Crop protection by RNA interference – a horizon scanning of approaches to inform risk assessment

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Introduction

RNA interference (RNAi)-based applications aim to inhibit the expression of specific essential genes in target organisms by uptake and processing of double-stranded RNA and subsequent degradation of target gene mRNA. While the research on RNAi-based pesticides was initially limited to endogenous applications, the development of technologies for exogenous applications, in particular RNAi sprays, has increased in recent years. A horizon scan was conducted with a specific emphasis to identify and illustrate the current state of RNAi developments and applications in crop protection as well as their biomanufacturing readiness levels.

Results of the horizon scan

In this study, more than 180 publications and 268 patent families were identified. In total, RNAi applications for more than 30 different pest species were identified, most of which belonged to the insect orders Lepidoptera, Hemiptera and Coleoptera, but also for fungi and viruses.

The number of global patent applications rose rapidly in the following years from 2003, but has been declining since around 2016. Around 150 patent applications were still registered in 2019 and 2020, which are expected to be granted in the near future.

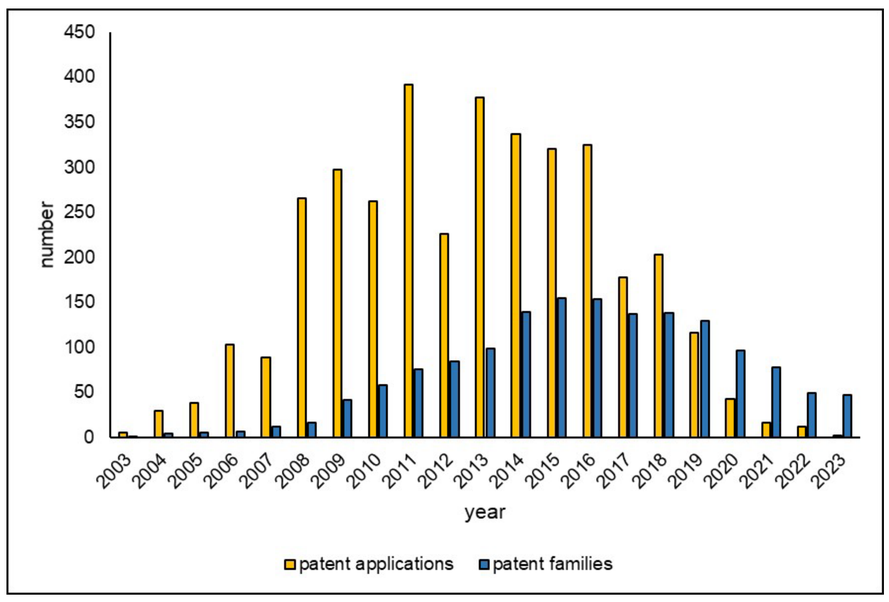

Figure 1: Number of patent applications and granted patent families registered

The number of publications steadily increased in the period from 2013 to 2016. From 2016 to 2019, the number per year remained stable with an observable dip in 2018. In the following period, the number rose again significantly to over 30 publications released in 2021.

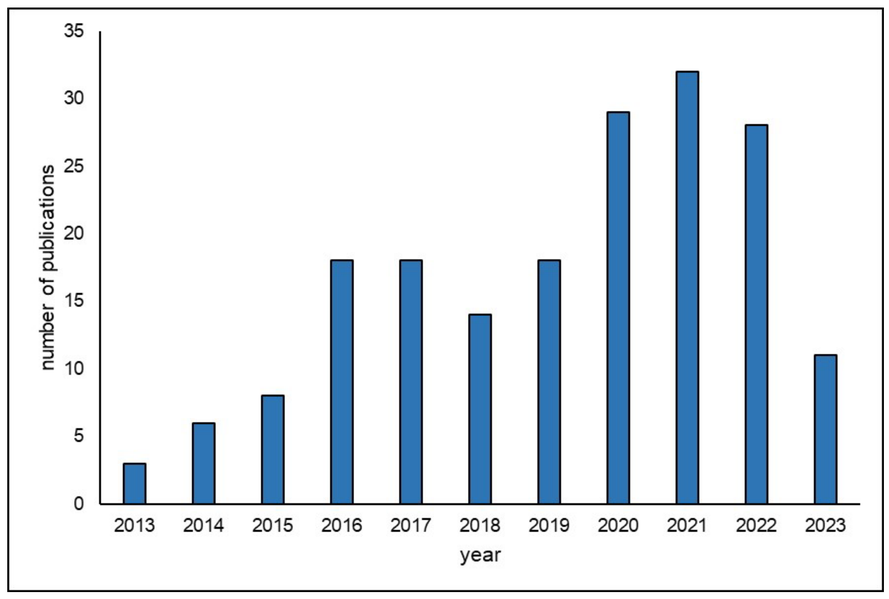

Figure 2: Number of relevant publications

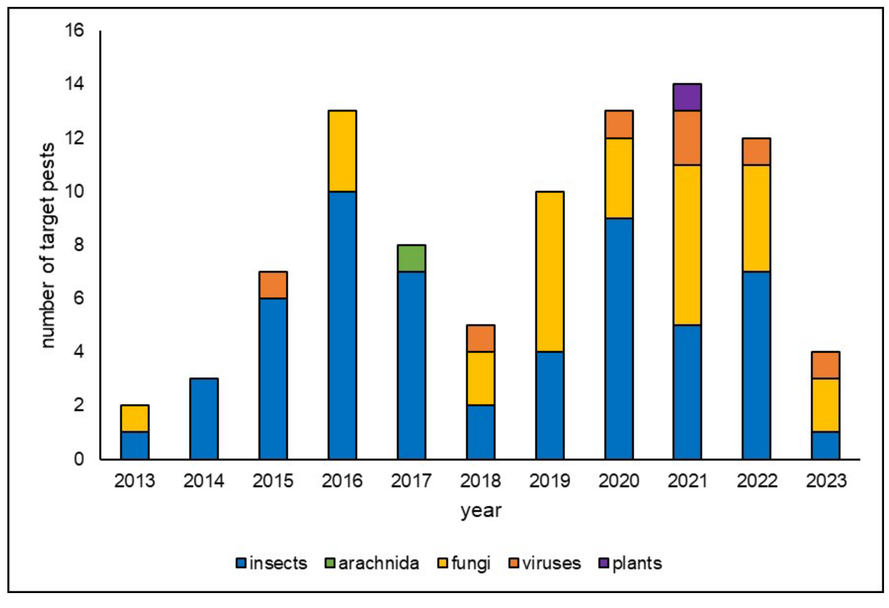

Figure 3: Number of target pests in dependence of their publication year.

While the development of such approaches was initially limited to a few, well-researched model organisms, a diversification of RNAi applications to agriculturally relevant pests like arthropods, fungi, viruses and plants has been observed since around 2018.

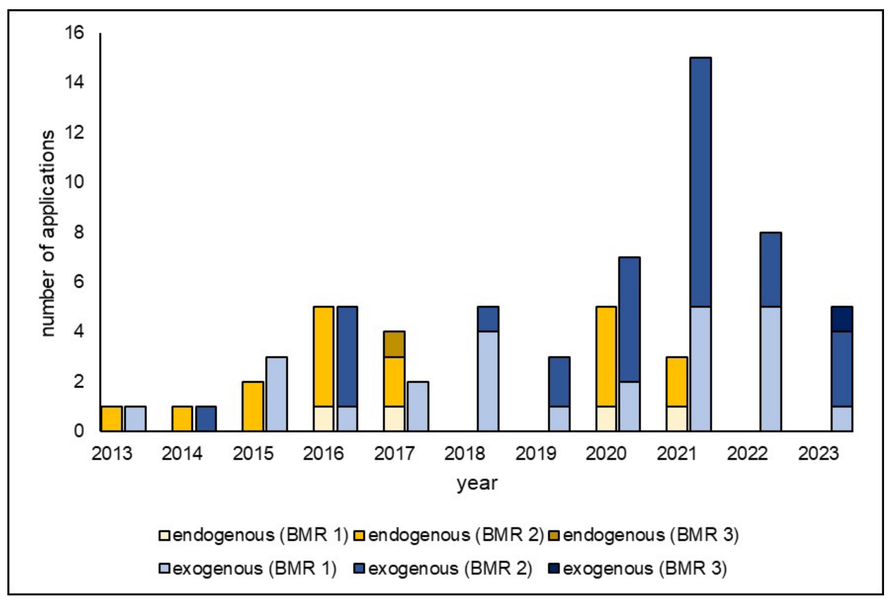

Figure 4: Number and development status (BMR) of RNAi applications published per year, separated into endogenous dsRNA transcription and exogenous dsRNA applications.

With the increasing use of RNAi to protect a wider range of crops, more exogenous applications have been researched and developed since 2018. This trend is presumably based on the fact that exogenous applications offer the possibility of a wide variety of applications through specific formulations and can be adapted more quickly to new or additional pests. The development status of both genetically modified plants and exogenous applications of RNAi in scientific publications is currently limited primarily to BMR 2, i.e. to the proven functionality. BMR 3, i.e. RNAi applications with market maturity and for commercial use, has only been achieved in three cases to date.

Summary and Outlook

In summary, we performed a horizon scan on RNAi-based applications for crop protection. In the near future exogenous RNAi applications in particular will be developed for commercialization and will also be registered for marketing authorization in Europe. For the authorization-relevant environmental risk assessment (ERA) of RNAi pesticides, adequate concepts and methods, particularly those focusing on adverse effects on non-target organisms, have to be developed. In the future, adequate ERA approaches will help to evaluate relevant properties such as specificity and degradability in RNAi-based appl. The assessment of the current state of applicable methods for ERA is the next part of this multistep project.

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Reference:

Germing et al., 2024: Crop protection by RNA interference – a review of approaches and current state of developments and use (under Revision).