RISE Foundation – www.risefoundation.eu

June 2020

EXPERT BRIEF

SUSTAINABLE CROP PROTECTION

BACKGROUND MATERIAL FOR THE ESAD PLATFORM

RISE Foundation's contribution to the ESAD EU platform

Contact:
elisabet.nadeu@risefoundation.eu

Suggested citation:

Nadeu, E (2020) Sustainable Crop Protection, Background Material for the ESAD Platform. Expert brief submitted to the European Sustainable Agriculture Dialogue, RISE Foundation.

RISE Foundation
Rural investment for a Sustainable Europe

SUMMARY

European Union (EU) legislation aims at reducing the risk and use associated to pesticide use in agriculture. However, recent reports by EU institutions and others are showing that current trends are not aligned with the objectives set by the Sustainable Use Directive and those recently established by the Green Deal.

While implementation of current regulation remains a challenge, further research in key areas could contribute to bridging the gaps.

This document identifies the main challenges and highlights three broad research areas that could contribute to meeting the required reductions in pesticide use and risk. These are: monitoring pests and pesticide use, boosting natural crop protection and reducing pest resistance and increasing plant resilience. Each topic is further divided into several elements for discussion.

ACKNOWLEDGMENTS

The European Sustainable Agriculture Dialogue (ESAD) is a multi-stakeholder platform created in 2019 that brings together 35+ key actors from across society – including industry, civil society, universities, and research centres – to discuss key topics, exchange views and standpoints, and recommend research needs to achieve sustainable agriculture.

ESAD is grateful to Elisabet Nadeu (RISE Foundation) for her outstanding work the past months to draft this paper. As an independent and external researcher to the ESAD group, she has provided an evidence-based and balanced perspective on the matters explored in this paper.

Selected members of the ESAD community were consulted and their inputs were taken into account by the external expert in the drafting process.

The paper does not reflect the views and opinions of single ESAD members that were consulted. As such, their contribution is not to be interpreted as an endorsement of the final paper.

European Sustainable Agriculture Dialogue

1. INTRODUCTION

The purpose of this research brief is to provide an overview of crop protection in the EU, understand the challenges ahead and identify the research gaps that need to be addressed to make EU crop protection systems more sustainable (and aligned with the objectives set in the Sustainable Use of Pesticides Directive).

1.1. Context – EU agriculture and the Green Deal

Sustainability goals and societal demands have changed in the last decades, shifting from focusing on economics and food availability to placing a stronger focus on reducing the environmental impacts of agricultural activities. The European Commission's (EC) Green Deal is adding new requirements for EU agriculture in order to tackle greenhouse gas emissions, halt biodiversity loss and improve human health. Specifically, the Farm 2 Fork strategy[i] aims at reducing agricultural inputs such as chemical pesticides use and risk by 50% by 2030.

This is expected to be achieved by further implementation of Integrated Pest Management, strengthened environmental risk assessment of pesticides, reducing the length of the pesticide authorisation process, and facilitating the placing on the market of pesticides containing biological active substances[ii]. The question still remains open as to whether the current proposals for the Common Agricultural Policy will be adapted to ensure the successful implementation of the Green Deal's objectives.

EU agriculture will need to change to adapt to the new challenges and societal demands, and crop protection will not be exempt from its transformation. The Sustainable Use of Pesticides Directive (2009/128/EC) (SUD) currently sets the framework for crop protection in the EU with the core aim to reduce pesticide use in EU agriculture. Yet, after a decade of implementation, the Directive has achieved very little. Whilst it is evident that further policy measures will be needed to push for a lower input system, further research is urgently required into the directions that can lead EU agriculture onto a more sustainable path.

1.2. Why do we need crop protection and what are its impacts?

Reducing crop losses has been a priority for farmers and land managers since the start of agriculture.

Crop losses inevitably raise costs and decrease net margins. It has been estimated that, globally, crop losses to pests could amount to an average of 50% for the major crops, and up to 75%, if crop protection tools (all types included) were not used[iii].

The ways through which crops are protected cannot be disassociated from the predominant forms of agriculture. Crop protection methods, mostly of a chemical nature, associated to the intensification and specialisation of our current agricultural systems have been accompanied by significant impacts to the environment and human health including biodiversity loss, soil degradation and water pollution.

Pesticides aim to compete with or eliminate pests and weeds. Fungicides, herbicides and insecticides are designed to compete with and or eliminate pests and therefore unintended effects on non-target organisms are almost unavoidable, including those on natural enemies that would contribute to reduce pest loads. Terrestrial biodiversity loss has occurred below-ground and above-ground, and aquatic biodiversity has declined tooiv. However directly linking precise impacts to certain pesticide use remains difficult because of the large number of other factors involved.

The effects of pesticides on non-target organisms can be direct and lethal, or sub-lethal but having impacts on the longer run health and numbers of such species. These losses mean that the vital ecosystem services that these organisms provide,

such as natural pest control, are impaired or lost. Of particular concern is the potential impact of pesticides on the removal of natural predators that play an important role in protecting crops against pestsv.

The degradation of many aspects of the environment is now well established and documented by EU and Member States. Exposure to pesticides has also been linked to a number of health conditionsvi. Assessing health risks from dietary exposure through consumption of food which may have pesticide residues is complex. Studies linking pesticide exposure and health outcomes are for the most part epidemiological studies. It is not possible to establish causal relationships between a specific substance and particular human health risk through such studies, and yet, these links would be helpful to guide action to protect public health.

Even in the case where scientists could assess the extent to which humans and biodiversity will be affected by a certain product or a mixture of them, it will always be up to regulators (and society) to decide which levels of acceptable impact are tolerated if the use of these products is considered important to protect crops.

Overall, and based on current regulation and knowledge, the European Food Security Agency (EFSA) considers EU food consumers are considered to be correctly and adequately protected from the impacts of pesticide residues in foodvii. Further research is needed to assess the impact of multiple presence of pesticides on human health and the environment.

1.3. Overview of the main practices and pesticide sales

Crop production is a knowledge-intensive activity.

There are several ways through which crops are protected. These include agronomic practices, landscape management tools, physical crop protection tools, biological pest control tools and chemical pest control. Forecasting and monitoring systems make these tools more effective. The development of precision agriculture utilising digital technologies, robotics, drones, artificial intelligence and big data is expected to increase the depth of the knowledge required to protect crops. This will require training but also investments.

The crop protection toolbox available to EU farmers could be summarised as the list of elements that constitute Integrated Pest Management (IPM), consisting in a set of hierarchically organised tools that define a path for crop protection management through prevention, monitoring and action, with the use of chemicals being a last resort. However, the extent to which the hierarchical use of these tools is effectively applied remains very difficult to know. Although EU countries must promote the use of IPM, it is not clear how it is enforced and whether it's working since there are no statistics on the use of prevention and monitoring or even physical and some biological tools.

A recent report by the European Commission[viii] considers that the assessment of the implementation of IPM to be '*the most widespread weakness in the application of the SUD*'. The report also states that while National Action Plans within the SUD '*must include indicators to monitor the use of PPPs containing active substances of particular concern*', France is the only country that has included this in their National Action Plan.

There is data on pesticide sales and these data show that there has not been a particular trend in their use over the last decade. Longer datasets from FAOSTAT[ix] show a downward trend between the

1990s and 2010, with a slight increase since. The actual consequences of the total amount of pesticide sold or used are difficult to interpret. For a start, there´s a large variability among what we call 'pesticides'.

There are many types of pesticides used for many different purposes, their mode of application differs, as do their modes of action. Some pesticides are high spectrum while others are highly specific. Dosage rates are also highly variable although they have tended to be reduced over time. All these factors make the risks associated to each pesticide different. To track progress on reducing the risks of pesticide use, the European Commission has recently introduced the use of two indicators to track how the risks associated to pesticide use are evolving. The objective of these indicators is to measure the progress achieved in the reduction of risks and adverse impacts from pesticide use for human health and the environment.

Harmonized Risk Indicator 1 (HRI 1), calculated '*by multiplying the quantities of active substances sold in plant protection products by a weighting factor*' decreased by 20% between 2011 and 2017. Harmonized Risk Indicator 2 (HRI 2), calculated by '*multiplying the number of emergency authorisations granted by Member States under Article 53 of Regulation (EC) No 1107/2009 by the same weighting factors*', increased by 50% during the same period.

This clearly shows there are limitations in the approval system and the use of alternatives to pesticides among farmers. The Harmonised Risk Indicators have started filling a gap in our ability to measure progress in pesticide risks but they have been criticised by many due to their limitations. The EC has committed to developing more sophisticated indicators in the future as more data becomes available. This is an area where progress is clearly needed.

1.4. Legislation on crop protection

Current policy aims to reduce the use and risk of plant protection products in agriculture.

There are three main pieces of legislation that regulate the use of pesticides in the EU. These are: Directive 2009/128/EC on the Sustainable Use of Pesticides, Regulation (EC) No 1107/2009 concerns the placing of plant protection products on the market, and Regulation (EC) No 396/2005 concerns maximum residue levels (MRL).

The SUD provides the overall framework on crop protection. The main objective of this Directive is to 'achieve a sustainable use of pesticides in the EU by reducing the risks and impacts of pesticide use on human health and the environment and promoting the use of Integrated Pest Management (IPM) and of alternative approaches or techniques, such as non-chemical alternatives to pesticides'x. The promotion of IPM as a pillar of the SUD, sought to create a tool to encourage low-pesticide input pest management together with organic farming.

Six other relevant regulations which impact on the permissible use of pesticides are the drinking water and water framework Directives, the Regulation concerning the packaging and labelling of dangerous chemicals, the requirements, inspection and maintenance of equipment used for pesticide application, the collection of data on pesticide use, and pesticide use in organic farming. Although very weakly, the CAP promotes the sustainable use of pesticides through its greening payments, cross-compliance, agri-environmental measures and farm advisory systems.

Despite the general EU aim to reduce use and risk of pesticides through the deployed legislation, this is not being currently achieved. A recent European Court of Auditors report on the progress achieved on the SUD stated that there were no clear criteria or specific requirements to ensure enforcement and that an insufficient number (less than 5%) of currently approved active substances are defined as low risk.[xi]

They made three recommendations[xii]: allowing IPM criteria to be linked to the payment of agricultural subsidies, improving statistics on plant protection products, and developing better risk indicators to assess progress towards achieving policy objectives.

A non-legislative document by the European Parliament has also stated that current implementation of the SUD is insufficient to reduce risks and dependency on the use of pesticides and encouraged more focus on non-chemical alternatives and low-risk plant protection products in order to achieve full implementation of the Directivexiii.

In addition to these, **other general criticisms to the current regulatory framework** which are stated often by other stakeholders are[xiv]:

- Ambiguity between reducing risks attributable to pesticides and reducing their use
- Complex approval process, not sufficiently resourced to work within the time periods and criteria set in legislation. This creates uncertainty and large costs for applicants as well as frequent resort to emergency and temporary authorisations
- Distrust in the approval process because the data used in the assessments originates in the applicant companies, sometimes subject to non-release for commercial reasons
- Concerns that human health and the environment are inadequately protected because of several issues including: impacts are not assessed for all groups of species, tests on individual species do not reveal the impacts on ecosystems, and the potential interactive 'cocktail' effects of multiple pesticides use are not taken into account.
- Innovative and potentially lower risk pesticides such as many biopesticides are deterred from the market by an approval procedure not suited to their characteristics.
- Other EU policies such as the CAP have not, to this point, given strong steer or sufficient practical incentives to help the implementation of IPM.[xv]
- The SUD lacks guidance or quantitative goals to Member States regarding National Action Plans (NAPs), milestones and indicators defined for implementing many of the IPM actions and measuring their impacts are also needed.

2. EU FUNDED CROP PROTECTION RESEARCH

A search on the CORDIS website allows one to see the large number of calls and projects related to crop protection since the FP1.

These projects are currently funded mainly under different areas of Horizon 2020 but also through the European Research Council (ERC) and the SME Instrument.

Topics range from addressing research gaps in the control of specific pests to designing cropping systems for integrated pest management and resilient. Over the years, the number of calls encompassing large number of elements of agricultural systems has increased, placing crop protection in the wider context of agricultural inputs and management of agricultural landscapes.

The H2020 call invested one billion euros to fund more sustainable agriculture, food and rural development[xvi].

The theme 'Sustainable Food Security' received the majority of funds (€753 million) and had the following call for tenders related to crop protection during the period 2016-2020:

ID	Title	Funded projects
SFS-08-2017	**Organic inputs – contentious inputs in organic farming**	**Organic-PLUS, RELACS**
SFS-10-2017	**Research and approaches for emerging diseases and pests in plants and terrestrial livestock**	**DEFEND, HOMED, RUSTWATCH**
SFS-13-2017	**Validation of diagnostic tools for animal and plant health**	**SWINOSTICS, VALITEST, VIVALDI**
SFS-17-2017	**Innovations in plant protection**	**SuperPests, OPTIMA, VIROPLANT**
SFS-28-2017	**Functional biodiversity – productivity gains through functional biodiversity: effective interplay of crop pollinators and pest predators**	**EcoStack**
SFS-29-2017	**Socio-eco-economics – socio-economics in ecological approaches**	**LIFT, UNISECO**
SFS-01-2016	**Solutions to multiple and combined stresses in crop production**	**SolACE**
SFS-02-2016	**Teaming up for good: Exploiting the benefits of species diversity in cropping systems**	**DIVERSify, ReMIX**
SFS-03-2016	**Testing and breeding for sustainability and resilience in crops**	**BREEDCAFS**
SFS-06-2016	**Weeding - strategies, tools and technologies for sustainable weed management**	**IWMPRAISE**
SFS-09-2016	**Spotlight on critical outbreak of pests: the case of Xylella fastidiosa**	**XF-ACTORS**
SFS-31-2016	**Farming for tomorrow - developing an enabling environment for resilient and sustainable agricultural systems**	**SURE-Farm**
SFS-04-2019-2020	**Integrated health approaches and alternatives to pesticide use** - 2019 Integration of plant protection in a global health approach (RIA) - 2020 Alternative to contentious pesticides (IA)	
SFS-05-2018-2019-2020	**New and emerging risks to plant health**	**FF-IPM, PRE-HLB**
	Stepping up integrated pest management - 2018 focus on decision support systems (RIA) - 2020 focus on European-wide demonstration farm network (CSA)	**IPM Decisions**
LC-SFS-19-2018-2019	**Climate-smart and resilient farming**	**MIXED, STARGATE**
SFS-29-2018	**Innovations in plant variety testing**	**INVITE, Innovar**

3. KEY ISSUES/CHALLENGES AND RESEARCH GAPS IN CROP PROTECTION

The way EU farmers protect crops will need to evolve to ensure the objectives in the SUD are met and to meet the new targets set by the Green Deal. Expected reductions in pesticide use will have to be compensated by a stronger focus on the IPM tools which are not chemical. For this to happen the right instruments need to be established and several research gaps addressed.

The first section of this document presented the current situation of crop protection in the EU and highlighted the following some of the issues and challenges to be addressed:

- Reducing the environmental and health impacts of current crop protection methods
- Difficulty in tracking progress in the implementation of Integrated Pest Management
- Lack of indicators to measure progress in the reduction of pesticide risk and use
- Adapting to changing climatic conditions while avoiding an increase in crop losses to weeds and pests
- Data lacking to make complete assessments on the impact of the simultaneous presence of different pesticides on the environment and human health

This will require increasing knowledge in certain areas in which there are currently large research gaps. Three main areas are identified based on the above diagnosis and interactions with stakeholders[xvii] which would benefit from EU funded research and would help to address current challenges.

- **Monitoring pests and pesticide use.** This includes elements than can contribute to better monitoring of pests and pesticide use.
- **Boosting natural crop protection through landscape planning and biocontrol.** This should fill current gaps of knowledge related to transitioning towards a less impactful way of protecting crops. This includes the expansion of biocontrol tools and redesigning cropping systems to allow crop protection to work with nature (e.g. creating buffers to reduce pest load) at the landscape level
- **Reducing pest resistance and increasing plant and systems resilience**. This area should place the focus on the plants themselves. Two key issues with large knowledge gaps have been selected: tackling resistance and improving crop resilience.

These three areas of research should involve a wide range of stakeholders to ensure effective take up and implementation of results, including (but not limited to): scientists (i.e. agronomy, environment), local and regional authorities, advisors, pesticide distributors, plant protection product companies, cooperatives, farmers and farmer associations.

Well-designed dissemination and communication plans should also target the general population to increase the understanding and need for sustainable crop protection systems in the EU.

Two more considerations that will not further be developed here:

- **It is important to develop socio-economic research** that improves the understanding between stakeholders and motivations for change. This topic will not be developed here but is noted as a key issue to allow the translation of research into practice. EU funded projects such as AgriLink[xviii] have contributed to bridging the existing gap between researchers, advisors and farmers.
- Little is known about the impact of exposure to a mixture of pesticides, even at low levels, on human and animal health. This is known as the "cocktail effect" and is often cited as a key gap in the assessment process prior to the release of new plant protection products on the market. EFSA has recently looked into the effects of

multiple pesticides on two human health issues (chronic effects on the thyroid system and acute effects on the nervous system) and concluded that 'consumer risk from dietary cumulative exposure is, with varying degrees of certainty, below the threshold that triggers regulatory action for all the population groups covered'[xix]. The report has been received with criticism for not using experimental studies[xx]. Further research is needed to test further effects on human health and the environment.

The issues and areas of research identified here can be broken further down to add more detail by the expert group in the ESAD platform.

		Research gaps		
		Monitoring pests and pesticide use	Boosting natural crop protection	Reducing pest resistance and increasing plant resilience
Challenges	Reducing impacts	**X**	**X**	
	Tracking IPM progress	**X**		
	Lack of indicators to measure SUD progress	**X**		
	Adapting to new conditions without increased impacts	**X**	**X**	**X**

Table 1.
Linking challenges and research gaps

3.1 Monitoring pests and pesticide use

It is often said that '**you can't manage what you can't measure'**, and pesticide use has a long way to go measurement wise.

A current challenge in EU crop protection lies in obtaining data to improve the management of pests and weeds at the farm level and, at another level, to assess progress in meeting the objectives established by EU legislation.

In short, this will also be needed to make sure that the objectives set by the Green Deal are also met. At the EU level, current monitoring is mostly limited to the requirements of the Water Framework Directive, although with a very limited number of pesticides present on the required monitored list (some MSs do make the list longer), as well as the monitoring required by the Regulation on Maximum Residue Levels.

There is no requirement to monitor pesticide residues nor other pollutants in EU agricultural soils. This is a clear limitation in the assessment of the impact taking into account that a recent study using soil samples from 11 EU MS found that 80% of agricultural soils contained pesticide residues.[xxi]

Data on pesticide use at the EU level is only publicly available since 2011 but even this data suffers from several shortcomings such as the fact that not all countries report the same and the data for which the MSs present the data does not always match.

Harmonised data collection is crucial to establish baselines and track progress, but is not considered here as a research gap per se.

The identified areas in which research could contribute to improve monitoring are:

DEVELOPING PEST MONITORING TOOLS AND NETWORKS TO FEED INTO FORECASTING MODELS

Some chemicals are used routinely on arable land rather than in response to an outbreak, with negative consequences on the environment and in particular soil health[xxii].

To reduce pesticide use and successfully implement IPM there is a need to improve and upscale pest monitoring networks in the EU and to be able to do so novel monitoring tools are needed. This is a challenging area. There are some interesting technologies already being developed for insects.

As an example, the EU funded project ENTOMATIC worked with intercommunicated insect traps and biosensors that fed into a spatial decision support system estimating the propagation of the plague and offering recommendations to the farmers[xxiii].

The Ecophyto 2 plan has devoted part of its resources to financing projects on the development of tools for decision making[xxiv].

DEVELOPING INDICATORS ON PESTICIDE RISK AND USE

The current choice of indicators to assess changes in pesticide risks and use by the European Commission has received many criticisms and there is a clear need to develop indicators to track the impact of pesticide policies on human health and the environment.

The most currently used indicator in the EU is the treatment frequency index, but it can't be used to measure changes in risks since it only measures the number of applications without considering the type of pesticide used. More research into this is needed. It could also include the development of indicators that could be implemented at the EU level, such as is currently the case for the common birds and butterflies index. As an example, France is using the NODU indicator in the context of the ECOPHYTO plan.

This indicator allows to estimate the intensity of use of plant protection products by linking the amount of each substance sold to a "unique dose", representing the maximum allowed dose for that particular substance for an average treatment[xxv].

DEVELOPING INDICATORS FOR INTEGRATED PEST MANAGEMENT (IPM)

An ideal IPM approach first gives priority to avoiding pest damage, then minimises its impacts first by encouraging natural resistance using cultural approaches, and then by biological means before resorting to chemical products. There is currently no indication of the tools that farmers are using and the actual implementation of IPM principlesxxvi remains unknown.

As mentioned above, developing better indicators for pesticide use will be an important first step in understanding the implementation of IPM in the EU. But this will only show a fraction of the picture and the development of indicators that allow both farmers and policy makers at the farm and member state level to see the extent of IPM implementation will be needed.

IPM requires farmers to be equipped with decision support systems. As an example, the H2020 funded DESSA[xxvii] project, showed that agrochemicals can be reduced between 10 and 30% when farmers had access to a software that gave them real-time support based on the conditions of their farm.

Another H2020 funded project focused on IPM indicators was EUCLID[xxviii], that developed an Assessment Tool to assist farmers in the use of IPM by comparing different combinations of measures of

IPM considering efficacy and direct costs but also impact to health and the environment.

Member State wise, France, through its Ecophyto programme, has created an online portal EcophytoPICxxix that brings together knowledge on integrated crop management and makes it available to practitioners.

3.2 Boosting natural crop protection through landscape planning and biocontrol[xxx]

In a context of reduced reliance on the chemical crop protection toolbox, alternatives will have to be developed, placing focus on the biocontrol sector and on practices that increase nature's own ability to deal with pests such as by redesigning cropping systems.

These two elements need to go hand in hand because effective implementation of some biocontrol tools, for instance of biological control agents (BCAs), will require rethinking the structure of agricultural landscapes to reduce pest pressure, prevent the development of resistance and help boost the role of natural enemies. Three examples of subareas for research would be:

DEVELOPING BIOCONTROL (AND LOW-RISK PRODUCTS?)

The European Commission, through its Green Deal, wants to promote organic agriculture and set targets for reductions in pesticide use and risk. The biocontrol toolbox will need to expand to meet these demands.

Particular focus should be placed on developing ways to deal with weeds that don't require synthetic chemical pesticides. Research is needed also to find alternatives to the use of copper compounds, which are already listed in the EC's candidate for substitution list[xxxi].

UNDERSTANDING THE ROLE OF SOIL BIOTA IN CROP PROTECTION

The Commission's proposal for Horizon Europe includes 5 mission areas, one of which is **Soil Health and Food**[xxxii].

This mission area is expected to provide "a powerful tool to raise awareness on the importance of soils, engage with citizens, create knowledge and develop solutions for restoring soil health and soil functions".

This is of particular importance when dealing with crop protection because crop protection benefits from well-functioning soils. Research into the role played by soil biota on crop protection and finding ways to enhance this service is needed.

Agro-ecology can play an important part in this.

The recently published Farm to Fork strategy expects that 'new knowledge and innovations will also scale up agro-ecological approaches in primary production through a dedicated partnership on agro-ecology living laboratories.'[xxxiii]

REDESIGNING CROPPING SYSTEMS

Agricultural developments in the last century have resulted in a reduction in the number of crop species on individual farms, compromised soil fertility and created landscape homogenisation.

Together, **these elements have reduced the resilience** of our agricultural system to mitigate the spread and impact of pest attacks.

Restoring and improving the capacity of our agricultural systems is needed to achieve a sustainable pesticide use. If the EC aims at reducing the risks of current pesticide use, research on redesigning cropping systems and crop diversification to allow for effective IPM implementation will be a central part of it.

3.3 Reducing pest resistance and increasing plant resilience

The evolution of resistance in weeds and pests is a threat to the effectiveness of pesticides. Resistance itself is an evolutionary process and can be expected to develop over time in target species, but it can also happen soon after the introduction of a new compoundxxxiv. Resistance at the plant level is not unresearched area but reducing resistance by focusing on the way cropping systems are designed has been less developed.

This has also happened with resilience, although further research on plant breeding for resilience should place stronger focus on increasing plant diversity and developing locally adapted resilient varieties.[xxxv]

Overall, the plant level, the discussion on resistance and resilience of crops is a social and legal one rather than a research one (societal acceptance of techniques that modify genetic material).

Research and long-term experiments are however needed on increasing the diversity of plant species in agricultural systems and creating effective designs in order to reduce the impact of pests, diseases, weeds and deal with external pressures (i.e. those expected with climate change).

REFERENCES

[i] COM (2020) 381 final

[ii] See the recently published Farm to Fork strategy (COM (2020) 381 final) and the Biodiversity Strategy (COM/2020/380 final).

[iii] Oerke, E.-C., 2006. Crop losses to pests. J. Agric. Sci. 144, 31–43

[iv] Some examples: Hallmann et al. 2017 DOI: 10.1371/journal.pone.0185809; Wepprich et al. 2019 DOI: 10.1371/journal.pone.0216270; Powney et al. 2019 DOI: 10.1038/s41467-019-08974-9; van Strien et al. 2019 DOI: 10.1016/j.biocon.2019.03.023; Malaj et al. 2014 DOI: 10.1073/pnas.1321082111

[v] Dainese, M., Martin, E.A., Aizen, M.A., Albrecht, M., Bartomeus, I., et al., 2019. A global synthesis reveals biodiversity-mediated benefits for crop production. Sci. Adv. 5, eaax0121

[vi] For more details and references see the RISE Report and its appendix: Buckwell, A., De Wachter, E., Nadeu, E., Williams, A. 2020. Crop Protection & the EU Food System. Where are they going? RISE Foundation, Brussels

[vii] The EFSA publishes annual reports on 'pesticide residues in food'. In 2017, in 96% of the analysed samples

pesticide residues fell within legal limits, and more than half of the tested samples reported no quantifiable pesticide residues. This indicates that pesticides are used as prescribed.

[viii] COM(2020) 204 final https://data.consilium.europa.eu/doc/document/ST-8238-2020-INIT/en/pdf

[ix] FAOSTAT data on Pesticide Use http://www.fao.org/faostat/en/#data/RP

[x] EU website on the SUD: https://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides_en

[xi] European Court of Auditors 2020. Special report on Sustainable use of plant protection products: limited progress in measuring and reducing risks. Publications Office of the European Union, Luxembourg.

[xii] https://www.brusselstimes.com/all-news/eu-affairs/94313/audit-report-eu-unable-so-far-to-reduce-the-use-of-pesticides-by-farmers/

[xiii] European Parliament resolution of 12 February 2019 on the implementation of Directive 2009/128/EC on the

sustainable use of pesticides (2017/2284(INI)).

[xiv] As listed in Buckwell, A., et al. 2020 RISE Foundation

[xv] For further information on CAP and pesticides visit: https://ec.europa.eu/info/food-farming-fisheries/sustainability-and-natural-resources/biodiversity-and-land-use/pesticides_en

[xvi] https://ec.europa.eu/info/news/european-commission-announces-eu1-billion-funding-more-sustainable-agriculture-food-and-rural-development_en

[xvii] In the process of researching for the RISE Foundation 2020 report on Crop Protection

[xviii] https://cordis.europa.eu/project/id/727577

[xix] Read it here: https://ec.europa.eu/food/plant/pesticides/max_residue_levels/cumulative_risk_en

[xx] https://www.euractiv.com/section/agriculture-food/news/ngo-challenges-new-efsa-studies-on-multiple-pesticides-as-unfit-for-purpose/?utm_source=EURACTIV&utm_campaign=70ec54f2dd-AgriFood_Brief_COPY_05&utm_medium=email&utm_term=0_c59e2fd7a9-70ec54f2dd-114960783

[xxi] Silva, V., Mol, H.G.J., Zomer, P., Tienstra, M., Ritsema, C.J., Geissen, V., 2019. Pesticide residues in European agricultural soils – A hidden reality unfolded. Sci. Total Environ. 653, 1532–1545

[xxii] Lamichhane, J.R., 2017. Pesticide use and risk reduction in European farming systems with IPM: An introduction to the special issue. Crop Protection 97, 1–6.

[xxiii] More information here: https://www.upf.edu/web/entomatic/

[xxiv] NOTE DE SUIVI 2018-2019 DU PLAN ECOPHYTO published in January 2020 https://agriculture.gouv.fr/telecharger/106541?token=4f4ae92c2619dc6d9eec9dd0c3331f0d

[xxv] Ministère de la Transition Écologique et Solidaire & Ministère de l'Agriculture et de l'Alimentation. 2017. Ecophyto: methodologie de calcul du NODU (Nombre de doses unités)

[xxvi] The list of the eight IPM principles can be found in the Annex II of the Sustainable Use of Pesticides Directive

[xxvii] https://cordis.europa.eu/project/id/854408

[xxviii] http://www.euclidipm.org/

[xxix] http://geco.ecophytopic.fr/

[xxx] See references in Lamichhane 2017

[xxxi] https://ec.europa.eu/food/plant/pesticides/approval_active_substances_en

[xxxii] https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme/mission-area-soil-health-and-food_en

[xxxiii] Section 3.1 in COM(2020) 381 final

[xxxiv] Hawkins, N.J., Bass, C., Dixon, A., Neve, P., 2019. The evolutionary origins of pesticide resistance. Biological Reviews 94, 135–155.

[xxxv] Lamichhane, J.R., Arseniuk, E., Boonekamp, P., Czembor, J., et al., 2018. Advocating a need for suitable breeding approaches to boost integrated pest management: a European perspective: Breeding for integrated pest management. Pest. Manag. Sci 74, 1219–1227.