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Assessing the economic impacts of stronger alignment of production standards applied to imported products on the EU's agricultural sector

Reducing all maximum residue levels of the most hazardous pesticides banned in the EU to the limit of quantification

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Contents

Abstract

This study assesses potential implications for EU trade, producers and consumers of lowering maximum residue levels (MRLs) for imported food and feed to the limit of quantification (LOQ) for the most hazardous pesticides banned in the EU. Drawing on a new dataset linking EU approval status, residue monitoring, authorisation for use in third countries and trade flows, it identifies 18 most hazardous active substances not approved in the EU with MRLs above the LOQ affecting 235 commodities and 86 exporting countries, and models three scenarios differing in assumed exporter adaptation. Across all scenarios, the direction of effects resulting from lowering the MRLs to the LOQ is similar — imports decline, EU production rises and consumer prices increase — but magnitude depends strongly on exporters' adaptation assumptions, ranging from negligible to substantial impacts.

When the reduction of MRLs to the LOQ leads to complete halt in the affected trade flows, we see a 41 % reduction in total EU agricultural imports. As producers in third countries are assumed to respond to this reduction by adjusting their practices, this reduction declines to 8 % and then to 0.4 % depending on the cost of adaptation and the extent of assumed use of the active substances in third countries.

EU production partly substitutes this reduction in imports as crop output expands while livestock output contracts. Price impacts depend on the scenarios: sizeable at world and EU levels under the no adaptation bound, but small once adaptation is taken into account. Results differ strongly across active substances, commodities and countries, so no uniform assumption about exporter behaviour holds. A targeted analysis of the active substance cyproconazole, undertaken to assess the representativeness of the substitution costs assumed in the scenarios, indicates that EU-approved alternative active substances are available but could raise production costs by 20–40 %. The study offers evidence on potential market impacts for the objective that pesticides banned in the EU should not return through imports. However, it faces limitations notable from the lack of available evidence at active substance–commodity–country level on use and substitution cost. This points to the need for further assessment. The study is not an impact assessment, as it does not cover either environmental nor social dimensions, and its results should be considered as a range bounding plausible outcomes rather than predicting them.

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Executive summary

While EU legislation already ensures that all food and feed placed on the EU market complies with high health and safety standards, a closer alignment of production standards would safeguard a level playing field for farmers and producers and consumer protection. In its Vision for Agriculture and Food, the European Commission stated the objective of establishing the principle that the most hazardous pesticides banned in the EU for health and environmental reasons should not re-enter the EU through imported products. To advance this commitment, in November 2025 the Commission announced that the Joint Research Centre (JRC) would conduct a supporting analytical study; the present report constitutes this study. Subsequently, in December 2025 the Commission proposed, as part of the package to streamline the food and feed safety legislation, that maximum residue levels (MRLs) that have been set based on good agricultural practices in third countries or Codex maximum limits may be lowered to the limit of quantification (LOQ) if considered appropriate in the light of the outcome of an impact assessment.

This study focuses on substances banned in the EU on hazard grounds, namely those classified as mutagenic or carcinogenic, toxic for reproduction, endocrine disruptors, persistent organic pollutants, persistent, bioaccumulative and toxic substances, and very persistent and very bioaccumulative substances. It assesses the implications of lowering Maximum Residue Levels (MRLs) for such substances to the Limit of Quantification (LOQ), including where the MRLs concerned have not been found to pose a consumer risk.

This report comprises five principal components. First, a comprehensive data assessment identifies which active substances (ASs) could be subject to MRL reduction to the LOQ, the evidence of their use in third countries, and the trade flows between the EU and third countries that could be affected. Second, stylised, standardised scenarios are constructed to characterise the effect of a reduction of MRLs to the LOQ for third countries, based on different assumptions regarding the response of third countries, the scope of that response and the corresponding adaptation costs. Third, these scenarios are implemented in an agro-economic model to examine their effects across trade flows, domestic competitiveness, and consumer prices. Fourth, an in-depth analysis of one specific AS (cyproconazole) assesses how well the standardised scenarios hold once AS-, country-, and commodity-specific characteristics are taken into account. Fifth, a qualitative analysis covers those commodities that are not represented in the agro-economic model, identifying the countries and commodities potentially exposed.

This report is not an impact assessment and should not be read as one. It addresses neither the environmental nor the social dimensions that underlie the substances' ban in the EU, and it has not undergone public consultation. Instead, the study examines potential implications, specifically for EU trade flows, the competitiveness of EU producers and consumers, of lowering to the LOQ all MRLs for the most hazardous substances banned in the EU that currently remain above the LOQ.

Key conclusions

The study compiled a new dataset on EU approval status, MRL levels, third-country authorisations, residue monitoring results and trade flows, enabling the identification of individual commodities and exporting countries that would be affected by a reduction of MRLs to the LOQ. This dataset provides a useful basis for subsequent, more targeted analyses.

Across the stylised scenarios simulated, the model results indicate that lowering MRLs to the LOQ can reduce EU imports of affected commodities, with potential implications for EU domestic production and consumer prices. While the direction of these effects is consistent, their magnitude is not, depending almost entirely on the assumptions made about the range of producers affected in third countries, their capacity to adapt their production practices and the costs of this adaptation. The plausibility of these assumptions depends, among other things, on the length of the period allowed for producers to adapt, which is not analysed in this report.

The scenarios therefore provide a deliberate bracket — an upper and a lower bound rather than a central projection — ranging from a 41 % reduction in EU agricultural imports where all exporters are affected and no adaptation occurs to 0.4 % where exposure is limited to the share of detections of active substances and adaptation costs are low.

Effects also spill across sectors: EU crop production expands across all scenarios, indicating an increased competitiveness of EU producers as import volumes decline. However, reduced imports raise feed costs, so that in the most extreme case – no adaptation scenario - EU livestock production contracts even as EU crop output expands, a distributional shift concealed by the aggregate figures. Under the more plausible intermediate and lower-bound scenarios, where some adaptation by third-country producers is assumed, this spillover to the livestock sector becomes negligible. Impacts on third countries depend principally on the cost for substituting the active substances and whether displaced exports can be redirected elsewhere: where they can, production is largely maintained; where they cannot, producer prices in the exporting country fall.

The results show strong heterogeneity across substances, commodities and countries. This signals that any uniform assumption about exporter behaviour is rather unrealistic (too optimistic in some cases, too pessimistic in others), calling for more refined and detailed substance- and country-specific assessment. The cyproconazole case study illustrates what such analysis yields: EU-approved alternative substances are available but raise related production costs by roughly 20 to 40 %, though the net increase may be lower where alternatives are more effective in controlling the associated pests and diseases they treat, and exposure is concentrated in a few pivotal suppliers.

Main findings

Of 976 active substances not approved in the EU, 80 meet the most hazardous criteria. Of these, only for 18 ASs MRLs above the LOQ exist and are either detected in EU imports or authorised in exporting countries. They affect 235 commodities from 86 countries, corresponding to 10 583 substance–commodity–country combinations (8.3 % of those theoretically possible) for which only 5 473 are traded with the EU. Three simulation scenarios are considered to bracket outcomes against a business-as-usual baseline, differing in the assumed exposure of exporters and the additional costs they incur in adapting their production practices.

Upper bound scenario (no adaptation: producers in all non-EU countries where any evidence of use of the ASs exists continue to use them): EU total agricultural imports fall by 41 % in volume, most sharply for citrus (-92 %) and soybeans (-90 %). EU aggregate agricultural production is projected to increase (+1.1 %), with agricultural area expanding by 1.9 million ha (+1.2 % of utilised agricultural area), led by citrus (+47 %), rapeseed (+41 %) and soybeans (+29 %), while livestock production contracts (pork -5.8 %, poultry -5.4 %,) as feed costs rise (oilseed cakes +87 %). EU consumer prices may rise steeply: coffee +332 %, soybean cakes +105 %, citrus +85 %. Third-country producers may cease their exports to the EU, leading to a decrease in producer prices in the exporting country.

Intermediate scenario (profit-driven adaptation by a share of producers reflecting assumption on AS use based on the number of authorisations for use and detections in monitoring, subject to a 20 % minimum; and costs of exporting to the EU assumed to increase by 20 %): EU overall agricultural imports decrease by 8 %, while EU production slightly increases (+0.23 %), most for citrus (+3.3 %), tomatoes and rapeseed (each +3 %). EU consumer prices increase most for table grapes (+6.5 %), coffee (+6 %), citrus (+5.6 %). Spillover effects on the livestock sector become negligible.

Lower bound scenario (profit-driven adaptation by a share of producers reflecting an assumed AS use derived from detections in monitoring alone, with no minimum applied, and costs of exporting to the EU assumed to increase by 5 %): EU total agricultural imports decrease by 0.4 %, with changes for most commodities concentrated near zero. EU production and consumer price increases remain below 1 % for all commodities.

A qualitative analysis of 180 commodities not explicitly represented in the agro-economic model used for the simulations (affecting 78 countries) identifies 30 exposed third countries, most of which could largely divert trade or absorb it domestically, although often at a lower sale price. The ASs glufosinate, spirodiclofen, mancozeb and metiram are the ones for which the greatest value of imports originates in countries where their residues have been detected or their use is authorised. The EU is not self-sufficient in 29 of these commodities and could generally switch suppliers, though at 2-9 % higher prices, with figs, almonds, hazelnuts and beans the least substitutable. A cyproconazole case study finds EU-approved alternatives raise production costs by about 20-40 %, though the net increase may be smaller as their use may provide benefits in terms of enhanced pest and disease control.

Limitations

This analysis is subject to a number of limitations, which must be made explicit to avoid that results are taken as definitive. Foremost, it rests on broad modelling assumptions about how producers in third countries would respond to a reduction of MRLs to the LOQ, applied homogenously across substances, commodities and countries even though considerable heterogeneity is to be expected. This uniformity was necessary given the absence of precise data on the extent to which ASs are used for specific country-commodity pairs, on the feasibility and cost of substituting an AS within the crop-protection strategy at country and commodity level. The analysis is further constrained by limited evidence on the factors that drive the response of exporters to MRL reductions in third countries where an AS is authorised for use.

The analysis does not address effects arising from MRL reduction for animal-based products, as the ASs considered are authorised for use on crops rather than in livestock production. The modelled scenarios also do not capture the potential effects of requiring imports to meet more stringent MRLs on EU consumers' perception of the quality, safety and sustainability of imported products.

The representativeness of the cost assumptions used in the scenarios could be tested against only a single AS. However, the heterogeneity found across countries and commodities in this specific case, together with the heterogeneity of impacts reported in the literature reviewed, reinforces the need for more disaggregated information when assessing the impacts of reducing MRLs to the LOQ.

These limitations notwithstanding, the analysis presented here can serve as first evidence to inform on the range of possible impacts that a reduction of MRLs to the LOQ across multiple ASs could produce. It identifies the key factors that should be further investigated to improve the assessment of impacts for any given substance.

Related and future work

The findings point to the need for further assessment of impacts, supported by better information on the actual use and agronomic importance of specific substances in exporting countries. Ex-post analyses of earlier MRL reductions to the LOQ would also be useful to better understand how producers and exporters actually respond, at what costs, and with what effects on trade, production and markets.

The food and feed safety simplification package that the Commission has proposed in December 2025 is under examination in the European Parliament and the Council. If adopted as proposed, it would allow for regulatory changes to lower the MRLs to the LOQ where appropriate based on a dedicated impact assessment.

1. Introduction

Following requests from farmers, citizens and co-legislators, the European Commission stated in its Vision for Agriculture and Food,[1] that "[it] *will establish a principle that the most hazardous pesticides banned in the EU for health and environmental reasons are not allowed back to the EU through imported products. To advance on this, the Commission will launch in 2025 an Impact Assessment (IA) that will consider the impacts on the EU's competitive position and the international implications and, if appropriate, propose amendments to the applicable legal framework*". Greater coherence of production requirements concerning the most hazardous pesticides banned in the EU, applied across domestic and imported products alike, would ensure that the EU's standards, aimed at providing a high level of protection for health and the environment, also correspond to consumer expectations regarding sustainable production methods.

Building on the commitment in the Vision for Agriculture and Food, and to respond to the societal concerns related to these environmental and human health externalities, the Commission announced in November 2025 the launch of an impact assessment (IA) on hazardous banned pesticides entering the EU through imported products. In that announcement the Commission referred to a study to be carried out by the Joint Research Centre (JRC) in support of the IA, intended to provide the analytical basis for potential appropriate and proportional amendments to the existing legal framework to progress towards greater reciprocity of standards. The present technical report is the result of that JRC analysis and constitutes the study referred to in the announcement.

In the meantime, on 16 December 2025, the Commission adopted a legislative proposal for a Food and Feed Safety Simplification Package (FFSSP, also referred to as Omnibus X). As noted in the accompanying staff working document, the European Parliament, a number of Member States in the Council and stakeholder groups have highlighted the perceived difference in the level of protection afforded by the plant protection products (PPP) and MRL regulations and have called for an alignment of production standards between imported and domestic products (EC, 2025). The proposal includes amendments to Article 14(2) of Regulation EC 396/2005, which establishes the possibility of lowering Maximum Residue Levels (MRLs) to the Limit of Quantification (LOQ) even where the MRLs are safe for EU consumers. The proposal also clarifies which substances qualify as "*most hazardous pesticides banned in the EU for health and environmental reasons".* Based on the scientific criteria set out in Regulation EC 1107/2009, this category includes substances with mutagenic, carcinogenic or reprotoxic properties[2] as well as endocrine disruptors with adverse effects on humans. The proposal reasons that no level of exposure to such substances should be permitted if a high level of protection for consumers in the Union is to be ensured. It further includes persistent organic pollutants (POPs), persistent, bioaccumulative and toxic (PBT) substances, and very persistent and very bioaccumulative (vPvB) substances, and substances with endocrine disrupting properties that may cause adverse effects on non-target organisms. The use of these substances give rise to environmental concerns of a global nature connected to the territory of the Union, such that prohibiting residues of these substances in food placed on the

[1] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - A Vision for Agriculture and Food - Shaping together an attractive farming and agri-food sector for future generations. COM(2025) 75.

[2] Mutagen category 1A & 1B, carcinogen category 1A & 1B, reprotoxic category 1A & 1B.

Union market aligns with international efforts to combat pollution and with global initiatives on sustainable development and biodiversity conservation.

The stringency of the EU regime provides a second element of context. The REFIT Evaluation of the EU legislation on the placing of PPPs on the market concluded that regulatory requirements for pesticides in the EU are among the strictest in the world (EC, 2020), while finding the evidence inconclusive as to the effects of the PPP Regulation on EU agricultural production. The harmonised procedures for the approval of active substances (ASs) reduces costs, but the stringency of the approval criteria reduces the range of substances available to farmers. Within the EU, of the 1 482 ASs listed in the EU Pesticide Database[3], 976 are not approved, 82 are pending assessment and 421 are approved. As an indicative benchmark of relative stringency, de Groot et al. (2026) found that 256 of the 523 ASs (48.9 %) approved in at least one Latin American country are not permitted in the EU. Although the evidence remains inconclusive, reduced availability of ASs may adversely affect yields and productivity, potentially placing the European agricultural sector at a disadvantage relative to world regions with a broader range of approved ASs.

The present report sets out the JRC's preliminary analysis of how the principle announced in the Vision for Agriculture and Food - that the most hazardous pesticides banned in the EU for health and environmental reasons should not re-enter the EU trough imported products - could potentially affect the EU's agricultural sector and global trade. **In particular we assess the potential implications for EU and third countries commodity markets and for EU consumers.** The analysis comprises five principal components.

First, we provide a comprehensive data assessment of the scope of the initiative, identifying which ASs could be subject to MRL reduction to the LOQ as a result of the implementation of the principle announced in the Vision for Agriculture and Food, the evidence of their use in third countries, the importance of the EU market for the countries in which such use is documented (the EU as a share of those countries' total exports of the relevant commodities), the importance of those countries as sources of EU imports (affected countries as a share of total EU imports) and the EU's self-sufficiency on the affected commodities.

Second, we construct stylised standardised scenarios characterising the effect of a reduction of the relevant MRLs to the LOQ for third countries in terms of (i) the behavioural response (namely continued use of the ASs or adjustment of practices to meet the new MRL requirements), (ii) the scope of that behavioural response (measured as the share of the country's exports affected), and (iii) the resulting trade implications for the affected countries and commodities (whether exports to the EU are stopped or face higher costs). Third, we implement these scenarios in an agro-economic model to examine their effects across trade flows, domestic competitiveness, and consumer prices.

Fourth, we conduct an in-depth analysis of one specific AS (cyproconazole) to assess how well the assumption of additional costs for replacing ASs used in the standardised scenarios hold once AS-, country-, and commodity-specific characteristics are taken into account. Last, we provide a qualitative analysis of exposure for those commodities that are not represented in the agro-economic model, identifying the critical countries and commodities in each case.

[3] https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/start/screen/active-substances

The present study does not meet the requirements of a full IA as set out in the Better Regulation Guidelines (EC, 2021). Any further policy action, including any regulatory changes should accordingly be informed by a more comprehensive analysis conducted in line with those guidelines.

2. Methodology

Under MRL Regulation EC 396/2005 (EC, 2005), MRLs are established on the basis of scientific risk assessments carried out by the evaluating Member State and the European Food Safety Authority (EFSA). They are set at levels that ensure a high level of consumer protection for all European consumer groups, while considering the relevant provisions of Regulation 1107/2009[4]. In addition, Regulation (EC) No 396/2005[5] establishes in accordance with the general principles laid down in Regulation (EC) No 178/2002[6] provisions related to maximum residue levels of pesticides residues in or on food and feed of plant and animal origin. In accordance with Article 5(1) of the latter Regulation, food law shall pursue one or more of the general objectives of a high level of protection of human life and health and the protection of consumers' interests, including fair practices in food trade, taking into account, where appropriate, the protection of animal health and welfare, plant health and the environment. In accordance with Article 43 of Regulation (EC) No 396/2005, the Commission may ask EFSA to carry out a targeted review of existing MRLs where, inter alia, a change to the approval status of an AS under Regulation (EC) No 1107/2009 warrants reconsideration. Existing MRLs are regularly revised and, in particular, where new scientific evidence demonstrates that they no longer ensure the required level of consumer protection, or where they can no longer be scientifically supported. Where no safe or adequately substantiated MRL can be established, the MRL is lowered to the LOQ or an alternative lower safe MRL, in accordance with Regulation (EC) No 396/2005. Under the current legislation., the reduction of an MRL is therefore the outcome of a risk assessment that does not confirm the safety of a higher level of residue. Conversely, whenever MRLs are set above the LOQ, this is done on the basis of a scientific risk assessment that confirms the safety of the envisaged MRLs for consumers. The Vision for Agriculture and Food adds to this approach the possibility that MRLs for the most hazardous substances banned in the EU for health and environmental reasons can be lowered to the LOQ even if they do not pose a risk to consumer health.

When trying to understand the impact of changes in MRLs on markets, the most relevant literature stems from the analysis of trade and Sanitary and Phytosanitary (SPS) measures. SPS measures such as MRLs can operate either to facilitate or make trade more complex (Santeramo and Lamonaca, 2022), depending on the relative impact of their compliance costs for producers and operators and their perceived benefits in terms of product safety, quality and sustainability for consumers. The literature also emphases the trade-enhancing effect of regulatory alignment. Accordingly, any change that widens the regulatory distance between trading partners is generally considered to have a negative impact on trade flows[7]. The empirical record, however, is more

[4] Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC.

[5] Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/EEC.

[6] Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety.

[7] Similar conclusions are found for legislation in other domains such as the European Union Deforestation Regulation, where Sharma and Villoria (2026) find that stricter compliance costs reallocate soybean exports from South America toward non-EU markets, mainly China, divert the EU imports toward North America, and increase the prices of soybean faced by EU users. In contrast, South American producers also experience reductions in producer prices. If South American producers were not to align with the regulation the impacts would be further increased.

heterogenous. Reviewing more than 1 300 estimated trade effects of SPS measures, Santeramo and Lamonaca (2022) find that, although most estimates are trade restrictive, the magnitude, direction, statistical significance and precision of the effects are case-specific, and vary with the type of SPS measure, the countries and commodities involved, and study design. Consistent with this, Hejazi et al. (2022), analysing MRL divergence across 51 fruits and vegetables, 85 countries and 162 AS, find that more stringent tolerance in the destination than in the origin market significantly reduces bilateral trade, dampening both the probability of exporting to a less-aligned market (the extensive margin) and the volumes shipped where trade already occurs (the intensive margin). The authors conclude that this dual effect likely reflects evidence that MRL misalignment imposes both fixed and variable trade costs. They find that this trade restrictive impact was more significant for insecticides MRLs, followed by herbicides, but generally not significant for fungicides. Ferro et al. (2015) focusing on 61 countries and 66 commodities, identified that the main compliance costs related to fixed costs as the impacts on trade were mostly related to the probability of trading with countries with lower MRLs rather than to the volumes of trade. In their analysis they also find that exporters from the less and least developed countries are more constrained by stricter standards than their competitors from the developed world. Xiong and Beghin (2014), using 109 plant products across 20 countries, reach similar conclusions but identify an asymmetry: importers with higher standards (i.e. lower MRLs) may experience an increase in their imports while exporters from less and least developed countries are disadvantaged. This signals that stricter MRLs alleviate information asymmetry by assuring the food safety of the products. Fiankor and Shingal (2025) using data for Swiss imports only, extend the evidence beyond volumes to trade value, number of varieties traded and import prices concluding that regulatory alignment does not only increase trade but also enhances food security by increasing product variety and lowering prices. Shingal and Ehrich (2024) also find that MRL stringency also increases quality of imports into the EU.

Focusing on the impacts of MRL stringency between the EU and Mercosur for soybean and maize, Martins and Burnquist (2026) find that when EU MRLs are more stringent that Mercosur standards, compliance costs reduce trade probability and volumes, however exporters can transfer these costs to importers through higher unit prices. Zhang (2025) analysing the impact of the EU's MRL stringency in Chinese exports finds that increased stringency (i.e. lower MRLs) reduces export values, however the impact is mainly driven by insecticide ASs and are heterogenous across commodities with higher impacts on fruits and vegetables. The impact is mostly at the intensive margin (value of exports) rather that at extensive one (exporting or not a product to a market) and is reversed when focusing on countries with which China has a regional trade agreement. Also analysing the impact of MRLs on Chinese exports, Chen et al. (2025) find that compliance costs are a main driver of the heterogeneity of impacts across commodities and ASs.

Taken together, this limited literature review yields a clear analytical expectation: **the trade effects of reducing MRLs to the LOQ will be heterogeneous across ASs, countries and commodities, and will depend on exporters' alignment and their capacity to adapt and on consumer preferences for more stringent standards.** This heterogeneity is what the scenario-based approach described below is meant to brace – it puts a lower and an upper bound around possible outcomes rather than trying to pinpoint a single, exact figure. In other words, it acknowledges the uncertainty and frames it as a "bracket" of what could happen, instead of claiming a precise estimate.

2.1. Data sources

The first step of the analysis involves identifying the ASs that would be affected by the Vision for Food and Agriculture initiative, the use of these ASs by country and commodity, and the associated trade flows for the affected country-commodity pairs. The following terminology is used throughout the report:

— *Relevant active substance:* an AS that is currently not approved in the EU, meets the "most hazardous" condition, has at least one commodity-specific MRL above the LOQ and for which there is evidence of use in at least one non-EU country.

— *Relevant commodity:* a plant product[8] for which the MRL of a relevant AS is currently above the LOQ.

— *Relevant country:* a country that exports to the EU a commodity for which the MRL of a relevant AS is currently above the LOQ.

— *Pair:* a combination of a relevant commodity and a relevant country.

— *Triad:* a combination of a relevant AS, a relevant commodity and a relevant country.

The data sources used in the stepwise identification of the triads of interest are described below. A descriptive analysis of the identified triads is provided in section 3.

2.1.1. Definition of a relevant active substance

An AS qualifies as being relevant for the analysis in this report only if it satisfies four conditions: first, it is "not approved" in the EU; second, it falls under the "most hazardous" definition; third, it has at least one commodity-specific MRL above the LOQ; and fourth, it is used on that commodity in at least one country outside the EU.

For the purpose of this study, the *"most hazardous active substances"* are defined as those meeting one or more of the following criteria: mutagenic category 1A or 1B, carcinogenic category 1A or 1B, toxic for reproduction category 1A or 1B, persistent organic pollutants (POPs), persistent, bio-accumulative and toxic (PBT) substances, and very persistent and very bio-accumulative (vPvB) substances, as well as endocrine disruptors that affect human health and/or non- target organisms. Therefore, a relevant AS for the analysis must be classified in at least one of these hazard categories, and the classification must be recognised in the relevant legal framework[9]. As the assessment of endocrine disruptors with adverse effects on humans or non-target organisms has begun only recently, EFSA's supplementary analysis is also used for this specific category.

In addition to meeting the hazard requirements, a relevant AS must have an MRL above the LOQ for at least one commodity. Where every MRL for a "most hazardous" AS is already set at the LOQ, the announcement made in the Vision for Agriculture and Food would have no additional impact.

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8 The analysis focuses on plant products only as ASs are not used directly for livestock production even when residues can also be found in animal products and specific MRLs are set also for these.

9 Available in Table 3 to Annex VI of the Classification, Labelling and Packaging (CLP) Regulation and its subsequent ATPs published in the Official Journal of the European Union and/or were identified as endocrine disruptor, PBT or vPvB in the context of Regulation (EC) No 1107/2009.

The information on the approval status of pesticides and on MRLs currently in place is taken from the EU Pesticide Database maintained by the Commission[10]. Data on the hazard classification of ASs is retrieved from the ECHA-CHEM database of the European Chemicals Agency[11] with the exception of Quinoxyfen which was only based on an EFSA assessment not yet incorporated into the ECHA-CHEM database. In both cases, the data used is that available on 30 April 2026.

Finally, evidence of use of "most hazardous" ASs should exist in at least one of the EU's trading partners to make the AS relevant in our study. The data sources used for establishing use are described in section 2.1.2. below.

2.1.2. Use of active substances by country and commodity

Comprehensive and harmonized data on the use of ASs across countries and products does not exist. The global datasets reported in the literature, such as PEST-CHEMGRIDS (Maggi et al., 2019) or the Global atlas of pesticide use (Zhang et al. 2026), are incomplete for the purpose of our analysis and rely on ad-hoc allocation rules to distribute aggregated sales data across pesticide types and crops. Even within the EU, crop- and substance-specific use data is lacking, as highlighted in the response of the Commission to the Council's request for a complementary study evaluating the impacts of the earlier, later withdrawn, proposal for a Sustainable Use of Pesticides Regulation (SUR) (EC, 2023).

In the absence of direct use data, we rely on two main sources of data as proxies for the use of a specific AS on a commodity in a specific county: (i) whether residues have been detected in official import controls, and (ii) whether the AS is authorised for use in a given country.

2.1.2.1. Detection of residues in imports

The EU Member States implement National Multi-Annual Control Plans (MANCP) and the EU coordinated Multiannual Control Programme (EU-MACP) to safeguard food safety and enforce compliance along the food chain. Through these instruments, the EU monitors MRL compliance for commodities both produced within the EU and imported. The EU-MACP run on a three-year cycle and specify the commodities and number of samples that each Member State analyses for pesticide residues. The EU-mandated MACP is supplemented by the MANCP with targeted, locally relevant monitoring to address specific risk trends.

We use data on residue-testing results for the period 2021-2023. We focus on the test undertaken for the relevant ASs on the relevant commodities. This leads to a total of over 134 000 individual residue tests carried out for the relevant ASs (see section 3.1)[12]. For each triad, EFSA has provided the total number of tests and the number of positive results (i.e. residues above the LOQ) from the monitoring reports of the MANCP and EU-MACP. The latter account for approximately 4.6% of total tests.

A detection is the strongest available evidence that an AS is used on a given crop produced for export to the EU. However, this does not provide a complete picture as testing is based on

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[10] https://food.ec.europa.eu/plants/pesticides/eu-pesticides-database_en

[11] https://chem.echa.europa.eu/

[12] The total number of samples tested from third countries for <u>all</u> ASs during the same period amounts to 237 500.

probability sampling under regularly updated priorities, therefore a substantial share of consignments entering the EU is not tested. Absence of a detection therefore cannot be equated with an absence of use, and we supplement the detection data with information on authorisation for use.

2.1.2.2. Authorisation of active substances by commodity in third countries

Data on authorised uses in third countries is not publicly available in a single public database. The plant protection product registration data presented in this report are derived from Homologa®, a global regulatory database developed, owned and maintained by Lexagri SAS. Homologa® is a registered trademark of Lexagri SAS. The data was accessed under licence.

The figures presented are aggregated summaries derived from a single extract of Homologa® taken on February 2026, reflecting the regulatory position as of 2026. The extract has not been updated since that date and does not represent the current regulatory position. Plant protection product approvals and maximum residue limits change frequently and without notice, and a material proportion of the entries underlying these figures may since have changed, lapsed or been superseded. The extract covers all countries available within the Basic Active Ingredient Information with Crops module and represents a subset of the Homologa® database rather than its full content. The data is presented for information and initial reference only. It is not a substitute for verification against the relevant national or regional regulatory authority. No reader should rely on it for any regulatory, commercial, trade or shipment decision without independently confirming the current position with the competent authority or a suitably qualified adviser.

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The coverage of Homologa® for less-developed countries is limited both in terms of range of countries and details of registration available for ACP countries. We, therefore, supplement the data on the registration of ASs for use with data provided by COLEAD. COLEAD is an international not-for-profit association founded in 1973 that works towards the sustainable transformation of food value chains, particularly horticultural ones, in countries and regions where development needs are greatest. Information compiled by COLEAD comes from multiple national sources, providing a homogenised overview of pesticide registration and use status. This overview is based on the latest national lists of registered PPPs made available to COLEAD by 27 ACP countries and two regional organisations (CSP and CPAC), covering a total of 39 ACP countries. Readers interested in accessing detailed data should visit colead.link.

2.1.3. Trade data

Trade data is sourced from two databases. EU imports are taken form the international trade in goods database (COMEXT), maintained by Eurostat. We use this database to calculate the EU's import dependency for specific commodities on the countries for which we have evidence of use. As COMEXT does not provide information on exports of third countries to non-EU destinations, we use UN COMTRADE to calculate the export dependency on the EU for non-EU countries.

As the four databases (EU pesticide database, residue monitoring database, COMEXT and UN-COMTRADE) use different nomenclatures, the JRC has carried out an ad-hoc matching process at the most disaggregated level possible. Since COMEXT reports data at the 8-digit level and UN-COMTRADE only at the 6-digit level, an exact comparability between the EU's import dependency and third countries' export dependency cannot be guaranteed. For example, where a MRL refers to peaches, EU imports are reported separately as peaches and nectarines (8-digit codes 08 09 30 20 and 08 09 30 30, respectively), whereas exports to the EU are reported jointly for peaches and nectarines (6-digit code 080930).

2.1.4. Additional data sources used

The three main sources described above were complemented with additional information. First, we assessed the EU overview table on import tolerances[13]. Import tolerances are the result of applications submitted by third countries to establish or modify EU MRLs for specific pesticide–commodity combinations, allowing imported products to comply with EU MRL requirements where authorised uses outside the EU differ from those within the EU. Import tolerances are subject to the same consumer safety requirements as other EU MRLs and can only be established where the resulting exposure to pesticide residues is considered safe for EU consumers, based on the applicable risk assessment. These applications are evaluated and, where accepted, implemented through EU regulations amending the applicable MRLs.

A total of 688 import tolerance requests were analysed, with particular focus on requests submitted after 2020 to identify potential evidence of ASs used in third countries that could be affected by a reduction of EU MRLs to the LOQ. The assessment showed that most of the ASs covered by these requests are currently approved for use in the EU and not classified within the harmonised risk categories considered in this study, and are thus not associated with MRLs expected to be lowered to the LOQ.

Only one potentially relevant case was identified: an import tolerance request related to the use of dimethomorph on grapes from the United States. However, this active substance–country combination was already identified using the Homologa® dataset, where dimethomorph is reported as registered for use on grapes in the United States. Therefore, the analysis of the import tolerance requests did not provide additional information on pesticide uses in third countries beyond the evidence already available from the main data sources considered in this study.

Last, international standards set by the Codex Alimentarius Commission of the Food and Agriculture Organization of the United Nations were considered through the assessment of the Codex maximum residue levels listed on the Codex Pesticide Residues in Food online Database[14].

2.2. CAPRI agro-economic model

The Common Agricultural Policy Regionalised Impact (CAPRI) modelling system is the main quantitative tool used in this study. CAPRI is a global, comparative static, partial equilibrium model for the agricultural and primary processing sectors. Comparative static results are best interpreted

[13] Overview table on import tolerances covering 2009-2025

[14] https://www.fao.org/fao-who-codexalimentarius/codex-texts/dbs/pestres/en/

as the long run outcome of some scenario, after all adjustments to the new equilibrium are completed. In CAPRI, regional supply modules represent the EU agricultural sector, and a global market module represents global agri-food commodity markets. These two main components are interlinked via an iterative process. Commodity prices from the global markets enter the profit maximisation system of the EU regions, while EU agricultural supply from the regions enters the trade balances. This model structure helps to capture price feedback from simulated policy changes along the primary supply chain, from commodity markets to EU farms (and vice-versa). The EU regional supply models follow a profit maximising behaviour under constraints, such as land availability, nutrient balances and policy obligations. The observed situation is interpreted as a profit-maximising choice by the agent, assuming that all constraints and coefficients are correctly specified with the exemption of costs or revenues not included in the model (Britz and Witzke, 2014). Profit maximisation is implemented through positive mathematical programming (PMP), which offers considerable flexibility in capturing important interactions between production activities and the environment, while allowing the modelling system to be calibrated to observed production statistics (Heckelei et al. 2012). The market model is a spatial multi-commodity model with global coverage (80 countries or country groups), representing about 60 primary and secondary agricultural products. International trade is modelled following the Armington assumption, differentiating goods by place of origin so that each bilateral trade flow can be modelled explicitly. The market model is calibrated to historical trade patterns[15] and incorporates projections for the future development of prices and market balances. Trade policy measures at the border are also included, such as tariffs, tariff-rate quotas (TRQs), variable levies and the EU entry-price system for fruit and vegetables. CAPRI has been widely used to analyse the impacts of different agricultural, trade, climate change, and environment-related scenarios on agricultural production, prices, trade flows and the environment (e.g. Hasegawa et al. 2018; Himics et al. 2018; Thom et al. 2023; Fellmann et al. 2025; Nordin et al. 2025; Stepanyan et al. 2026).

The CAPRI model has been used to analyse pesticide-related policies in the past (e.g. Barreiro-Hurle et al. 2021, Klinnert et al. 2024), but its suitability here is limited. While pesticide use in the EU supply modules is captured explicitly (Fellmann et al. 2023), it is not represented explicitly in the market module for the rest of the world. Since this study concerns changes in pesticide use in third countries, the implications of these changes have to be introduced via assumptions. The way in which the behavioural responses assumed in the scenarios are implemented is described in section 2.3.5. Moreover, the model does not cover individual commodities with the level of detail at which MRLs are set and therefore the model-based analysis cannot provide a full picture of the impact of reducing MRLs to the LOQ for the relevant commodities. To partly overcome this limitation, we provide a qualitative analysis for commodities not covered by the model in section 2.5. However, in that analysis the intensity dimension discussed in section 2.3.3 is not taken into account and therefore the analysis is based on hazard (all the production that could use the relevant ASs) and not on risk (the production using the relevant ASs).

Further details on the CAPRI model can be found on the model's webpage at www.capri-model.org

[15] While the calibration tries to mimic the underlying trade data, different commodity definitions and optimization constraints may lead to situations where the former is not fully aligned with the representation of trade flows in the model.

2.3. Scenario definition

The stylised scenarios applied in the CAPRI model to assess the impacts of reducing MRLs to the LOQ for the relevant triads are defined across three principal dimensions: behavioural response, scaling, and cost of adaptation. The behavioural response is understood as the strategic operational adjustment made by third-country producers of a specific country–commodity pair exporting to the EU once an MRL is reduced to the LOQ. Producers either adapt or do not adapt to the new requirements. Where they adapt, exports to the EU continue but under potentially higher production and logistical costs. Where producers cannot adapt, they stop exporting to the EU. The behavioural response can be imposed uniformly across all pairs or determined at the country-commodity level by a switching rule. The scaling factor determines whether the behavioural response applies to all or only a part of a country-commodity pair's exports to the EU. If it applies to all (i.e. unscaled) it affects 100% of the trade flow. If scaled, the behavioural response affects a share of trade based on the available evidence of use. Last, the cost of adaptation needs to be defined. The scenarios are designed to capture the simultaneous reduction of all MRLs above the LOQ for the relevant ASs. A critical limitation is our use of standardized and uniform assumptions across all triads which are implemented as AS–commodity–country (triad specific) shocks (see section 2.3.5).

Therefore, for the **scenario definition**, three main variables apply: (i) which **behavioural response** is assumed (adapt farming practices, do not adapt farming practices), (ii) how each behavioural response is translated into a **trade shock** (i.e. either as export flow reduction or additional cost), and (iii) the **intensity** of the trade shock (scaling). We discuss these three aspects in turn and conclude with a summary of the scenarios implemented in section 2.3.4. Results for each scenario are then presented in practice in chapter 3.

2.3.1. Behavioural response of exporting producers to a reduction of MRLs to the LOQ

Once the MRL is reduced to the LOQ for a specific AS and commodity, and taking into account the range of adaptation options open to producers using that AS in a specific country[16] we consider two responses:

- **Not adapt:** exporting producers do not adjust their practices, and hence future residue levels are expected to remain unchanged compared to patterns detected to date. Once the MRL is reduced to the LOQ, the exports become non-compliant and are rejected at the border.
- **Adapt**: exporting producers adjust their production practices to maintain access to the EU market.

Besides assuming that all producers for all commodities in all countries follow the same behaviour, the behavioural choice followed by each country could be modelled depending on which of the behavioural options is most beneficial for a country. For this we can compare the production value of each country–commodity pair under the two intermediate scenarios where all third countries

[16] A non-exhaustive list of actions that producers could follow include: (i) trade diversion - maintain current production practices (using the hazardous AS) and divert their exports to non-EU markets; (ii) substitution – replace the AS with an alternative permitted by the new EU standards or alternative agricultural practices to maintain market access; (iii) adaptation of the timing of use of the AS to avoid the presence of residues or (iv) hybrid strategies combining (i), (ii) and (iii).

simultaneously ‘adapt’ and ‘not-adapt’[17]. A country is assigned the behavioural response that yields the higher value of production.

2.3.2. Translating each behavioural response into trade shocks in the model

Each behavioural response is translated into a shock to the trade flow of the relevant country-commodity pair. Where producers of a commodity in a country with evidenced use of an AS whose MRL is reduced to the LOQ do not change their production practices, their exports are no longer accepted in the EU. Accordingly, we limit that country’s export of the commodity to the EU. This corresponds to option (i) in footnote 16.

Where producers do adapt, the response is captured as an increase in the cost of exporting to the EU for that country-commodity pair. On the assumption that producers currently use the most cost-effective option available, adaptation is by definition more costly and raises the cost of exporting to the EU. The additional cost may comprise of:

- higher costs for crop protection alternatives that exclude the AS whose MRL has been reduced to the LOQ;
- lower yields due to less effective pest control in the absence of the said AS; or
- additional testing and segregation of compliant production to ensure that shipments are not rejected at the EU border.

This corresponds to options (ii) and (iii) in footnote 16. The exact implication in terms of cost increase is heterogeneous across triads and a precise estimate would require an in-depth analysis beyond the scope of this study. When deciding on the cost increase to be used in the scenarios the following (limited) evidence was found.

- A crop protection strategy substituting for Chlorpyrifos in the US across six crops (alfalfa, almonds, citrus, cotton, grapes and walnuts) was estimated by Lee et al. (2025) examining the case of the withdrawal of this AS from the California market in 2020. Per hectare crop protection costs for alternatives to Chlorpyrifos for the six crops was estimated on average 2.5 to be more expensive with a maximum of 5.4 times for grapes and a minimum of 1.4 for almonds. Once changes in prices of alternative ASs after the ban were incorporated into the analysis the increase is crop protection costs increased to 2.9 times[18]. Assuming that cost of plant protection products accounts for approximately between 10 % and 20 % of total costs[19], the substitution of this AS led to approximately a 20% increase in production costs.
- The analysis of cyproconazole presented in section 3.5 shows that only the additional cost of the replacement could be 100 % of crop protection costs (20 % of total costs considering the share of crop protection costs over total costs) without adding other costs related to testing or value chain segregation. Moreover, the cost is not homogenous across crops and countries.

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17 The value of production considers both the value of exports at the price of the destination market and the value of total production minus exports at domestic prices.

18 Data taken from appendix D from Lee et al. (2025).

19 Using FADN data for 2023 the share of crop protection costs stands on average for the EU across all farms at 5.4 %. of total intermediate consumption (SE300 over SE275) and 20.8 % of crop specific costs (SE300 over SE284N).

— With regards to segregation costs, Pizarro et al. (2025) finds that the cost to segregate non-GM crops at elevator level based on US data are $0.03 to $0.04 per bushel for non-GM soybeans and $0.07 to $0.08 per bushel for non-GM corn (between 0.3% and 2% of the value of the product).

— Last, evidence reported in the media, even when not supported by data that could be validated by the JRC, suggests that the combined impact of higher costs, reduced yields and additional testing can amount to between 10% and 20% of the total export value[20].

Two conflicting considerations can be taken into account when making assumptions on the potential cost impact of substituting the targeted AS on production costs. On the one side, the cost of substituting multiple ASs should be higher than that of substituting just one. Therefore, the 20% cost increase reported for Chlorpyrifos would be a lower bound. On the other hand, impacts of conversion from conventional to organic production methods (without considering the increase in revenues via prices or subsidies) have also been reported to be in the range of 20% of total income (Crowder and Reganold, 2015; Blockeel et al., 2024). As the transition to organic production is a deeper change that just substituting one or multiple ASs, 20% could also be considered an upper bound of the implications of replacing multiple ASs.

In the absence of a more detailed assessment of the exact costs of these practice changes over time, **the scenarios constructed where adaptation can occur assume a lower bound estimate of 5 % and an upper bound of 20% in the total cost of affected commodity-country pairs.** The 20 % additional cost could also be considered an estimate of the cost in the short-term when availability of alternatives and farmer familiarity with them is limited. On the other hand, a 5 % cost could be a considered the mid-term impact when these initial hurdles have been, at least partly, overcome or if MRLs are aligned to the EU by third countries. The robustness of this additional cost assumption is tested in the case study described in section 2.4. However, it is critical to note that the parameter intends to reflect the average change across all triads, with some triads possibly leading to higher changes whereas others may be below the assumed value.

Details on how this is implemented in the model are presented in section 2.3.5 below.

2.3.3. Intensity of the trade impact (scaling)

A key parameter for the scenario definition is understanding how many producers, at triad level, will be affected by the reduction of MRLs to the LOQ. The reduction will only affect producers exporting to the EU who are using the relevant ASs in the relevant crops. We consider three options for scaling: everyone is affected (no scaling), only the share of producers equal to the share of tests that resulted in quantifiable residues, and the share of producers equal to the share of tests that resulted in quantifiable residues and an additional share to take into account that the AS is approved for use.

At the most extreme case, we may assume that every single producer exporting to the EU a specific commodity from a country using the ASs whose MRL are reduced to the LOQ. Therefore, the behavioural response applies to the entire trade flow between that country and the EU. This assumption represents an upper bound impact, as production methods vary even within a single

[20] For example, news.tuoitre.vn/eu-tightens-checks-on-vietnamese-farm-exports-over-pesticide-residues-103260327170113043.htm

country and usage of the same AS across every single producer is in most cases highly unlikely. On the other extreme, the behavioural response could be assumed to be taken only by exporters using the relevant ASs approximated by detections at the border[21].

In the absence of precise use data, the evidence described in section 2.1.2 can instead be used to approximate the share of exports produced with a specific AS. Specifically, the share of positive AS detections relative to the total number of official control tests can be taken to reflect the extent of use by exporting producers. In this context, we define 'detections' in reference to quantifiable residues of ASs identified through the sampling and analysis strategies applied by EU Member States during official controls at designated points of entry for imported food products, combined with the information available on authorisation of an AS for the specific country and commodity.

This approach treats historical detection rates and authorisation information jointly as an empirical proxy for the extent of use of an AS on a commodity in the exporting country. Notably, residue montioring data indicates that detections are recorded for only 8 % of the AS–country-commodity triads whose MRL is to be reduced to the LOQ. On the assumption that testing is representative, even when the volumes of trade represented by the triads is not taken into account, this suggests that most commodities entering the EU already carry no quantifiable residues of the affected ASs. That inference depends on detection being a valid proxy for use, which in turn depends on the representativeness of testing: because sampling is risk-based, targeted and incomplete, the absence of a detection is not conclusive evidence of non-detectable use. The three main testing programs for which EFSA has provided data (EU Multi-Annual Control Program and National Multi-Annual Control Plans – EU MACP & MANCP -, and the temporary increased controls and emergency measures under Regulation (EU) 2019/1793) are nonetheless designed to achieve representative coverage of AS–commodity combinations. On that basis we treat the data as broadly representative and regard the assumption that untested triads would carry residues as speculative. Therefore, for these triads a zero-scaling factor is applied.

Conversely, even without historical detections, a reduction of the MRL to the LOQ may still imply risk-mitigation reactions by third countries seeking to avoid non-compliance. However, this assumption applies only where a trading partner holds a verified authorisation for the AS on that specific commodity.

To accommodate this uncertainty, we propose a combined detection-and-authorisation approach as an intermediate scaling option. Under this approach, triads without detections are assigned the median detection rate for the relevant combination of pesticide type and world region, subject to a minimum of 20% to capture the risk-mitigation response by producers in third countries associated with testing and value chain segregation that may occur even where detection rates are low.

2.3.3.1. Aggregating scaling factor to country commodity pairs when minimum residue levels are reduced to the limit of quantification for multiple active substances

While the scenarios are defined at the country-commodity-pair level, the policy operates at the level of the individual AS. Therefore, a pair may have detections or authorisation information for more

[21] This extreme could be furthered reduced if in a specific country sufficient producers already grow the commodity without the targeted ASs for the domestic market. In such a case that production could be re-directed to the EU market substituting the one of non-compliant exporters from this country maintaining the trade flow, without changes of production practices, only supply chain reshuffling costs.

than one relevant AS. The aggregation approach depends on the scaling factor used. Where scaling is based on detection alone, the aggregated detection rate is the sum of detections across all relevant substances divided by the total number of tests, as shown in Equation 1, where ASF is the aggregated scaling factor for commodity *j* in country *k*, D is the number of positive detections of AS *i* in imports, and T is the total number of tests carried out on imports.

Equation 1
$$ASF_{j,k} = \frac{\sum_{i=1}^{i=n} D_{i,j,k}}{\sum_{i=1}^{i=n} T_{i,j,k}}$$

Where both detections and information on authorisation are combined, we take the average of two components: the detection rates for substances that were detected (subject to the minimum threshold defined above) and, for substances that were authorised but not detected, the median detection rate at the region and AS type level (again subject to the minimum threshold defined above). To this average we add 5 percentage points for each additional AS, whether detected or authorised, to signal the greater burden of forgoing several ASs at once. The result of this combination is used as the aggregated scaling factor unless it falls below the highest substance-specific detection rate, in which case the latter is used.

2.3.4. Summary of implemented scenarios

The scenarios to be assessed are defined along four dimensions which can take one or more values, as summarised in Table 1.

Table 1. Key dimensions for scenario definition under simultaneous reduction of MRLs to LOQ for relevant active substances.

Dimension	**Options**	**Description**
Behavioural response	*Change practices [adapt]*	Continue exporting to the EU, but with additional costs
	Continue with current practices [do not adapt]	Stop exporting to the EU
	Commodity-country-pair specific, depending on most profitable option	Adapt or do not adapt depending on which case yields the higher total value of production (considering both domestic and export prices)
Switching Rule	*Comparison of value of production per country–commodity pair between a full-adapt and full-not-adapt scenario*	The producers in the country decide to adapt or to not adapt for each commodity depending which case yields the higher value of production.
Scaling factor	*No scaling*	Adapt – Additional cost applied to all exports to the EU. Not adapt – Exports to the EU reduced by 100 %
	Residue detections plus median detection rate for AS type and world region for ASs with only information on authorisation [EFSA +]	Impacts are scaled by the average detection share for the substance. Where there are no detections, but authorisation exists, the regional/substance-type median is used. A minimum of 20 % is applied when detections or medians are below this percentage, and 5 percentage points are added for each AS detected or authorised.
	Residue detections [EFSA]	The impacts are scaled by the share of detections of the ASs in the commodity from the country over total tests, totalled across ASs.
Export cost increase	*20 %*	Additional costs of adapting production to meet the MRL reduced to the LOQ.
	5 %	

Source: own elaboration.

Based on the details provided above and by combining the different alternatives for the dimensions considered (behavioural response, scaling and cost increase), we run three scenarios reflecting a range of effects: an upper bound (not adapt – no scale), an intermediate case (switch – EFSA+- 20%) and a lower bound (switch – EFSA -5%). In the upper-bound scenario a uniform behavioural response of not adapt is assumed across every single producer in every commodity-pair, with no scaling. The other two scenarios instead let each country choose between the two behavioural responses based on profit maximization and differ in terms of scaling (how many producers are affected) and cost of alternatives. The first of these scenarios combines detections and authorisations (with the 20% minima) and assumes a 20% adaptation cost, while the second one uses detections alone and applies a 5% cost. The reader is reminded that none of these scenarios is 100% realistic as compliance costs are unlikely to be homogenous and, as shown in section 2.4, vary across triads. However, the scenarios are still useful to understand the market impacts of aligning pesticide related production standards applied to imported products on the EU's agricultural sector. From a temporal perspective, the scenarios could also reflect how the measure would affect markets in the short, medium and long term with an increase in the number crop protection alternatives available and a reduction of their cost as well as potential MRL convergence between countries. The three scenarios are summarised Table 2.

Table 2. Naming and specification of the scenarios implemented under the standardized simultaneous reductions approach.

Scenario name	**Behavioural response**	**Scaling**	**Aggregation**	**Additional Cost**
Not adapt – no scale	Not adapt	No scaling	Not applicable	Not applicable
Switch - EFSA+ - 20 %	Switching based on profit maximisation	Residue detections + authorisations with minimum floor of 20 %	Average scaling factor + 5 percentage points per unique AS, with correction factor (see **Table 12.** **Table 12**)	20 %
Switch – EFSA – 5 %	Switching based on profit maximisation	Residue detections	Across detections and total tests	5 %

Source: own elaboration.

2.3.5. Implementing the behavioural responses in the CAPRI model

For implementing the behavioural response when producers in third countries do not adapt their practices to avoid that their exports become non-compliant and are rejected at the EU border, we close the trade flow between the country and the EU for the relevant commodities. In the scenario "Not adapt – no scale" the trade flow is closed in full. No adjustment is made for the frequency or intensity of detections; therefore, all affected country–commodity pairs are treated equally.

This is implemented as an increase in bilateral trade costs between the exporting country and the EU. Specifically, an additional non-tariff measure (NTM)-equivalent cost is introduced into the CAPRI market module by increasing bilateral transport costs as depicted in Equation 2:

Equation 2 $$\Delta TC_{i,j,k} = 10 \times P^{imp}_{i,j,k,BAS}$$

where:

— $\Delta TC_{i,j,k}$ is the additional trade cost applied to imports of commodity k by EU region i from exporter j;

— $P^{imp}_{i,j,k}$ is the baseline bilateral import price;

— the factor 10 represents an additional cost equivalent to 1000 % of the baseline import price.

The shock is applied only to country–commodity pairs with existing baseline trade flows. This avoids modifying inactive trade routes and ensures that the approach targets currently relevant EU suppliers.

Rather than imposing an explicit quantitative ban, the approach creates a prohibitive economic disincentive by strongly increasing the cost of affected imports. Trade flows remain endogenous in the model and may adjust according to substitution possibilities, Armington preferences, and market equilibrium conditions. The scenario therefore approximates a loss of EU-market access for non-adapting exporters while preserving the behavioural structure of the CAPRI market model. No additional costs or reductions are introduced for country–commodity combinations without identified detections.

In the other two scenarios, a regulatory adjustment pathway in which exporters respond differently depending on the expected profitability of maintaining access to the EU market is implemented. Country–commodity combinations are separated into adapting and non-adapting groups using a profitability-based switching rule, derived through the pair-wise comparison of the full adaptation and the no adaptation scenarios. The scenario combines halting trade flows for non-adapting exporters with additional compliance costs for exporters that adapt their production systems.

In the “Switch - EFSA+- 20%” scenario, for **non-adapting exporters**, trade reductions are implemented through a reduction of bilateral EU import flows. A country–commodity matrix defines the affected combinations and provides the corresponding reduction factor based on residue detections and AS authorisation information.

For each affected exporter–commodity pair, bilateral imports into the EU are fixed at a reduced level relative to the initial trade flow following Equation 3.

Equation 3 $$TF^{SIMU}_{EU,r,c} = TF^{CUR}_{EU,r,c} \times (1 - Reduction_{r,c})$$

Where:

— $TF^{SIMU}_{EU,r,c}$ is the simulated reduced bilateral trade flow from exporter r for commodity c;

— $TF^{CUR}_{EU,r,c}$ is the initial CAPRI bilateral trade flow;

— $(1 - Reduction_{r,c})$ is the estimated affected share derived from residue detections and authorisation information.

For **adapting exporters**, access to the EU market is maintained, but adaptation is represented by an increase in costs reflecting compliance costs associated with replacing or modifying the use of non-approved ASs.

This additional cost is introduced as a non-tariff measure equivalent increase in the model's bilateral transport cost term following Equation 7.

Equation 4 $$\Delta TC_{r,c} = CostShock_{r,c} \times P^{imp}_{EU,r,c,BAS}$$

Where:

— $\Delta TC_{r,c}$ is the additional bilateral trade cost term in CAPRI;

— $CostShock_{r,c}$ is the additional cost factor calculated from residue detections and authorisation information;

— $P^{imp}_{EU,r,c,BAS}$ is the baseline CAPRI import price.

The resulting cost increase is introduced in CAPRI through an absolute change in the model's bilateral transport costs term following Equation 5

Equation 5 $$tCost_{EU,r,c} = tCost_{EU,r,c} + \Delta TC_{EU,r,c}$$

The additional cost factor is derived from the estimated exposure to affected ASs. residue detection rates are used when available. When no detection rate exists but evidence of AS use is available, the median detection rate for the corresponding AS group and world region is used with 20 % minima instead as explained in section 2.3.3 above. The final exposure indicator combines the adjusted active-substance information and is used to scale the adaptation cost.

Country–commodity combinations without residue detections or use-authorisation information receive neither trade reductions nor additional adaptation costs. The final market response, including changes in production, consumption, prices, and trade reallocation, is determined endogenously by the CAPRI market equilibrium.

In the "Switch - EFSA - 5%" scenario, the implementation follows the same profitability-based switching approach and CAPRI implementation structure described for the previous scenario. Exporters are classified into adapting and non-adapting groups according to the profitability switching rule. Non-adapting exporters face proportional reductions in EU trade flows, while adapting exporters maintain market access but face additional non-tariff measure equivalent costs introduced in the bilateral transport costs term.

The main differences are related to the calculation of the exposure factor and the magnitude of adaptation costs. In this scenario, exposure is based exclusively on residue detection information. Detection rates are calculated by aggregating the total number of positive detections relative to the total number of tests, capturing the cumulative occurrence of non-approved AS residues for each country–commodity combination.

For non-adapting exporters, the trade reduction factor corresponds directly to this cumulative residue detection rate following Equation 6:

Equation 6 $$TF^{SIMU}_{EU,r,c} = TF^{CUR}_{EU,r,c} \times (1 - EFSA\_rate_{r,c})$$

For adapting exporters, compliance costs are assumed to be lower than in the previous scenario (5 % versus 20 %). This cost shock is then introduced in CAPRI following the same NTM-equivalent transport cost implementation described previously.

Contrary to the 20 % adaptation scenario, this scenario does not include assumptions based on active substance authorisation databases or regional median values subject to a minimum. Only observed residue detections are considered. Country–commodity combinations without residue detections receive neither trade reductions nor adaptation costs.

2.3.6. A simplified counterfactual analysis of the scenarios underlying assumptions

The scenarios assume that EU imports from countries with evidenced use of an AS will either be discontinued or become more costly than imports from countries without such evidence. Therefore, the import share held by countries with evidenced use should fall relative to that of countries without such evidence. We test whether this has been the case in the past when MRLs for other ASs have been reduced to the LOQ using as an example the lowering of MRLs to the LOQ for the active substance chlorpyrifos following its nonrenewal of approval.

The approval of the AS chlorpyrifos was due to expire in January 2020. In 2019, EFSA's updated human-health assessment concluded that the recorded toxicological effects met the criteria for classification as toxic for reproduction, category 1B (developmental toxicity), and that the human-health approval criteria in Article 4 of Regulation (EC) No 1107/2009 were not met (EFSA, 2019). On 6 December 2019, the Standing Committee on Plants, Animals, Food and Feed (PAFF Committee) voted in favour, by the required qualified majority, of two draft implementing regulations to not renew the approvals of chlorpyrifos and chlorpyrifos-methyl, which the Commission adopted subsequently on 10 January 2020. On 18 February 2020, Member States voted in favour of the Commission's proposal to lower the MRLs of both substances in food and feed to the LOQ from 13 November 2020 (EC, 2020). This meant that as of that date, the MRL for citrus was lowered to the LOQ. The MRL for apples for this AS had already been lowered to the LOQ in 2016 as the previously valid MRLs (higher than LOQ) has raised concerns for consumer protection (EC, 2016).

These two reductions provide a quasi-experiment for assessing how the import share of countries with and without evidenced use of chlorpyrifos responded to the reduction of the MRL to the LOQ. As residue-testing data is not available for the years of the reductions, the analysis relies on authorisation as the proxy for use. We compare the three years before and after each reduction of the MRL: in the case of apples, the before period refers to 2013-2015 and for citrus to 2016-2018. In both cases the after period is 2022-2024; allowing to check both short term (for citrus) and mid-term (for apples) impact dynamics.

The underlying import data for the two commodities are summarised in Table 3. While in the absence of a rigorous experimental design, such as those applied in the literature reviewed in Section 2, causality cannot be claimed, we see that countries where the AS was not authorised gain a competitive advantage compared to those where it was. Imports of citrus (apples) from countries where chlorpyrifos was authorised decreased by 63 % (19 %) between the two periods, while imports from countries where it was not authorised increased by 10 % for citrus and fell only by 20 % for apples. The share of countries with authorised uses of total EU imports fell from 31% to 17% for apples and from 13% to 10% for citrus. The pattern holds regardless of the direction of total EU imports, which fell by roughly one-third for apples and rose by 6% for citrus.

Table 3. Dynamics of imports to the EU of products for which chlorpyrifos MRLs were reduced to the LOQ for countries where the AS was or was not approved.

Commodity	**Apples**	**Citrus**
Year of MRL reduction to LOQ	2016	2020
Period before reduction	2013-2015	2016-2018
Current period for comparison	2022-2024	2022-2024
Imports from countries with chlorpyrifos approved for use before MRL reduction (1000 tons)	362.35	817.81
Imports from countries with chlorpyrifos approved for use after MRL reduction (1000 tons)	133.26	659.69
Percentage change in imports from countries with chlorpyrifos approved for use between the two periods	-63 %	- 19 %
Percentage change in share of EU imports from countries with chlorpyrifos approved for use between the two periods	-45 %	-24 %
Percentage change in share of EU imports from countries with chlorpyrifos not approved for use between the two periods	+20 %	+4 %
Change in total EU imports between the two periods	-33 %	+6 %

Source: own elaboration based on COMEXT and Homologa®. Homologa® (Lexagri SAS). Aggregated from a single extract taken on February 2026, reflecting the position as of 2026. Not updated since, and not the current regulatory position. Provided for reference only, without warranty. See section 2.1.2.2. Current data: www.homologa.com

These results are consistent with the assumed mechanism: following a reduction of the MRLs to the LOQ, EU imports appear to shift from countries where the substance was authorised (a proxy for use) towards countries where it was not (a proxy for non-use). The evidence is suggestive rather than conclusive, given the two-commodity scope, the reliance on authorisation rather than measured residues, and the confounding effect of other supply and demand shocks over the period, but it nonetheless supports the direction of the assumption underlying the scenarios. Whether this pattern can be generalized is still to be confirmed. This pattern can be assessed in the future focusing on the reduction of MRLs to the LOQ for neonicotinoids (clothianidin and thiamethoxam), that took effect on 7 March 2026.

2.4. Cyproconazole as a case study

To complement the standardised CAPRI scenarios, we have performed a targeted analysis of cyproconazole in the production of the commodities for which its MRL remains above the LOQ, focusing on the principal source countries for those commodities. This AS was selected considering the most recent EFSA risk assessment and the draft Commission Regulation, subsequently prepared on the basis of that assessment, which proposed maintaining several MRLs. This draft Regulation was never adopted as the European Parliament objected the draft as presented (EP, 2024). The list of MRLs that were proposed to be maintained was used as reference for this case study.

A two-stage systematic literature search was performed to capture the most relevant peer-reviewed evidence on cyproconazole, its EU-approved alternatives, and the associated agronomic and economic outcomes. First, every abstract returned by Scopus was screened. Second, a more focused Google Scholar search was performed, selecting only the titles from the last five years that directly addressed cyproconazole, alternative fungicides, disease-control efficacy, yield response or cost-benefit aspects. Where an included paper cited further studies meeting the inclusion criteria, those studies were retrieved and incorporated. The search returned 12 records from Scopus and

961 records from Google Scholar, of which 104 were peer-reviewed articles[22]. Together these articles provided evidence on the performance of alternative fungicides to cyproconazole across crops and diseases.

Trade-flow information was gathered for 2021-2023 from Eurostat COMEXT (EU imports from third countries) and UN Comtrade (third-country exports to the EU). Import- and export-share percentages were calculated for each crop to highlight the importance of cyproconazole-authorised producers to the EU market.

To determine which fungicides are legally permissible, the Homologa® and EU pesticides databases were consulted for every crop-country combination. The EU pesticides database was used specifically to identify whether an AS is authorised (approved) or not within the EU. Residue data were obtained from official controls carried out by Member States under the EU Multi-Annual Control Programme (MACP), National Multi-Annual Control Programmes (MANCPs) and, where relevant, temporary increased controls and emergency measures under Regulation (EU) 2019/1793. These data provide the number of samples analysed, the proportion with residues above the LOQ, and the relevant MRLs for each commodity. Because several producing countries lack published residue data, a conformal-prediction technique was applied to impute the most probable ASs used on a given crop in these “no-data” countries.

Countries for the cost-impact analysis were selected based on two criteria: (i) trade relevance for the EU - a high import or export share for a given crop - and (ii) the presence of cyproconazole residues above the LOQ in monitoring reports. For each selected country the relative frequency of cyproconazole versus the identified EU-approved alternatives was quantified using the authorised-substance lists from the EU pesticide database together with the imputed data where necessary. These figures formed the basis for assessing the practical difficulty and the expected economic burden of switching to compliant fungicides.

2.5. Qualitative analysis of country and commodity exposure to the alignment of pesticide standards

The qualitative analyses carried out focus on commodities and countries not represented explicitly in the CAPRI model and are intended to complement those. The overarching objective is to identify commodities and countries which are most exposed to the reduction MRLs for the most hazardous ASs to the LOQ. The approach qualitatively evaluates the potential economic exposure of both exporting third countries and the EU to the reduction of MRLs to the LOQ through descriptive analyses and the use of trade indicators. The analyses only consider whether the ASs have been detected in imports or authorised for use, without any correction for intensity of use. Therefore, the conclusions only identify potential impacts and would need to be revised taking into account intensity of use data to assess the actual extent the ASs are used for the commodities in the countries. The analyses are conducted separately for exporting third countries (focusing on the relative importance of trade with the EU for their economy and their potential for adapting to change via trade diversion and domestic absorption) and the EU (highlighting specific trade

[22] Search conducted on 17/06/2026.

dependencies that may potentially cause short-term impacts, and potential for diversification of supply sources and self-sufficiency).

Specifically, this analysis focuses on 180 agricultural commodities not covered in CAPRI; the EU as importing entity; 78 out of the 86 exporting third countries (eight third countries[23] do not export any of the commodities covered in this chapter and are therefore excluded); 16 active substances out of the total 18 considered in CAPRI (two active substances[24] do not have any MRL above the LOQ for the commodities covered in this report and are therefore excluded).

2.6. Access to detailed results

The results of the analysis, aggregated where required by the proprietary nature of the Homologa® and COLEAD data on authorisation of ASs in third countries, together with the CAPRI scenario results and the analysis for commodities not explicitly represented in CAPRI, is made available through three visualisations developed by the JRC and hosted on the Data-Modelling platform for resource economics (DataM). The links to each of the visualizations are:

— Triad-specific data on residues detections and trade flows.

— Results of the three scenarios implemented in CAPRI.

— Analysis of the exposure to the reduction of MRLs to LOQ for commodities not explicitly represented in CAPRI.

2.7. Caveats and limitations

Our analysis while scientifically robust, faces some important limitations that must be made explicit to avoid that results are taken as definitive. First, we lack precise data on the extent to which ASs are used for specific country-commodity pairs which would provide a more precise measurement of the share of producers that would be affected by the reduction of MRLs to the LOQ. While residue detections in imports can be considered undisputable evidence that the AS was used for that commodity in a specific country, the contrary is not certain. The lack of detections does not mean lack of use. The AS could be used at a level or with a management strategy that leaves no residues.

Second, we lack triad-specific data on the implications of substituting an AS as part of the crop protection strategy in a country for a commodity. In our analysis we consider a low and high estimate of the costs that this substitution could entail. However, these assumptions are applied homogenously across the board to all relevant triads, which is unlikely to reflect reality. In some cases, this will lead to an overestimation of the cost while in others it will underestimate the challenge of substituting the ASs. In addition, even producers not using the relevant AS could also face additional costs if ex-ante testing or value chain segmentation is implemented to guarantee market access, similar to what has happened in the past in the case of genetically modified organisms (Basnet et al. 2023).

[23] Afghanistan, Armenia, Bolivia, Central African Republic, Dominica, Eritrea, Georgia, Namibia.

[24] Benthiavalicarb, chlordecone.

Third, we lack evidence on the factors which drives the response of exporters to MRLs reductions in third countries with authorised use of an AS: whether they adapt their production practices, prefer diverting their exports to other markets, or if a segregation of the compliant production is applied along the supply chain without changes in production practices. Additional ex post analyses of the impact of past reduction of MRLs could be considered to further investigate these aspects.

Fourth, the modelled scenarios in CAPRI do not consider the potential impact of more stringent MRLs on the perceived quality, safety and sustainability of imported products by EU consumers, which could enhance total import demand for compliant products in the EU.

Fifth, we only consider impacts for a limited number of commodities and do not consider effects related to the reduction of MRLs for animal-based products as ASs are authorised for use on crops not on livestock. Only 20 % of the affected triads are captured in the model; however, they account for 82.3 % of total EU imports and 58.9 % of total samples in which residues above LOQ were detected. When providing evidence for commodities not explicitly represented in the agro-economic model used to assess impacts in section 3.6, we focus on exposure without any correction for intensity of use. Therefore, the results presented only identify the total production at risk in terms of commodities and countries. The confirmation of whether all the production at risk will face an actual challenge when MRLs are reduced to the LOQ will depend on the extent of use of the ASs in the countries and the costs of replacing them as part of the farmers' crop protection strategy.

Sixth, when assessing the representativeness of the cost assumptions used in the CAPRI model scenarios in section 3.5 we could only undertake the analysis for a single AS. The heterogeneity found across countries and commodities for a single AS, together with the heterogeneity of impacts reported in the literature summarised in section 2, further highlight the need to use more granular information when assessing the impacts of reducing MRLs to the LOQ.

Nevertheless, the analysis presented here can serve as a comprehensive first evidence on the range of possible impacts of reduced MRLs to the LOQ across multiple ASs. It identifies key factors which should be further investigated to improve the assessment of impacts. Further information would be required in particular on the actual use and agronomic importance of specific substances in exporting countries.

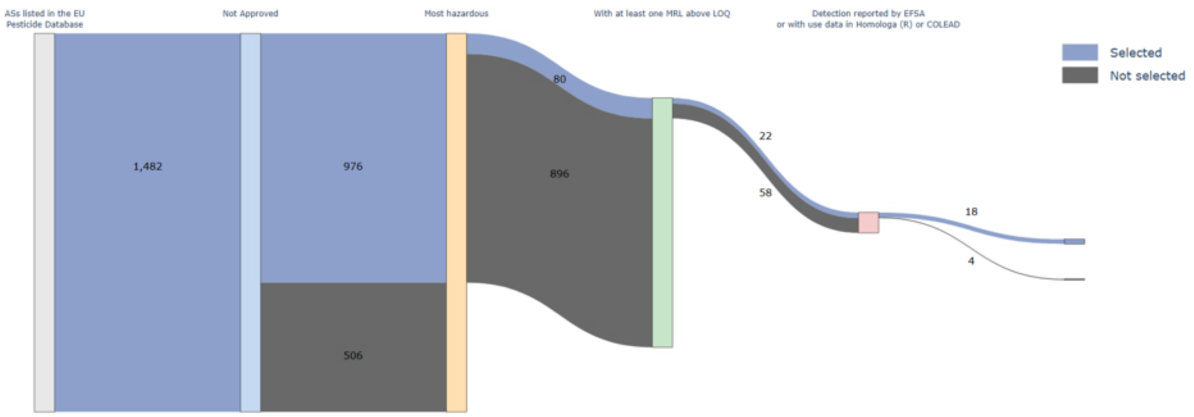
3. Results

In this chapter we present the results of the analysis following the different approaches described above. We start with a descriptive analysis of the data collected that underpins the construction of the scenarios. Next, we provide details of the magnitude of the trade effects that are implemented in the CAPRI agro-economic model and the results in terms of production, trade-flows and prices from the three scenarios analysed. Complementing this, we provide the results of the literature review for cyproconazole, to provide more granularity on the heterogeneity of the behavioural responses and cost impacts. Lastly, we describe the exposure to the reduction of MRLs to the LOQ for the commodities not explicitly represented in the CAPRI agro-economic model. Results are presented at an aggregated level; the reader can find more details in the dashboards provided.

3.1. Relevant active substances, commodities and countries

Drawing on the EU database of ASs maintained by DG SANTE25, of the total of 976 ASs not approved in the EU, 80 ASs meet the "most hazardous" criteria. Restricting this set to ASs with at least one MRL above the LOQ leads to a universe of 22 ASs (Figure 1 and Table 4). Of these 22 ASs, residues have been detected for 14, and 17 are reported by Homologa®/COLEAD as being authorised for use in at least one country. This shows that the option assessed applies only to a limited set of ASs not approved in the EU. Combining the two conditions gives the final set of 18 ASs that form the basis of the analysis, and from which the candidate for in-depth analysis is drawn. The list of relevant ASs is presented in Table 5.

Figure 1. Graphic representation of the identification process of relevant active substances.



Source: own elaboration based on EU Pesticide database, ECHA-CHEM, residue monitoring results, Homologa® and COLEAD databases. Homologa® (Lexagri SAS). Aggregated from a single extract taken on February 2026, reflecting the position as at 2026. Not updated since, and not the current regulatory position. Provided for reference only, without warranty. See section 2.1.2.2. Current data: www.homologa.com

[25] https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/start/screen/active-substances

Table 4. Number of active substances by classification.

	All	"Most hazardous" #
Not approved [1]	976	80
[1] with at least one MRL above the LOQ [2]	-	22
[2] and with at least one residue detection reported	-	14
[2] and with at least one country with authorisation reported in Homologa® or COLEAD	-	17
[2] and with residues reported or with use data in Homologa® or COLEAD	-	18

Most hazardous denotes an AS meeting one or more of the following criteria: mutagenic cat 1A or 1B, carcinogenic cat. 1A or 1B, toxic for reproduction cat. 1A or 1B, persistent organic pollutants (POPs), persistent, bio-accumulative and toxic (PBT) substances, and very persistent and very bio-accumulative (vPvB) substances and endocrine disruptors affecting human health and/ or non- target organisms.

Source: own elaboration based on DG SANTE pesticide, ECHA-CHEM, residue detections, Homologa® and COLEAD databases. Homologa® (Lexagri SAS). Aggregated from a single extract taken on February 2026, reflecting the position as of 2026. Not updated since, and not the current regulatory position. Provided for reference only, without warranty. See section 2.1.2.2. Current data: www.homologa.com

Table 5. Active substances subject to the analysis under the comprehensive approach.

Active substance	With at least one residue detection	With at least one authorising country in Homologa® or COLEAD
Benomyl	X	X
Benthiavalicarb		X
Carbendazim	X	X
Chlordecone	X	
Clofentezine	X	X
Cyproconazole	X	X
Dicofol		X
Dimethomorph	X	X
Flufenacet (formerly fluthiamide)		X
Glufosinate	X	X
Isopyrazam	X	X
Mancozeb	X	X
Mepanipyrim	X	X
Metiram	X	X
Metribuzin		X
Quinoxyfen	X	X
Spirodiclofen	X	X
Thiophanate-methyl	X	X

Source: own elaboration based on DG SANTE pesticide, residue detections, Homologa® and COLEAD databases. Homologa® (Lexagri SAS). Aggregated from a single extract taken on February 2026, reflecting the position as of 2026. Not updated since, and not the current regulatory position. Provided for reference only, without warranty. See section 2.1.2.2. Current data: www.homologa.com

The next step is to establish which commodities have MRLs above the LOQ for the identified ASs. As MRLs are set per active-substances-commodity pair, several substances of interest may have an MRL above the LOQ for the same commodity.

As shown in Table 6, as of 30 April 2026, 304 unique commodities had MRLs above the LOQ for at least one of the 18 relevant ASs. Residues were detected over the period 2021-2023 for only 75 commodities, that is, for 229 of the commodities for which MRLs could be lowered to the LOQ, no detection above the LOQ was recorded in the three most recent years available. The set of relevant commodities widens to 235 once those with information on authorisation in the two databases are included. The full list of commodities is provided in Annex 1 (covering both those with detections via monitoring and those with information on authorisation in Homologa® or COLEAD). In this annex, green-shaded rows indicate commodities represented in the agro-economic model used for scenario analysis.

Table 6. Number of unique commodities with commodity-specific MRLs above the LOQ for the selected active substances.

	# of commodities
With at least one MRL above the LOQ [1]	304
[1] and detected by monitoring	75
[1] and with use data in Homologa® or COLEAD	235
[1] and detected by monitoring or with use data in Homologa® or COLEAD	235

Source: own elaboration based on DG SANTE pesticide, residue detections, Homologa® and COLEAD databases. Homologa® (Lexagri SAS). Aggregated from a single extract taken on February 2026, reflecting the position as of 2026. Not updated since, and not the current regulatory position. Provided for reference only, without warranty. See section 2.1.2.2. Current data: www.homologa.com

Table 7 shows the distribution of MRLs above the LOQ across the 18 ASs for both all commodities and for those explicitly represented in the agro-economic model used for the analysis. Four of the ASs with at least one MRL above the LOQ have not been detected in imports (benthiavalicarb, dicofol, flufenacet and metribuzin), even though authorisations records show them to have been authorised for use in at least one country for all (dicofol, flufenacet and metribuzin) or some (benthiavalicarb) of the commodities concerned. Regarding international standards, dicofol maintains some Codex maximum residue limits on spices and tea that were set in 2005 and 2013 respectively. However, those Codex maximum residue limits could be considered obsolete as this substance is classified as POP by the Stockholm convention. No codex values exist for flufenacet, metribuzin and benthiavalicarb. Detections are recorded for 22.5 % of the AS–commodity pairs, rising to a maximum of 68 % for benomyl and carbendazim 66 % of authorised AS–commodity pairs occur in at least one country; for 11 of the 18 ASs authorisation coverage is complete (in at least one country the AS is authorised for use for every commodity whose MRLs are above the LOQ), while only one AS (chlordecone) appears not to be authorised in any country. The latter is consistent with chlordecone's 2009 listing in Annex A of the Stockholm Convention on Persistent Organic Pollutants (POPs), which requires all parties to eliminate its production and use.

Table 7. Number of commodities with commodity-specific MRLs above the LOQ by active substance.

	MRLs above LOQ			
Active substance	**All**	**With residue detections reported by monitoring**	**Authorised for at least one commodity in one country**	**Commodities explicitly represented in the model**
Benomyl	37	26	37	17
Benthiavalicarb	5	-	1	1
Carbendazim	37	26	37	17
Chlordecone	240	2	-	2
Clofentezine	37	6	37	14
Cyproconazole	46	8	46	24
Dicofol	16	-	16	5
Dimethomorph	89	33	89	8
Flufenacet (formerly fluthiamide)	4	-	4	3
Glufosinate	148	20	148	31
Isopyrazam	55	8	24	7
Mancozeb	132	42	125	25
Mepanipyrim	14	1	9	4
Metiram	132	42	60	21
Metribuzin	8	-	8	2
Quinoxyfen	40	2	17	6
Spirodiclofen	55	22	55	13
Thiophanate-methyl	38	19	38	16

Note: figures do not sum to those in Table 6 as a commodity may be counted for two or more active substances.

Source: own elaboration based on DG SANTE pesticide, residue detections, Homologa® and COLEAD databases. Homologa® (Lexagri SAS). Aggregated from a single extract taken on February 2026, reflecting the position as of 2026. Not updated since, and not the current regulatory position. Provided for reference only, without warranty. See section 2.1.2.2. Current data: www.homologa.com

Of the 235 commodities where residues were detected via monitoring or with use data in Homologa® or COLEAD, 43 are explicitly represented in the CAPRI model. While this represents a limited share of total commodities (18.3 %), coverage is substantial in terms of total trade volume, accounting for 82.3 % of total EU imports and 58.9 % of total samples for which residues above LOQ were detected.

The third dimension is the set of countries for which detection or registered-use information is available. Evidence of residues or use exists for at most 86 countries (Table 8) ranging from a maximum of 68 for dimethomorph to a minimum of 1 for benthiavalicarb (Table 9). In general, the number of countries authorising an AS exceeds the number for which residues have been detected in imports (for 14 of the 18 AS), and only for chlordecone, metiram and benomyl are there detections from countries with no evidence of authorisation.

Table 8. Total number of unique countries associated with the 18 selected active substances.

	Number of countries
At least one AS detected via monitoring	67
At least one AS with use data in Homologa® or COLEAD	66
At least one AS detected via monitoring or with use data in Homologa® or COLEAD	86

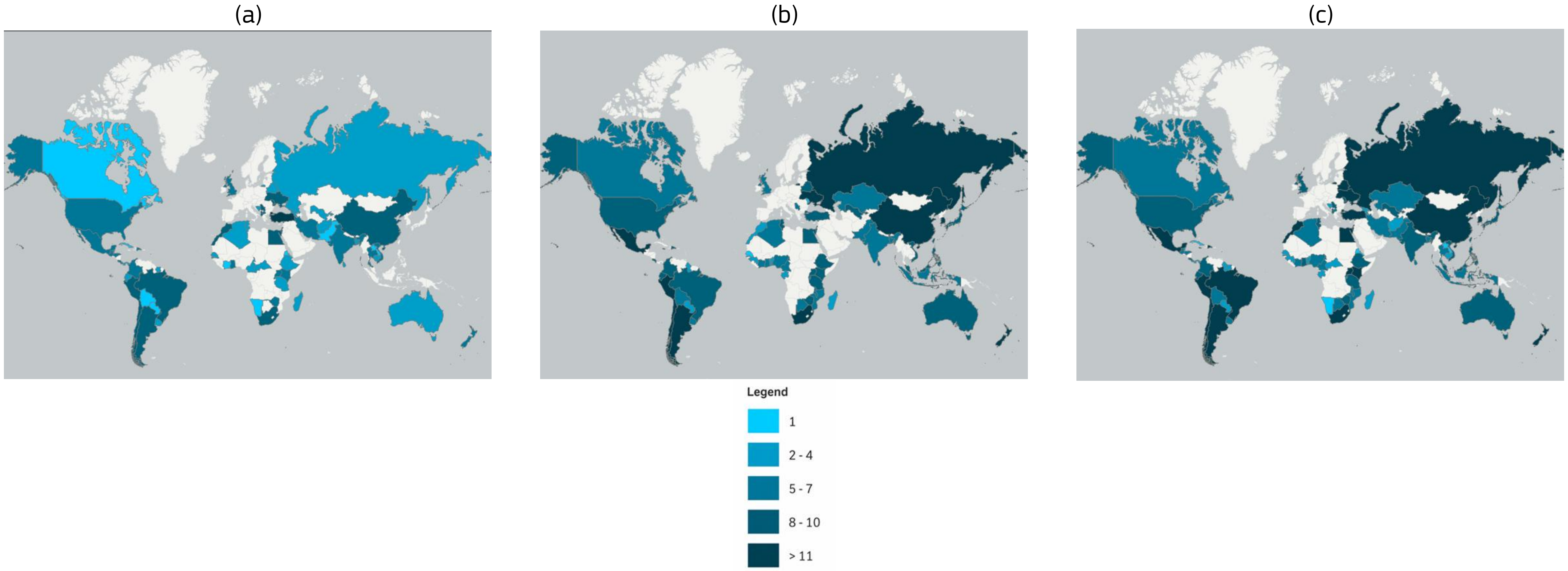
Source: own elaboration based on DG SANTE pesticide, residue detections, Homologa® and COLEAD databases. Homologa® (Lexagri SAS). Aggregated from a single extract taken on February 2026, reflecting the position as of 2026. Not updated since, and not the current regulatory position. Provided for reference only, without warranty. See section 2.1.2.2. Current data: www.homologa.com

Table 9. Total number of unique countries per active substance.

	Number of countries		
Active substance	**Total**	**With residue detections**	**With use status**
Benomyl	55	44	25
Benthiavalicarb	1	-	1
Carbendazim	63	44	43
Chlordecone	2	2	-
Clofentezine	28	8	27
Cyproconazole	42	13	39
Dicofol	2	-	2
Dimethomorph	68	34	57
Flufenacet (formerly fluthiamide)	15	-	15
Glufosinate	52	14	52
Isopyrazam	21	6	18
Mancozeb	69	44	51
Mepanipyrim	6	1	6
Metiram	57	44	36
Metribuzin	13	-	13
Quinoxyfen	12	6	10
Spirodiclofen	40	21	32
Thiophanate-methyl	55	23	48

Source: own elaboration based on DG SANTE pesticide, residue detections, Homologa® and COLEAD databases. Homologa® (Lexagri SAS). Aggregated from a single extract taken on February 2026, reflecting the position as of 2026. Not updated since, and not the current regulatory position. Provided for reference only, without warranty. See section 2.1.2.2. Current data: www.homologa.com

Figure 2. Number of active substances with residues detected (a), authorised for use (b) or both (c) by country.



Source: own elaboration based on DG SANTE pesticide, residue detections, Homologa® and COLEAD databases. Homologa® (Lexagri SAS). Aggregated from a single extract taken on February 2026, reflecting the position as of 2026. Not updated since, and not the current regulatory position. Provided for reference only, without warranty. See section 2.1.2.2. Current data: www.homologa.com

Looking at countries with most detected or authorised ASs (Figure 2) one can see that residues of the relevant ASs have been detected for a greater number of ASs in Turkey followed by a number of countries in the Americas as well as Morocco, South Africa and China. Looking at the number of relevant ASs that are authorised for use per country, Mexico, Peru, Argentina, Chile, Russia, Ukraine, China and South Africa have more than 11 ASs authorised. Last, when considering both detections of residues and authorisation for use, in addition to the countries with the higher number of ASs authorised for use, Brazil, Belarus and several countries in Africa (e.g. Egypt, Kenya, Uganda) also fall into the same category.

Combining the three dimensions gives the number of AS–commodity–country triads to be considered when constructing the scenarios. To do so we proceed as follows. Multiplying the number of countries with detections or registered use for the substance (86 countries) by the number of AS–commodity pairs with MRLs above the LOQ (1 480), results in a total of 127 280 potential active substance–commodity–country triads. Out of these, 10 583 triads (8.3 %) have either a residue detection or a registered use for the AS. For each of these, a behavioural response and a scaling factor has to be specified to assess the impact of reducing the MRL to the LOQ. As mentioned above, these triads cover 235 commodities originating in 86 countries. Their distribution across use and detection categories, and the subset with recorded EU trade, is summarised in Table 10.

Table 10. Number of active substance – country – commodity triads by category of use information, and the subset with recoded EU trade, for the two groups of commodities considered in the study.

	All commodities		**Represented in CAPRI**
	Total	With recorded trade**	Total
With use status for the AS in the country and commodity	10 071	5 473	1 993
With detection of AS residue in imports of the commodity from the country	807	750	369
With both use status and residue detection*	295	—	—

* The "use status" and "detection" categories overlap: the 295 triads satisfying both are included in each of the first two rows. Combining them (10 071 + 807 − 295) gives 10 583 distinct triads with either a detection or a registered use (this figure represents the scope of the analysis).

** "With recorded trade" means UN COMTRADE records exports of the commodity from the country to the EU. Of the 10 071 use-status triads, 4 598 have no such record (i.e., 5 473 are traded); of the 807 detection triads, 57 have none (i.e., are 750 traded).

Source: own elaboration based on DG SANTE pesticide, residue detections Homologa® and COLEAD databases. Homologa® (Lexagri SAS). Aggregated from a single extract taken on February 2026, reflecting the position as of 2026. Not updated since, and not the current regulatory position. Provided for reference only, without warranty. See section 2.1.2.2. Current data: www.homologa.com

3.2. Detections via monitoring

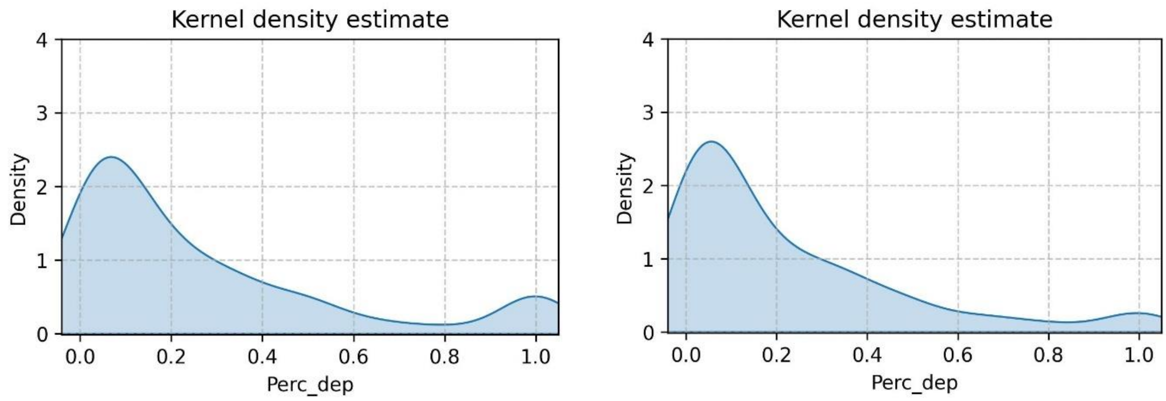
As set out in section 2.3.3. scaling can be based on detections via monitoring. Focusing on the 807 triads with detected residues the median share of tests detecting residues is 13.89 %, with 4.63 % of the pairs below 25 % [Quartile 25] and 36.36 % above 75 % [Quartile 75]. If we focus only on the commodities explicitly represented in CAPRI the number of triads falls to 396 and the corresponding median, Q25 and Q75 values are 11.72 %, 3.27 % and 33.33 % respectively. The distribution of detection intensity is provided in Figure 3 and the share of triads above selected thresholds are presented in Table 11.

Table 11. Number of active substance – country – commodity triads per category of use information and type of commodity.

Intensity of detection above…	% of total triads	% of triads for commodities explicitly represented in CAPRI
5 %	73.73	67.93
10 %	59.36	52.78
20 %	40.64	37.37
30 %	32.22	28.28
40 %	22.3	17.93
50 %	14.75	11.11
Number of triads	**807**	**396**

Source: own elaboration based on residue detections.

Figure 3. Distribution of detection rates across active substance-country-commodity triads.



All commodities | Commodities represented in CAPRI

Source: Own elaboration based on residue detections.

3.3. Scaling of shocks in the scenarios

As described in section 2.3.3 scaling differs across the three scenarios. In the 'not adapt – no scale' scenario we assume that the full export flow is disrupted once the MRL is reduce to the LOQ; therefore, we apply no scaling factor as the impact is assumed for the total trade flow26. In the other two scenarios the scaling factor is constructed following two alternative paths, differing in the evidence used, the minimum scaling rates and the aggregation rule. These are summarised in Table 12.

[26] Alternatively, one could think of this scenario of one where a 100% scaling factor is applied.

Table 12. Steps for the construction of the scaling factor in each scenario.

	Switch EFSA+- 20%		**Switch EFSA – 5%**
Scaling factor per AS calculated as	Residue detections	Share of detections over total tests	Share of detections over total test
	Authorisation	Median share of detections for same type of AS and world region	Zero
Minimum threshold	20 %		Not applied
Aggregation	Approach	Average of scaling factors per AS Additional 5 % for each unique active substance	Share of total detections over total tests carried out
	Correction rule	If aggregated value is below any of the AS specific residue detection rates the AS-specific detection rate is used	Not applied

Source: own elaboration.

Imputing detection rates for ASs for which authorisation information is available relies on the median detection rate for the same AS class (fungicides, herbicides, or insecticides) and world region (considering Africa, Asia, North and Central America, South America, and non- EU Europe). The median detection rates are reported in Table 13.

Table 13. Median residue detection rates by type of active substance and world region.

	Active substance type			
World region	Fungicides	Herbicides	Insecticides/acarides	**TOTAL**
Africa	15.4	4.7	2.0	**13.5**
Asia	21.7	17.6	2.4	**18.0**
North and Central America	12.5	40.0	12.5	**12.5**
Non-EU Europe	16.7	20.0	7.1	**16.7**
South America	11.8	15.0	6.9	**11.4**
TOTAL	**16.7**	**10.0**	**3.1**	**13.9**

Out of the 18 ASs analysed, only 14 had detections (see Table 5): ten fungicides (benomyl, carbendazim, cyproconazole, dimethomorph, isopyrazam, mancozeb, mepanipyrim, metiram, quinoxyfen and thiophanate-methyl), three insecticides/acaricides (chlordecone, clofentezine and spirodiclofen) and one herbicide (glufosinate).

Source: own elaboration based on residue detections.

Applying these scaling paths leads to different shocks applied in the scenarios. First, the “switch – EFSA+- 20%” scenario shocks 346 country-commodity pairs, against only 87 (75% less) in “switch – EFSA – 5%”. Second, the share of pairs for which each behavioural response is assigned differs. Under “switch – EFSA+- 20%”, the value of production is higher under adaptation (continued export to the EU) for 51 % of pairs, a figure that falls to 47 % under the “switch – EFSA – 5%”. Summary statistics for the scaling factors are given in Table 14, and the distribution of shocks for the most important commodities is depicted in Figure 4 and Figure 5 and summarised in Table 15 and Table 16 .

Table 14. Summary statistics of the scaling factors used in the three scenarios.

	Not adapt – no scale	**Switch EFSA+- 20%**		**Switch EFSA – 5%**	
		Not adapt	Adapt	Not adapt	Adapt
Minimum	100	0.0	0.0	0.0	0.0
Median	100	35.0	7.0	9.3	0.9
Mean	100	38.3	6.9	14.5	1.3
Maximum	100	88.9	12.2	100	5.0
Number of pairs scaled	346	167	179	46	41

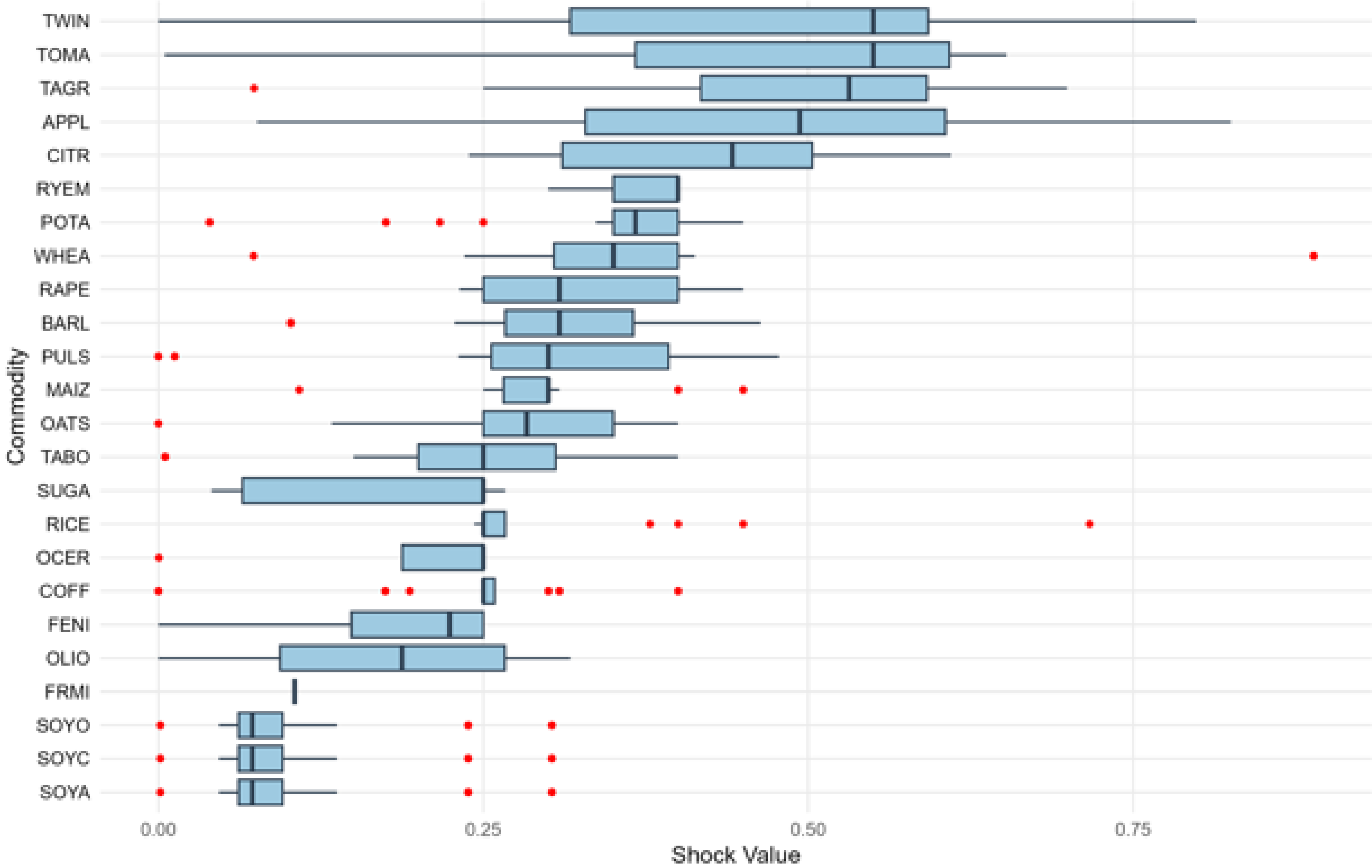
Source: own elaboration.

By construction, the shocks in the "switch – EFSA+- 20%" scenario are larger than under "switch – EFSA – 5%". Please note that some figures may fall below the 20 % minimum assumed by design in that scenario because several stand-alone commodities are aggregated into a single CAPRI commodity. As noted in section 2.1.3, trade with third countries is not homogenously reported across COMEXT and UN-COMTRADE, so a commodity that is not itself subject to trade impact (a zero-scaling factor) may be aggregated with others that are, producing the composite scaling factor applied to the combined CAPRI commodity. Second, the scaling factors are higher for triads that follow the "not adapt" behavioural response when one would consider that the incentive to adapt would be higher the larger the trade effect assumed. However, the switching rule is based on the comparison of scenarios where all triads adapt or not adapt. In those scenarios we do not consider the scaling factor.

The full set of shocks per country – commodity pair can be accessed on the visualisation dashboard for the CAPRI model results. Please note that the shocks reported in the dashboard already incorporate the cost increase when adapting while the ones depicted in the report are only the scaling factors. To recover the pure scaling factor as reported here, divide the dashboard value by the cost increase used in each scenario[27].

[27] I.e. multiply by five (in the case of the switching - EFSA+-20% scenario) and by twenty (in the case of the switching – EFSA – 5% scenario).

Figure 4. Distribution of scaling factors for the "switching – EFSA+- 20%" scenario.

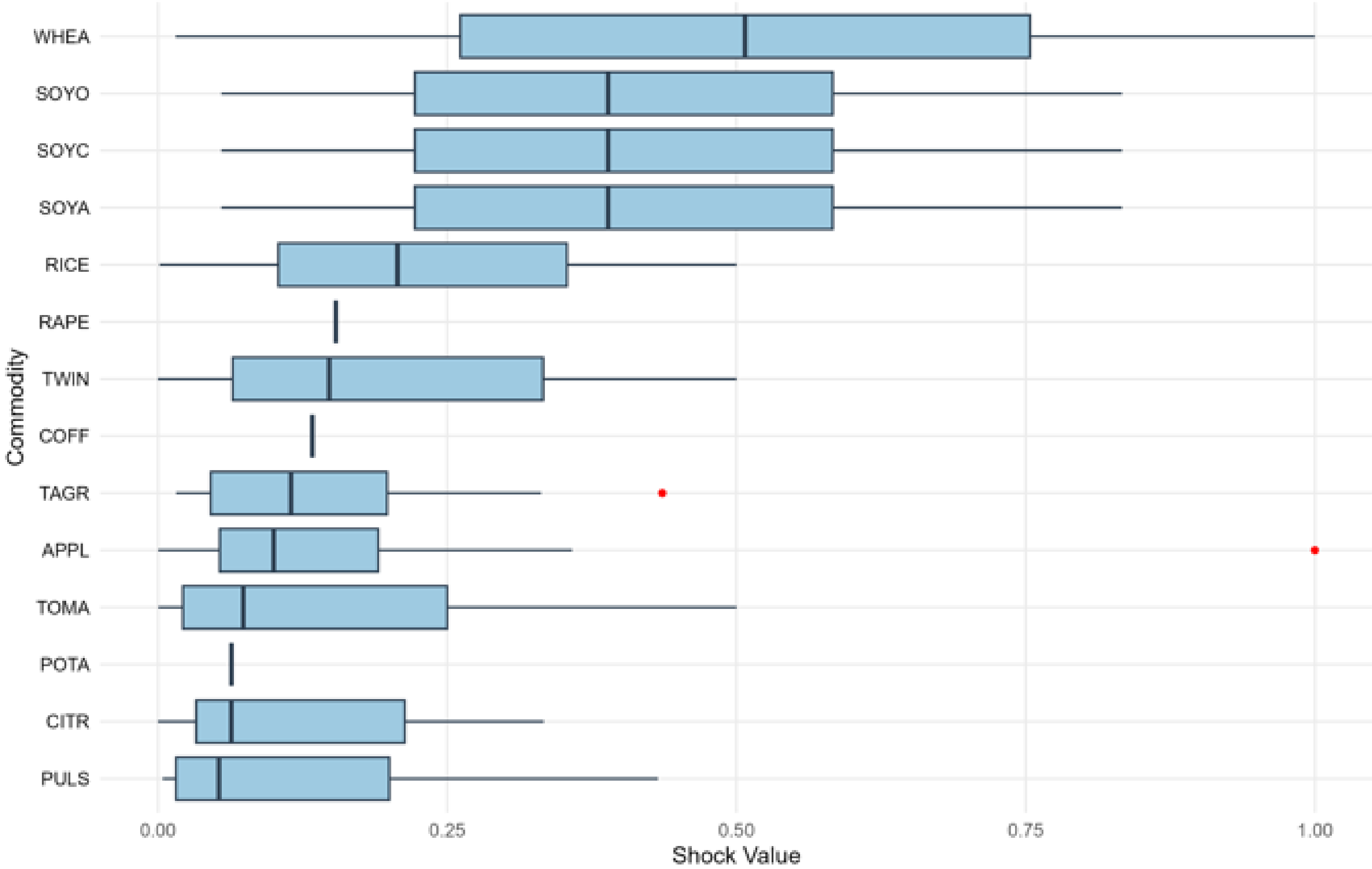


N = 346

Note: Lines show median vales, bars the Q25-Q75 interval, whiskers Q1-Q99 internal and red dots outliers. For commodity codes please refer to Annex I.

Source: own elaboration.

Figure 5. Distribution of scaling factors for the “switching – EFSA - 5%” scenario.



N = 87

Note: Lines show median vales, bars the Q25-Q75 interval, whiskers Q1-Q99 internal and red dots outliers. For commodity codes please refer to Annex I.

Source: own elaboration.

Table 15. Summary statistics of scaling factors by commodity for the "switching – EFSA+ - 20%" scenario

Commodity	Number of countries affected	Minimum	Median	Mean	Maximum
Apples	28	7.6 %	49.3 %	49.3 %	100.0 %
Barley	14	10.2 %	30.9 %	31.1 %	46.4 %
Citrus	24	23.9 %	44.2 %	41.3 %	61.0 %
Coffee	13	0.0 %	25.0 %	24.1 %	40.0 %
Cassava	4	0.0 %	22.4 %	17.5 %	25.0 %
Maize	17	10.8 %	30.0 %	29.7 %	45.0 %
Oats	10	0.0 %	28.4 %	27.0 %	40.0 %
Other cereals	4	0.0 %	25.0 %	18.8 %	25.0 %
Olive Oil	4	0.0 %	18.8 %	17.3 %	31.7 %
Potatoes	25	3.9 %	36.7 %	35.0 %	45.0 %
Pulses	19	0.0 %	30.0 %	30.0 %	47.7 %
Rapeseed	11	23.1 %	30.9 %	32.3 %	45.0 %
Rice	18	24.3 %	25.0 %	29.6 %	55.0 %
Rye and meslin	3	30.0 %	40.0 %	36.7 %	40.0 %
Soybeans	19	0.8 %	34.5 %	36.7 %	83.3 %
Soyabean cake	19	0.8 %	34.5 %	36.7 %	83.3 %
Soybean oil	19	0.8 %	34.5 %	36.7 %	83.3 %
Sugar	5	4.1 %	25.0 %	17.4 %	26.7 %
Grapes	7	0.5 %	25.0 %	23.8 %	40.0 %
Tomatoes	24	7.4 %	53.2 %	48.7 %	69.9 %
Wine	19	0.5 %	55.0 %	47.3 %	65.4 %
Wheat	25	0.0 %	55.0 %	47.5 %	79.8 %

Source: own elaboration.

Table 16. Summary statistics of scaling factors by commodity for the "switching – EFSA - 5%" scenario

Commodity	Number of countries affected	Minimum	Median	Mean	Maximum
Apples	15	0.0 %	10.0 %	18.4 %	100.0 %
Citrus	14	0.0 %	6.3 %	11.5 %	33.3 %
Coffee	1	13.3 %	13.3 %	13.3 %	13.3 %
Potatoes	1	6.3 %	6.3 %	6.3 %	6.3 %
Pulses	9	0.4 %	5.3 %	12.4 %	43.2 %
Rapeseed	1	15.4 %	15.4 %	15.4 %	15.4 %
Rice	3	0.1 %	20.7 %	23.6 %	50.0 %
Soybeans	4	5.5 %	38.9 %	41.6 %	83.3 %
Soyabean cake	4	5.5 %	38.9 %	41.6 %	83.3 %
Grapes	4	5.5 %	38.9 %	41.6 %	83.3 %
Soybean oil	14	1.6 %	11.5 %	14.6 %	43.6 %
Tomatoes	9	0.0 %	7.4 %	16.6 %	50.0 %
Wine	6	0.0 %	14.8 %	20.4 %	50.0 %
Wheat	2	1.5 %	50.8 %	50.8 %	100.0 %

Source: own elaboration.

To get an idea of the magnitude of the shocks in both scenarios, besides the number of country commodity pairs affected reported in Table 15 and Table 16, we can report the number of unique countries and commodities affected by the shocks and the baseline trade volumes affected. In the more stringent28 “Switch – EFSA+ - 20%” scenario trade from 24 countries and 38 commodities is shocked. These 24 countries are the origin of 41 % of total EU imports for the commodities and the shock applied affects 43 % of it (approximately 18 % of total imports). When reducing the evidence used for implementing the shocks in the “Switch – EFSA- 5%” scenario, these figures are reduced to 14 countries, 26 commodities, 30 % of the total EU imports for the commodities coming from those 14 countries and 20 % of it shocked (approximately 6 % of total imports).

3.4. CAPRI model scenarios

We present here a summary of the results obtained from implementing the three scenarios described in section 2.3.4. Results are provided for production of the affected commodities in the EU, trade-flows between third countries and the EU and prices both for producers in third countries and for consumers in the EU. In addition, we present a more detailed analysis of the results for two commodities, one for which the EU is a net importer and another for which the EU is close to self-sufficiency. More details on the impacts can be consulted in the dedicated dashboard.

3.4.1. Impacts on EU imports from third countries

Changes in EU import flows by crop and scenario are presented in Figure 6, Figure 7 and Figure 8. For each crop, the boxplots represent the distribution of percentage changes in import flows across individual exporting countries, capturing how impacts differ among EU trade partners. The central line inside each box indicates the median response, i.e. the percentage change experienced by the middle exporting country. The box itself represents the interquartile range (IQR), containing the middle 50 % of country-level import-flow changes and therefore illustrating the dispersion of impacts across exporters. The whiskers indicate the range of non-outlier observations, showing the broader variability among exporting countries. The diamonds represent the aggregate change in total EU imports for each crop, accounting for the relative importance of each exporting country in total EU trade flows. Differences between the boxplots and the diamonds indicate whether changes are driven by broad shifts across many exporters or by changes affecting major suppliers. The data behind the figure is presented in Table 17.

The effects on EU import flows vary considerably across scenarios, reflecting the different assumptions regarding the ability and economic incentives of exporting countries to adapt their production practices to comply with changes in EU MRLs. Differences between the distribution of country-level changes and the aggregate EU import response indicate whether the overall impact is driven by changes among major suppliers or reflects a redistribution of trade flows across smaller exporting countries.

Under the no-adaptation scenario (Not adapt – No scale) the trade flow impacts are largest, representing an upper-bound estimate of potential impacts. Overall trade flows are reduced by 41% in volume. The strongest reductions in total EU imports (represented by the diamonds) are observed for barley (-84 %), citrus (-92 %), coffee (-56 %), maize (-70 %), soybeans (-90 %) and oil cakes (-60 %). For these commodities, affected exporters account for an important share of EU imports,

[28] More stringent in the sense that more trade flows are affected as we consider both detections via monitoring and information on authorization of use even when no residues have been detected.

meaning that losses from major suppliers are not fully offset by increases from alternative exporters.

However, the impacts are highly heterogeneous across exporting countries. Several commodities, particularly rapeseed, oil cakes, vegetable oils, and sunflower seed cake, show a wide distribution of responses, indicating substantial reallocation of trade flows between suppliers. While exporters affected by the lowering MRLS to the LOQ lose access to the EU market, unaffected exporters may increase exports due to substitution effects. For example, in vegetable oils, the central 50 % of exporting countries ranges from -93 % to +183 %, indicating that some suppliers experience reductions while others achieve significant gains. The median exporting country increases exports to the EU by +57 %, and the upper whisker reaches +1416 %, highlighting strong increases for some exporters. However, the aggregate EU import change (diamond) is negative (-63 %), showing that losses among major suppliers dominate the increases observed among smaller exporters.

Similar reallocation patterns are observed for cereals and rapeseed, where large upper whiskers (+439 % and +1983 %) indicate substantial increases in exports from some countries. Nevertheless, the aggregate EU response remains negative (-66 % and -49 %), suggesting that these changes mainly represent a redistribution of EU suppliers rather than an increase in total imports.

In the Adaptation based on profitability switching – 20% additional cost with EFSA+ scaling scenario (Switch – EFSA+ - 20%), exporters decide whether to adapt based on the profitability of maintaining access to the EU market. Compared with the no-adaptation scenario, overall trade impacts are reduced because not all exporters are affected (i.e. the scaling factor) and moreover part of the affected exporters adjust their production practices and continue supplying the EU market (the switching factor).

However, this scenario still generates important changes in trade patterns because it assumes higher adaptation costs (20 % × estimated exposure) and factors in a broader measure of exposure, combining residue detections with information on ASs authorisations. Therefore, impacts are observed not only where residues have been detected but also where evidence suggests the potential use of non-approved ASs.

Overall, the volume of agricultural products imports in the EU fall by 8%. Despite this more limited aggregate EU import changes for most commodities, substantial heterogeneity remains for citrus, rapeseed, soybean oil, table grapes, tomatoes and wheat, where country-level changes range between -89 % and +443 %. This indicates that adaptation reduces overall market impact but does not eliminate redistribution among exporting countries.

For citrus and soybeans, aggregate EU imports fall by -26 % and -12 % respectively, but these aggregated effects hide significant changes in supplier composition. For these same products, at least 75 % of exporting countries increase their exports to the EU, with the first quartile already above zero. This suggests that while some suppliers face adaptation costs, other exporters benefit from trade reallocation. Moreover, the model allows trade diversion via third countries which in principle would not happen as the MRL applies irrespective of the origin of the commodity but in our scenarios the trade shocks are triad specific. For example, the model response to the stop of imports or the additional costs of replacing the two ASs relevant for coffee[29] in the 29 countries

[29] Cyproconazole and glufosinate.

where we have evidence of use (either in detections via monitoring or with authorisation for use) which represent more than 80% of the total imports for coffee of the EU, leads to an increase in exports of coffee from the USA to the EU which are mainly driven by higher imports of the USA from the countries that reduce their exports to the EU. Nevertheless, the additional import volumes from these countries are not sufficient to replace the shipments from the affected countries.

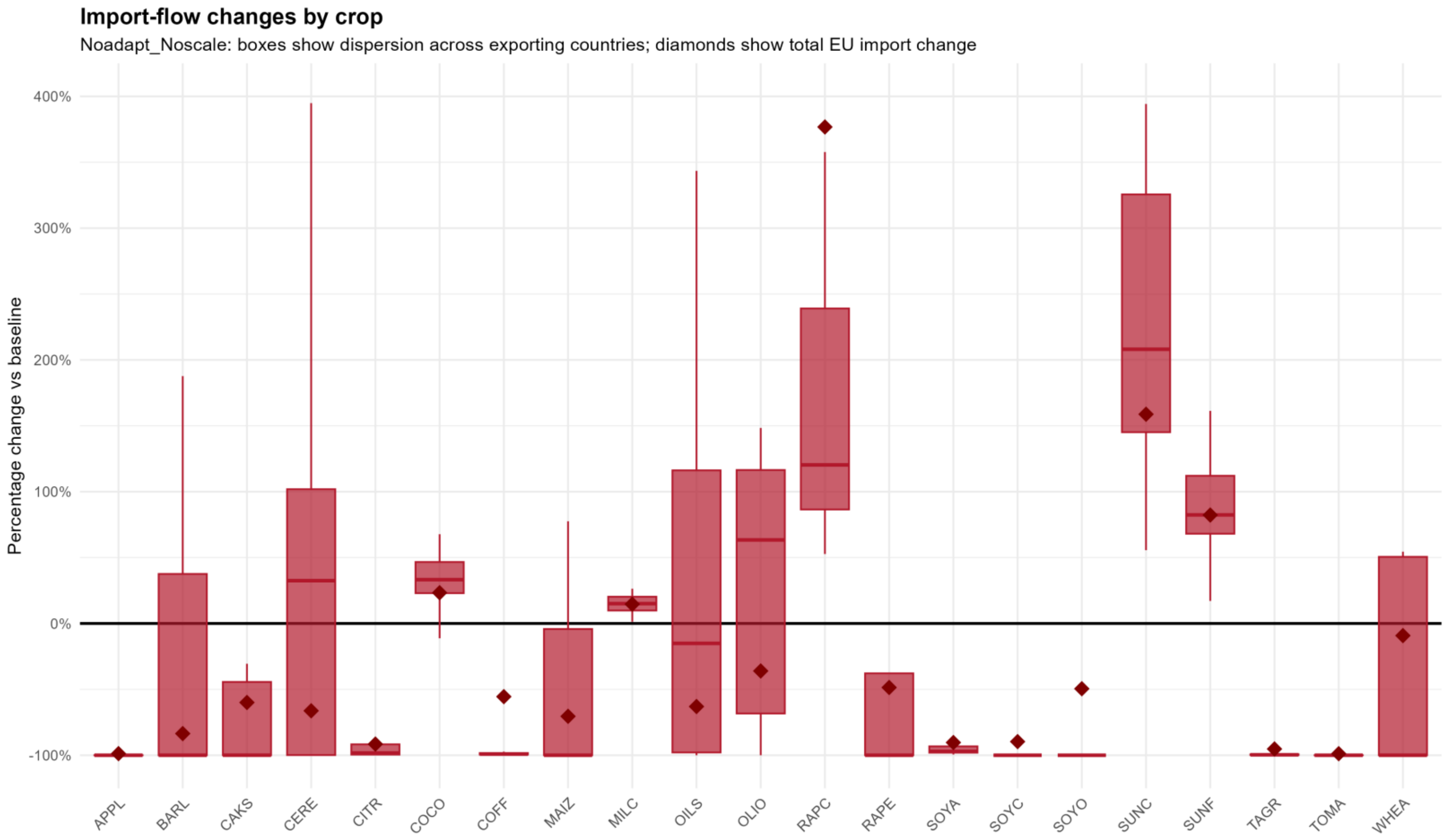
For commodities such as rapeseed, the large dispersion across exporters (IQR -15 % to +36 %; upper whisker +92 %) indicates that certain suppliers strongly benefit from substitution effects. This highlights that even when adaptation occurs, the redistribution of market shares across exporting countries can remain significant.

Under the Adaptation based on profitability switching – 5 % additional cost with EFSA scaling scenario (Switch – EFSA - 5%), the impacts on EU import flows are substantially smaller (0.4 %). In this scenario, exposure is based only on observed detections. As detections represent only the share of production where residues were observed, the affected trade volumes and adaptation costs are considerably lower than in the previous scenarios. Consequently, most commodities show changes concentrated around zero, both in terms of median exporting country responses and aggregate EU import effects.

Only a limited number of commodities, including apples, citrus and table grapes, present noticeable differences between exporters. For these commodities, country-level changes reach up to +20 %, but aggregate EU import changes remain limited (-15 %, -3 % and -4 %, respectively), indicating that either affected exporters represent a small share of EU supply or that substitution among suppliers compensates for reductions.

Overall, the comparison across scenarios highlights that assumptions on exporter adaptation and the estimated exposure to affected active substances strongly determine the magnitude of trade impacts. The Not adapt – no scale scenario provides an extreme upper-bound impact case, where affected exporters lose market access and large reallocations occur. Introducing profitability-based adaptation reduces aggregate impacts considerably, although supplier redistribution remains relevant, particularly when exposure is expanded using pesticide authorisation information. Finally, the switch – EFSA - 5% based scaling scenario produces the smallest impacts, as trade impacts and adaptation costs are limited to the observed relevance of pesticide detections.

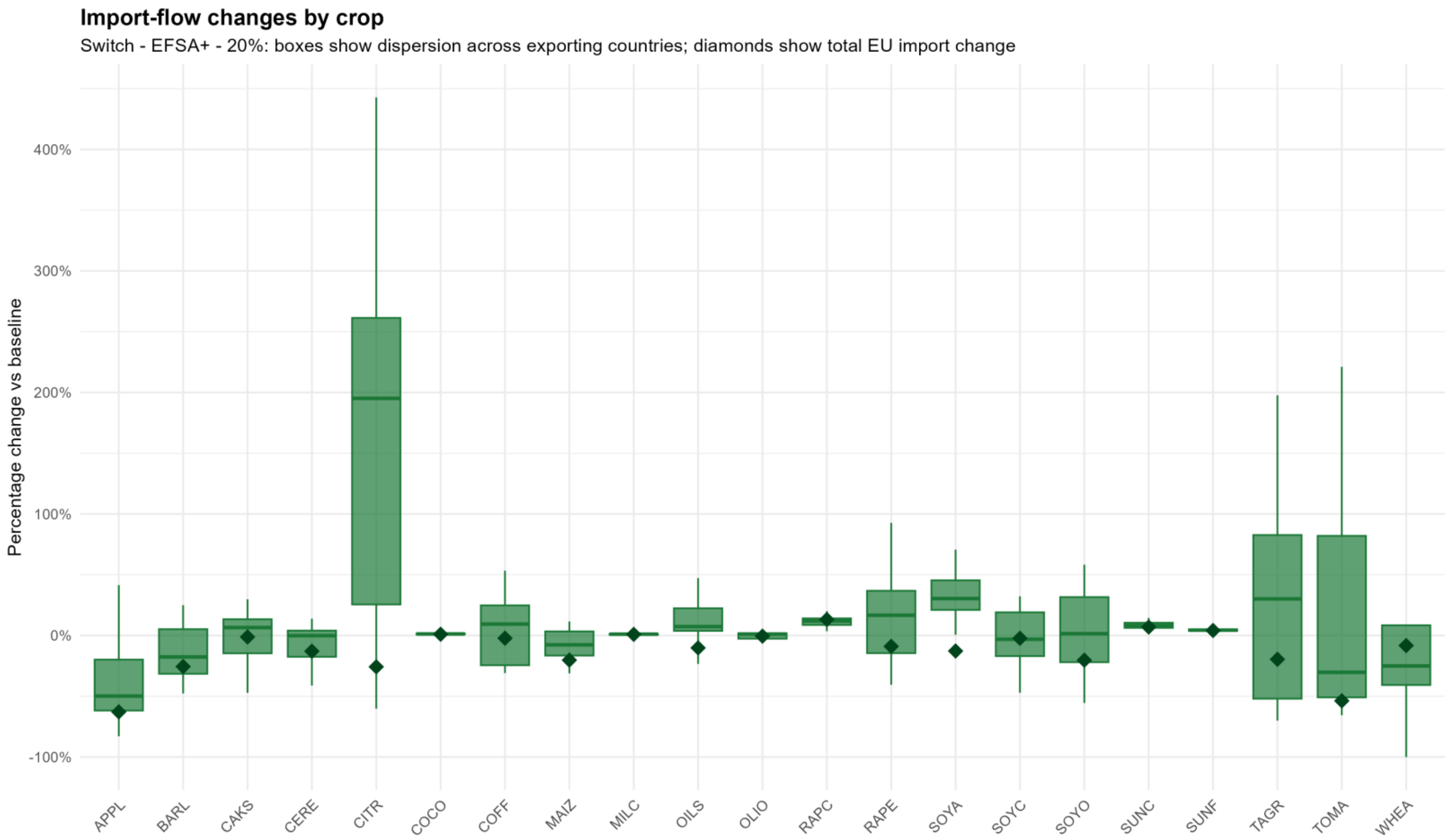
Figure 6. Distribution of percentage changes in import flows towards the EU across exporting countries for each commodity under the “not adapt – no scale” scenario (median-IQR).



Commodity codes can be found in Annex I. Boxplots represent the distribution of percentage changes in import flows across individual exporting countries. The central line inside each box indicates the median response while the extremes of the box represent the interquartile range (IQR), containing the middle 50 % of country-level import-flow changes. The whiskers indicate the range of non-outlier observations. Diamonds represent the aggregate change in total EU imports for each crop.

Source: Own elaboration.

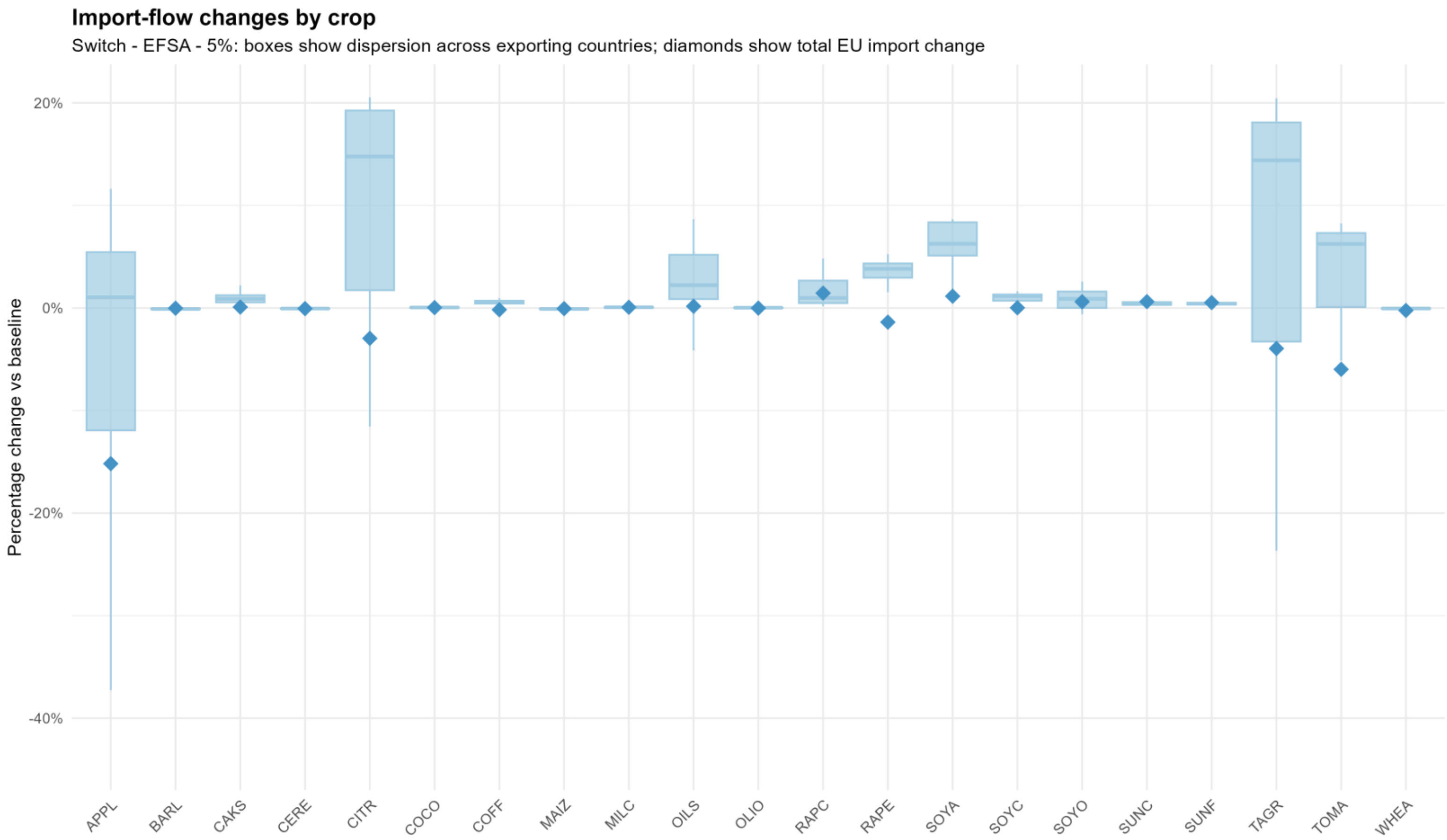
Figure 7. Distribution of percentage changes in import flows towards the EU across exporting countries for each commodity under the "Switching – EFSA+ - 20%" scenario (median-IQR).



Commodity codes can be found in Annex I. Boxplots represent the distribution of percentage changes in import flows across individual exporting countries. The central line inside each box indicates the median response while the extremes of the box represent the interquartile range (IQR), containing the middle 50 % of country-level import-flow changes. The whiskers indicate the range of non-outlier observations. Diamonds represent the aggregate change in total EU imports for each crop.

Source: Own elaboration.

Figure 8. Distribution of percentage changes in import flows towards the EU across exporting countries for each commodity under the “Switching – EFSA – 5%” scenario (median-IQR).



Commodity codes can be found in Annex I. Boxplots represent the distribution of percentage changes in import flows across individual exporting countries. The central line inside each box indicates the median response while the extremes of the box represent the interquartile range (IQR), containing the middle 50 % of country-level import-flow changes. The whiskers indicate the range of non-outlier observations. Diamonds represent the aggregate change in total EU imports for each crop.

Source: Own elaboration.

Table 17. Descriptive statistics of percentage changes in import flows towards the EU across exporting countries for each commodity under simulated scenarios.

	Country specific change in EU imports												Total change in EU imports		
	Minimum			Median			Mean			Maximum					
Commodity	[1]	[2]	[3]	[1]	[2]	[3]	[1]	[2]	[3]	[1]	[2]	[3]	[1]	[2]	[3]
Apple	-100.0	-82.9	-37.3	-100.0	-49.8	1.0	-73.8	-32.0	-4.4	453.1	98.0	11.6	-98.8	-62.8	-15.2
Barley	-100.0	-47.7	-0.2	-100.0	-17.6	-0.1	-24.5	-14.8	-0.1	289.7	24.9	0.3	-83.6	-25.5	0.0
Oil cakes	-100.0	-47.1	-19.2	-86.6	6.5	0.9	537.8	0.5	0.3	5 436.9	29.8	2.4	-60.0	-1.2	0.1
Cereals	-100.0	-98.2	-0.4	32.5	-0.1	-0.1	39.2	-10.5	-0.1	394.8	13.9	0.1	-66.3	-12.9	-0.1
Citrus	-100.0	-60.2	-11.6	-98.1	195.2	14.8	1 312.3	164.2	10.4	20 685.2	442.8	20.5	-91.5	-25.8	-3.0
Cocoa	-11.2	0.3	0.0	33.2	1.3	0.1	33.5	1.3	0.1	67.7	2.5	0.2	23.3	1.0	0.0
Coffee	-99.7	-30.9	-1.4	-98.5	9.4	0.6	1600.1	7.7	0.4	28 564.3	53.3	1.0	-55.5	-2.2	-0.2
Maize	-100.0	-31.2	-0.1	-100.0	-7.7	-0.1	-59.4	-8.8	-0.1	77.5	11.6	0.1	-70.5	-20.3	-0.1
Oilseeds	-100.0	-36.8	-14.3	57.3	7.3	2.2	164.5	10.5	2.6	1 433.0	47.3	8.7	-63.0	-10.2	0.2
Olive Oil	-100.0	-32.6	0.0	63.4	1.2	0.0	38.7	-5.0	0.0	148.4	2.2	0.1	-36.0	-0.5	0.0
Rapeseed cakes	52.7	3.5	0.2	502.3	12.0	1.0	474.0	15.2	3.0	801.3	50.9	16.9	376.8	13.2	1.5
Rapeseed	-100.0	-40.6	-15.5	225.9	16.7	3.8	584.8	14.1	3.6	2 009.7	92.7	19.5	-48.6	-8.9	-1.4
Soybeans	-99.4	-30.3	-4.7	-95.6	30.4	6.3	488.3	29.2	6.0	4 376.7	70.7	8.7	-90.3	-12.8	1.2
Soybean cakes	-100.0	-47.1	-19.2	-100.0	-3.1	1.2	2 996.7	0.8	0.2	7 2321.2	32.3	1.6	-89.7	-2.3	0.0
Soybean Oil	-100.0	-55.5	-24.0	-100.0	1.5	0.9	6 56.9	3.1	-1.1	6 666.9	58.3	2.6	-49.5	-20.3	0.6
Sunflower cakes	55.6	4.9	0.0	330.3	8.2	0.4	325.2	8.4	0.4	740.0	14.5	0.8	158.8	7.0	0.6
Sunflower seeds	-1.1	-1.0	-0.3	82.4	4.4	0.4	85.7	4.0	0.4	161.3	6.6	1.5	82.3	4.1	0.5
Grapes	-100.0	-70.0	-43.8	-99.7	30.1	14.4	341.1	25.7	5.7	7 185.5	197.7	20.4	-95.2	-19.6	-4.0
Tomatoes	-100.0	-65.5	-23.5	-100.0	-30.3	6.3	129.8	15.0	2.5	2 616.0	221.1	8.2	-98.8	-53.8	-6.0
Wheat	-100.0	-100.0	-3.6	-100.0	-25.0	-0.1	-38.4	-20.3	-0.2	54.5	9.0	0.0	-9.2	-8.3	-0.2

[1] "not adapt – no scale" scenario; [2] "Switching = EFSA+ - 20%" scenarios; [3] "Switching – EFSA – 5%" scenario

Source: own elaboration.

3.4.2. Impacts on trade flows and producer prices for third countries

Figure 9 illustrates the relationship between changes in EU import flows and producer price in third countries responses across commodities under the three pesticide MRL scenarios. Each point represents one commodity. The x-axis shows the percentage change in total EU imports relative to the baseline, while the y-axis shows the corresponding percentage change in producer prices in third countries. In contrast to the analysis in Section 3.4.1, here the producer-price indicator is calculated as a weighted average using baseline import volumes, ensuring that price changes affecting major suppliers have a stronger influence on the reported commodity-level response than changes affecting small exporters. The bubble size represents the baseline level of EU imports for each commodity, with larger bubbles corresponding to commodities with higher import volumes. Therefore, larger bubbles indicate sectors where changes in import availability or prices may have greater market relevance.

The dashed horizontal and vertical lines indicate the baseline situation (0 % change) and divide the figure into four quadrants:

— **Upper-left quadrant (EU imports decrease, third country producer prices increase):** commodities where reductions in EU imports are associated with upward pressure on third country producer prices. This represents cases where reduced availability of imported products may increase market prices.

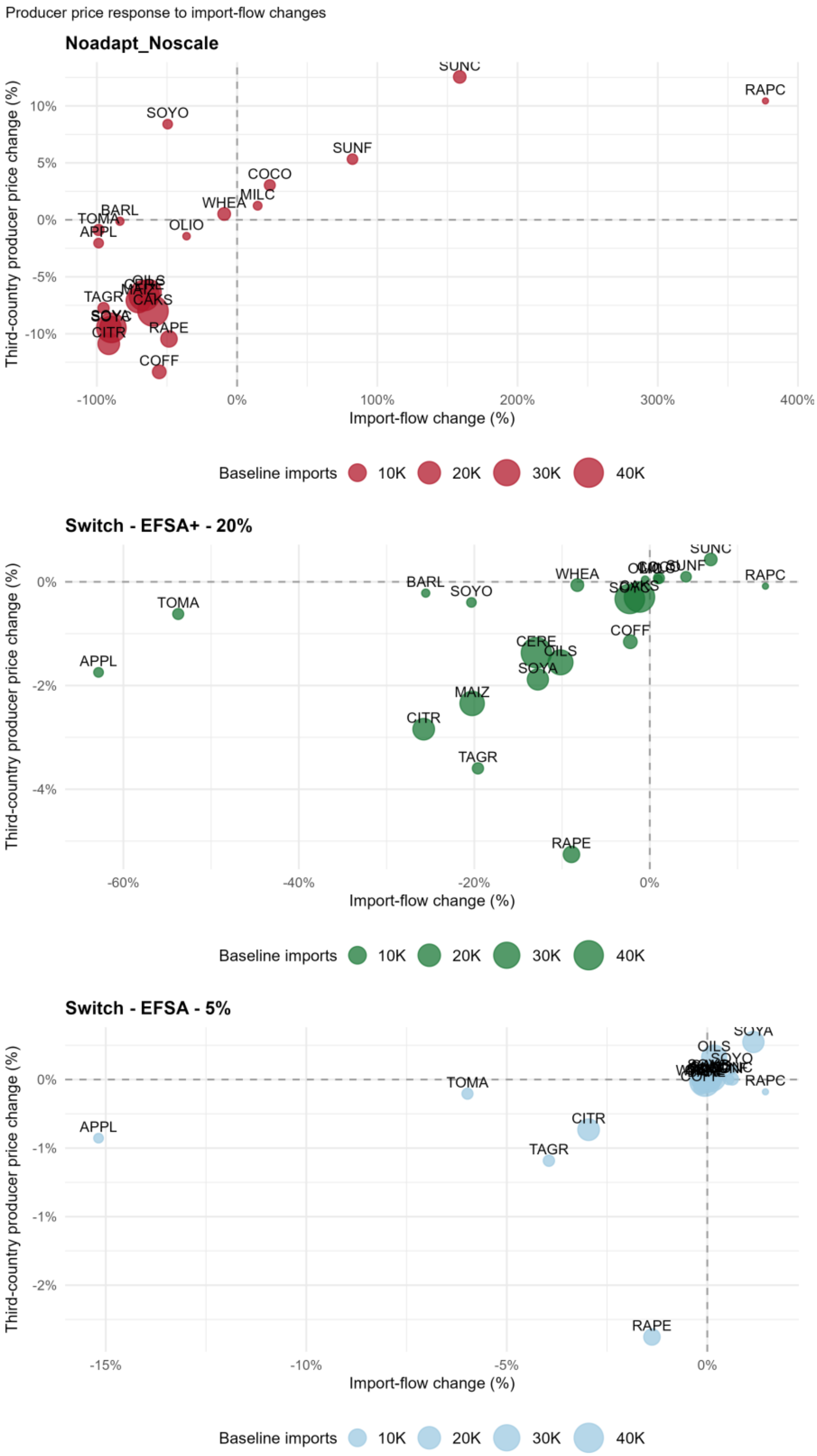
— **Lower-left quadrant (imports decrease, third country producer prices decrease):** commodities where import reductions occur together with lower producer prices, indicating that other market adjustments, such as changes in domestic production, consumption, or global price effects, offset the expected price increase.

— **Upper-right quadrant (imports increase, third country producer prices increase):** commodities where imports expand while prices also increase, suggesting broader market adjustments or increased demand effects rather than a simple supply-driven response.

— **Lower-right quadrant (imports increase, third country producer prices decrease):** commodities where increased import availability is associated with downward pressure on producer prices.

The comparison across scenarios highlights how assumptions regarding exporter adaptation and the estimated exposure to non-approved active substances influence the relationship between changes in EU import flows and producer price responses. Overall, larger market effects are concentrated in the Not adapt – No scale scenario, while the two adaptation scenarios substantially reduce both import effects and price adjustments.

Figure 9. Relationship between changes in EU import flows and third countries' producer price responses by commodity under alternative scenarios.



Bubble size represents baseline EU import volumes. Import-flow changes and producer-price changes are weighted by baseline import volumes, giving greater importance to major exporting countries in the calculation of commodity-level effects.

Source: own elaboration.

Under the Not adapt – no scale scenario, the largest changes are observed, reflecting the assumption that affected exporters are unable to modify their production practices and therefore lose access to the EU market. Several commodities experience substantial reductions in exports to the EU, with the strongest declines observed for tomatoes (-98.8 %), apples (-98.8 %), table grapes (-95.2 %), soybean cakes (-89.7 %), citrus (-91.5 %) and soybeans (-90.3 %). These reductions are generally associated with lower producer prices in exporting countries, with the maximum decrease detected for coffee (close to 15 %) but reaching also -10.9 % for citrus, -9.5 % for soybean cakes, -9.4 % for soybeans and -7.7 % for table grapes. This indicates that exporters affected by the lowering of MRLs to the LOQ lose an important market outlet and are not fully able to compensate through alternative destinations, leading to downward pressure on producer prices. The lower-left quadrant contains most affected commodities, including soybeans, soybean cakes, citrus, table grapes, oil cakes, rapeseed and coffee, showing simultaneous reductions in EU export opportunities and producer prices. However, producer price effects remain relatively moderate compared with the magnitude of trade-flow reductions, generally remaining below 10 % for most commodities, suggesting that market adjustments outside the EU partly absorb the impact of reduced EU access.

Conversely, a smaller group of commodities moves to the upper-right quadrant, particularly rapeseed cakes, sunflower cakes and sunflowers. These commodities combine increased exports to the EU (+376.8%, +158.8 % and +82.3 %, respectively) with higher producer prices (+10.5 %, +12.6 % and +5.3 %, respectively). This suggests that exporters that are not affected by the lowering of MRLs to the LOQ benefit from trade reallocation, gaining market share in the EU while experiencing improved economic returns.

Under the “Switch – EFSA+ - 20%” scenario, market impacts are considerably reduced. Allowing exporters to adapt maintains EU market access for economically viable suppliers and limits the magnitude of trade effects. Most commodities show smaller changes in both EU import flows and producer prices. Nevertheless, some commodities remain negatively affected. Apples, tomatoes, citrus, soybean oils and table grapes show reductions in EU import flows of -62.3 %, -53.8 %, -25.8 %, -20.3 % and -19.6 %, respectively, combined with producer-price decreases ranging from -0.4 % to -3.6 %. These cases indicate that, even with adaptation possibilities, some exporters either do not adapt due to profitability constraints or face increased production costs that reduce their competitiveness. At the same time, a limited number of commodities benefit from supplier substitution effects. Rapeseed cakes, sunflower cakes and sunflower show increased access to the EU market, with import-flow increases of +12.8 %, +6.5 % and +3.7 %, respectively, thus benefitting from the reduction in soybeans trade. However, producer price responses remain limited (-0.1 %, +0.4 % and +0.1 %, respectively), indicating that adaptation strongly reduces the economic gains observed for alternative suppliers compared with the no-adaptation scenario.

Under the “Switch – EFSA - 5%” scenario, changes are much more limited. Since exposure is based only on observed residue detections and adaptation costs are lower, most commodities remain close to the baseline situation, indicating limited effects on international trade patterns. Only a few commodities present noticeable deviations. Apples, tomatoes, table grapes, citrus and rapeseed experience reductions in EU import flows of -15.2 %, -6.0 %, -4.0 %, -3.0 % and -1.4 %, respectively, with associated producer price changes remaining small (between -0.1 % and -1.9 %). In contrast, soybeans show small increases in exports to the EU (+2.8 %) together with limited positive producer price responses (+0.3 %), reflecting minor trade reallocation towards unaffected suppliers.

The ranking of impacts across scenarios is quite stable with spearman correlation coefficients ranging from 0.86 to 0.60 depending on the scenarios compared (Table 18).

Table 18. Spearman ranking correlation coefficients for impacts across commodities and scenarios.

Scenarios	Spearman correlation coefficient
"Not adapt - no scale" / "Switching - EFSA+ - 20%"	0.86
"Not adapt - no scale" / "Switching - EFSA - 5%"	0.60
"Switching – EFSA= - 20%" / "Switching - EFSA - 5%"	0.63

Source: own calculations.

In this section we have only discussed impacts at the commodity level, however the visualisation dashboard allows the interested reader to access additional details.

Overall, as expected the results indicate that the largest economic effects occur when exporters are assumed to be unwilling to adapt. In this case, lowering MRLs to the LOQ generate substantial redistribution of EU suppliers, with some exporters losing market access and others benefiting from increased demand. Introducing rational profitability-based adaptation significantly reduces these impacts, while the Switch – EFSA - 5% scenario results in marginal changes compared to the baseline without intervention.

3.4.3. Impacts on EU production

Changes in EU production for selected commodities are reported in Table 19. The results show that stricter alignment of production standards for imports leads to reduction of export flows to the EU, hence an increase in EU agricultural production, although the magnitude of the response strongly depends on assumptions regarding exporter adaptation. The production response is largest in the no-adaptation scenario (Not adapt – No scale), where affected third-country suppliers lose access to the EU market, generating stronger opportunities for import substitution by EU producers. When adaptation by exporters is introduced, the increase in EU production is substantially reduced.

Under the **"Not adapt – No scale" scenario**, EU agricultural production increases by 1.1 %, accompanied by an expansion of agricultural area of +1.9 million hectares (+1.2 % of the utilised agricultural area, UAA). This represents the upper-bound response: as reduced import availability creates incentives for EU producers to increase domestic supply. The largest production increases are concentrated in the crops whose EU imports are most affected. The strongest responses are projected for citrus (+46.8 %), rapeseed (+40.5 %), table grapes (+29.8 %) and soybeans (+29.4 %). Other sizable increases occur for pulses (+21.8 %), potatoes (+13.4 %), other arable field crops (+12.6 %), and tomatoes (+8.3 %). These results indicate a strong substitution effect, largely concentrated in sectors with higher exposure to affected third-country suppliers and where EU producers have the capacity to expand production. The spatial distribution of impacts shows that increases in production are not uniform across the EU. Member States specialised in the expanding commodities experience the strongest gains, with production increases reaching up to +12.1 % at Member State level. The largest positive changes are concentrated in countries with significant oilseed, protein crop and fruit production systems, while some regions show smaller adjustments or slight reductions depending on their production structure.

In contrast, the livestock sectors experience a reduction in production, particularly pork meat (-5.8 %), poultry meat (-5.4 %), sheep and goat meat (-3.7 %), and beef (-3.6 %). These reductions are mainly driven by indirect effects from crop markets. Lower imports and the resulting increase in demand for EU crops lead to higher prices for key feed-related commodities, particularly oilseeds (+29 %) and oilseed cakes (+87 %) (see chapter 3.4). As these products are important components of animal feed, higher prices increase livestock production costs, reducing the competitiveness of

EU animal production. As a consequence, livestock supply contracts despite the expansion observed in crop sectors.

Table 19. Production changes between baseline and scenarios for the main crop sectors in the EU.

	Change in EU production in scenario...		
Commodity	**No adapt – no scale**	**Switching – EFSA+ - 20%**	**Switching – EFSA - 5%**
Citrus fruits	46.7 %	3.3 %	0.3 %
Rapeseed	40.2 %	3.0 %	0.5 %
Table grapes	29.7 %	2.2 %	0.3 %
Soya seed	28.6 %	2.3 %	0.5 %
Oilseeds	27.5 %	2.0 %	0.3 %
Pulses	20.6 %	0.9 %	0.5 %
Other arable field crops	13.7 %	1.5 %	0.1 %
Potatoes	13.1 %	1.6 %	0.0 %
Tomatoes	8.3 %	3.0 %	0.3 %
Table olives	7.7 %	0.3 %	0.0 %
Vegetables and Permanent crops	6.6 %	0.9 %	0.1 %
Sunflower seed	4.8 %	0.0 %	0.0 %
Olive oil	2.5 %	0.1 %	0.0 %
Wine	2.5 %	0.2 %	0.0 %
Cereals	1.8 %	0.6 %	0.1 %
Wheat	1.6 %	0.3 %	0.1 %
Apples, pears and peaches	1.1 %	0.4 %	0.1 %
Dairy products	0.4 %	0.0 %	0.0 %
Barley	0.1 %	0.6 %	0.1 %
Eggs	-2.9 %	-0.1 %	0.0 %
Beef	-3.5 %	-0.2 %	0.0 %
Sheep and goat meat	-3.5 %	-0.2 %	0.0 %
Meat	-5.2 %	-0.2 %	0.0 %
Poultry meat	-5.3 %	-0.2 %	0.0 %
Pork meat	-5.6 %	-0.2 %	0.0 %
Oil cakes	-20.9 %	-1.8 %	-0.3 %
Soya oil	-86.9 %	-5.6 %	-1.0 %
Soya cake	-87.1 %	-5.7 %	-1.0 %

Source: own elaboration.

Under the **"Switch – EFSA+ - 20%" scenario**, the production response is substantially smaller. EU agricultural production increases by 0.23 % and UAA, by 152 thousand hectares (+0.1 % UAA). Exporters that are able to adapt maintain access to the EU market, reducing the need for domestic production expansion. The strongest increases remain concentrated in similar commodities but at a much lower magnitude: citrus (+3.3 %), tomatoes (+3.0 %), rapeseed (+3.0 %), table grapes (+2.2 %), oilseeds (+1.8 %), grain maize (+1.6 %), potatoes (+1.6 %) and soybeans (+1.4 %). Compared with the no-adaptation scenario, the production increase is roughly an order of magnitude smaller for the most affected sectors. This indicates that assuming at least some exporters will adjust their production practices significantly limits the need for import substitution within the EU. Spatial effects are also more limited, with Member State production changes reaching approximately +1.4 %. The geographical pattern mirrors the no-adaptation scenario, with stronger increases in regions specialised in the commodities most affected by import adjustments, but at considerably lower intensity.

On the other hand, under the "Switch – EFSA - 5% scenario", EU production changes are even more marginal. Since this scenario only considers observed residue detections and applies lower adaptation costs, trade impacts are limited and the incentive for EU production expansion is strongly reduced. The largest increases remain below 1 %, with the highest responses observed for soybeans (+0.5 %), rapeseed (+0.4 %), tomatoes (+0.3 %), table grapes (+0.3 %), oilseeds (+0.3 %) and citrus (+0.3 %). Most other agricultural sectors remain essentially unchanged compared with the baseline. The spatial distribution confirms the limited impact of this scenario, with Member State production changes remaining within approximately ±0.1 %. This indicates that when trade effects and adaptation costs are scaled only to observed pesticide residue detections, the resulting changes in EU agricultural production are negligible.

Overall, the comparison across scenarios highlights that EU production responses are mainly driven by the extent of import reductions and the capacity of exporters to adapt. The Not adapt – no scale scenario generates the strongest structural adjustment, with significant expansion of crops previously supplied by affected exporters and measurable changes in agricultural land use. Profitability-based adaptation substantially reduces the need for EU production expansion, while the Switch – EFSA - 5% scenario produces only marginal production and spatial changes, indicating limited effects on EU agricultural supply when the affected production share is restricted to observed pesticide detections.

For livestock sectors, the production impacts become negligible under both adaptation scenarios. Since exporters maintain access to the EU market and effects on crop imports are substantially reduced, the increase in feed-related commodity prices is limited. Consequently, the indirect cost pressure on livestock producers observed in the “Not adapt – No scale” scenario largely disappears.

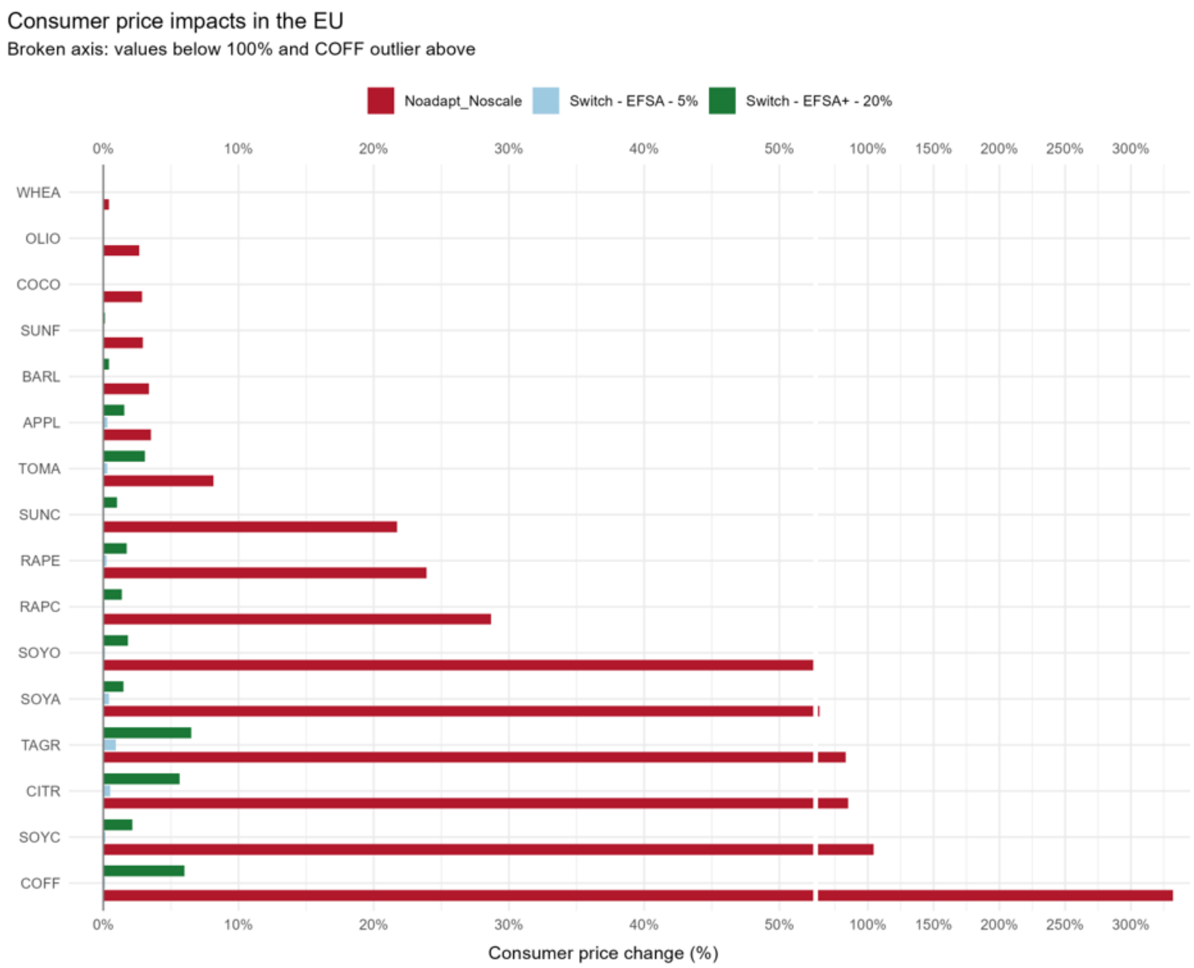
3.4.4. Impacts on EU consumer prices

Figure 10 shows the impact of the different pesticide MRL scenarios on EU consumer prices. Overall, consumer price responses vary across scenarios, reflecting differences in the assumed willingness of exporters to adapt and the extent to which EU import supply is affected.

The largest consumer price increases are observed under the ‘not adapt – no scale’. This reflects the assumption that affected exporters do not modify their production practices and lose access to the EU market, reducing import availability and generating upward pressure on EU prices. The strongest impact is observed for coffee, where consumer prices increase by 332 %, signalling a high dependency of EU supply on exporters affected by the lowering of MRLs to the LOQ and limited possibilities for alternative suppliers to compensate for the reduction in imports. Further commodities showing considerable consumer price increases, comprise soybean cakes (+105 %), citrus (+85 %), table grapes (+83 %), soybeans (+63 %) and soybean oil (+55 %). These commodities appear highly dependent on imports from affected exporters, resulting in strong transmission of import reductions to EU consumer prices. Relevant but lower increases are observed for oilseed-related commodities, including rapeseed cakes (+29 %), rapeseed (+24 %) and sunflower cakes (+22 %), indicating that although trade reallocation occurs, alternative suppliers cannot completely offset the reduction in imports from affected exporters. For most remaining commodities, consumer price impacts are considerably milder. Commodities such as tomatoes (+8 %), apples (+4 %), barley (+4 %), cocoa (+3 %), sunflower seed (+3 %), olive oil (+3 %), and wheat (+0.5 %) show limited price transmission, suggesting that affected suppliers represent a smaller share of EU availability or that market adjustment mechanisms reduce the final impact on consumers.

In the scenario where the behavioural response between adaptation and not is based on rational profitability switching, a 20 % additional cost is assumed for adaptation and scaling is based on residue detections and use authorization information (Switch – EFSA+ - 20%), consumer price impacts are substantially reduced compared with the no-adaptation scenario. Allowing exporters to adapt enables part of the affected suppliers to maintain access to the EU market, reducing supply constraints and limiting price increases. The largest remaining effects are observed for table grapes (+6.5 %), coffee (+6.0 %), citrus (+5.6 %) and tomatoes (+3.1 %). These results indicate that, even when adaptation is possible, some market effects remain due to adaptation costs, exporters choosing not to adapt, or limited substitution possibilities. Other commodities show smaller increases, including soybean cakes (+2.0 %), rapeseed (+1.7 %), soybean oil (+1.6 %), apples (+1.6 %), rapeseed cakes (+1.3 %) and soybeans (+1.0 %).

Figure 10. EU consumer price impacts by commodity under alternative scenarios.



Bars represent percentage changes in EU consumer prices relative to the baseline for each commodity and scenario. The broken x-axis is used to improve readability, allowing moderate price changes to be compared while still displaying extreme responses for highly affected commodities. Positive values indicate an increase in consumer prices compared with the baseline.

Source: own elaboration.

Under the assumption that additional costs are only 5% and scaling is only based on residue detections (Switch – EFSA - 5% scenario), consumer price effects are very mild. Since exposure is based only on observed residue detections and adaptation costs are lower, the affected share of production and trade is substantially reduced. All commodities show consumer price increases below 1 %. The largest responses occur for table grapes (+0.9 %), citrus (+0.5 %), soybeans (+0.4

%), tomatoes (+0.3 %) and apples (+0.3 %), while changes for all other commodities are close to zero.

Overall, the comparison across scenarios shows that consumer price impacts are mainly driven by the degree of reductions on EU import supply. The 'Not adapt – no scale scenario' represents an upper-bound case, generating substantial price increases for commodities where the EU relies strongly on affected exporters. Introducing profitability-based adaptation considerably reduces these effects, while the 'Switch – EFSA - 5%' scenario produces negligible changes, suggesting limited consumer impacts when the affected production share is scaled to observed pesticide residue detections.

3.4.5. A closer look at soybeans, soybean cakes and tomatoes

To better understand the dynamics that lead to the results summarised above we take a closer look at the dynamics behind the changes in production, trade and prices. We focus on two commodities that differ in terms of EU self-sufficiency and in final use. For soybeans and soybean cakes the EU widely depends on imports and the final use is mainly for feed. On the contrary, the EU is nearly self-sufficient in tomatoes, and the final use is human consumption. We also focus on two specific countries that represent most of the imports to the EU for these commodities, Brazil which accounts for nearly 50 % of total EU soybean imports and Morocco which accounts for more than 70 % for tomato imports. We compare the results across the three scenarios.

Out of the 18 ASs of interest, residues for four have been detected in soybean and soybean cakes imported from Brazil and three are authorised for use in the country for soybeans. Imports of soybean from Brazil to the EU decrease by 95 % (591 kt) when we implement the 'not adapt – no scale' scenario. The impact decreases steadily when producers can decide to change practices to continue exporting. The reduction is more than divided by three (30 %) when evidence is taken for both detections and authorisation for use with a 20 % additional cost for adaptation ('Switch – EFSA+ - 20%' scenario) and falls to just 4 % if only detection is taken into account and adaptation is assumed to imply just a 5 % cost increase ('Switch – EFSA – 5%' scenario). Total Brazilian soybean exports are almost unaffected across all scenarios, indicating that most of the displaced EU trade is absorbed by other markets. However, the decline in Brazilian producer prices (-5.6 %, 1% and no change for each of the three scenarios) suggests that alternative markets do not fully replace the value of the lost EU demand, specially so when the effect is assumed to be highest. In the case of soybean cake imports from Brazil into the EU, these decrease by 100 % (9 525 kt) 25% or 0.1% depending again on the intensity of the shock assumed and the cost of substituting the AS in soybean production, indicating that part of the EU demand previously supplied by Brazil is redirected towards alternative suppliers. Total Brazilian exports of soybean cake decline from 35 % (6 358 kt) in the upper bound scenario or are even not affected if scaled to ASs detected and substitution comes at a relatively low cost, showing that the loss of access to the EU market is only partially compensated by exports to other destinations only if the impacts are felt by all exporters. Brazilian producer prices decrease from 10.9 % to no change, reflecting again a downward pressure on returns proportionate to the share of EU demand that is assumed to be affected.

The reduction in Brazilian exports contributes to changes in EU sourcing patterns, with trade flows shifting towards suppliers that are not affected by the lowering of MRLs to the LOQ. The contraction in imports of soybeans and soybean cake also affects downstream markets, particularly through changes in oilseed availability, crushing activity and feed-related supply chains. These effects are most pronounced in the *'Not adapt – no scale'* scenario, where the complete loss of Brazilian soybean cake exports to the EU—by far the larger trade flow in volume terms—generates substantial adjustments throughout the oilseed, crushing and feed supply chains. Under the *'Switch – EFSA+ – 20%'* scenario, the effect is considerably smaller, but soybean cake exports to the EU still decline by 14%. Although Brazilian soybean exports to the EU increase by 30%, this increase is small in absolute volume compared with the reduction in soybean cake trade and therefore does not fully offset the effects on the broader soybean complex. The lower demand for Brazilian soybean cake may also reduce crushing activity and, consequently, demand for soybeans as an input, contributing to the decline in Brazilian soybean producer prices. Under the 'Switch – EFSA – 5%' scenario, soybean cake exports are only marginally affected and soybean exports to the EU increase slightly, resulting in limited effects on oilseed availability and related value chains.

The impacts on the production and trade of soybeans and soybean cakes in Brazil are summarised in Table 20.

Table 20. Main figures and production and trade dynamics resulting from the simulations of the three scenarios for soybeans and soybean cakes in Brazil.

		Scenario		
	commodity	**Not adapt – no scale**	**Switch – EFSA+ – 20%**	**Switch – EFSA – 5%**
Brazilian exports to the EU	[1]	−591 kt (−95%)	+187 kt (+30%)	+41 kt (+7%)
	[2]	−9,525 kt (−100 %)	−1,362 kt (−14 %)	−12 kt (−0.1 %)
Total Brazilian exports	[1]	Almost unaffected	Almost unaffected	Almost unaffected
	[2]	−6,358 kt (−35 %)	−754 kt (−4 %)	Not affected
Brazilian producer price	[1]	−5.6 %	−1 %	0 %
	[2]	−10.9 %	−1 %	0 %
Trade diversion to non-EU markets	[1]	Most exports are redirected to alternative markets.	Soybean exports to the EU recover while total exports remain stable.	Trade remains close to the baseline.
	[2]	Alternative markets only partly compensate for the loss of EU demand.	Alternative markets compensate only part of the reduced EU demand.	Trade remains largely unchanged.
Main market effect		The loss of soybean cake trade drives major impacts in the soybean value chain.	Soybean exports recover, but reduced soybean cake trade continues to affect the value chain.	Market impacts are limited as trade flows remain close to the baseline.

[1] soybeans; [2] soybean cake.

Source: own elaboration

In the case of tomato imports from Morocco, residues from eight of the relevant ASs have been detected despite the fact that for only two we have information on authorisation. In the 'Not adapt – no scale' scenario, EU imports from Morocco decrease by 100 % (325 kt), reflecting the loss of access to the EU market due to identified ASs constraints. As for the case of Brazil and soybeans, the impact decreases steadily when producers can decide to change practices to continue exporting. The reduction is nearly halved (60 %) when evidence is taken for both detections and authorisation for use with a 20 % additional cost for adaptation ('Switch – EFSA+ - 20%' scenario) and falls to just 2 % if only detection is taken into account and adaptation is assumed to imply just a 5 % cost increase ('Switch – EFSA – 5%' scenario). The affected export volumes are redirected towards alternative markets. Despite the sharp reduction in exports to the EU, total Moroccan tomato production remains broadly unchanged. This indicates that producers maintain production levels by reallocating exports rather than reducing supply.

Indeed, the increase of Moroccan tomato exports to non-EU destinations, mostly to the UK, compensate for the reduction in export flows to the EU. The increase in trade towards alternative markets shows a geographical redistribution of Moroccan exports rather than a contraction of the sector. The reduction of EU tomato imports from all countries where evidence of use of the relevant ASs is found amounts to 1 874 ktons (-99 %) in the most extreme case and falls to 1 020 (54 %) and 113 (6 %) when the scope of affected countries or the existence and costs of additional alternatives is allowed. This reduction of imports is partially compensated by adjustments in the EU market. EU net tomato production increases by 1 537 ktons (+8 %); 553 ktons (3 %) and 62 ktons (0.3 %) respectively. Therefore, EU tomato producers can replace up to 82% of the reduction in imports, however at the cost of significant increase in consumer prices (8 %). At the same time, EU tomato exports decrease by 1 017 ktons (-26 %), indicating that part of the production previously destined for external markets is redirected towards satisfying internal demand. As the size of the trade impacts diminish so does the increase in domestic prices (3 % and 0.3 % for the other two scenarios respectively), thus reducing the share of reduction in imports that is compensated by EU domestic production to approximately 55 %. reflecting an expansion of domestic supply in response to reduced import availability.

This case illustrates that the impact of stricter EU import requirements on third countries depends strongly on the ability of exporting countries to access alternative markets and substitute the relevant ASs in their production process. In the *'Not adapt – no scale'* scenario, Moroccan tomato exports to the EU are almost entirely redirected to non-EU destinations, while total production remains broadly unchanged. Under the *'Switch – EFSA+ – 20%'* and *'Switch – EFSA – 5%'* scenarios, the impact on EU trade is substantially smaller, reducing the need for trade reallocation and limiting impacts on both the Moroccan export sector and the EU market. The impacts on the production and trade of soybeans and soybean cakes in Brazil are summarised in Table 21.

Table 21. Main figures and production and trade dynamics resulting from the simulations of the three scenarios for tomatoes in Morocco.

	Scenario		
	Not adapt – no scale	**Switch – EFSA+ – 20%**	**Switch – EFSA – 5%**
Moroccan exports to the EU	−325 kt (−100%)	−195 kt (−60%)	−7 kt (−2.2%)
Eu tomato imports	−1,874 kt (−99%)	−1,020 kt	−113 kt
EU tomato production	+1,537 kt (+8%)	+553 kt (+3%)	+62 kt (+0.3%)
EU tomato exports	−1,017 kt (−26%)	−458 kt (−11%)	−44 kt (−1%)
EU consumer price	+8%	+3%	+0.3%
Moroccan total tomato production	Broadly unchanged	Broadly unchanged	Broadly unchanged
Moroccan export diversion to non-EU markets	Strong reallocation	Moderate reallocation	Limited reallocation
Main market effect	Severe loss of EU market access; EU market tightened	Moderate reduction in EU market access	Minor reduction in EU market access

Source: own elaboration

3.5. Targeted analysis for cyproconazole

This section provides the results of a detailed analysis of cyproconazole, and AS not approved in the EU since 31 May 2021. Cyproconazole is a triazole fungicide widely employed to protect cereals, legumes, coffee and other crops. Cyproconazole is a relevant AS according to the criteria set out in section 3.1. Under the harmonised classification it is labelled as 'toxic for reproduction' categories 1B (H360D - 'may damage the unborn child'), has 46 MRLs currently above the LOQ, residues havve been detected by monitoring in eight commodities coming from 13 different countries and is authorised for use in 39 countries for 46 unique commodities.

Out of the 46 commodities that currently have MRLs above LOQ, 28 could be lowered to the LOQ based on the conclusion of the EFSA risk assessment (Anastassiadou et al. 2021). Of the remaining 18 commodities, 10 are explicitly captured in the CAPRI agro-economic model used for the simulations and are analysed in detail here30. These 10 products represented in CAPRI cover both those for which the EU is self-sufficient (e.g. wheat, barley) and those for which the EU relies on imports (e.g. coffee beans, soybeans). It also covers products mainly used for food (coffee, wheat) and for feed (soybeans) (Table 22). In this table we report the total number of countries with detections or information on authorisation (e.g. there are four countries for which residues of cyproconazole have been detected in imports of Beans [Argentina, Bolivia, Brazil and Ukraine] and 11 where information on authorization is available [Argentina, Botswana, Brazil, Chile, Colombia, Dominican Republic, Ghana, New Zealand, Rwanda, Uganda and Zimbabwe]). In addition, in the second column we report the number of countries (for both detections and information on authorisation) which represent 80% of EU imports (e.g. for beans the 4 countries with detections do not reach 80% of imports, nor do the 11 for which we have information on use) or the countries for which the EU represents more than 50% of their exports (e.g. for beans Bolivia among the countries where residues have been found and Colombia for countries with information on authorisation). Residues of cyproconazole have been detected in imports of these commodities from four distinctive countries (Argentina, Bolivia, Brazil, Ukraine) and four commodities (beans, coffee, rapeseed and soybeans) and this AS is authorised for use in more than 140 countries. The countries from which we import significant amounts also represent the different regions of the world. This diversity allows us to explore multiple dimensions driving the heterogeneity, behavioural responses and additional costs of adaptation, even when the AS specific heterogeneity is not captured.

[30] The other eight commodities are apricots, asparagus, borage seeds, celeries, cherries, globe artichokes, gold of pleasure seeds, and lettuce and salads plants.

Table 22. Commodities explicitly represented in the agro-economic model used for the simulation and that would be affected by the reduction of MRLs to LOQ for cyproconazole.

Commodity (self-sufficiency ratio)	**Number of countries with detections / information on authorisation**	**Number of countries with residues detected or information on authorisation (covering 80 % of EU imports or with export dependency above 50 % to the EU).**
Barley (112.2 %)	0 / 23	0,0,0 / 23,2, 23
Beans (99.1 %)	4 /11	4,1,4 / 11,1,11
Coffee (0 %)	1/13	1,1,1 / 13,3,13
Common millet/proso millet (94.3 %)	0 / 8	0,0,0 / 1,0,1
Oat (100.0 %)	0 /19	0,0,0 / 19,0,19
Peas (65.9 %)	0 / 13	0,0,0 / 0,2,2
Rapeseeds/canola seeds (78.8 %)	1 /12	1,1,1 / 12,3,12
Soybeans (8.6 %)	1 / 19	1,0,1 / 2,0,2
Sugar beet (110.3 %)	0 / 11	0,0,0, / 31,1,31
Wheat (122.4 %)	0 / 31	0,0,0 / 31,1,31
TOTAL	6 / 147	6 / 132

The last column reports the number of total countries that either cover 80 % of the EU's total imports for the commodity, have more than 50% of their total exports directed to the EU and the combination of both.

Source: own elaboration based on residue detections, Homologa®, COLEAD, COMEXT and UN-COMTRADE databases. Homologa® (Lexagri SAS). Aggregated from a single extract taken on February 2026, reflecting the position as at 2026. Not updated since, and not the current regulatory position. Provided for reference only, without warranty. See section 2.1.2.2. Current data: www.homologa.com

For some crops (e.g. oats, peas, rapeseed/canola) the main EU suppliers are countries that either do not use cyproconazole or have not recorded residues above the LOQ. However, for six crops the EU depends heavily on a single exporter that has also authorisation of use for cyproconazole. For barley, rapeseed/canola, sugar-beet, oats, peas and wheat, Ukraine plays a pivotal role, supplying a large share of the EU market while remaining a cyproconazole-authorised producer and residues have been detected in imports of rapeseed. In the case of coffee beans and soybeans, Brazil is the dominant supplier and is the only country among the authorised users that shows residues above the LOQ. For sugar beet, the EU is the principal destination for the exports of Turkey and New Zealand. Finally, wheat, peas and oats also involve other notable exporters - Russia, Kazakhstan, Israel, Peru, South Africa and Belarus - whose trade links with the EU are sufficiently strong to justify attention.

Regarding residue detections via monitoring, no residues have been found for six of the ten commodities; barley, common millet, oats, peas, sugar beet and wheat. Residues in beans have been found in imports from four countries (Argentina, Bolivia, Brazil and Ukraine) with detection rates ranging from 100 % (Bolivia) to 1.8 % (Argentina). cyproconazole residues have also been found in 13 % of the shipments of coffee beans form Brazil, in 21 % of the imports of rapeseed from Ukraine, and 6 % of the imports of soybeans from Brazil.

3.5.1. Chemical classification and agronomic applications

Cyproconazole is a sterol-biosynthesis inhibitor (SBI) belonging to the demethylation-inhibitor (DMI) subgroup (Fungicide Resistance Action Committee (FRAC)[31] group 3). The product is supplied as soluble concentrate for dilution in water and foliar spray application. It is applied as an individual AS with a single mode of action or in mixtures with other ASs to a broad range of crops (fruits, vegetables, coffee and cereals) to aid resistance management (Cao et al. 2019; Jørgensen & Heick, 2021).

Since the first triazoles appeared in the 1970s, DMIs have offered strong control of foliar fungal diseases, protecting yields and quality, and helping to avert economic losses. For example, the 2021 US maize tar spot outbreak destroyed 5.9 million tonnes of US maize grain, and cost approximately $1.53 billion[32] (Ross et al. 2023). Another example is the reported annual economic losses due to soybean rust which amount to no less than $2 billion in Brazil (Alves et al. 2021).

The (sterol biosynthesis inhibiting (SBI) class to which cyproconazole belongs is divided into four sub-groups, each of which inhibits a different enzyme in the sterol-biosynthesis pathway. Three of these groups are used in agriculture:

- Demethylation Inhibitors (DMIs) – FRAC 3
- Amines – FRAC 5
- Keto-Reductase Inhibitors (KRIs) – FRAC 17

DMIs have a broad spectrum of activity against many fungal pathogens, amines have a narrower spectrum, and KRIs are specifically effective against botrytis (gray mold) and have the narrowest spectrum. Amines include fungicides such as fenhexamid, benalaxyl, metalaxyl, flutolanil, tolylfluanid, and dichlofluanid. Apart from metalaxyl (Gupta & Gupta, 2025), these fungicides have low toxicity.

An important issue to consider in the use of pesticides is the emergence of pest resistance. FRAC defines fungicide resistance as an acquired, heritable reduction in the sensitivity of a fungus to a specific anti-fungal agent (or fungicide)[33]. Because DMIs share the same target site, pests resistant to cyproconazole are also resistant to other DMIs, but cross-resistance does not occur between different SBI sub-groups. FRAC therefore recommends rotating or mixing products from different FRAC groups to slow the development of resistance.

Beyond SBIs, other major relevant groups with different modes of action include

- Quinone outside Inhibitors (QoIs) – FRAC Group 11 (e.g. azoxystrobin, pyraclostrobin, trifloxystrobin, picoxystrobin). They are broad-spectrum but carry a high resistance risk.
- Succinate Dehydrogenase Inhibitors (SDHIs) – FRAC Group 7 which contains a large number of active ingredients (e.g. fluxapyroxad, bixafen, pydiflumetofen, flutolanil). These are effective against a wide range of pathogens and have a medium resistance risk.

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31 https://www.frac.info/

32 Calculation obtained using the annual maize price of $259.55/t (World Bank Commodity Prices database).

33 https://www.frac.info/fungicide-resistance-management/background-information/

- Multi-site Inhibitors – FRAC Groups M1, M3, M4, M5, etc. (e.g. copper hydroxide M1, mancozeb M3, captan M4): These fungicides act on multiple target sites within the fungus, making resistance development very unlikely. These are often used in mixtures or rotations to protect higher-risk single-site fungicides.
- Methyl benzimidazole carbamates (MBCs) – FRAC Group 1 (e.g. carbendazim, thiophanate-methyl). They have a high resistance risk and cross-resistance is common within this group.
- Phenylpyrroles – FRAC Group 12 (e.g. fludioxonil): These act by disrupting osmotic signal transduction in fungi. They are primarily used as seed treatments and against Botrytis and Fusarium species, with a low to medium resistance risk.
- Antibiotic Fungicides – FRAC Group 24 (e.g. kasugamycin). These inhibit protein synthesis in bacteria and certain fungi. They have a low resistance risk.
- Dicarboximides – FRAC Group 2 (e.g. procymidone): These fungicides carry a medium to high resistance risk.
- Organophosphates (fosetyl-Aluminium) – FRAC Group 33: This fungicide has a low resistance risk.
- Botanicals and Biologicals: Some products like azadirachtin (crude) are botanical extracts with fungicidal properties. Similarly, lactic acid is a biochemical agent rather than a conventional synthetic fungicide.

Table 23 summarises the principal fungal diseases that affect each of the ten focus crops, the active ingredients that are commonly employed to control those diseases, and the agronomic benefit that growers can expect from a successful treatment. Across the crop spectrum most products belong to the DMI subgroup of SBIs. For barley all fungicides in the table are DMIs except for fluxapyroxad, which is an SDHI. For beans fungicides include DMIs, QOIs and SDHIs. For coffee fungicides include DMIs, a QOI (pyraclostrobin) and a multi-site inhibitor (copper hydroxide, FRAC M1). For common millet DMI, a wide array of fungicides spanning DMIs (e.g. difenoconazole), SDHIs (bixafen, fluxapyroxad), multi-site inhibitors (mancozeb, copper oxychloride) and other chemicals (e.g., benzimidazoles, phenylpyrroles) are authorised to control rust and powdery mildew, thereby protecting leaf area and grain quality. Fungicides used to treat maize include DMIs (prothioconazole, cyproconazole), QoIs (pyraclostrobin), SDHIs (fluxapyroxad), and multi-component mixtures (e.g. mefentrifluconazole + pyraclostrobin + fluxapyroxad).

For oats, the list combines DMIs (prothioconazole, tebuconazole), QoIs (pyraclostrobin), and multi-site inhibitors (epoxiconazole, copper-based products). For peas disease control relies on a multi-site inhibitor (mancozeb, FRAC M3) and a QoI-DMI combination (azoxystrobin + tebuconazole).

For rapeseed, the portfolio mixes DMIs (prothioconazole, tebuconazole), an SDHI (bixafen), a QoI (pyraclostrobin) and a multi-site inhibitor (procymidone, FRAC M2). Fungicides used for protecting rice include DMIs (propiconazole) and QoIs (azoxystrobin, pyraclostrobin), together with an SDHI (fluxapyroxad) and antibiotic-type bio-fungicides (validamycin, kasugamycin). DMIs (difenoconazole, metconazole, prothioconazole, tebuconazole), QoIs (pyraclostrobin, azoxystrobin), SDHIs (pydiflumetofen) and multi-site inhibitors (mancozeb) are used in soybean production, whereas the DMI-QoI combination epoxiconazole + pyraclostrobin controls cercospora leaf spot, rust and powdery mildew in sugar beet production.

For wheat, an extensive portfolio spans multiple MoA groups: SBIs (various DMIs), QoIs (pyraclostrobin), SDHIs (fluxapyroxad), multi-site inhibitors (copper hydroxide, mancozeb).

Table 23. Target fungal diseases controlled by fungicides in major crop species and the agronomic benefits reported in the literature.

Crop	Target diseases	Fungicides	Application benefits	References
Barley	Leaf blight, Scald (caused by *Rhynchosporium comune*)	Triadimenol; fluxapyroxad; flutriafol; prothioconazole + tebuconazole; flutriafol + prothioconazole + tebuconazole; prochloraz; triadimefon; propiconazole; cyproconazole; fenarimol	Reduces disease stress, supports plant vigour and grain quality	Hiddar et al. (2023); McLean & Hollaway (2018); Kerse & Ballard (1989); Kerse & Ballard (1984)
Beans	Chocolate spot, rust	Boscalid + pyraclostrobin; azoxystrobin; tebuconazole; metconazole; cyprodinil + fludioxonil	Controls rust and chocolate spot in field beans, protecting yield by reducing foliar disease severity during pod fill	Gillbard (2021)
Coffee	Coffee-berry disease, coffee leaf rust	Trifloxystrobin; azoxystrobin; triadimenol; cyproconazole; epoxiconazole; pyraclostrobin; copper hydroxide; hydroxide + pyraclostrobin; hydroxide + cyproconazole	Reduces the severity of leaf rust and maintains berry yield	Honorato et al (2015); da Costa et al. (2019)
Common millet/proso millet	Rust, powdery mildew	Azoxystrobin; difenoconazole; epoxiconazole; bixafen; fluxapyroxad; mancozeb; copper oxychloride; benzimidazoles; phenylpyrroles	Controls rust and powdery mildew, protecting leaf area and supporting grain quality	Homologa®
Maize	Grey leaf spot, northern corn leaf blight, Tar-spot	Mefentrifluconazole + pyraclostrobin + fluxapyroxad; prothioconazole + trifloxystrobin; pyraclostrobin; cyproconazole + picoxystrobin; mefentrifluconazole + pyraclostrobin;	Enhances resistance to fungal pathogens, ensuring better cob quality	Telenko et al. (2022); Ross et al. (2023)

Crop	Target diseases	Fungicides	Application benefits	References
		pydiflumetofen + azoxystrobin + propiconazole; pyraclostrobin + metconazole; azoxystrobin + flutriafol; propiconazole; flutriafol + bixafen; propiconazole + pydiflumetofen + azoxystrobin		
Oats	Septoria, Blackleg, stem rust, leaf Rust, Net Form of Net Blotch, Powdery Mildew, Scald, Sclerotinia, Nodorum Blotch, Septoria Tritici Blotch, Spot Form Net Bloch, and Stripe Rust, Red Leather Leaf	Epoxiconazole; propiconazole; prothioconazole; tebuconazole; azoxystrobin + prothioconazole; pyraclostrobin + epoxiconazole; prothioconazole + tebuconazole; epoxiconazole + azoxystrobin; azoxystrobin + epoxiconazole; azoxystrobin + propiconazole	Not reported	(AW Vater Co, n.d.)
Peas	Black spot	Mancozeb; azoxystrobin + tebuconazole	Protects from infections	(AW Vater Co, n.d.)
Rapeseed/canola	Blackleg and Sclerotinia	Azoxystrobin; procymidone; prothioconazole; prothioconazole + bixafen; azoxystrobin + prothioconazole; pydiflumetofen + fludioxonil; prothioconazole + tebuconazole; prothioconazole + tebuconazole	Reduces Blackleg and Sclerotinia incidence, protecting stem integrity and pod-fill to maintain seed yield	(AW Vater Co, n.d.)
Rice	Sheath blight, narrow brown leave spot	Azoxystrobin; propiconazole + azoxystrobin + propiconazole; azoxystrobin + propiconazole; trifloxystrobin + propiconazole; propiconazole; fluxapyroxad; pyraclostrobin; flutolanil; antibiotics (validamycin and kasugamycin)	Triazole fungicides reduce sheath blight and brown spot severity, protect grain quality and milling yield, and improve overall yield.	Uppala & Zhou (2018)

Crop	Target diseases	Fungicides	Application benefits	References
Soybean	Phyllosticta leaf-spot, rust, powdery mildew	Azoxystrobin; cyproconazole; difenoconazole; epoxiconazole; fluquinconazole; flutriafol; metconazole; myclobutanil; picoxystrobin; propiconazole; prothioconazole; tebuconazole; tetraconazole; azoxystrobin + cyproconazole; cyproconazole + propiconazole; flusilazole + carbendazim; flutriafol + carbendazim; flutriafol + thiophanate-methyl; pyraclostrobin + epoxiconazole; trifloxystrobin + cyproconazole; trifloxystrobin + propiconazole; trifloxystrobin + tebuconazole	Reduces the severity of Asian soybean rust, reduces defoliation, and increases grain yield	(Scherm et al., 2009)
Sugar beet	Cercospora leaf spot, rust, powdery mildew	Epoxiconazole + pyraclostrobin	Controls diseases and increases yield; positive economic return	Heick et al. (2020)
Wheat	Leaf rust, powdery mildew, Septoria leaf spot, doexyivalenol Fusarium-head-blight	Fosetyl-aluminium; azoxystrobin + difenoconazole; azoxystrobin + cyproconazole; azoxystrobin + tebuconazole; lactic acid; azadirachtin (crude)+ lactic acid; trifloxystrobin + tebuconazole; azadirachtin (crude); pyraclostrobin + epoxiconazole; captan + hexaconazole; propiconazole; bromuconazole; cyproconazole; epoxiconazole/carbendazim; flusilazole/carbendazim; flutriafol; propiconazole; tebuconazole; tebuconazole/carbendazim; prothioconazole + tebuconazole; metconazole; prothioconazole; tebuconazole	Ensures healthier flag leaf, improving photosynthesis and yield	Paul et al. (2008, 2010, 2018)

Source: Own compilation from cited literature and product specifications accessed online [July 2026] via www.pomais.com.

Many of these fungicides are not approved in the EU (e.g. cyproconazole, epoxiconazole, hexaconazole, fenarimol, flutriafol, flusilazole, mancozeb, propiconazole, prochloraz, triadimenol, triadimefon), but some still have MRLs above the LOQ and would not be targeted by the reduction analysed in this study as they are not classified for one or more of the 'most hazardous' categories. On the other hand, it is worth noting that biological agents can be also used to combat fungal disease.

3.5.2. Alternative fungicides to cyproconazole

3.5.2.1. EU-approved triazoles

Ten triazoles remain approved in the EU, with expiration dates in the time period from 2026 to 2031 (Table 24). Approval can be renewed if the active substance continues to meet current approval criteria in force at the time of re-evaluation. They can be used as stand-alone AS in products or in mixtures with fungicides from other FRAC groups to broaden the spectrum and mitigate resistance. Therefore, a non-negligible number of ASs that can provide crop protection like cyproconazole are approved in the EU.

Table 24. List of triazole fungicides approved by the EU.

Alternative triazole fungicides	Current approval expiration date#
Bromuconazole	30 April 2027
Difenoconazole	31 January 2028
Mefentrifluconazole	20 March 2029
Metconazole	31 August 2031
Paclobutrazol	31 January 2029
Penconazole	15 October 2026
Prothioconazole	31 March 2027
Tebuconazole	15 August 2026
Tetraconazole	31 March 2027
Triticonazole	31 July 2028

Valid as of July 2026, these dates may be extended to allow for completion of the renewal processes.

Source: EU Pesticide Database.

3.5.2.2. Alternatives to chemical fungicides

Biological control agents are an important alternative for chemical fungicides. As most biocontrol ASs that have been approved for use in the EU are micro-organisms and they are exempt from MRLs, producers using them have a clear advantage in export markets because no residue testing is required. However, field evidence shows that these biocontrol ASs rarely achieve satisfactory disease control when pathogen pressure is high (Gabardo et al., 2019). Their efficacy depends on favourable environmental conditions, precise timing and adequate coverage, and they are typically combined with cultural measures or chemical ASs to obtain reliable protection. Consequently, while the regulatory exemption from MRLs offers a compliance benefit, biocontrol agents are not generally able to replace chemical fungicides as stand-alone solutions under severe disease pressure (Gabardo et al., 2019). As such, biocontrol ASs are best deployed as preventive components in integrated systems, for example targeting botrytis on grapes, soil-borne pathogens in citrus, and seed treatments, rather than as direct alternatives to DMIs or SDHIs under severe foliar disease pressure. At least 43 biological agents are currently used to prevent the disease that would be treated by cyproconazole in three of the crops that would be affected by the reduction of

MRLs to LOQ (barley, beans and millets). These are widely used in two of the most important countries in terms of production of these crops for which we have evidence of use of this AS on the 10 commodities (Brazil and Ukraine).

3.5.3. Status of alternatives in main countries of interest

Based on an analysis of trade-flows, residues and authorisations five countries require particular attention because they account for a large share of EU imports and have cyproconazole based products authorised for use (Ukraine, Brazil, Argentina, Turkey and Russia). The presence (or absence) of the alternatives to cyproconazole described above was examined for the most relevant crops in each of these countries.

Ukraine uses several EU approved alternatives to cyproconazole. azoxystrobin and prothioconazole are found on maize, barley, oats, peas, rapeseed, soybeans, sugar-beet and wheat, while tetraconazole appears on barley, peas, soybean, sugar-beet and wheat and metconazole on barley, rapeseed and wheat. The coexistence of these AS with cyproconazole indicates that it may be possible to substitute the triazole.

In Brazil there are alternatives to cyproconazole which are approved in the EU in use for cereal production such as fosetyl-aluminium, bixafen, metalaxyl-m, fluazinam and fluxapyroxad. However, it also uses some that are not approved in the EU such as propiconazole, flutriafol and mancozeb. Moreover, of those not approved ASs only flutriafol still has MRLs above LOQ for some categories of cereals but does not fall under the most hazardous category which is the object of this study. On the other hand, we have no evidence that pyraclostrobin (EU-approved) is used for coffee production, even if it is authorised for use in this crop. Brazil also uses EU approved alternatives to cyproconazole for soybean production, such as prothioconazole and pyraclostrobin.

Argentina uses EU-approved alternative fungicides for the production of beans such as azoxystrobin and metalaxyl-m and there is no evidence of cyproconazole use for beans production. For sugar beet production Turkey uses EU-approved alternatives to cyproconazole such as difenoconazole, azoxystrobin and tetraconazole. Russia uses EU-approved alternative fungicides to cyproconazole for the production of peas such as metalaxyl-m, and tetraconazole for wheat used. In conclusion, it seems that the alternatives identified for cyproconazole are available for the most relevant country – commodity pairs.

3.5.4. Performance and cost of the alternatives identified for the relevant crops

There are a limited number of studies that evaluate the performance of alternative fungicides, some of which do not directly compare them with cyproconazole. The most relevant efficacy and economic data are summarised in Table 25. Only alternatives that are EU-approved and that demonstrate a clear advantage (or at least parity) over cyproconazole have been retained. The table demonstrates that for each of the major crops, at least one EU-approved alternative attains a similar or higher level of disease suppression and can generate comparable or better economic returns, especially when the disease pressure is moderate to high. Moreover, the limited availability of alternative fungicides increases the risk of resistance.

Table 25. EU approved alternative fungicides performance across crops.

Crop (pest)	Best EU-approved alternative(s)	Yield benefit/economic return#	Remarks
Maize (tar-spot)	Prothioconazole + trifloxystrobin; metconazole + pyraclostrobin; mefentrifluconazole + pyraclostrobin; mefentrifluconazole + fluxapyroxad + pyraclostrobin	Mefentrifluconazole + pyraclostrobin: Up to + 238 kg ha^{-1} yield and partial return + € 34 ha^{-1} over cyproconazole + Picoxystrobin under high disease pressure. Prothioconazole + trifloxystrobin outperform cyproconazole + picoxystrobin in yield (+9.1 %)	Other mixtures such as metconazole + pyraclostrobin likely to outperform cyproconazole + picoxystrobin when the disease is severe. mefentrifluconazole + fluxapyroxad + pyraclostrobin are likely to match yield and partial return. mefentrifluconazole + pyraclostrobin + fluxapyroxad and pyraclostrobin were found to outperform cyproconazole + picoxystrobin in yield.
Soybean (rust)	Azoxystrobin; tebuconazole; prothioconazole + trifloxystrobin	Two studies: a) Yield difference of best alternative vs. best cyproconazole mixture +14 %; b) tebuconazole and prothioconazole or the mixtures of trifloxystrobin and Tebuconazole, all approved by the EU, perform similarly with better results in severity control than cyproconazole.	Azoxystrobin and tebuconazole are comparable or superior in disease control to cyproconazole. The use of trifloxystrobin + prothioconazole can outperform the use of azoxystrobin + cyproconazole or picoxystrobin + cyproconazole in yield.
Wheat (yellow rust, leaf rust, FHD)	Prothioconazole + tebuconazole; metconazole	For rusts yield increase difference between azoxystrobin 18.2 % + difenoconazole 11.4 % and azoxystrobin 18.2 % + cyproconazole 7.3 % is +6.2 %	EU-approved fungicides such as tebuconazole and blends such as azoxystrobin 18.2 % + difenoconazole 11.4 % and trifloxystrobin 25

Crop (pest)	Best EU-approved alternative(s)	Yield benefit/economic return[#]	Remarks
		Wheat yellow rust: cost-benefit of azoxystrobin 11 % + tebuconazole 18.3 % is 1:8.14 compared to 1:6.92 of azoxystrobin 18.2 % + cyproconazole 7.3 % Fusarium head blight index (IND) and doexyivalenol (DON metconazole; prothioconazole + tebuconazole; and tebuconazole lead to yield increases of are +450.4, 444.5, and 419.1 kg ha^{-1} compared with no treatment.	% + tebuconazole 50 % achieve higher yields than cyproconazole or cyproconazole blends. Other non-EU approved alternatives are best in cost-benefit terms (e.g. propiconazole 25 %: 1:14.37) Studies on Fusarium head blight index (IND) and doexyivalenol (DON) do not directly compared fungicide alternatives to cyproconazole.
Coffee (leaf rust)	Pyraclostrobin (QoI)	Severity reduction ~ 98 % compared to no treatment; cyproconazole achieved a severity reduction of ~ 93 %	Provides control on a par with cyproconazole-based regimes and is EU-approved.
Beans (chocolate spot)	Boscalid + pyraclostrobin; Azoxystrobin + tebuconazole	Boscalid + pyraclostrobin lead to a yield gain of up to + 17 % compared to 3.5 % yield gain of cyproconazole + chlorothalonil.	Both mixtures are permitted in the EU and outperform cyproconazole + chlorothalonil in yield.

[#] Yield benefit expressed as the difference between treated and untreated plots, or as partial economic return if reported.

Source: own elaboration based on available literature – full details in Source: own elaboration based on EFSA detection and UN-COMTRADE. Annex 3.

In addition to agronomic performance, the economic feasibility of replacing cyproconazole must be examined. The attractiveness of any alternative fungicide depends not only on its agronomic performance but also on its cost to the farmer. Because price information is scarce, we could not access country specific prices for the alternatives and relied on the New South Wales Department of Primary Industries (NSW-DPI) retail-price guide for winter-cereal foliar fungicides. The guide uses Equation 7 to approximate the cost per hectare.

Equation 7 $$\boldsymbol{Cost}\left(\frac{\text{€}}{\mathbf{ha}}\right) = \boldsymbol{Price}\left(\frac{\text{€}}{\boldsymbol{litre}}\right) \times (\boldsymbol{Application\ Rate\ in\ Litres\ per\ hectare})$$

Cost is the product of the price per litre and the recommended application rate (mL ha-1). Converting the Australian dollar values to euro (using the average 2024 exchange rate of 1AUD ~ €0.60) yields the cost range shown in Table 26.

Table 26. Cost per hectare of EU-approved fungicides (application rates shown).

Fungicide	**Application rate (mL/ha)**	**Cost (€/ha)**
Azoxystrobin	160–640	1.56-6.24
Prothioconazole 150 + bixafen 75	300-500	7.75-12.92
Prothioconazole 150 + azoxystrobin 200	200-400	2.70-5.40
Prothioconazole 175 + trifloxystrobin 150[a]	600-750	17.00-21.30
Prothioconazole 480	70-130	2.02-3.74
Prothioconazole 210 + Tebuconazole 210	150-300	2.34-4.68
Metconazole + pyraclostrobin[a]	-	56.08-61.95
Mefentrifluconazole 100 + fluxapyroxad 50	750	29.14
Tebuconazole 430	145-290	1.00-2.00
Tebuconazole 370 + azoxystrobin 222	170-340	3.06-6.12

[a] Obtained from fungicide selling companies (e.g. FBN) and trials (Wise et al. 2019).

Source: New South Wales Department of Primary Industries (NSW-DPI) retail-price guide for winter-cereal foliar fungicides unless otherwise mentioned.

From the data presented we can see that replacing cyproconazole with any of the EU-approved fungicides listed in Table 26 raises the per hectare expenditure, because the stand-alone cost of cyproconazole is only €0.20 – €0.79 ha^{-1} (depending on whether the low or high application rate is used)34 while the alternatives range from €1.00 ha^{-1} (tebuconazole 430) up to €61.95 ha^{-1} (metconazole + pyraclostrobin).

Specific examples illustrate how the cost difference depends on the recommended spray volume and whether cyproconazole is applied on its own or as a blend:

[34] The mixture azoxystrobin 200 + cyproconazole 80 costs aud 43.06 with application rates varying between 200 and 800 ml ha^{-1}. the cost of the cyproconazole component is obtained by (1) recognising that it forms 80 g l^{-1} of the 200 g l^{-1} azoxystrobin + 80 g l^{-1} cyproconazole mixture, i.e. 28.6 % of the product; (2) converting the listed price of 20 aud l^{-1} to euros using the average 2024 rate 0.60 €/aud rate to give ~ 12.1 €/l; (3) applying the 28.6 % share to this price to arrive at a cyproconazole price of ~ 3.46 €/l; (4) proportionally scaling the recommended spray volume of 200–800 ml ha^{-1} to 57–229 ml ha^{-1} (0.057–0.229 l ha^{-1}) for cyproconazole; and (5) multiplying the volume by the cyproconazole price, yielding a cost of roughly €0.20–€0.79 per hectare.

— The least expensive EU-approved products are the single-active Tebuconazole and prothioconazole, costing between €1 and €4 ha^{-1} depending on the application rate. The cheapest alternative, tebuconazole alone is about two to four times more expensive than cyproconazole, and azoxystrobin alone, is roughly three to eight times more expensive than cyproconazole, while the most complex mixtures (e.g., mefentrifluconazole + pyraclostrobin, metconazole and pyraclostrobin, prothioconazole + trifoxystrobin, trifloxystrobin + prothoconazole) can be 150 to 300 times more expensive.

— Substituting cyproconazole (with a cost range from €0.20 ha^{-1} to €0.79 ha^{-1}) with the tebuconazole 370 + azoxystrobin 222 blend would increase the per hectare cost by about 1 430 % at the lowest recommended rate (from €0.20 ha^{-1} to €3.06 ha^{-1}), and by 675 % at the highest rate (from €0.79 ha^{-1} to €6.12 ha^{-1}). Replacing cyproconazole with prothioconazole 150 + azoxystrobin 200 increases the cost by 1 250 % at the lowest recommended spray rate (from €0.20 ha^{-1} to €2.70 ha^{-1}) but reduces the cost by about 584 % at the highest rate (from €0.79 ha^{-1} down to €5.40 ha^{-1}).

— Substituting a blend using cyproconazole (with a cost range from €2.4 ha^{-1} to €9.6 ha^{-1}) with the tebuconazole 370 + azoxystrobin 222 blend would increase the per hectare cost by about 28 % at the lowest recommended rate (from €2.40 ha^{-1} to €3.06 ha^{-}), but would actually reduce the cost by roughly 36 % at the highest rate (from €9.60 ha^{-1} to €6.12 ha^{-1}). Replacing the same cyproconazole blend with prothioconazole 150 + azoxystrobin 200 increases the cost by 13 % at the lowest recommended spray rate (from €2.40 ha^{-1} to €2.70 ha^{-1}) but reduces the cost by about 44 % at the highest rate (from €9.60 ha^{-1} down to €5.40 ha^{-1}).

Efficacy studies documented in the section 3.5.2 show that many of the higher-priced mixtures deliver substantial yield gains under moderate to high disease pressure. For example, in the maize tar-spot trials of Ross et al. (2023) the combination mefentrifluconazole + pyraclostrobin increased yield by 696 kg ha^{-1} under low-severity conditions and by 921 kg ha^{-1} under high-severity conditions, i.e. ~ 35 % more grain than the cyproconazole + picoxystrobin blend. The metconazole + pyraclostrobin mixture gave yields that were + 555 kg ha^{-1} (low) and + 781 kg ha^{-1} (high), again outperforming the cyproconazole-based treatment (+3 kg ha^{-1} (low) and + 683 kg ha^{-1} (high)). Even the single-active pyraclostrobin increased yields by + 257 kg ha^{-1} (low) and + 579 kg ha^{-1} (high), although under the most severe disease pressure its gain was 26 % lower than that of cyproconazole.

In the independent maize study of Telenko et al. (2022) the prothioconazole + trifloxystrobin mix produced a 7.9 % yield increase, whereas the cyproconazole + Picoxystrobin combination delivered a -1.2 % change relative to the untreated control.

For soybean rust, Lana et al. (2018) reported that cyproconazole alone gave a 27.7 % yield response, while the EU-approved ASs Azoxystrobin and Tebuconazole each provided 29.6 %. Moreover, the EU-approved trifloxystrobin + prothioconazole mixture achieved the highest response of 64.8 %, i.e. ~ 314 % higher than cyproconazole.

In wheat, field data from India (Tak et al. 2021) show that the EU-approved blend azoxystrobin 11 % + tebuconazole 18.3 % delivered an 18 % higher benefit-to-cost ratio than the non-EU blend azoxystrobin 18.2 % + cyproconazole 7.3 %, even though the absolute yield increase (~ 50 % vs ~ 55 %) was slightly lower. In South-African wheat, tebuconazole gave a 68 % yield increase, virtually identical to the 67.6 % increase reported for cyproconazole. Meta-analyses of wheat fusarium-head-blight trials (paul et al. 2010) rank eu-approved combinations metconazole and prothioconazole + tebuconazole among the top performers, with yield gains of ~ 450 kg ha^{-1}.

The extra cost that farmers must spend on an approved alternative may be largely compensated by the additional grain produced as well as by the avoidance of health and environmental externalities linked to cyproconazole.

A maize study comparing fungicides dealing with tar spot indicate high economic returns for alternative fungicides compared to the combined use of cyproconazole with Picoxystrobin. Results show return differences of \$111.7 ha^{-1}, \$93 ha^{-1}, \$45.1 ha^{-1}, \$42.4 ha^{-1}, and \$11.5 ha^{-1} for mefentrifluconazole and pyraclostrobin, metconazole and pyraclostrobin, flutriafol and bixafen, pyraclostrobin, and mefentrifluconazole and fluxapyroxad and pyraclostrobin, respectively. Moreover, a cost-benefit analysis comparing the use of different fungicides indicates that the use of azoxystrobin 11 % + tebuconazole 18.3 % yields higher benefits (+18 %) than azoxystrobin 18.2 % + cyproconazole 7.3 %.

Nevertheless, the reduction in the number of available alternatives such as difenoconazole, heightens the risk of resistance development. Fewer fungicide classes increase the likelihood of resistant pathogen populations, which could raise future control costs for growers.

Based on the evidence, chemical and biological fungicides are available that farmers could use as alternatives to cyproconazole. There is less evidence regarding the current use of cyproconazole and the costs of changing to use an alternative fungicide. However, the evidence indicates that the cost of changing to an alternative fungicide may not be substantial in the short-term, especially if the yield using the alternative fungicide matches or even increases the yield obtained with the use of cyproconazole. In the medium term the lack of a wide range of alternative fungicides may cause resistance issues, which may erode yields and consequently income.

3.5.5. Potential impact of replacing cyproconazole

The evidence presented in this section has examined the feasibility of substituting cyproconazole in the production of ten major crops if the MRL for cyproconazole was reduced to the LOQ. Among the fungicides currently authorised in the EU, ten triazole active ingredients and a limited set of DMI-QoI or DMI-SDHI blends provide disease control that is equal to or superior to that achieved with cyproconazole-based products for the crops under review. The most widely applicable alternatives are azoxystrobin, prothioconazole, tebuconazole and metconazole, either as single-active formulations or in combination with a QoI or an SDHI. Our analysis assumes that these ASs will remain approved in the EU, were it not to be the case costs would probably have to be revised upwards.

Trade-flow analysis confirms that the EU is a primary destination for a substantial share of barley, rapeseed, sugar beet, oats, peas and wheat produced in countries that currently rely on cyproconazole. In those supply chains a transition to EU-approved alternatives would be necessary; where such a transition is not feasible, exporters would need to adopt product segregation or redirect shipments to non-EU markets.

The quantitative assessment of cost and yield effects shows that the cost of the EU-approved alternatives is generally higher than that of a cyproconazole-only treatment (≈ €0.20 – €0.79 ha^{-1}). Assuming that cyproconazole is replaced with the cheapest alternative (tebuconazole) the increase in crop protection costs ranges from 100 % to 200 %. Considering that crop protection costs amount to 20 % of the total crop specific costs (see footnote 19) the total cost increase would be around 20 % to 40 %. However, this cost does not take into account the additional costs related to value chain segregation and additional testing that could be needed to reduce the risk of non-compliance when exporting to the EU. Nevertheless, the additional expense of replacing cyproconazole for an alternative is reduced when an extra grain revenue is generated by higher yields.

It should be stressed that the data underpinning these conclusions are derived from a relatively limited set of peer-reviewed studies, most of which focus on a few agro-ecological zones (North America, South America and India). Pathogen dynamics, climatic conditions, cropping practices and resistance levels differ markedly across regions, so the magnitude of yield gains and the exact price premium observed in the literature may not be reproduced everywhere. Consequently, the 20 % to 40 % figure should be interpreted as a broad indicator rather than a precise forecast for any individual production system.

However, besides the estimate of a precise cost increase associated with replacing cyproconazole the main contribution of this section is to showcase the heterogeneity of impacts across commodities and countries. For this, we focus on four main characteristics of the country commodity pair: the number of alternative ASs that can tackle the same pest as cyproconazole (i.e. fungus-based diseases), the effectiveness of those alternatives compared to cyproconazoles, the relative cost of those alternatives compared to cyproconazole and the risk of developing resistance due to limited crop protection alternatives. Based on these four criteria we can conclude that the impact in costs of production can be higher, lower or approximately the average as summarized in Table 27. As it can be seen the heterogeneity is driven by commodities (potentially lower for beans but higher for soybeans) and by countries (potentially higher costs in Brazil but lower in Argentina); but we also find commodities with different expected costs across different countries (sugar beet in Turkey and Ukraine). Adding the additional dimension of different ASs would most probably only increase this heterogeneity, therefore calling for a detailed triad-specific analysis to obtain a better representation of impacts compared to the homogenous approach used in the scenarios described in section 2.3.

Table 27. Qualitative assessment of potential cost of replacing cyproconazole based on key characteristics.

	Higher cost than average	**Approximately average cost**	**Lower cost than average**
Number of alternatives	None or only one	Several	Multiple
Effectiveness of alternatives	Lower	Similar	Similar
Additional cost of alternatives	Very high	High	Limited or none
Risk of developing resistance	High	Medium	Low
Country commodity examples for cyproconazole	Brazil – coffee beans Brazil – soybeans	Ukraine – barley Ukraine – oats Ukraine – rapeseed Ukraine – sugar beet Ukraine – wheat Russia – peas Russia - wheat	Argentina – beans Turkey – sugar beet

Source: Own elaboration.

3.6. Qualitative analysis of exposure for commodities not explicitly represented in CAPRI

For the sake of conciseness, the chapter synthesises key results. However, the full and detailed analysis is reported in Annex 4. The results presented in this chapter highlight the main exporting third countries —i.e. those with comparatively higher dependency on exports to the EU— and imported commodities —i.e. those for which the EU is not self-sufficient. Also, the results included in tables and figures refer to commodities with both detection status and registration in third countries. However, additional figures and information on countries and commodities, are available in the online dashboard referenced in section 2.6. Please note that all figures are constructed only for the commodities not explicitly represented in CAPRI.

3.6.1. Third countries' exposure

A third country's potential exposure can be tackled from at least three perspectives: (1) A third country's absolute export value to the EU of the considered commodities; (2) The relative importance of a third country's export to the EU relative to its total export of the same commodities (export dependence); (3) The relative importance of a third country's export to the EU relative to its total domestic agricultural production (macroeconomic dependence).

Figure 11 show these three relevant dimensions —export dependence, production dependence, and absolute export values— displaying only the third countries that fall among the 15 top ranked countries in at least one of the three dimensions. In principle, the top-right quadrant of Figure 11 should capture the third countries with highest combined dependence on exports to the EU of total exports and agricultural production. However, no country appears in this quadrant, revealing that no third country is highly exposed in terms of both export to the EU on total exports and on domestic agricultural production.

Differently, 16 third countries[35] appear in the bottom-right quadrant, hence showing a relatively high export dependency on the EU market, but a relatively low macroeconomic dependency of their domestic agricultural production on these exports. If exports to the EU were to be disrupted, the impact would likely concentrate mainly upon export operators but with relatively limited effects on the overall domestic economy. Among these countries, those showing the highest absolute export values to the EU are Turkey (5.1 billion $), Morocco (2.8 billion $), Colombia (2.3 billion $), Brazil (1.3 billion $), and Ukraine (1.2 billion $). The remaining countries in this quadrant —Bosnia and Herzegovina, Benin, Uruguay, Moldova, Cameroon, Serbia, Republic of North Macedonia, United Kingdom, Panama, Suriname, and Senegal— show absolute export values lower than 1 billion $. For the countries in this quadrant, which we can refer to as "**export-dependent countries**", it may be concluded that, while the national agricultural production may not be highly exposed, those segments of the economy operating in the pesticide-commodity exports may be highly exposed, and the economic value at stake for these segments is particularly higher in the case of Turkey, Morocco, Colombia, Brazil, and Ukraine.

On the other hand, only three third countries appear in the top-left quadrant, hence showing a relatively high macroeconomic dependence of domestic agricultural production on exports to the EU, but a relatively low dependence of total exports on exports to the EU. These countries are Costa Rica (14 % of domestic agricultural production to export to the EU), Ecuador (9 %), and Peru (7 %). All these countries also show a non-insignificant absolute value exported to the EU, respectively 1.7 billion $, 3 billion $, and 3.8 billion $. These countries, which can be referred to as "**production dependent countries**", show that a relatively low share of exports to the EU can still be

[35] In descendent order of percentage share of export to the EU on export to world: Bosnia and Herzegovina, Morocco, Uruguay, Benin, Cameroon, Moldova, United Kingdom, Ukraine, Republic of North Macedonia, Serbia, Panama, Suriname, Colombia, Turkey, Senegal, Brazil.

economically significant for the country, and consequently exposes the national economy to the reduction of MRLs for the most hazardous ASs to the LOQs.

Lastly, the bottom-left quadrant shows the 11 third countries[36] with relatively low export and macroeconomic dependency. However, some of these countries show a relatively high absolute export value to the EU, including (in descending order): United States (17 billion $), China (1.6 billion $), Vietnam (2.3 billion $), Chile (2 billion $), Israel (1.2 billion $), South Africa (1.2 billion $) and Canada (1.4 billion $). The remaining countries show export values lower than 1 billion $. For the countries in this quadrant, which can be referred to as countries with "**export value at stake**", it may be considered that, while neither the national production nor the total exports are particularly exposed, the value at stake for the operators specifically involved in exports to the EU of the considered pesticide-commodities may be not insignificant.

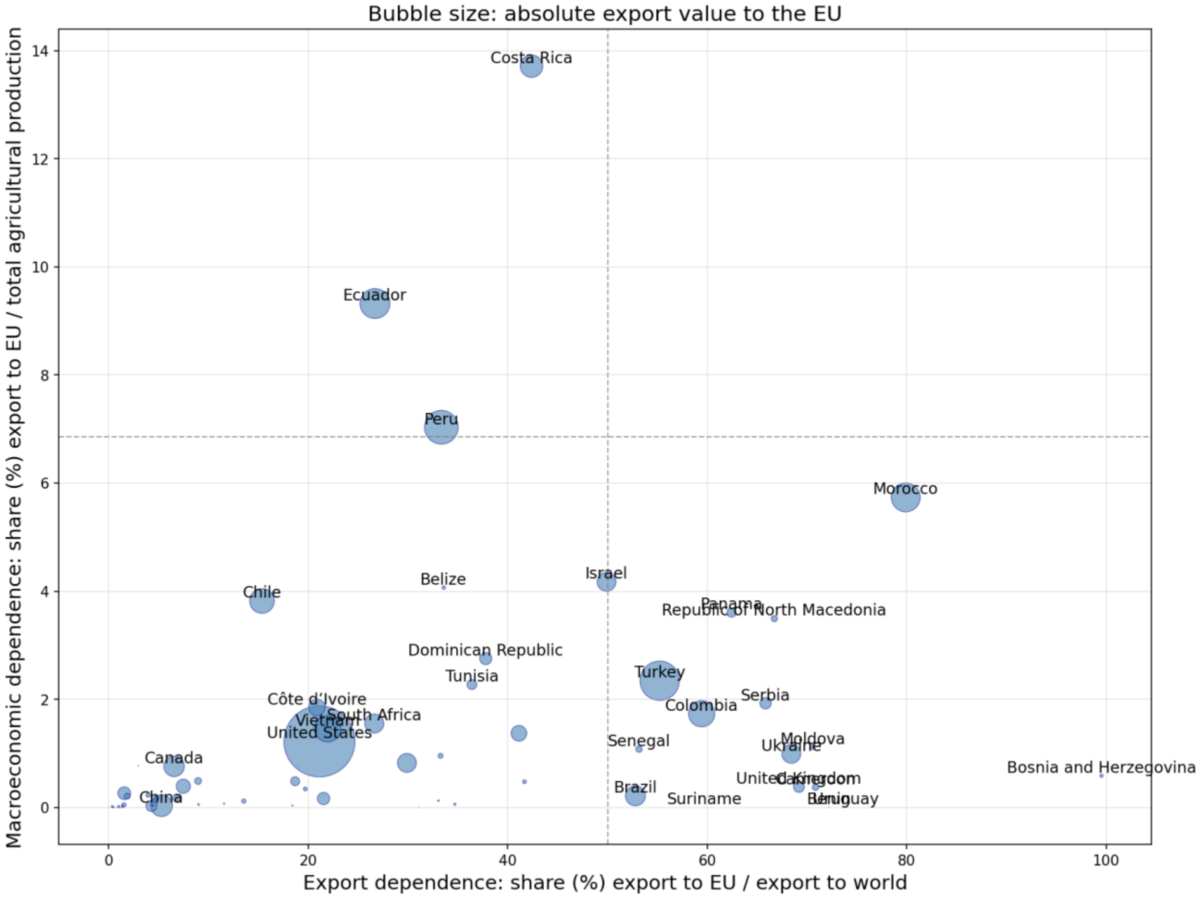
Therefore, for a proper identification of the third countries somehow exposed to the reduction of MRLs to LOQs, it should be considered that different forms of exposure exist, each with different possible implications. Specifically, according to the analyses presented in Figure 11, 30 third countries are (qualitatively) identified as potentially exposed, namely:

- As **export dependent countries**: Bosnia and Herzegovina, Morocco, Uruguay, Benin, Cameroon, Moldova, United Kingdom, Ukraine, Republic of North Macedonia, Serbia, Panama, Suriname, Colombia, Turkey, Senegal, Brazil.
- As **production dependent countries**: Peru, Ecuador, and Costa Rica.
- As **countries with export value at stake**: United States, Vietnam, Chile, China, Canada, South Africa, Israel, Côte d'Ivoire, Dominican Republic, Tunisia, Belize. With a special focus on United States, China, Vietnam, Chile, Israel, South Africa and Canada which show the highest export values (1 billion $ or above).

For the sake of conciseness and relevance of the analysis, the following analyses will focus on the 30 third countries which we classify as exposed.

[36] In descendent order of absolute export value to the EU: United States, Vietnam, Chile, China, Canada, South Africa, Israel, Côte d'Ivoire, Dominican Republic, Tunisia, Belize.

Figure 11. Third countries' dependency on exports to the EU across all commodities not explicitly covered in CAPRI.



Note: The figure shows the 30 shortlisted third countries, including the top 15 countries with highest absolute export value to the EU, top 15 countries with highest share of export to the EU on total export, and the top 15 countries with highest share of export to the EU on total agricultural production.

Source: Own elaboration based on UN Comtrade data (export values) and FAOSTAT data (domestic agricultural production).

According to additional analyses provided as Annex 4, 16 third countries[37] have decreased their average export share to the EU in the past 10 years. Cameroon has reduced its reliance on the EU market by 79 %, and Benin by 67 %, suggesting that a significant trade diversion might be taking place. This is particularly relevant for both countries, which appear to be relatively less diversified in its export destinations but, at the same time, being somehow already in an export diversion path. In the same period, Brazil, Chile, Côte d'Ivoire, Panama, Senegal, United Kingdom, and Uruguay show a reduction of their reliance on the EU market by 8 % to 20 %, which might signal some tendency of change in trade patterns.

Metiram, mancozeb, carbendazim, thiophanate-methyl, and benomyl have been detected as residues or are authorised for use respectively in 17, 15, 11, 10, and 10 third countries which have

[37] Benin, Brazil, Cameroon, Chile, China, Côte d'Ivoire, Dominican Republic, Ecuador, Israel, Morocco, Panama, Senegal, Tunisia, United Kingdom, Uruguay, and Vietnam.

the EU as destination for more than 50 % of their total exports, whereas mepanipyrim and quinoxyfen affect only two countries dependent by at least 50 % on the EU market, metribuzin only one, and for dicofol and flufenacet there is no country meeting this criterion. Thus, metiram, mancozeb, carbendazim, thiophanate-methyl, and benomyl seem to be the active substances affecting the most third countries' exports to the EU. The analyses however only consider whether the ASs have been detected in imports or authorised for use, without any correction for intensity of use (as done with the rate of residue detections in the scenarios modelled), therefore the conclusions only identify potential exposure but would need to be confirmed using intensity of use data. Although a country may currently have a high dependency on the EU market, it may still show some capability to divert its export flows to other non-EU export destinations or towards its internal market if access to the EU were to be disrupted. Two indicators can help assess the extent to which a third country has possibility to divert its trade, namely:

- Export concentration (or diversification) index, specifically a Normalized Herfindahl–Hirschman Index (NHHI) [38]. A high diversification may signal a relatively higher capacity for the third country to divert (part of) its exports to other destinations, thus a lower exposure to MRLs' reductions.
- Export competitiveness, specifically a Symmetric Revealed Comparative Advantage (S-RCA) Index[39], which measures how strong a country is in the export of a commodity relative to the world: the strongest the country, the higher its capacity to divert export flows.

Figure 12 shows the NHHI diversification index and the S-RCA competitiveness index for the 30 most exposed third countries. Most countries are comparatively very competitive and very diversified in export flows (bottom-right quadrant), suggesting a comparatively higher potential capability to divert trade routes in response to MRLs being reduced to the LOQ. These countries40 may rely not only on a greater number of possible export destinations, but on a stronger specialization in exporting the considered commodities.

The third countries showing the highest diversification (NHHI < 0.2) —hence the highest potential to divert their export routes— are Tunisia, South Africa, Ecuador, United States, Canada, Vietnam, and China. In particular, China, Canada, United States and South Africa show very high number of export destinations, varying between 119 and 166 countries. According to these figures, China appears to be the third country with the most diversified export pattern for the commodities for which the considered ASs are used. Conversely, Benin and United Kingdom show the lowest diversification and competitiveness (top-left quadrant), indicating the comparatively lowest capability of these two countries to divert export flows. This calls for particular attention on these two countries, which are highly exposed and possibly in a worse position to change their trade patterns following the reduction of MRLs to the LOQ by the EU for the relevant ASs.

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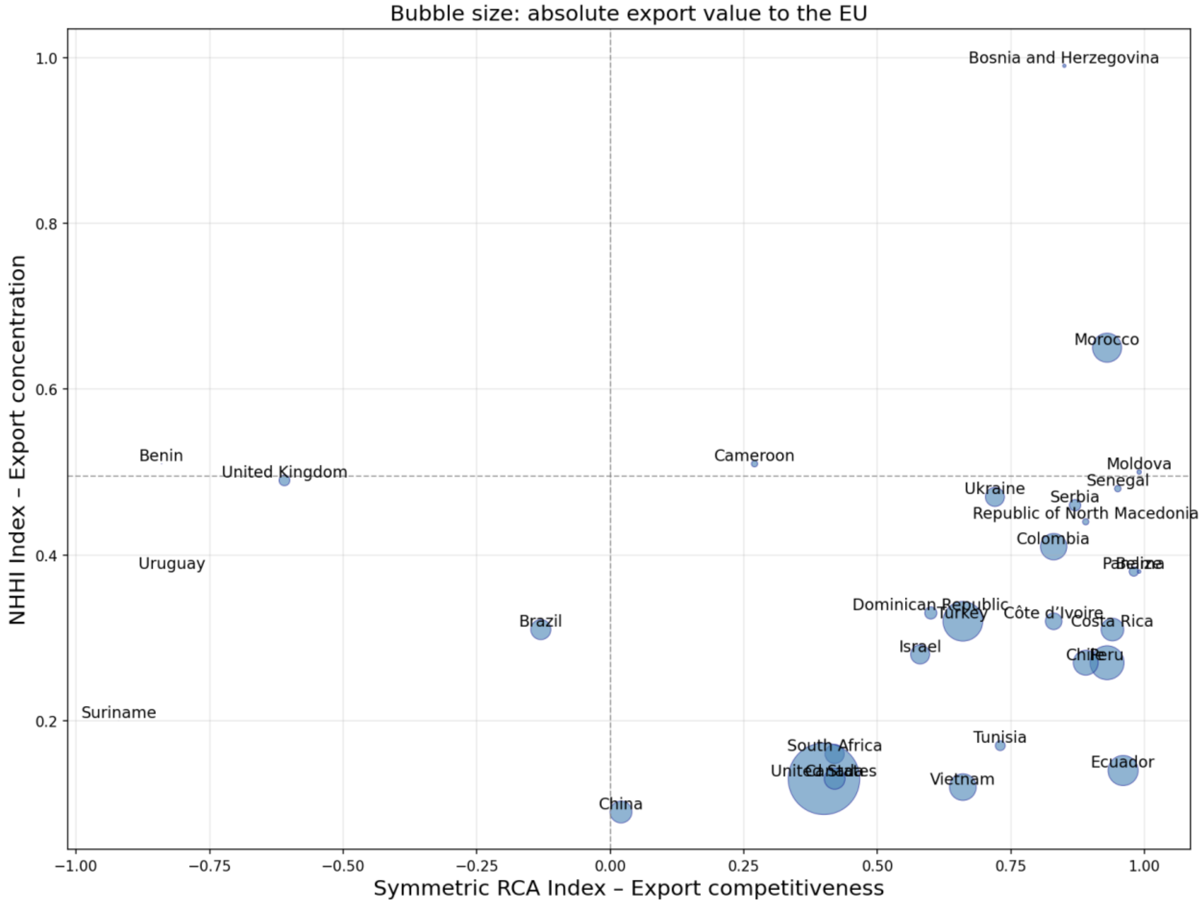
[38] Diversification is measured as NHHI = (HHI – 1/N) / (1 – 1/N), where *N* is the number of export destinations and HHI = $\sum_i s^2$, *s* being the percentage share of export value going to destination country *i*.

[39] S-RCA = (RCA – 1) / (RCA + 1) and RCA = (Xc,p / Xc) / (Xw,p / Xw), where Xc,p = export value of country c in product p (where p is the sum of pesticide-detected or registered commodities); Xc = total export value of country c; Xw,p = world export value of product p (where p is the pesticide-detected or registered commodities); Xw = total world export value.

[40] Senegal, Serbia, Ukraine, Republic of North Macedonia, Colombia, Panama, Belize, Costa Rica, Dominican Republic, Cote d'Ivoire, Turkey, Chile, Peru, Israel, Tunisia, Ecuador, Vietnam, South Africa, United States, China, and Canada.

Figure 12. Potential capacity of most dependent third countries to divert export flows to alternative destinations for the commodities not explicitly covered in CAPRI.



Note on the indexes: The **NHHI** index scores a country with a value from 0 to 1, where 0 signals the highest diversification and 1 means no diversification. Although no exact threshold exists to establish whether a country is sufficiently diversified or not, it is possible to identify the least diversified third countries —hence the potentially more exposed— through a comparative analysis among countries. The **symmetric RCA** scores a country from -1 to 1, 1 indicating the strongest export position (or competitiveness in global trade), and -1 meaning no competitiveness in exporting the considered commodities. When the index takes negative value, the world (i.e. other countries) is more competitive in exporting the commodities considered compared to the third country. Conversely, when it takes positive value, the third country is more competitive than the rest of the world.

Source: Own elaboration based on UN Comtrade data. Only third countries selected in Figure 11 are reported.

Bosnia, Morocco, Cameroon, Brazil, Suriname, and Uruguay show a mixed capability to divert export flows, due to either low diversification of export destinations but high competitiveness (bottom-left), or vice-versa high diversification but low competitiveness (top-right). Bosnia and Herzegovina appears as extremely non-diversified third country, with a NHHI value of 0.99. This is mostly due to a very low number of destinations (five export destinations) and a very small number of exports towards non-EU destinations (0.5 %). Morocco and Cameroon also show a relevantly high NHHI, included between 0.65 and 0.5. This might signal a potentially non-sufficiently diversified trade to divert exports. To note also that Brazil, United Kingdom, Uruguay, Benin and Suriname are the only third countries being less competitive in exporting the considered commodities compared to the rest of the world. Similarly, while Uruguay and Suriname have shown relatively high diversification, their export remain destinated to relatively few countries. A negative S-RCA combined with few existing export destinations may signal a potentially high difficulty to divert exports. Conversely, Brazil has shown a quite significant diversification of export destinations. Therefore, a negative S-RCA may still be compensated by a high diversification capacity.

In principle, a third country that exports and imports the same commodity at the same time may decide to replace (part of) its imports by re-directing exports to the domestic industry. This can be measured through:

- **Net Trade Ratios**[41], which is equal to the ratio of export volume of a commodity to the import volume of the same commodity of a certain third country. The lower the ratio, the higher the possibility for the country to re-direct the export to the domestic market while reducing the imports of the same commodity.
- **Domestic Absorption Capacity**[42], which is equal to the ratio of export volumes of a commodity to the volume used in domestic production for the same commodity. The lower the ratio, the higher the capacity of the country to use the exported commodity in the domestic industry.

Figure 13 shows the Net Trade Ratios and Domestic Absorption Capacity of the 30 most exposed third countries. United Kingdom, Benin, Vietnam, and United States show the highest potential for re-directing exports to the domestic industry. It is interesting to note that Benin and United Kingdom were the countries with lowest potential for diverting export flows (Figure 12). Therefore, while these countries may have more difficulties in diverting exports to alternative destinations, they may still have a comparatively stronger capacity to absorb them in the domestic market.

Panama, Costa Rica and Ecuador show the lowest potential for domestic absorption. Their domestic absorption ratio is greater than 1, respectively 7.9, 5, and 2.2. In these countries, and especially in Panama and Costa Rica, the capacity of the domestic industry to absorb the commodities may be limited to a relatively low share of existing export volumes. Specifically, in Panama the volumes used domestically represent 13 % of existing exports of the considered commodities, in Costa Rica 20 %, and in Ecuador 46 %. Nonetheless, as shown in Figure 12, these countries are also among the best positioned to divert their exports to alternative destinations. Hence, while they may be less able to absorb disrupted exports domestically, they may likely be able to trade it with non-EU importing countries. Moldova, Morocco and Colombia are in a similar situation, although they showed only mixed potential for diverting export flows (Figure 12). Compared to Panama, Costa Rica and Ecuador, these countries may encounter more difficulties.

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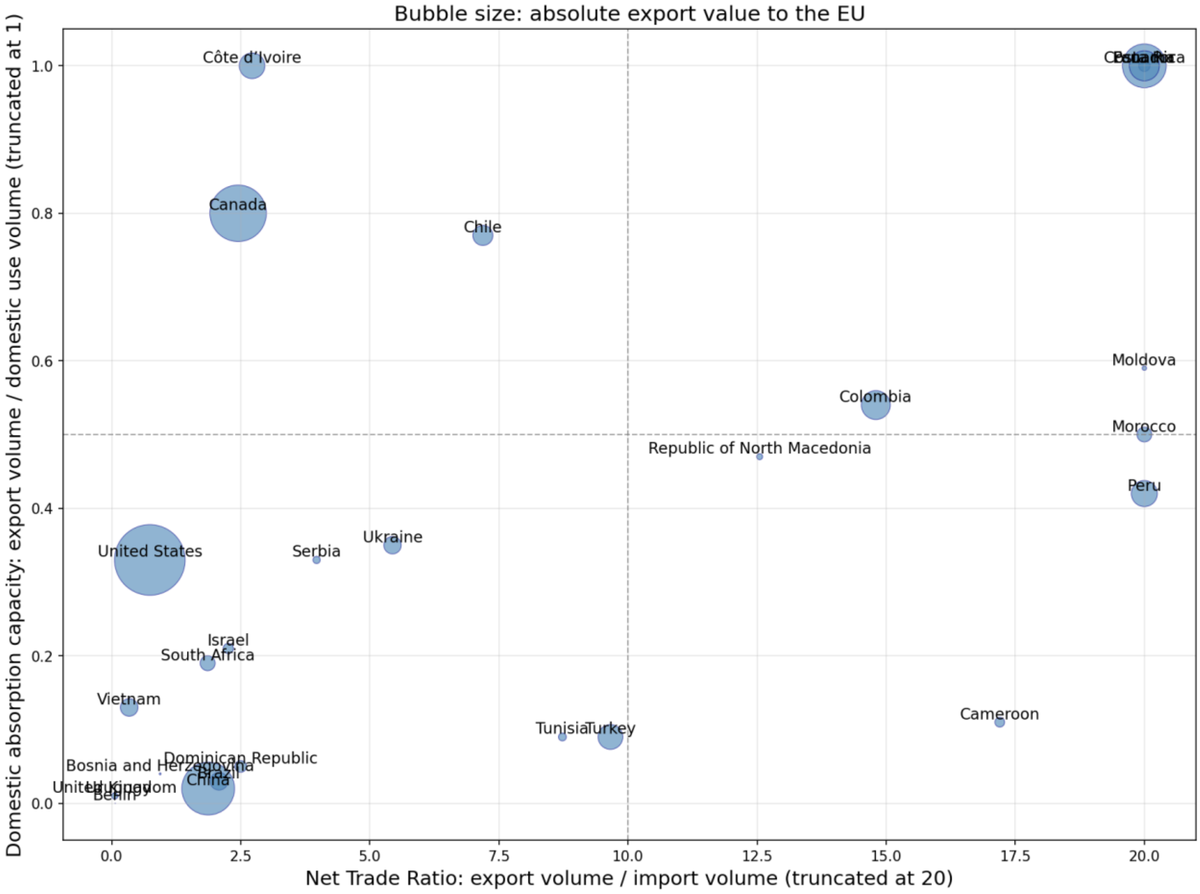
41 Ratio between a country's export volume of the considered pesticide-commodities and its import volumes of the same commodities.

42 Ratio between a country's export volumes of the considered commodities and its domestic use volumes of the same commodities. Domestic use is calculated as: (domestic production volumes + imported volumes) – exported volumes.

Figure 13. Potential capacity of most dependent third countries to re-direct export flows to the domestic market for the commodities not explicitly covered in CAPRI.



Note on the indexes: the **Net Trade Ratio** assumes values from 0 onwards. If the ratio is higher than 1, exports exceed imports (domestic demand) and the capacity of the country to replace imports with exports is relatively low. Conversely, if the ratio is lower than 1, imports exceed exports, and the country may be able to replace imports with exports. The **Domestic Absorption Capacity** takes values from 0 onwards. If the ratio is higher than 1, domestic industries do not use much of the commodity and domestic absorption capacity is potentially limited. Conversely, if the ratio is minor than 1, the number of commodities used in the country is higher than the amount exported, so that the domestic industry has a stronger capacity to absorb it.

Source: Own elaboration based on UN Comtrade data (export and import volumes) and FAOSTAT data (domestic production volumes).

Peru, Cameroon, Republic of North Macedonia, Canada, Chile and Cote d'Ivoire found themselves in a mixed situation, whereby they show either a high Net Trade Ratio but low Domestic Absorption Capacity (Peru, Cameroon, and Republic of North Macedonia), or low Net Trade Ratio but high Domestic Absorption Capacity (Canada, Chile and Cote d'Ivoire). In the former case, the countries may be able to place part of their exports in the domestic market. In the latter case, the countries may place only a limited share of their exports on the domestic market, but their export is to a larger extent dependent on the imports of the same commodities (i.e. re-export), which may be (to some extent) reduced.

The remaining countries (Turkey, Tunisia, Ukraine, Serbia, Israel, United States, Vietnam, United Kingdom, Benin, Bosnia and Herzegovina, South Africa, Dominican Republic, China, Brazil, and Uruguay) show a higher potential for absorbing part of the exports in the domestic industry. This potential is particularly greater for United States, Vietnam, United Kingdom, Benin and Uruguay which show a Net Trade Ratio closer or smaller than 1. This means that their exports are largely or entirely covered by imports of the same commodities (which in turn signals potentially large re-exports), and hence they may be reducing re-exporting while not affecting (or affecting less) domestic production of the considered commodities.

Overall, third countries that are most exposed appear to have some potential to divert exports to alternative destinations and/or to the domestic market. Nonetheless, additional price analyses (see Annex 4) show that the majority of third countries may sell at lower prices when diverting exports to the domestic market of alternative non-EU destinations. Among the 28 analysed third countries (two countries were excluded due to missing price data), 19 countries[43] appear likely to get lower prices in both domestic market and alternative non-EU destinations compared to what they get in the EU. This means that these countries, if diverting their export routes, may be likely incurring economic losses. Besides, eight countries (Costa Rica, South Africa, Brazil, Chile, Serbia, Peru, Morocco, and United Kingdom) appear likely to incur economic losses on prices if diverting exports to the domestic market, but not necessarily if diverting them to alternative non-EU destinations. On the other hand, Cameroon may be incurring lower prices if diverting to alternative non-EU destinations but not if diverting to the domestic market. Only one third country, namely Colombia, appear to be in the position not to incur economic losses if diverting to the domestic market or alternative export destinations.

3.6.2. EU exposure

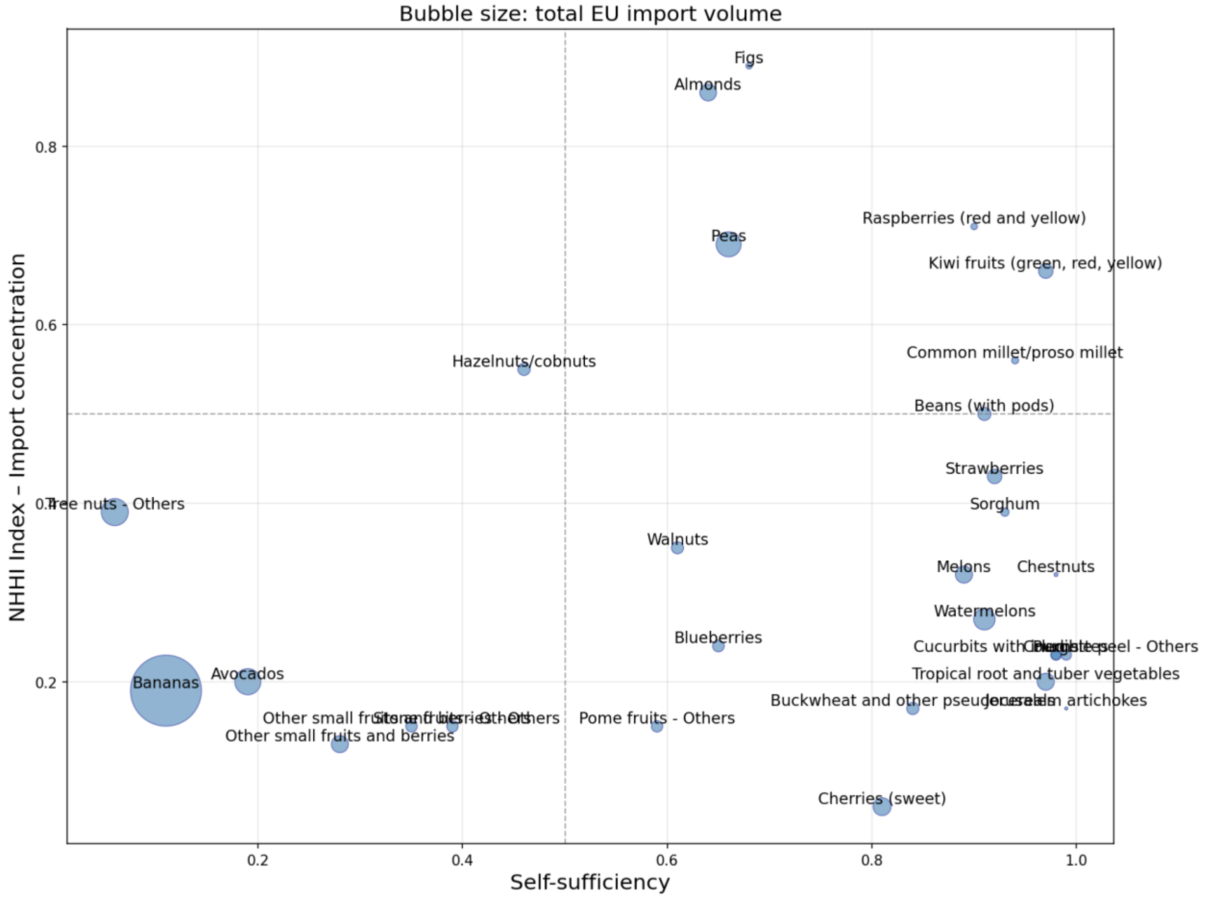
The reduction of MRLs to the LOQs may expose the EU in relation to those commodities for which the considered ASs were detected in imports or authorised for use. However, actual exposure may be assumed mainly when the EU is not self-sufficient in the production of the considered commodities, hence it relies on imports. This can be measured through the Self-sufficiency Index[44], which can be used to short-list the pesticide-commodities to which the EU is more exposed. However, when the EU largely relies on third countries with detected residues or where the ASs are authorised for use to import the considered commodities and is less self-sufficient (i.e. it has relatively low ability for domestic production), it might still be possible to rely on other supply sources (i.e. other exporting countries). When the import of commodities for which the EU is not self-sufficient is relatively important and largely coming from third countries with detected residues where the ASs are authorised for use, then the EU can be considered more exposed. This can be measured through a Normalized Herfindahl–Hirschman Index (NHHI, see footnote 38). The higher the NHHI index, the lower the possibility of the EU relying on alternative sources.

Figure 14 shows the commodities for which the EU is less-self-sufficient, and the concentration of import sources for these commodities (NHHI index). The figure only reports the commodities for which the EU is not self-sufficient (index < 1). The EU is not self-sufficient in the production of 29 commodities among the considered ones.

[43] United States, Ukraine, Turkey, Côte d'Ivoire, China, Bosnia and Herzegovina, Republic of North Macedonia, Israel, Canada, Vietnam, Moldova, Albania, Ecuador, Kenya, Mexico, Egypt, Panama.

[44] The Index is calculated as: (total EU production / (total EU production + total EU import – total EU export).

Figure 14. EU dependency on imports from third countries with detected or registered status, by commodity for the commodities not explicitly covered in CAPRI.



Note on considered commodities: Only commodities with self-sufficiency < 1 are reported in the figure. The commodities with self-sufficiency above 1 are: Apricots, Asparagus, Aubergines/eggplants, Beetroots, Broccoli, Brussels sprouts, Carrots, Cauliflowers, Celeriacs/turnip rooted celeries, Celeries, Celery, Celery leaves, Cotton seeds, Cucumbers, Cultivated fungi, Currants (black, red and white), Escaroles/broad-leaved endives, Flowering brassica, Fungi, mosses and lichens, Garlic, Gherkins, Globe artichokes, Head brassica, Head cabbages, Hops, Lamb's lettuces/corn salads, Leeks, Lettuces, Lettuces and salad plants, Lupins/lupini beans, Onions, Other root and tuber vegetables except sugar beets, Other root and tuber vegetables except sugar beets - Others, Peas (with pods), Pumpkins, Radishes, Solanaceae and Malvaceae, Spinaches, Spinaches and similar leaves, Spring onions/green onions and Welsh onions, Sweet peppers/bell peppers, Turnips, Witloofs/Belgian endives.

Note on the indexes: the Self-sufficiency index assumes values from 0 onwards, where a value equal or bigger than 1 signals self-sufficiency (i.e. the domestic production is at least equal the domestic use). Conversely, values minor than one signal that the EU is (to some extent) not self-sufficient: the lower the value (i.e. the closer to zero), the smaller the self-sufficiency of the EU.

Source: Own elaboration based on COMEXT data (import and export volumes) and Eurostat data (Self-sufficiency ratio and EU production volumes).

However, 14 of them (Melons, Raspberries (red and yellow), Watermelons, Beans (with pods), Strawberries, Sorghum, Common millet/proso millet, Kiwi fruits (green, red, yellow), Tropical root and tuber vegetables, Plums, Cucurbits with inedible peel – Others, Chestnuts, Jerusalem artichokes, and Courgettes) approach self-sufficiency (~90% or more of domestic use is covered by domestic production). This suggests a relatively limited EU exposure for these commodities. For eight commodities (Pome fruits – Others, Walnuts, Almonds, Blueberries, Peas, Figs, Cherries (sweet), and Buckwheat and other pseudocereals) the EU produces 50 % or more of what it uses, for which the EU may be considered moderately exposed. For seven commodities (Tree nuts – Others, Bananas, Avocados, Other small fruits and berries, Other small fruits and berries – Others, Stone fruits – Others, and Hazelnuts/cobnuts) the EU produces less than half of what it uses. The EU may be considered highly exposed for these commodities.

Among the commodities with lowest self-sufficiency, Hazelnuts/Cobnuts show the lowest diversification of input sources, while the other commodities show fairly high diversification. Hence, the EU may be particularly exposed to impacts in the import of Hazelnuts/Cobnuts. Among commodities approaching self-sufficiency, there are seven (Peas, Raspberries (red and yellow), Kiwi fruits (green, red, yellow), Common millet/proso millet, and Beans (with pods)) with comparatively lower diversification of supply, and particularly low for Figs and Almonds. The EU may be considered moderately exposed to these commodities as it may still have the capacity to largely compensate reductions on import supply through a combination of increased domestic production and increased import from few alternative sources.

Fourteen commodities (Strawberries, Sorghum, Walnuts, Melons, Chestnuts, Watermelons, Blueberries, Cucurbits with inedible peel - Others, Tropical root and tuber vegetables, Pome fruits - others, Buckwheat and other pseudocereals, Jerusalem artichokes, Stone fruits – others, Cherries (sweet)) show both high supply diversification and potential to reach self-sufficiency. Consequently, the EU may be less exposed to changes in the imports of these commodities.

While the existence of alternative exporting countries may allow the EU to rely on alternative supply sources, this might imply higher costs. It is therefore necessary to assess whether prices for the commodity in third countries with detected or registered status are significantly different (lower or higher) from those of other exporters of the same commodity. This can be assessed by estimating a ratio of the price from third countries with detection or registered status, on those without (Table 28). If the ratio is higher than 1, then average prices are currently less convenient for third countries with detected or registered status, and the EU may incur lower costs if relying on alternative import sources.

For the majority of commodities —Almonds, Avocados, Buckwheat and other pseudocereals, Cherries (sweet), Chestnuts, Figs, Hazelnuts/cobnuts, Jerusalem artichokes, Kiwi fruits (green, red, yellow), Melons, Plums, Strawberries, Tree nuts – Others, and Watermelons— import prices from countries without detected or registered status are lower than those from countries with detected or registered status (ratio > 1). This suggests that the EU is not likely to pay higher prices if relying on alternative import sources for these commodities. The difference between countries without and with detected or registered status is particularly higher (ratio > 2) for Buckwheat and other pseudocereals, and Jerusalem artichokes.

Conversely, for Bananas, beans (with pods), Common millet/proso millet, Peas, Sorghum, and Walnuts, prices appear to be on average higher in third countries without detected or registered status, implying that the EU may be more likely to pay higher prices for these commodities from alternative import sources. The ratio is particularly low for Walnuts (~0.5).

Table 28. Price differences between third countries with and without detected or registered status, by commodity for the commodities not explicitly covered in CAPRI.

Commodity	**Mean price in third countries <u>with</u> detected residues or authorised uses of ASs ($/kg)**	**Mean price in third countries <u>without</u> detected residues or authorised uses of ASs ($/kg)**	**Price ratio between the two groups**
Almonds	2.4741	2.2374	1.1058
Avocados	1.1715	0.7253	1.6151
Bananas	0.3508	0.3888	0.9023
Beans (with pods)	0.9043	1.0651	0.849
Buckwheat and other pseudocereals	0.515	0.2507	2.054
Cherries (sweet)	3.8565	2.0682	1.8646
Chestnuts	2.9205	1.8302	1.5957
Common millet/proso millet	0.2322	0.3077	0.7547
Figs	1.2035	0.8243	1.46
Hazelnuts/cobnuts	2.1488	1.7001	1.264
Jerusalem artichokes	1.5591	0.6129	2.5439
Kiwi fruits (green, red, yellow)	2.1671	1.4993	1.4455
Melons	0.5128	0.3069	1.671
Peas	0.4988	0.5178	0.9634
Plums	0.88	0.5995	1.4681
Sorghum	0.2781	0.2918	0.9533
Strawberries	1.9335	1.5077	1.2825
Tree nuts - Others	1.4845	1.2477	1.1899
Walnuts	1.255	2.318	0.5414
Watermelons	0.5188	0.3758	1.3807

Note: Only commodities for which price data can be retrieved are reported in the table. To reduce errors and outliers in reported prices, rows where either volume or value is 0 or missing were removed. Countries with export volume < 1,000 kg for a commodity are excluded. For each commodity, countries with unit values outside [Q1 – 1.5×IQR, Q3 + 1.5×IQR] are excluded.

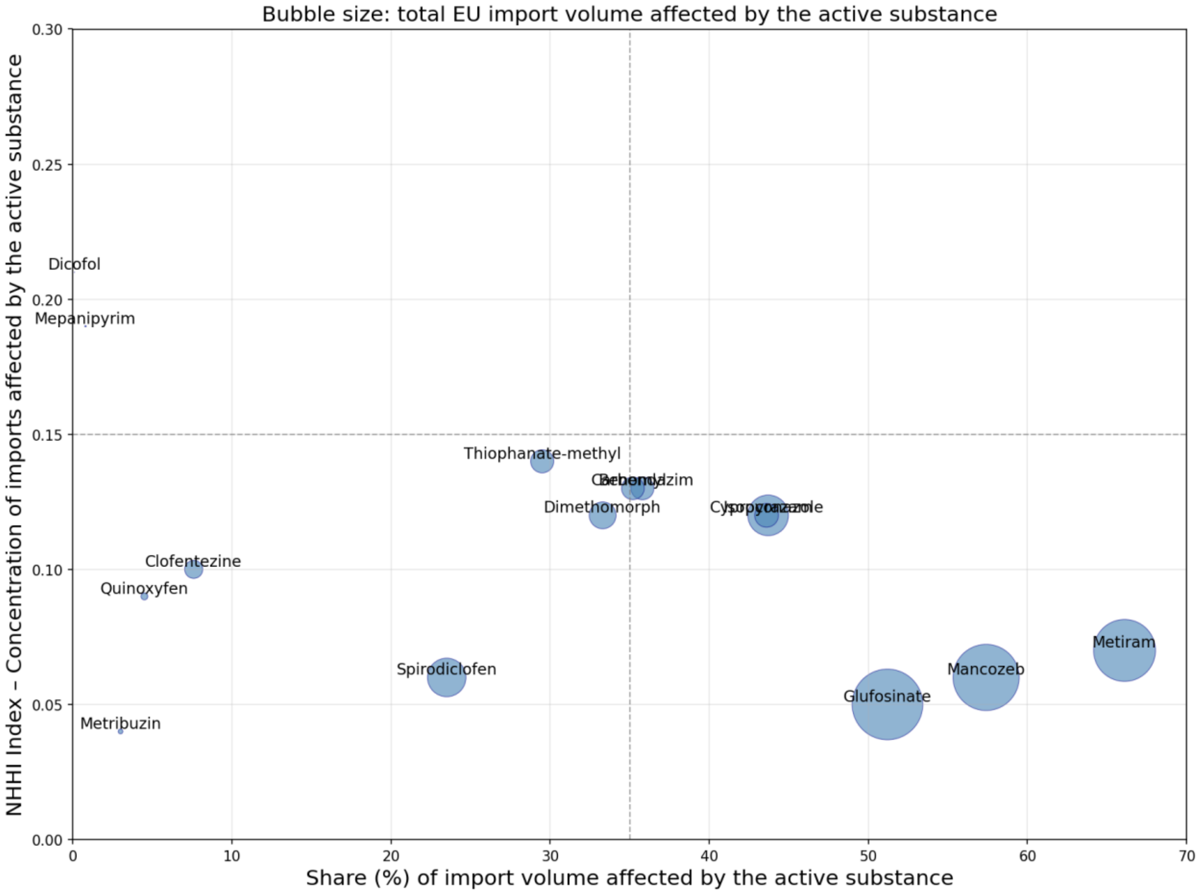
Source: Own elaboration based on UN Comtrade data.

Since each commodity is affected by one or few most hazardous active substances (unlikely by all), it is relevant to observe EU exposure also in terms of group of commodities affected by each single active substance. Two aspects can be assessed (Figure 15): (1) the share of total EU imports of the considered commodities related to each specific active substance: the higher the share, the higher the potential EU exposure to that specific substance; and (2) the potential EU's capacity to diversify the import sources of commodities affected by each active substance, measured through a NHHI index: the higher the index value, the lower the EU diversification of import sources of (hence potentially higher exposure to) that specific substance.

Overall, EU import sources appear largely diversified for all active substances, at least when compared to the diversification of input sources for each single commodity (Figure 14). Dicofol and mepanipyrim appear as the least diversified (NHHI ~ 0.2). However, these substances expose only a very minor portion of EU imports (< 5 %).

Metiram, mancozeb and glufosinate appear to be the only active substances affecting more than 50% of EU import volumes —respectively 66 %, 57 % and 51 %— hence potentially the active substances exposing the most EU imports. However, also isopyrazam and cyproconazole affect about 44 % of EU import volumes, appearing as largely exposing EU imports, while carbendazim, benomyl, dimethomorph, thiophanate-methyl and spirodiclofen affect a not insignificant share of EU import volumes of the commodities considered, varying between 23 % and 36 %. The import sources of commodities related to these substances appear to be very diversified. However, attention should be paid to them as they affect EU imports the most.

Figure 15. Concentration of import sources and EU dependency on imports affected by each active substance for the commodities not explicitly covered in CAPRI.



Source: Own elaboration based on COMEXT data.

4. Conclusions

In its Vision for Agriculture and Food, the European Commission stated that the most hazardous pesticides banned in the EU for health and environmental reasons should not re-enter the EU through imported products as a matter of principle. To advance this commitment, the Commission announced that the JRC would conduct a supporting analytical study; the present report constitutes this study.

For this study we compiled a dataset for assessing the exposure of imported commodities and third countries to a reduction of existing MRLs to the LOQ for the most hazardous ASs not approved in the EU, combining information on AS approval status, hazard classification, MRLs above the LOQ, AS residues detected through monitoring, AS authorisations for use in third countries and third-country exports to the EU by commodity. This allows us to understand the scope of AS-commodity-country triads that would be affected if existing MRLs above the LOQ for the most hazardous ASs not approved in the EU were reduced to the LOQ.

Twenty-two most hazardous ASs that are not approved in the EU retain at least one MRL above the LOQ. Of these 22 ASs, 14 have been detected as residues in imports of food and feed commodities in the EU via monitoring programmes (EU MACP and MANCPs), and an additional four are authorised for use in at least one third country, giving the final set of 18 ASs on which this analysis is based. These affect 235 unique commodities and 86 countries for which residues of the relevant ASs have been detected in imports or the ASs are authorised for use, corresponding to 10 583 substance–commodity–country triads with either a detection or a registered use. Of these, 5 473 are reflected in recorded EU trade on the basis of registered use, and 750 on the basis that only residue detections in imports are considered.

Based on this data set we constructed stylised standardized scenarios and implement them in an agro-economic model to simulate the potential impacts of a simultaneous reduction of all MRLs of the relevant ASs to the LOQ. These scenarios accommodate uncertainty on three main aspects; (i) how producers in third countries would respond to the reduction of the relevant MRLs to the LOQ, (ii) how many producers exporting to the EU would be affected and (iii) what the implications of substituting the ASs would be. The three scenarios designed cover a spectrum from a very stringent case (all farmers in countries where evidence of use exists stop exporting to the EU) to a very mild case (only the share of farmers corresponding to the level of residue detections is affected and these farmers can adapt at moderate cost). Each scenario is applied homogenously across all triads, although heterogeneity at country, commodity and AS level is to be expected in reality. The three scenarios also could also be read as a temporal sequence of how the reduction of MRLs to the LOQ could affect producers in third countries: the scope for adaption is limited in the short term and widens at declining costs as the time horizon lengthens. Moreover, considering a longer time horizon could also imply that third countries could eventually align their MRLs for the relevant ASs with EU levels.

The simulated impacts show a common pattern - reduced imports to the EU, increased production in the EU and increased consumer prices – differing in intensity rather than direction, with intensity decreasing when scenarios become more nuanced regarding the responses of producers in third countries. Under the very stringent scenario the impacts are substantial and affect most of the trade with third countries. As the stringency decreases the impacts affect fewer number of countries and commodities and diminish in magnitude. For example, total EU imports of the commodities analysed fall by 41 % under the stringent scenario but by 8 % or even less than 1 % in the scenarios where producers are assumed to be able to substitute the ASs and lower intensity of use is assumed in third countries. Under more lenient assumptions about the cost of substituting the ASs, the impacts would be even smaller. Beyond these general results, there is heterogeneity in impacts across countries and commodities.

The plausibility of applying a standardised impact across commodities and countries was tested through an in-depth analysis of the AS cyproconazole, which finds that the expected additional cost of substituting this AS ranges between 20 % and 40% of production costs, without taking into account the potential increase in crop protection effectiveness of the alternatives. Even for a single AS we find that the costs of substitution vary significantly. The findings support the conclusion that assessing the impacts of reducing MRLs to the LOQ requires AS specific in-depth analysis rather than uniform assumptions applied across all AS – commodity – country triads. The findings point to the need for further assessments of impacts, and in particular for better information on the actual use and agronomic importance of specific substances in exporting countries concerned.

A number of commodities important to developing countries are not represented in the agro-economic model, so their exposure could be assessed only qualitatively. However, in section 3.6.1 we see that some of the countries most exposed to this measure are developing countries. The implications for these countries would merit further, more detailed analysis to understand the extend of use of the ASs in those countries as well as the costs of changing production practices to avoid residues of the relevant ASs.

Finally, the caveats and limitations described in section 2.7 apply throughout and call for a cautious interpretation. The results are not intended to predict actual impacts, but to give a possible range, depending on how much producers in third countries rely on the assessed ASs and how costly substation proves. The study does not address either environmental or social impacts, does not consider eventual implementation periods that would allow operators to adjust to the new MRLs, and it has not been subject to public consultation. Any further policy action should accordingly be informed by a more comprehensive analysis.

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List of abbreviations and definitions

Abbreviations	Definitions
AS	Active Substance
DMI	Demethylation-inhibitor
FFSSP	Food and Feed Safety Simplification Package
FRAC	Fungicide Risk Assessment Committee
IA	Impact Assessment
KRI	Keto-Reductase Inhibitors
LOQ	Limit of Quantification
MBC	Methyl Benzimidazole Carbamates
MRL	Minimum Residue Level
NHHI	Normalized Herfindahl–Hirschman Index
PPP	Plant Protection Products
QoI	Quinone outside Inhibitors
SBI	Sterol biosynthesis-inhibiting
SPS	Sanitary and Phytosanitary
S-RCA	Symmetric Revealed Comparative Advantage
WTO	World Trade Organization

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Annexes

Annex 1. Commodities that are affected by at least one MRL that would be reduced to LOQ under the policy scenario.

Table 29. Commodities that are affected by at least one MRL that would be reduced to LOQ under the policy scenario.

	Commodity	CAPRI codes
1	Apples	APPL
2	Barley	BARL
3	Beans	PULS*
4	Beans (without pods)	PULS*
5	Birds eggs	EGGS
6	Birds eggs - Chicken	EGGS
7	Bovine	BEEF
8	Cassava roots/manioc	FENI
9	Cereals - Others	OCER
10	Citrus fruits - Others	CITR
11	Coffee beans	TROP
12	Goat	SGMT
13	Grapefruits	CITR
14	Grapes	TAGR
15	Lemons	CITR
16	Limes	CITR
17	Maize/corn	MAIZ
18	Mandarins	CITR
19	Milk	MILK
20	Oat	OATS
21	Oilseeds	OILS
22	Olives for oil production	OLIV
23	Oranges	CITR
24	Peaches	APPL
25	Pears	APPL
26	Peas (without pods)	PULS
27	Potatoes	POTA
28	Poultry	POUM
29	Pulses - Lentils	PULS
30	Pulses - Others	PULS
31	Rapeseeds/canola seeds	RAPE
32	Rice	RICE
33	Rye	RYEM
34	Sheep	SGMT

	Commodity	CAPRI codes
35	Soybeans	SOYA
36	Sugar beet	SUGB
37	Swine	PORK
38	Table grapes	TAGR
39	Table olives	TABO
40	Teas	TEAS
41	Tomatoes	TOMA
42	Wheat	WHEA
43	Wine grapes	TWIN
44	Almonds	
45	American persimmons/Virginia kaki	
46	Amphibians and Reptiles	
47	Anise/aniseed	
48	Apricots	
49	Asparagus	
50	Aubergines/eggplants	
51	Avocados	
52	Baby leaf crops (including brassica species)	
53	Bananas	
54	Basil and edible flowers	
55	Beans (with pods)	
56	Beetroots	
57	Birds eggs - Duck	
58	Birds eggs - Geese	
59	Birds eggs - Quail	
60	Black caraway/black cumin	
61	Blueberries	
62	Borage seeds	
63	Brazil nuts	
64	Breadfruits	
65	Broccoli	
66	Brussels sprouts	
67	Buckwheat and other pseudocereals	
68	Bulb vegetables - Others	
69	Cane fruits	
70	Carambolas	
71	Caraway	
72	Cardamom	
73	Carrots	
74	Cashew nuts	

	Commodity	CAPRI codes
75	Cauliflowers	
76	Celeriacs/turnip rooted celeries	
77	Celeries	
78	Celery	
79	Celery leaves	
80	Chards/beet leaves	
81	Cherimoyas	
82	Cherries (sweet)	
83	Chervil	
84	Chestnuts	
85	Chinese cabbages/pe-tsai	
86	Chives	
87	Coconuts	
88	Common millet/proso millet	
89	Coriander	
90	Cotton seeds	
91	Courgettes	
92	Cranberries	
93	Cresses and other sprouts and shoots	
94	Cucumbers	
95	Cucurbits with edible peel	
96	Cucurbits with edible peel - Others	
97	Cucurbits with inedible peel	
98	Cucurbits with inedible peel - Others	
99	Cultivated fungi	
100	Cumin	
101	Currants (black, red and white)	
102	Dates	
103	Dill	
104	Durians	
105	Equine	
106	Escaroles/broad-leaved endives	
107	Fennel	
108	Fenugreek	
109	Figs	
110	Flowering brassica	
111	Flowering brassica - Others	
112	Fruit spices	
113	Fungi, mosses and lichens	
114	Garlic	

	Commodity	CAPRI codes
115	Gherkins	
116	Globe artichokes	
117	Gold of pleasure seeds	
118	Gooseberries (green, red and yellow)	
119	Granate apples/pomegranates	
120	Guavas	
121	Hazelnuts/cobnuts	
122	Head brassica	
123	Head cabbages	
124	Herbal infusions from roots - Ginseng	
125	Herbs and edible flowers	
126	Herbs and edible flowers - Others	
127	Honey and other apiculture products (7)	
128	Hops	
129	Horseradishes	
130	Jambuls/jambolans	
131	Jerusalem artichokes	
132	Kaki/Japanese persimmons	
133	Kales	
134	Kiwi fruits (green, red, yellow)	
135	Kohlrabies	
136	Kumquats	
137	Lamb's lettuces/corn salads	
138	Land cresses	
139	Laurel/bay leaves	
140	Leafy brassica	
141	Leafy brassica - Others	
142	Leeks	
143	Legume vegetables - Lentils	
144	Legume vegetables - Others	
145	Lettuces	
146	Lettuces and salad plants	
147	Lettuces and salad plants - Others	
148	Litchis/lychees	
149	Loquats/Japanese medlars	
150	Lupins/lupini beans	
151	Macadamias	
152	Mangoes	
153	Medlars	
154	Melons	

	Commodity	CAPRI codes
155	Milk - Cattle	
156	Milk - Goat	
157	Milk - Horse	
158	Milk - Sheep	
159	Miscellaneous fruits with edible peel	
161	Miscellaneous fruits with inedible peel, large	
163	Miscellaneous fruits with inedible peel, small	
165	Mustard seeds	
166	Oil fruits	
167	Okra/lady's fingers	
168	Onions	
169	Other farmed terrestrial animals	
170	Other root and tuber vegetables except sugar beets	
171	Other root and tuber vegetables except sugar beets - Others	
172	Other small fruits and berries	
173	Other small fruits and berries - Others	
174	Papayas	
175	Parsley	
176	Parsley roots/Hamburg roots parsley	
177	Parsnips	
178	Passionfruits/maracujas	
179	Peas	
180	Peas (with pods)	
181	Pecans	
182	Peppercorn (black, green and white)	
183	Pine nut kernels	
184	Pineapples	
185	Pistachios	
186	Plums	
187	Pome fruits - Others	
188	Poppy seeds	
189	Prickly pears/cactus fruits	
190	Pumpkins	
191	Purslanes	
192	Quinces	
193	Radishes	
194	Raspberries (red and yellow)	
195	Red mustards	
196	Rhubarbs	
197	Roman rocket/rucola	

	Commodity	CAPRI codes
198	Root and tuber vegetables	
199	Rosemary	
200	Sage	
201	Salsifies	
202	Seed spices	
203	Seed spices - Others	
204	Shallots	
205	Solanaceae and Malvaceae	
206	Solanaceae and Malvaceae - Others	
207	Sorghum	
208	Soursops/guanabanas	
209	Spinaches	
210	Spinaches and similar leaves	
211	Spinaches and similar leaves - Others	
212	Spring onions/green onions and Welsh onions	
213	Star apples/cainitos	
214	Stone fruits - Others	
215	Strawberries	
216	Swedes/rutabagas	
217	Sweet peppers/bell peppers	
218	Tarragon	
219	Terrestrial invertebrate animals	
220	Thyme	
221	Tree nuts - Others	
222	Tropical root and tuber vegetables	
223	Turnips	
224	Walnuts	
225	Watercresses	
226	Watermelons	
227	Wild terrestrial vertebrate animals	
228	Witloofs/Belgian endives	
229	Azaroles/Mediterranean medlars	
230	Blackberries	
231	Cane fruits - Others	
232	Dewberries	
233	Elderberries	
234	Mulberries (black and white)	
235	Rose hips	
236	Algae and prokaryotes organisms	

Note: Cells highlighted in green indicate crops that are directly represented in CAPRI. (*) indicates crops or activities that are not represented in CAPRI as a stand-alone but as part of a group or aggregated categories.

Source: own elaboration.

Annex 2. Triads for which detections are reported on the monitoring programmes but no register of exports to the EU are not found in UN-COMTRADE.

Table 30. Triads for which detections are reported on the monitoring programmes but no register of exports to the EU are not found in UN-COMTRADE.

Active Substance	Commodity	Exporting country
Benomyl	Apricots	China
Benomyl	Aubergines/eggplants	Sri Lanka
Benomyl	Aubergines/eggplants	Suriname
Benomyl	Beans (with pods)	Algeria
Benomyl	Beans (with pods)	Bangladesh
Benomyl	Grapefruits	Central African Republic
Benomyl	Grapefruits	Zimbabwe
Benomyl	Mandarins	Argentina
Benomyl	Mangoes	Bangladesh
Benomyl	Oranges	Zimbabwe
Benomyl	Plums	Thailand
Benomyl	Table grapes	Afghanistan
Benomyl	Wine grapes	Georgia
Carbendazim	Apricots	China
Carbendazim	Aubergines/eggplants	Sri Lanka
Carbendazim	Aubergines/eggplants	Suriname
Carbendazim	Beans (with pods)	Algeria
Carbendazim	Beans (with pods)	Bangladesh
Carbendazim	Grapefruits	Central African Republic
Carbendazim	Grapefruits	Zimbabwe
Carbendazim	Mandarins	Argentina
Carbendazim	Mangoes	Bangladesh
Carbendazim	Oranges	Zimbabwe
Carbendazim	Plums	Thailand
Carbendazim	Table grapes	Afghanistan
Carbendazim	Wine grapes	Georgia
Chlordecone	Cassava roots/manioc	Dominica
Clofentezine	Raspberries (red and yellow)	Zimbabwe
Dimethomorph	Broccoli	Ecuador
Dimethomorph	Celery leaves	Cambodia
Dimethomorph	Courgettes	Bangladesh
Dimethomorph	Cumin	Bangladesh
Dimethomorph	Spinaches	Vietnam
Dimethomorph	Wine grapes	Eritrea
Mancozeb	Bananas	Mexico
Mancozeb	Carrots	Argentina
Mancozeb	Grapefruits	Central African Republic

Active Substance	Commodity	Exporting country
Mancozeb	Grapefruits	Zimbabwe
Mancozeb	Oranges	Central African Republic
Mancozeb	Oranges	Ethiopia
Mancozeb	Oranges	Zimbabwe
Mancozeb	Pears	Central African Republic
Mancozeb	Strawberries	Iran
Metiram	Bananas	Mexico
Metiram	Carrots	Argentina
Metiram	Grapefruits	Central African Republic
Metiram	Grapefruits	Zimbabwe
Metiram	Oranges	Central African Republic
Metiram	Oranges	Ethiopia
Metiram	Oranges	Zimbabwe
Metiram	Pears	Central African Republic
Metiram	Strawberries	Iran
Quinoxyfen	Table grapes	Namibia
Spirodiclofen	Plums	Thailand
Spirodiclofen	Strawberries	Iran
Thiophanate-methyl	Apricots	China
Thiophanate-methyl	Plums	Thailand

Source: own elaboration based on EFSA detection and UN-COMTRADE.

Annex 3. Details on the evaluations of the performance of alternative fungicides to cyproconazole.

In this annex we provide more details on the field trials found in the literature with regards to the performance in terms of yield increase or severity of the diseases for the most important disease and crops. The evidence found is fragmented and does not follow a standard protocol for experiments or variable measured. Therefore, conclusions should be taken with caution. For the different diseases, crops and world regions we find that cyproconazole is among the most effective solutions to prevent losses and while in some cases alternatives authorized in the EU exist this is not true in others. Therefore, our conclusion is that before assessing the cost of not using the AS a more detailed analysis is needed probably involving requesting evidence from the affected countries. This evidence would need to be assessed to see whether it is unbiased.

Findings are reported for tar spot in maize; rust in soybeans; yellow rust, leave rust, fusarium head blight index (IND) and doexyivalenol (DON) in wheat; leaf rust in coffee and chocolate spot in beans. Evidence is found from the US, Brazil, India and the UK; however, the breadth of some of it is limited.

Maize – tar spot

Results of different indicators used to evaluate the effectiveness of a range of fungicides on the tar spot in the US (Wanatah and West Lafayette) are reported in Ross et al. (2023) and summarized in Table 31. The percentage reduction in disease severity was calculated from results on severity of the control group and alternative fungicides, and the effectiveness was measured at different parts of the plant and using different indicators (% reduction in symptom severity, % reduction of spot stromata, % green canopy increase).

Table 31. Comparison of the effects (disease intensity and green canopy) of fungicides on tar spot in maize in the US.

	Reduction in Tar spot symptom severity (%)				**Reduction in Tar spot stromata* (%)**		**Green canopy**		
Fungicide(s)	**Lower canopy#**	**Ear leaf**	**Upper canopy**	**Lower canopy**	**Ear leaf**	**Upper canopy**	**% increase) WA**	**% diff between control and fungicide application WL**	**EU approved**
Pyraclostrobin – Quinone outside inhibitor (QoI); Strobilurin	35.8 %	43.7 %	48.4 %	42.2 %	40.8 %	35.6 %	14.6 %	11.2 %	Yes
Propiconazole - DMI; triazole	28.3 %	35.3 %	41.1 %	29.4 %	27.6 %	20.3 %	17.2 %	3.5 %	No
Cyproconazole + picoxystrobin (DMI+QoI)	37.6 %	49.6 %	49.5 %	45.1 %	42.1 %	37.3 %	16.1 %	11.2 %	No (both)
Mefentrifluconazole + pyraclostrobin (DMI+Qoi)	46.2 %	49.6 %	50.5 %	48.0 %	52.6 %	49.2 %	12.8 %	13.1 %	Yes
Metconazole + pyraclostrobin (DMI+QoI)	45.7 %	53.8 %	53.7 %	48.0 %	50.0 %	47.5 %	12.6 %	11.2 %	Yes
Prothioconazole + trifloxystrobin (DMI+QoI)	51.4 %	55.5 %	51.6 %	57.8 %	55.3 %	47.5 %	18.2 %	6.2 %	Yes
Flutriafol + bixafen (DMI combination)	26.0 %	34.5 %	27.4 %	21.6 %	19.7 %	20.3 %	8.4 %	11.0 %	No (flutriafol)
Mefentrifluconazole + fluxapyroxad + pyraclostrobin (three-way mixture with a QoI and DMI)	46.8 %	48.7 %	47.4 %	48.0 %	51.3 %	45.8 %	9.4 %	13.5 %	Yes
Propiconazole + pydiflumetofen + azoxystrobin	23.1 %	35.3 %	35.8 %	34.3 %	36.8 %	32.2 %	10.2 %	8.7 %	No (propiconazole)

Lower canopy represents disease ratings taken from two leaves below the ear leaf (ear leaf – two leaves). * Stromata is the macroscopic fungal reproductive bodies that appear on the plant canopy and are used as an indicator of disease intensity.

Source: Own elaboration based on Ross et al. *(2023).*

Table 32 shows the yield and partial return differences between several active ingredients and no treatment for maize in the US (Indiana). Under a high tar spot severity, the combined use of cyproconazole with picoxystrobin yielded higher partial returns than most alternatives only behind mefentrifluconazole and pyraclostrobin, and metconazole + pyraclostrobin with partial returns differences of $34.3 ha-1 and $15.8 ha-1, respectively. However, under a low tar spot severity the combined use of cyproconazole with picoxystrobin yielded lower partial returns than most alternatives. The partial return difference ($ ha-1) between the better alternatives and the combined use of cyproconazole with picoxystrobin were $111.7 ha-1, $93 ha-1, $45.1 ha-1, $42.4 ha-1, and $11.5 ha-1 for mefentrifluconazole and pyraclostrobin, metconazole and pyraclostrobin, flutriafol and bixafen, pyraclostrobin, and mefentrifluconazole and fluxapyroxad and pyraclostrobin, respectively.

Table 32. Comparison effects (yield difference and return) of fungicides on tar spot in maize in the US.

Fungicide(s)	Yield difference – TS low (kg/ha)	Yield difference – TS high (kg/ha)	Ground partial return – TS low ($/ha)	Ground partial return – TS high ($/ha)	Aerial partial return – TS low ($/ha)	Aerial partial return TS high ($/ha)	EU approved
Pyraclostrobin – Quinone outside inhibitor (QoI); strobilurin	256.8	578.7	20.5	75.2	14.5	69.2	Yes
Propiconazole - DMI; triazole	-106.2	621.6	-49.5	74.2	-55.5	68.2	No
Cyproconazole + picoxystrobin (DMI+QoI)	2.8	682.9	-21.9	93.7	-27.9	87.7	No (both)
Mefentrifluconazole + pyraclostrobin (DMI+Qoi)	696.7	921.2	89.8	128.0	83.8	122.0	Yes
Metconazole + pyraclostrobin (DMI+QoI)	554.5	780.5	71.1	109.5	65.1	103.5	Yes
Prothioconazole + trifloxystrobin (DMI+QoI)	-220.4	762.1	-78.1	88.9	-84.1	82.9	Yes
Flutriafol + bixafen (DMI combination)	298.2	297.3	23.2	23.1	17.2	17.1	No (Flutriafol)
Mefentrifluconazole + fluxapyroxad + pyraclostrobin (three-way mixture with a QoI and DMI)	120.8	726.1	-10.4	92.5	-16.4	86.5	Yes
propiconazole + pydiflumetofen + azoxystrobin	-492.8	641.8	-115.3	77.6	-121.3	71.6	No (Propiconazole)

Source: Own elaboration based on Ross et al. *(2023).*

Table 33 shows the results of the effect of fungicides applied to maize on tar spot severity and yield in the US (Telenko et al. 2022). The best results in terms of yield response are obtained from applying a mixture of prothioconazole and trifloxystrobin. This reduced the tap spot severity from 5.3 % to 1.8 %. Although cyproconazole performed slightly better in reducing tar spot severity (1.7 %) the yield response obtained was lower (-1.2 %) than the control.

Table 33. Effect of fungicides applied to maize on tar spot ear leaf severity and yield in the US.

Fungicide(s)	Yield response (%)	Tar spot severity (%)[1]	EU approved
Control – no fungicide	-	5.3	
Propiconazole	-0.2 %	3.6	No
Prothioconazole	0.5 %	2.9	Yes
Flutriafol + bixafen	2.4 %	2.8	No (Flutriafol)
Azoxystrobin + propiconazole	4.5 %	2.7	No (Propiconazole)
Benzovindiflupyr + azoxystrobin + propiconazole	4.5 %	2.5	No
Azoxystrobin + flutriafol	0.8 %	2.1	No
Pyraclostrobin + metconazole	1.5 %	2.0	Yes
Pydiflumetofen + azoxystrobin + propiconazole	2.2 %	2.0	No (Propiconazole)
Mefentrifluconazole + pyraclostrobin	5.1 %	1.8	Yes
Cyproconazole + picoxystrobin	-1.2 %	1.7	No (both)
Pyraclostrobin	1.6 %	1.6	Yes
Prothioconazole + trifloxystrobin	7.9 %	1.5	Yes
Mefentrifluconazole + pyraclostrobin + fluxapyroxad	6.0 %	1.4	Yes

[1] Tar spot severity was rated by visually assessing the percentage of the symptomatic leaf area on the ear leaf of five plants per plot at the dent growth stage (R5).

Source: Telenko et al. (2022).

Soybean – soybean rust

Soybean rust is a very severe disease of soybeans that can caused up to 78-90 % yield losses and significant economic losses . The estimated costs due to Asian soybean rust control in Brazil, since the 2001/2002 crop season have increased from $177 million to $1.94 billion in 2012/2013 with a maximum cost of $2.38 billion in 2007/2008 (Godoy et al. 2016). Table 34 shows the mean percentage yield response and control severity for seven fungicides used to control this disease. As can be seen, approved fungicides can deliver higher yield response and control severity than cyproconazole for this disease and commodity.

Table 34. Comparison of yield response and control severity of soybean rust by fungicides in Brazil.

Fungicide	Yield response (%)	Control severity (%)	EU approved
Azoxystrobin	29.6 %	61.8 %	Yes
Cyproconazole	27.7 %	55.8 %	No
Tebuconazole	29.6 %	57.8 %	Yes
Azoxystrobin + cyproconazole	49.2 %	79.0 %	No (Cyproconazole)
Picoxystrobin + cyproconazole	51.1 %	80.2 %	No (both)
Pyraclostrobin + epoxiconazole	47.2 %	76.7 %	No (Epoxiconazole)
Trifloxystrobin + prothioconazole	64.8 %	83.6 %	Yes

Source: own elaboration based on Lana et al. (2018).

This is further confirmed by the field trials reported by Schem et al. (2009). Table 35 shows the median values of weighted response rations for soybean rust severity and yield of different active ingredients based on a synthesis of 71 fungicide efficacy trials conducted in Brazil from 2003/2004 to 2006/2007. Combinations of ingredients tend to perform better than single ingredients and, although cyproconazole performs better than the rest of fungicides in yield response, alternative fungicides such as tebuconazole and prothioconazole or the mixtures of trifloxystrobin and tebuconazole, all approved by the EU, perform similarly with better results in severity control than cyproconazole.

Table 35. Comparison of yield response and control severity of soybean rust by fungicides by active ingredient in Brazil.

Active ingredient and typical rate (g ha^{-1})	n	R_s	R_y	Eu Approved
Azoxystrobin (50)	23	0.568	1.366	Yes
Cyproconazole (30 or 40)	29	0.514	1.624	No
Difenoconazole (50)	26	0.738	1.169	Yes
Epoxiconazole (50)	60	0.559	1.298	No
Fluquinconazole (62.5)	21	0.809	1.185	No
Flutriafol (62.5)	24	0.510	1.430	No
Metconazole (54)	17	0.526	1.467	Yes
Myclobutanil (100)	23	0.427	1.242	No
Picoxystrobin (60)	18	0.465	1.425	No
Propiconazole (125)	17	0.559	1.307	No
Prothioconazole (75 or 100)	30	0.325	1.598	Yes
Tebuconazole (100)	141	0.379	1.629	Yes
Tetraconazole (50)	61	0.462	1.377	Yes
Azoxystrobin + cyproconazole (60 + 24)	37	0.241	1.586	No (Cyproconazole)
Cyproconazole + propiconazole (24 + 75)	42	0.374	1.466	No (both)
Flusilazole + carbendazim (100 + 50 or 75 + 150)	22	0.147	1.361	No (both)
Flutriafol + carbendazim (50 + 300)	20	0.432	1.528	No (both)
Flutriafol + thiophanate-methyl (60 + 300)	51	0.433	1.419	No (both)
Pyraclostrobin + epoxiconazole (66.5 + 25)	31	0.388	1.563	No (Epoxiconazole)
Trifloxystrobin + cyproconazole (56.2 + 24)	36	0.346	1.653	No (Cyproconazole)
Trifloxystrobin + propiconazole (50 + 50)	24	0.525	1.418	No (Propiconazole)
Trifloxystrobin + tebuconazole (50 + 100)	33	0.327	1.569	Yes

Rs is defined as the disease severity of a given fungicide treatment divided by the disease severity of the corresponding untreated check. The smaller R_S, the better the control efficacy. R_y is defined as the yield of a given fungicide treatment divided by the yield of the corresponding untreated check. The greater R_y, the better the yield response.

Source: Own elaboration based on Scherm et al. (2009).

Wheat – Yellow rust, leave rust

Table 36 shows the effect of fungicides (fungicides and organic) on yellow rust and yield of wheat in India (Punjab) by comparing treatment with fungicides versus no treatment. Yield losses have been reported in billions of dollars (Tak et al. 2021). The cost benefit analysis shows that the use of azoxystrobin 11 % + tebuconazole 18.3 % yields higher benefits (+18 %) than azoxystrobin 18.2 % + cyproconazole 7.3 %.

Table 36. Comparison of the effect of fungicides used to treat wheat yellow rust on yield increase and cost-benefit ratio in Punjab (India).

Active ingredient(s)	Yield increase (%) 2016-17	Yield increase (%) 2017-18	Cost:Benefit ratio	EU approved
Fosetyl-aluminium 80 %	6.5 %	10.2 %	1:1.59	Yes
Azoxystrobin 18.2 % + difenoconazole 11.4 %	67.2 %	35.8 %	1:6.23	Yes
Azoxystrobin 18.2 % + cyproconazole 7.3 %	55.1 %	35.5 %	1:6.92	No
Azoxystrobin 11 % + tebuconazole 18.3 %	49.9 %	32.5 %	1:8.14	Yes
Lactic acid	12.9 %	10.2 %	1:7.45	No
Azadirachtin (Crude)+ lactic acid	20.5 %	16.3 %	1:11.86	No (Lactic acid)
Trifloxystrobin 25 % + tebuconazole 50 %	55.1 %	37.7 %	1:6.95	Yes
Azadirachtin (crude)	6.5 %	13.2 %	1:6.44	Yes (Extract)
Pyraclostrobin 12.5 % + epoxiconazole 4.7 %	54.3 %	33.6 %	1:8.55	No (Epoxiconazole)
Captan 70 %+ hexaconazole 5 %	52.2 %	24.5 %	1:4.23	No (Hexaconazole)
Propiconazole 25 %	63.3 %	32.5 %	1:14.37	No

Source: Own elaboration based on Tak et al. (2021).

Table 37 shows the yield increase (%) from using fungicides as opposed to not treating leaf rust in wheat in South Africa.

Table 37. Comparison of the effect on yield increase of active ingredients used to treat leaf rust vs unsprayed control in wheat in South Africa.

Active ingredient	Yield increase (%)	EU approved
Bromuconazole	24.2	Yes
Cyproconazole	49.6	No (both)
Epoxiconazole/carbendazim	52.7	No
Flusilazole/carbendazim	29.8	No
Flutriafol	38.9	No
Propiconazole	38.9	No
Tebuconazole	50.0	Yes
Tebuconazole/carbendazim	46.4	No (carbendazim)

Source: Boshoff et al. (2002).

Wheat – fusarium head blight index (IND) and doexyivalenol (DON)

Paul et al. (2008) evaluated the efficacy of triazole-based fungicides for fusarium head blight index (IND) and doexyivalenol (DON) in wheat. DON is a major trichothecenes mycotoxin produced by fusarium head blight and is considered to be a threat to public health since it can lead to chronic toxic effects on humans and animals that consume contaminated foods and feeds (Ran et al., 2013). Based on the results of the close to 400 field trial conducted in the US reported in Table 38, we can see that the best alternative in terms of efficacy against the fusiarium head blight and DON are the combination of prothioconazole and tebuconazole, metconazole and prothioconazole, all of them approved by the EU.

Table 38. Efficacy of Selected Fungicide Treatments against Fusarium Head Blight and Deoxynivalenol (DON) Accumulation in Wheat in the US.

Fusarium head blight index	% efficacy	N	EU approved	Doexyivalenol (DON)	% efficacy	N	EU approved
Prothioconazole + tebuconazole	51.81	73	Yes	Metconazole	45.12	50	Yes
Metconazole	49.84	71	Yes	Prothioconazole	42.88	60	Yes
Prothioconazole	48.31	69	Yes	Prothioconazole + tebuconazole	41.73	56	Yes
Tebuconazole	40.00	143	Yes	Tebuconazole	22.89	104	Yes
Propiconazole	31.61	63	No	Propiconazole	12.19	45	No

Source: Own elaboration based on Paul et al. (2008).

A pattern confirmed in a posterior analysis using EU data from 1995 to 2013 conducted by Paul et al. (2018) which is summarized in Table 39.

Table 39. Efficacy of Selected Fungicide Treatments against Fusarium Head Blight and Deoxynivalenol (DON) accumulation in wheat (% efficacy; number of observations) in the US.

	% efficacy			
Fungicide(s)	**Fusarium head blight index**	**Doexyivalenol**	**N[3]**	**EU approved**
Metconazole	52.2	45.5	214	Yes
Prothioconazole + tebuconazole	51.5	38.2	213	Yes
Prothioconazole	49.9	40.3	109	Yes
Pyraclostrobin + tebuconazole + prothioconazole	45.7	30.5	17	Yes
Pyraclostrobin + metconazole 1	41.8	26.6	28	Yes
Pyraclostrobin + metconazole 2	15.7	-1.8	18	Yes
Tebuconazole	39.6	20.1	249	Yes
Pyraclostrobin + tebuconazole	31.2	9.1	13	Yes
Pyraclostrobin (full flag leave emergence)	5.5	-5.9	61	Yes
Pyraclostrobin (boot)	11.2	-15.3	35	Yes
Pyraclostrobin (full head emergence)	21.8	-17.8	50	Yes
Azoxystrobin	-17.6	-16.1	17	Yes
Fluoxastrobin	5.1	-13.1	12	Yes
Azoxystrobin + propiconazole	10.2	-15.0	19	No (Propiconazole)
Trifloxystrobin + prothioconazole	17.4	1.3	19	Yes

[#] Number of experiments in which a given treatment was evaluated.

Source: Paul et al. (2018).

Coffee – coffee leaf rust

In the case of coffee available evidence shows that substitution of cyproconazole can be more challenging. For Brazil, none of the best performing fungicides to treat coffee leaf rust in terms of yield increase compared to untreated plants are approved in the EU as shown in Table 40. However, similar protection against the effect of the disease is reported for some approved ASs such as pyraclostrobin (Table 41), but under high disease pressure the performance of this alternative declines (Table 42).

Table 40. Yield increase when using active ingredients to treat coffee leaf rust compared with no product application in Brazil.

Active ingredient(s)	Yield increase compared with those of the plants that did not receive any product application (%)	EU approved
Cyproconazole on soil in November and cyproconazole + azoxystrobin on leaves	74.1%	No (cyproconazole)
Triadimenol on soil in November and cyproconazole + trifloxystrobin on leaves in December and February	33.9 %	No (cyproconazole and triadimenol)
Flutriafol on soil in November and flutriafol on leaves in December and February	59.3 %	No
Cyproconazole + azoxystrobin on leaves in December, February and April	79.0 %	No (cyproconazole)
Epoxiconazol + pyraclostrobin on leaves in December and March	99.1 %	No (epoxiconazole)

Source: Own elaboration based on Honorato et al. (2015).

Table 41. The effect of active ingredients used to treat coffee leaf rust in terms of severity reduction (%) in Brazil.

Active ingredient	Coffee leaf rust severity reduction (%)	EU approved
Trifloxystrobin	8.99 %	Yes
Azoxystrobin	79.4 %	Yes
Triadimenol	82.02 %	No
Cyproconazole	93.26 %	No
Epoxiconazole	96.63 %	No
Pyraclostrobin	98.50 %	Yes

Source: Own elaboration based on Honorato et al. (2015).

Table 42. Comparison of the effect of active ingredients used to treat coffee leaf rust on coffee leaf rust severity in Brazil.

Active ingredient(s)	Coffee leaf rust severity (%) – experiment 1	Coffee leaf rust severity (%) – experiment 2	EU Approved
Control – no active ingredient	1.9 %	17 %	
Copper Hydroxide	No effect on severity	No effect on severity	Yes
Cyproconazole	<0.3 %	<0.3 %	No
Pyraclostrobin	0.1 %	1.0 %	Yes
Copper hydroxide + PyraNclostrobin	1.0 %	2.0 %	Yes
Copper hydroxide + cyproconazole	0.9 %	1.0 %	No

Source: Own elaboration based on da Costa et al. (2019).

Beans – chocolate spot

For this disease, Gillbard (2021) reports that fungicides approved in the EU can provide better yield response compared to untreated beans based on data from the UK as summarized in Table 43.

Table 43. Yield response of alternative fungicides vs. no treatment to control chocolate spot in beans in the UK.

Active ingredient	Chocolate spot Yield response versus untreated	EU Approved
Boscalid + pyraclostrobin	Up to 17 %	Yes
Azoxystrobin + tebuconazole/metconazole	Up to 10 %	Yes
Cyprodinil + fludioxonil	-	Yes
Cyproconazole + chlorothalonil	3.5 %	No

Source: Own elaboration based on Gillbard, (2021).

Annex 4. Additional details of the qualitative analysis of exposure for commodities not explicitly represented in CAPRI.

The detailed analyses presented in this Annex are a more detailed extension of those reported in section 3.6, and are intended to complement those conducted with the CAPRI model by focusing on commodities that fall outside its current coverage. The overarching objective is to identify commodities and countries which are most exposed to the reduction of MRLs to the LOQ for the most hazardous ASs.

Due to existing data limitations, it is not possible to predict or quantify impacts, establish causal effects (e.g. on prices), or to define behavioural patterns. Therefore, these analyses qualitatively evaluate the potential economic exposure of both exporting third countries and the EU to the reduction of MRLs to the LOQ limits through descriptive analyses and the use of trade indicators. As such, it does not take into account the intensity of use of the ASs in third countries and only identifies potential hotspots that would merit additional analysis.

The analyses are conducted separately for exporting third countries —focusing on the relative importance of trade with the EU for their economy and their potential for adapting to change via trade diversion and domestic absorption — and the EU —highlighting specific trade dependencies that may potentially cause short-term effects, and potential for diversification of supply sources and self-sufficiency.

Specifically, the analyses cover:

- 180 agricultural commodities not covered in CAPRI;
- The whole EU (no Member State breakdown) as importing entity;
- 78 out of the 86 exporting third countries (eight third countries[45] do not export any of the commodities covered in these complementary analyses, and are therefore excluded);
- 16 active substances out of the total 18 considered in CAPRI (two active substances[46] are not related to the commodities covered in this report and are therefore excluded).

The results highlight the main exporting third countries —i.e. those with comparatively higher dependency on exports to the EU— and imported commodities —i.e. those for which the EU is not

[45] Afghanistan, Armenia, Bolivia, Central African Republic, Dominica, Eritrea, Georgia and Namibia.

[46] Benthiavalicarb and chlordecone.

self-sufficient. Also, the results included in tables and figures refer to commodities with both detection status and registration in third countries. However, additional figures and information on countries and commodities are available in the online dashboard referred to in section 2.6.

THIRD COUNTRIES' EXPOSURE

Question 1. How dependent are third countries to exports to the EU?

A third country's exposure can be tackled from at least three perspectives:

- A third country's absolute export value to the EU of the considered commodities (see Question 1a);
- The relative importance of a third country's export to the EU relative to its total export of the same commodities (see Question 1b);
- The relative importance of a third country's export to the EU relative to its total domestic agricultural production (see Question 1c).

For a qualitative selection of the third countries most exposed to the reduction of MRLs to the LOQ, this three information can be combined (see Question 1c). In addition, it can be relevant to assess a third country's exposure to specific active substances measured as the share of a country's export to the EU on the export to the world of commodities affected by each specific active substance (Question 1d). This point of view is potentially relevant when the reduction of the MRLs to the LOQ is considered on a case-by-case for a specific active substance.

Question 1a. Which are the main exporting third countries to the EU in terms of value, and which are the main commodities exported to the EU by each third country?

In the first place, it is of interest to observe the value of the main export flows to the EU of the considered commodities. The absolute export values alone cannot help disentangling which third countries are actually more exposed to the reduction of MRLs to the LOQ, as this depends on the importance of export value relative to the country trade and economy. Yet, it is helpful to understand current trade patterns —which third countries do undergo trade with the EU of the considered commodities— as well as the overall values at stake.

Considering the total export value (Table 44), United States appear to be by far the main exporting country to the EU of the considered commodities. It accounts for more than 16 billion $, about 30% of the total export to the EU of the considered commodities.

Turkey follows with about 5.1 billion $ export value, about 9% of total export. Peru exported about 3.7 billion $ (~6%) followed by Ecuador (2.9 billion $, 5.2%), Morocco (~ 2.7 billion $, ~5%), Vietnam (2.3 billion $, 4.2%), Colombia (2.3 billion $, 4%) and Chile (2 billion $, 3.6%). The remaining countries (Vietnam, Colombia, Chile, Costa Rica, China, Canada, Brazil, South Africa and Israel) have exported to the EU less than 2 billion $ each. Overall, the above third countries covered about 80% of total export to the EU of the considered pesticide commodities.

The main commodities exported to the EU differ among third countries (Table 44), whereby for some third countries the export to the EU is mainly linked to one or few commodities, and for other third countries it consists of a more balanced trade of many commodities.

For instance, considering the main exporting countries (in absolute terms), the United States' export is largely represented by Tree nuts (46.4 %) followed by Almonds (24.9 %), Turkey's export is by 46.7 % represented by Hazelnuts/cobnuts, 64.2% of Peru's export is represented by Avocados (37.9

%) and Blueberries (26.3 %), and Ecuador, Colombia and Costa Rica's export consists mainly of Bananas by respectively 98.6 %, 80.5 %, and 88 %.

Other third countries' export is relatively more distributed over more commodities. For example, about 86.5 % of China's export consists of Fungi, mosses and lichens, Cultivated fungi, Asparagus, Sweet peppers/bell peppers, and Horseradishes. Likewise, about 85 % of Chile's export is distributed over Walnuts, Avocados, Hazelnuts/cobnuts, and Blueberries, whereas almost 71% of South Africa's export accounts for Avocados, Blueberries, Tree nuts – Others, and Plums. Therefore, the main exporting third countries show varying commodity specialization and patterns when it comes to exporting to the EU.

Table 44. Main third countries exporting the considered commodities (detected or registered) to the EU by export value, and main commodities exported to the EU by each third countries (for the commodities not explicitly covered in CAPRI).

Third country	Total export value (million $) to the EU	Cumulative share (%) of the ranked export values	Main commodities as share (%) of the total export value ($) to the EU
United States	16 628.9	29.6	Tree nuts - Others: 46.4 % Almonds: 24.9 % Pistachios: 12.1 % Others (101): 25.0 %
Turkey	5 120.3	38.72	Hazelnuts/cobnuts: 46.7 % Sweet peppers/bell peppers: 11.7 % Others (35): 53.9 %
Peru	3 754.4	45.4	Avocados: 37.9 % Blueberries: 26.3 % Mangoes: 17.7 % Others (17): 20.8 %
Ecuador	2 956.6	50.66	Bananas: 98.6 % Others (25): 2.5 %
Morocco	2 751.5	55.56	Raspberries (red and yellow): 27.4 % Beans (with pods): 25.3 % Sweet peppers/bell peppers: 19.8 % Strawberries: 10.9 % Others (7): 16.9 %
Vietnam	2 318	59.69	Cashew nuts: 95.5 % Others (32): 5.4 %
Colombia	2 269.8	63.73	Bananas: 80.5 % Avocados: 18.6 % Others (23): 0.9 %
Chile	2 009	67.3	Walnuts: 27.4 % Avocados: 22.2 % Hazelnuts/cobnuts: 18.1 % Blueberries: 17.2 % Others (34): 18.5 %
Costa Rica	1 676.2	70.29	Bananas: 88.0 % Others (27): 16.4 %

China	1 566.5	73.08	Cultivated fungi: 41.5 % Fungi, mosses and lichens: 41.5 % Asparagus: 26.8 % Sweet peppers/bell peppers: 26.8 % Horseradishes: 18.2 % Garlic: 13.4 % Basil and edible flowers: 10.9 % Herbs and edible flowers: 10.9 % Others (34): 21.2 %
Canada	1 395.7	75.56	Legume vegetables - Others: 48.6 % Legume vegetables - Lentils: 23.7 % Cherries (sweet): 19.1 % Others (70): 15.7 %
Brazil	1 310.4	77.89	Guavas: 39.8 % Mangoes: 39.8 % Melons: 25.3 % Others (48): 36.3 %
South Africa	1 196.6	80.02	Avocados: 23.4 % Blueberries: 20.7 % Tree nuts - Others: 13.3 % Plums: 13.2 % Macadamias: 11.8 % Others (63): 44.5 %
Israel	1 176.3	82.12	Dates: 50.4 % Avocados: 20.9 % Beetroots: 14.5 % Others (49): 52.9 %
Other third countries	10 044.8	100	-

Note: the percentage shares reported for the commodities of a third country do not necessarily sum up to 100%. This is due to the fact that some of the reported commodities refer to the same product code of the Common Nomenclature (CN) used for the UN Comtrade database from which trade data were retrieved.

[A] Other third countries include (ordered from the highest to the lowest export value): Canada, Egypt, Ukraine, Côte d'Ivoire, United Kingdom, Australia, Ghana, Dominican Republic, Mexico, Russia, India, Serbia, Tunisia, Madagascar, New Zealand, Panama, Nigeria, Tanzania, Senegal, Cameroon, Thailand, Republic of North Macedonia, Guatemala, Uganda, Argentina, Mozambique, Moldova, Malawi, Honduras, Albania, Belize, Bosnia and Herzegovina, Mauritius, Jamaica, Ethiopia, Belarus, Uzbekistan, Malaysia, Philippines, Togo, Sri Lanka, Botswana, Rwanda, Indonesia, Korea-South, Japan, Kazakhstan, Benin, Zimbabwe, Uruguay, Cambodia, Gabon, Cuba, Burundi, Laos.

The following countries had zero export value reported: Guyana, Suriname, Iran, Paraguay, Algeria, Guinea, Pakistan, Bangladesh, Taiwan.

Source: Own elaboration based on UN Comtrade data. Third countries summing up to a cumulative share of 80% export to the EU of the considered pesticide-commodities are shortlisted. For each third country, only commodities with 10% or more of the country export of the pesticide-commodities to the EU are reported, while the remaining commodities are grouped under "others".

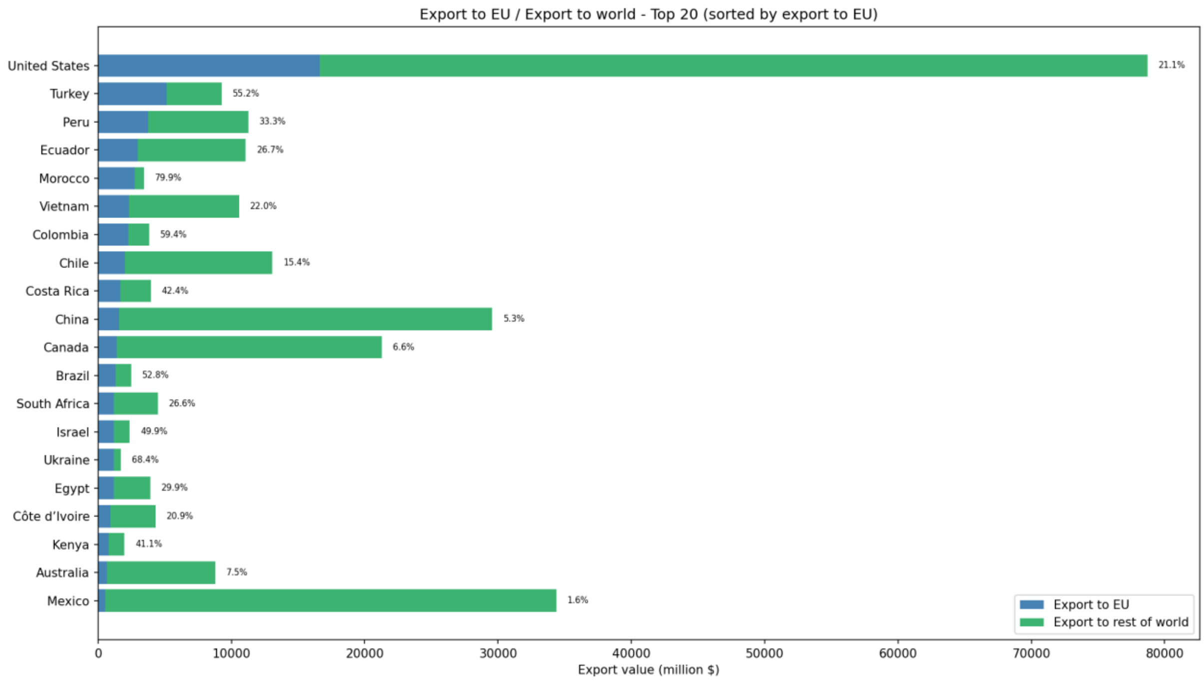
Question 1b. How important is for the third countries the export to the EU of the considered commodities relative to their total export of the same commodities?

A third country's absolute export value to the EU is not sufficient to assess the extent to which this country is exposed to the reduction of MRLs to the LOQ. In fact, while the absolute exported value may seem high, its relative importance to the considered third country may be low. The relative importance of the EU market for third countries' exports, which could be also referred to as third countries' export dependency on the EU market, is measured as the percentage share, for each third country, of the value exported to the EU on the total value exported to the world (Figure 16 and Figure 17): the higher the share, the higher the dependency on the EU market. Although a clear threshold to identify structural dependency does not exist, third countries can be ranked from the highest to the lowest share. The third countries ranking at the top are those revealing a higher dependency —with potentially higher exposure to the reduction of MRLs to the LOQ.

The third countries exporting the highest value to the EU are not necessarily those that are most dependent on the EU market to export (Figure 16). For instance, the United States is the third country with highest export value to the EU; however, it relies on the EU market for export only by 21.1 %, showing a significantly lower dependency compared to other third countries. Likewise, China, Canada and Australia, which are among the 20 highest exporting countries to the EU, show a dependency on EU market for export of respectively 5.3 %, 6.6 % and 7.5 %.

The third countries with the highest export dependency on the EU market are not necessarily those with the highest absolute export value (Figure 17). For instance, Bosnia and Herzegovina shows the highest export dependency of 99.5 %, signaling almost total dependence. This is followed by Morocco, Uruguay, Benin, Cameroon and Moldova, with shares varying between 70 % and 80 %. Also, a high export dependency is shown by United Kingdom, Republic of North Macedonia, Serbia, Panama, Suriname, Colombia, Mauritius, Turkey, Senegal and Brazil, all with an export dependency above 50 %. Israel, Costa Rica and Albania also show an export dependency between 40 % and 50 %.

Figure 16. Percentage share of export to the EU on total export of the pesticide-commodities (detected or registered), by third country, ordered from the highest to the lowest export value to the EU (for the commodities not explicitly covered in CAPRI).

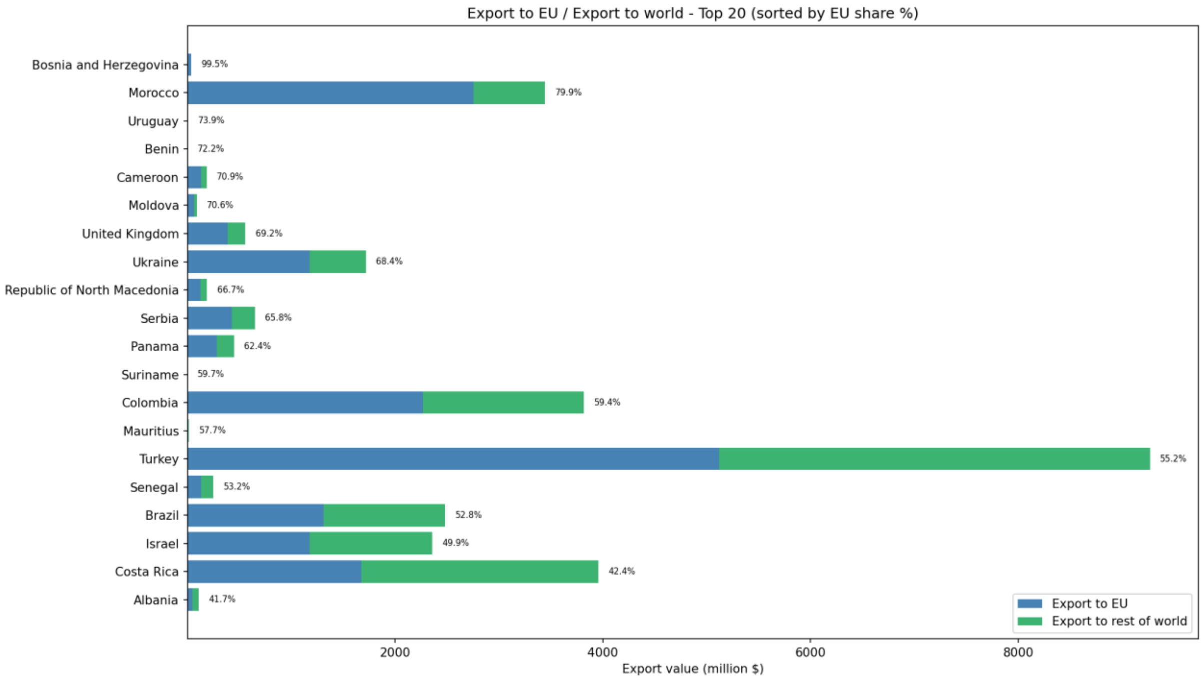


Source: Own elaboration based on UN Comtrade data. First 20 countries are displayed. Ordered by absolute export value to the EU.

Nonetheless, many of these third countries also show a very low absolute value exported of the considered commodities, not only to the EU, but more in general to the world. As a matter of fact, having a high dependency on exports to the EU does not necessarily come with high export values overall. In these cases, even when the share appears high, actual exposure may be considered relatively low.

Consequently, both the absolute export value to the EU and the share of exports to the EU on the total export to the world should be taken into account when identifying the most exposed countries. Those third countries showing high export dependency and, at the same time, relatively high export values are Morocco, Ukraine, Colombia, Turkey, and Brazil. These countries may be considered as highly exposed to the reduction of MRLs to the LOQ.

Figure 17. Percentage share of export to the EU on total export of the pesticide-commodities (detected or registered), by third country, ordered from the highest to the lowest share (for the commodities not explicitly covered in CAPRI).



Source: Own elaboration based on UN Comtrade data. First 20 countries are displayed. Ordered by percentage share.

Question 1c. How important is for the third countries the export to the EU of the considered commodities relative to their value of domestic agricultural production?

There is a third important dimension of a third country's exposure to the reduction of MRLs to the LOQ, which is the relative importance of export to the EU of the considered commodities on the domestic agricultural production. This measure can mirror (to some extent) how important the export of the considered pesticide-commodities is on the national agricultural economy. In fact, while a third country may rank at the top of exported values to the EU (and/or the share of dependency on the EU market), its exports may reveal relatively unimportant compared to the national economy. This dimension, which we can refer to as production dependence, can be assessed via the percentage share of export value to the EU on the national domestic agricultural production: the higher the share, the higher the dependency of the national economy on the exports to the EU. Conversely, a third country with relatively low production dependence may reveal relatively high capacity to absorb potential impacts to these trade flows.

Figure 18 shows the three relevant dimensions —export dependence, production dependence, and absolute export values— displaying only the third countries that fall among the 15 top ranked countries in at least one of the dimensions. In principle, the top-right quadrant of Figure 18 should capture the third countries with highest combined dependence on exports to the EU of total exports and agricultural production. However, no country appears in this quadrant, revealing that no third country is exposed in terms of both export to the EU on total exports and on domestic agricultural production.

Differently, 16 third countries[47] appear in the bottom-right quadrant, hence showing a relatively high export dependency on the EU market, but a relatively low macroeconomic dependency of their domestic agricultural production on these exports. Among these countries, those showing the highest absolute export values to the EU are Turkey (5.1 billion $), Morocco (2.8 billion $), Colombia (2.3 billion $), Brazil (1.3 billion $), and Ukraine (1.2 billion $). The remaining countries in this quadrant —Bosnia and Herzegovina, Benin, Uruguay, Moldova, Cameroon, Serbia, Republic of North Macedonia, United Kingdom, Panama, Suriname, and Senegal— show absolute export values lower than 1 billion $. For the countries in this quadrant, which we can refer to as "**export dependent countries**", it may be concluded that, while the national agricultural production may not be highly exposed, those segments of the economy operating in the pesticide-commodity exports may be highly exposed, and the economic value at stake for these segments is particularly higher in the case of Turkey, Morocco, Colombia, Brazil, and Ukraine.

On the other hand, only three third countries appear in the top-left quadrant hence showing a relatively high macroeconomic dependence of domestic agricultural production on exports to the EU, but a relatively low dependence of total exports on exports to the EU. These countries are Costa Rica (14 % of domestic agricultural production to export to the EU), Ecuador (9 %), and Peru (7 %). All these countries also show a non-insignificant absolute value exported to the EU, respectively 1.7 billion $, 3 billion $, and 3.8 billion $. These countries, which can be referred to as "**production dependent countries**", show that a relatively low share of exports to the EU can still be economically significant for the country, and consequently exposes the national producers to the reduction of MRLs to LOQs.

Lastly, the bottom-left quadrant shows the 11 third countries[48] with relatively low export and macroeconomic dependency. However, some of these countries show a relatively high absolute export value to the EU, including (in descending order): United States (17 billion $), China (1.6 billion $), Vietnam (2.3 billion $), Chile (2 billion $), Israel (1.2 billion $), South Africa (1.2 billion $) and Canada (1.4 billion $). The remaining countries show export values lower than 1 billion $. For the countries in this quadrant, which can be referred to as "**export value at stake**", it may be considered that while neither the national production nor the total exports are particularly exposed, the value at stake for the operators specifically involved in exports to the EU of the considered pesticide-commodities may be not insignificant.

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47 In descendent order of percentage share of export to the EU on export to world: Bosnia and Herzegovina, Morocco, Uruguay, Benin, Cameroon, Moldova, United Kingdom, Ukraine, Republic of North Macedonia, Serbia, Panama, Suriname, Colombia, Turkey, Senegal and Brazil.

48 In descendent order of absolute export value to the EU: United States, Vietnam, Chile, China, Canada, South Africa, Israel, Côte d'Ivoire, Dominican Republic, Tunisia and Belize.

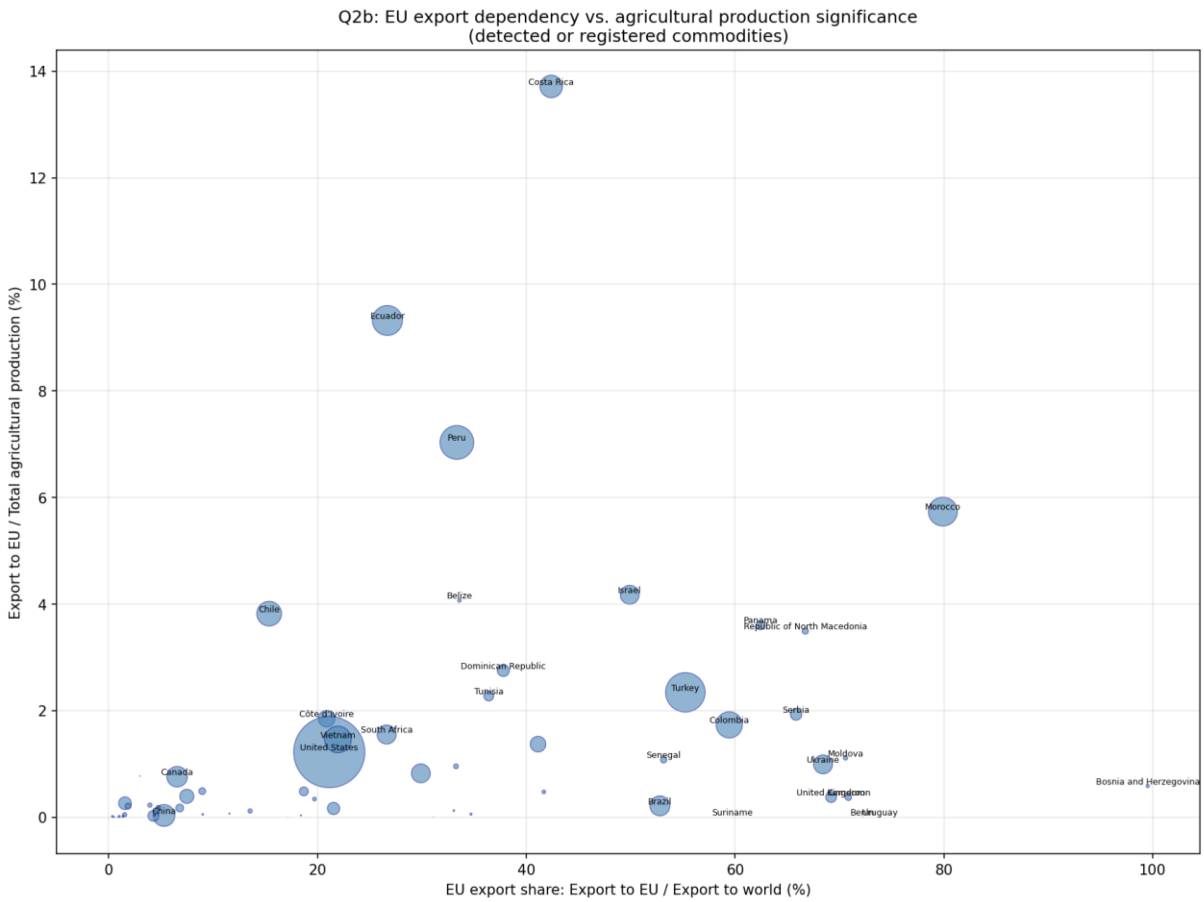
Therefore, for a proper identification of the third countries somehow exposed to the reduction of MRLs to LOQs, it should be considered that different forms of exposure exist, each with different possible implications. Specifically, according to the analyses presented in Figure 18, 30 third countries are (qualitatively) identified as potentially exposed, namely:

- As **export dependent countries**: Bosnia and Herzegovina, Morocco, Uruguay, Benin, Cameroon, Moldova, United Kingdom, Ukraine, Republic of North Macedonia, Serbia, Panama, Suriname, Colombia, Turkey, Senegal, Brazil.
- As **production dependent countries**: Peru, Ecuador, and Costa Rica.
- As **countries with export value at stake**: United States, Vietnam, Chile, China, Canada, South Africa, Israel, Côte d'Ivoire, Dominican Republic, Tunisia, Belize.

  With a special focus on United States, China, Vietnam, Chile, Israel, South Africa and Canada which show the highest export values (1 billion $ or above).

For the sake of conciseness and relevance of the analysis. The following questions from 2c to 4c will focus on the 30 identified exposed third countries.

Figure 18. Top third countries by export value to the EU, export dependence on the EU (export to EU / export to the world), and macroeconomic dependence (export to the EU / domestic agricultural production) for the commodities not explicitly covered in CAPRI.



Note: for each of the three dimensions, the 15 top third countries are displayed (removing double-counting among dimensions). The bubble size measures the absolute export value to the EU.

Source: Own elaboration based on UN Comtrade (export values) and FAOSTAT data (domestic agricultural production).

Question 1d. How dependent are third countries on exports to the EU of commodities related to each active substance?

The previous questions 1a, 1b and 1c focus on the export values related to all commodities exported by the third countries. Nonetheless, it is also relevant to assess the third countries' exposure to each active substance considered for reduction of MRLs to the LOQ.

To do so, for each third country identified in Question 1c, the export value to the EU, to the world, and the share of export to the EU on the export to the world, are measured only for the pesticide commodities affected by each specific active substance (Table 45).

Firstly, active substances differ in terms of how many third countries' exports to the EU they affect. For instance, there are active substances that affect the export to the EU of several third countries, including mancozeb (60 third countries), dimethomorph (51), metiram (45), carbendazim (44), glufosinate (42), thiophanate-methyl (37) and benomyl (37). Other active substances also affect the export to the EU of a significant number of third countries, like spirodiclofen (29), cyproconazole (21), clofentezine (18), and isopyrazam (13). Conversely, there are some active substances affecting the export to the EU of fewer third countries, including metribuzin (9), quinoxyfen (7), mepanipyrim (4), dicofol (1), and flufenacet (0). Thus, there may be a significant difference in terms of third countries affected by the reduction of MRLs to the LOQs for different active substances.

However, the figures can change significantly when considering for how many third countries the export affected by each active substance is highly dependent on the EU market. For example, metiram, mancozeb, carbendazim, thiophanate-methyl, and benomyl affect respectively 17, 15, 11, 10, and 10 third countries dependent on export to the EU by at least 50% (share of export to the EU on export to world), whereas mepanipyrim and quinoxyfen affect only two countries dependent by at least 50 % on the EU market, metribuzin only one, and dicofol and flufenacet no country. When considering a very high dependence on the EU market for export (higher than 75 %), eight third countries are affected by metiram, six by carbendazim, five by benomyl, and four by mancozeb. The remaining active substances affect three or less third countries with very high export dependence, while no country is affected by dicofol, flufenacet and metribuzin. Consequently, the number of third countries affected by each active substance decreases significantly when considering only the countries that are highly or very highly dependent on exports to the EU. However, metiram, benomyl, carbendazim and mancozeb seem to remain the active substances exposing the most third countries.

Relevant example of third countries highly exposed to the MRLs' reduction of certain active substances can be drawn from Table 45, which reports the third countries and affecting active substances for relevant export values (> 250 million $) and export dependency on the EU (>50 %). Morocco is dependent on the EU market for the export of commodities affected by five active substances. In particular, mancozeb, metiram, clofentezine benomyl, and carbendazim affect a high value of the country's export to the EU (between 0.7 and 2 billion $ in total), on which the country's total export is highly dependent by 74 % or more. Brazil is also dependent on the EU market for the export of commodities affected by five active substances. In this case, mancozeb, thiophanate-methyl, glufosinate, benomyl, and carbendazim affect an export value to the EU between 0.6 and 1.2 billion $, for which export the country is dependent on the EU by 50 % to 66 %.

Likewise, Colombia's EU-dependent export is affected by five active substances (glufosinate, mancozeb, metiram, isopyrazam, spirodiclofen), all affecting a high export value to the EU between

0.4 and 2.3 billion $, on which export the country is dependent on the EU between 60 % and 72 %. Serbia and Turkey's EU-dependent exports are affected by three active substances each. In Serbia, benomyl, carbendazim and thiophanate-methyl affect an export value to the EU of about 350 million $, which is about 66 % of its total export of the same commodities. In Turkey, glufosinate, spirodiclofen, and dimethomorph affect an export value between 0.9 to 5 billion $, which is about 55 % of its total export of the same commodities.

For Côte d'Ivoire, Dominican Republic, Panama, Israel and Ukraine two active substances each appear to affect the relevant export values to the EU on which the country is highly dependent. mancozeb and metiram expose both Côte d'Ivoire, Panama and Dominican Republic, while Ukraine is exposed by cyproconazole and spirodiclofen, and Israel by glufosinate and spirodiclofen.

Table 45. Main active substances affecting export value to the EU, by third country for the commodities not explicitly covered in CAPRI.

Third country	Active substance	Export to EU (million $)	Export to world (million $)	Exports to EU / Export to world (%)
Brazil	Mancozeb	1 212.3	2081.12	58.3
Brazil	Thiophanate-methyl	1 053.88	1 662.2	63.4
Brazil	Glufosinate	743.58	1 464.85	50.8
Brazil	Benomyl	633.63	966.4	65.6
Brazil	Carbendazim	633.63	966.4	65.6
Colombia	Glufosinate	2 266.81	3 665	61.9
Colombia	Mancozeb	2 264.93	3 801.06	59.6
Colombia	Metiram	2 252.81	3 743.97	60.2
Colombia	Isopyrazam	1 827.6	3 005.61	60.8
Colombia	Spirodiclofen	422.41	591.55	71.4
Côte d'Ivoire	Mancozeb	609.41	815.89	74.7
Côte d'Ivoire	Metiram	447.44	574.73	77.9
Dominican Republic	Mancozeb	297.45	483.74	61.5
Dominican Republic	Metiram	297.45	483.74	61.5
Israel	Glufosinate	1 127.14	2241.4	50.3
Israel	Spirodiclofen	293.07	501.87	58.4
Morocco	Mancozeb	1 956.02	2 359.94	82.9
Morocco	Metiram	1 956.02	2 359.94	82.9
Morocco	Clofentezine	1 283.8	1 731.6	74.1
Morocco	Benomyl	695.59	759.66	91.6
Morocco	Carbendazim	695.59	759.66	91.6
Panama	Mancozeb	280.77	449.7	62.4
Panama	Metiram	280.77	449.7	62.4
Serbia	Benomyl	343.59	523.58	65.6
Serbia	Carbendazim	343.59	523.58	65.6
Serbia	Thiophanate-methyl	343.59	523.58	65.6
Turkey	Glufosinate	4 043.27	7 152.7	56.5
Turkey	Spirodiclofen	1 126.9	2 016.82	55.9
Turkey	Dimethomorph	943.66	1 760.04	53.6
Ukraine	Spirodiclofen	587	621.24	94.5
Ukraine	Cyproconazole	579.7	1 084.86	53.4

Source: Own elaboration based on UN Comtrade data. Third countries ordered in alphabetic order. For each third country, the top five active substances in terms of export value to the EU are reported.

There are also cases where a high value is affected by an active substance, but the country has relatively low dependence on the EU for the export of those commodities. The most notable case is the United States, for which an export value varying between 0.4 billion $ and 16 billion dollars is affected by glufosinate, spirodiclofen, mancozeb, dimethomorph and quinoxyfen; however, the dependence on the EU for exporting the affected commodities varies between 5 % and 30 %. A similar case is brought by Vietnam, where an export value to the EU up to two billion $ is affected by spirodiclofen, glufosinate, mancozeb, metiram and carbendazim, although the country is dependent on the EU for the export of the affected commodities only by 26 % or less.

Summing up the export values to the EU and the number of third countries affected by each active substance (Table 46), particular attention could be paid to the reduction of MRLs to LOQs for glufosinate, spirodiclofen, mancozeb, and metiram, affecting between 16 and 44 billion $ export to the EU from 29 to 60 third countries, of which 6 to 17 show high dependence on exports to the EU of the commodities affected by these active substances.

Isopyrazam, dimethomorph, carbendazim, benomyl, thiophanate-methyl, clofentezine and cyproconazole also affected an export value varying between one and 5.5 billion $ from 13 to 51 third countries, of which 4 to 11 are highly dependent on exports to the EU of the affected commodities.

Lastly, quinoxyfen, metribuzin, mepanipyrim, and dicofol are the substances affecting a smaller amount of export value —less than 1 billion $ each— and up to nine third countries, of which one or two highly dependent on exports to the EU. Flufenacet appears to affect no third country and no export value to the EU.

Table 46. Total export value to the EU and number of third countries affected by each active substance, ranked by export value to the EU for the commodities not explicitly covered in CAPR).

Active substance	Export value to EU (million $)	No. of third countries exporting to the EU (value > 0 $)	Third countries with export to the EU being at least 50% of their total export
Glufosinate	44 022.48	42	6
Spirodiclofen	27 024.75	29	9
Mancozeb	23 110.71	60	15
Metiram	16 827.22	45	17
Isopyrazam	5 461.8	13	4
Dimethomorph	5 042.39	51	8
Carbendazim	4 858.82	44	11
Benomyl	4 715.07	37	10
Thiophanate-methyl	3 875.17	37	10
Clofentezine	2 368.11	18	6
Cyproconazole	1 382.06	21	5
Quinoxyfen	767.81	7	2
Metribuzin	244.81	9	1
Mepanipyrim	15.49	4	2
Dicofol	1.46	1	0
Flufenacet (formerly fluthiamide)	0	0	0

Source: Own elaboration based on UN Comtrade data.

Question 2 - What is the potential capacity of the third countries most dependent on exports to the EU to divert their export flows?

Question 1c identifies third countries which rely the most on exports to the EU. Question 2 focuses on these third countries. Although a country may currently have a high dependency on the EU market, it may still show some capability to divert its export flows to other non-EU export destinations or towards its internal market. While the data at hand does not allow us to predict actual behavioral change of third countries, there are certain indicators that can help assess the extent to which a third country has possibility to divert its trade, namely:

- Trade (export) diversification index, specifically a Normalized Herfindahl–Hirschman Index[49] (NHHI) (Question 2a);
- Trade (export) competitiveness, specifically a Symmetric Revealed Comparative Advantage (RCA) Index (Question 2b);
- Export trend to the EU over the past ten years (Question 2c);
- Price differences between EU and non-EU export destinations (Question 2d).

Question 2a. How diversified are the third countries' export destinations?

Even when a high share of a third country's exports is directed to the EU, this country might still rely on a relatively diversified portfolio of export destinations. A high number of export destinations (other than the EU) may signal a relatively higher capacity for the third country to divert (part of) its exports to other destinations. Thus, higher diversification may imply lower exposure to MRLs reduction to the LOQ.

The NHHI diversification index (Table 47) scores a country with a value from 0 to 1, where 0 signals the highest diversification and 1 means no diversification. Although no exact threshold exists to establish whether a country is sufficiently diversified or not, it is possible to identify the least diversified third countries —hence the potentially more exposed— through a comparative analysis among countries.

Bosnia and Herzegovina appears as extremely non-diversified third country, with a NHHI value of 0.99. This is mostly due to a very low number of destinations (five export destinations) and a very small number of exports towards non-EU destinations (0.5 %). Morocco, Cameroon, Benin, and Moldova also show a relevantly high NHHI, included between 0.65 and 0.5. This might signal a potentially non-sufficiently diversified trade to divert exports.

All remaining third countries show an NHHI lower than 0.5, hence indicating a more diversified portfolio of export destinations. United Kingdom and Ukraine —with NHHI respectively 0.49 and 0.47— also show a very high number of current export destinations (109 and 113 destinations), which indicates a potentially very high ability to divert their export from EU to non-EU countries. Similar situation appears for Turkey and Brazil, with respectively 155 and 134 export destinations.

The third countries showing the highest diversification (NHHI < 0.2) —hence the highest potential to divert their export routes— are Tunisia, South Africa, Ecuador, United States, Canada, Vietnam, and China. In particular, China, Canada, United States and South Africa show very high number of export destinations, varying between 119 and 166 countries. According to these figures, China appears to be third country with the most diversified export of the considered pesticide-commodities.

It is important to note, however, that some third countries show a relatively low NHHI, but still rely on a few export destinations. This is due to the fact that their exports are well balanced (or

[49] Diversification is measured as $NHHI = (HHI - 1/N) / (1 - 1/N)$, where N is the number of export destinations and $HHI = \sum_i s^2$, s being the percentage share of export value going to destination country i.

distributed) among the few destinations available. The most notable cases are Suriname (three destinations), Uruguay (three), Belize (four) and Panama (eight).

Table 47. Diversification of the export of pesticide-commodities (detected or registered) of the third countries most dependent on the EU market for the commodities not explicitly covered in CAPRI.

Country name	**Number of export destinations**	**NHHI**
Bosnia and Herzegovina	5	0.99
Morocco	75	0.65
Cameroon	28	0.51
Benin	21	0.51
Moldova	17	0.5
United Kingdom	109	0.49
Senegal	24	0.48
Ukraine	113	0.47
Serbia	36	0.46
Republic of North Macedonia	16	0.44
Colombia	55	0.41
Uruguay	3	0.38
Panama	8	0.38
Belize	4	0.38
Dominican Republic	47	0.33
Côte d'Ivoire	73	0.32
Turkey	155	0.32
Brazil	134	0.31
Costa Rica	57	0.31
Israel	96	0.28
Peru	71	0.27
Chile	83	0.27
Suriname	3	0.2
Tunisia	82	0.17
South Africa	119	0.16
Ecuador	65	0.14
United States	166	0.13
Canada	133	0.13
Vietnam	60	0.12
China	156	0.09

Source: Own elaboration based on UN Comtrade data. Only third countries selected in Question 2b, ranked in descending order of NHHI.

Question 2b. How specialized and competitive is the third country in the export of the considered commodities compared to the world?

Besides the current number of export destinations, a third country may be very competitive in the export of commodities even if currently it is exporting across few destinations. Through the measure of a Symmetric Revealed Comparative Advantage (S-RCA) Index[50], it is possible to assess how strong a country is in the export of a commodity relative to the world: the strongest the country, the higher its capacity to divert export flows to other non-EU destinations.

A S-RCA scores a country from -1 to 1, 1 indicating the strongest export position (or competitiveness in global trade), and -1 meaning no competitiveness in exporting the considered commodities. When the index takes negative value, the world (i.e. other countries) is more competitive in exporting the commodities considered compared to the third country. Conversely, when it takes positive value, the third country is more competitive than the rest of the world (Table 48).

Brazil, United Kingdom, Uruguay, Benin and Suriname are the only third countries being less competitive in exporting the considered commodities compared to the rest of the world. This is particularly relevant in the case of Benin, which shown a relatively lower export diversification (previous Question 2a). Similarly, while Uruguay and Suriname have shown relatively high diversification, their export remain destinated to relatively few countries (as shown in previous Question 2a). A negative S-RCA combined with few existing export destinations may signal a potentially high difficulty to divert exports. Conversely, United Kingdom and Brazil have shown a quite significant diversification of export destinations. Therefore, a negative S-RCA may still be compensated by a high diversification capacity.

South Africa, Canada, United States, Cameroon and China show a positive but relatively low (< 0.5) S-RCA, indicating a moderately low advantage compared to the rest of the world. This is particularly relevant for Cameroon, which has also shown a moderately low diversification (previous Question 3a) and therefore may be less capable to divert its exports. Differently, China, Untied States, South Africa and Canada are among the most diversified third countries in terms of export, hance they may compensate a moderately low comparative advantage with very diversified export routes.

All the remaining countries show a moderately to high competitiveness in their exports (S-RCA > 0.5). The most competitive third countries (with S-RCA > 0.9) appear to be Belize, Moldova, Panama, Ecuador, Senegal, Costa Rica, Morocco and Peru. Among these countries, Morocco and Moldova have also shown a relatively lower export diversification (Question 2a), whereby their very high competitiveness may contribute to enhance their capacity to divert exports.

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50 S-RCA = (RCA – 1) / (RCA + 1) and RCA = (Xc,p / Xc) / (Xw,p / Xw), where Xc,p = export value of country c in product p (where p is the sum of pesticide-detected or registered commodities); Xc = total export value of country c; Xw,p = world export value of product p (where p is the pesticide-detected or registered commodities); Xw = total world export value.

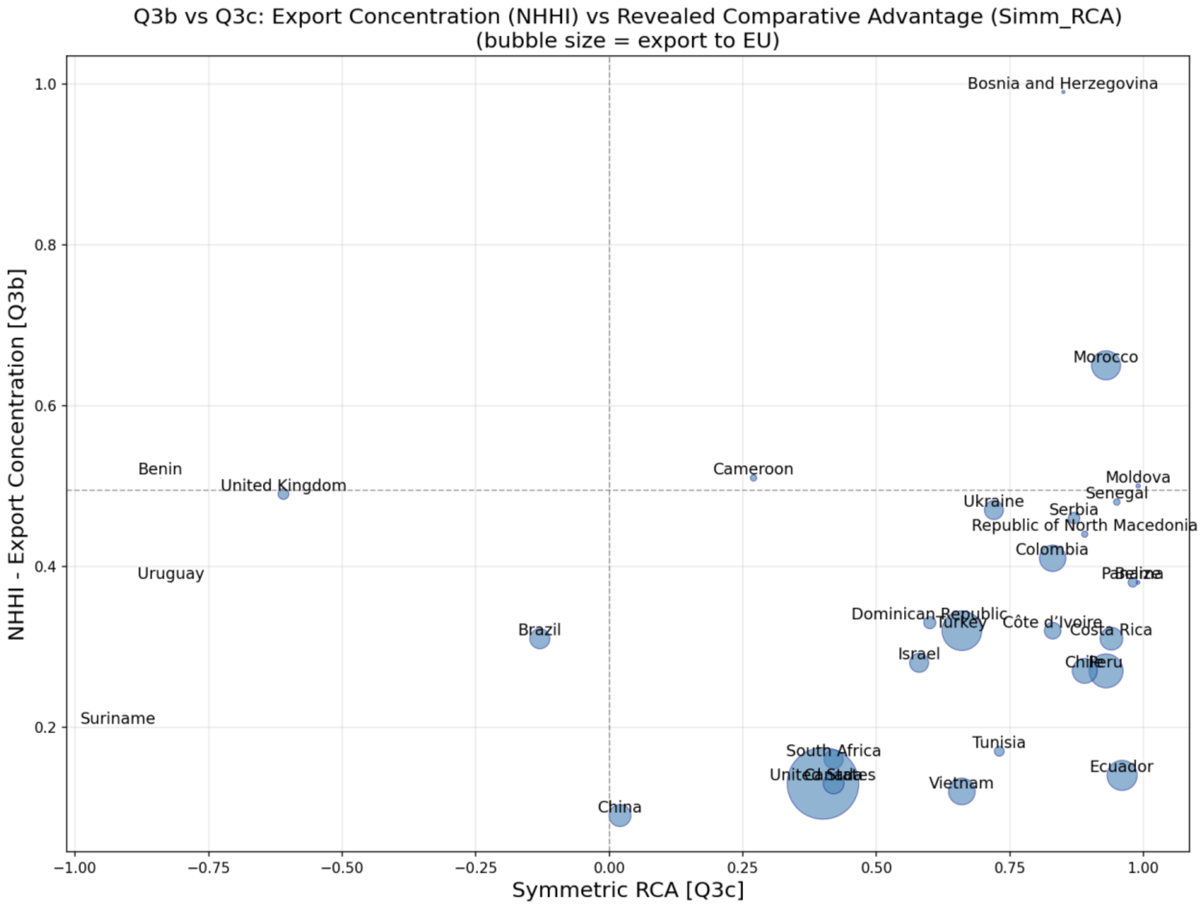
Table 48. Competitiveness of the exports of pesticide-commodities (detected or registered) of the third countries most dependent on the EU market for the commodities not explicitly covered in CAPRI.

Country	**RCA**	**S-RCA**
Belize	302.37	0.99
Moldova	190.11	0.99
Panama	85.95	0.98
Ecuador	52.6	0.96
Senegal	41.32	0.95
Costa Rica	32.53	0.94
Morocco	27.39	0.93
Peru	27.46	0.93
Chile	16.71	0.89
Republic of North Macedonia	17.57	0.89
Serbia	13.86	0.87
Bosnia and Herzegovina	12.26	0.85
Colombia	10.76	0.83
Côte d'Ivoire	11.1	0.83
Tunisia	6.45	0.73
Ukraine	6.11	0.72
Vietnam	4.88	0.66
Turkey	4.96	0.66
Dominican Republic	3.98	0.6
Israel	3.78	0.58
South Africa	2.47	0.42
Canada	2.44	0.42
United States	2.33	0.4
Cameroon	1.72	0.27
China	1.04	0.02
Brazil	0.77	-0.13
United Kingdom	0.24	-0.61
Uruguay	0.1	-0.82
Benin	0.09	-0.84
Suriname	0.04	-0.92

Source: Own elaboration based on UN Comtrade data. Only third countries selected in Question 1c, ranked in descending order of revealed competitive advantage.

Interpolating diversification of export destinations (Question 2a) and Revealed Comparative Advantage (Figure 19), it appears clearly that most countries are comparatively very competitive and very diversified in export flows (bottom-left quadrant); therefore, having potentially high capability to divert trade routes in response to MRLs' reduction to LOQ. Differently, Benin and United Kingdom show the lowest diversification and competitiveness (top-left quadrant), hence the lowest potential capability to divert export flows. Bosnia, Morocco, Cameroon, Brazil, Suriname, and Uruguay show mixed capability to divert export flows, due to either low diversification but high competitiveness (bottom-left), or high diversification but low competitiveness (top-right).

Figure 19. Diversification of export sources and revealed comparative advantage for the commodities not explicitly covered in CAPRI.



Source: Own elaboration based on UN Comtrade data.

Question 2c. Has the third country increased or decreased its reliance on the EU to export its commodities?

Although a third country may reveal a clear high dependence on the EU for exporting, observing the temporal evolution of its export flows (in volume) to the EU may highlight ongoing adjustments enhancing or reducing its dependency. For example, a third country with currently mid-high dependence may appear to be decreasing significantly its dependence over the past 10 years, hence being already on the path for diverting trade routes.

To account for the Covid-19 trade disruptions, exports trend to the EU are not only observed for the entire period 2015-2024 (Figure 20 and Table 49), but also for the pre- and post-Covid periods 2014-2019 and 2022-2024 (Table 49). Between 2024 and 2014, 16 third countries51 have decreased their average export share to the EU. Camerron has reduced its reliance on the EU market by 79 %, and Benin by 67 %, suggesting that a significant trade diversion might be taking place. This is particularly relevant for both countries, which appear to be relatively less diversified in

[51] Benin, Brazil, Cameroon, Chile, China, Côte d'Ivoire, Dominican Republic, Ecuador, Israel, Morocco, Panama, Senegal, Tunisia, United Kingdom, Uruguay, and Vietnam.

their export destinations (previous Question 3a) but, at the same time, being somehow already on an export diversion path. In the same period, Brazil, Chile, Côte d'Ivoire, Panama, Senegal, United Kingdom, and Uruguay show a reduction of their reliance on the EU market by 8 % to 20 %, which might signal some tendency of change in trade patterns. In all other cases, the decrease has been lower than 8%, with China showing a substantially stable trend (-0.1 %). In the case of Cameroon, Panama and Israel, the reduction might be due, to a significant extent, to the Covid-19 disruptions, whereby their average export share to the EU for the period 2022-2024 has decreased compared to the period 2015-2019 by respectively 32 %, 12 % and 9 %.

On the other hand, all other countries[52] have shown an increase in their reliance on the EU market in the period 2014-2024. However, the increase has been relevant only in the case of Moldova (+62.4 %), Belize (+32.2 %), Republic of North Macedonia (+12.5 %), Ukraine (+11.4 %), Colombia (+10.9 %), and Bosnia and Herzegovina (+10.7 %). All other countries have shown an increase lower than 10%, with Canada and Suriname, showing a substantially stability (change ~0 %). The figure may be considered most significant for Moldova considering also that it is among the third countries with lowest export diversification (previous Question 2a). Similarly, Suriname is among the countries with no competitive advantage in exporting the considered commodities. Hence, its increasing reliance on the EU market may signal potentially higher difficulties to divert exports in case of need.

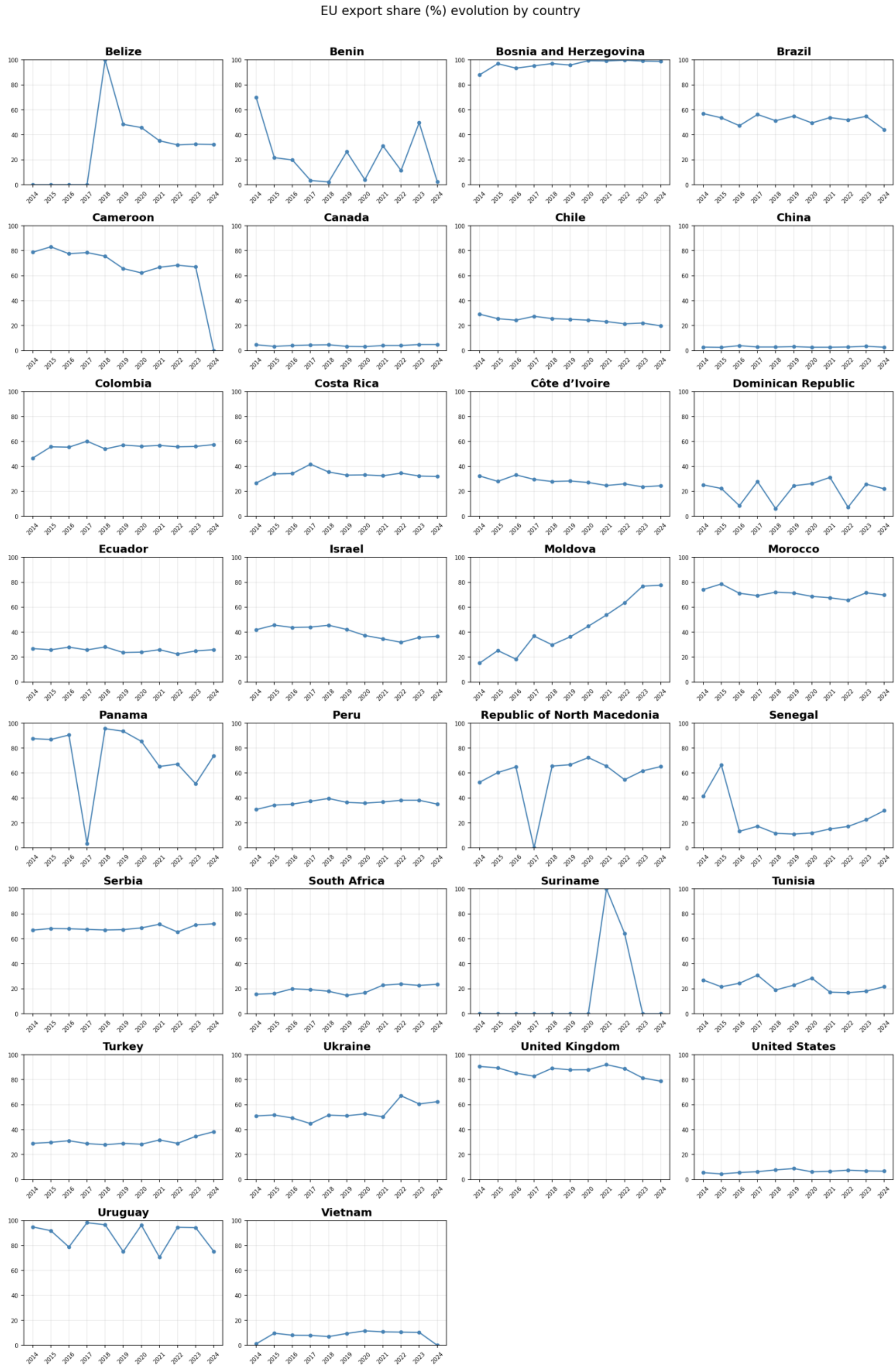
[52] Belize, Bosnia and Herzegovina, Canada, Colombia, Costa Rica, Moldova, Peru, Serbia, South Africa, Turkey, Ukraine, and United States.

Table 49. Export trend to the EU of pesticide-commodities (detected or registered) of the third countries most dependent on the EU market for the commodities not explicitly covered in CAPRI.

Third country	Average (%) export value to EU 2014-2019	Average (%) export value to EU 2022-2024	Change (%) between 2014 and 2024	Change between average 2014-2019 and average 2022-2024
Belize	24.7	32.2	32.2	7.5
Benin	23.9	21.2	-67.4	-2.7
Bosnia and Herzegovina	94.5	99.2	10.7	4.7
Brazil	53.4	50.3	-12.9	-3.1
Cameroon	76.6	45.1	-78.8	-31.5
Canada	4	4.5	0.2	0.5
Chile	26.2	21.1	-9.3	-5.1
China	3	2.9	-0.1	-0.1
Colombia	54.8	56.4	10.9	1.6
Costa Rica	34.2	32.9	5.2	-1.3
Côte d'Ivoire	29.9	24.7	-7.8	-5.2
Dominican Republic	19.1	18.4	-3.2	-0.7
Ecuador	26.4	24.5	-0.9	-1.9
Israel	43.9	34.8	-5.2	-9.1
Moldova	27	72.7	62.4	45.7
Morocco	72.8	69	-4.4	-3.8
Panama	76.2	64.1	-13.8	-12.1
Peru	35.6	37.2	4.3	1.6
Republic of North Macedonia	51.7	60.6	12.5	8.9
Senegal	26.9	23.2	-11.4	-3.7
Serbia	67.6	69.6	5.1	2
South Africa	17.3	23.4	8	6.1
Suriname	0	21.5	0	21.5
Tunisia	24.3	18.9	-5.3	-5.4
Turkey	29.3	34	9.3	4.7
Ukraine	49.9	63.4	11.4	13.5
United Kingdom	87.6	83	-11.8	-4.6
United States	6.4	7	1.2	0.6
Uruguay	89.3	88.1	-19.6	-1.2
Vietnam	7.2	7	-1.2	-0.2

Source: Own elaboration based on UN Comtrade data. Only third countries selected in Question 1c, in alphabetic order. Note that trade is measured in volume, not in value.

Figure 20. Trends of share (%) of total export directed to the EU in the period 2014-2024, by third country for the commodities not explicitly covered in CAPRI.



Source: Own elaboration based on UN Comtrade data. Only third countries selected in Question 2b.

Question 2d. Could the third countries export the considered commodities to alternative non-EU countries at comparable prices?

A third country may reveal relatively high potential for diverting its export routes towards new countries. Yet, export prices may differ significantly among export destinations. Hence, it is important to assess whether and to what extent average prices of the considered commodities may differ between EU and non-EU export destinations. To this end, we measure the ratio of the prices in the EU on the prices in the exporting third countries, as well as the ratio of the prices in the EU on the prices in non-EU export destinations (Table 50): if the ratio is higher than 1, then exporting third countries have more convenience to export to the EU rather than to the domestic market or non-EU export destinations. For the correct interpretation of results, it is key to acknowledge that this analysis does not account for possible price dynamics triggered by MRLs' reduction. Instead, it focuses on possible current structural differences in prices, which may be potentially reflected also in real price dynamics.

Considering the ratio between EU prices and third countries' prices, all third countries except Cameroon (ratio ~0.9) and Belize (~0.8) would currently get lower prices in the domestic market than in the EU market on average, suggesting that most third countries appear to have a potential economic disadvantage in diverting exports to the domestic market. This is particularly evident in Vietnam (5.7), United States (4.3), Turkey (4.2), Morocco (4.0), Panama (3.3), Tunisia (3.0) and Chile (3.0). Given the higher ratios, it may be assumed that price-related economic losses may be potentially higher for these countries if they divert to the domestic market. The remaining countries —Bosnia and Herzegovina, Brazil, Cameroon, Canada, Chile, China, Colombia, Costa Rica, Côte d'Ivoire, Dominican Republic, Ecuador, Israel, Moldova, Morocco, Panama, Peru, Republic of North Macedonia, Serbia, South Africa, Tunisia, Turkey, Ukraine, and United Kingdom— show a ratio among 1 and 3, suggesting that also for these commodities, to some extent, diverting to alternative destinations may imply an economic loss.

Similarly, considering the ratio between EU prices and prices in non-EU export destinations, the majority of third countries (15 out of 26) would likely get worse prices in other non-EU destinations compared to what they currently get in the EU market. These countries —notably Belize, Bosnia and Herzegovina, Brazil, Cameroon, Canada, Chile, China, Colombia, Costa Rica, Côte d'Ivoire, Dominican Republic, Ecuador, Israel, Moldova, Morocco, Panama, Peru, Republic of North Macedonia, Serbia, South Africa, Tunisia, Turkey, Ukraine, United Kingdom, United States, and Vietnam— may incur economic losses if diverting export flows. In particular, the highest ratios (i.e. the higher potential losses) are shown by United States (2.9), Turkey and Ukraine (2.0), and China (1.6). On the other hand, Brazil, Cameroon, Canada, Chile, China, Colombia, Costa Rica, Côte d'Ivoire, Dominican Republic, Ecuador, Israel, Moldova, Morocco, Panama, Peru, Republic of North Macedonia, Serbia, South Africa, Tunisia, Turkey, Ukraine, and United Kingdom, seem to get better prices in non-EU destinations than in the EU, signaling that these countries may be less likely to incur economic losses if diverting export flows.

Table 50. Difference in prices between the EU market, the rest of the world, and the exporting third countries for the commodities not explicitly covered in CAPRI.

Third country	EU Price ($/kg)	Third country price ($/kg)	Non-EU price ($/kg)	Price ratio (EU / third country)	Price ratio (EU / non-EU)
Belize	0.36	0.4702	0.3528	0.7656	1.0204
Bosnia and Herzegovina	1.1054	0.6544	0.7236	1.6892	1.5276
Brazil	0.8864	0.3427	0.9906	2.587	0.8948
Cameroon	0.2461	0.2881	0.2167	0.8544	1.1357
Canada	1.3885	0.6151	0.9917	2.2572	1.4001
Chile	4.1259	1.3556	4.0905	3.0436	1.0087
China	1.8624	0.8273	1.1924	2.2512	1.5619
Colombia	0.5326	0.8041	0.5542	0.6623	0.9610
Costa Rica	0.4933	0.2951	0.5168	1.6715	0.9545
Côte d'Ivoire	0.6753	0.4433	0.9468	1.5232	0.7132
Dominican Republic	0.9509	0.4413	1.0834	2.155	0.8777
Ecuador	0.7662	0.3144	0.6878	2.4371	1.1140
Israel	1.8979	1.5907	1.34	1.1931	1.4163
Moldova	0.5699	0.2505	0.4937	2.275	1.1543
Morocco	1.6279	0.4038	2.1976	4.0311	0.7408
Panama	0.4339	0.1296	0.4205	3.348	1.0319
Peru	1.6253	0.6919	1.9884	2.3491	0.8174
Republic of North Macedonia	0.686	0.5396	0.4791	1.2713	1.4319
Serbia	1.4395	0.6546	1.7427	2.199	0.8260
South Africa	1.6718	0.6276	1.7454	2.6637	0.9578
Tunisia	1.7956	0.5859	1.8225	3.0647	0.9852
Turkey	3.403	0.8088	1.709	4.2075	1.9912
Ukraine	0.7943	0.3325	0.3982	2.3888	1.9947
United Kingdom	1.4337	0.991	3.1121	1.4467	0.4607
United States	4.7599	1.1035	1.6545	4.3136	2.8769
Vietnam	5.8684	1.0229	4.8819	5.7368	1.2021

Source: Own elaboration based on COMEXT and FAOSTAT data.

Question 3 – To what extent could third countries absorb the export flows in the domestic industry?

As in previous Question 2, also Question 3 focuses on the same third countries most dependent on export to the EU, as identified under Question 1c. Besides the ability to divert exports to other non-EU destinations, third countries may also be using themselves a relatively large share of the exported commodity, and/or relying also on the import of the same commodity. A country where the export of the commodity is disrupted may be able to re-direct the commodity to domestic industries, and/or replace existing imports of the same commodity. Thus, two aspects can be assessed:

- Net Trade Ratios measuring how much bigger or smaller is a country's export of a commodity relative to its import of the same commodity, indicating the potential to replace imported volumes with exported ones (Question 3a);
- Domestic Absorption Capacity measuring how much bigger or smaller is a country's export of a commodity relative to its domestic use of that commodity, indicating how much of a disrupted export could be absorbed domestically (Question 3b);

Question 3a. To what extent could a third country replace its imports of a commodity with its exports of the same commodity?

In principle, a third country that exports and imports the same commodity at the same time may decide to replace (part of) its imports by re-directing exports to the domestic industry. This can be measured through Net Trade Ratios[53], which is equal to the ratio of export volume of a commodity to the import volume of the same commodity of a certain third country. The lower the ratio, the higher the possibility for the country to re-direct the export to the domestic market while reducing the imports of the same commodity.

The Net Trade Ratio assumes value from 0 onwards (Table 51). If the ratio is higher than 1, exports exceed imports (domestic demand) and the capacity of the country to replace imports with exports is relatively low. Conversely, if the ratio is lower than 1, imports exceed exports, and the country may be able to replace imports with exports.

In eight third countries the imports are larger than exports of the considered commodities, namely in Bosnia and Herzegovina (Net Trade Ratio equal 0.94), Suriname (0.74), United States (0.74), Senegal (0.36), Vietnam (0.34), Uruguay (0.13), Benin (0.07) and United Kingdom (0.06). In these cases, potentially, all exports to the EU might replace existing imports of the same commodities.

The remaining third countries[54] all have exports higher than imports (ratio > 1). However, for some of these countries it may still be possible to partly replace some share of imports with exports. For example, Serbia, Côte d'Ivoire, Dominican Republic, Canada, Israel, Brazil, China and South Africa have a ratio varying between 1.8 and 4, which practically means that these countries could potentially replace between 25 % and 54 % of their imports with exports. Hence, they show some degree pf potential absorption capacity. Other countries, like Cameroon, Colombia, Republic of North Macedonia, Turkey, Tunisia, Chile and Ukraine, show a ratio varying between 5 and 17, which indicates that these countries can replace between 5 % and 19 % of their imports with exports, which could be assessed as a limited abortion capacity.

For some other third countries, the ratio is extremely high (> 50), meaning that the capacity of the country to replace imports with exports is very limited or substantially absent (1 % or less of the exports could replace imports). These countries are Belize, Panama, Peru, Ecuador, Moldova, Morocco, and Costa Rica.

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53 Ratio between a country's export volume of the considered pesticide-commodities and its import volumes of the same commodities.

54 Belize, Panama, Peru, Ecuador, Moldova, Morocco, Costa Rica, Cameroon, Colombia, Republic of North Macedonia, Turkey, Tunisia, Chile, Ukraine, Serbia, Côte d'Ivoire, Dominican Republic, Canada, Israel, Brazil, China and South Africa.

Table 51. Ratio between a third country exports and imports of the considered pesticide-commodities (detected or registered) for the commodities not explicitly covered in CAPRI.

Third country	Export volume (thousand tonnes)	Import volume (thousand tonnes)	Net Trade Ratio (Export / Import)
Belize	334.74	0	31 490 022.3
Panama	1 048.89	0.04	26 747.13
Peru	5 541.13	20.03	276.62
Ecuador	15 627.61	93.23	167.63
Moldova	159.27	0.96	165.28
Morocco	1 790.58	16	111.92
Costa Rica	7 373.74	126.33	58.37
Cameroon	777.33	45.19	17.2
Colombia	6 819.31	460.68	14.8
Republic of North Macedonia	300.78	23.97	12.55
Turkey	5 013.07	518.99	9.66
Tunisia	515.03	58.96	8.73
Chile	3 291.86	457.83	7.19
Ukraine	2 483.59	456.34	5.44
Serbia	432.48	109.03	3.97
Côte d'Ivoire	5 359.81	1 969.23	2.72
Dominican Republic	1 120.93	449.08	2.5
Canada	26 018.19	10 629.13	2.45
Israel	868.93	383.64	2.26
Brazil	2 574.88	1 238.5	2.08
China	22 735.03	12 139.36	1.87
South Africa	1 832.03	985.26	1.86
Bosnia and Herzegovina	30.98	33.05	0.94
Suriname	0.02	0.03	0.74
United States	40 687.21	55 015.31	0.74
Senegal	184.45	507.09	0.36
Vietnam	2 524.55	7 460.7	0.34
Uruguay	1.63	12.58	0.13
Benin	1.43	21.16	0.07
United Kingdom	331.13	5 826.33	0.06

Source: Own elaboration based on UN Comtrade data. Countries are ordered in descending order of Net Trade Ratio.

Question 3b. To what extent could a third country re-direct its exports towards its domestic market?

Another way to assess how much a country's export may be re-directed to the domestic market can be measured through the Domestic Absorption Capacity[55], which is equal to the ratio of export volumes of a commodity to the volume used in domestic production for the same commodity.

The ratio takes a value from 0 onwards (Table 52). The lower the ratio, the higher the capacity of the country to use the exported commodity in the domestic industry. If the ratio is higher than 1, domestic industries do not use much of the commodity and domestic absorption capacity is potentially limited. Conversely, if the ratio is minor than 1, the amount of the commodity used in the country is higher than the amount exported, so that the domestic industry has a stronger capacity to absorb it.

For the majority of the third countries, the domestic absorption ratio is minor than 1, meaning that the domestic use of the considered commodities is much higher than the exports. The ratio is particularly low (<0.2) for Vietnam, Cameroon, Tunisia, Turkey, Dominican Republic, Bosnia and Herzegovina, Brazil, China, United Kingdom, Uruguay and South Africa. For these countries, therefore, there is a much higher potential capacity of the domestic industry to absorb the considered commodities. Also, a relevant potential for domestic absorption is shown by Canada (0.8), Chile (0.77), Moldova (0.59), Colombia (0.54), Morocco (0.5), Republic of North Macedonia (0.47), Peru (0.42), Ukraine (0.35), United States (0.33), Serbia (0.33) and Israel (0.21). It is important to note, however, that a domestic use higher than export does not necessarily mean that all exports can be actually absorbed; instead, it suggests that a larger share of existing exports may be potentially absorbed.

On the other hand, four countries show a ratio greater than 1, namely Panama (7.9), Costa Rica (5), Ecuador (2.2), and Côte d'Ivoire (1.3). In these countries, and especially in Panama and Costa Rica, the capacity of the domestic industry to absorb the commodities may be limited to a relatively low share of existing export volumes. Specifically, in Panama the volumes used domestically represent 13% of existing exports of the considered commodities, in Costa Rica 20 %, in Ecuador 46 % and in Côte d'Ivoire 78%. Therefore, more attention could be paid to these countries, and especially to Ecuador and Costa Rica, whose domestic agricultural production (as previously shown in Question 1d) is more dependent on exports to the EU.

55 Ratio between a country's export volumes of the considered commodities and its domestic use volumes of the same commodities. Domestic use is calculated as: (domestic production volumes + imported volumes) – exported volumes.

Table 52. Domestic absorption capacity of the pesticide-commodities (detected or registered) of the third countries with highest dependence on the EU market for the commodities not explicitly covered in CAPRI.

Third country	Domestic absorption ratio (Export / Domestic use)	No. of commodities included	No. of commodities excluded
Panama	7.86	1	0
Costa Rica	4.97	20	8
Ecuador	2.19	21	5
Côte d'Ivoire	1.28	24	120
Canada	0.8	23	50
Chile	0.77	25	13
Moldova	0.59	1	1
Colombia	0.54	17	8
Morocco	0.5	7	4
Republic of North Macedonia	0.47	3	1
Peru	0.42	16	4
Ukraine	0.35	20	2
United States	0.33	43	61
Serbia	0.33	5	1
Israel	0.21	28	24
South Africa	0.19	25	43
Vietnam	0.13	8	25
Cameroon	0.11	20	88
Tunisia	0.09	19	11
Turkey	0.09	23	14
Dominican Republic	0.05	32	142
Bosnia and Herzegovina	0.04	2	0
Brazil	0.03	17	34
China	0.02	28	14
United Kingdom	0.01	14	37
Uruguay	0.01	5	5
Benin	0	4	67
Belize		1	0

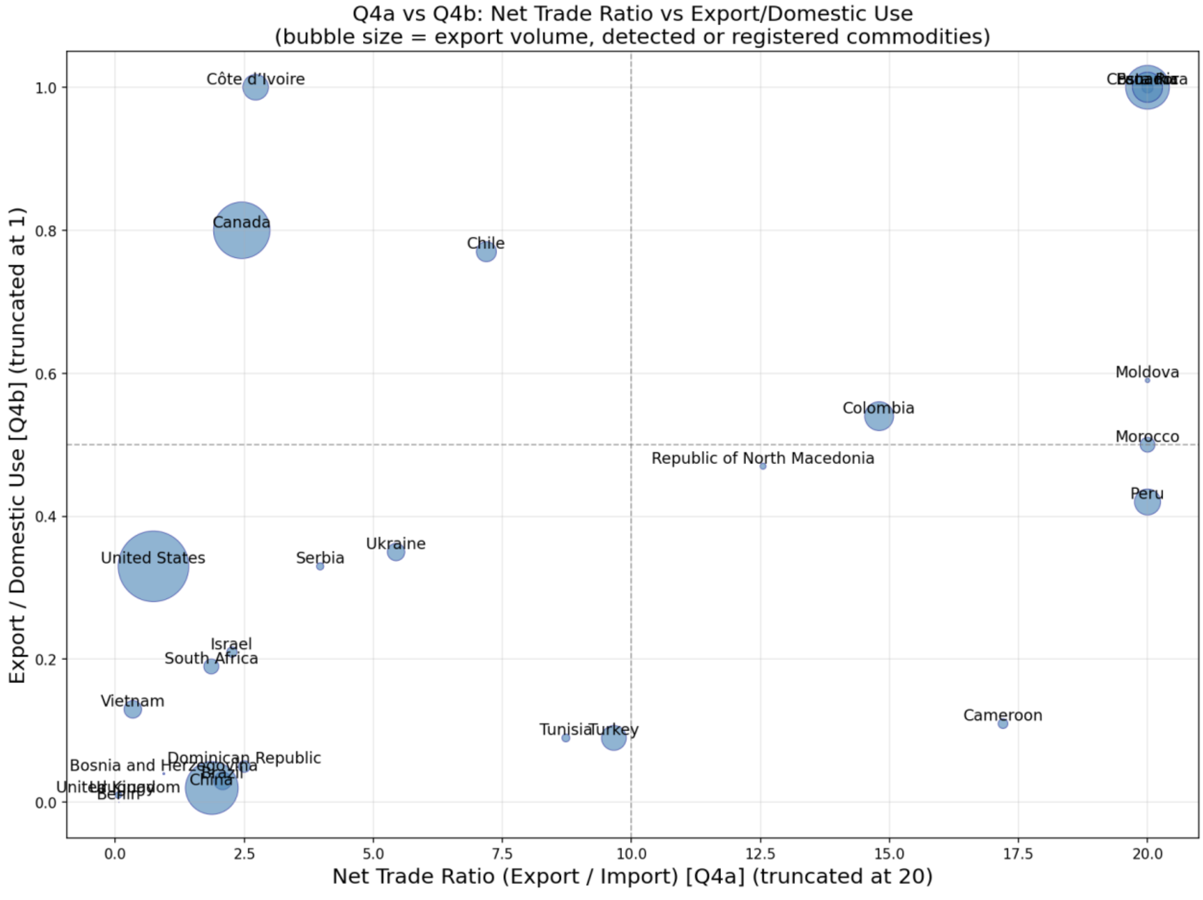
Note: An important limitation of this analysis is that the data on export volumes and for domestic production volumes do not all the considered commodities. In fact, while it was possible to match 99% of the commodities with detected or registered status with UN Comtrade commodities (export volumes), this was possible only for 46.7% of the commodities reported in FAOSTAT (domestic production). Hence, the analysis of domestic absorption capacity is limited to the commodities available in FAOSTAT, and the results may not fully represent the reality. The table reports the number of commodities included and excluded from the calculation of domestic absorption capacity for each third country.

Source: Own elaboration based on UN Comtrade data (export volumes) and FAOSTAT data (domestic production volumes).

To better understand third countries' capacity for re-directing exports to the domestic market, it is useful to interpolate Net Trade Ratios (Question 3a) and Domestic absorption capacity (Question 3b) (Figure 21). Firstly, United Kingdom, Benin, Vietnam, and United States (bottom-left quadrant) appear to have the highest potential for re-directing exports to the domestic industry, showing both Net Trade Ratios minor than 1 and very low export/domestic use ratio. To note that Benin and

United Kingdom also appear to be the third countries with lowest potential for diverting export flows (Question 2a and 2b); therefore, they may (to some extent) compensate lower capacity to divert to alternative export destinations with a relatively high potential for domestic use. Following, also China, Israel, South Africa, Dominican Republic, Turkey, Bosnia and Herzegovina, Serbia, Ukraine and Tunisia (bottom-left quadrant) show a relatively high potential for domestic use of the considered commodities (Net Trade Ratio < 10; Domestic absorption ratio < 0.5), although the Net Trade Ratio is not minor than 1 (hence imports are smaller than exports and may not be fully replaced). On the contrary, Panama, Costa Rica, Ecuador, Moldova, Morocco and Colombia (top-right quadrant) show the lowest potential for domestic absorption of exports. Morocco also showed a not high potential for diverting export flows (previous Question 2b), hence it might be comparatively more exposed.

Figure 21. Net Trade Ratios and Domestic absorption capacity by third country for the commodities not explicitly covered in CAPRI.



Source: Own elaboration based on UN Comtrade data (export volumes) and FAOSTAT data (domestic production volumes).

EU EXPOSURE

Question 4 – What is the EU self-sufficiency level in the production of the considered commodities?

The reduction of MRLs to the LOQ may expose the EU in relation to those pesticide-commodities (for which the considered active substances were detected or registered). However, actual exposure occurs when the EU is not self-sufficient in the production of the pesticide-commodities, hence it relies on imports. This can be measured through the Self-sufficiency Index[56], which can be used to short-list the pesticide-commodities to which the EU is more exposed. This includes the analyses of total EU imports, domestic production, exports of and self-sufficiency in pesticide-commodities.

The index assumes values from 0 onwards, where a value equal or bigger than 1 signals self-sufficiency (i.e. the domestic production is at least equal the domestic use). Conversely, values minor than one signal that the EU is (to some extent) not self-sufficient: the lower the value (i.e. the closer to zero), the smaller the self-sufficiency of the EU.

Table 53 reports the commodities for which the EU is not self-sufficient (index < 1). The lowest self-sufficiency is reported for Tree nuts (0.06), Bananas (0.11) and Avocados (0.19). Also, a very low self-sufficiency (<0.5, i.e. the EU produce less than 50 % of what it uses) is reported for Other small fruits and berries (0.28), Other small fruits and berries – Others (0.35), Stone fruits – Others (0.39), and Hazelnuts/cobnuts (0.46). Although there is no common rule or threshold to establish the severity of lack of self-sufficiency, it is reasonable to consider the EU very exposed to impacts in the import of these commodities.

A moderately low self-sufficiency (0.5 – 0.75) is reported for Pome fruits – Others (0.59), Walnuts (0.61), Almonds (0.64), Blueberries (0.65), Peas (0.66), Figs (0.68), Cherries (sweet) (0.81), Buckwheat and other pseudocereals (0.84). In this case the EU can be considered moderately exposed to reductions in the import of these commodities, whereby the domestic production can be assumed flexible (to some extent) and potentially bridge part of the gap.

For the remaining commodities, the EU approaches self-sufficiency (0.89 – 0.99). hence, although the EU is not self-sufficient, its exposure to changes in imports of these commodities is relatively low. These commodities include: Melons, Raspberries (red and yellow), Watermelons, Beans (with pods), Strawberries, Sorghum, Common millet/proso millet, Kiwi fruits (green, red, yellow), Tropical root and tuber vegetables, Plums, Cucurbits with inedible peel – Others, Chestnuts, Jerusalem artichokes, and Courgettes. In this case, it is possible and realistic to assume the potential capacity of the EU to bridge the gap domestically, or at least to reduce it to an unsignificant minimum amount.

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56 The Index is calculated as: (total EU production / (total EU production + total EU import – total EU export).

Table 53. Self-sufficiency of the EU for the pesticide-commodities (detected or registered) for the commodities not explicitly covered in CAPRI.

Commodity	Self-sufficiency	EU Domestic use (1000 tonnes)	EU production (1000 tonnes)	EU imports (1000 tonnes)	EU exports (1000 tonnes)
Tree nuts - Others	0.06	2 238.79	125.04	2 263.07	149.32
Bananas	0.11	17 533.66	1 998.78	15 633.99	99.11
Avocados	0.19	2 259.66	438.92	2 115.68	294.95
Other small fruits and berries	0.28	446.86	123.86	903.97	580.96
Other small fruits and berries - Others	0.35	349.01	123.86	408.57	183.43
Stone fruits - Others	0.39	369.85	144.70	408.57	183.43
Hazelnuts/cobnuts	0.46	869.21	401.86	479.00	11.66
Pome fruits - Others	0.59	548.75	323.60	408.57	183.43
Walnuts	0.61	1 077.94	653.36	455.61	31.04
Almonds	0.64	2 210.82	1 404.57	868.07	61.82
Blueberries	0.65	845.58	552.52	426.41	133.35
Peas	0.66	3 795.94	2 502.31	1 946.11	652.48
Figs	0.68	352.91	241.67	125.45	14.21
Cherries (sweet)	0.81	3 243.15	2 625.56	995.80	378.21
Buckwheat and other pseudocereals	0.84	2 565.54	2 161.66	465.75	61.87
Melons	0.89	5 873.07	5 237.06	907.24	271.22
Raspberries (red and yellow)	0.90	691.10	622.14	132.65	63.69
Watermelons	0.91	9 494.40	8 609.01	1 430.92	545.53
Beans (with pods)	0.91	3 354.95	3 065.23	537.06	247.34
Strawberries	0.92	3 909.32	3 608.74	656.55	355.96
Sorghum	0.93	2 365.43	2 189.43	220.98	44.98
Common millet/proso millet	0.94	2 291.42	2 161.66	154.12	24.37
Kiwi fruits	0.97	2 755.92	2 672.99	651.51	568.58
Tropical root and tuber vegetables	0.97	30 418.00	29 584.23	907.68	73.91
Plums	0.98	4 652.62	4 561.91	319.97	229.26
Cucurbits with inedible peel	0.98	1 546.07	1 518.23	337.48	309.65
Chestnuts	0.98	947.13	923.88	48.39	25.14
Jerusalem artichokes	0.99	1 847.49	1 822.60	30.82	5.93
Courgettes	0.99	4 881.41	4 853.57	337.48	309.65

Note: The commodities with self-sufficiency above 1 are: Apricots, Asparagus, Aubergines/eggplants, Beetroots, Broccoli, Brussels sprouts, Carrots, Cauliflowers, Celeriacs/turnip rooted celeries, Celeries, Celery, Celery leaves, Cotton seeds, Cucumbers, Cultivated fungi, Currants (black, red and white), Escaroles/broad-leaved endives, Flowering brassica, Fungi, mosses and lichens, Garlic, Gherkins, Globe artichokes, Head brassica, Head cabbages, Hops, Lamb's lettuces/corn salads, Leeks, Lettuces, Lettuces and salad plants, Lupins/lupini beans, Onions, Other root and tuber vegetables except sugar beets, Other root and tuber vegetables except sugar beets - Others, Peas (with pods), Pumpkins, Radishes, Solanaceae and Malvaceae, Spinaches, Spinaches and similar leaves, Spring onions/green onions and Welsh onions, Sweet peppers/bell peppers, Turnips, Witloofs/Belgian endives.

Source: Own elaboration based on COMEXT data (import and export volumes) and Eurostat data (Self-sufficiency ratio and EU production volumes). Commodities are ranked from the smallest to the highest self-sufficiency value.

Question 5 – Could the EU rely on alternative supply sources for commodities in which it is not self-sufficient?

Question 4 identifies the commodities for which the EU is not self-sufficient, i.e., the commodities to which changes in imports would potentially limit their availability in the domestic market Question 5 focuses on the commodities in which the EU is not self-sufficient as identified in Question 4. While for self-sufficient commodities the EU can be considered not exposed to these changes, it remains key to understand whether the EU could feasibly retrieve the commodities from non-domestic sources. To this end, two aspects can be investigated:

- The diversification of EU import sources other than the third countries with detected or registered status of the considered active substances (Question 5a);
- The difference in prices between imports from third countries with detected or registered status, and other potential suppliers (Question 5b).

Question 5a. How dependent is the EU on the import of the considered commodities from the third countries with detected or registered status? Could the EU rely on alternative supply sources?

When the EU largely relies on third countries with detected or registered status to import the considered commodities and is less self-sufficient (i.e. it has relatively low ability for domestic production), it might still be possible to rely on other supply sources (i.e. other exporting countries). In general, when the import is relatively important and largely coming from third countries with detected or registered status, then the EU can be considered more exposed. This can be measured through the share of a commodity import to the EU coming from third countries with detected or registered status (Table 54). The lower the share, the higher the possibility for the EU to rely on alternative sources. The EU's ability to rely on other sources can also be measured via a Normalized Herfindahl–Hirschman Index57 (NHHI) (Table 54). The higher the NHHI index, the lower the possibility of the EU relying on alternative sources.

Several of the commodities for which the EU is not self-sufficient (Question 4) are actually imported, to a very large extent, from third countries with detected or registered status. It is interesting to note, among other things, the case of *Bananas* which are by far the most imported commodity, in terms of volume, among the ones for which the EU is not self-sufficient). More than 90 % of imports of Figs, Almonds, Raspberries (red and yellow), Peas, Beans (with pods), Strawberries, Sorghum, Melons, Avocados, and Bananas originate in third countries with detected or registered status. Similarly, more than 80 % of imports of Kiwi fruits (green, red, yellow), Common millet/proso millet, Hazelnuts/cobnuts, Walnuts, and Plums originate in third countries with detected or registered status. This might signal that, for these commodities, the room for diverting to alternative import sources may be very small.

Yet, the overall diversification of import sources is relatively high for many of these commodities. For example, Bananas, Avocados, and Plums show an NHHI minor than 0.3, while Melons, Walnuts, Strawberries and Beans (with pods) show an NHHI equal or minor 0.5. This may indicate that, in the eventuality that a significant number of third countries with currently detected or registered status

[57] NHHI = (HHI – 1/N) / (1 – 1/N); where N is the number of origins (countries exporting to the EU) and HHI = $\sum_i s^2$; where *s* is the percentage share of import volume coming from country of origin *i*.

of the active substances will adjust their production practices, then the EU may still have a relatively high possibility for diversifying import sources of these commodities despite high shares of imports coming from third countries with detection status (as it is the case of Bananas, Avocados and Plums). Conversely, Figs, Almonds, Raspberries (red and yellow), Peas, Kiwi fruits (green, red, yellow), Common millet/proso millet, and Hazelnuts/cobnuts show a NHHI higher than 0.5, signaling a lower diversification of import sources. The diversification is particularly low (NHHI > 0.7) for Figs, Almonds, and Raspberries (red and yellow). Consequently, in the event of a reduction of MRLs to LOQs, these commodities may be the most difficult ones to retrieve from alternative sources.

On the other hand, 75 % or more of imports of Cucurbits with in-edible peel – Others, Tropical root and tuber vegetables, Stone fruits – Others, Other small fruits and berries – Others, Pome fruits – Others, and Other small fruits and berries, originate from third countries without detected or registered status. Also, for all these commodities the diversification of import sources is relatively high (NHHI < 0.25). Hence, despite a lack of EU' self-sufficiency in the production of these commodities, the EU appears to have large possibility of relying on alternative sources. Tree nuts – Others, Chestnuts, Courgettes, Buckwheat and other pseudo-cereals, and Cherries (sweet) show a moderate possibility for diversification of import sources. In fact, for these commodities the share of imports from third countries with detected or registered status varies between 4 7% and 63 %, and a relatively high diversification (NHHI < 0.4).

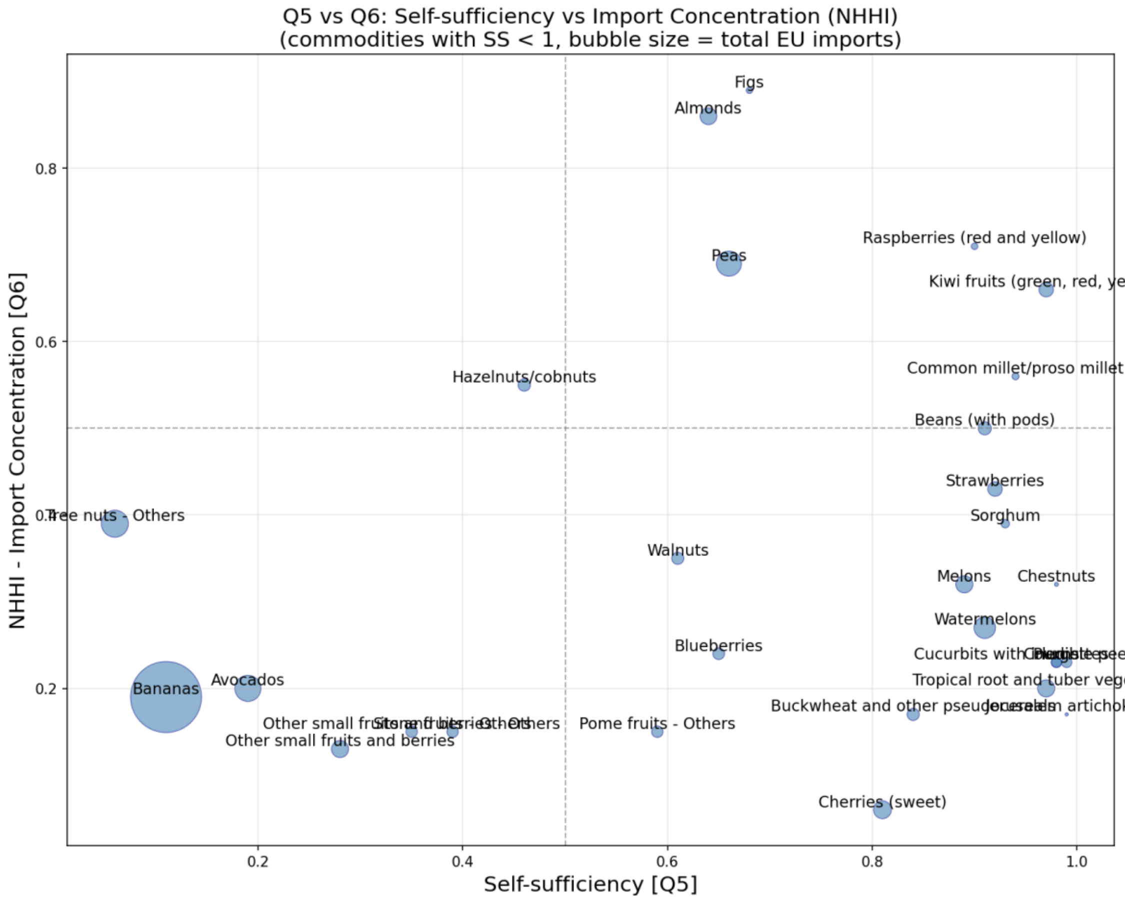
Table 54. Diversification of import sources and EU reliance on third countries with detected or registered status of the active substances, for the commodities not explicitly covered in CAPRI.

Commodity	Total EU imports (1000 tonnes)	EU imports from pesticide-related third countries (1000 tonnes)	EU imports from third countries with detected or registered status / Total EU imports (%)	No. of countries exporting to the EU	NHHI
Figs	125.45	122.21	97.4	61	0.89
Almonds	868.07	857.24	98.8	77	0.86
Raspberries (red and yellow)	132.65	120.34	90.7	52	0.71
Peas	1 946.11	1 828.75	94	77	0.69
Kiwi fruits (green, red, yellow)	651.51	533.75	81.9	27	0.66
Common millet/proso millet	154.12	128.76	83.5	53	0.56
Hazelnuts/cobnuts	479	406.57	84.9	59	0.55
Beans (with pods)	537.06	512.36	95.4	93	0.5
Strawberries	656.55	632.61	96.4	57	0.43
Sorghum	220.98	207.73	94	57	0.39
Tree nuts - Others	2 263.07	1 421.85	62.8	116	0.39
Walnuts	455.61	371.47	81.5	68	0.35
Chestnuts	48.39	25.25	52.2	35	0.32
Melons	907.24	842.23	92.8	60	0.32
Watermelons	1 430.92	460.1	32.2	52	0.27
Blueberries	426.41	302.4	70.9	56	0.24
Courgettes	337.48	170.01	50.4	82	0.23
Cucurbits with inedible peel - Others	337.48	5.1	1.5	82	0.23
Plums	319.97	276.07	86.3	49	0.23
Avocados	2 115.68	1 974.99	93.3	75	0.2
Tropical root and tuber vegetables	907.68	6.49	0.7	95	0.2
Bananas	15 633.99	15 451.71	98.8	85	0.19
Jerusalem artichokes	30.82	4.98	16.2	70	0.17
Buckwheat and other pseudocereals	465.75	220.91	47.4	93	0.17
Stone fruits - Others	408.57	78.83	19.3	98	0.15
Other small fruits and berries - Others	408.57	10.03	2.5	98	0.15
Pome fruits - Others	408.57	91.63	22.4	98	0.15
Other small fruits and berries	903.97	59.14	6.5	106	0.13
Cherries (sweet)	995.8	560.76	56.3	93	0.06

Source: Ownelaboration based on COMEXT data.

Considering the commodities with lowest self-sufficiency level (left quadrants in Figure 22), Hazelnuts/Cobnuts shows the lowest diversification of input sources, while the other commodities show fairly high diversification. Hence, the EU may be highly exposed to MRLs' reductions in relation to this commodity. Also, among commodities approaching self-sufficiency (right quadrants in Figure 22), Figs, Almonds, Raspberries, Peas, Kiwi fruits, Common millet, and Beans show comparatively lower diversification of supply (particularly low for Figs and Almonds). The EU may be also moderately exposed to MRLs' reduction in relation to these commodities. However, 15 commodities58 show both high supply diversification and potential to reach self-sufficiency, hence indicating a lower exposure of the EU to MRLs' reduction in relation to these commodities.

Figure 22. Self-sufficiency and diversification of import sources by commodity for the commodities not explicitly covered in CAPRI.



Source: Own elaboration based on COMEXT data (import and export volumes) and Eurostat data (Self-sufficiency ratio and EU production volumes). Only commodities with self-sufficiency minor than 1 are displayed.

Question 5b. Could the EU retrieve the considered commodities from third countries without detected or registered status at comparable prices?

While the existence of alternative exporting countries may allow the EU to rely on alternative supply sources, this might imply higher costs. It is therefore necessary to assess whether the commodity prices of third countries with detected or registered status are significantly different (lower or

58 Strawberries, Sorghum, Melons, Chestnuts, Watermelons, Walnuts, Blueberries, Cucurbits, Tropical root and tuber vegetables, Buckwheat, Jerusalem Artichokes, Cherries (sweet) and Pome fruits – Others.

higher) from those of other available exporters. This can be assessed by estimating a ratio of the price from third countries with detection or registered status, on those without (Table 55): if the ratio is higher than 1, then average prices are currently more convenient for third countries with detected or registered status, and the EU may incur higher costs if relying on alternative import sources. For the correct interpretation of results, it is key to acknowledge that this analysis does not account for possible price dynamics triggered by MRLs' reduction. Instead, it focuses on possible current structural differences in prices, which may be potentially reflected also in real price dynamics.

For the majority of commodities —Almonds, Avocados, Buckwheat and other pseudocereals, Cherries (sweet), Chestnuts, Figs, Hazelnuts/cobnuts, Jerusalem artichokes, Kiwi fruits (green, red, yellow), Melons, Plums, Strawberries, Tree nuts – Others, and Watermelons— import prices from countries without detected or registered status are lower than those from countries with detected or registered status (ratio > 1). This suggests that the EU is not likely to pay higher prices if relying on alternative import sources for these commodities. The difference between countries without and with detected or registered status is particularly higher (ratio > 2) for Buckwheat and other pseudocereals, and Jerusalem artichokes. Conversely, for Bananas, beans (with pods), Common millet/proso millet, Peas, Sorghum, and Walnuts, prices appear to be on average higher in third countries without detected or registered status, implying that the EU may be more likely to pay higher prices for these commodities from alternative import sources. The ratio is particularly low for Walnuts (~0.5).

Table 55. Price difference between exporting third countries with and without detected or registered status of the considered active substances, for the commodities not explicitly covered in CAPRI.

Commodity	Mean price of exports from third countries <u>with</u> detected or registered status ($/kg)	Mean price of exports from third countries <u>without</u> detected or registered status ($/kg)	Price ratio (countries with / without detected or registered status)
Almonds	2.4741	2.2374	1.1058
Avocados	1.1715	0.7253	1.6151
Bananas	0.3508	0.3888	0.9023
Beans (with pods)	0.9043	1.0651	0.849
Buckwheat and other pseudocereals	0.515	0.2507	2.054
Cherries (sweet)	3.8565	2.0682	1.8646
Chestnuts	2.9205	1.8302	1.5957
Common millet/proso millet	0.2322	0.3077	0.7547
Figs	1.2035	0.8243	1.46
Hazelnuts/cobnuts	2.1488	1.7001	1.264
Jerusalem artichokes	1.5591	0.6129	2.5439
Kiwi fruits (green, red, yellow)	2.1671	1.4993	1.4455
Melons	0.5128	0.3069	1.671
Peas	0.4988	0.5178	0.9634
Plums	0.88	0.5995	1.4681
Sorghum	0.2781	0.2918	0.9533
Strawberries	1.9335	1.5077	1.2825
Tree nuts - Others	1.4845	1.2477	1.1899
Walnuts	1.255	2.318	0.5414
Watermelons	0.5188	0.3758	1.3807

Note: to reduce errors and outliers in reported prices, rows where either volume or value is 0 or missing were removed. Countries with export volume < 1,000 kg for a commodity are excluded. For each commodity, countries with unit values outside [Q1 - 1.5×IQR, Q3 + 1.5×IQR] are excluded.

Source: Own elaboration based on UN Comtrade data.

Question 6 – To which active substance is EU trade most exposed?

The reduction of MRLs to the LOQ may affect one or more of the relevant ASs, but not necessarily all. Since each commodity is affected by one or few hazardous active substances (unlikely by all), it is relevant to observe EU exposure not only in terms of single commodities, but also in terms of group of commodities affected by each single active substance. Two aspects can be assessed:

- The share of EU imports exposed to each single active substance (Question 6a);
- The potential EU's capacity to diversify the import sources of commodities affected by each active substance (Question 6b).

Question 6a. The MRLs' reduction of which active substance would expose EU imports the most?

The EU exposure to specific active substances can be measured through the share of total EU imports of the considered commodities related to each specific active substance (Table 56): the higher the share, the higher the potential implications for EU exposure. Metiram, mancozeb and glufosinate appear to be the only active substance affecting more than 50 % of EU import volumes —respectively 66 %, 57 % and 51 %— hence potentially the active substances exposing the most EU imports. However, also isopyrazam and cyproconazole affect about 44 % of EU import volumes, appearing as largely exposing EU imports, while carbendazim, benomyl, dimethomorph, thiophanate-methyl and spirodiclofen affect a not insignificant share of EU import volumes of the considered commodities, varying between 23 % and 36 %.

The remaining active substances —namely clofentezine, quinoxyfen, metribuzin, mepanipyrim, dicofol, and flufenacet— expose a much less significant portion of EU imports, generally minor than 8 %. In particular, mepanipyrim and dicofol expose less than 1 % of EU imports, and Flufenacet expose no EU imports. Consequently, from the perspective of EU imports, most attention should be paid to metiram, glufosinate, mancozeb, and isopyrazam, and a still significant attention to dimethomorph, carbendazim, benomyl, cyproconazole, and thiophanate-methyl which also affect significantly EU imports. Interestingly, as assessed in Question 2c, metiram, mancozeb, dimethomorph, thiophanate-methyl, benomyl, carbendazim and glufosinate are substances also largely exposing a high number of exporting third countries to the MRLs' reduction. Hence, these substances seem relevant from both EU and third countries perspectives. Likewise, mepanipyrim, dicofol, and flufenacet are the substances exposing the least both the EU and third countries.

Table 56. EU import volumes, values and share of import volumes affected by each considered active substance for the commodities not explicitly covered in CAPRI.

Active substance	Total EU import volumes associated to the active substance (1000 tonnes)	Total EU import values associated to the active substance (million €)	Share (%) of total EU import volumes for which the active substance was detected or registered
Metiram	21 296.6	19 949.26	66.1
Mancozeb	24 298.67	26 615.12	57.4
Glufosinate	27 728.64	46 334.41	51.2
Isopyrazam	9 177.11	6 064.27	43.7
Cyproconazole	3 131.98	1 957.41	43.6
Carbendazim	2 909.54	5 214.01	35.8
Benomyl	2 859.64	5 078.77	35.2
Dimethomorph	3 995.98	5 173.46	33.3
Thiophanate-methyl	2 959.06	4 173.37	29.5
Spirodiclofen	8 251.75	2 5993.5	23.5
Clofentezine	1 811.49	2 559.17	7.6
Quinoxyfen	268.26	582.9	4.5
Metribuzin	124.1	250.35	3
Mepanipyrim	11.61	19.69	0.8
Dicofol	0.84	2.38	0.1
Flufenacet (formerly fluthiamide)	0.00	0.00	0.00

Source: Own elaboration based on COMEXT data.

Question 6b. Could the EU rely on other supply sources if the reduction of MRLs to LOQ was implemented for specific active substances?

The previous question highlights EU's exposure to changes in the import of commodities affected by single active substances. In addition, it remains necessary to assess the potential EU's capacity to diversify the import sources of commodities affected by each active substance. This can be measured through a NHHI index (

Table **57**): the higher the index value, the lower the EU diversification of import sources. Overall, EU import sources appear largely diversified for all active substances, at least when compared to the diversification of input sources for each single commodity (previous Question 6a). Dicofol and mepanipyrim appear as the least diversified (NHHI ~ 0.2). However, as previously shown in Question 7, these substances expose only a very minor portion of EU imports.

Conversely, the substances that seemed to expose most of EU imports are (according to Question 7) glufosinate, mancozeb, and metiram. The import sources of commodities related to these substances, however, appear to be very diversified. Therefore, it appears that, from the point of view of single substances, the EU import sources are highly diversified. The conclusions, however, differ when looking specifically at the diversification of input sources by specific commodity (as previously shown in Question 6b). Hence, it seems advisable to assess EU capacity to diversify mostly at commodity level, in order to spot the critical determinants of EU exposure.

Table 57. EU diversification of import sources of commodities affected (with detected or registered status) by each active substance for the commodities not explicitly covered in CAPRI.

Active substance	N (exporting countries)	HHI	NHHI
Dicofol	104	0.2147	0.21
Mepanipyrim	108	0.2009	0.19
Thiophanate-methyl	153	0.1441	0.14
Benomyl	144	0.1374	0.13
Carbendazim	144	0.1374	0.13
Cyproconazole	149	0.1264	0.12
Dimethomorph	175	0.1284	0.12
Isopyrazam	149	0.1243	0.12
Clofentezine	150	0.1067	0.1
Quinoxyfen	122	0.0998	0.09
Metiram	178	0.0718	0.07
Mancozeb	188	0.0684	0.06
Spirodiclofen	174	0.0682	0.06
Glufosinate	192	0.0574	0.05
Metribuzin	154	0.0427	0.04

Source: Own' elaboration based on COMEXT data.

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