What if crop protection were environment-friendly?

Synthetic pesticides are often denounced as harmful to both human health and the environment. European Union (EU) policy has a tendency to encourage a reduction in their use. But what effective alternatives are there to protect plant health and boost crop yields?

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Plant protection products (PPPs) are formulations containing active substances, key ingredients that repel, control or eliminate crop-disruptive living organisms such as weeds, pests and insects, thus preventing crop losses and enabling high agricultural yields. The 'active substances' can be produced by chemical synthesis or derived from a biological source such as plants, animals, microbes or minerals. 'Pesticides' is a broader category, also comprising biocides used to control organisms harmful to human and animal health.

The use of pesticides has remained relatively stable globally in recent years. This is also the case for PPP sales in the EU, but with considerable differences between Member States. At the same time, the biopesticides market is growing (see next section). On the other hand, the number of active substances approved for use in the EU has decreased, because they did not pass the strict safety assessment in place, were no longer profitable or because better alternatives were identified.

Together with intensive modern breeding techniques, the use of fertilisers, irrigation and mechanisation, the increase in PPP use contributed to boosting agricultural yields. However, yields have now reached their plateau, given the current cultivation techniques and varieties in developed countries, while agricultural losses due to harmful organisms and weeds are still significant. In parallel with their growing use, synthetic PPPs have been at the centre of controversy, as they have worrying consequences for human health and the environment, including soil. At the same time, the pests they fight are becoming increasingly resistant, making the need for alternatives even more crucial. Current EU legislation lists 'candidates for substitution', i.e. active substances currently on the market, which could potentially be replaced by non-chemical control and prevention. Guidelines for the sustainable use of pesticides and the promotion of integrated pest management with alternative approaches in the EU were set out in a separate piece of legislation. With all this in mind, is it possible to reduce the use of synthetic pesticides while feeding 3 billion more people by 2050?

Potential impacts and developments

Biological control agents (BCAs) or 'biopesticides' is an umbrella term for a set of tools used to control pests such as insects, weeds and plant diseases, using other organisms. These long-used methods rely on natural mechanisms, but are not without risk, notably for biodiversity, as non-target species could be negatively affected by BCAs. For example, some organisms, such as insect pests and plants, communicate with the help of pheromones or other semiochemicals to modify a recipient's behaviour. Applications of this in pest control include population suppression by affecting the survival and/or reproduction of insect pests. First used over one hundred years ago, semiochemicals are considered eco-friendly, but face application challenges due to their physical instability and high cost of deployment in the field.

Advances in genetics could help us understand mechanisms of plant self-defence, a kind of plant immune system, as a basis for new plant protection methods. For example, a spray-on biopesticide containing a molecule involved in the plant immune system can trick the plant into believing it is under attack, initiating a protective response. This in turn reduces the need for PPPs without altering the genetic sequence of the plant. The substance then degrades, reducing risk to the environment and human health. The effectiveness and safety of this method, however, are still to be proven in field tests. Another promising approach involves plant microbiomes. Microbes living on and around plants benefit plant health and are affected by cultivation

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PE 641.529 – February 2020

practices. It is now possible, through DNA sequencing and computational bioinformatics, to assemble databases on microbes, which are based on samples collected from 'survivor' plants. Algorithms applied to such a database then find the best microbiome combinations, which can then be applied to seeds – a sort of 'plant probiotics'. These complement natural processes in plants in much the same way as gut flora in humans, helping to improve overall plant and soil health, and increasing crop yields without the need for agro-chemicals, while they can even help prevent bacterial food poisoning.

Another approach to decreasing PPP use is the breeding of resistant cultivars. Many (often wild) crop varieties are resistant to specific pests and diseases. Although not prioritised in the past, these resistance genes are becoming as important today as a propensity for high yield. It is suggested that high-precision gene editing enabled by CRISPR-Cas9 could make the process very efficient. Alternatively, genetic material from other species, such as micro-organisms, could be introduced to crops. However, issues around genetic manipulation remain the subject of intense discussion and some controversy.

Lastly, the internet of things has also arrived, enabling smart farming practices, and helping to accurately predict, detect and manage diseases and pest outbreaks. This can facilitate approaches such as mapping the layout of wildflowers across fields to attract pest-eating predators to the right places, and, while it does not eliminate the need for PPPs, it significantly reduces it.

Anticipatory policy-making

Seemingly safer alternatives, e.g. nature-based methods and products, may appear harmless, but they are not without risks. When using selective, narrow-range PPPs instead of one broad-spectrum product, PPPs often need to be sprayed more often, or require a combination of approaches to achieve a desired result. Therefore, in light of the development of new plant protection approaches which could reshape the agricultural landscape, assessments and authorisation procedures may need to be updated to better understand the overall risks and impacts associated with their individual and combined use. Furthermore, the research seems inconclusive as to whether a reduction in PPP use is possible for all crops and across all circumstances without negative effects on productivity, crop quality and farmers' income.

Development of new PPPs is an expensive and lengthy process: industry costs have almost doubled since 1995 and it now takes more than 11 years between the first laboratory synthesis and the first sale of a PPP. Such costs and administrative compliance can be particularly burdensome for SMEs. With the biopesticide market growing, the EU is funding research in sustainable plant protection options. Environmentally friendly methods for protecting plant health are also a focus of the UN's International Year of Plant Health in 2020.

EU legislation on PPPs is designed to ensure a high level of protection for human health and the environment, and PPPs are among the best-studied categories of products. The legislation prioritises non-chemical alternatives for plant protection and allows for faster procedures for authorising low-risk active substances. The European Commission recently evaluated EU chemicals legislation and found significant benefits, but also identified areas for improvement. As part of the European Green Deal, the Commission has also promised to propose measures for reducing the use of and risks associated with synthetic pesticides, to increase the land area under organic farming and to develop innovative plant protection methods. The European Parliament assessed the pesticides authorisation procedure in 2018 and called for, among other things, all studies, data and information used in the authorisation procedure to be made publicly available, as well as stronger post-market evaluation, and called for studies on long-term toxicity. With regard to products and approaches involving genetic manipulation, according to a recent Court of Justice of the EU judgment, organisms obtained by new breeding techniques, even if they do not involve the insertion of foreign DNA, fall under EU GMO legislation. More clarity as to how novel genomic techniques are to be legally classified and regulated in the future is expected in 2021.

Finally, continued guidance and support from the EU and national authorities will be needed, as farmers may be resistant to transition away from products they have grown accustomed to using. Consumers' desires for 'perfect'-looking products and their attitudes to alternative plant protection approaches could also play a role in their uptake by the agricultural sector.

These issues will be covered in more detail in a forthcoming STOA study on the future of crop protection.