



# What role for R&I in reducing the dependency on pesticides and fertilising products in the EU agriculture?

How to align the European Green Deal's pesticide and fertiliser reduction targets with Europe's research and innovation needs

This briefing paper provides an overview of the current technical and scientific knowledge and additional research needs for the achievement of pesticides and fertiliser reduction objectives under the Green Deal.

**Publication date:**

October 2020

**Author:**

Gauthier Schefer

**Acknowledgements:**

With thanks to IEEP colleagues Ben Allen, Nora Hiller, Jean-François Hulot and Elisa Kollenda for their support and comments on earlier drafts.

## SUMMARY

The Farm to Fork and Biodiversity strategy targets for pesticide and fertiliser reduction reflect a desire in Europe to reduce the impact of excess inputs into agricultural systems, and thus reduce the negative impacts on the environment, climate and human health. However, these reduction objectives present current European agricultural and land management systems with a dilemma of how to reduce the use of inputs to agricultural systems but maintain a level of production necessary to meet societal needs. Addressing this question requires a greater focus on research and innovation in this area.

Existing research efforts on pesticides (through current Horizon 2020 calls) have focused on improving IPM techniques, the development of alternative pest control through a mix of land management, genotyping, bio-products, and monitoring techniques for emerging pests. On fertilisers, research fostered the development of integrated and management tools, advisory (including sensing) services and bio-based circular nutrient cycles.

At present, however, these individual approaches have not fully addressed the solutions that are needed to reduce agricultural inputs, whilst continuing to maintain agricultural outputs that match societal needs. As a result, there are three broad areas which will need additional attention in future R&I programmes. These are:

- Monitoring and indicators to better track use and risk, which could feed into decision support systems for farmers.
- Ecosystem interaction and biocontrol to help upscale alternative farming techniques under reduced input conditions such as agroecology.
- Alternative inputs, crop diversity and new species to enhance crop resilience and outputs while preserving soil fertility.

In addition to these specific research needs, the EU will need to develop, partly through R&I programmes, greater upscaling, advisory and outreach programmes to ensure that the results of current and future research are implemented at the scale needed to address EU ambitions.

The Common Agricultural Policy and the European innovation partnerships benefit from research on the path to sustainable agriculture in Europe (Commissioner Janusz Wojciechowski on the occasion of the EU R&I Days).<sup>1</sup> To make the role of R&I a more systemic instrument in addressing agricultural sustainability, current and future findings need to be tied to specific actions set out in the Farm to Fork and Biodiversity strategies and become concrete instruments in reaching the pesticides and fertilisers reduction targets. This paper draws some of the research directions that could lead to making reduction objectives a reality on agricultural fields.

## Outline

This briefing paper aims at providing an overview of the technical and scientific information available and the one needed for the achievement of pesticides and fertiliser reduction objectives in the EU. First, the paper introduces the context of these targets and their respective legislative framework under EU law. It then presents a state of play of current research, mainly conducted under the Horizon 2020 framework program. Finally, remaining research needs are addressed to deliver on the Farm to Fork and Biodiversity strategies commitments and the way they could be targeted through Horizon Europe. A more detailed summary of the known

---

<sup>1</sup> Naujokaitytė, G (2020) Final proposals for research moonshots presented to the European Commission, *Science Business*, 22 September.

consequences of pesticides and fertiliser application on the European environment and of the applicable legislation can be found in Annex 1.

## Context

The European Commission published its Communication on the 'European Green Deal'<sup>2</sup> on 11 December 2019, setting out the key political objectives for the next five years. The priorities are centred around sustainability and a new growth strategy for the European Union (EU). Two communications followed, aiming at addressing the current state of agriculture and biodiversity in Europe. The Farm to Fork Strategy<sup>3</sup>, which elaborates a systems approach to the agriculture and food sector's sustainability, and the Biodiversity Strategy to 2030<sup>4</sup>, establishing a vision for the protection and restoration of ecosystems.

In a complementary manner, both these strategies include reduction objectives pertaining to the prevalence of pesticides and fertilisers in European agriculture. First, the aim is to reduce the overall use and risk of synthetic chemical pesticides by 50% and the use of more hazardous pesticides by 50% by 2030. The second is a commitment to reduce nutrient losses by at least 50% while ensuring that there is no deterioration in soil fertility, which will reduce the use of fertilisers by at least 20% by 2030.

These new political targets are the continuation of a growing corpus of European legislation that has tried to address the well-established scientific consensus on the harmful impacts of plant protection products (PPP) application and chemical fertilisers on biodiversity, water, soil and air pollution (Box 1: Summary of the main legislation applicable to pesticides and fertilisers).<sup>5</sup>

### Box 1: Summary of the main legislation applicable to pesticides and fertilisers

Crop protection products are mainly regulated in the EU under the Sustainable Use of Pesticides Directive (SUD) (2009/128/EC), Regulation (EC) No 1107/2009 on the Placing of PPP products on the

<sup>2</sup> European Commission (2019), Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, *The European Green Deal*, COM(2019) 640 final, Brussels 11.12.2019

<sup>3</sup> European Commission (2020), Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, *A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system*, COM(2020) 381 final, Brussels, 20.5.2020

<sup>4</sup> European Commission (2020), Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, *EU Biodiversity Strategy for 2030 Bringing nature back into our lives*, COM(2020) 380 final Brussels, 20.5.2020

<sup>5</sup> European Environmental Agency (2020) *European environment – State and outlook 2020*, December 2019.

market and Regulation (EC) No 396/2005 on Maximum Residue Levels (MRL). The overarching SUD Directive explicitly aims at reducing the “risk and impact” of pesticides on health and the environment in the EU. A major tool in the achievement of this ambition, the Directive promotes increased uptake of alternatives to chemicals in European agriculture through integrated pest management practices (IPMs). IPMs are a set of concrete agronomic and landscape management techniques, such as crop rotation or conservation tillage, governed by the general principle that PPP must be a last resort solution to manage pests.<sup>6</sup> To that effect, Member States must draw and report on National Action Plans that promote the integration of such practices in their agriculture.

The basis for the calculation of advancement in reaching the 50% reduction objectives by 2030 will be the Harmonised Risk Indicators 1 and 2 (HRI 1 and 2) pursuant to Directive (EU) 2019/782 of 15 May 2019.<sup>7</sup> HRIs are European-level indicators, and another key element of the SUD Directive, aiming at capturing PPP use in Europe, given that their dosage and spectrums differ significantly.

The current Fertilisers Regulation<sup>8</sup>, adopted in 2019 as part of the Circular Economy Package, extends the legal framework for fertilisers’ authorisation and circulation in Europe beyond mined and inorganic sources<sup>9</sup>. Organic fertilisers are now covered by harmonisation rules, thus provided wider market access. Furthermore, with the objective of reducing heavy-metal pollution in soils and limiting toxic effects on humans, the Regulation introduced a content limit for cadmium in fertilisers of 60mg/kg.

Fertiliser inputs are also limited in certain areas (Nitrate Vulnerable Zones) by the Nitrates Directive<sup>10</sup>, legislation which aims at preventing leaching of nutrients originating from agricultural activities to the groundwater and surface water. Nutrient management plans are already required under the Common Agricultural Policy. They are found in agri-environment programmes, as well as forming

---

<sup>6</sup> The Directive 2009/128/EC lays down IPM’s principles in Annex III.

<sup>7</sup> Directive (EU) 2019/782 of 15 May 2019 amending Directive 2009/128/EC of the European Parliament and of the Council as regards the establishment of harmonised risk indicators, Official Journal L 127/4, 16.5.2019

<sup>8</sup> Regulation (EU) 2019/1009 of the European Parliament and of the Council of 5 June 2019 laying down rules on the making available on the market of EU fertilising products and amending Regulations (EC) No 1069/2009 and (EC) No 1107/2009 and repealing Regulation (EC) No 2003/2003, Official Journal L 170/1, 25.6.2019

<sup>9</sup> Such as was the case in Regulation (EC) 2003/2003 of the European Parliament and of the Council of 13 October 2003 relating to fertilisers, Official Journal L 304, 21.11.2003

<sup>10</sup> Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources, Official Journal L 375, 11.12.2008

part of the Statutory Management Requirements (SMR) of Cross Compliance.<sup>11</sup>

These reduction objectives present current European agricultural and land management systems with a dilemma.<sup>12</sup> The type of farming that is the most widespread in Europe is concentrated and specialised production, where preventive spreading is typically applied to the crop before and throughout its growth (including the seed, coated in pesticide). In these systems, the yield and quality of crops rely on chemical inputs.

For instance, 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.<sup>13</sup> Furthermore, according to the European Commission, the use of fertilisers is responsible for about 60% of registered yield increase in European agriculture in the last 50 years.<sup>14</sup>

Hence, pesticides sales<sup>15</sup> and fertiliser consumption are still on the rise in the biggest EU input-consumer countries, even where explicit reduction targets have been put forward by governments, such as the Ecophyto plan<sup>16</sup> in France or National Action Plan (NAPAN) in Belgium<sup>17</sup> (see Figure 1).

---

<sup>11</sup> Regulation (EU) 1306/2013 of the European Parliament and of the Council of 17 December 2013 on the financing, management and monitoring of the common agricultural policy and repealing Council Regulations (EEC) No 352/78, (EC) No 165/94, (EC) No 2799/98, (EC) No 814/2000, (EC) No 1290/2005 and (EC) No 485/2008, 17.12.2013.

<sup>12</sup> Lamichhane, J R, Dachbrodt-Saaydeh, S, Kudsk, P, and Messéan, A (2016) Toward a Reduced Reliance on Conventional Pesticides in European Agriculture, *Plant disease*, Vol. 100, No. 1

<sup>13</sup> Nadeu, E (2020) Sustainable Crop Protection, Background Material for the ESAD Platform. Expert brief submitted to the European Sustainable Agriculture Dialogue, RISE Foundation., p.3

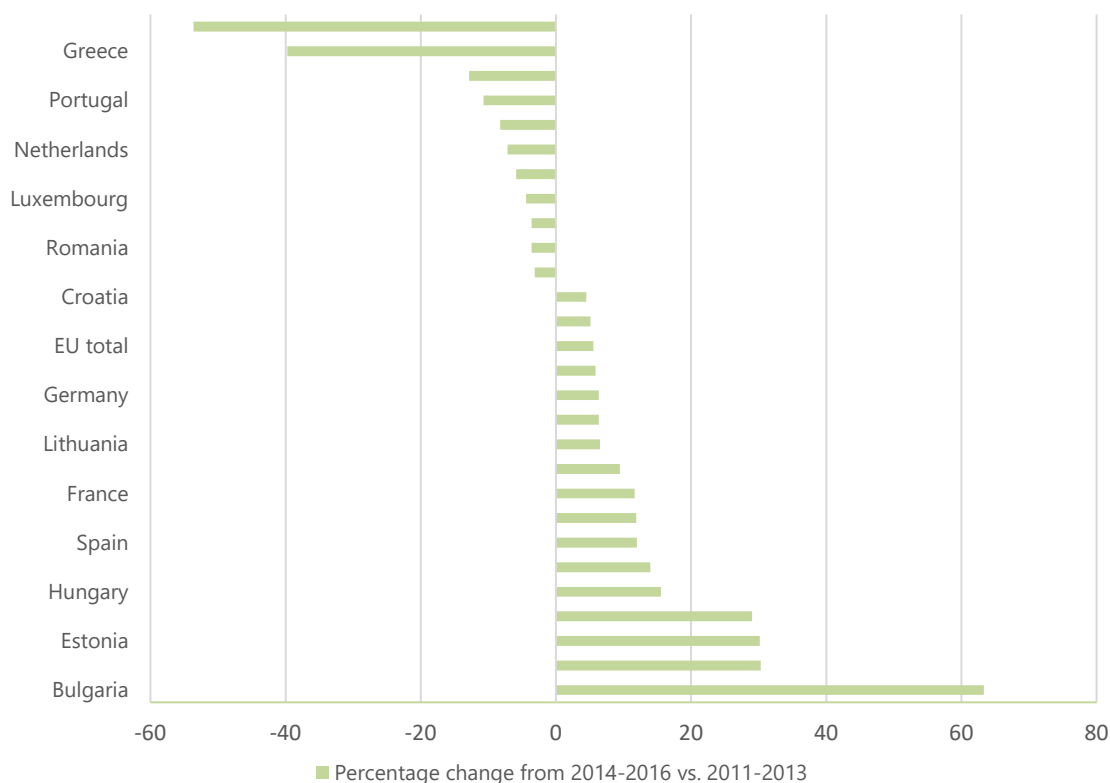
<sup>14</sup> Halleux, V (2019), Briefing. EU fertilising products, European Parliamentary Research Service, 26 June.

<sup>15</sup> The difficulties in tracking pesticides consumption will be addressed hereafter.

<sup>16</sup> <https://agriculture.gouv.fr/ecophyto>

<sup>17</sup> <https://fytoweb.be/fr/plan-de-reduction/plan-daction-national/programme-2018-2022-du-napan>

**Figure 1: Percentage change in pesticides sales in EU countries**



Source: European Environmental Agency (EEA), 2018.

A transition towards the reduced application of PPP and fertilisers input requires alternatives for the maintenance of crop protection and soil fertilisation. Although several landscape and crop management techniques could offer alternatives, most of the projection of their potential for crop protection and fertilisation is still very reliant on available and upcoming research findings. As stated by the European Commission in its orientations for the Strategic Plan of Horizon Europe “A comprehensive EU policy to balance nutrient cycles is not yet well developed. Research and innovation are needed to look at how the EU could move to living within the planetary boundaries, with regards to nutrient flows.”<sup>18</sup> The following section will underline the many individual projects under the current European framework research program, Horizon 2020, that could provide elements of a solution.

<sup>18</sup>[https://ec.europa.eu/info/sites/info/files/research\\_and\\_innovation/strategy\\_on\\_research\\_and\\_innovation/documents/ec\\_rtd\\_orientations-he-strategic-plan\\_122019.pdf](https://ec.europa.eu/info/sites/info/files/research_and_innovation/strategy_on_research_and_innovation/documents/ec_rtd_orientations-he-strategic-plan_122019.pdf) See the part of Cluster 6 devoted to Circular Systems.

## RESEARCH STATE OF PLAY: AN OVERVIEW OF HORIZON 2020 ACTIVITIES

Environmental and agronomic issues associated with chemical or organic inputs have all been addressed by scientists over the years. Many recent and ongoing research projects funded under different areas of Horizon 2020, including Marie Skłodowska-Curie Actions, the European Research Council (ERC) and the SME Instrument address the challenge of agricultural production under reduced input application. This section presents an overview of research developments of particular interest to the achievement of the Farm to Fork and Biodiversity 2030 reduction targets.

### *Pesticides*

Various research projects have been conducted to measure and target the best set of crop protection and land management techniques for local situations under reduced pesticides application scenarios.

Integrated Pest Management (IPM) is designated in the Farm to Fork strategy as “one of the main tools in reducing the use of, and dependency on, chemical pesticides in general, and the use of more hazardous pesticides in particular.”<sup>19</sup> Given the low uptake of IPM by Member States in their National Action Plan, Horizon projects gathering scientists under networks for targeted IPM research, such as the C-IPM project<sup>20</sup>, constitute an overarching framework for strategic scientific developments and planning on IPM. This approach is complemented by the development of field decision support systems, with the aim of integrating IPM into practices. For example, the DESSA project<sup>21</sup> developed precision farming software based on field sensors measurements, showing both yield increases and pesticides application reduction on prototype farms. Despite this research focus, more must be done on addressing barriers to IPM implementation in practice.

Most research undertaken on crop protection management involves a mix of genotyping for crops or pathogens and sets of management practices, many already highlighted in the IPM principles (crop rotation, covers, etc.). Agronomic experiments for innovative crop protection methods have so far helped define herbicide substitutes, biocontrol agents (PURE project<sup>22</sup>, VIROPLANT<sup>23</sup>) and bio-stimulants (EUCLID<sup>24</sup>) in most European

---

<sup>19</sup> European Commission (2020), *Farm to Fork Strategy*, *op. cit.*

<sup>20</sup> <https://cordis.europa.eu/project/id/618110/reporting>

<sup>21</sup> <https://cordis.europa.eu/article/id/413366-decision-support-tool-reduces-pesticides-boosts-crop-performance-and-yields-economic-gains>

<sup>22</sup> <https://cordis.europa.eu/project/id/265865/reporting>

<sup>23</sup> <https://www.vioplant.eu/>

<sup>24</sup> <https://cordis.europa.eu/article/id/413367-technologies-and-tools-to-reduce-agricultural-pests-in-europe-and-china>

pedoclimatic conditions. Following an approach to reduce the risk of PPP application to the environment and humans, the nEUROSTRESSPEP developed new biopesticides that aim at reducing pest insect survival abilities<sup>25</sup>. The ongoing Ecostack project focuses on identifying beneficial organisms interaction throughout European fields that could unravel solutions for ecological pest control.<sup>26</sup> A complementary study on ecosystems services provided by semi-natural habitats (QuESSA)<sup>27</sup>, offers additional insights on ecological pest-control. Furthermore, protection methods for specific crops of importance to European agricultural production have also been studied such as fruits crops<sup>28</sup> or olives.<sup>29</sup> Ecosystems services enhancement in these projects has practical correlation for example with the achievement of the Biodiversity Strategy objective of 10% of agricultural area under high-diversity landscape features.

It is also worth mentioning that most of the studies outlined here show positive crop performance under these alternative crops protection management systems over conventional approaches.

The Farm to Fork and Biodiversity strategies encourage agricultural practices that have strong synergies with a PPP reduction objective, for example, the objective of 25% UAA under organic farming by 2030. Organic farming regimes have proven consequences on input reduction, given the fact that most of the conventionally used inputs are suppressed. However, the wide use of substances such as copper (classified as a candidate for substitution under the PPP Regulation) fungicide in organic regimes<sup>30</sup> can be problematic. Two research projects in progress (RELACS<sup>31</sup> and Organic-PLUS<sup>32</sup>) are specifically aiming to replace “controversial” inputs in organic farming. Conclusive findings could be integrated into future initiative such as the implementation of the future organic farming action plan.

Another essential pillar of plant health, the monitoring of future and upcoming plant diseases to counteract the potential outbreak of new diseases caused by climatic and seasonal changes, or pest transmission from extra-European regions, is studied by several projects. These target livestock diseases, such as African-swine fever and lumpy-skin disease

---

<sup>25</sup> <https://cordis.europa.eu/article/id/410223-peptide-based-highly-selective-eco-friendly-pest-control>

<sup>26</sup> <https://cordis.europa.eu/project/id/773554/fr>

<sup>27</sup> <https://cordis.europa.eu/project/id/311879/reporting>

<sup>28</sup> <https://cordis.europa.eu/project/id/613678/reporting>

<sup>29</sup> <https://cordis.europa.eu/project/id/605073/reporting>

<sup>30</sup> Copper is also widely used under conventional treatments, see Kühne, S, Roßberg, D, Röhrig, P, von Mering, F, Weihrauch, F, Kanthak, S, Kienzle, J, Patzwahl, W, Reiners, E and Gitzel, J (2017) The use of copper pesticides in Germany and the search for minimization and replacement strategies. *Organic Farming* No 3, (1) pp 66-75.

<sup>31</sup> <https://cordis.europa.eu/project/id/773431/fr>

<sup>32</sup> <https://cordis.europa.eu/project/id/774340>



(DEFEND project<sup>33</sup>), forest pests and pathogens (HOMED<sup>34</sup>), or crops (RustWatch projects focusing on wheat<sup>35</sup>).

### *Fertilisers*

Landscape and agricultural management techniques provide an essential component of nutrient cycle management to improve production. Thus, broader research projects on soil management for its maintenance and restoration provide insights at achieving reduced fertiliser application and avoiding nutrient losses. As an example, the ISQAPER project<sup>36</sup> seeks land management approaches for soil improvement tailored to soil and climatic conditions, notably using a soil quality tool. In a complementary manner, the LANDMARK<sup>37</sup> project provides advice to farmers by giving insight on management impact on the main soil functions.

Most of the nutrient-focused Horizon 2020 projects are targeted at nutrient recycling technologies, which, according to a recent scientific study on tomato plants treated with bio-fertiliser, could potentially help improve “yield, soil quality and fertiliser savings”.<sup>38</sup> For example, with the ambition of fostering a circular nutrient approach, the NUTRIMAN project developed a business to farmer platform where “mature technologies and products” for the recovery of fertiliser (nitrogen and phosphorus) are showcased.<sup>39</sup> Similarly, the NewFert<sup>40</sup> project investigates biowaste fertiliser production as a means to reduce dependency on mineral fertilisers. A similar approach to mineral fertilisers reduction through the use of bio-based fertilisers, and of optimised fertilisers application according to crop requirements, i.e. the closing of nutrient cycles, is under development (LEX4BIO project).<sup>41</sup> Bio-based solutions for fertiliser production and biostimulants for increased soil nutrient fixation are additionally developed by an ongoing project (B-FERST).<sup>42</sup> Provided these bio-fertilisers are applied with minimal trade-offs as regard soil organic matter management and soil contamination with organic pollutants<sup>43</sup>, it could, according to the various projects authors, entice reduced nutrient losses and problematic inputs whilst helping the restoration of soil quality.

---

<sup>33</sup> <https://defend2020.eu/about-us/>

<sup>34</sup> <https://cordis.europa.eu/project/id/771271/fr>

<sup>35</sup> <https://cordis.europa.eu/project/id/773311/fr>

<sup>36</sup> <https://www.isqaper-project.eu/>

<sup>37</sup> <http://landmark2020.eu/>

<sup>38</sup> <https://www.nature.com/articles/s41598-019-56954-2>

<sup>39</sup> <https://nutriman.net/farmer-platform>

<sup>40</sup> <https://cordis.europa.eu/project/id/668128>

<sup>41</sup> <https://cordis.europa.eu/project/id/818309>

<sup>42</sup> <https://cordis.europa.eu/project/id/837583>

<sup>43</sup> Mäder, P and Bünemann, E (2020) Soil. Expert brief submitted to the European Sustainable Agriculture Dialogue, FiBL

Similar to digital farming approaches to pesticides application, the Mo-biLab<sup>44</sup> project recently developed mobile laboratories for field nutrient sensing.<sup>45</sup> According to the project, reduced fertilisation could be the result of an accurate depiction of soil nutrient content. Another integrated approach, the NUTRI2CYCLE project (through the EIP-Focus Group on Nutrient Recycling) aims at benchmarking nutrient flows and providing a toolbox of scenarios for innovations. The innovations would be followed and improved by the EIP group until maturation. A single project, FAIRWAY,<sup>46</sup> is looking at nutrient cycling through its impact on water quality, i.e. nitrate and pesticides pollution resulting from leaching. It ambitions the development of an integrated approach, via the implication of multi-actor platforms, for the management of inputs and water policies.

## R&I NEEDS GOING FORWARD

The Farm to Fork and Biodiversity strategy targets reflect a desire in Europe to reduce the impact of excess fertiliser and pesticide inputs into agricultural systems and thus reduce the negative impacts on biodiversity and ecosystems.

Existing research efforts on pesticides have focussed on improving IPM techniques, the development of alternative pest control through a mix of land management, genotyping, bio-products, and monitoring techniques for upcoming pests. On fertilisers, research fostered the development of integrated and management tools, advisory (including sensing) services and bio-based circular nutrients. At present, however, these individual approaches have not fully addressed the solutions that are needed to reduce agricultural inputs, whilst continuing to maintain agricultural outputs that match societal needs. As a result, there are three broad areas which will need additional attention in future R&I programmes. These are:

- Monitoring and indicators
- Ecosystem interaction and biocontrol
- Alternative inputs, crop diversity and new species

Some of these needs are already identified in Cluster 6 of Horizon Europe<sup>47</sup> but face limited integration in current policies. Thus, in addition to these specific research needs, the EU will need to develop, partly through R&I programmes, greater upscaling, advisory and outreach programmes to ensure that the results of current and future research are implemented at the scale needed to address EU ambitions. Rural development programs

---

<sup>44</sup> <https://cordis.europa.eu/project/id/765262>

<sup>45</sup> Other SMEs are offering similar services such as AgroCares.

<sup>46</sup> <https://cordis.europa.eu/project/id/727984/fr>

<sup>47</sup> Titled "Food, Bioeconomy, Natural Resources, Agriculture and Environment"

under the Common Agricultural Policy already have European Innovation Partnerships in place that could play a greater role in that regard. Furthermore, “lighthouses”, outlined as places for the dissemination of scientific findings by the final report of the soil health and food mission board<sup>48</sup>, and living laboratories, should play a strategic role in making research available to farmers.

The launch of the Horizon Europe framework programme should converge with a capitalisation of research findings evidenced in Horizon 2020 and a translation in upcoming legislative reforms. This could be implemented in the envisaged revisions of the Sustainable Use of Pesticides Directive and its provisions on IPM, in the revision of the Regulation on the placing on the market of plant protection product, and in the Member States’ integrated nutrient management action plan, amongst others. A revival of the withdrawn Soil Framework Directive would also serve as an umbrella policy through which coordinated actions towards soil health and soil quality could be directed, building on existing and new research. The current development of the CAP strategic plans by Member States for the next programming period will be an essential programming tool to ensure a strategic implementation agenda for fertilisers and pesticides research outputs.

#### *Research needs on monitoring and indicators*

In order to quantify signs of progress made towards the reduction of pesticides’ use and risk, nutrient losses and fertiliser application, research should converge with policymaking in improving the statistical instruments available. Novel monitoring tools could be developed through research so that the revision of the SUD Directive can help improve the Harmonized Risks Indicators<sup>49</sup>, and so that the revision of the Pesticides Statistics Regulation can allow pesticides statistics to go beyond sales data. At the Member States level, the most currently used indicator is the treatment frequency index, which cannot measure changes in risks as it only measures the number of applications without considering the type of pesticide used.<sup>50</sup> Alternative indicators such as the French “Nombre de Doses Unités” (NODU) can provide an example, as it estimates 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

---

<sup>48</sup> “Soil health and food” is one of the mission areas foreseen by Horizon Europe; the mission board and an assembly where the IEEP takes part advise the European Commission for designing the mission, targeting 75% of healthy soils in the EU by 2030.

<sup>49</sup> European Court of Auditors (2020) Sustainable use of plant protection products: limited progress in measuring and reducing risks, Special Report n°5.

<sup>50</sup> Nadeu, E (2020), *op. cit.*

particular substance for an average treatment.<sup>51</sup> Similarly, the development of monitoring instruments could help harmonise further statistics on fertiliser consumption at the EU-level.<sup>52</sup>

The achievement of pesticides reduction targets entices an improvement of the monitoring of pests and disease irruption in the EU. Several projects have already focussed on this area, among them, approaches such as was developed in the context of olive trees by the ENTOMATIC project should be fostered. The project established a spatial decision support system to estimate the propagation of a plague and offered recommendations to the farmers on how it should be addressed.<sup>53</sup>

Research on the implementation of IPM techniques in Member States has already concluded on the need for more and better tracking of the impacts. Not only can IPM management practices offer an opportunity to track the use of pesticides in Member States, but they are also instrumental in reaching reduced fertiliser application, the use of balanced fertilisation being a key principle of IPM.<sup>54</sup> To foster concrete implementation, research can draw from the adoption by farmers of precision farming tools and decision support systems, developed under the DESSA and EUCLID project for example.

These approaches are very complementary to the Farm Sustainability Tool for Nutrients, mandatory for farmers under the next CAP programming period. Research should thus work alongside policymakers and end-users on the design of tools that are cheap and intuitive enough for integration in all relevant European daily farming practices.

The R&I investments into decision support systems for above-ground agricultural management would additionally benefit from enhanced research into soil monitoring devices. Projects such as MobiLab have already developed mobile laboratories for field nutrient sensing. Monitoring tools could thus help to improve the understanding of role soil biota play in crop protection and in nutrient cycling, hence, the margin for reduced fertilisation and pesticides reduction.

#### *Ecosystems interaction and biocontrol*

Enhanced research into soil functions and restoration is of strategic research importance as evidenced by the Soil Health and Food mission area

---

<sup>51</sup> Ministère de la Transition Écologique et Solidaire and Ministère de l'Agriculture et de l'Alimentation (2017) Ecophyto: méthodologie de calcul du NODU (Nombre de doses unités).

<sup>52</sup>[https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental\\_indicator\\_-\\_mineral\\_fertiliser\\_consumption](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_mineral_fertiliser_consumption)

<sup>53</sup> <https://www.upf.edu/web/entomatic/>

<sup>54</sup> [https://ec.europa.eu/food/plant/pesticides/sustainable\\_use\\_pesticides/ipm\\_en](https://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides/ipm_en)

under the European Commission's proposal for Horizon Europe.<sup>55</sup> Improved understanding of how to simultaneously improve soil health (typically impacted by high input use and overworking of the soil) and productivity will be instrumental in addressing the F2F and Biodiversity strategy objectives.

In the context of reduced input application, research should help enhance our understanding of the above and below-ground interactions for bio-control (for example weeds control without herbicides) and nutrient cycling. This would complement research on natural ecosystems interaction and the role for semi-natural habitats such as was developed under QUESSA. In addition, this could provide further incentive to reach the Biodiversity Strategy target of 10% of the utilised agricultural area under high-diversity landscape features. Restoration agriculture, in particular the agroecology living laboratories anticipated in the Farm to Fork strategy<sup>56</sup>, could provide an experimental ground for the study of ecosystems interaction. The implementation could draw from the DELPHY network of farms transitioning to agroecology in France, established under the Ecophyto 2 plan, aiming at 30.000 farms.<sup>57</sup> A focus on alternative management techniques could also investigate potential benefits of practices such as targeted shallow harrowing for soil nitrogen mineralisation, its impact on soil productivity and nutrient cycling.

#### *Alternative inputs, crop diversity and new species*

Many problematic substances are still commonly used in European farms, or used at levels that become problematic, be it mineral fertilisers compounds, or pesticides which are already listed in the European Commission's candidate for substitution list. Research on alternative and bio-fertilisers, instrumental in achieving a nutrient balance in European soils, is already well underway. Research in this area should be pursued with regard for instance to closing the nutrient cycles between cities and rural areas, i.e. improving, in particular, the recycling of urban waste. This would bring in links with broader areas of R&I investment in the EU in relation to the circular bioeconomy. In the same direction, greater research on alternatives to high-risk pesticides should be developed, as is currently being done on copper compounds and mineral oils in the RELACS<sup>58</sup> and Organic-PLUS<sup>59</sup> projects.

---

<sup>55</sup>[https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme/missions-horizon-europe/soil-health-and-food\\_en](https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme/missions-horizon-europe/soil-health-and-food_en)

<sup>56</sup> European Commission (2020), *Farm to Fork Strategy*, *op. cit.*

<sup>57</sup> <https://agriculture.gouv.fr/ecophyto-objectif-30-000-exploitations-agricoles>

<sup>58</sup> <https://cordis.europa.eu/project/id/773431/fr>

<sup>59</sup> <https://cordis.europa.eu/project/id/774340>

Agricultural holdings in Europe show a concentration and specialisation trend: mono-cropping accelerated, resulting in declining soil fertility and landscape homogenisation. As a result, the resilience of crops to disease and pest has decreased, and nutrient losses to the environment have only increased.<sup>60</sup> The current dependency on pesticides and fertiliser products is correlated. In order to revert the trend, research is needed on the impact of crop diversification and of redesigned cropping systems, for example, mixed cropping with legumes.<sup>61</sup> Furthermore, natural nitrification inhibitors could be investigated to naturally prevent nitrate leaching into the environment and waters.<sup>62</sup> This would be complementary to plant science research into the development of new crops that allow more field diversity, enhance plant-resistance to pest and improve nutrient (such as nitrogen) fixation.

Beyond crop or land management specific research, greater social research is needed into food commodity systems, and how society receives nutrition beyond the common crop staples that dominate much of EU and global agriculture. This requires a holistic approach encompassing all stages from primary production to transformation and distribution, enabling analysing all side-effects and co-benefits innovation, to design future-proof sustainable food systems.

## CONCLUSION

Reduction of pesticides and fertilisers' application in European agriculture is both desirable in terms of environmental consequences<sup>63</sup> and by EU citizens. To maintain a competitive and productive agricultural production, scientific research urgently needs to be upscaled and implemented on the ground. Specific needs have been outlined in this paper. The development of improved indicators and monitoring could feed into decision support systems. A better understanding of ecosystems interaction would foster biocontrol and help to upscale alternative farming techniques such as agroecology. Alternative input (low-risk pesticides and bio-fertilisers) could be further explored alongside research on crop breeding techniques and more resilient crops mixes on agricultural fields. These needs could align with the Specific Programme Decision on Horizon Europe 2018/0225(COD).<sup>64</sup>

---

<sup>60</sup> Nadeu, E (2020), *op. cit.*

<sup>61</sup> Mäder, P and Bünemann, E (2020), *op. cit.*

<sup>62</sup> Coskun, D., Britto, D., Shi, W. et al. (2017) Nitrogen transformations in modern agriculture and the role of biological nitrification inhibition. *Nature Plants* 3, article number 17074.

<sup>63</sup> See Annex 1.

<sup>64</sup><https://www.consilium.europa.eu/en/press/press-releases/2020/09/29/council-finalises-its-position-on-the-horizon-europe-package/>

Furthermore, a better inclusion of research in the transformative agenda and policy initiatives of the Green Deal will be a guarantee that findings are capitalized upon and disseminated beyond the labs, reaching farmers in their daily practices. This central position of research in achieving the Green Deal objectives also requires substantial financial backing. The recent reduction announced by the Council of cluster 6's budget ("Food, Bioeconomy, Natural Resources, Agriculture and Environment") from 10 billion to 8,95 billion euros, would strongly impede on the capacity of the EU to make agriculture more sustainable. If Europe is to implement its ambitions, the research budget needs to be ring-fenced and strategically aligned with legislative revisions to deliver on the Farm to Fork and Biodiversity strategies' objective by 2030.

## ANNEX 1

### Environmental and legislative overview of pesticides and fertilisers application

#### *An adverse impact on ecosystems*

In the last State of the European Environment report, <sup>65</sup>the European Environmental Agency draws links between nearly all declining trends in European rural ecosystems and the current levels of PPP application. It has, for example, close ties with the 39 % decline in 15 EU Member States of the grassland butterfly populations, and detrimental incidence on non-target species.<sup>66</sup> Pest control products in particular adversely impact soil microbiota, often used as a proxy for soil biodiversity and fertility, hampering its production capabilities. Even in the case of active substances qualified as low-risk, the measurement of hazards originating from the combination of active substances – or cocktail effect, a situation that frequently occurs in the field application of PPP, is still not well known by scientists.

The application of inorganic and mineral fertilisers (45% of input in 2014)<sup>67</sup>, overconcentration of manure in intensive livestock systems (38% of input in 2014)<sup>68</sup> also have a noticeable impact on European ecosystems. Synthetic Nitrogen (N) is particularly used in central Europe and synthetic Phosphorus (P) in eastern and southern Europe.<sup>69</sup> Whilst essential plant nutrients, farmers typically add more N and P than the crops take in, resulting in a positive gross nutrient balance.

Overall, it has been estimated that for every five tonnes of N entering the EU agri-food chain, only one tonne is converted to finished products for human consumption.<sup>70</sup> Excessive fertilisation causes leakages in water bodies, resulting in eutrophication and deterioration of water quality. European agriculture is thus responsible for 70% of nitrogen entering rivers and lakes and for 94% of ammonia emissions (2015 figure), largely from the storage and application of manure and fertilisers<sup>71</sup>.

Moreover, fertilisers contain toxic residues, such as cadmium, that are persistent in soils, causing diffuse pollution and potential health hazards upon human consumption of cultivated products.

#### *Legislative framework on the use and risk of pesticides*

Whilst the impact of pesticides and the needs for reduction is documented, the achievement of the reduction targets introduced by the Farm to Fork and the Biodiversity strategies requires an overview of their coverage under EU law.

Crop protection products are mainly regulated in the EU under the Sustainable Use of Pesticides Directive (SUD) (2009/128/EC), Regulation (EC) No 1107/2009 on the Placing of PPP products on the market and Regulation (EC) No 396/2005 on Maximum Residue Levels (MRL). Six other relevant

---

<sup>65</sup> European Environmental Agency (2019), op. cit.

<sup>66</sup> Zaller, JG, and Brühl, CA, (2019) Editorial: Non-target Effects of Pesticides on Organisms Inhabiting Agroecosystems. *Frontiers in Environmental Science* 7:75.

<sup>67</sup> Last data available is for 2014 [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental\\_indicator\\_-\\_gross\\_nitrogen\\_balance](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_gross_nitrogen_balance)

<sup>68</sup> *Ibid.*

<sup>69</sup> [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental\\_indicator\\_-\\_mineral\\_fertiliser\\_consumption](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_mineral_fertiliser_consumption)

<sup>70</sup> <https://www.circularagronomics.eu/the-project/>

<sup>71</sup> European Network for Rural Development, (2018) Report: Improving soil and water management through management plans, *ENRD Thematic Group on sustainable management of water and soils*.



Regulations impact to a lesser extent the permissible use of pesticides, 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.<sup>72</sup>

The overarching SUD Directive explicitly aims at reducing the “risk and impact” of pesticides on health and the environment in the EU. A major tool in the achievement of this ambition, the Directive promotes increased uptake of alternatives to chemicals in European agriculture through integrated pest management practices (IPMs). IPMs are a set of concrete agronomic and landscape management techniques, such as crop rotation or conservation tillage, governed by the general principle that PPP must be a last resort solution to manage pests.<sup>73</sup> To that effect, Member States must draw and report on National Action Plans that promote the integration of such practices in their agriculture.

However, two recent reports, by the European Court of Auditors<sup>74</sup> (ECA) and by the European Commission<sup>75</sup>, highlighted slow rates of implementation in Member States. It primarily concerns the measurement of pesticides application and use and the diffusion of IPM practices. Few countries have a viable definition and a plan for dissemination, which means that only scarce data is available on IPM implementation. As regard use and risk, most National Action Plans (except France), do not include the required indicators on the monitoring of PPP “containing active substance of particular concern”. The ECA also reports that still under 5% of approved active substances qualify as low-risk.

As mentioned in the Farm to Fork Strategy, the basis for the calculation of advancement in reaching the 50% reduction objectives by 2030 will be the Harmonized Risk Indicators 1 and 2 (HRI 1 and 2) pursuant to Directive (EU) 2019/782 of 15 May 2019.<sup>76</sup> HRIs are European-level indicators, and another key element of the SUD Directive, aiming at capturing PPP use in Europe, given that their dosage and spectrums differ significantly. HRI 1 is calculated ‘by multiplying the quantities of active substances sold in plant protection products by a weighting factor’.<sup>77</sup> Active substances are grouped into four categories and assigned to a weighting based on the approval status of the active substances and their properties. HRI 2 uses the same weighting factor, applied to emergency authorisations granted by Member States under the PPP Regulation.

The release of these two indicators in 2019 constitutes statistical progress, however, the first results underline the absence of progress towards reducing pesticides use in Europe: emergency procedures for pesticides approval dramatically increased (+50%), fuelled by criticism over the complexity of the regular approval procedure. Among the most common criticism, the reliance on sales data in the absence of application data for most countries, or the use of applicant companies’ data for the evaluation of risks, raises concerns over the environmental risk assessment of pesticides. Additionally, as individual substances are approved, cocktail effects are not addressed.<sup>78</sup>

---

<sup>72</sup> Nadeu, E (2020) *op. cit.*

<sup>73</sup> The Directive 2009/128/EC lays down IPM’s principles in Annex III.

<sup>74</sup> European Court of Auditors (2019), *op. cit.*

<sup>75</sup> European Commission (2020) Report from the Commission to the European Parliament and the Council 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, COM(2020) 204 final, 20.5.2020

<sup>76</sup> Directive (EU) 2019/782 of 15 May 2019, *op. cit.*

<sup>77</sup> Nadeu, E (2020) *op. cit.*

<sup>78</sup> See Buckwell, A, De Wachter, E, Nadeu, E, Williams, A (2020) Crop Protection & the EU Food System. Where are they going? RISE Foundation, p.7 for other criticism.

### *Legislative framework governing nutrient cycling and nutrient management*

Positive gross nitrogen and phosphorus (to a lesser extent) balance, with an adverse effect on soil and water pollution, is the current norm in most Member States.<sup>79</sup> However, the COVID-19 pandemic has made even more stringent the need to have a more circular economy that can sustain itself and use domestic resources such as manure and bio-fertilisers for that purpose.

The current Fertilisers Regulation<sup>80</sup>, adopted in 2019 as part of the Circular Economy Package, extends the legal framework for fertilisers' authorisation and circulation in Europe beyond mined and inorganic sources<sup>81</sup>. Organic fertilisers are now covered by harmonisation rules, thus provided wider market access. As of 16 July 2022, manufacturers can choose between applying the new Regulation and CE-marking the product or complying with national rules and sell the product to other EU countries based on the mutual recognition rules for fertilisers "such as organic and organo-mineral fertilisers, soil improvers, inhibitors, plant biostimulants, growing media or blends".<sup>82</sup> Furthermore, with the objective of reducing heavy-metal pollution in soils and limiting toxic effects on humans, the Regulation introduced a content limit for cadmium in fertilisers of 60mg/kg. Fertiliser inputs are also limited in certain areas (Nitrate Vulnerable Zones) by the Nitrates Directive<sup>83</sup>, legislation which aims at preventing leaching of nutrients originating from livestock manure to the groundwater and surface water. Other pieces of legislation impact nutrient management practices, such as the wastewater treatment<sup>84</sup> and sewage sludge Directives<sup>85</sup>, or the Water Framework Directive<sup>86</sup> whereby Member States are required to develop River Basin Management Plans, setting out local actions and demonstrating methods to avoid pollution of their watercourses.

Nutrient management plans are already required under the Common Agricultural Policy. They are found in agri-environment programmes, as well as forming part of the Statutory Management Requirements (SMR) of Cross Compliance.<sup>87</sup> With the idea of turning European agricultural systems towards better nutrient management practices, the Commission proposal for the 2021-2027 Common Agricultural Policy included among the cross-compliance requirement for all farmers benefiting from direct payments under Pillar I a Farm Sustainability Tool for Nutrients (FaST). The FaST is proposed in the framework of the Good Agricultural and Environmental Conditions (GAECs) 5 as a smart farming tool that will collect field information relevant to the farmer, warn him of legal requirements that apply to his plot (such as the proximity of protected areas or nutrient dosage) and generate a nutrient management plan from the information collected<sup>88</sup>.

---

<sup>79</sup> Halleux, V (2019), *op. cit.*

<sup>80</sup> Regulation (EU) 2019/1009, *op. cit.*

<sup>81</sup> Such as was the case in Regulation (EC) No 2003/2003.

<sup>82</sup> <https://ec.europa.eu/growth/sectors/chemicals/specific-chemicals/>

<sup>83</sup> Council Directive 91/676/EEC, *op. cit.*

<sup>84</sup> Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment, Official Journal L 135, 30.5.1991

<sup>85</sup> Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture, Official Journal L 181, 04.07.1986

<sup>86</sup> Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, Official Journal L 327, 22.12.2000.

<sup>87</sup> Regulation (EU) 1306/2013, *op. cit.*

<sup>88</sup> [https://ec.europa.eu/info/news/new-tool-increase-sustainable-use-nutrients-across-eu-2019-feb-19\\_en](https://ec.europa.eu/info/news/new-tool-increase-sustainable-use-nutrients-across-eu-2019-feb-19_en)

**The Institute for European Environmental Policy (IEEP)** is a sustainability think tank with offices in Brussels and London. As a not-for-profit research organisation with over 40 years of experience, we are committed to advancing evidence-based and impact-driven sustainability policy across the EU and the world.

