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Protection of Biodiversity in the Risk Assessment and Risk Management of Pesticides (Plant Protection Products & Biocides) with a Focus on Arthropods, Soil Organisms and Amphibians

Summary

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Protection of Biodiversity in the Risk Assessment and Risk Management of Pesticides (Plant Protection Products & Biocides) with a Focus on Arthropods, Soil Organisms and Amphibians

Summary

by

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Table of contents

1. Background information

Croplands and pastures represent one of the greatest terrestrial biomes on earth. In Europe, agriculture is a leading land-use which constitutes nearly half of the EU-27 land area. Modern, intensified agriculture is among other factors characterized by an increasing use of pesticides, where pesticides are plant protection products and biocides (e.g. herbicides, disinfectants, insecticides, rodenticides, repellents). The conservation of biodiversity is a major legislative objective and recent evaluations indicated that biodiversity loss does not appear to be slowing down. One of the general protection goals in the authorization of pesticides asserts that no unacceptable effects on biodiversity can be accepted following the use of plant protection products or biocides. This report deals with the effects of pesticides on biodiversity in agricultural landscapes and focusses on two organism groups: arthropods and amphibians.

Terrestrial arthropods and soil invertebrates represent the majority of biodiversity and animal biomass in the agricultural landscape and are recognized as major food items of vertebrates. They provide ecosystem services such as pollination, maintenance of nutrient cycling, regulation of micro climate and local hydrological processes as well as detoxification of environmental pollutants.

Amphibians are a group of organisms suffering current population decline, observed with great concern by many experts on a global scale. Significant declines of amphibian and reptile populations and species are occurring also in Western Europe. Amphibians are more sensitive than birds or mammals to environmental changes and contamination because they may face alteration and contamination in both terrestrial and aquatic environments and their skin is highly permeable. This report additionally gives some information about reptiles, with a special focus on the likelihood and relevance of reptile species exposure to plant protection products in Germany.

The term “pesticide” describes plant protection products and biocides. The former are used in the agricultural production process to protect crop plants (or their plant products) against harmful organisms like insects, fungi, or other plants. The term ‘biocides’ is used for substances to control organisms that are harmful to humans, their activities or the products they use or produce, or for animals or for the environment in the non-agricultural sector.

2. Arthopods and soil organisms

2.1 Habitats in agricultural landscapes and pesticide inputs

In a first step, the available habitat of so called non-target arthropod (NTA) species in the agricultural landscape was described using a quantitative approach elaborated in a Geographic Information System (GIS). This habitat characterized by field margin and hedges mainly comprises narrow margins, the majority being below 3 m wide. The exposure of plant protection products in these narrow margins is determined by spray drift but additionally they might be oversprayed near the field with 50% of the plant protection products field application rate. By combining drift values and Treatment Indices for specific crops, it is possible to calculate a Margin Treatment Index, in order to characterize the input intensity of plant protection products in different field margin types.

In contrast to plant protection products, biocides are normally not directly applied to agricultural sites. Biocides are divided into 23 different product types and at least some of them can reach terrestrial habitats in agricultural landscapes. For instance, disinfectants and insecticides (product types 3 and 18) used in the animal housing are applied on agricultural sites via manure and sewage sludge. Furthermore, wood preservatives (product type 8) can be applied on wooden piles in the cultivation of e.g. fruits or hops. Contrary to the environmental risk assessment for plant protection products, there is no distinction between in-field and off-field or in-crop and off-crop in the assessment of biocides. Thus, no specific scenario is available which quantifies biocide input in (narrow) field margins. Field margins may be however exposed to biocides if they are subjected to leaching and run-off.

2.2 Species, influencing factors, and ecological sensitivity

In a next step, a meta-analysis of 132 studies concerning eight arthropod groups revealed that agricultural intensification and pesticide usage affects arthropods predominantly negatively while plant species richness, availability of floral resources, and the occurrence of semi-natural habitats had positive effects on the abundance or species richness of most groups. Arthropod groups showing a high susceptibility towards pesticides combined with the availability of extensive data from published literature are butterflies and moths (herbivores and pollinators), carabid beetles and spiders (both predators). Field margins and hedgerows can constitute a habitat for a wide range of species (nearly 2000 reported) including e.g. Coleoptera, Diptera, Lepidoptera, and Araneae. For the butterflies, beetles and spiders, where data were available, most analysed species either preferred the field margins/ conservation headlands or seemed to use field margins/ headlands and crop to a similar extent. Since life history trait data to characterise ecological sensitivity is not available for most arthropod species, we propose instead to focus on threatened species recorded on red lists. Of the recorded Macrolepidoptera and spiders in field margins and woody structures around 10% belonged to (nearly) threatened species.

2.3 Risk assessment

The current approach in the assessment of the risk for non-target arthropods exposed to plant protection products is historically derived from biological pest control strategies. The test species used belong to so called 'beneficial insects' important in integrated pest control practices. The risk assessment of biocides addresses the effects of ecologically functional groups in relevant environmental compartments (water, sediment, soil, and air). The terrestrial part –the soil compartment – considers especially soil organisms (e.g. earthworms) while tests with other non-target arthropods are only needed in the risk assessment if a potential risk for non-target arthropods can be assumed. This can be the case when a specific mode of action of the active substances is to be assessed and/or in cases of high releases of the active substance into the environment. The proposed arthropod test species are also here ‘beneficial insects’. However, ‘beneficial insects’ only represent a restricted subset of arthropod biodiversity, since they are mostly predators or parasitoids. The sensitivity of the current test species might be similar to other arthropods but their life history does not reflect the range of life history strategies for the highly diverse arthropods, e.g. of the “off-crop” habitat. Phytophagous insects might additionally be exposed to plant protection products through consumption, depletion of food source, and reduction of host plant quality.

The assessment of recovery from effects of plant protection products used in the risk assessment approach needs to be separated from recolonisation processes. If, after a breakdown, a population increase occurs within a few weeks, recolonisation is a more likely process for species with only one reproductive phase per year. Recolonisation is largely dependent on the mobility (dispersal ability) of the species and the surrounding habitat (landscape context). In-field recolonisation might also draw from the arthropod population of the field margins and crop fields are therefore acting as sinks for these populations.

Arthropods represent major food items for vertebrates and their abundance is especially important during the rearing phase of young and chicks. Even short time reductions in their biomass might affect the next trophic level. This aspect needs further consideration to link the different groups assessed separately in current risk assessment procedures of pesticides.

Arthropod presence and biomass also in-field should be included as an endpoint in risk assessment.

Current testing of plant protection products includes in-crop field studies as highest tier. Since arthropod community composition and life histories as well as exposure to plant protection products differ between fields and field margins, the application of an uncertainty factor or the conduct of specific off-crop studies is suggested in conclusion with the outcome of the ESCORT 3 workshop. However, the testing of off-crop arthropod communities needs further evaluation to account for the variability of arthropod communities throughout Europe and to select sensitive groups and quantitative sampling methods.

In the standardized tests to assess the effect of plant protection products and biocides on soil organisms only a few test species are used. An ecological relevance of the test organisms often plays a secondary role because of practicability considerations. Soil organisms below-ground and non-target arthropods above-ground are not independent from each other. In the risk assessment of plant protection products non-target arthropods (above ground) are separated from soil organisms (below ground). However, many above ground insects have below ground larvae (e.g. carabid beetles, diptera) and this separation seems artificial. In the risk assessments of biocides such a separation does not really exist, since it considers the different environmental compartments. It is proposed to evaluate the sensitivity of life stages of so-called Non-Target-Arthopods that live in soil in comparison to the sensitivity of test species like earthworms or collembolan.

Any management of agricultural fields (e.g. tillage, plant protection products) impacts directly and indirectly above- and below-ground processes. In the risk assessment of soil organisms a mixed approach may be advisable which assesses the presence of key species (e.g. lumbricids) and species belonging to other relevant trophic levels.

2.4 Risk management

The German risk management for plant protection products regarding terrestrial off-field areas is based on use restrictions (e.g. usage of low drift nozzles and/or requirements regarding buffer strips in-field). In many cases, these use restrictions have not to be implemented by farmers due to existing exceptions (e.g. next to narrow off-field structures < 3 m).

To enhance the management of agricultural landscapes to support terrestrial biodiversity, it is proposed to pursue three additional goals: (1) the preservation and enhancement of the existing field margins and hedgerows including a reduction of inputs of plant protection products (e.g. in-field buffer strips), (2) the increase of plant species richness and the provision of adequate floral resources from the field to the landscape level, (3) the appropriate management of off-field habitats to create e.g. areas with varying structural complexity of the vegetation.

If the assessment of biomass of arthropods is taken into account because of their function as food for many organisms in the landscape, risk assessment and management procedures also need to be established for the in-field area. Due to the allocation of a sufficient amount of high quality in- and off-field habitats, the abundance, species richness, diversity, and biomass of arthropods will be enhanced so that in-crop population losses could be compensated and an adequate food supply for arthropod-feeding species is provided.

Not only the total amount of such in- and off-field habitat is crucial, these structures have also to be properly arranged in the landscape, to allow the emergence of habitat networks and to cover a range of several habitat types.

No-tillage management practices enhance on the one side the diversity of soil fauna in cropped fields. On the other side, however, the influence of herbicides that are always used in combination with no-tillage systems on the biodiversity of agricultural landscapes is currently matter of debate. Indirect effects via food web disruption should be evaluated.

3. Amphibians

3.1 Occurrence in agricultural landscapes and exposition to pesticides

Amphibian species living in agricultural landscapes are at risk of exposure to pesticides both in fields and in neighbouring non-crop areas. They perform species specific migrations on crop fields which temporally coincide with the application of pesticides. Depending on the vegetation cover of field crops and their related interception values, amphibians are at different exposure risks. Direct overspray of plant protection products of amphibians depends on the activity of individuals during daytime and availability of shelter. Because of amphibians being mostly nocturnal species, the risk of receiving full direct overspray is likely to be low. Amphibians resting in fields are slightly buried in the soil surface (digging species), use sites beneath the plants or enter animal burrows. Resting in fields without any type of cover is very unlikely. However, a higher exposure risk is caused by their movements on treated soil or vegetation, due to their potentially intense skin-soil or skin-vegetation contacts. Preferred habitats in crop fields are areas next to breeding ponds and wet spots. Under normal cultivation, there is a rather high risk for amphibians to be exposed to plant protection products because of their long sojourn in fields. Amphibians can be exposed to plant protection products outside crop fields by spray drift and run-off. This risk increases strongly with lower shares of non-arable land. Exposure of biocides in manure and sewage sludge might be other potential exposure scenarios in-field and on grasslands.

3.2 Toxicity of registered plant protection products for amphibians

The results of a literature review indicated that the transport of plant protection products across the skin is likely to be a significant route of exposure for amphibians and that plant protection products can diffuse one or two orders of magnitude faster into amphibians than into mammals. Since only a few studies were published on terrestrial amphibian life-stages a study to assess the toxicity of plant protection products on juvenile frogs was conducted. We studied the effects of seven plant protection products on juvenile European common frogs (*Rana temporaria*) in a laboratory overspray scenario. Mortality ranged from 100% after one hour to 40% after seven days at the recommended label rate of currently registered products. Effects were not restricted to a specific class of plant protection products and seem to be influenced not only by the active substance but also the formulation additives. The demonstrated toxicity is alarming and needs further research to understand the underlying mechanisms. The results also indicate that existing risk assessment procedures for plant protection product regulation are not protecting amphibians. Even if protection products were tested, similar effects and consequences cannot be excluded for biocidal products as active substances and formulation additives might be identical.

3.3 Risk management

Measures for risk management implemented to protect amphibian should include a) an overall reduction of plant protection product use, b) specific measures on hot spots of amphibian presence in crop fields, and c) modifying the mode and/or timing of plant protection product application. While sound amphibian management on wet spots or pond edges (buffer areas) is easily to apply and can be easily implemented, other measures are more difficult to implement but may offer some potential future prospects: e.g. short-term time shifting of plant protection product application dates, replacing a plant protection product, alternative application techniques like plant protection product injection into soil instead of spraying. In all cases, effects on other organisms groups have to be considered in an overall approach.

3.4 Reptiles

There are no systematic quantitative studies on reptile occurrences in cropped fields available, but from existing information and observations it can be assumed that they are common visitors in agricultural land and thus, their presence potentially coincide with plant protection product application. Based on a very scarce body of literature and own observations, we conclude on reptiles having a lower risk of plant protection product exposure than amphibians. They usually do not migrate that extensively between different habitats and cross crop fields to a less extent. If present on fields, they are likely to be close to field edges. However, own accidental findings show that some reptiles, for instance sand lizard, also may be sporadically active within crop fields at places with more than 100 m distance from the field edge. Reptiles, contrary to most amphibian species, are also active during daytime. On sunny days lizards often do sunbathing in grass-herb edges adjacent to crop fields providing open sandy soils or rocks. Under this scenario, the exposure risk by spray drift of plant protection products applied on neighbouring fields is presumably high. This is even more the case if we consider permanent crops like orchard or wineyards.