Fact Check, 23.02.23

PESTICIDES IN CONVENTIONAL AND ORGANIC FARMING

Organic farming is not what it claims to be. Organic farmers also spray poisons - and not in short supply. Whether synthetic or natural is irrelevant. This is what the advocates of an industrial model of agriculture are increasingly claiming, thus damaging the reputation of organic farming. Reason enough for a fact check.

The negative impacts of pesticide use on the environment, biodiversity and health have increasingly become the focus of European policy.[1] In 2019, the Food and Agriculture Organization (FAO), the World Biodiversity Council IPBES, and the Intergovernmental Panel on Climate Change (IPCC) issued alarming reports warning of the impacts of land use on biodiversity and climate. In response to these challenges, the EU Commission presented its Farm to Fork strategy in May 2020. This is intended to initiate the transition to a fair, climate- and biodiversity-friendly agricultural and food system in Europe. Key measures include halving the use and risks of pesticides and expanding organic farming to 25 % of EU farmland by 2030.

Yet – or perhaps because of this – advocates of the industrial farming model declare that organic farming is not what it claims to be. In doing so, they essentially argue mainly two claims:

1. Organic farmers use pesticides, and do so with similar frequency to conventional farmers.
2. Natural pesticides allowed in organic farming are of comparable toxicity to the (mostly synthetic) pesticides only allowed in conventional farming.

If these claims were true, not only would the expectations of organic consumers be disappointed; but it would also have to be questioned whether the planned expansion of organic agriculture under the Farm to Fork strategy will be able to make the hoped-for contribution to the protection of pollinators and the restoration of biodiversity.

However, if the claims are untrue, such insinuations would not only discredit the European Green Deal and its Farm to Fork strategy but also cause significant economic damage to the European organic sector, which employs hundreds of thousands of people. According to market analyses, the *avoidance of pesticide residues* is a main motive for the purchase of organic products.[2][3] Therefore, we subjected the above claims that organic products would not meet this expectation to a fact check: We conducted a systematic toxicological comparison of **A**ctive **S**ubstances (AS) approved only in **Conv**entional agriculture (**ConvAS**) with the natural **A**ctive **S**ubstances approved in **Org**anic agriculture (**OrgAS**) in Europe[4]. The results of this fact check are published in the Scientific Journal Toxics and will be summarized in the following.

1 https://www.europarl.europa.eu/doceo/document/A-8-2018-0475_EN.htm
2 https://de.statista.com/statistik/daten/studie/2419/umfrage/bioprodukte-gruende-fuer-den-kauf/
3 https://www.fibl.org/de/infothek/meldung/bio-bleibt-im-trend-wachstumspotenzial-beim-auswaerts-essen
4 Please note that only AS intended for use on agricultural land are subject to this assessment, while substances immobilized in traps or dispensers (such as pheromones), or used for post-harvest treatment or storage (such as CO2) are not.

1. Are conventional and organic pesticides similarly toxic?

To say it right away: The answer is no. If one takes the **Hazard classifications** and **health-based guidance values** from the EU approval procedure as a yardstick for assessing *pesticide toxicity* - meaning their ability to exert acute and long-term adverse effects on ecosystems and human health - then OrgAs perform worlds better than ConvAS. But one thing at a time:

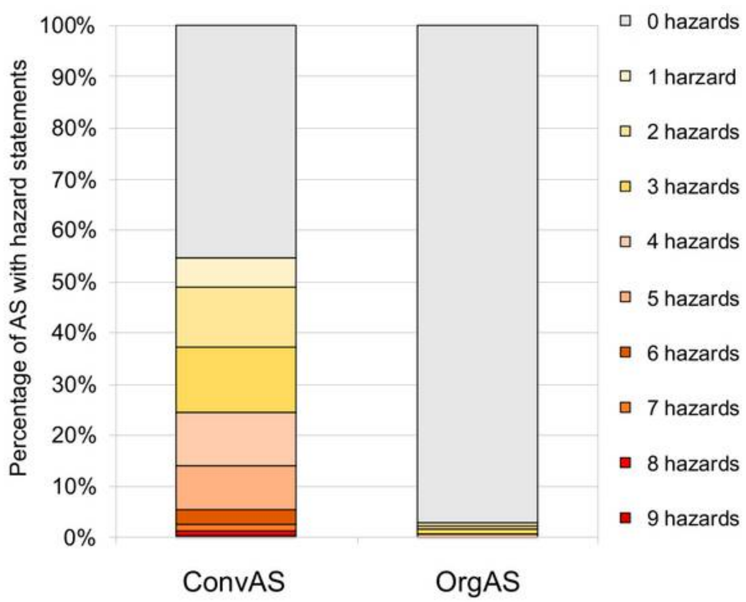
Hazard classifications are assigned by regulatory authorities and identified on pesticide packaging and safety data sheets in the form of so-called GHS hazard statements. They describe different degrees of toxicity (harmful, toxic, fatal) in case of ingestion, inhalation or skin contact, as well as different degrees of scientific certainty (suspected, presumed, proven) for carcinogenic, reproductive or mutagenic effects. Hazard statements also inform about negative environmental effects, especially on aquatic ecosystems.

Health-based guidance values define the Acceptable Daily Intake (ADI) for regular dietary intake, the Acute Reference Dose (ArfD) for safe one-meal consumption, and the Acceptable Operator Exposure Level (AOEL) for safe non-dietary exposures to pesticides.

1.1 Hazard statements of ConvAS versus OrgAS

Comparing the mostly synthetic pesticide active substances approved in conventional agriculture (ConvAS, n=256) with the natural active substances approved in organic agriculture (OrgAS, n=134) based on their hazard classifications, significant differences become apparent: Of the synthetic pesticide active substances, 55 % (140 of the 256 active substances) carry between 1 and 9 hazard statements. Of the natural active substances, only 3 % (or 4 of the 134 natural active substances) carry between 1 and 5 hazard statements (see Figure 1).

Figure 1: Hazard statements for ConvAS (n=256) compared to OrgAS (n=134)



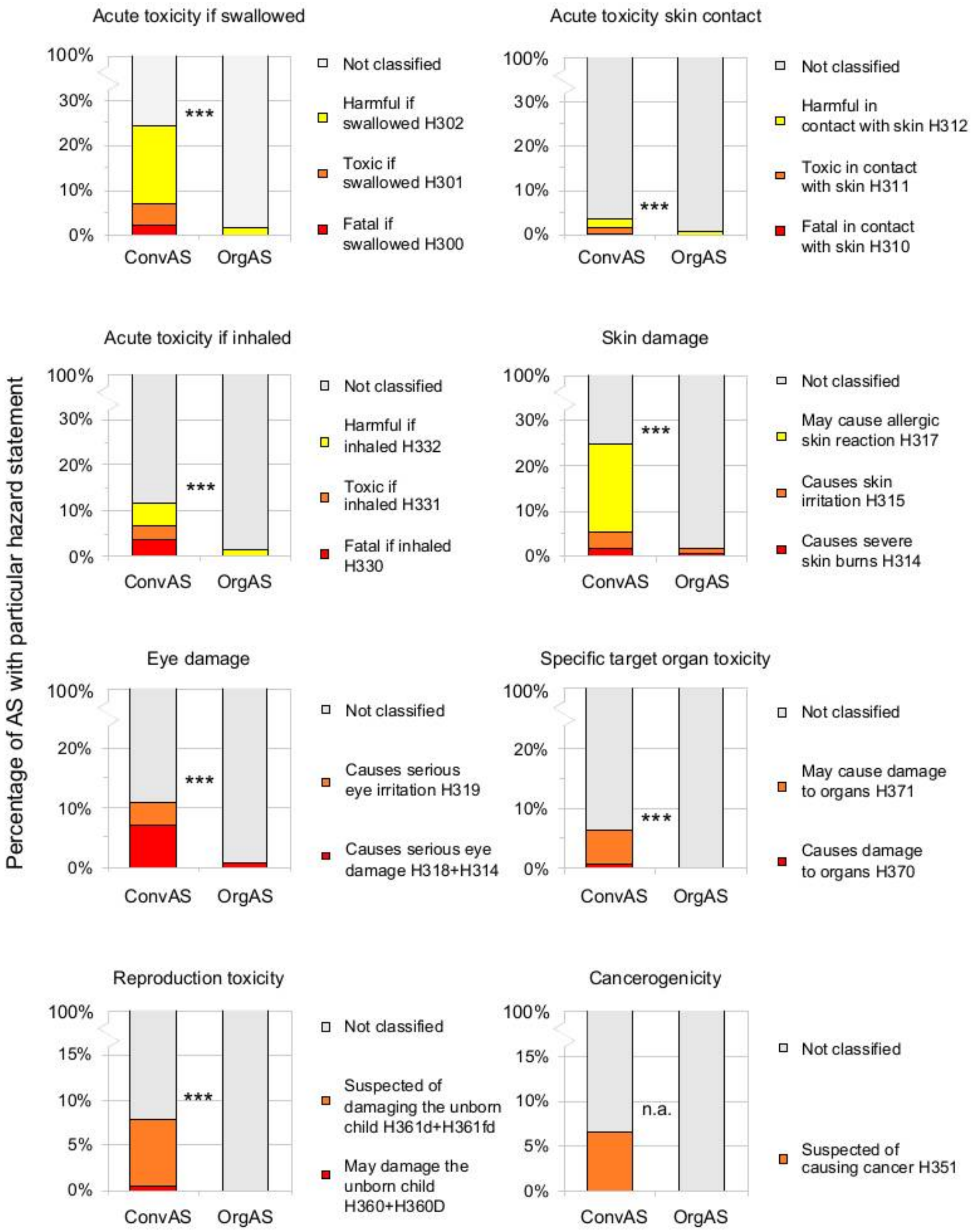
As can be seen in the following figures, 8 % of ConvAS are suspected of *harming the unborn child* and 7 % are suspected of *causing cancer*. Another 7 % cause or may cause *damage to organs*, 5 % are *toxic if swallowed*, and another 3 % are *fatal if swallowe*d.

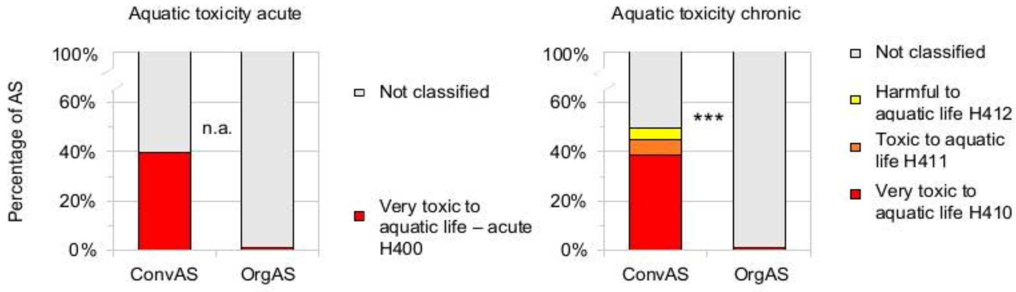
None of the above hazard classifications are found in the currently approved natural active substances allowed in organic agriculture.

In addition, 40 % (102 AS) of ConvAS were classified as very toxic to aquatic life, but only 1.5 % (2 AS) of OrgAS, namely the two insecticides pyrethrins and spinosad (Figure 2). Regarding chronic aquatic toxicity, 50 % (127 AS) of ConvAS were harmful, toxic, or very toxic to aquatic life with long-lasting effects, compared to only 1.5 % (2 AS, pyrethrins and spinosad) of OrgAS.

The remaining hazard statements for OrgAS concern sulfur, which *causes skin irritation* (H315) and hydrogen peroxide, which causes *severe skin burns and eye damage* (H314) and is also *harmful if swallowed* (H302). Pyrethrum also carries the hazard statements *harmful* if swallowed (H302), in contact with skin (H312) and inhalation (H332).

Figure 2: Comparison of ConvAS vs OrgAS based on hazard statements



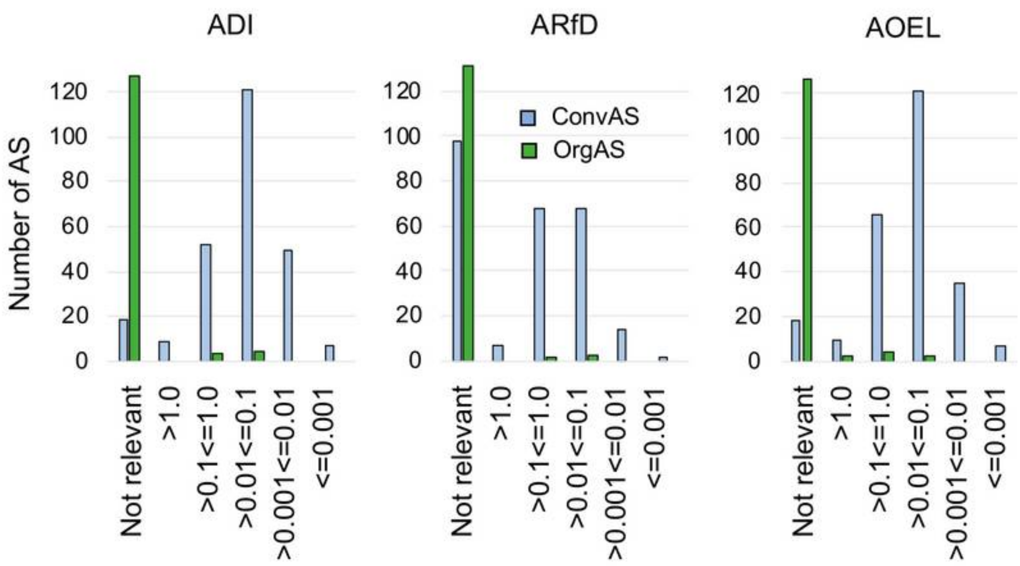


1.2 Health-Based Guidance Values of ConvAS versus OrgAS

Striking differences between ConvAS and OrgAS are also evident when using the health-based guidance values as a benchmark. In 93 % of the ConvAS, but only in 7 % of the OrgAS, the setting of health-based guidance values was considered relevant by EFSA.

Within the OrgAS, the insecticides spinosad, pyrethrins, and azadirachtin, and the fungicide thymol, showed the lowest acceptable dietary and non-dietary exposure levels, which were in the range between 0.1 and 0.01 mg kg−1 of body weight. The lowest acceptable dietary exposure levels within the ConvAS were two orders of magnitude lower (between 0.001 and 0.0001 mg kg−1 of body weight), and concerned five synthetic herbicides, tembotrione, sulcotrione, fluometuron, metam (also a nematicide, insecticide, and fungicide), and diclofop, and two insecticides, emamectin and oxamyl (Figure 3).

Figure 3: Comparison of ConvAS and OrgAS based on health-based guidance values



The above comparisons show that the hazard statements and health guidance values established by the European authorities attribute a significantly lower risk potential for human health and the environment to those naturally occurring active substances that are approved for organic farming than to the synthetic active substances used in conventional agriculture. **Statements to the effect that the natural pesticide active substances used in organic farming would be of similar toxicity to the synthetic pesticide active substances used in conventional farming is not supported by the evidence.**

2. What makes OrgAS so different from ConvAS?

One explanation for this significant difference in toxicity lies in the nature and origin of the respective pesticide AS. Of the 256 ConvAS, nearly 90 % consist of **synthesized derivatives of petroleum chemistry**. These AS were selected in laboratory screening programs to identify those compounds with the highest toxicity to target organisms. As an unintended side effect, "modern" insecticides from the pyrethroid group, for example, are up to 10,000 times more lethal to the non-target organism "honey bee" than the first-generation insecticide DDT. In contrast, all of the 134 OrgAS that were subject to this assessment are **natural or naturally-derived substances** (as required by the EU Organic Regulation (EU) 2018/848).

Now, of course, we know that "natural" does not automatically mean "non-toxic". Just think of the deadly poisons of some plants, snakes or fungi that nature has produced in the course of evolution. But if we look at the OrgAS listed in the EU pesticide database, we quickly realize that their vast majority consists of substances that can be considered non-toxic: 75 of the 134 pesticide-active substances that may be applied to organically managed land, are not even "substances" in the true sense, but **microorganisms**. More precisely, they are bacteria, viruses or fungi that are natural "soil inhabitants" and usually have no hazardous properties.

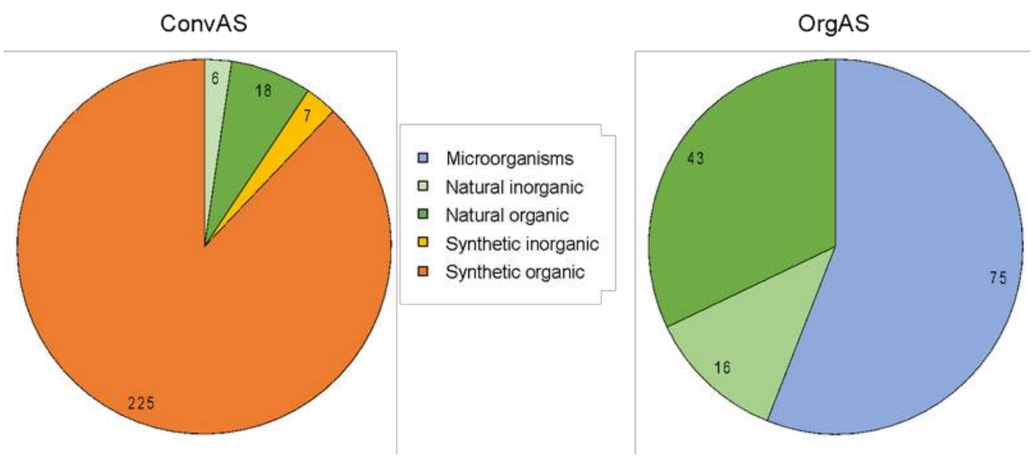
The remaining 59 OrgAS is a very heterogeneous group of "substances", both in terms of their origin and their mode of action:

46 %, or 27 of the 59 AS that do not belong to the microorganisms are of plant origin; most of these are essential oils, but other plant extracts with fungicidal, insecticidal, or deterrent activity are also included.

29 %, or 17 other active substances allowed in organic farming, are of inorganic origin. These include minerals, salts and elemental substances based on copper, sulfur, iron phosphate, sodium and potassium hydrogen carbonate (also known as baking powder), and ordinary quartz sand.

25 %, or the 15 remaining substances, are composed of substances of animal origin (e.g., sheep fat as a repellent), substances of plant and animal origin (fatty acids for different uses), substances of microbiological origin (e.g. cerevisans from yeasts to stimulate the plant immune system), paraffin oils (against sucking insects), and fermentation products (e.g., vinegar against bacterial and fungal diseases).

Figure 4: Origin of ConvAS (n = 256) versus OrgAS (n = 134)



For 42 % of these 59 remaining OrgAS, no increased risk is to be expected simply because they are either approved as low-risk substances (e.g. iron phosphate, baking powder, yeast extracts or washing soda) or as so-called basic substances (sunflower oil, onion oil, fructose vinegar, milk, etc).

However, even if all low-risk substances, basic substances, and microorganisms are excluded from this comparative assessment, the differences in the proportion of hazard classifications between the remaining group of 34 OrgAS and the ConvAS remain statistically significant. This is because for 31 of the remaining 34 OrgAS, the regulators did not consider hazard classifications to be warranted.

This significant difference in hazard profile is associated with a fundamentally different mode of action. Almost all chemically synthesized ConvAS exert their effects by influencing biochemical processes in the respective target organisms or in case of undesirable side effects in non-target organisms. In this context, most synthetic AS act as "single-site" inhibitors of enzymes or transmembrane receptors essential for cell metabolism and signal transduction.

Among OrgAS, such a single-site mode of action is found only in two secondary plant compounds, azadirachtin and pyrethrins, and in the bacterial agent spinosad. While azadirachtin inhibits the hormonally induced molting of insect larvae, both pyrethrins and spinosad inhibit the transmission of nerve impulses. Interestingly, these three natural insecticides alone account for seven of the eleven health and environmental hazard statements and about one-third of the health guidance values of all 134 OrgAS evaluated.

All other OrgAS in the EU usually have a multi-site mode of action or act in other ways by driving away pests or strengthening the plant's defenses, which is the main reason why resistance development is rarely observed with OrgAS, unlike ConvAS. OrgAS such as copper or sulfur affect cellular processes in fungi simultaneously at different levels. Other OrgAS, such as vinegar or soap, act in a physicochemical way by damaging the cell membrane. Baking soda (potassium hydrogen carbonate) or slaked lime (calcium hydroxide) alter the pH and desiccate the target organism, while plant oils form a physical barrier between the plant and insect pests. Substances such as garlic extract or quartz sand act as repellents via odor or taste

Regardless of their individual toxicity, a major characteristic of all plant, animal or microbial substances is that their breakdown and degradation have formed the basis for energy production and material cycles in all ecosystems for millions of years. Consequently, natural substances are usually degraded much faster than substances from the chemical laboratory. Their residence time in the ecosystem - and thus the time during which they can have a toxic effect - is thus shorter than that of most synthetic pesticides.

With certain limitations, this also applies to natural pesticide active substances of mineral origin. They, too, are involved in biogeochemical cycles and are subject to chemical transformations and weathering processes in the course of which their biological activity decreases. In addition, all bio-compatible mineral active substances are known as essential nutrients or micronutrients for plants.

How often do organic farmers use natural pesticides?

The untrue claim that natural pesticides are as toxic as conventional ones is often linked to another insinuation: Their use in organic agriculture is similar to the use of synthetic pesticides in conventional agriculture.

The simplest way to test the veracity of this claim would be to compare **pesticide use data** from conventional and organic farms. But unfortunately, this is not possible. This is because, although the EU Pesticides Regulation requires farmers to document their pesticide applications in detail and on a daily basis, a group of member states and farmers' associations[5] successfully opposed (until recently) the use of these application data for statistical purposes[6].

In June 2022, member states agreed to collect and publish pesticide use data annually from 2028. But until then, the only figures available remain sales data in kilograms of pesticide active substances sold. And it is precisely this data that critics of organic farming refer to when they accuse organic farming of using pesticides at a comparable or even higher rate than conventional farming.

Basis of such claims is a **misleading interpretation of the pesticide sales data** that member states have to publish annually. In the following, we will illustrate this with a concrete example from Austria. Austria counts on member states level a share of 25% organic farming, which equals the target the farm-to-fork strategy has set as average all over the EUfor the entire EU.

Box: Misleading interpretation of pesticide sales figures

In Austria, about **25 %** of agricultural land is **farmed organically**. But as organic farming grew, so did the number of its critics: An association sponsored by the food trade and the Austrian Ministry of Agriculture, which according to its definition *wants to show consumers transparently and without judgment how food is produced in Austria* informs on its website that organic farming is *nowhere near as 'sacred' as people outside agriculture in particular like to portray it,* to follow up with the following question: ***Did you know that at last count, 43 % of the pesticides sold in Austria were organic?***

The obvious conclusion for the average reader can only be: Organic farmers spray more often than conventional ones. How else could 43 % of the pesticides sold go to their account, although they "only" cultivate 25 % of the land?

One thing is clear: If this were really the case, organic farming would disappoint the expectations of its customers. This is because the EU organic regulation not only restricts the use of pesticides to substances that occur naturally, it also restricts their use to cases where cultural and biological plant protection measures (choice of varieties, crop rotation, beneficial insects, etc) alone are not sufficient.

To prevent misunderstandings, one thing should be said right away: Organic farming adheres to the guidelines and demonstrably sprays less frequently than conventional farming. On more than 90% of the agricultural area, the use of pesticides is practically dispensed with in organic farming. This is especially true for arable crops such as wheat, corn, rye, barley, etc. In contrast, conventional arable

5 The Austrian Chamber of Agriculture, for example, warned against "farmer bashing" in connection with the collection of pesticide use data for statistical purposes: https://www.ots.at/presseaussendung/OTS_20220202_OTS0042/oesterreichs-pflanzenbau-punktet-mit-qualitaet-und-transparenz

6 In contrast, organic associations and environmental organizations had advocated the publication of these pesticide data.

farming routinely sprays herbicides, often fungicides, and, depending on the crop and weather, insecticides. These differences are also reflected in the German Ministry of Agriculture's figures[7] on pesticide expenditure on conventional and organic arable farms during the 2017/18 growing season: For the former, pesticide expenditure per hectare of arable land was 106 euros; for organic farms, it was just 2 euros.

So how does this fit with the statement that 43 % of the pesticide volume sold in Austria is accounted for by organic products? The answer can be found in the sales figures[8] published by the Austrian authorities - if one relates these sales figures in kilogram (kg) to the corresponding hectare application rates in kilograms per hectare (kg/ha). The sales figures show that in 2020, natural fungicides, which include mainly copper, sulfur, sulfur lime and baking soda, accounted for the lion's share of pesticides with a sales volume of **1,203,400 kg**. Typical hectare application rates for these natural fungicides range from **1 kg/ha** (Copper) to **12 kg/ha** (baking soda).

At **660,8oo kg**, the sales volume of synthetic fungicides was significantly lower in the same year. And the hectare application rates of these synthetic fungicides are even much lower; they typically range between **0,05** and **0,25 kg/ha.**

Since the authority only publishes aggregated sales data of synthetic fungicides from various chemical groups as well as aggregated sales data of all natural fungicides (that may be used in organic farming) instead of disclosing the sales data of all individual active substances, we will have to work approximately with average values for the hectare application rates of chemical-synthetic and natural fungicides for the further calculation:

For an average fungicide application with a natural active substance, the average hectare application rate is calculated to be **6.5 kg/ha** in this approximation. For an average fungicide application with a synthetic active substance, on the other hand, the mean hectare application rate is calculated to be only **0.15 kg/ha**.

These approximate values can now be used to calculate the areas that can be treated in each case: **4,405,000 hectares** could be treated with the quantity of synthetic fungicides sold. The quantity of inorganic fungicides sold, on the other hand, is only sufficient for **185,000 hectares**, as the following table shows.

Table 1: Frequency of use of naturally occurring and synthetic fungicides

	SYNTHETIC FUNGICIDES	NATURAL FUNGICIDES
Sales volume 2020*	660.8 t	1,203.4 t
Typical hectare application rates	0.05 kg/ha – 0.25 kg/ha	1 kg/ha -12 kg/ha
Average hectare application rates	0.15 kg	6.5 kg/ha
Area that can be treated	$\frac{660{,}800 \text{ kg}}{0.15 \text{ kg/ha}}$ =	$\frac{1{,}203{,}400 \text{ kg}}{6.5 \text{ kg/ha}}$ =
	4,405,333 ha	**185,138 ha**

7 BMEL 2019, Agrarpolitischer Bericht, p.87: https://www.bmel.de/SharedDocs/Downloads/DE/Broschueren/Agrarbericht2019.pdf?__blob=publicationFile&v=4

8 Source: Sales Figures from 2020 of the Austrian “Bundesanstalt für Agrarwirtschaft und Bergbauernfragen” (2020)

With the above approximate calculation, we have learned that with **660 tons** of synthetic chemical fungicides, an area **24 times larger** is treated than with **1,203 tons** of naturally occurring fungicides.

If we assume for simplicity's sake that 100% of the use of natural fungicides would be attributable to organic farming - which is a considerable overestimation of its actual contribution - and if we also take into account that organic farmers farm only about one third of the area farmed by conventional farmers, the result of this rough calculation is that the average conventional farmer uses synthetic chemical fungicides eight times more frequently than the average organic farmer uses natural fungicides.[9]

The situation is similar for **insecticides**. Here, too, the per-hectare application rates between synthetic and natural active substances differ by one to three orders of magnitude. With **herbicides**, the difference is even clearer, since herbicides are responsible for more than half of pesticide use in conventional agriculture. In organic farming, however, herbicides are taboo.

The claim that pesticide use in organic farming is comparable to that in conventional farming is therefore not supported by the evidence.

Summary & Conclusions

The hazard classifications and health-based guidance values from the European approval procedure certify that the natural pesticide active substances permitted in organic farming have a significantly lower hazard potential than the approved synthetic pesticide active substances. In addition, their use in organic farming is significantly less frequent than the use of synthetic pesticides in conventional farming.

These results are in line with findings from the scientific literature: global insect mortality[10], the worldwide decline of amphibians[11] or harmful effects on aquatic ecosystems[12] [13], are not associated with natural but with synthetic pesticide active substances in the vast majority of published studies. Also, it is synthetic pesticides, not natural ones, that enter remote wildlife refuges[14] and glacier ice[15] via pesticide drift and global distillation, and enter the bodies of animals and humans through the food chain that would not otherwise come into contact with these substances[16]. Finally, it is not natural but synthetic pesticides whose residues are detectable in 85% to 95% of the fruit and vegetables from conventional agriculture[17].

9 This significant difference is due to the fact that in organic farming, fungicides are mainly used in permanent crops (fruit and wine growing) and in special crops such as vegetables. In contrast, organic farmers hardly use fungicides in arable farming, the most important sector in terms of area (excluding grassland).

10 Van Lexmond, M.B., Bonmatin, JM., Goulson, D. et al. Worldwide integrated assessment on systemic pesticides. Environ Sci Pollut Res 22, 1–4 (2015). https://link.springer.com/content/pdf/10.1007/s11356-014-3220-1.pdf

11 Brühl, C., Schmidt, T., Pieper, S. et al. Terrestrial pesticide exposure of amphibians: An underestimated cause of global decline? Sci Rep 3, 1135 (2013). https://www.nature.com/articles/srep01135.pdf

12 ETC/ICM Report 1/2020: Pesticides in European rivers, lakes and groundwaters: https://www.eionet.europa.eu/etcs/etc-icm/products/etc-icm-report-1-2020-pesticides-in-european-rivers-lakes-and-groundwaters-data-assessment

13 Matthias Liess et al. Pesticides are the dominant stressors for vulnerable insects in lowland streams, Water Research; Volume 201, 1 August 2021, 117262: https://www.sciencedirect.com/science/article/abs/pii/S0043135421004607?via%3Dihub

14 Kruse-Plaß et al. Pesticides and pesticide-related products in ambient air in Germany, Environ Sci Eur (2021) 33:114: https://www.enkeltauglich.bio/wp-content/uploads/2021/10/2021-Environmental_Sciences_Europe.pdf

15 https://www.researchgate.net/publication/221925647_Global_Distillation_in_an_Era_of_Climate_Change

16 OECD SERIES ON PESTICIDES Number 25 The Assessment of Persistency and Bioaccumulation in the Pesticide Registration Frameworks within the OECD Region: https://www.oecd.org/env/ehs/pesticides-biocides/43045062.pdf

17 CVUA Stuttgart, Ökomonitoring 2020: http://www.untersuchungsaemter-bw.de/pdf/oekomonitoring2020.pdf

The claims repeatedly made in defense of an industrial model of agriculture that the use of pesticides in organic agriculture is comparable to that of conventional agriculture in terms of the toxicity and the intensity of their application are untrue. These insinuations damage consumer confidence in organic products and thus cause significant economic damage to the organic sector.

Such false statements also undermine the European Union's Farm to Fork strategy, which (rightly) sees an expansion of organic farming to 25 percent of farmland as a key measure for achieving the goals of the European Green Deal. With this paper, we hope to counteract the spread of defamatory and factually incorrect statements about organic farming.

Please note: The data presented in this fact check can be found in more detail *here.*

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