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# Executive Summary

Plant protection products, including pesticides, are important to agricultural producers working to ensure crop production for expanding populations in the United States and in foreign markets. The use of these pesticides, which include insecticides, fungicides, rodenticides, and herbicides, can leave pesticide residues on crops and food products.

Governments seek to regulate pesticide residues to ensure that agricultural products are safe to consume and are not harmful to human, animal, or plant life or health. They require that a pesticide or the active ingredient/substance in a pesticide be approved for use before establishing a maximum residue level (MRL) for each specific pesticide/crop combination. An MRL is the highest level of a given pesticide's residue on a given crop that is legally tolerated in a government's jurisdiction.[1] Tens of thousands of MRLs exist worldwide since each MRL is specific to a pesticide/crop combination.

Stakeholders throughout the world's agricultural supply chains are concerned with the differences in MRLs across markets, including when they are missing or low. However, what constitutes a "missing" or "low" MRL is not strictly defined by the agricultural trade community. Generally, agricultural exporters consider MRLs to be "missing" when a market to which they wish to export does not have an MRL for the pesticide/crop combination that they use/produce. There are several reasons why MRLs may be missing in a particular importing market: for example, a particular pesticide may not be registered in the market for use on any crops, or if the pesticide is registered for use, it may not have established an MRL for a specific crop, or the market may not have adopted an existing Codex MRL for a pesticide/crop combination.

According to many stakeholders in the United States and worldwide, pesticide-related policies in some countries are creating significant challenges to agricultural trade. Farmers are increasingly adjusting production practices in response to evolving policies and regulations governing MRLs on agricultural products. These policy and regulatory changes, and the associated uncertainty, can negatively affect farmers' costs as well as their ability to access export markets, which may affect their income. The impacts from missing or low MRLs can vary by country and may be particularly problematic for farmers exporting minor or specialty crops,[2] which have fewer existing MRLs. This is discussed in further detail in chapter 2 of this report.

The U.S. Trade Representative (USTR) requested the U.S. International Trade Commission (USITC or Commission) to conduct an investigation and prepare a two-volume report on the global economic impact of pesticide MRLs on farmers around the world. The scope of this investigation is limited to pesticide and MRL policies related to food crops. The first volume included descriptions of the approaches, regulations, and practices of national and international bodies in setting MRLs and

[1] This MRL definition is used by the Codex Alimentarius Commission (an international standard-setting body discussed later in this report) and major agricultural markets, including the United States and the European Union. EPA, "About Pesticide Tolerances," September 16, 2016; Codex, "Maximum Residue Limits (MRLs)," 2018; European Commission, "Maximum Residue Levels" (accessed February 20, 2020).

[2] The United States defines specialty crops as "fruits and vegetables, tree nuts, dried fruits, horticulture, and nursery crops (including floriculture). These crops include plants that are "cultivated or managed and used by people for food, medicinal purposes, and/or aesthetic gratification." Specialty Crop Competitiveness Act of 2004, Pub. L. No. 108-465, § 3 (2004); USDA AMS, "What Is a Specialty Crop?" (accessed February 25, 2020).

governing pesticide use. The first volume also covered challenges and concerns faced by industry stakeholders in meeting export market MRLs and the costs and effects of compliance and noncompliance with those MRLs for producers in a range of countries. This second volume of the report provides economic modeling assessments exploring the impact of low and missing MRLs on trade, production, and farm income. This second volume also includes U.S. crop case studies describing the effects of low and missing MRLs on a variety of fruits, vegetables, and other specialty crops. It describes the impact of compliance and noncompliance with export market MRLs on U.S. production and export of these products and notes the impact of low and missing MRLs on the integrated pest management (IPM) programs used by growers in several U.S. agricultural sectors.

The regulation of pesticide residues can be a sensitive subject. It is therefore important to place our findings in this report in context. The United States has long and consistently recognized the right of nations to regulate to protect human, animal, and plant life and health, as well as the environment.[3] In the text of its trade agreements, for example, the United States has recognized that each party has the right to determine for itself what level of protection is appropriate for its own people.[4] At the same time, the United States includes in its trade agreements provisions for parties to avoid creating "unnecessary obstacles to trade," to base their decisions on science, and when they regulate, to do so transparently and in accordance with good regulatory practices.[5]

Pursuant to the USTR's request, the report in its two volumes examines the many challenges and concerns U.S producers and producers in other exporting countries face with respect to compliance and noncompliance with MRLs, and the costs agricultural producers incur as a result of low and missing MRLs. The Commission was not asked to determine whether various MRLs around the world are science-based, are developed transparently and in accordance with good regulatory practices, or create "unnecessary obstacles" to international trade. Instead, our report is best viewed as helping to answer the relatively more straightforward part of a more difficult question. Putting aside whether they are necessary or unnecessary, what kind of "obstacles" (challenges and costs) do missing and low MRLs create, and what is the magnitude of those costs? Thus, the report does not undertake a critique of pesticide regulations. Rather, as requested, it assesses and describes the economic costs and trade effects associated with those regulations. Understanding those costs and effects is important as governments develop and implement the pesticide regulations that they consider appropriate to protect human health and the environment.

# Costs and Effects of Missing and Low MRLs: U.S. Producer Case Studies

Case studies included in the report describe the actual and potential costs and effects associated with missing or low MRLS, based on interviews with industry representatives and producers. These case studies incorporate the perspective of U.S. producers of a diverse range of specialty crops grown in different regions of the United States, and shipped to a wide variety of export markets. Summarized

[3] See, e.g., WTO SPS Agreement, Art. 2; USMCA, Preamble; USMCA, Art. 9.3.1(a). USMCA is the most recently concluded U.S. trade agreement.
[4] See, e.g., USMCA, art. 9.6.4(a).
[5] See, e.g., USMCA, Preamble; USMCA, art. 9.3.1; USMCA, art. 9.6, USMCA, art. 9.13, USMCA, art. 28.2.

below, the case studies encompass a number of highly perishable fresh fruits and vegetables as well as products such as hops and nuts, which have a longer shelf life, and illustrate how compliance and noncompliance with import market MRLs affect U.S. farmers.

Highly perishable specialty crops are often disproportionately affected by findings of noncompliance, given how quickly their quality can deteriorate while exporters await further testing or attempt to find alternate markets for rejected shipments. Specialty crops with longer shelf lives, on the other hand, face challenges related to the time a crop is in the "channels of trade" (i.e., the time between the crop's harvest and its sale to a buyer). This is due to the possibility that an MRL may change between the time the crop is grown and the time the processed product is exported or consumed. Regardless of perishability, specialty crops are often disproportionately affected by MRL issues, including when MRLs are missing, low, or diverging. This is in part because specialty crops are generally minor crops. Minor crop issues, such as a limited availability of pesticides and MRLs, are explored in greater detail in volume 1, both in chapter 4 and in several foreign producer case studies in chapter 5 of that volume, as well as in chapter 2 of this volume.

The costs and effects of divergent, missing, or low MRLs vary widely, and depend on a variety of factors. These include whether producers choose to bear the costs of complying with the importing market MRL or whether they choose not to comply and lose access to that market as a result. This decision and the costs involved depend on the availability of effective pesticides as alternatives to the pesticides for which MRLs are missing or low, as well as the capacity of the producer to adjust to missing or low MRLs given pest pressure or growing season conditions.

Missing, low, or diverging MRLs can also have significant impacts on farmers by disrupting IPM programs designed to control pests and diseases. IPM programs focus on long-term prevention of pests using a variety of pest management tools such as habitat manipulation, modification of agricultural cultural practices, the use of resistant varieties, and biological controls in addition to chemical controls.[6] These programs use information about pest life cycles and how they interact with the environment to manage the pest damage while minimizing production costs to farmers and impact to the environment and human and animal health.[7] In most cases, however, cultural and other farming practices are not sufficient to manage pest pressures; pesticide use is part of most IPM programs. The aim of IPM is "the

[6] Biological controls are the use of natural enemies of the pest, and cultural controls are grower practices that reduce pest establishment, reproduction, dispersal, and survival. Beneficial insects are an example of biological controls in an IPM system. For example, the green lacewing (scientifically known as *Chrysoperla rufilabris*) is widely used in various situations to control many different pests, including aphids and the eggs of other insects. After an adult lacewing lays its eggs on a crop, the predatory lacewing larvae feed directly on the pest or its eggs. Asparagus farmers in Peru use green lacewing to control pests, such as the lesser cornstalk borer, that feed on and damage asparagus. Green lacewing larva are also released to help control aphids in strawberries and are used in California. While biological controls can help to keep pest numbers low, insecticide applications may still be necessary. UC IPM, "What Is Integrated Pest Management (IPM)?," accessed August 26, 2020; industry representative, interview by USITC staff, Peru, December 9, 2019; Beneficial Insectary, "Green Lacewing," accessed December 3, 2020.; UC IPM, "Agriculture: Strawberry Pest Management Guidelines," accessed December 3, 2020.
[7] EPA, "Integrated Pest Management (IPM) Principles," September 28, 2015.

judicious use of pesticides" when it is determined through monitoring that pesticide use is required, and the goal is to use a pesticide to remove only the targeted organism.[8]

U.S. industry representatives increasingly cite concerns that recent actions in key U.S. export markets to lower pesticide use could disrupt IPM programs that are of critical importance to domestic agricultural industries. These programs are costly to develop and are the result of years of research. When the ability to use a pesticide that is part of IPM program is lost due to reduction or removal of an MRL, it can disrupt the entire IPM program, which can lead to higher costs as producers turn to more expensive or less effective alternative pesticides or are forced to redesign their IPM programs. While IPM systems are important to many growers, the sensitivity to changes in the export market MRLs of U.S. IPM systems for two U.S. agricultural sectors in particular (nuts and hops) are described in greater detail in chapter 2 of this report.

**Apples and Pears:** The United States is one of the world's largest producers of apples and pears, with combined annual U.S. production valued at more than $3 billion.[9] Although the United States is a major supplier to a variety of export markets, U.S. producers have cited the loss of MRLs in the EU as contributing to a substantial decline in U.S. exports there. The EU, which had previously been the third-largest U.S. export market for apples, has notably reduced its imports of both pears and apples from the United States in recent years. Subsequently, apple and pear producers have shifted exports to less MRL-restrictive markets and have engaged in pre-export testing to limit the likelihood of MRL violations. Pre-export testing and monitoring MRLs in export markets may cost the industry up to $25 million annually.[10] Despite these measures, the U.S. apple and pear sectors have continued to experience multiple MRL violations in export markets, often due to missing MRLs.[11] These violations have raised costs due to destroyed shipments and increased inspections in some key markets.

**Celery:** The United States is one of the world's largest producers of celery, with a crop value of $475 million in 2019. Although the majority of U.S. production is consumed domestically, export markets are important to this industry. Japan is the second-largest export market (after Canada) for U.S. growers, worth $4.3 million in 2019. The U.S. industry experienced MRL violations on celery in Japan as a result of a reduction in Japan's temporary MRL on acephate on celery. These MRL violations resulted in enhanced inspection and port delays not only for the grower-shippers that inadvertently triggered the

[8] EPA, "Integrated Pest Management (IPM) Principles," September 28, 2015; industry representative, interview by USITC staff, August 14, 2020; UC IPM, "What Is Integrated Pest Management (IPM)?" (accessed August 26, 2020).
[9] Apples constitute the vast majority of the total value of both crops. In 2019, the value of U.S. apple production was approximately $2.7 billion, while total U.S. pear production came to about $347 million. Combined, in 2019, these two products would constitute slightly in excess of $3 billion in U.S. production. In most years approximately half of U.S. pear production is exported; in 2019, for example, the U.S. pear sector exported approximately $163 million in production. By contrast, about one-third of U.S. apple production is exported in most years. USDA, NASS, "National Statistics for Apples," 2020; USDA, NASS, "National Statistics for Pears," 2019; Agricultural Marketing Resource Center, "Pears," July 2015.
[10] Industry representative, email message to USITC staff, September 25, 2020.
[11] An MRL violation occurs when a sample of a treated exported agricultural product is tested at port for presence of a pesticide residue and is found to have exceeded the existing MRL of that market. In some instances this can occur if a pesticide residue exceeds an established MRL, while in others this can occur if a market has not yet established an MRL for a pesticide and the MRL is set either to a low numerical default or no residue at all is permitted. MRL violations are described in further detail in chapter 1 of this report, and the implications of violations for U.S. crop exports are discussed in chapter 2.

violations, but for the entire U.S. celery industry. U.S. industry representatives are concerned that enhanced inspections could contribute to revenue losses from reduced demand and lower prices in Japan.

**Pulses:** The United States is the fifth-largest producer of chickpeas and the third-largest for lentils globally, producing nearly 660,000 tons of chickpeas and lentils combined, and exports are extremely important to this industry. Farmers of pulses (including lentil and chickpea farmers) in the United States rely on the active ingredient glyphosate for both weed control and as a desiccant to dry the crop before harvest. However, several export markets around the world are reviewing their pesticide and MRL policies regarding glyphosate. Industry representatives report that without the necessary MRLs for this key herbicide, particularly in the EU, the industry has few effective alternatives for these important steps in the growing process. The alternatives that do exist are reportedly less effective, contributing to income loss for growers through lower crop yields and quality. These commodities are frequently bulked and blended before export, and U.S. growers have noted that this practice has sharpened their concerns about being able to comply with low and missing MRLs in major export markets. Other industry representatives have noted that these impacts could intensify if other export markets choose to align their own import tolerances with those of the EU. [12]

**Cranberries:** U.S. cranberries are a specialty crop with a value of close to $500 million in 2019.[13] Since most global cranberry production occurs in the United States, the costs of missing MRLs or changes to MRLs for cranberries in foreign markets are largely borne by the U.S. cranberry sector. Several pests represent a substantial challenge to the U.S. cranberry industry, and the loss of MRLs in certain key markets, or missing MRLs, can limit the ability of cranberry growers to effectively respond to these pest pressures. For example, the recent non-renewal of chlorothalonil and chlorpyrifos in the EU and subsequent lowering of MRLs to the low default level is a concern for cranberry growers. Additionally, because cranberries are frequently processed before export and maintain a long shelf life, even the potential loss of a key MRL may reportedly lead farmers to proactively limit that pesticide’s use, potentially affecting quality. A change in an MRL can undermine the marketability of a processed cranberry product well after the cranberry has been grown and harvested. Finally, the common practice of blending cranberries from various growers for export often contributes to an industry-wide effort to grow to the lowest MRL among key export markets. These issues can contribute to yield loss (when cranberry growers are unable to effectively control emerging pest pressures), higher operational costs, and lower expected revenue for U.S. growers.

**Sweet Cherries:** The United States is the second-largest global producer of sweet cherries (after Turkey), with 2019 U.S. production of over $650 million.[14] In contrast to some of the other temperate fruits described in this chapter (like cranberries and tart cherries), the vast majority of U.S. sweet cherries are exported in their fresh form to foreign markets. Because of this, MRL violations, which increase inspection and testing of future shipments as well as port delays, cost growers time and money and can erode the value of this fragile fruit. Additionally, growing pressures from pests, in particular the spotted wing drosophila (SWD), represents a rising challenge for the U.S. sweet cherry sector, as there are lower or missing MRLs for key insecticides used in addressing this fruit fly in certain key export markets,

[12] Industry representative, telephone interview by USITC staff, October 31, 2019.
[13] USDA, “Another Large U.S. Cranberry Crop Expected in 2019,” 2019.
[14] USDA, NASS, “National Statistics for Cherries,” 2020.

notably the EU. These low and missing MRLs can also contribute to increased costs for U.S. growers by forcing them to use more expensive insecticides, or face reduced yields—and subsequent revenue—if orchards are left untreated.

**Tart Cherries:** The United States grew $36 million of tart cherries in 2019 and is the fifth-largest producer of tart cherries in the world. Tart cherries are processed into a variety of high-value products before consumption, such as juice and dried cherries, making channel of trade issues problematic for this industry. As with U.S. sweet cherries, SWD has emerged as the industry's main pest issue over the last five years. Responding to this pest pressure results in higher production and export costs. MRL issues in foreign markets, particularly those in the EU, complicate responding to the pest pressure; one insecticide used in controlling SWD is not registered in the EU, while another insecticide that has the same MRL in both the EU and the United States reportedly costs twice as much. Overall, the lack of key insecticide MRLs for SWD in important export markets will likely contribute to yield loss, reductions in U.S. exports, and increased production costs for U.S. tart cherry growers.

**Sweet Potatoes:** The United States is the largest global exporter of sweet potatoes, with annual production valued at $588 million in 2019. Fungal diseases are a major concern for the U.S. sweet potato industry, as they reduce yields. While the U.S. industry relies heavily on cultural methods of control, such as crop rotation, fungicides provide additional options to control fungal disease. Export markets are an important source of revenue to the industry, providing up to six times the returns offered by the domestic market. However, low and missing MRLs in export markets, particularly the EU, offer growers a choice: either they can use less effective and potentially more expensive products to comply, which raises production costs and reduces yields, or they can use more effective pesticides, which results in the loss of export markets where such products are not permitted.

**Edible Nuts**: The United States is the world's leading producer of almonds and pistachios. These nuts are an important U.S. agricultural export, worth over $7 billion in 2019. U.S. edible nut industries have spent decades and millions of dollars battling a pest, the navel orangeworm, which spreads the fungus that produces aflatoxin, a fungal toxin dangerous to human health. To control navel orangeworm, the industry created an IPM program which includes the use of certain key pesticides. However, certain key U.S. export markets have begun to remove the registrations for some of these pesticides and lower the MRLs associated with those pesticides. There are concerns within the nut sectors that some important pesticides that farmers rely on may face increasing scrutiny in these markets and as a result may lose MRLs in those markets. The industries report that if those tools are lost, their IPM programs will be disrupted with little time to adjust, requiring them to choose between losing access to some of the most important export markets or facing potential increases in the prevalence of aflatoxin.

**Hops:** The U.S. hop industry, as one of only two major global producers, is highly dependent on exports and has invested considerable time and money to develop IPM systems to address threats to U.S. hop production from multiple pests and disease, including powdery mildew. However, since its IPM system depends on the availability of certain pesticides to function properly, the U.S. hop industry is increasingly concerned about the negative impacts that missing and low MRLs may have on their future production and profitability. Despite significant efforts by the U.S. industry to harmonize MRLs across markets, the EU has recently rejected the renewal of an important fungicide used against powdery mildew. The industry is apprehensive that the MRL for the relevant active ingredient may be lowered and it may not be able to secure an import tolerance for this fungicide, an outcome that could undermine U.S. production and exports. The slow pace of approval of new active ingredients in other export markets is also of concern.

# Summary of Findings of Quantitative Economic Effects of MRLs

To assess the economic effects of missing or low MRLs on production, exports, farmer income, and prices, the Commission used a combination of gravity modeling, which is commonly used for estimating the effects of trade costs and trade facilitation measures, and other quantitative approaches. Using gravity modeling, chapter 3 presents a picture of global MRLs and how they compare across countries; estimates the relationships between MRLs and trade costs between countries; and quantifies the effects of MRLs on bilateral trade, prices, total imports, and total exports in many countries throughout the world. Chapter 4 examines the effects of MRLs on a more local level, focusing on individual farms and specific specialty crops (Costa Rican bananas and U.S. tart cherries) using a supply response analysis and a farm income statement analysis.

The Commission's model results show that globally, MRLs have affected bilateral trade in two ways: through the heterogeneity (divergence) in MRLs between importing and exporting countries and through the stringency of MRLs in the importing country. While the Commission's analysis shows that global trade patterns have been significantly affected by both MRL heterogeneity and stringency, the magnitudes and even directions of these effects differ across crops.

For most of the crops included in this analysis, including grains and oilseeds as well as a variety of fresh fruits and vegetables, the results of the Commission analysis show that MRL heterogeneity (divergence) deters bilateral trade. The Commission analysis also indicates that for a majority of the 30 largest crops (by trade) included in the analysis, stricter MRLs are associated with lower foreign imports.

The Commission used the estimated effects of MRL heterogeneity and stringency on bilateral trade to examine the global effects of changes in MRLs on prices and total imports and exports in different countries using a simulation gravity model. A hypothetical scenario in which the European Union (EU) would reduce all of its MRLs by 90 percent (roughly the magnitude of recent MRL changes) was simulated for three broad crop groups that have been described in case studies in both volumes of the report: tropical fruit, temperate fruit, and beans and peas. A reduction in EU MRLs was found to have potentially significant impacts on EU members and their closest trading partners. However, other countries less reliant on the EU market were able to mitigate the effects of the changes by shifting their trade patterns towards other partners. The Commission's results demonstrate that the MRL policies set within countries can have a potentially significant global impact. For the countries that export the most to the EU, the changes in prices can have real consequences for their consumers and producers. For other countries that are able to mitigate the changes, they can still result in significant alterations in trading patterns. For the crop groups examined in this report, the impacts for each market depend on the crop group. For tropical fruits, MRL heterogeneity had a trade-decreasing impact, while stringency had a trade-increasing impact. For both temperate fruit and fresh and dried beans and peas, increased MRL heterogeneity and stringency deter trade.

The simulation gravity model, while effective at measuring many of the effects of MRL changes on trade and prices, may not fully reflect some of the long-term impacts on production or income caused by reductions in exports to specific partners or price changes. The Commission therefore conducted additional analyses that supplement the economic models of trade and price effects of MRLs described above, including a supply response analysis and a farm income statement analysis for bananas produced in Costa Rica and tart cherries produced in the United States.

The supply response analysis, which considers producers' reaction to changes in global prices for their crops, indicates that this factor alone would likely result in relatively modest production impacts, particularly if these industries are able to adjust by shifting export destinations in a global market. However, if industries face severe trade impacts with key export destinations and have few alternative markets, price reductions and corresponding supply reductions are likely to be more substantial.

At the farm level, changes in MRLs in export markets (and MRL removals in particular) can have a range of effects that can impact a farm's production, costs, and profitability. When MRL removals occur in markets that farmers rely on for a large portion of their sales, they may change their production practices by switching to other pesticides, which are frequently more costly, less effective, or both. The analysis presented here indicates that this can decrease farmers' profitability. In the presentation of a more catastrophic scenario related to MRL removals, a lack of alternative pesticide products or limited IPM options made production infeasible. Even in cases where most of a farm's sales are made domestically, the decision to forego exports rather than implement these types of pesticide and farm practice changes can be the difference between profitability and unprofitability in years when domestic prices are low. Noncompliance with MRLs in foreign export markets presents a highly risky scenario that can substantially reduce a farmer's profitability, even if noncompliance occurs for only a small portion of their overall sales. Finally, there may be opportunities for well-positioned farms to improve their prices and operating income in cases where they are uniquely capable of meeting foreign MRLs.

Taken together, the results of the quantitative analyses in this report indicate that MRLs can have significant effects on the countries and farmers that most directly face those limits. This is particularly true for farmers that export intensively to particular markets and face limited pesticide alternatives. However, in many cases in which trade between specific markets is less intensive, the effects on countries overall may be less substantial.