Comparing Pesticide Regulations: What can Belgium (EU) and Washington State (US) Learn from One Another?

Ona Ambrozaite[1*], Kirsten B. Butner[2], Dezmond Cole[3], Eline D'Haene[4], Jasmine De Rop[4], Willem Desmedt[4], Nathaniel Laughner[5], Ruben Savels[6], Esther Van Parys[6], Hao Nick Zhang[7]

[1]Johns Hopkins University, Department Chemistry, Baltimore, Maryland
[2]Johns Hopkins University School of Public Health, Department of Molecular Microbiology and Immunology, Baltimore, Maryland
[3]Johns Hopkins University School of Medicine, Department of Biological Chemistry, Baltimore, Maryland
[4]Ghent University, Faculty of Bioscience Engineering, Department of Plants and Crops, Ghent, Belgium
[5]Johns Hopkins University School of Medicine, Department of Cellular Biology, Baltimore, Maryland
[6]Ghent University, Faculty of Bioscience Engineering, Department of Agricultural Economics, Ghent, Belgium
[7]Johns Hopkins University, Department of Materials Science and Engineering, Baltimore, Maryland
https://doi.org/10.38126/JSPG220201
Corresponding author: oambroz1@jhu.edu
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Executive Summary: On a global scale, pesticide use has almost doubled since 1990, with the world market expected to reach $130 billion by the end of 2023. With a rapidly growing world population, the use of pesticides, also called plant protection products (PPP), has played an important role in increasing crop yields to ensure adequate food availability. In the early 1960s, growing concern and awareness about the potential for PPP to non-specifically affect the surrounding ecosystem led to a growing field of resistance. Governmental and intergovernmental bodies have since placed sustainable agricultural practices at the top of their agendas, leading to the use of PPP becoming an increasingly controversial topic of discussion. This policy analysis broadly describes PPP regulation systems in the US and the EU by providing historic accounts of key policy developments of PPP use and their regulations. A direct comparison between regulatory systems for PPP in the US and in the EU is then explored. Washington State and Belgium were chosen as case studies in order to provide a more detailed look into the complexities of such systems and allow for a comparative approach to examine the opportunities and challenges for policy changes. Additionally, suggestions as to what the EU and the US entities can learn from one another to improve the respective PPP regulation systems are investigated. Finally, the analysis explores the potential of strengthening transatlantic cooperation through the establishment of an intergovernmental framework that deals with collection of scientific evidence on PPP and their use. As a result, this analysis acts as a tool for policymakers to better comprehend the different approaches to PPP regulation in the US and the EU as the need to feed the growing world population becomes more urgent, all while safeguarding human and ecosystem health through well-informed policies on PPP use.

I. Introduction: Plant protection products and their associated risks

To achieve sustainable food systems, governmental and intergovernmental bodies have made sustainable food systems and agricultural practices a priority. The United Nations aims for Sustainable Development Goal (SDG) 2 (Zero Hunger) and SDG 12 (Sustainable Production and Consumption), the European Union has instituted the Farm to Fork strategy as a core strategy of the European Green Deal, and the United States has established the recent Agricultural Innovation Agenda (AIA) (FAO 2021; European Commission 2020; USDA 2020).

The use of plant protection products (PPP) is a much-debated topic within discussions on sustainable agricultural practices. PPP, also called pesticides, are chemical formulations containing, amongst others, an active substance which protects plants and crops from pests, diseases, weeds and other plant pathogens in agriculture, forestry, and gardening. PPP have played an important role in maintaining crop yields, although attention needs to be paid to their impact on human and ecosystem health (Popp, Pető, and Nagy 2012, 243–55). PPP can have side exposures and corresponding adverse outcomes for non-target organisms and areas, as well as lead to the development of resistance among pests and pathogens targeted by pesticides, which could result in a subsequent need for farmers to use higher dosages of said pesticides and rotate or mix different pesticides to gain the same crop yields (Hawkins et al. 2018, 135–55).

With a growing world population, the agricultural sector has focused on increasing crop yields to ensure adequate food availability, which is one of the pillars of food security. The Green Revolution that started in the mid-20th century with advancements in controlled irrigation, mechanization, synthetic pesticides, synthetic fertilizers and plant breeding has increased agricultural productivity significantly. Agriculture has moved, most notably in the Western World, towards larger farm sizes, specialization, and automation. The widespread use of monocultures has increased agricultural efficiency but also the odds and severity of pest and disease outbreaks, as well as soil degradation (Oerke 2005, 31–43). If no appropriate measures are taken, this could threaten the food security that the agricultural sector is striving to achieve.

Despite mounting evidence demonstrating the feasibility and necessity of reducing pesticide usage, farmers' use of PPP has steadily increased over the last 60 years in the European Union, the United States, and China (Deguine et al. 2021). Several studies have shown, however, that significant reductions in pesticide use are possible in conventional arable farming without detrimental effects on yields or profitability, provided that appropriate farming practices are implemented (Lechenet et al. 2017). Overall, farmers' hesitancy to implement alternative crop protection strategies might be due to a lack of education, outreach, decision support tools, and incentives from federal and local governments to undertake such a transition.

The use of PPP also has implications for human health, with consistent exposure through inhalation, digestion, and dermal contact having a range of negative effects. There has been an increased amount of attention on the possible neurological, immunological, endocrinological, and carcinogenic effects of pesticides, as well as effects upon vulnerable groups such as children and pregnant women (Mokarizadeh et al. 2015, 258-278).

In this analysis, we examine the regulatory systems for PPP in reference to potatoes in the EU and the US to identify opportunities and challenges for policy changes in each entity. The sustainability debate regarding PPP centers around (1) safeguarding food security and farmers' income generation and (2) ensuring the safety of humans and the environment from harmful chemicals and their residues.

II. Methods

Potato, a tuber vegetable, was chosen since it is a main staple in many countries of the world. Both Belgium and Washington State are important producers of potatoes. Out of an EU total of 54 million tons of potatoes produced in 2020, Belgium produced 4 million tons, making Belgium the fifth largest potato producer in the EU (Eurostat Statistics 2021). In comparison, Washington State produces 20% of all US potatoes (Washington State Potato Commission). Furthermore, in potato farming, pesticide use is relatively high due to frequent occurrence of fungal and viral pathogens. *Rhizoctonia solani*, *Phytophthora infestans*, *Alternaria,* and *Sclerotinia* are fungi that are

commonly treated with different active ingredients (Proefcentrum Aardappelteelt). Viruses, such as potato virus Y and potato leaf roll virus, can also heavily impact crop yield and are transmitted primarily by aphids, making the use of insecticides a common practice (Xu and Gray 2020, 367–75).

A case study focusing on pesticide use in potato production was conducted to informatively illustrate the similarities and differences in pesticide regulation programs and reduction objectives between Belgium and Washington State. To understand pesticide use in both entities, publicly available information on pesticide regulation as well as State and federal policies were examined and compared.

In addition to looking at publicly available information, interviews were conducted with representatives from Washington State Conservation Commission and Proefcentrum Aardappelteelt (PCA), a potato cultivation research center in the Flemish region of Belgium, to investigate the opportunities and challenges of reducing pesticide use.

This methodology resulted in a comparison of current pesticide regulations and practices as well as relevant policies of reduction of pesticide use in Washington State in the US and Belgium in the EU.

III. Results

i. Defining the regulatory system for PPP in the United States

Pesticide regulation in the US began in 1947 with the enactment of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (Bosso 1988, 4-5). The initial goal of FIFRA was to establish a standard for labeling and registration of pesticides. The next pieces of legislation on pesticide regulation were two amendments to the Federal Food, Drug, and Cosmetic Act (FFDCA) that would control which pesticides are allowed to be used in food products. These were known as the Pesticides Control Amendment (PCA) and the Food Additives Amendment (FAA) which were finalized in 1954 and 1958, respectively (Nownes 1991, 3-5). These amendments brought forth the Generally Recognized As Safe (GRAS) term, which is used by the Food and Drug Administration (FDA) to designate that a chemical or substance added to the food product is considered safe by experts.

The public's opinion on and knowledge of pesticides and their impacts on human and ecosystem health changed with the publication of Rachel Carson's *Silent Spring* in 1962 and scientific studies that discovered adverse effects from pesticides (Nownes 1991, 4-5). There were attempts throughout the 1960s to pass legislation that would reform FIFRA. The proposals included moving FIFRA authority from the United States Department of Agriculture (USDA) to the Food and Drug Administration (FDA), providing greater public access to pesticide registration data and mandating better interagency cooperation. None of these proposals gained enough support to pass in Congress. However, an amendment was made to FIFRA in 1964 that made it possible to stop the registration process of any pesticide found to be dangerous to human health (Osteen and Fernandez-Cornejo 2013, 1020).

Key regulatory amendments to FIFRA occurred in 1972 as the Environmental Protection Agency (EPA) was created and a complete revision was spurred by concerns about short- and long-term toxicity of pesticides. In 1972, an amendment from the Federal Environmental Pesticides Control Act (FEPCA) required EPA to register and "reregister" older pesticides according to the newly established scientific standards. As a result, manufacturers had to provide data that showed no "unreasonable adverse effects" on human health or the environment with both new registrations and re-registrations. Additionally, pesticide regulation safety and efficacy data were required to be made publicly available after a successful registration (Osteen and Fernandez-Cornejo 2013, 1020).

Consequently, this led to banning of DDT and chemically similar compounds with the addition of standardized collection of data concerning risk assessment. The pesticide manufacturers became responsible for data collection and testing the safety of other pesticide products. Once testing was completed, the EPA was required by law to decide whether to continue marketing of the pesticide through this "reregistration" process (Wayland and Fenner-Crisp 2016, 5). Further alterations of the registration process occurred in 1978 (P.L. 95-396), 1988 (P.L. 100-532) and 1996 (P.L. 104-170). These

changes added fees and streamlined the registration process to supplement appropriations in order to offset the costs of reregistration and tolerance reassessment.

The most recent amendments to FIFRA were made through Pesticide Registration Improvement Extension Acts, such as PRIA 1-4, in order to improve the registration process even further. These Acts have been renewed every five years since 2004, with the most recent PRIA 4 signed into law in 2019. The amendments to the pesticide registration process have refined it throughout the years by creating fees that provide the resources to register pesticides as well as exemptions and fee waivers for smaller farmers to promote competition. Additionally, funds are renewed every five years for healthcare costs of pesticide-related injuries as well as education programs that aim to reduce exposure to toxic pesticides (EPA 2022).

With regards to consumer protection, the Food Quality Protection Act of 1996 (FQPA) brought amendments to both FIFRA and FFDCA. These changes increased consumer protection by setting limits of pesticide residues upon raw and processed foods and requiring confirmation that exposure to the chemical does not bring harm to the consumer. Another critical amendment from FQPA was the implementation of a periodic review of all registered pesticides every 15 years in a registration review process. A summary of major Acts and Amendments pertaining to pesticide regulation in the US mentioned in this analysis can be found in Table 1.

Currently, the Pesticide Environmental Stewardship Program (PESP) helps promote reduction of pesticide use and maintenance of a monitoring system of alternative solutions. The program, established in 1994, awards $50,000 in grants to regional areas of EPA in order to promote Integrated Pest Management (IPM) practices and relies on regional specialists for data collection and the program's oversight. PESP is also part of EPA PestWise program, which is a consortium of four EPA environmental stewardship programs—PESP, the Strategic Agriculture Initiative, the Biopesticide Demonstration Program and the Pesticide Registration Renewal Improvement Act Partnership—that aims to protect human and ecosystem health through innovative IPM practices and educational efforts (US EPA, Office of Pesticide Programs 2010).

Beyond the programs mentioned, legislation has been introduced that concerns the reduction of pesticide use and removal of gaps that allow unregistered or expired registered pesticides to continue to be used. Senator Cory Booker (D-NJ) has submitted a bill called Protecting America's Children from Toxic Pesticides Act (PACTPA) to help with such efforts and ban pesticides such as paraquat, parathion and paraffin oils that are already prohibited in other major agricultural hubs. PACTPA, however, has lacked significant progress in recent years. Nevertheless, EPA continues to re-evaluate pesticides when necessary, all the while introducing new policies to help track pesticides that have off-target effects, but without any solidification into law to track their enforcement (117th Congress).

While EPA is responsible for pesticide regulation at the federal level, its enforcement has largely become a responsibility of each individual state (Janasie 2019, 4). Each state has been authorized to pass its own pesticide regulations since 1975, provided they are at least as stringent as federal regulations. The pesticide regulation authority for each state is implemented through FIFRA and state pesticide laws, and each state can require registration of pesticides that are exempt under FIFRA. If there is a need for a particular pesticide under special circumstances, states are also authorized to add uses to that pesticide under section 24(c) of FIFRA. Each state regulates pesticides to a varying degree, with states such as California implementing tighter restrictions on specific pesticides and New York banning aerosol application of phorate and Washington of paraquat (Donley 2019, 6-8).

Table 1: Summary of major Acts and Amendments pertaining to pesticide regulation in the US.

Act or Amendment	Impact
Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) – 1947	Improved pesticide producer integrity by instating the registration process
Pesticides Control Amendment (PCA) – 1954	Established safety limits for pesticide residues on food products
Food Additives Amendment (FAA) – 1958	Introduced the Delaney Clause that required pesticides to be generally recognized as safe by scientific experts
Federal Environmental Pesticides Control Act (FEPCA) – 1972	Required pesticides to be re-registered and increased the level of scientific rigor required when registering pesticides to increase safety
Food Quality Protection Act (FQPA) – 1996	Improved standards for preventing pesticide residue on food products and created a periodic pesticide registration review process
Pesticide Registration Improvement Act (PRIA 1) – 2003	Created a fee system that helped cover registrations of pesticides and provide funds for worker protection activities
Pesticide Registration Improvement Renewal Act (PRIA 2) – 2007	Continued the fee system of PRIA 1
Pesticide Registration Improvement Extension Act (PRIA 3) – 2012	Expanded the fee system to cover more registrations and allocated funds for the IT aspect of pesticide registration
Pesticide Registration Improvement Extension Act (PRIA 4) – 2018	Expanded the fee system and established new reporting requirements for pesticide registration

Although the use of numerous harmful pesticides has been significantly reduced on an individual state level, the current processes of FIFRA and EPA make removal of already approved pesticides slow on a national scale. As a result, this has allowed outdated and harmful pesticides such as paraquat, ingestion of which can be fatal, and dermal or eye contact can have serious lasting effects, to remain on the market. Moreover, there has been an increase in the use of pesticides that consist of more than one active ingredient, but the use of such pesticides currently lacks protective policies and research about their consequences to human and ecosystem health (Schulz 2021, 3).

Washington: American case study on the legislative framework of potato PPP

Washington State has one of the highest potato yields per acre in the world, with 30 tons of potatoes per acre (Washington State Potato Commission, n.d.). Furthermore, the State is notable for its State- and local-level legislative frameworks aimed at promoting agricultural practices that facilitate reduced pesticide use and public health risks and minimize adverse environmental impacts. In 1997,

the State's legislature declared that all State agencies that have pest control responsibilities are required to adhere to the principles of IPM (Regular Session Fifty-Fifth Legislature 1997). The cities of Seattle and Olympia have legislation that takes reduction of pesticide use even further. In 1999, the city of Seattle implemented a pesticide reduction strategy to eliminate the use of most hazardous herbicides and pesticides and achieve a 30% reduction in overall pesticide use (City of Seattle 1999). In 2005, Olympia City Council passed a resolution to adopt strategies and guidelines to reduce and eliminate, over time, the city's purchase and use of pesticides (Resolution M-1621 2005).

In February 2012, potato commissions of Washington, Idaho and Oregon established a collaborative research alliance called the Northwest Potato Research Consortium (NPRC). NPRC provides more than $1.5 million annually to fund research on a variety of topics related to potato production, including developing methods consistent with principles of IPM to better understand and control potato pests and pathogens. The tri-state initiative is comprised of scientists from institutions such as Oregon State University, Washington State University and the University of Idaho, in addition to private research entities. As part of NPRC, the investigators periodically publish IPM guidance for farmers in Washington, Idaho and Oregon to cost-effectively manage insects and mites, including those that pose significant management challenges (Schreiber et al. 2019).

Another research initiative aimed at reducing pesticide use is administered by the Washington State Commission on Pesticide Registration (WSCPR). In 1995, the State's legislature created WSCPR to address the high costs of obtaining and maintaining EPA pesticide registration and help farmers in Washington have access to safe and effective pest control products. Since 1999, WSCPR has expanded its mandate with projects that do not rely on pesticide registration, including biological and mechanical control of pests (Washington State Division of Agriculture, n.d.). WSCPR actively supports studies and activities that would decrease the use of pesticides and supports research on and implementation of IPM and pesticide resistance programs in the State, with support ranging from $2,500 to $35,000 (Washington State Commission on Pesticide Registration 2022).

ii. Defining the regulatory system for PPP in the European Union

At the European level, an active regulatory system has been developed over decades to reduce the risks associated with the use of PPP. The earliest Council Directives extend back to the 1970s (e.g., Directive 76/895/EEC of 1976 on maximum levels of pesticide residues on fruits and vegetables and Directive 79/117/EEC of 1978 that prohibited marketing and use of PPP containing certain active substances, among them dichlorodiphenyltrichloroethane, or DDT), but extensive regulatory activity truly began in the early 1990s (European Commission 2003).

The centerpiece of the EU regulatory system is Directive 91/414/EEC of 1991, which aimed to harmonize the process of risk assessment and pesticide approvals across different European Member States. This Directive initiated a safety review of all active substances used in PPP in the EU (of which at that time existed approximately 1,000) (Directive 91/414/EEC 1991).

Directives 79/117/EEC and 91/414/EEC were repealed in 2009 and replaced by Regulation 1107/2009, which is known as the most stringent pesticide regulation in the world (Robinson et al. 2020). Regulation 1107/2009 established that PPP can only be placed on the market if their use complies with defined protection goals, guaranteeing a high level of safety for humans and the environment. The EU places the burden of proof on the PPP industry to demonstrate that active substances have few harmful or unacceptable effects on human or animal health (e.g., mutagens, carcinogens, reproductive toxicants, or endocrine disruptors) and the environment. A dual system is in place, under which the European Food Safety Authority (EFSA) evaluates active substances used in PPP, and Member States evaluate and authorize products in which these active substances and adjuvants such as surfactants or oils are present at the national level (European Commission 2009).

As well as restricting market access of unsafe active substances, the EU also regulates the legal maximum levels of PPP residues in food and feed. This is covered by Regulation 396/2005/EEC, which

consolidated the earlier Directives of 76/895/EEC (fruits and vegetables), 86/362/EEC (cereals) and Regulation 2377/90/EEC (veterinary medicinal products) (Council Regulation (EEC) 396/2005/EEC 2005, Council Directive 76/895/EEC 1976, Council Directive 86/362/EEC 1986, Council Regulation (EEC) 2377/90 1990). Official control of PPP residues in food of plant and animal origin is performed regularly, and the residues may not exceed the set maximum residue levels (MRLs), which are based on good agricultural practices and levels of exposure necessary to protect consumers (EFSA 2018). In addition to individual MRL for each active ingredient, EFSA also considers the potential harmful effects due to cumulative exposure to multiple active ingredients, even if each of them is within the acceptable limit (the so-called "cocktail effect").

In addition to both regulations, Directive 2009/128/EEC, also called the "Sustainable Use of Pesticides Directive", of 2009 went even further and promoted a well-thought-out and safe application of PPP as well as the development of effective alternative methods such as IPM, non-chemical alternatives and promotion of organic farming (Council Directive 2009/128/EEC 2009). This Directive was translated by various EU Member States into National Action Plans that set out specific quantitative objectives, targets, measures and timetables for the first time. The main actions that were implemented by various Member States can be divided into the following four categories:

- Actions related to application: inspection of pesticide application equipment, prohibition of aerial spraying and limitation of pesticide use in sensitive areas.
- Actions related to prevention: protection of aquatic environment and drinking water.
- Actions related to awareness raising and training: information and awareness raising about pesticide risks and training and certification of users, advisors and distributors of PPP.
- Actions related to information mapping and monitoring: systems for gathering information on acute pesticide poisoning incidents as well as chronic poisoning developments, when available.

The cornerstone of Directive 2009/128/EEC is IPM, which aims to keep application of pesticides low. The Directive laid out general principles of IPM and in 2014 made the creation of conditions for the implementation of these principles mandatory for all Member States. IPM aims to keep interventions that aim to prevent and/or suppress harmful organisms to plants at levels that are economically and ecologically justified and which reduce or minimize risk to human health and the environment (European Commission, n.d.). Prevention is key to IPM and is achieved by implementing various strategies such as crop rotation, use of adequate cultivation techniques, resistant/tolerant cultivars, and hygiene measures, as well as protection and enhancement of important beneficial organisms. Monitoring based on field observations as well as warning, forecasting, early diagnosis systems, and having sound threshold values help farmers decide whether and when to apply plant protection measures (European Court of Auditors 2020). If pest control is needed, sustainable biological, physical, and other non-chemical methods that provide satisfactory pest control must be preferred to chemical methods. In general, plant control measures should come with a targeted application, reduced doses and application frequency as well as anti-resistance strategies to maintain the effectiveness of PPP.

Nevertheless, a 2020 review of the progress of implementation of Directive 2009/128/EEC published by the European Commission revealed that most Member States had failed to promote the sustainable use of pesticides and had not met the requirements set out in the Directive and/or the National Action Plans (European Commission 2020). Therefore, in 2022, a new regulation was proposed by the European Commission that set out legally binding targets for the EU and its Member States to reduce the use and risk of chemical pesticides by 50%. This reduction must be met by 2030 to meet the goals set out by the European Green Deal and the associated Farm to Fork and Biodiversity Strategies. A summary of major Directives and Regulations pertaining to pesticide regulation in the EU mentioned in this analysis can be found in Table 2.

Table 2: Summary of major Regulations and Directives pertaining to pesticide regulation in the EU.

Directive or Regulation	Impact
Directive 76/895/EEC – 1976	Improved pesticide producer integrity by instating the registration process Maximum levels of pesticide residues on fruits and vegetables
Directive 79/117/EEC – 1978	Prohibited marketing and use of PPP containing certain active substances, among them DDT
Directive 86/362/EEC – 1986	Installed maximum levels of pesticide residues in and on cereals
Regulation (EEC) No 1734/88 – 1988	Regulated export from and import into the Community of certain chemicals
Directive 91/414/EEC – 1991	Harmonized authorization, market placement, use and control of PPP among EU member States Implemented the directive stated in regulations: • Regulation (EEC) No 3600/92 • Regulation (EC) No 1972/1999 • Regulation (EC) No 451/2000 • Regulation (EC) No 2266/2000 • Regulation (EC) No 1112/2002 • Regulation (EC) No 1490/2002 • Regulation (EC) No 2229/2004 • Regulation (EC) No 1095/2007 • Regulation (EC) No 33/2008 • Regulation 1107/2009/EEC • Regulation (EU) No 188/2011
Regulation (EC) No 178/2002 – 2002	Created the European Food Safety Authority (EFSA) to ensure that the Community has access to high-quality, independent and efficient scientific and technical support in order to achieve a high level of health protection in relation to legislation concerning safety of food and feed
Regulation 396/2005/EEC – 2005	Harmonized Maximum Residue Levels of pesticide residues in food and feed within the Community to ensure a high level of consumer protection
Regulation 1107/2009/EEC – 2009	Introduced a new regulatory framework for the authorization of PPP to further streamline the implementation of Directive 91/414/EEC Implemented the regulation stated in: • Regulation (EU) No 540/2011 • Regulation (EU) No 544/2011 • Regulation (EU) No 545/2011 • Regulation (EU) 546/2011 • Regulation (EU No 547/2011 • Regulation (EU) No 283/2013 • Regulation (EU) No 284/2013
Directive 2009/128/EEC – 2009	Framework to promote the sustainable use of pesticides through integrated pest management and alternative approaches such as non-chemical alternatives to pesticides Introduced the National Action Plans for pesticides in Member States

Belgium: EU case study on the legislative framework of potato PPP

Belgium is the largest exporter of prepared or preserved potatoes in the world. Potato production itself has a strong position in Belgian agriculture, achieving a potato yield of 40 tons per hectare in 2020, with a total harvested area of about 100,000 ha (FAOSTAT 2022). Due to the implementation of Directive 2009/128/EEC, all Belgian growers are required to implement IPM practices since 2014 (Council Directive 2009/128/EC 2009). Nevertheless, the precise implementation of IPM guidelines varies slightly between the Flemish, Walloon and Brussels Capital Regions (European Commission 2014). For the remainder of this analysis, the Flemish guidelines are used as a reference.

In the Flemish region, growers are required to adhere to a detailed list of IPM practices, specific to each major cropping system (Department of Agriculture and Fisheries 2021). Three classes of measures exist: class 1 measures have to be implemented fully, class 2 measures at least partially, and class 3 are non-mandatory recommendations. Examples of class 1 measures include planting of certified disease-resistant varieties whenever possible, implementing monitoring programs, using validated and well-calibrated low-drift spraying equipment and returning all leftover crop protection products to an approved producer. Each grower must also register with an approved certification and inspection body, which then performs farm inspections every three years to verify compliance with all relevant IPM guidelines. Class 2 measures include, for example, the use of catch and cover crops to control diseases and removal of diseased plants. Finally, class 3 measures are site-specific practices such as breaking up of non-draining soil layers and implementing false seed beds or precision irrigation, which are required only in certain areas and circumstances (e.g., heavy clay soils, dry areas, or parcels with exceptionally severe weed pressure).

To add, dedicated and government-funded research centers exist in Belgium for each of the major crops or their systems. Each of the research centers supports growers in the implementation of IPM and other sustainable agricultural practices. For potato growers, PCA (Proefcentrum Aardappelteelt, *Potato cultivation research center)* fulfills this function by providing official lists of disease-resistant cultivars to potato growers (based on internal trials), offering management programs for specific pests and pathogens and, most importantly, operating a warning model for potato growers. The warning model incorporates climate data, field monitoring and other information to determine periods of high risk for outbreaks of the main potato pests and pathogens (PCA 2018). Based on this model, PCA sends alerts to registered potato growers, thereby enabling them to apply crop protection products when necessary rather than according to fixed schedules, as required under the principles of IPM (PCA 2022).

The research center also continuously tries to develop more sustainable crop protection schemes. It has developed herbicide, fungicide and insecticide programs that do not use any active ingredients classified as a candidate for substitution at the EU level while still retaining sufficient diversity to ensure resistance management. Moreover, it continuously tests novel biostimulants, biopesticides and other products that may reduce the need for use of conventional pesticides.

IV. Discussion

i. Opportunities and challenges for the regulatory PPP system in the US

It is quite apparent that the need for increased agricultural production persists at the cost of increased pesticide use. Due to differences between individual states and their agricultural outputs, policy changes should be aimed at both federal and state levels. Currently, there are many political bodies that try to amend the current legislation while also proposing new policies to create sustainable solutions. Two examples of such proactive approaches are Protecting America's Children from Toxic Pesticides Act (PACTPA) and Saving America's Pollinators Act (SAPA) (116th Congress). Both proposed legislations focus on a stricter system of pesticide registration as the method of regulation. However, the pressure to accommodate multiple stakeholders' demands often conflicts with the ban or removal of several pesticides listed in PACTPA and SAPA. Therefore, it would be conducive to target the federal level to change the registration and maintenance of data collection for scientific studies, while at the state

level enforcement could be much more consistent with individual pesticides and respective cropping systems.

Currently, EPA is the primary federal body for pesticide regulation matters. The funding and the number of dedicated staff, however, do not align with the multiplex of problems in the pesticide regulation process. An example of this problem is the relationship between FIFRA and the Endangered Species Act (ESA). EPA has an opportunity to improve how it meets its duties with regards to ESA when it registers pesticides under FIFRA. For most of EPA's history, however, the Agency has met these duties for less than five percent of its FIFRA-related decisions. This has resulted in over twenty ESA lawsuits against the Agency, which has increased in frequency in recent years. Also, the current situation has created uncertainty for farmers, unnecessary expenses and inefficiencies for EPA and delays in how EPA protects endangered species (EPA). Nevertheless, the current Biden-Harris administration has set out a comprehensive work plan to navigate this issue and provide resilient solutions by coordinating with various stakeholders and other government agencies.

To add, amendments to FIFRA should be pursued that would make significant changes in pesticide-related policies. PACTPA, for instance, would target the emergency exemption registration process of FIFRA that currently allows bypassing of the established pesticide registration process. EPA registers nearly 65% of pesticides through conditional registrations and frequently waives requirements for completion of a comprehensive registration process when extending the use of such conditional registrations.

Additionally, several lawmakers have indicated interest in establishing better safety standards for underserved populations that are often the ones that get exposed to pesticides the most. PACTPA would also amend FIFRA so that labels on pesticides are translated and printed in Spanish, considering the workers who are exposed to pesticides most frequently often come from Spanish-speaking backgrounds. While PRIA 4 has renewed funding for programs that focus on such issues, the funding is not substantial for the current large-scale use of pesticides.

There are many other possible targets for pesticide regulation as EPA continues to oversee the process. USDA could play a bigger role helping with the enforcement of such regulations, as each state enforces FIFRA according to its unique needs. Another avenue that could provide more effective pesticide regulation is the upcoming Farm Bill that is passed every five years and has titles within each renewal that could provide a holistic approach to this topic. Widespread education about pesticides' harm and their proper handling could be another helpful approach, especially knowing the vast number of pesticides and the variations in their toxicity.

ii. Opportunities and challenges for the regulatory PPP system in the EU

A first and important step in the EU could be to further enforce the legislation already in place regarding the reduction of pesticide use. As many EU Member States failed to meet the pesticide reduction goals set out in Directive 2009/128/EEC, the EU Commission could consider taking legal action through an infringement procedure where, if no further measures are taken, the European Court of Justice could impose financial penalties for non-compliance (Communication from the Commission COM/2022/518 2022). Overall, the failure to comply with this Directive puts into question the attainability of further and even more strict pieces of legislation.

Consequently, the proposed new legislation of the European Commission on sustainable use of pesticides, which is regarded as an ambitious next step in the EU move towards reducing use of pesticides and their associated risks, should provide the necessary mechanisms and incentives to achieve these new targets. The proposed binding reduction targets would, however, still enable Member States to implement the measures according to their specific contexts, providing flexibility in the means by which to reach the set targets. In addition to setting more ambitious targets, there remains the need for additional policy measures such as incentives for use of alternatives to pesticides (e.g., prevention measures such as adequate crop diversification and rotation and curative measures such as non-chemical interventions) and funding towards research and development of alternative strategies and products.

There has additionally been intense opposition from several Member States and lobbying organizations to postpone or repeal this proposal, especially in the context of the war in Ukraine and its potential impact on food security. The opposition has already resulted in addition of several amendments to the proposed regulation that would reduce its scope and ambition, and experts have raised concerns over their effects on biodiversity that underpins agricultural production (Pe'er et al. 2022).

Furthermore, the transition to reduce the use of pesticides is mainly to be funded by the new Common Agricultural Policy (CAP), which was adopted in 2021 and entered into force on January 1st of this year. However, the budget and funding mechanisms are not aligned with the proposed regulations on the reduction of pesticide use. This raises the question of whether the proposed regulations will have the necessary incentives to aid Member States in the transition to decrease the use of pesticides. As a result, alignment and integration of policymaking processes in agricultural and related domains could be pursued to ensure that cross-cutting goals are achieved more effectively and cost-efficiently (Alons 2017, 1604-1622).

iii. What can the EU and the US learn from one another?

To strengthen bilateral collaboration on the topic between the two entities, the first prerequisite would be to strengthen the platforms on which pesticide-related data and scientific evidence is shared between the US and the EU. Due to the nature of collected data on the impact of individual pesticides on human and ecosystem health, it would save time and other resources if the process of collecting and assessing data could be coordinated and harmonized. An example of such coordination is the NPRC in the US Pacific Northwest, which draws on substantial resources and technical expertise of experts from major research institutions. It also facilitates the exchange of information not only between researchers themselves but also between researchers and farmers. Member States of the EU could likewise establish such initiatives nationally or internationally, utilizing the intellectual capital of their major academic research centers.

On a higher institutional level, strengthening coordination and cooperation at an intergovernmental level could have positive outcomes for both the US and the EU, while additional lessons could be learned from the current governance of pesticides. Stronger intergovernmental cooperation could bring benefits by providing such information, relevant insights and best practices to other regions and countries where pesticide regulation is currently far less strict. It could also reduce the competitive advantage and leakage effects that these regions and countries might have with regards to pesticide use in agriculture, providing a more level playing field for the US and the EU. Cooperation between the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) already exists in the form of the Joint FAO/WHO Meeting on Pesticide Residues (JMPR) and the Joint Meeting on Pesticide Management (JMPM). The United Nations Environment Programme (UNEP) is part of such meetings, exemplifying that the topic of pesticide use cuts across agricultural as well as human and ecosystem health issues at an intergovernmental level–an approach that might be implemented in the US and the EU as well.

To add, the EU has a strong model regarding consolidation of pesticide legislation. This model of overarching policy could help establish a similar simplicity-driven approach in the US, where there are multiple federal and state groups that monitor pesticide regulation along with legislation both at the federal and state levels. In the US, pesticide legislation is currently divided between several federal bodies. Due to this fragmentation of authority, it is often difficult to find concise information regarding pesticides and the policies surrounding them.

In addition, each EU Member State tracks pesticide usage underneath a standardized system for consistent data collection. Similarly, in the US, it could be beneficial if future legislation and the EPA implemented a standardized system for both large and small-scale farmers to report pesticide usage. Updated financial models that extrapolate the costs of pesticide reduction/replacement could also be resourceful to both the US and the EU given the ever-changing demands on the international agricultural supply. Overall, it is clear that both entities are aware of the need for sustainable

pesticide alternatives and could benefit from collaborative initiatives that prioritize such needs.

Additionally, as demonstrated by the EU, there is a need for legally binding pesticide use reduction goals since stakeholders in the agricultural sector are not likely to move towards such goals on their own, even with the use of promotions, suggestions, directives and amendments. Directive 2009/128/EEC in the EU demonstrated that Member States did not make the expected transition to reducing pesticide use in agriculture, leading the European Commission to later adopt legally binding targets. The US could learn from this example and refrain from making the same misconception about the willingness of stakeholders to reduce pesticide use. Financial incentives that enforce reduction targets that are tailored to the size of the farming operation could prove to be useful given the lack of commitment to already established regulations. Many stakeholders are in favor of sustainable solutions, government policies backed by convincing evidence and policies that will ensure the continuation of agricultural output. While the EU is focusing on convincing Member States, the US will need to consolidate the current policies across States and the scientific evidence around sustainable options to progress forward in this field.

Both EPA and FIFRA have also stated that compliance is becoming more difficult to enforce, especially with interference from the global pandemic caused by SARS-CoV-2. However, follow-up measures are important to the implementation of a new system, and both the US and the EU have opportunities to improve in this area. The EU, however, has made significantly more progress in this regard through the conception and gradual implementation of the Green Deal. It is therefore important to quantify all measures of pesticide use in order to ensure compliance with the policies.

iv. Pesticide use in Latin America: Comparison to the US and the EU

As in the United States and Europe, countries in Latin America use pesticides extensively in their agricultural activities to boost crop yields and protect them from pests and diseases. However, the data needed to assess pesticide exposure is scarce, and subsequent regulation of pesticide use varies widely across the region that has a vast agricultural landscape. Some countries have strict regulations in place, while others have weaker enforcement and monitoring systems.

Overall, in Latin America, the majority of regulatory decisions regarding pesticides focus on hazards instead of risks. The Andean countries (Bolivia, Colombia, Ecuador, Peru and Venezuela) are an exception since they adhere to the Andean manual as a regulatory framework to assess risks from the agricultural use of pesticides (Casallanovo et al. 2021, 901-904).

In recent years, there has been a growing concern about the health and environmental impacts of pesticide use in the region, leading to calls for tighter regulations and greater transparency in the use of the chemicals. Compared to the US and the EU, countries in Latin America generally have less stringent regulations on pesticide use and may use pesticides that have been banned or restricted in these other regions, making it an issue of concern for food safety and public health. Potential solutions that have been proposed include harmonization of risk assessment schemes with other regions such as the US and the EU, enhancement of data sharing within Latin America and with other regions and characterization of pesticide use in each country (Casallanovo et al. 2021, 901-904).

V. Conclusion

The US and the EU share common goals of increasing human and ecosystem health while feeding their ever-growing populations. Both regions can learn from each other and benefit from taking a joint stance on pesticide use. Here are the major policy recommendations for the US and the EU covered in this analysis:

Policy recommendations for the US:

- Set targets for reducing pesticide use and increasing adoption of alternative agricultural approaches.
- Reform policies of registration and use of pesticides in agriculture.
- Provide funding for farmers and stakeholders to implement these measures.

- Develop educational programs to teach handling of pesticides and associated safety measures necessary to reduce health risks.

Policy recommendations for the EU:

- Set targets for reducing pesticide use and increasing adoption of alternative agricultural approaches.
- Incentivize the development and adoption of alternative agricultural approaches.
- Reform policies of registration and use of pesticides in agriculture.
- Develop educational programs to teach handling of pesticides and associated safety measures necessary to reduce health risks.

In addition to these recommendations, the US and the EU can learn from each other in other areas of governance-related issues such as strengthening intergovernmental cooperation and promoting harmonized collection of data and scientific evidence on pesticides and their uses. It is clear that farmers and civilians who are exposed to pesticides in both regions would greatly benefit from educational programs that teach handling of pesticides and associated safety measures necessary to reduce health risks. Nevertheless, implementing such measures and regulations requires sufficient funding available not only to farmers but all stakeholders involved. By implementing these measures, the US and the EU can not only assist with the transition to reduced pesticide use but also help achieve similar ambitions in other regions and countries worldwide. Finally, the unique transatlantic science diplomacy collaboration between early-career researchers from the US and the EU on this analysis is an example of the aforementioned benefits of working towards common goals. The product of this analysis demonstrates the power of science diplomacy to develop sustainable solutions for the global transition to sustainable agriculture and a sustainable future for all.

References

Alons, Gerry. 2017. "Environmental policy integration in the EU's common agricultural policy: greening or greenwashing?." *Journal of European Public Policy* 24, no. 11: 1604-1622. https://doi.org/10.1080/13501763.2017.1334085.

Bosso, Christopher J. 1988. "Transforming Adversaries into Collaborators." *Policy Sciences* 21, no. 1: 3–22. https://doi.org/10.1007/bf00145119.

Casallanovo, F., Daniela Mejias Simone, Gustavo Souza Santos, Thamires Sá de Oliveira Kaminski, Ana Paola Cione, and Natalia Peranginangin. 2021. "Estimating pesticide environmental concentrations in Latin America: The importance of developing local scenarios." *Integr Environ Assess Manag,* 17: 901-904. https://doi.org/10.1002/ieam.4396

Chakir, Raja, and Julien Hardelin. 2010. "Crop Insurance and Pesticides in French agriculture: an empirical analysis of multiple risks management," Working Papers (2010) hal-00753733, HAL. https://hal.archives-ouvertes.fr/hal-00753733.

City of Olympia. 2006. "Resolution M-1621." Accessed October 15, 2022. https://cms7files.revize.com/olympia/Document_center/Government/City%20Council%20&%20Mayor/Ordinances%20&%20Resolutions/Council%20Resolutions/M-1621.pdf.

City of Seattle. n.d. "Pesticide Use Reduction Strategy." Accessed October 15, 2022. https://www.seattle.gov/documents/Departments/ParksAndRecreation/PoliciesPlanning/pesticide%20reduction%20strategy.pdf.

Claassen, Roger, Joseph C. Cooper, and Fernando Carriazo. 2011. "Crop Insurance, Disaster Payments, and Land Use Change: The Effect of Sodsaver on Incentives for Grassland Conversion." *Journal of Agricultural and Applied Economics* 43, no. 2: 195–211. https://doi.org/10.1017/s1074070800004168.

Congress.gov. "Actions - H.R.1337 - 116th Congress (2019-2020): Saving America's Pollinators Act of 2019." March 13, 2019. http://www.congress.gov/.

De Vaulx de Champion, M., S. Kempeneers, and C. Rousseau. 2014. *Belgian Action Plan to Reduce the Risks and Impacts Linked to Pesticides*. Brussels. https://food.ec.europa.eu/system/files/2019-03/pesticides_sup_nap_bel_en.pdf.

Deguine, Jean-Philippe, Jean-Noël Aubertot, Rica Joy Flor, Françoise Lescourret, Kris A.G. Wyckhuys, and Alain Ratnadass. 2021. "Integrated Pest Management: Good Intentions, Hard Realities. A Review." *Agronomy for Sustainable Development* 41, no. 3. https://doi.org/10.1007/s13593-021-00689-w.

Department of Agriculture and Fisheries. 2021. "IPM-Richtlijnen: Checklist Februari 2021." Accessed July 2, 2022. https://lv.vlaanderen.be/sites/default/files/attachments/ipm_richtlijnen_-_checklist_2021_februari.pdf.

Donley, Nathan. 2019. "The USA Lags behind Other Agricultural Nations in Banning Harmful Pesticides - Environmental Health." *Environ Health* 18, no. 44. https://doi.org/10.1186/s12940-019-0488-0.

Environmental Protection Agency. 2022. "EPA Announces Plan to Protect Endangered Species and Support Sustainable Agriculture." Accessed October 15, 2022. https://www.epa.gov/newsreleases/epa-announces-plan-protect-endangered-species-and-support-sustainable-agriculture.

European Commission. 2003. "Presence of Persistent Chemicals in the Human Body Results of Commissioner Wallstrom's Blood Test." Accessed June 17, 2022. https://ec.europa.eu/commission/presscorner/detail/en/MEMO_03_219.

European Commission. 2009. "Questions and Answers on Plant Protection Products." Accessed October 18, 2022. https://ec.europa.eu/commission/presscorner/detail/fr/MEMO_09_8.

European Commission. 2020. "On the experience gained by Member States on the implementation of national targets established in their National Action Plans and on progress in the implementation of Directive 2009/128/EC on the sustainable use of pesticides." Accessed December 8, 2022. https://food.ec.europa.eu/system/files/2020-05/pesticides_sud_report-act_2020_en.pdf.

European Commission. 2022. "Enforcing EU Law for a Europe That Delivers." Accessed November 24, 2022. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0518&qid=1681353390884

European Commission. n.d. "Integrated Pest Management (IPM)." Accessed July 17, 2022. https://food.ec.europa.eu/plants/pesticides/sustainable-use-pesticides/integrated-pest-management-ipm_en.

European Court of Auditors. 2020. "Sustainable Use of Plant Protection Products: Limited Progress in Measuring and Reducing Risks." Accessed February 20, 2023. https://op.europa.eu/webpub/eca/special-reports/pesticides-5-2020/en/#:~:text=IPM%20is%20an%20important%20part,became%20mandatory%20in%2020145.&text=Source%3A%20ECA%2C%20based%20on%20Annex,support%20more%20sustainable%20pest%20control.

European Food Safety Authority. 2018. *How Pesticides Are Regulated in the EU - EFSA and the Assessment of Active Substances.* https://www.efsa.europa.eu/en/corporate/pub/pesticides-ebook-180424.

European Parliament and Council, Council of 21 October 2009, "Establishing a framework for Community action to achieve the sustainable use of pesticides." Directive 2009/128/EC. October 21, 2009. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32009L0128

European Parliament and Council, Council Regulation (EC) No 1107/2009 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." Regulation (EC) No 1107/2009. October 21, 2009. https://eur-lex.europa.eu/eli/reg/2009/1107/oj

European Parliament and Council, Council Regulation (EC) No 178/2002 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." Regulation (EC) No 178/2002. January 28, 2002. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32002R0178

European Parliament and Council, Council Regulation (EC) No 396/2005 of 23 February 2005, "Maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/EEC Text with EEA relevance." Regulation (EC) No 396/2005. February 23, 2005. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32005R0396

European Union, Commission Implementing Regulation (EU) No 540/2011 of 25 May 2011, "Implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council as regards the list of approved active substances." Regulation (EU) No 540/2011. May 25, 2011. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32011R0540

European Union, Commission Regulation (EC) No 1095/2007 of 20 September 2007, "Amending Regulation (EC) No 1490/2002 laying down further detailed rules for the implementation of the third stage of the programme of work referred to in Article 8(2) of Council Directive 91/414/EEC and Regulation (EC) No 2229/2004 laying down further detailed rules for the implementation of the fourth stage of the programme of work referred to in Article 8(2) of Council Directive 91/414/EEC." Regulation (EC) No 1095/2007. September 20, 2007. https://eur-lex.europa.eu/eli/reg/2007/1095/oj

European Union, Commission Regulation (EC) No 1112/2002 of 20 June 2002, "Laying down the detailed rules for the implementation of the fourth stage of the programme of work referred to in Article 8(2) of Council Directive 91/414/EEC." Regulation (EC) No 1112/2002. June 20, 2002. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2002.168.01.0014.01.ENG&toc=OJ%3AL%3A2002%3A168%3ATOC

European Union, Commission Regulation (EC) No 1490/2002 of 14 August 2002, "Laying down further detailed rules for the implementation of the third stage of the programme of work referred to in Article 8(2) of Council Directive 91/414/EEC and amending Regulation (EC) No 451/2000." Regulation (EC) No 1490/2002. August 14, 2002. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32002R1490

European Union, Commission Regulation (EC) No 1972/1999 of 15 September 1999, "Amending Regulation (EEC) No 3600/92 laying down the detailed rules for the implementation of the first stage of the programme of work referred to in Article 8(2) of Council Directive 91/414/EEC concerning the placing of plant protection products on the market." Regulation (EC) No 1972/1999. September 15, 1999. https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:31999R1972&print=true

European Union, Commission Regulation (EC) No 2229/2004 of 3 December 2004, "Laying down further detailed rules for the implementation of the fourth stage of the programme of work referred to in Article 8(2) of Council Directive 91/414/EEC." Regulation (EC) No 2229/2004. December 3, 2004. https://eur-lex.europa.eu/eli/reg/2004/2229/ojhttps://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex:32005R0396

European Union, Commission Regulation (EC) No 2266/2000 of 12 October 2000, "Amending Regulation (EEC) No 3600/92 laying down the detailed rules for the implementation of the first stage of the programme of work referred to in Article 8(2) of Council Directive 91/414/EEC concerning the placing of plant protection products on the market." Regulation (EC) No 2266/2000. October 12, 2000. https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32000R2266

European Union, Commission Regulation (EC) No 33/2008 of 17 January 2008, "Laying down detailed rules for the application of Council Directive 91/414/EEC as regards a regular and an accelerated procedure for the assessment of active substances which were part of the programme of work referred to in Article 8(2) of that Directive but have not been included into its Annex I." Regulation (EC) No 33/2008. January 17, 2008. https://eur-lex.europa.eu/eli/reg/2008/33/oj

European Union, Commission Regulation (EC) No 451/2000 of 28 February 2000, "Laying down the detailed rules for the implementation of the second and third stages of the work programme referred to in Article 8(2) of Council Directive 91/414/EEC." Regulation (EC) No 451/2000. February 28, 2000. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex:32000R0451

European Union, Commission Regulation (EEC) No 3600/92 of 11 December 1992, "Laying down the detailed rules for the implementation of the first stage of the programme of work referred to in Article 8 (2) of Council Directive 91/414/EEC concerning the placing of plant protection products on the market." Regulation (EEC) No 3600/92. December 11, 1992. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:31992R3600

European Union, Commission Regulation (EU) No 188/2011 of 25 February 2011, "Laying down detailed rules for the implementation of Council Directive 91/414/EEC as regards the procedure for the assessment of active substances which were not on the market 2 years after the date of notification of that Directive Text with EEA relevance." Regulation (EU) No 188/2011. February 25, 2011. https://eur-lex.europa.eu/eli/reg/2011/188/oj

European Union, Commission Regulation (EU) No 283/2013 of 1 March 2013, "Setting out the data requirements for active substances, in accordance with Regulation (EC) No 1107/2009 of the European Parliament and of the Council concerning the placing of plant protection products on the market." Regulation (EU) No 283/2013. March 1, 2013. https://eur-lex.europa.eu/eli/reg/2013/283/oj

European Union, Commission Regulation (EU) No 284/2013 of 1 March 2013, "Setting out the data requirements for plant protection products, in accordance with Regulation (EC) No 1107/2009 of the European Parliament and of the Council concerning the placing of plant protection products on the market." Regulation (EU) No 284/2013. March 1, 2013. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32013R0284

European Union, Commission Regulation (EU) No 544/2011 of 10 June 2011, "Implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council as regards the data requirements for active substances." Regulation (EU) No 544/2011. June 10, 2011. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32011R0544

European Union, Commission Regulation (EU) No 545/2011 of 10 June 2011, "Implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council as regards the data requirements for plant protection products." Regulation (EU) No 545/2011. June 10, 2011. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32011R0545

European Union, Commission Regulation (EU) No 546/2011 of 10 June 2011, "Implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council as regards uniform principles for evaluation and authorisation of plant protection products." Regulation (EU) No 546/2011. June 10, 2011. https://eur-lex.europa.eu/eli/reg/2011/546/oj

European Union, Commission Regulation (EU) No 547/2011 of 8 June 2011, "Implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council as regards labelling requirements for plant protection products." Regulation (EU) No 547/2011. June 8, 2011. https://eur-lex.europa.eu/eli/reg/2011/547/oj

European Union, Council of 15 July 1991, "Concerning the Placing of Plant Protection Products on the Market." Directive 91/414/EEC. July 15, 1991. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A31991L0414

European Union, Council of 21 December 1978, "Prohibiting the Placing on the Market and Use of Plant Protection Products Containing Certain Active Substances." Directive 79/117/EEC. December 21, 1978. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31979L0117

European Union, Council of 23 November 1976, "Relating to the Fixing of Maximum Levels for Pesticide Residues in and on Fruit and Vegetables." Directive 76/895/EEC. November 23, 1976. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31976L0895.

European Union, Council of 24 July 1986, "Fixing of maximum levels for pesticide residues in and on cereals." Directive 86/362/EEC. July 24, 1986. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex:31986L0362

European Union, Council Regulation (EEC) No 1734/88 of 16 June 1988, "Concerning export from and import into the Community of certain dangerous chemicals." Regulation (EEC) No 1734/88. June 16, 1988. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31988R1734

European Union, Council Regulation (EEC) No 2377/90 of 26 June 1990, "Laying down a Community Procedure for the Establishment of Maximum Residue Limits of Veterinary Medicinal Products in Foodstuffs of Animal Origin." Regulation (EEC) No 2377/90. June 26, 1990. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31990R2377

Eurostat Statistics. 2021. "The EU Potato Sector - Statistics on Production, Prices and Trade." Accessed November 5, 2022. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=The_EU_potato_sector_-_statistics_on_production%2C_prices_and_trade.

Food and Agriculture Organization of the United Nations. 2022. "FAOSTAT database." Accessed October 19, 2022. https://www.fao.org/faostat/en/#data/QCL.

Hawkins, Nichola J., Chris Bass, Andrea Dixon, and Paul Neve. 2018. "The Evolutionary Origins of Pesticide Resistance." *Biological Reviews* 94, no. 1: 135–55. https://doi.org/10.1111/brv.12440.

Interprovinciaal Proefcentrum voor de Aardappelteelt – PCA. 2018. "Waarschuwingsdienst Aardappelziekte PCA: Hoe Werkt Het?" Accessed December 4, 2022. https://www.pcainfo.be/Kenniscentrum/Ziekten/category/schimmels/waarschuwingsdienst-aardappelziekte-pca-hoe-werkt-het.

Janasie, Catherine. 2019. "State and Local Regulation of Pesticides: What does FIFRA allow?" National Sea Grant Law Center. Accessed October 9, 2022. https://nsglc.olemiss.edu/projects/ag-food-law/index.html.

Lechenet, Martin, Fabrice Dessaint, Guillaume Py, David Makowski, and Nicolas Munier-Jolain. 2017. "Reducing Pesticide Use While Preserving Crop Productivity and Profitability on Arable Farms." *Nature Plants* 3, no. 3. https://doi.org/10.1038/nplants.2017.8.

Mokarizadeh, Aram, Mohammad Reza Faryabi, Mohammad Amin Rezvanfar and M. Abdollahi. 2015. "A comprehensive review of pesticides and the immune dysregulation: mechanisms, evidence and consequences." Toxicology Mechanisms and Methods 25: 258 - 278. https://doi.org/10.3109/15376516.2015.1020182.

Nownes, Anthony J. 1991. "Interest Groups and the Regulation of Pesticides: Congress, Coalitions, and Closure." *Policy Sciences* 24, no. 1: 1–18. https://doi.org/10.1007/bf00146462.

Oerke, E. C. 2005. "Crop Losses to Pests." *The Journal of Agricultural Science* 144, no. 1: 31–43. https://doi.org/10.1017/s0021859605005708.

Osteen, Craig D, and Jorge Fernandez-Cornejo. 2013. "Economic and Policy Issues of U.S. Agricultural Pesticide Use Trends." *Pest Management Science* 69, no. 9: 1001–25. https://doi.org/10.1002/ps.3529.

PCA. n.d. "PCA Proefcentrum aardappelteelt, Flanders." Accessed September 1, 2022. https://www.pcainfo.be/.

PCA. n.d. "Vlotte Oogst." Accessed October 13, 2022. https://www.pcainfo.be/.

Pe'er, Guy, John A. Finn, Mario Díaz, Maren Birkenstock, Sebastian Lakner, Norbert Röder, Yanka Kazakova et al. 2022. "How can the European Common Agricultural Policy help halt biodiversity loss? Recommendations by over 300 experts." *Conservation Letters*: e12901. https://doi.org/10.1111/conl.12901.

Popp, József, Károly Pető, and János Nagy. 2012. "Pesticide Productivity and Food Security. A Review." *Agronomy for Sustainable Development* 33, no. 1: 243–55. https://doi.org/10.1007/s13593-012-0105-x.

Regular Session Fifty-Fifth Legislature, Convened January 13, 1997. "1997 Session Laws of the State of Washington". April 27, 1997.

Robinson, Claire, Christopher J. Portier, Aleksandra Čavoški, Robin Mesnage, Apolline Roger, Peter Clausing, Paul Whaley, Hans Muilerman, and Angeliki Lyssimachou. 2020. "Achieving a High Level of Protection from Pesticides in Europe: Problems with the Current Risk Assessment Procedure and Solutions: European Journal of Risk Regulation." *European Journal of Risk Regulation* 11 (3): 450–80. https://doi:10.1017/err.2020.18

Schreiber, A., Andrew Jensen, Silvia Rondon, Erik Wenninger, Stuart Reitz, and Tim Waters. 2019. "Integrated Pest Management Guidelines for Insects and Mites in Idaho, Oregon and Washington Potatoes." https://www.nwpotatoresearch.com/images/documents/Northwest-Potato-Insect-Management-Guidelines-2019W-1.pdf.

Schulz, Ralf, Sascha Bub, Lara L. Petschick, Sebastian Stehle, and Jakob Wolfram. 2021. "Applied Pesticide Toxicity Shifts toward Plants and Invertebrates, Even in GM Crops." *Science* 372, no. 6537: 81–84. https://doi.org/10.1126/science.abe1148.

U.S Congress. Protect America's Children from Toxic Pesticides (PACTPA) Act. S. 269 118th Congress. Introduced February 2nd, 2023. https://www.congress.gov/bill/118th-congress/senate-bill/269/actions?s=1&r=1&q=%7B%22search%22%3A%5B%22Protecting+America%27s+Children+from+Toxic+Pesticides%22%5D%7D

US EPA, Office of Pesticide Programs. 2010. "About Us: PestWise: US EPA." Accessed December 1, 2022. https://web.archive.org/web/20110202121343/http://www.epa.gov/pesp/about/index.html.

Washington State Commission on Pesticide Registration. 2022. *Request for Proposals Guidelines*. Accessed October 8, 2022. https://s3.wp.wsu.edu/uploads/sites/2002/2021/09/WSCPR-FY22-RFP.pdf.

Washington State Division of Agriculture. n.d. "Pesticides." Accessed October 8, 2022. https://agr.wa.gov/departments/pesticides-and-fertilizers/pesticides.

Washington State Potato Commission. n.d. "Potatoes in Washington." Accessed October 13, 2022. https://www.potatoes.com/washington-s-potato-history.

Washington State Potato Commission. n.d. "Washington's Potato History." Accessed October 8, 2022. https://www.potatoes.com/washington-s-potato-history#:~:text=Washington%20State%20produces%2020%20percent%20of%20all%20U.S.%20potatoes.

Wayland, Susan, and Penelope Fenner-Crisp. 2016. *Reducing Pesticide Risks: A Half Century of Progress* .Washington DC: EPA. https://www.epaalumni.org/userdata/pdf/pesticides.pdf.

Xu, Yi, and Stewart M. Gray. 2020. "Aphids and Their Transmitted Potato Viruses: A Continuous Challenges in Potato Crops." *Journal of Integrative Agriculture* 19, no. 2: 367–75. https://doi.org/10.1016/s2095-3119(19)62842-x.

Ona Ambrozaite is a National Science Foundation Graduate Research Fellow (NSF GRF) pursuing a Ph.D. in Chemistry at Johns Hopkins University. She studies synthesis of low-dimensional materials with tunable morphologies, phases, and resulting properties. Beyond the laboratory work, she is involved in many

science diplomacy and science policy areas, including as the Science Diplomacy Chair of the Johns Hopkins Science Policy Group (JHSPG) and the Science Diplomacy Committee Chair of the National Science Policy Network (NSPN).

Kirsten Butner is a graduate from the Johns Hopkins School of Public Health with an MHS in Molecular Microbiology and Immunology. She wrote her thesis on combining chitosan and ferritin nanoparticles with mRNA to pursue a universal influenza vaccine and is currently working with The Carter Center's Conflict Resolution Program to promote health and peace in Syria.

Dezmond Cole is a Ph.D. student in the Biochemistry, Cellular & Molecular Biology Graduate Program (BCMB) at the Johns Hopkins University School of Medicine. Advised by Dr. Erin Goley in the Department of Biological Chemistry, Dezmond studies how tick-borne human pathogens hijack the host cytoskeleton during infection. Outside of the lab, Dezmond serves as the President of the Johns Hopkins Science Policy Group (JHSPG), and he serves on the JHU School of Medicine Department of Biological Chemistry's Diversity, Equity, and Inclusion Committee.

Eline D'Haene is an educational counsellor on sustainable agriculture and food systems at Ghent University. Eline defended her Ph.D. in 2020 after working 5 years on the influence of religion on food systems studying the case of milk and dairy products in Ethiopia.

Jasmine De Rop is a Ph.D. student and academic assistant in the Department of Plants and Crops at Ghent University, involved in teaching plant crop protection chemistry and environmental fate and management of plant protection products while conducting doctoral research on the formulation of microbial biocontrol agents to agricultural crops.

Willem Desmedt is a postdoctoral scientist in the Department of Plants and Crops at Ghent University. Willem's research focuses on sustainable management of plant pests and diseases through biocontrol organisms and compounds that stimulate the innate plant immune system.

Nathaniel Laughner is a Ph.D. student in the Biochemistry, Cellular & Molecular Biology Graduate Program (BCMB) at the Johns Hopkins University School of Medicine. Advised by Dr. Deborah Andrew, Nate studies the transcriptional mechanisms that mediate organ development using the salivary gland development of Drosophila melanogaster as a model system. Nate serves as the Vice President of the Johns Hopkins Science Policy Group (JHSPG).

Ruben Savels is a Ph.D. student and academic assistant in the Department of Agricultural Economics at Ghent University, involved in teaching agricultural and environmental economics, management and policy. His research focuses on the operationalization and institutionalization of agroecology in Flanders, Belgium.

Esther Van Parys is a Ph.D. student in the Department of Agricultural Economics within the division of Agri-Food Marketing and Chain Management at Ghent University. Her research focuses on the pathways, sustainable boundaries, and limitations of scaling-up short food supply chains.

Hao Nick Zhang is a Ph.D. student in the Department of Materials Science and Engineering at the Johns Hopkins University, funded by the National Science Foundation Graduate Research Fellowship (NSF GRF). His research focuses on carbon utilization using electrochemical methods. The goal of the project is to design processes to reduce greenhouse gasses with high degree of tunability and efficiency so it can mitigate the effects of climate change.

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