseline. We depart from the standard framework in two ways.

Segmented markets. Each crop can be grown with two techniques. The conventional technique is free of EU residue requirements and can only be sold outside the EU. The EU-compliant technique meets EU maximum residue levels (MRLs) and is the only one that can be sold to EU consumers. A tighter EU MRL therefore does not apply to all foreign production, only to the output that exporters sell to the EU. Farmers abroad can respond by changing how they produce for the EU market, by shifting land between the two techniques, or by selling less to the EU.

Endogenous pesticide use. Pesticide use is an outcome of the model, not a fixed input. Farmers combine land, labour and pesticides, and the pesticide input is itself a bundle of individual active substances. Following the USDA version of the GTAP-AEZ computable general equilibrium model, we set the elasticity of substitution between pesticide input and other inputs at 0.13 (as shown by Gohin (2024), this value implies a price elasticity which is broadly consistent with the empirical evidence). How much of each substance is applied per hectare responds to prices and to regulation. If one substance is restricted, farmers adjust their use of the others. This lets us trace how a residue rule changes the quantity and the toxicity of pesticides embodied in the food the EU consumes.

Toxicity footprint

We weight each active substance by a toxicity index relative to glyphosate (glyphosate = 1). We compute three versions: acute mammal toxicity (oral LD50), acute bird toxicity (LD50), and the Harmonised Pesticide Load Indicator (HPLI; Vandevor et al., 2025), which combines environmental fate, ecotoxicity and human-health hazards. The EU toxicity footprint is the toxicity-weighted pesticide use embodied in EU crop consumption, wherever the crop was grown.

The MRL policy

The policy lowers EU MRLs, effectively to the limit of quantification, for a set of 20 active substances that are already banned in the EU but still used abroad. This list is broader than the one assessed by Barreiro-Hurle et al. (2026), as it includes all substances banned in the EU that are used abroad on at least one crop and have an MRL above the LOQ. Examples include mancozeb, metribuzin, cyproconazole, carbendazim, thiophanate-methyl and glufosinate. Twelve of these substances appear in our application-rate data for the three crops; the other eight have no recorded use on them. The rule applies to every crop sold in the EU, domestic or imported. Since EU farmers already cannot use these substances, the burden of adjustment falls on foreign producers who export to the EU. They must cut the use of the targeted substances in the EU-compliant technique. The other banned substances and all approved substances are not directly constrained.

Scenarios

Two features of the policy's effect are uncertain, so we bracket each one with a low and a high value.

1. **How much application rates fall.** A lower MRL does not translate one-for-one into lower application rates, because residues also depend on timing, dose and crop. We consider a **mild reduction**, in which compliant producers cut the use of the targeted substances by 30%, and a **strong reduction**, in which they cut it by 90%.
2. **How easily farmers can replace the restricted substances (κ).** In the low-substitutability case ($\kappa = 0.5$), substances work as complements: restricted substances are hard to replace, as when they play a specific role in a treatment programme. In the high substitutability case ($\kappa = 1.0$), farmers can partly offset a restricted substance by using more of the others, with a unit elasticity of substitution.

Crossing the two dimensions gives four scenarios:

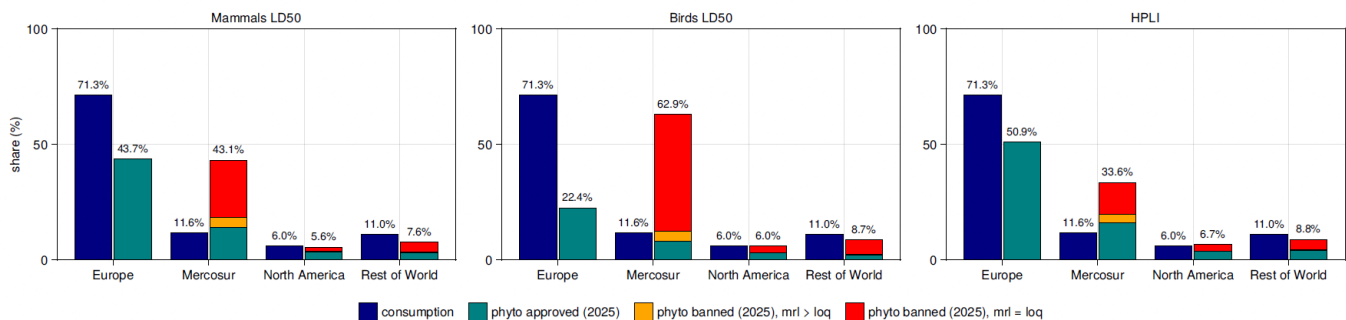
	Mild reduction (–30%)	Strong reduction (–90%)
Low-substitutability ($\kappa = 0.5$)	Scenario 2	Scenario 1
High-substitutability ($\kappa = 1.0$)	Scenario 4	Scenario 3

For each scenario and each toxicity index, we report:

- the change in EU pesticide use, in the EU toxicity footprint and in the share of EU crop consumption imported from outside the EU;
- a decomposition of the footprint change into four sources:
 - total consumption (scale);

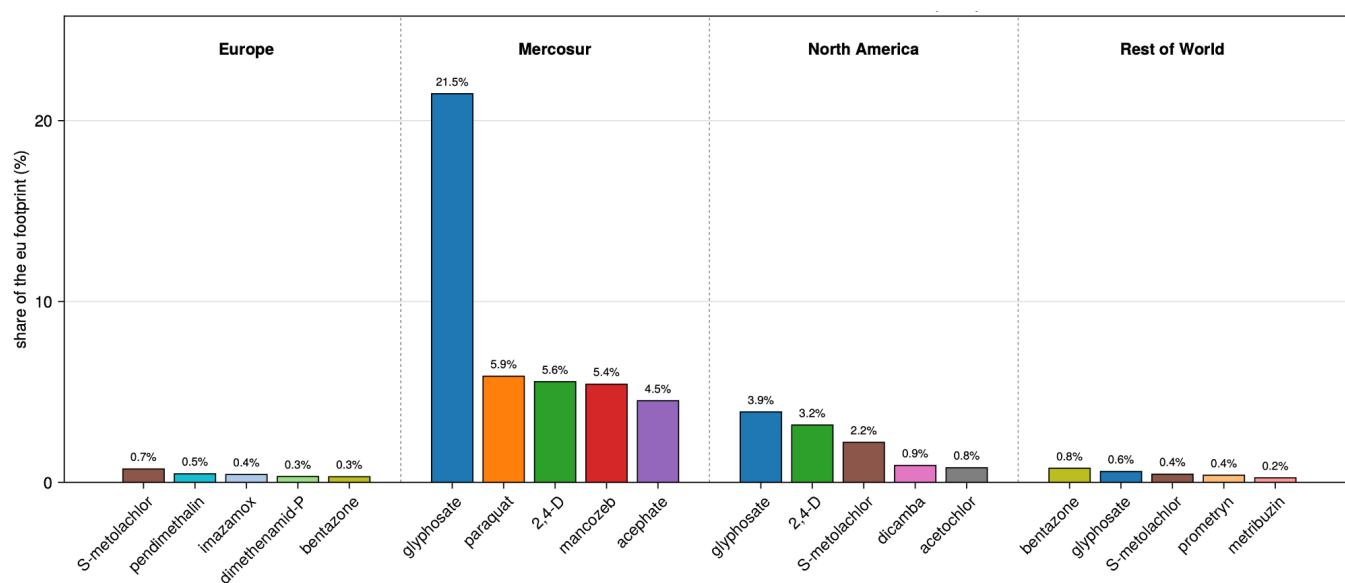
- the mix of crops (crop);
- where crops are sourced from (crop-country);
- how toxic production is per unit of output (intensity);
- price effects: crop price indices in EU countries, and production prices of EU-compliant crops in non-EU regions.

Figure A1: The footprint of EU consumption (EU rules 2025)



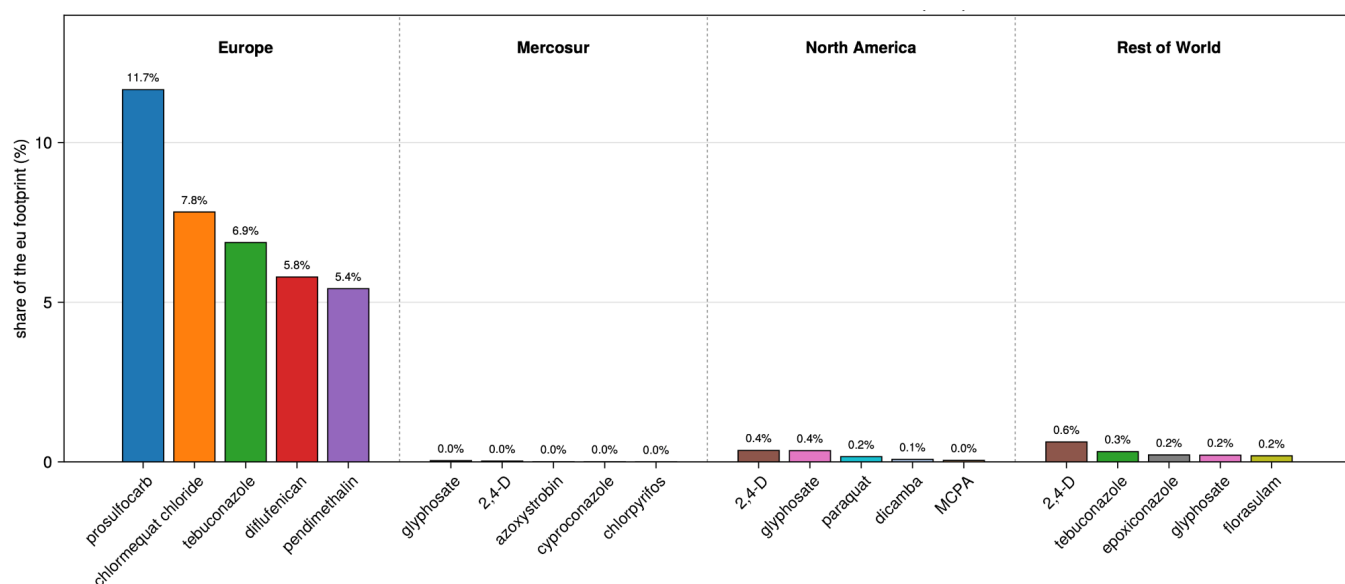
Notes: Same quantities as in Figure 1 (2019), with the EU approval status and MRLs in force in 2025, except that EU farmers' use of substances banned between 2019 and 2025 is set to zero, so that the European bar contains no banned use. For each region of origin, the left bar gives its share of aggregate EU consumption of soybean, maize and wheat, measured in calorie equivalents, and the right bar its share of the pesticide footprint of that consumption. The footprint is the quantity of each active substance applied per tonne of output, weighted by its toxicity and attributed to EU final demand. Toxicity weights are the acute oral LD50 for mammals (panel a) and for birds (panel b), and the Harmonised Pesticide Load Indicator (HPLI; Vandevoorde et al., 2025) (panel c). Substances are approved if authorised in the EU under the 2025 rules and banned otherwise. The banned part is split by the EU maximum residue level (MRL) in force in 2025 for the substance and crop: at the limit of quantification (LOQ) and above the LOQ; uses with no specific EU MRL fall under the default limit of 0.01 mg/kg and are counted at the LOQ.

Figure A2: Top 5 active substances in the footprint of EU soybean consumption, by region of origin (HPLI)



Note: For each region of origin, the bars give the five active substances that contribute most to the pesticide footprint of EU consumption of soybean, as a percentage of that footprint. Toxicity weights are the Harmonised Pesticide Load Indicator (HPLI; Vandevoorde et al., 2025). Quantities refer to 2019.

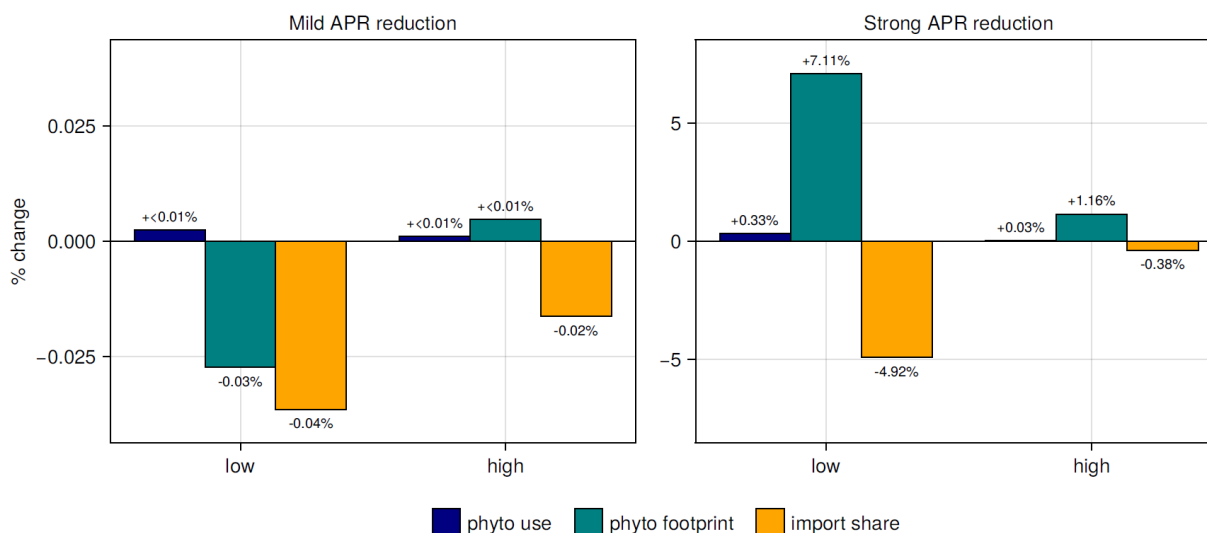
Figure A3: Top 5 active substances in the footprint of EU wheat consumption, by region of origin (HPLI)



Note: For each region of origin, the bars give the five active substances that contribute most to the pesticide

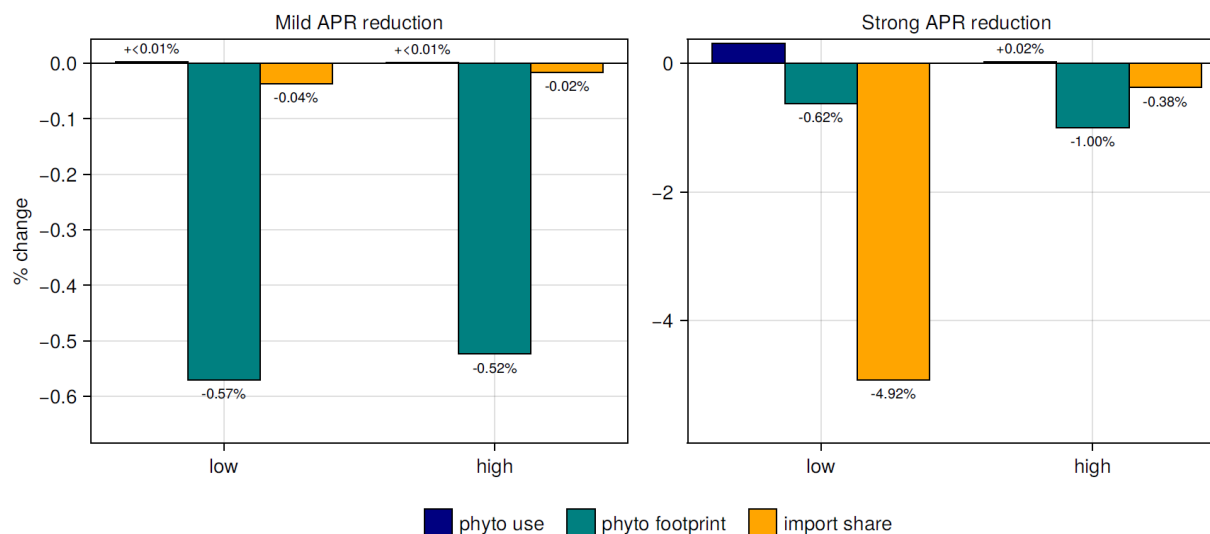
footprint of EU consumption of wheat, as a percentage of that footprint. Toxicity weights are the Harmonised Pesticide Load Indicator (HPLI; Vandevoorde et al., 2025). Quantities refer to 2019.

Figure A4: Change in the pesticide footprint of EU consumption and in trade flows (Mammals LD50)



Note: Bars show the % change from the baseline in three EU outcomes: (i) phyto use: toxicity-weighted pesticide use by EU farmers; (ii) phyto footprint: toxicity-weighted pesticide use embodied in all crops consumed in the EU, whether grown domestically or imported; (iii) import share: the share of EU crop consumption sourced from outside the EU. The toxicity measured refers to Mammals' LD50 Acute Oral Dose.

Figure A5: Change in the pesticide footprint of EU consumption and in trade flows (Birds LD50)



Note: Bars show the % change from the baseline in three EU outcomes: (i) phyto use: toxicity-weighted pesticide use by EU farmers; (ii) phyto footprint: toxicity-weighted pesticide use embodied in all crops consumed in the EU, whether grown domestically or imported; (iii) import share: the share of EU crop consumption sourced from outside the EU. The toxicity measured refers to Birds' LD50 Acute Oral Dose