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# Neonicotinoids in sugar beet cultivation in Central and Northern Europe: Efficacy and environmental impact of neonicotinoid seed treatments and alternative measures

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ABSTRACT

The use of neonicotinoids in sugar beet seed treatments is widespread across Europe because they effectively control most harmful arthropods. In most European countries, neonicotinoids (clothianidin, thiamethoxam and imidacloprid) are used in seed treatments on almost 100% of conventionally cultivated sugar beet fields. Additional foliar insecticide applications during the growing period with e.g. carbamates or pyrethroids are not conducted on most fields. Currently, the use of neonicotinoids in seed treatments of bee attracting crops such as rapeseed is banned in the European Union. The European Food Safety Authority will re-evaluate the risk for pollinators posed by neonicotinoids in seed treatments presumably by 2017. A possible total ban of neonicotinoids also in beet crops is likely which might increase the application of foliar insecticides throughout the growing period. In this article, the significance of neonicotinoids for the Central and Northern European sugar beet cultivation is reviewed and alternatives are considered. Current and former uses of insecticides, frequency of arthropod pests and their control, effects on yield and problems arising from resistances against insecticides are included in this review as well as environmental hazards. Exposure of non-target organisms to neonicotinoids in sugar beet seed treatments seems to be rather unlikely: both seed pelleting procedure and drilling technique conform to highest technical standards in terms of abrasion and drift of insecticides. The release of neonicotinoids to the environment *via* guttation or residues at harvest is low. Moreover, neonicotinoids in seed treatments can hardly be replaced as a control measure for the most damaging pest *Myzus persicae* Sulz. due to a lack of effective alternatives together with resistance of many populations against carbamates and pyrethroids. To control damaging seedling pests, tefluthrin in seed treatments often might be as effective as neonicotinoids, but its efficacy can be reduced under severe pest pressure of e.g. *Atomaria linearis* Steph. However, damaging arthropod pests do not occur in every field in every year. Thus, there is a potential for reducing the area treated with neonicotinoids in sugar beet. Monitoring systems and models to identify regions (and years) with a high risk of harmful pest incidences should be developed and decisions on the use of insecticides in seed treatments should be based on the probability of pest occurrence. Such situation-based pest management practices are needed to improve the sustainability of agricultural systems and to reduce the potential for harmful side effects of insecticides for the environment.



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## 1. Introduction

Since the introduction of imidacloprid – the first active ingredient of the neonicotinoid group – in 1991, neonicotinoids became the most widely used insecticides in the world controlling many pests and associated diseases in crop production (Jeschke and Nauen, 2008). Their systemic uptake in plants leads to a sufficient protection of all parts of the crop against many harmful arthropods during critical stages of crop growth, which is the reason for their broad application in seed treatments (Jeschke et al., 2011). This specific application is associated with a reduced operator risk (Simon-Delso et al., 2015). Furthermore, it was regarded as rather harmless for non-target organisms such as pollinators, because the percentage of area treated on a specific field is lower as compared to foliar applications such as sprays. Thus, less exposure of beneficial organisms to toxic compounds seemed to occur (Baker et al., 2003) compared to aboveground whole area insecticide applications (Talebi et al., 2008).

In spring 2008, more than 11,000 bee colonies were damaged by insecticidal dust that was built during the sowing of neonicotinoid treated maize seeds in the German Upper Rhine valley. This accident provoked an intensive debate about the potential risk for honeybees and other pollinators posed by neonicotinoids in seed treatments across Europe (Budge et al., 2015; Gibbons et al., 2015; Godfray et al., 2014; Goulson, 2013; Kessler et al., 2015; Nuyttens et al., 2013). In 2013, the European Commission banned the use of clothianidin, thiamethoxam and imidacloprid in seed and foliar treatments of bee attracting crops such as rapeseed and maize (EU regulation No 485/2013). The EFSA (European Food Safety Authority) currently re-evaluates the environmental risks posed by these active ingredients used in seed treatments. A final decision is anticipated presumably by 2017. Sugar beet was not affected by this ban because the seeds are pelleted with a high quality, so they have a high resistance to abrasion and a low risk for dust emission (Forster et al., 2012). In addition, sugar beet does not flower when cultivated for sugar production and thus, is considered to be not attractive for pollinators. In many European countries, 100% of sugar beet seeds are treated with insecticides of the neonicotinoid group. If seed treatments with neonicotinoids are banned in general, an impact on sugar beet cultivation is likely. Many harmful arthropods are known (Lange, 1987) that currently are efficiently controlled by neonicotinoids in seed treatments of sugar beet (Vasel et al., 2013). Today, additional insecticide applications such as sprays against aphids during the growing period are rarely conducted due to the long-lasting protection of the crop during critical developmental stages by neonicotinoids in seed treatments (Buhre et al., 2014; Vasel et al., 2013).

However, if neonicotinoids are no longer available for sugar beet seed treatments, an increase of alternative foliar applied insecticides during the growing period is likely, which has been shown for oilseed rape (Budge et al., 2015). It is essential not only to evaluate environmental hazards and risks posed by neonicotinoids in seed treatments. Moreover, alternative insecticides such as sprays with pyrethroids or carbamates might lead to a more harmful impact on e.g. pollinators and non-target organisms than neonicotinoids in seed treatments currently might do. In addition, alternatives to neonicotinoids might be critical in controlling pests efficiently due to possible resistance of pests against e.g. carbamates and pyrethroids, which is the case for the aphid *Myzus persicae* Sulz. (Nauen and Elbert, 2003). Efficiency of alternatives can also be reduced because the optimal point in time for insecticide applications for e.g. aphid control might not coincide with suitable weather conditions. Furthermore, some harmful arthropods exist for which seed treatments are the only control measure, e.g. the soil pest *Atomaria linearis* Steph. or *Agriotes* spp. that attack young sugar beet seedlings leading to total plant losses and reduced stand establishment (Heijbroek and Huijbregts, 1995). Thus, it is important to assess possible consequences of a total neonicotinoid ban in advance.

In view of the current situation, the following review evaluates the significance of neonicotinoids in seed treatments for sugar beet cultivation in Central and Northern Europe in consideration of alternative insecticides, including (i) uses of insecticides (ii) frequency of pests, efficacy of pest control and pest induced yield losses, (iii) problems arising from resistances against insecticides and (iv) environmental hazards. The focus of this review was on Central and Northern European countries because these important beet growing countries comprise comparable environmental conditions, pest situations and cultivation practices.

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