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An attempt to describe the effects of conventional cropping on non-target arthropods as a reference for risk assessment

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Department Environmental Biology

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CONTENTS

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SUMMARY

To be able to extend and refine the assessment of the effects of genetically modified crop varieties on non-target arthropods, it is necessary to have a sound knowledge to which extent conventional cropping is affecting these organisms. This study is a first, small scale attempt to describe non-target arthropods in crops as a reference for *a priory* risk assessment in the Netherlands. Because of the small scale of the study, a number of practical restrictions were imposed upon it:

1. The description of the reference was to be based on literature only.
2. Potato and maize are the only crops that would be taken into consideration, because it was expected that for these crops genetically modified varieties will become available soon.
3. Only field studies done in NW-Europe were to be taken into account, since arthropod fauna are different in other regions.
4. Studies in which chemicals were used that are prohibited in Dutch agriculture are not considered in this study.
5. Since digital literature databases do not provide literature older than 1990, and agricultural practice alters in time, references from 1990 onwards were collected. Older references were used when found as citations in more recent publication, but not older then 1980. All types of literature were to be taken into considerations, from scientific articles and reviews to reports and proceedings.
6. Species richness and abundance in numbers or biomass of species groups were considered to be the effect variables of interest. No species groups were to be excluded from the study. Only effects within cropping fields were taken into considerations. No before hand choice of the period within year was made, although our main interest was in summer populations.

The aim of this study is:

> *To describe the known effects of conventional cropping of potato and maize on non-target arthropods in the fields as a reference for the risk assessment of the application of genetically modified crop varieties of potato and maize in the Netherlands.*

It was decided to setup a framework. This framework resulted in a database in which all literature could be stored and then analyzed. The framework was discussed with a number of experts to ensure its completeness and usability.

All experts notified that describing a reference of the presence of non-target arthropods in conventionally managed potato and maize fields based on literature would be difficult, if not impossible, due a lack of enough relevant literature. They argued that an *a priori* reference that would be reliable enough to compare with the results of impact studies of genetically modified crop varieties, of which the design is not known in advance, should have to incorporate knowledge of variance due to all the important sources of variance. Because of i) the lack of standard practice in potato and maize culture and ii) the many factors influencing the arthropod species richness and abundance, variance in arthropod measurements can expect to be large.

Literature searches confirmed that only limited data for such a general applicable reference are available (table 4 & 5). From the studies dealing with non-target arthropods in conventional agriculture, a minority was conducted in maize or potato fields.

Only a few of the references that could be used, marginally described the agricultural practice applied. Since in many cases no description of agricultural practice was found, it is also unclear what chemicals were being used and, therefore, whether these data meet our requirements for use. Also, an analysis of the effect of the separate management activities in the agricultural practice of maize and/or potato is impossible to make due to a lack of data (table 6).

Most of the references that more or less met our requirements provide information on variance in measurements of species richness or abundance, mostly of carabids and spiders. When this information is analysed according to the different sources of variance involved, it turns out that most source of variance are covered, be it with usually few references per source of variance (table 7 & 8).

We concluded that we did not find enough data to describe a general applicable reference of the presence of non-target arthropods in conventionally managed potato and maize fields and that the data given in this study should not be regarded as such.

The possible reasons for not finding enough data to enable a description of a reference of non-target arthropods in conventional potato and maize crops are discussed. This discussion is aimed at giving insight into the difficulties one can expect to meat when trying to describe an *a priori* reference for risk assessment of genetically modified crops based on published data only.

1 INTRODUCTION

The Bureau Genetisch Gemodificeerde Organismen (Bureau GGO) of the National Institute of Public Health and Environment (RIVM) is responsible for the administrative and technical-scientific implementation of the granting of licenses according to the GMO Decree, as well as for supporting policy making on the issue of genetically modified organisms (GMO's). In practice this means, among other things, the processing of notifications for contained use and introduction into the environment of GMO's, including gene therapy research. The Ministry of Housing, Spatial Planning and the Environment is responsible for granting consents on those notifications.

In the licensing procedure for deliberate release of genetically modified (GM) crops a risk assessment of the application of the GM crop has to be made. One of the aspects of such an assessment is the effect that the application could have on non-target arthropods in the field. Non-target arthropods are considered important for several reasons. For example, detritivorous arthropod species help to degrade organic material on the fields, while predatory arthropods, such as carabids and spiders, may play an important role in pest control. Arthropods are also important as part of the food chain. Apart from that, non-target arthropods are a characteristic part of the biodiversity of rural areas.

The risk assessment is conducted according to EU Directive 2001/18/EC on the deliberate release of GMO's and focuses on the assessment of risks associated with the release of the GMO's into the environment. To be able to extend and refine the assessment of the effects of genetically modified varieties on non-target arthropods, it is necessary to have a sound knowledge to which extent conventional cropping is affecting these organisms. Conventional agriculture affects non-target arthropods and these effects are obviously accepted by society. So, when a genetically modified variety will not give rise to additional adverse environmental risks compared to conventional varieties (e.g. when non-target arthropods are concerned), the legal framework states that consent should be given. Therefore, CML- Leiden was asked to describe the effects of conventional cropping on non-target arthropods as a reference for the risk assessment.

However, because the research budget was limited, a number of practical restrictions were imposed on the study:

1. The description of the reference was to be based on literature only.
2. Potato and maize are the only crops that would be taken into consideration, because it was expected that for these crops genetically modified varieties will become available soon.
3. Only field studies done in NW-Europe were to be taken into account, since arthropod fauna are different in other regions, such as USA, Canada and New Zealand.
4. Pesticides that are allowed in Dutch agriculture change in time. Therefore studies, in which prohibited chemicals were used, are not considered in this study. The data on permitted chemicals were provided by I. Koomen, LNV.
5. Since digital literature databases do not provide literature older than 1990, and agricultural practice alters in time, references from 1990 onwards were collected. Occasionally older references were used, which were found as citations in more recent publication. All types of literature were to be taken into considerations, from scientific articles and reviews to reports and proceedings.

So the aim of this study is:

To describe the known effects of conventional cropping of potato and maize on non-target arthropods in the fields as a reference for the risk assessment of the application of genetically modified crop varieties of potato and maize in the Netherlands.

2 METHODS

2.1 Introduction

The general aim of this study as given above was not very specific. As a matter of fact, it raised a number of questions that needed to be answered before the research could start. The most important of these questions were:

- What is to be regarded as 'conventional cropping of potato and maize'?
- What 'non-target arthropods' need to be considered?
- What types of effects are relevant?

As an answer to these questions it was decided to setup a framework. This framework resulted in a database in which all literature could be stored and then analyzed. The framework was discussed with a number of experts to ensure its completeness and usability.

2.2 Setup of the framework

Agriculture can be regarded as a complex of a large number of strongly interrelated management activities. For describing its effects, one can choose to regard it as one system, or to describe the effects of the different management activities. In the system approach, one does not have to bother about how the different management activities will change when some aspects of agriculture, such as crop varieties application, is changing. One simply measures the overall effect of the new agricultural practice on, say, arthropods species. Of course, if one finds an effect it is unknown which processes actually do affect the species. In the approach in which one tries to describe the effects of the different management activities, more understanding is gained on the cause-effect relationships. This would enable predictions of future changes in agricultural practice. However, the effects of the different management activities are very difficult to distinguish in field studies, since one management activity can seldom be changed without changing other activities. In this study, it was decided to try to describe both the overall effect of the complete cropping system, and, if available, the effects of the management activities.

The first step in the design of the framework was the description of the management activities that make up conventional potato and maize cropping practice. This was based on Kempenaar et al. (2003).

The second step was to decide on which non-target arthropods to focus. Several approaches could be followed. One approach could be to describe the non-target arthropods that are present in crops. In this approach a distinction could be made between under ground living, ground dwelling, leaf and stem living, and flower visiting species. Another approach could take the functional role of the arthropods as a starting point, and make a distinction between herbivorous, detrivorous, predatory, and parasitoid species. In this approach, arthropods that are an important food source for, say, birds could be emphasized. It was decided not to make a choice between these approaches before hand, but simply to make a list of all species groups of interest in accordance with literature and the expert opinions.

Finally, species richness and abundance in numbers or biomass of species groups and not individual species were taken as the effect variables. Only effects within cropping fields were taken into considerations. No before hand choice of the period within year was made, although our main interest was in summer populations.

2.3 Interviews with experts

Dr. F. Smeding (Louis Bolk instituut, Driebergen), Dr. K. Booij (Alterra, Wageningen), Dr. ir. F.A.N. van Alebeek, Dr. ir. A. Veerman and Ing. J. Groten (PPO, Lelystad) were consulted to comment on the framework, to provide literature and to advise on pitfalls in the interpretation of the outcome. Smeding is expert on food webs in (organic) agriculture; Booij is expert on arthropods in agricultural systems; Van Alebeek, Veerman and Groten are experts on agricultural practice of organic, potato and maize agriculture, respectively.

2.4 Database setup and literature search

A database was setup to collect and classify data from literature and to generate tables of overviews of data. The tables created in the database were based on the framework (see above).

Published data (peer-reviewed articles in scientific journals, reports, data from books etc.) were collected by searching in:

- literature databases (a.o. ISI Web of Science, local and national libraries);
- citations in references;
- literature listed by experts.

The searches in the literature databases started with the input of single key-words or combinations of keywords from the list in Table 1. For examples of the key-word combinations see Appendix 1. These searches resulted in lists of papers, which were subsequently, screened for relevance for the project. This was done first on the basis of the abstract. Secondly, when the reference was potentially of interest, e.g. dealing with non-target arthropods and the research might have been carried out in potato or maize fields the paper was collected either digitally of via the library. Subsequently it was checked if the data were about potato and maize culture.

Table 1. Overview of main key-words used for literature search:

KEY-WORDS ON ARTHROPODS	KEY-WORDS ON FARMING
abundance	agriculture
araneae	agro-ecology
arthropod(s)	anbau
biodiversity	arable
carabidae	conventional
fauna	corn
insect(s)	crop(ping)
insekten	evaluation
invertebrate	farming
macro-arthropods	Farm Scale Evaluation
nichtzielorganismen	field
non-target	mais
species richness	maize
	management
	plough(ing)
	potato
	rotation
	Solanum tuberosum
	system
	system comparative studies
	Zea mays

In addition to the direct result of key-word input in the literature databases, references were searched as citations in other relevant papers, or via the ISI Web of Knowledge as other papers that cited the relevant paper. Both types of papers were screened for relevance as described above.

Also experts provided titles of papers, authors and books of interest for this project. Again these were screened for relevance for the project.

This literature search provides a list with potential usable data for the project. For a study to be included in the analysis, it had to give data on arthropod species or groups either as biomass, numbers or diversity and had to meet the requirements, according to the restrictions mentioned in chapter 1. References before 1980 were not included.

Data of studies were excluded when concerning organic farming, culture of genetically modified varieties, or when prohibited chemicals were applied. Lists with permitted chemicals for potato and maize culture were provided by I. Koomen (LNV-PD). In case of uncertainty of the used chemicals in the studies (e.g. by using different brand names in different countries), the active component of the chemical was retrieved via the supplier-website on the internet and compared with data from the CTB website (www.ctb-wageningen.nl). When the chemical was on the permitted list, data were recorded in the database. Data were also recorded in the database, when no information was available on agricultural practice and chemicals used. Data on arthropod fauna were only used when measurements were done in the potato or maize field, not in years after or before potato or maize cultivation.

3 RESULTS

3.1 Framework

For describing conventional potato and maize cropping, we made a selection of the management activities described by Kempenaar et al. (2003). Our selection was based on the considerations that the activity should potentially affect arthropods, only in the cropping field. Therefore, activities like transport and variety breeding were left out. Next, we tried to indicate whether the activity may change by applying genetically modified varieties to indicate the relative importance of the activity for the reference description. We assumed two types of genetically modified varieties now available: herbicide-tolerant and insect-resistant varieties. We also assumed two types of future varieties: varieties with altered food characteristics (e.g., extra vitamins built in) and environmental stress resistant varieties (e.g., drought tolerant) (Koomen, pers. comm.). The result is given in table 2.

Table 2: probability of change of management activity when genetically modified varieties are applied. ++: change due to available genetically modified varieties; +: change due to future genetically modified varieties; -: no change expected; blancs: presently not applied.

MANAGEMENT ACTIVITY	POTATO	MAIZE
1. STARTING MATERIAL		
Fungicide application	+	+
2. TILLAGE AND PLANTING/SOWING		
Crop rotation / previous crop	+	+
Manuring before ploughing	+	+
Ploughing	++	++
After ploughing tillage	++	++
Sowing/planting	-	-
After sowing tillage	+	
3. CROP MANAGEMENT		
Fertilisation	+	
Mechanical weeding	++	++
Herbicide application	++	++
Insecticide application	++	++
Nematocide application	+	
Fungicide application	+	
Irrigation	+	+
4. HARVEST AND POST-CULTIVATION		
Leaf destruction	+	
Harvesting	-	-
After harvesting tillage	++	++
Cover / legume application	+	+
Sprout control	+	

We assumed that the application of herbicide-tolerant varieties affects all weed control activities, including most forms of tillage. Present insect-resistant varieties, i.e., Bt-varieties, will undoubtedly change the use of insecticides. Especially the future application of environmental stress resistant varieties might strongly influence management activities. If we regard fungi and nematode resistant varieties as belonging to this group of varieties, they not only may change the use of chemical fungicides and nematocides, but also rotation practice. The need for fertilizers may change as well as the need for irrigation, which may also affect the applications of legumes and other ground cover plants. Herbivory of crops may change in case of application of varieties with altered food characteristics, and as a consequence, herbicide, fungicide, and nematocide use may change.

3.2 Points of interest from expert interviews

All experts agreed that describing a general applicable reference of the arthropod community in conventional maize and potato crops based on existing literature would be impossible. They argued that a description of a reference should acknowledge the different sources of variance that occurs in species richness and abundance measurements of non-target arthropods in the field and that not enough literature on the arthropod community in conventional maize and potato crops is available to describe this variance.

The reasoning of all experts started with the statement that there exists no 'standard' conventional maize or potato cropping practice. Ever since the 80s cropping practice has become more and more location and farmer specific. Practice may differ in application of varieties, timing of the management activities (e.g., ploughing in autumn versus spring), application of pesticides and fertilizers, rotation scheme, and combinations of these activities. For example, very subtle, but significant differences may exist in time of sowing in combination with herbicide use.

Furthermore, arthropod abundances may highly fluctuate in time, both within and between year, and in space, within and between fields, but also between geographic regions. Differences in abundance of carabids of a factor 50 within a field are not uncommon. The variance in abundance measurements can be somewhat lowered by choosing fixed locations within fields (e.g., the centre) and fixed period of the year (e.g., June, when most agricultural activities except harvesting have been finished and populations are more or less stable), and by measuring species groups instead of separated species. However, the amount of variance remains huge. Besides, arthropod species have differences in life cycles: some generate once a year, others have several generations per season. As a consequence, the abundance of some species might be strongly affected by weather and other sources of variation during winters, while other species are more affected by sources during growing seasons. The developmental stage in which arthropod species survive the winter (e.g. adult, larvae or egg) and winter conditions may affect species numbers during the growing season differently. As a result, any reference description of arthropod species richness and abundances would have to acknowledge these sources of variance. To assess such variance, a large number of field studies covering different regions and years would be necessary.

Another consideration made by some experts was about which non-target arthropods would be of greatest interests and for what reasons. Answering this question could strongly influence the data needed for describing a reference. For example, if the predatory arthropods are of main interest because of their possible role in controlling pests, the reference description should concentrate on the location within the field and period of the year that indicate the ability to fulfil that role best. For carabids this could mean that one should measure the winter or early spring population depending on which population determines summer abundance. Another example is that, if the non-target arthropods are considered important as food for vertebrates, the populations of pray arthropods at the moment of high predation could be of main interest, which might also be after harvesting. When it is not possible to choose before hand on the importance of the different aspects of the non-target arthropod community, one may have to conclude that one needs to collect data of many different non-target arthropods, at all locations, all year round.

Yet another problem is that conventional agriculture is changing so fast that if one demands from a genetically modified variety to perform better than a reference, the reference should be updated regularly. A monitoring system would be preferable.

All experts agreed that there are not enough data published to base a description of a reference on. Data on species richness and abundance of non-target arthropods in maize or potato are rare, even when one does not restrict oneself to north-western Europe.

3.3 Data from literature

3.3.1 General overview

Introduction

As already stated before, the amount of literature on the species richness and abundance of non-target arthropods in conventional potato and maize cropping is limited. This makes it impossible to describe the effects of the separate management activities of cropping practice on arthropod communities. Yet, the information on which management activities have the greatest impact on arthropods, together with the estimated change in management activities due to the application of GMO's (3.1), could give an idea of the potential impact of the application of GMO's.

In order to provide at least some insight in what is known about the effects of the separate management activities, we will discuss some reviews here. Most of this literature reviews the impact on arthropods of agriculture in general, and does not make distinctions between different crops. We start by discussing the impact of intensification of agriculture in general, and go from there into more detailed management activities. We only discuss results from field studies.

Intensity of conventional agriculture

Several recent studies have described the effects of the intensification of agriculture since the 2nd world war on arthropods. Robinson & Sutherland (2002), stated that post-war monitoring in Britain showed that the Lepidoptera that occur widely on farmland generally appear not to be declining, whereas those with restricted distributions are declining. Trends in moth numbers in different habitats show a general decline in farmland populations. Aphid populations have shown little marked change since the 60s in one study, while another one showed a dramatic decline in cereals since the 70s. According to Robinson & Sutherland (2002), a number of field studies across Europe have shown declines in many carabid species, with a few species becoming more common. This is confirmed by Holland (2002), who states that "There is evidence that the abundance and diversity of Carabidae are declining in the long term since farming started to become more intensive in the 1950s". As an example, he describes the 'Sussex Study' that showed a decline of carabid density between the 70s and the 90s to 30% of the initial densities in 100 cereal fields. Robinson & Sutherland (2002) found that there have also been declines in many bumblebee species throughout Europe. According to Nyffeler & Sunderland (2003), comparative studies showed that the relative abundance of linyphiid spiders rises with intensity of agricultural management as compared to other spiders. "The mechanism could be that the majority of spiders perish or emigrate from a field when it is disturbed by cultivation or an agrichemical application, but a small number of highly invasive, colonizing linyphiid species […] return to the field rapidly", they state. The most detailed study of long-term trends in invertebrate abundance in Britain shows that most groups have declined in numbers, while some showing little change, notably Collembola, carabids and other predatory insects. More intensive field management, degradation in habitat quality, and increasing habitat homogeneity (across all scales) are currently thought of as the most important drivers behind this loss (Robinson & Sutherland 2002).

Organic and integrated versus conventional agriculture

Organic agriculture can be characterized by the prohibition of synthetic chemicals (Hole et al., 2005). Comparing it with conventional agriculture may therefore show the effects of the use of synthetic herbicides and insecticides and of inorganic fertilizers. However, one should be careful in interpreting results of comparative studies, because organic agriculture usually incorporates a range of other management practices that are uncommonly used in conventional systems, which makes it difficult to separate effects of certain activities from others (Hole et al., 2005). In this overview, we also include results from studies of integrated and other types of reduced input agriculture (Holland et al., 1994).

Holland et al. (1994) state that "non-target arthropods […] showed higher populations in the lower-input or integrated areas in 7 out of the 9 studies where they were assessed", while Bengtsson et al. (2005) found that organic farming usually increases species richness, a.o., of insects, having on average 30% higher species richness than conventional farming systems. This effect of organic farming was largest in studies at the plot scale. On average, organisms were 50% more abundant in organic farming systems. Predatory insects respond positive to organic farming, while non-predatory and pests species did not. The positive effects on abundance were prominent at the plot and field scale, not at the farm scale.

Hole et al. (2005) discussed results from studies on butterflies, spiders, beetles and other arthropods. The two studies on butterflies showed inconsistent results: one showed higher total abundance on organic farms, while the other found no significant differences, probably due to a rigorous control for variation in rotation and non-crop habitat between farm pairs in the latter study. Most studies (7 out of 10) on spiders showed a higher abundance of spiders on organic farms. The other studies found no differences. Most studies on beetles (13 out of 21) found higher abundances on organic farms. Carabids were usually more abundant on organic farms, and sometimes also have higher species richness, while the staphylinids and some individual species of carabids showed inconsistent results. Overall, the results of the studies on other arthropods suggest that organic farm fields contain a greater abundance and diversity of arthropods (7 out of 10). Aphids tend to be more abundant on convention farms. Hole et al. (2005) conclude that the majority of the studies reviewed demonstrate that species abundance and/or richness tend to be higher on organic farms. However, they also stress the difficulties to interpret these results adequately. They plead for longitudinal, system-level studies to address these difficulties.

Level of spatial scale

The found impact management activities could depend on the level of scale that is studied. Thomas et al. (2002) state that "carabid distributions within fields are nearly always aggregated, and may be associated mainly with weed cover, crop density, and soil factors – especially moisture […]. Adjacent habitats also play a role depending on the permeability of field boundaries permitting movement between fields. […] At the farm and landscape scales, carabids probably exist as meta-populations”. This means that one should make a distinction between different levels of scale in studying and describing the effects of agriculture on arthropods. This is confirmed by Bengtsson et al. (2005), who found that the effects of organic as compared to conventional agriculture that could be detected depended on the level of scale studied.

Rotation

The only review we came across, in which rotation is discussed is that of Hance (2002). He states that non-rotational cropping seems to be more favorable to carabid communities, maybe due to continuity. The preceding crop can have high influence on carabid densities. A cover crop may reduce the negative impact of bare soil on carabid assemblages between two cultures. In contrast, Desender en Alderweireldt (1990) found clearly more species in maize in rotation with other crops than in maize monocultures.

Tillage

Stinner & House (1990) are very definite in the effects of tillage on arthropods: “Compared to other cultural practices […] tillage is a strong determinant of invertebrate distribution and abundance.” “One of the most frequent and widespread observations regarding arthropods […] is the increase in soil- and litter-inhabiting predatory arthropods, especially ground beetles (Carabidae) and spiders, as tillage decreased”. Also, they state, a greater abundance of predatory foliage-inhabiting insects was found in no-tillage systems than in conventional tillage, i.e., ploughing where the ground is inverted. This is usually attributed to higher weed density in the former. Holland & Luff (2000) seem to be less certain: “Any soil cultivation affects the carabids assemblage, but studies comparing ploughing with reduced tillage have shown varying results, according to local conditions”, while Hance (2002) says that “several authors have pointed out that deep tillage influences carabid beetle populations by reducing both abundance and diversity of assemblages, even though it may encourage some species”.

Fertilizers

Hance (2002) found that applying organic matter and manure seems to increase the density of carabids, although different species or groups of species may differ in their reaction. Holland & Luff (2000) refine this statement: “Whilst fertilizer application is generally beneficial to carabids, comparisons of conventional and organic farming systems suggest that localized short-term variations in species’ abundances are more important than the overall farming system used.” Hance also concludes that the influence of chemical fertilizers is poorly documented.

Pesticides

Robinson and Sutherland (2002) express a general opinion when stating that increased use of pesticides is resulting in smaller, species-depauperate plant and invertebrate communities. Squire et al. (2003) found that between the 1970s and 1990s arable weeds declined more than any other category of plants, and that in some parts of England as many as 20% of species might have been lost. Many farmland invertebrates also showed steep declines. Nevertheless, they state, the effects of pesticides could rarely be distinguished at the scale of the field and the milder climate towards the end of the century possibly increased the ranges and population size of some species. It was rarely possible to relate a change in population to one specific factor, such as pesticide use.

Herbicides

According to Schütte (2003), "Over the period of increased herbicide use (1950-1985), species diversity […] of the associated agricultural flora was reduced 30-70% in Germany […]. The reservoir of seeds in soil has been reduced 30.000-300.000 seeds/m^2 to 1000-2500 seeds/m^2 within the last decades". The fall of floral species diversity is thought to have led to the decline of epigeal arthropods species diversity by 45-85%. The biomass of these epigeal arthropods decreased even further. Mechanical weeding does not reduce the density and diversity of agricultural associated flora as much as herbicides. However, mechanical weeding does not lead to a recovery of the flora at locations where the seed bank has been eliminated by herbicide use. Concerning Carabidae, Hance (2002) states that "herbicides and fungicides are currently not directly toxic to carabids, but may influence survival through habitat modification or food removal. Numerous studies have shown that carabid activity-density is higher in weedy plots than in herbicide-treated plots."

Insecticides

Holland & Luff (2000) state that "insecticides have a localized and short-term effect [on carabids], as many carabids rapidly re-invade sprayed crops. The long-term effect of pesticide usage at a landscape scale is, however, more difficult to predict, and may have contributed to the observed decline in carabid diversity in the wider countryside." Hance (2002) also found that densities of carabids drop after an insecticide treatment. Recovery can take two month. Application of organic matter may reduce the effect of insecticides. Meissle and Lang (2005) state that plant protection methods usually not only reduce the target pest, but influence the community of non-target organisms in a direct or indirect way. Broad spectrum insecticides have severe effects on many groups of non-target organisms. However, sprayed insecticides remain on the plant surface and have temporarily limited range of action, as they are sensitive to UV radiation and washed of by rainfall.

SUMMARY

Although sometimes inconsistent results are found, most authors ascribe the decrease in arthropod species richness and abundance that occurred since the Second World War in rural areas in north-western Europe due to the intensification of agriculture. The increased use of pesticides and increased intensity of tillage are considered to affect arthropods negatively, while applying organic fertilizers probably is beneficial. Both intensity of tillage and the use of herbicides seem to affect arthropods through a decrease of weeds. Except for after sowing tillage, all of the activities that are considered to affect non-target arthropods most, are probably also affected by present available types of GMO's (table 3). This confirms the felt need for knowing the effects of GMO's on non-target arthropods. Yet, many authors stress that the changes in arthropod communities are usually difficult to ascribe to a specific activity, because changing an activity usually affects the complete agricultural system. Besides, long term agricultural practice (e.g. rotation) and landscape factors may have strong influence on arthropods, depending on the species life cycle and mobility. For this reason, long term, large scale research of complete agricultural systems is recommended.

Table 3: probability of change of management activity when genetically modified varieties are applied. ++: change due to available genetically modified varieties; +: change due to future genetically modified varieties; -: no change expected; blancs: presently not applied; bold: activities that seems to affect non-target arthropods most according to general literature overview

MANAGEMENT ACTIVITY	POTATO	MAIZE
1. STARTING MATERIAL		
Fungicide application	+	+
2. TILLAGE AND PLANTING/SOWING		
Crop rotation / previous crop	+	+
Manuring before ploughing	+	+
Ploughing	**++**	**++**
After ploughing tillage	**++**	**++**
Sowing/planting	-	-
After sowing tillage	**+**	
3. CROP MANAGEMENT		
Fertilisation	**+**	
Mechanical weeding	++	++
Herbicide application	**++**	**++**
Insecticide application	**++**	**++**
Nematocide application	+	
Fungicide application	+	
Irrigation	+	+
4. HARVEST AND POST-CULTIVATION		
Leaf destruction	+	
Harvesting	-	-
After harvesting tillage	**++**	**++**
Cover / legume application	+	+
Sprout control	+	

3.3.2 Defining a reference from literature

Only a limited number of relevant papers was found in literature (table 4 & 5). From these papers some do not meet the requirements, since non-permitted chemicals have been used, or data have been pooled over different crops or different farming systems (biological, conventional or integrated). From the papers that have been recorded in the database information about separate management activities and chemicals used is mostly unavailable (table 6). For both maize and potato only seven relevant papers were found, covering only two and three countries, respectively.

Two papers on maize studied the effects of a management activity: Desender & Alderweireldt (1990) found higher, but probably not significantly, carabid species richness in maize in rotation and Fadl et al. (1996) found no effects of soil cultivation time (autumn, spring or uncultivated) on total seasonal catches of the carabid *Pterostichus melanarius,* but suggest that spring cultivation reduces larval/pupal survival. Only one paper on potato studied a management activity: De Snoo et al. (1995) found that the species richness of carabids in one year was significantly higher in unsprayed potato crop edges. The other papers focussed either on methodology, population dynamics or predator-pray relationships, on the effects of complete agricultural systems, such as organic versus conventional cropping, or on the effects of GMO's on arthropods (appendix 2).

Because the experts, we talked to, agreed that an adequate reference should provide a description of the variance in species richness and abundance measurements, we collected information on variance of species richness and of species group abundance in the references from table 4 and 5. The results are given in table 7 & 8. No information was gathered on

Table 4: Overview of literature available on non-target arthropods in maize culture in NW-Europe.

AUTHOR(S)	COUNTRY	YEAR(S) OF STUDY	
Alderweireldt (1989)	Belgium	1986	
Alderweireldt *et al.* (1991)	Belgium	1986	
Desender and Alderweireldt (1988)	Belgium	1986	
Desender and Alderweireldt (1990)	Belgium	1986,1988	
Hance (1995)	Belgium	?	a
Irmler (2003)	Germany	1988-1996	b
Lang (2000)	Germany	1995,1996	c
Lang *et al.* (1999)	Germany	1994	*
Ludy and Lang (2004)	Germany	2001	
Meissle and Lang (2005)	Germany	2001	(a)
Samaké and Volkmar (2000)	Germany	1997, 1998	a
Fadl *et al.* (1996)	Ireland	1991-1994	b
Haughton *et al.* (2003)	United Kingdom	2000, -01, -02	a
Hawes *et al.* (2003)	United Kingdom	2000, -01, -02	a
Brooks *et al.* (2003)	United Kingdom	2000, -01, -02	a

a= Chemicals used in study, such as herbicide and/or pesticide, are not permitted in The Netherlands (List I. Koomen, LNV; CTB-website); b= data on arthropods pooled over different crops or different types of farming systems; c= maize or potato in rotation, but no measurements on arthropods in these crops. Figures between brackets indicate that part of the data set did not meet the requirements to record. In appendix 2 more detailed information is given about the separate articles. * See appendix for addition comments.

variance of individual species. Whenever possible, we give the lowest and highest value of a range of observations. We sometimes had to deduce these values from graphs, so some inaccuracy is unavoidable. When averages ± standard deviation (SD) were given these where calculated into averages ± 95% confidence limits (SD * 1.96). In the tables the lower and higher 95% confidence limit is given. Of course, this approach ignores outliers. It should be noted that details of the underlying agricultural practices in the studies is not always clear, e.g. the use of (non)-permitted chemicals sprayed.

Table 7 and 8 show that only a very few studies incorporate all the different sources of variance that need to be taken into consideration when describing a general applicable reference. In some cases, important sources are simply not studied. In other, data are pooled in such a way that the variance from certain sources cannot be found in the paper. Sometimes sources of variance cannot be distinguished, for example when different fields were measured in different year.

It should be noted that the different studies use different measuring methods and that de results are given in different units. For this reason, the information on variance cannot be summarized into overall numbers.

Considering species richness in maize (table 7), no information is available on variance due to different regions and the information on variance between farms and between years cannot be distinguished from variance from other sources. Variance of species richness within fields of spiders seems high (2-11) as compared to carabids (14-18), while carabid species richness variance can be high between fields (17-32). Variance in carabid species richness within years seems low. It should be noted that these results are based on very limited data, only one to two studies each.

Table 5: Overview of literature available on non-target arthropods in potato culture in NW-Europe.

Author(s)	Country	Year(s) of study	
Kromp (1990)	Austria	1981	(a)
Kromp (1999)	Austria	1980, (1981)	
O'Sullivan and Gormally (2002)	Ireland	1999	a
Lang (2000)	Germany	1995,1996	c
Andersen and Eltun (2000)	Norway	1989-1996	c
Booij (1994)	The Netherlands	1984-1986	b
Booij and Noorlander (1992)	The Netherlands	1985-1987	
de Snoo *et al.* (1995)	The Netherlands	1990-1991	(a)
Armstrong (1995)	United Kingdom	1992	a
Cole et al. (2005)	United Kingdom	1998-2000	
Holland et al. (1998)	United Kingdom	1992-1997	
Holland et al. (2002)	United Kingdom	1992-1997	

a= Chemicals used in study, such as herbicide and/or pesticide, are not permitted in The Netherlands (List I. Koomen, LNV; CTB-website); b= data on arthropods pooled over different crops or different types of farming systems; c= maize or potato in rotation, but no measurements on arthropods in these crops. Figures between brackets indicate that part of the data set did not meet the requirements to record. In appendix 3 more detailed information is given about the separate articles.

Reliable information on the variance of species richness in potato is only available on carabids (table 7). Within fields it is known from one study and varies between about 5-14. No good data are available on between field and between farm variance. Three studies give data on variance between regions, the highest of which is a variance in species richness per pitfall per day of 0.5-0.8. According to one study species richness varies between 5-9 species within a year. On other study found between year variance of about 9-12 species. For the variance on the abundance in species groups in maize no information is available due to between farm, between region and between year differences. Only one study gives variance due to between field differences: carabid numbers caught in 10 trapping days may vary between 0-55. Relatively much data are available on de variance of abundance of different group within fields and within year (table 8). We cannot summarize these because of different units, but it is obvious that in some cases the variance within years can be very high (in aphids, for example).

In potato, no information is available on variance in species group abundance due to between fields and between farms differences. Within fields variance of carabid numbers can be as high as between 0-395 (complete year counts). Between regions the difference in counts per pitfall per summer can be 15-93 carbids. Within year, the highest variance found is between 4-33 carabid numbers per pitfall per week and between years 157-268 carabid numbers per pitfall per year were found.

Table 6: Overview on available data in fourteen relevant publications on potato and maize practice together. The management activities of the agricultural practice listed are based on the framework (see paragraph 2.1 and table 2 & 3). Symbols illustrate the number of references that do provide information on the management activity: ++, +, ±, -, -- refer to 12-14, 9-11, 6-8, 3-5 or 0-2 references that published information on constituent processes.

MANAGEMENT ACTIVITY	
1. STARTING MATERIAL	
Fungicide use	--
2. TILLAGE AND PLANTING/SOWING	
Crop rotation / previous crop	± / -
Manuring before ploughing	-
Ploughing	**--**
After ploughing tillage	**--**
Sowing/planting	--
After sowing tillage (only potato)	**--**
3. CROP MANAGEMENT	
Fertilisation	**-**
Mechanical weeding	-
Herbicides application / names of herbicides used	**- / -**
Other pesticide application / names of pesticides	**- / -**
Irrigation	--
4. HARVEST AND POST-CULTIVATION	
Leaf destruction	--
Harvesting	--
After harvest tillage	**--**
Cover/legume application	--
Sprout control	--

Table 7: Variance in measurements of species richness in literature. Lowest and highest number of species is given. In italics: lower and higher 95% confidence limits. Number of cases (n) between brackets. ><: sources of variance cannot be distinguished. More information can be found in appendix 2.

SPECIES RICHNESS			SOURCE OF VARIANCE					
			SPACE				TIME	
AUTHORS	SPEC. GROUP	CATCH. METH.	WITHIN FIELDS	BETWEEN FIELDS	BETWEEN FARMS	BETWEEN REGIONS	WITHIN YEAR	BETWEEN YEAR
Maize								
D & A, 1990	Carab.	Pitfal	*14-18 (6)* *16-20 (6)* *21-24 (6)*	15-22 (3)	-	-	Pooled	Pooled
I, 2003	Carab.	Pitf.	Pooled	*17-32 (27)*	Pooled	Pooled	Pooled	Pooled
L & L, 2004	Aran.	Plant search	*2.4-11.0 (60)*	Pooled	Pooled	Pooled	Pooled	-
M & L, 2005	Aran.	Pl.s.	Pooled	*8.5-14.5 (4)* >	*8.5-14.5 (4)* <	-	Pooled	-
S & V, 2000	Aran.	Pitf.	Pooled	17-20 (2) 19-24 (2) >	-	-	Pooled	17-20 (2) 19-24 (2) <
B, 2003	Carab.	Pitf.	Pooled	Pooled	Pooled	Pooled	11.6-12.8 (3)	Pooled
Potato								
K, 1990	Carab.	Pitf.	Pooled	25-32 (2) >	-	-	Pooled	25-32 (2) <
K, 1999	Carab.	Pitf.	Pooled	Pooled	Pooled	26-32 (3)	Pooled	Pooled
O & G, 2002	Carab.	Pitf.	Pooled	-	-	-	5-9 (5)	-
A, 1995	Carab.	Pitf.	Pooled	-	-	14-20 (2)	Pooled	-
C, 2005	Carab.	Pitf.	Pooled	13-18 (3) >	Pooled	Pooled	Pooled	13-18 (3) <
C, 2005	Aran.	Pitf.	Pooled	13-18 (3) >	Pooled	Pooled	Pooled	13-18 (3) <
S, 1995	Carab.	Pitf.	*7.3-16.3 (24)* *5.0-13.9 (25)*	Pooled	Pooled	-	Pooled	9.4-11.8 (2)
H, 2002	Carab.	Pitf.	Pooled	Pooled	-	0.5-0.8 (3)	Pooled	Pooled

Table 8: Variance in measurements of species group abundance in literature. Lowest and highest number of species is given. In italics: lower and higher 95% confidence limits. Number of cases (n) between brackets. ><: sources of variance cannot be distinguished. More information can be found in appendix 2.

Species group abundance				Source of variance					
				Space				Time	
Authors	Species group	Catch. Method.	Unit	Within field	Between fields	Between farms	Between regions	Within year	Between years
Maize									
A, 1991	Col.	Quadr. Sampl.	Ad. per m^2	Pooled	-	-	-	0-75 (11)	-
	Carab.			*5.8-11.0 (330)*	-	-	-	Pooled	-
	Staph.			*12.8-21.6 (330)*	-	-	-	Pooled	-
D & A, 1988	Carab.	Div.	Ad. per m^2	10-30 (ca. 300)	-	-	-	0-50 (10)	-
H, 1995	Aph.	Pl. s.	Ind. per 40 plants	Pooled	-	-	-	0-3750 (32)	-
I, 2003	Carab.	Pitf.	Ind. per 10 trapping days	Pooled	*0-55 (27)*	Pooled	Pooled	Pooled	Pooled
L, 1999	Carab. + Lycos.	Div.	Mg biomass per 0.5 m^2	*10-50 (6)* *5-25 (6)* *20-40 (6)* *6-14 (6)*	-	-	-	*10-30 (4)*	-
L & L, 2004	Aran.	Pl.s.	Ind. per plant	*0.6-11.3 (60)*	Pooled	Pooled	Pooled	Pooled	-
H, 2003	Lepid.	Div.	Ind. per half-field per month	Pooled	Pooled	Pooled	Pooled	1.6-2.6 (3)	Pooled
	Coll.			Pooled	Pooled	Pooled	Pooled	23-3-42.1 (2)	Pooled
	Carab.			Pooled	Pooled	Pooled	Pooled	1.6-2.7 (2)	Pooled
B, 2003	Coll.	Pitf.	Ind. per pitf.	Pooled	Pooled	Pooled	Pooled	85.6-292.0 (3)	Pooled

Table 8 (continued): Variance in measurements of species group abundance in literature: Lang et al., 1999

SPECIES GROUP ABUNDANCE				SOURCE OF VARIANCE					
				SPACE				TIME	
Authors	SPEC. GROUP			WITHIN FIELD	BETWEEN FIELDS	BETWEEN FARMS	BETWEEN REGIONS	WITHIN YEAR	Between years
MAIZE									
L, 1999	Carab.	divers	divers	*1.4-3.3 (6)*	-	-	-	1.5-4.2 (4)	-
				0-3.1 (6)					
				1.4-5.0 (6)					
				1.8-6.6 (6)					
	Staph.			*0.8-8.2 (6)*	-	-	-	1.7-4.5 (4)	-
				1.7-3.0 (6)					
				0.8-2.5 (6)					
				1.4-3.4 (6)					
	Aph.			*0-0.7 (6)*	-	-	-	0.33-37.4 (4)	-
				0.5-3.2 (6)					
				0-21.6 (6)					
				0-101.5 (6)					
	Cicad.			*0.2-4.8 (6)*	-	-	-	1.7-2.5 (4)	-
				0.1-3.2 (6)					
				0.4-3.8 (6)					
				0.9-3.1 (6)					
	Dipt.			*9.0-21.7 (6)*	-	-	-	5.8-15.3 (4)	-
				2.6-8.9 (6)					
				6.0-10.3 (6)					
				0-20.5 (6)					
	Hymen.			*3.4-7.5 (6)*	-	-	-	5..5-24.2 (4)	-
				9.6-38.7 (6)					
				13.4-13.6 (6)					
				4.6-9.8 (6)					
	Thysan.			*0-2.2 (6)*	-	-	-	1.0-7.3 (4)	-
				5.3-9.3 (6)					
				0.8-3.2 (6)					
				0.2-8.2 (6)					
	Other insects			*2.9-10.5 (6)*	-	-	-	3.3-8.4 (4)	-
				3.0-6.7 (6)					
				1.8-4.8 (6)					
				6.0-10.8 (6)					
	Lycos.			*0.7-2.0 (6)*	-	-	-	0.7-1.3 (4)	-
				0-1.5 (6)					
				0-1.5 (6)					
				0-3.0 (6)					
	Other spiders			*11.4-24.0 (6)*	-	-	-	17.7-26.5 (4)	-
				5.8-32.5 (6)					
				13.5-39.5 (6)					
				14.5-38.3 (6)					

Table 8 (continued): Variance in measurements of species group abundance in literature.

SPECIES GROUP ABUNDANCE				SOURCE OF VARIANCE					
				SPACE				TIME	
AUTHORS	SPEC. GROUP	CATCH. METH.	UNIT	WITHIN FIELD	BETWEEN FIELDS	BETWEEN FARMS	BETWEEN REGIONS	WITHIN YEAR	BETWEEN YEARS
POTATO									
K, 1990	Carab.	Pitf.	Ind. per pitf. per day	Pooled	1.4-1.8 (2) >	-	-	Pooled	1.4-1.8 (2) <
K, 1999	Carab.	Pitf.	Ind. per pitf. per day	Pooled	Pooled	Pooled	0.8-1.8 (3)	Pooled	Pooled
O & G, 2002	Carab.	Pitf.	Ind. per field per day	Pooled	-	-	-	9-59 (5)	-
S, 1995	Carab.	Pitf.	Ind. per pitf. per week/ year	*42.6-493.4 (24)* *0-394.2 (25)*	Pooled	Pooled	-	15-34 (11) 4-33 (12)	157-268 (2)
A, 1995	Carab.	Pitf.	Ind. per pitf. per summer	*78.3-108.4 (6)* *13.3-16.7 (6)*	-	-	15.0-93.3 (2)	-	-
H, 1998	Carab.	Pitf.	Ind. per pitf. per day	Pooled	Pooled	-	0.2-0.6 (3)	-	Pooled
	Linyph.			Pooled	Pooled	-	0.8-4.0 (3)	-	Pooled
H, 2002	Carab.	Pitf.	Ind. per pitf. per day	Pooled	Pooled	-	0.4-0.8 (3)	Pooled	Pooled

4 DISCUSSION

4.1 Summary of the results

All experts notified that describing a reference of the presence of non-target arthropods in conventionally managed potato and maize fields based on literature would be difficult, if not impossible, due a lack of enough relevant literature. They argued that an *a priori* reference that would be reliable enough to compare with the results of impact studies of GMO's of which the design is not known in advance, should have to incorporate knowledge of variance due to all the important sources of variance. Because of i) the lack of standard practice in potato and maize culture and ii) the many factors influencing the arthropod species richness and abundance, variance in arthropod measurements can expect to be large.

Literature searches confirmed that only limited data for such a general applicable reference are available. From the studies dealing with non-target arthropods in conventional agriculture, a minority was conducted in maize or potato fields.

Only a few of the references that could be used, marginally described the agricultural practice applied. Since in many cases no description of agricultural practice was found, it is also unclear what chemicals were being used and, therefore, whether these data meet our requirements for use. An analysis of the effect of the management activities in the agricultural practice of maize and/or potato is therefore impossible to make.

Most of the references that more or less met our requirements provide information on variance in measurements of species richness or abundance, mostly of carabids and spiders. However, when this information is distributed over the different sources of variance that were studied, it turned out that usually very few references cover a certain source of variance.

We therefore conclude that we did not find enough data to describe a general applicable reference of the presence of non-target arthropods in conventionally managed potato and maize fields and that the data given in this study should not be regarded as such.

4.2 Why are published data on arthropods in potato and maize fields so rare?

We can think of at least four reasons for the lack of published data on arthropods in conventional potato and maize crop fields.

Firstly, descriptive results of research can hardly be published in scientific journals nowadays and, therefore, studies that just try to assess the arthropod community of crop fields are probably rare. So, the only way to get information published on these communities is as part of an answer on a usually very specific and narrow scientific question. The research design for answering these questions is usually such that all sources of variance that are nor relevant are controlled for either by stratification, i.e., that the source of variance is simply excluded, for example by doing the measurement only within one field within one year, or by pooling the other sources of variance.

Secondly, obviously, the specific and narrow questions that are asked by researchers and their commissioners are much more often about cereals than about potato or maize. This could simply be due to the fact that the area used for cereal cropping is larger than that for potato or maize. Also, questions about separate management activities of maize and potato cropping are seldom asked.

Thirdly, results that cannot answer the question posed, are hard to get published. Our impression from our talks to the experts is that very often studies on arthropods in agriculture have disappointing results: several experts indicated that they had large numbers of unpublished data. This could be due to the large amount of variance that can be expected in arthropod measurements, according to the experts. This is supported by Rothery et al. (2003) who calculated that in a study aimed at finding difference between genetically modified herbicide-tolerant crops and conventional crops within a field ('half-field design') covering a range of geographic variation within the UK, about 60 fields per crop measured over three years were needed to be able to detect differences of ecological significance. Such large scale studies are rare and many studies may simply have a set-up too small for answering their research questions so that the results remain unpublished. The results published may therefore be a selected sample of the results of all studies performed: the ones that were lucky to show significance.

A fourth reason is simply the lack of money for analysing the collected samples. Experts told us that many collected samples remain unanalysed because the time it costs to analyse a sample is long and is therefore relatively expensive as compared to the collecting itself. How researchers decide on which samples they analyse and which not, is unknown to us but could be related to the previous issue: when researchers have a first impression that the study does not give significant results, they might easily decide not to analyse the samples.

4.3 Did we restrict our literature search too much?

Undoubtedly, if we had not restricted our literature search to studies of conventional potato and maize crops within north-western Europe from 1980 onwards, we would have found more data. But our aim was, according to our commission, to describe a reference for potential potato and maize GMO cropping in the Netherlands. We don't think that skipping our restriction would have led to more data that could be used for a reference. Data from before 1980 cannot be used for assessing effects of present agriculture practice due to large changes in that practice. If we had included data from North America, we would have included completely different communities. For example, spider faunas are quite different between North America and Europe, also at the level of species groups (Nyffeler & Sunderland, 2003). If we had skipped the restriction to the two crop types, we may have been able to give a general description of the arthropod communities in conventional arable cropping. But although this could have been useful information for a general discussion on the demanded performance of GMO's as compared to conventional crop varieties, it would in our view not be useful for the in advance risk assessment of modified potato and maize varieties. The same goes for allowing studies in our dataset in which not allowed pesticides were applied.

4.4 Is the expected large amount of variance in arthropod measurements really a problem?

Large amount of variance in data from the field is a well known phenomenon in ecological research. This doesn't mean that ecologists never find significant results, also not in studies aimed at arthropods in agriculture as is shown by the general overview in 3.3.1. Apart from the above discussed possibility that this is partly due to luck, i.e. that in a number of the cases that are published the variance happened to be relatively small, this is also due to fact that research design is usually such that variance that is irrelevant for answering the research question is controlled for, that is that irrelevant sources of variance are excluded.

However, in describing an *a priori* reference, it is much more difficult to exclude certain sources of variance. This is due to the fact that it is not known in advance where the studies of the effects of a GMO on non-target arthropods, with which the reference will have to be compared, will be performed – on which field, on which farm, in which region –, when it will be performed – in which months, in which year -, under which cropping practice, aimed at which arthropod groups and with which measurement methods. Of course, in theory some of the sources of variance can be controlled for by prescribing the study designs of the future GMO studies. One measurement method could be chosen by which during a fixed period of time a fixed number of measurements at a fix place within the field a selected group of arthropods is measured. But at this moment such a prescription is not available. And even then, a large number of fields could be needed as the above discussed calculations of Rothery et al. (2003) show. So, we think that the amount of variance is indeed a problem for describing a reference, even under strict prescriptions.

4.5 Are other approaches possible for an a priori risk assessment of GMO effects on non-target arthropods in the field?

Our literature search was completely focussed on species richness and abundance of non-target arthropods. However, other aspects of the ecology of these groups could also be taken into consideration. One suggestion is to collect literature on the time it takes for a population to recover after the application of a certain agricultural activity such as the application of an insecticide (Luttik, pers. comm.). These time-lags may be independent of crop type, and therefore more literature could proof to be available. For risk assessment this information could be used by estimating how the time-lag would change for GMO's. For example in case of insect control, insect-resistant Bt-maize expresses during the whole growing season in all green tissues and pollen, while the effect of an insecticide is usually limited in time (Holland & Luff, 2000; Meissle & Lang, 2005).

Also, we focussed our literature search only on conventional maize and potato cropping, not on management activities. Would a focus on the separate management activities give us enough information to estimate effects of GMO application, assuming that we could estimate the changes in management activities due to the application of GMO's? Of course, we do not know whether such an approach would result in a large amount of papers and reports. From our overview based on reviews (3.3.1) we have the impression that only literature on tillage and pesticide use might be abundant. But if enough information turned out to be available, this could only be used for risk assessment of applying genetically modified potato and maize varieties if it can be assumed that the effects of different management activities does not differ greatly between crops or regions. Although this assumption seems reasonable, it would need to be checked.

Measuring a reference of species richness and abundance of arthropods in conventional potato and maize cropping is, of course, an alternative for collecting that information from literature. By doing so, optimal information can be achieved on the management activities of interest. However, to be able to deal with all the sources of variation a large data set is needed. Once the variance of non-target arthropods species richness and abundance within the fields is known, statistical power analyses can show what research design is needed to assess the effects of GMO crop varieties as compared to conventional crop

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APPENDIX 1: Key word combinations for literature searches

Examples of combinations of key-words used in ISI Web of Knowledge:

potato AND insect
potato AND arthropod
maize AND insect
maize AND arthropod
conventional farming
conventional farming AND potato
conventional farming AND insect OR arthropod
conventional farming AND biodiversity
conventional crop(s)
conventional crop OR conventional farming AND insect OR arthropod
conventional crop OR conventional farming AND biodiversity
conventional crop OR conventional farming AND potato
conventional crop OR conventional farming AND maize
non-target AND insect OR arthropod
non-target AND insect OR arthropod AND potato
non-target AND insect OR arthropod AND maize
non-target AND insect OR arthropod AND farming
farming AND maize AND arthropod
farming AND potato AND arthropod
arthropod fauna
farming system
conventional system
system evaluation
system AND potato
system AND maize
ploughing AND potato
ploughing AND maize
rotation AND potato
rotation AND maize
Solanum tuberosum AND insect
Zea mays AND insect
corn AND insect
corn AND arthropod
corn AND rotation

Other key-words used separate or in combinations:

GMHT
crop rotation
conventional management
agro-ecology
aerial arthropod
epigeal arthropod
invertebrate biodiversity
carabidae
aranae
farm scale evaluation
non-target arthropods
arable field
arable farming
biodiversity
abundance
species richness
crop management
farming management
maize potato
macro-arthropods
system comparitive studies
nichtzielorganismen
anbau
mais
Bt-mais
insekten

APPENDIX 2: Literature overview of data on non-target arthropods in maize

Figures on species or groups have been retrieved from graphs and tables.

Alderweireldt	**1989 Belgium Maize**
An ecological analysis of the spider fauna (Araneae) occurring in maize fields, Italian ryegrass and their edge zones, by means of different multivariate techniques **In:** **Agriculture, Ecosystems and Environment** Volume: 27 Pages: 293-306	
Agricultural practice:	Rotation with 1-year shift (maize/rye/exp. field with different crops)
Chemical sprayed:	Unknown
Arthropod catching method:	24 pitfalls Ø = 4.4 cm, depth 9.0 cm, filled with 4% formaline with some detergent. Guiding plates (250x50 mm) around pitfall. Transect from the edge zone to centre (100 m from edge); n=4 7 time periods (May-September)
Data recorded in database:	spider species *Erigone altra* data per sample point along transect pooled over all sample periods
Other usable data:	Data for three other sample points in transect % males of 4 spider species.
Other data in article; not directly relevant for the project:	-

Species name	Avg. nr. of ind. per m^2 ± sd	comment
Erigone altra	162 ± 25.9	Centre data

Alderweireldt, Desender and Pollet	**1991 Belgium Maize**
Abundance and dynamics of adult and larval coleopteran in different agro-ecosystems **In:** **Advances in Coleopterology (eds: Zunino, Belles, Blas)** Pages: 223-232	
Agricultural practice:	Unknown
Chemical sprayed:	Unknown
Arthropod catching method:	Quadrat sampling (12.5x12.5 cm, depth 10-12 cm) In margin and centre of maize field; n=30 6 four-week periods in 1986
Data recorded in database:	for ind. of different coleoptera families
Other usable data:	monthly data on avg. nr. of ind. of total Coleoptera for maize margin and maize centre
Other data in article; not directly relevant for the project:	monthly data on avg. nr. of ind. of adult and larval Staphylinidae and Carabidae in de maize margin

	Avg. nr. of ind. per m^2 ± 95% conf. limit			
	In centre		In margin	
Carabidae	8.4	± 2.6	53.9	± 9.6
Chrysomelidae	0.0		3.1	± 1.6
Cryptophagidae	0.2	± 0.3	4.7	± 2.2
Curculioniae	0.3	± 0.5	5.8	± 2.6
Elateridae	0.2	± 0.3	3.3	± 2.0
Hydraenidae	0.5	± 0.6	0.6	± 0.7
Hydrophilidae	0.0		0.2	± 0.4
Staphylinidae	17.2	± 4.4	119.1	±22.0

Desender and Alderweireldt **1988** **Belgium** **Maize**	
Population dynamics of adult and larval Carabid beetles in a maize field and its boundary **In:** **Journal of Applied Entomology** Volume: 106 Pages: 13-19	
Agricultural practice:	maize sown early May, harvested and ploughed in September
Chemical sprayed:	Unknown
Arthropod catching method:	Quadrat sampling (12.5x12.5 cm, depth 10-12 cm); fenced pitfalls with guiding plates. 40x40 cm, height 25 cm, with in centre a pitfall; In margin and centre of maize field; n=30; Sampled near maize stems and in between rows ± 4 weeks sampling period
Data recorded in database:	carabid beetles (adult and larval) in centre of maize field adults for end of June (pooled data for between rows and near maize stems)

	Avg. nr. of ind. per m^{+2} ± 95% conf. limit
	End of June
Carabidae	50.1 ±16

Species name	**Avg. nr. of ind. per m^{+2} ± 95% conf. limit**
Clivina collaris	18.8 ±.9.1
Clivina fossor	7.1 ± 3.9

Other usable data:	Other sampling periods (April/May, July/Aug., Aug./Sept.,Nov
Other data in article; not directly relevant for the project:	data for larval beetles (mainly centre maize field) data for the *Clivina collaris* and *Clivina fossor* two mentioned species for between rows and near maize stems

Desender and Alderweireldt **1990** **Belgium** **Maize**	
The carabid fauna of maize fields under different rotation regimes **In:** **Med. Fac. Landbouww. Rijksuniv. Gent** Volume: 55 (2b) Pages: 493-500	
Agricultural practice:	Rotation with 1-year shift (maize/rye/exp. field with different crops) Maize sown early May, harvested and ploughed in September
Chemical sprayed:	Unknown
Arthropod catching method:	pitfalls Ø = 95 mm, depth ? mm, filled with 10% formaline. Continuous 14-days sampling period from end May- end September
Data recorded in database:	Total nr. of carabid species (± 95% conf. Limit); during whole sampling period in all pitfalls) For 1986 and 1988 in maize field with the mentioned rotation and for 1988 in monoculture maize field

	Total nr. of carabid species
Maize in rotation 1986	22
Maize in rotation 1988	18
Maize in monoculture	15

Other usable data:	No other data available
Other data in article; not directly relevant for the project:	-

Hance	**1995 Belgium Maize**
Relationships between aphid phenology and predator and parasitoid abundances in maize fields **In:** ***Arthropod natural enemies in arable land I: Density, spatial heterogeneity and dispersal* (eds. Toft and Riedel)** Pages: 113-123	
Agricultural practice:	maize sown May 13 (year unknown), 4 varieties fertilisation in ratio N:P:K 120:90:180 kg/ha
Chemical sprayed:	'CAPSOLANE' (herbicide) applied, **NOT** on list of permitted chemicals in The Netherlands
Arthropod catching method:	visual (?) observations per 10 maize plants; window traps with two water pans Ø = ?), filled with water + liquid soap; yellow traps (water pans Ø = 21 or 30 cm?), filled with water + liquid soap
Data recorded in database:	No data usable data for this project due to non-permitted chemicals used
Other usable data:	-
Other data in article; not directly relevant for the project:	From visual observations: Number of individuals of aphids (2 species mixed) per 40 plants per maize variety from May – September Number of *Coccinella septempunctata* (Coccinellidae) per 160 plants (maize varieties pooled) from May – September From window and yellow traps: Numbers of *Coccinella septempunctata* (Coccinellidae) and *Chrysopa carnea* (Chrysopidae) per trap from May – September Total numbers of individuals of Coccinellidae and Carabidae species in the window and yellow traps

Irmler	**2003 Germany Maize**
The spatial and temporal pattern of carabid beetles on arable fields in northern Germany (Schleswig-Holstein) and their value as ecological indicators **In:** **Agriculture, Ecosystems and Environment** Volume: 98 Pages: 141-151	
Agricultural practice:	Part of data deals with a study with maize in rotation: Species in rotation: maize, oat, rape, grass and rye
Chemical sprayed:	Unknown
Arthropod catching method:	pitfalls Ø = 56 mm, depth ? mm, filled with formalin + detergent. in centre of field
Data recorded in database:	No data usable data for this project, since data have been pooled over different years with different crops
Other usable data:	-
Other data in article; not directly relevant for the project:	Data on number of species or individuals per 10 trapping days (± se) pooled for different sites and crops.

Lang	**2000 Germany**	**Maize, Potato**
The pitfalls of pitfalls: a comparison of pitfall trap catches ad absolute density estimates of epigeal invertebrate predators in arable land **In:** **Anzeiger fur schadlingskunde - Journal of Pest Science**	Volume: 73	Pages: 99-106

Agricultural practice:	Crops on the field: 1994: maize 1995: winter wheat 1996: potato Detailed information on management activities only available for winter wheat cultivation
Chemical sprayed:	Detailed information during winter wheat cultivation, not for potato and maize Prior to potato cultivation 'Round-up' (herbicide) was sprayed
Arthropod catching method:	5 photoeclectors height 25 cm (5 cm in soil), covering 0.25 m^2 soil surface, with 2 pitfalls (Ø = 7 cm, depth ? mm, containing ethylene glycol + detergent) inside. A roof covered the traps; one unfenced pitfall (description see above) was placed at 1m from each photoeclector A at random in each plot Eight 7-days sampling periods (at about six-weeks intervals) during winter wheat cultivation
Data recorded in database:	No usable data for this project since data have mainly been collected for winter wheat cultivation. Data published only cover winter wheat cultivation
Other usable data:	-
Other data in article; not directly relevant for the project:	-

Lang, Filser and Henschel	**1999 Germany Maize**
Predation by ground beetles and wolf spiders on herbivorous insects in a maize crop **In:** **Agriculture, Ecosystems and Environments** Volume: 72 Pages: 189-199	
Agricultural practice:	Maize field harrowed and fertilised with liquid manure end of June 1994
Chemical sprayed:	'Starane' (herbicide) applied early June 1994 No herbicide and insecticide application afterwards
Arthropod catching method:	pitfall trapping (Ø= 7 cm, filled with ethylene-glycol and detergent, and covered with opaque roof), and D-vac suction (90 s intervals with 2.2 kW motor and nozzle Ø= 15 cm) (within enclosures) 10 enclosures (0.5m^2, Ø= 79 cm, height 25 cm of which 10 cm dug into the soil, covered with a nylon net (mesh size 0.3 mm). Total height of enclosure 100 cm; maize plants were cut to the height of 100 cm to fit in enclosures
Data recorded in database:	Average number of individuals (± sd) per arthropod group early July in 'natural density assessment enclosures'

	Avg. nr. (± sd) of ind. per arthropod group early July per 0.5 m^2	
Carabidae	2.33	± 0.49
Lycosidae	1.33	±0.33
Staphylinidae	4.50	±1.91
Beetle larvae	0.83	±0.40
Other spiders	17.67	±3.21
Other Predators	0.50	±0.22
Aphididae	0.33	±0.21
Cicadellidae	2.50	±1.15
Diptera	15.33	±3.25
Hymenoptera	5.50	±1.06
Thysanoptera	1.00	±0.63
Other insects	6.67	±1.94

Other usable data:	Average numbers of individuals per arthropod group late August Average biomass +/- sd of Carabidae and Lycosidae pooled early July and late August
Other data in article; not directly relevant for the project:	Data on enclosures that are predator enriched or predator-reduced
Additional comments:	Data are not from natural maize stands, since maize height was manipulated to fit in enclosures (see arthropod catching method).

Ludy and Lang	**2004 Germany Maize**
How to catch foliage-dwelling spiders (Aranea) in maize fields and their margins: a comparison of two sampling methods **In:** **Journal of applied Entomology** Volume: 128 (7) Pages: 501-509	
Agricultural practice:	Three sites with two maize cultivars (Antares and Navares - Syngenta) per site (2ha/field) Sown end of April, harvested in October
Chemical sprayed:	no insecticides herbicides applied in May: Lentagran, Zintan Pack, Mikado (On Dutch list: Lentagran WP, Mikado and both the components separate of which Zintan Pack is composed; if Zintan Pack is permitted is unclear)
Arthropod catching method:	per sampling data per field 20 plants selected; from 10 plants spiders were collected by suction sampling (opening 3.0 x 0.6 cm; sampling period 33.68 ± 11.12 s); 10 plants by drop cloth (20 times beaten with plastic stick (27.98 ± 8.5 s) sampling from center of maize field (al least 20 meter from margin) 5 sampling dates
Data recorded in database:	Total number of spider species in all maize fields: 21 Average number of spider individuals per maize plant: 0.59 ± 0.27 Average number of spider species per maize plant: 0.66 ± 0.22
Other usable data:	Data of total number of species and individuals per maize plant for the different sampling dates Data of total number of species and individuals available for a with nettles and some herbs planted margin adjacent to the maize field.
Other data in article; not directly relevant for the project:	Overview of numbers per spider family caught in all sites habitat and sampling methods pooled data on ind. of all spiders and different spider families for the different sampling dates

<table>
<tr><td colspan="2">Meissle and Lang 2005 Germany Maize</td></tr>
<tr><td colspan="2">Comparing methods to evaluate the effects of Bt maize and insecticide on spider assemblages
In:
Agriculture, Ecosystems and Environment Volume: 107 Pages: 359-370</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Agricultural practice:</td><td>At four sites a maize field, cv Antares, was divided in four 30 x 50 m plots. Each plot had a different treatment: Bt maize with/without insecticides, conventional maize with/without insecticides.
Management, fertilisation, herbicide treatments and sowing according standard practice.
Sowing end April/early May, herbicide treatment after ± three weeks, harvest in October</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Chemical sprayed:</td><td>herbicides used unknown
insecticide pyethroid Baytroid is not on Dutch list of permitted chemicals; therefore only unsprayed data can be used</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Arthropod catching method:</td><td>stem eclector (Ø = 8 cm, with 100 ml flask filled with 5% acetic acid, forming a stem trap (Barber 1931); emptied every 14 days); plant removal (individual plants completely sampled by removal and washing); beating sheet: single plants were beaten (sampling time 2.0 ± sd 0.4 min); spiders collected on 0.44 m² round sheet; suction sampling (sampling period 2.2 ± 0.3 min)
sampling at about 10 meter from plot edges
six sampling dates (from early July to late September)</td></tr>
<tr><td>Data recorded in database:</td><td>Data for the conventional maize field without insecticide spraying early July
<table><tr><th>Sampling method</th><th>Numbers of individuals (± se)</th></tr><tr><td>Stem eclector</td><td>0.12 ± 0.06</td></tr><tr><td>Plant removal</td><td>0.07 ± 0.14</td></tr><tr><td>Beating sheet</td><td>0.13 ± ?</td></tr><tr><td>Suction sampling</td><td>0.13 ± ?</td></tr></table>Total species and family numbers for all sampling methods pooled in conventional maize without insecticides: 11 ± 0.58 (se) species and 5.75 ± 0.48 (se) families</td></tr>
<tr><td>Other usable data:</td><td>Data available for other sampling dates</td></tr>
<tr><td>Other data in article; not directly relevant for the project:</td><td>Comparable data available for the insecticide-sprayed and Bt maize (sprayed and unsprayed)treatment
Pooled data of all treatments on avg. nr. of spider ind per 10 plants (± se)
Overview of all spiders recorded in any treatment of sampling period</td></tr>
</table>

Samaké and Volkmar **2000** **Germany** **Maize**	
Untersuchungen zum Einfluß ausgewählter Herbizide auf epigäische Raubspinnen in transgenen und herkömmlichen Mais- und Zuckerrübenbeständen **In:** **Mitt. Dtsch. Ges. Allg. Angew. Ent.** Volume: 12 Pages: 365-369	
Agricultural practice:	Unknown
Chemical sprayed:	'Gardoprim Plus' (Metolarchlor + Terbuthylazin) applied, **NOT** on list of permitted chemicals in The Netherlands No insecticides or fungicides applied
Arthropod catching method:	Barberfalls (Barber 1931), filled with 1% formalin-solution. Continuous 7-days sampling during growing season of maize (May – September)
Data recorded in database:	No data usable data for this project due to non-permitted chemicals used
Other usable data:	-
Other data in article; not directly relevant for the project:	Relative proportion, numbers of most abundant spider species and total species number per four falls per day and spider species diversity in maize-stands in 1997 and 1998.

Fadl, Purvis and Towey **1996** **Ireland** **Maize**	
The effects of time of soil cultivation on the incidence of *Pterostichus melanarius* (Illig.) (Coleoptera: carabidae) in arable land in Ireland **In:** **Ann. Zool. Fennici** Volume: 33 Pages: 201-214	
Agricultural practice:	Two of the seven fields have maize in the rotation cycle during measurements. No additional information on agricultural practice.
Chemical sprayed:	Unknown
Arthropod catching method:	10 pitfalls (Ø = 5 cm, filled with water with detergent), 7 days open at 14 days interval. Falls in line (5 meter in between two falls) in centre of each field
Data recorded in database:	No data usable data for this project since data of all crops in a year
Other usable data:	-
Other data in article; not directly relevant for the project:	weekly nr. of ind. of *Pterostichus melanarius* pooled over all crops in a year

Brooks et al.	**2003**	**United Kingdom**	**Maize**
Invertebrate responses to the management of genetically modified herbicide-tolerant and conventional spring crops. I. Soil-surface-active invertebrates			
In:			
Phil Trans. R. Soc. Lond. B	Volume: 358	Pages: 1847-1862	
Haughton, et al.	**2003**	**United Kingdom**	**Maize**
Invertebrate responses to the management of genetically modified herbicide-tolerant and conventional spring crops. II. Within-field epigeal and aerial arthropods			
In:			
Phil Trans. R. Soc. Lond. B	Volume: 358	Pages: 1863-1877	
Hawes et al.	**2003**	**United Kingdom**	**Maize**
Responses of plants and invertebrate trophic groups to contrasting herbicide regimes in the Farm Scale Evaluations of genetically modified herbicide-tolerant crops			
In:			
Phil Trans. R. Soc. Lond. B	Volume: 358	Pages: 1899-1913	

Agricultural practice:	201 fields all over United Kingdom, half conventionally managed, half with genetically modified herbicide-tolerant crops of sugar- and fodderbeet, maize, spring oilseed rape. Conventionally grown crops followed farmers' normal practice, and they used usual advise channels or advisors. Additional information electronic appendix of Champion et al 2003*
Chemical sprayed:	Major herbicides sprayed in the crops are listed in table 1 in Champion et al. 2003*. Most used is atrazine, which is NOT on the list of permitted chemicals in The Netherlands.
Arthropod catching method:	Overview of field sampling in Firbank et al. 2003**. Brooks et al: Pitfalls Ø 6 cm, filled with 50% ethylene glycol solution. 12 traps evenly distributed in each half-field in four lines (2, 8, 32 m from the edge) Three periods of 14 days trapping: late May/early June, July an August in maize. Haughton et al: Aerial arthropods were visually recorded by walking along 100 m transects once in June, July and August. In maize from step-ladder due to height of plants visual inspections in 5 x 5 m square. Bees recorded within 2 and butterflies within 5 meter. Epigeal arthropods sampled by Vortis suction sampler (comparable to D-vac suction sampler) (5 x 10 s suctions at 2 and 32 meter from the crop edge in June and August) Hawes et al: see above: Brooks et al. 2003 en Haughton et al. 2003.
Data recorded in database:	No data usable data for this project due to non-permitted chemicals used
Other usable data:	-
Other data in article; not directly relevant for the project:	Brooks et al: Analysis for total Carabidae, 15 most commonly captured carabidae, species diversity in carabidae, total Collembola (and some families), Aranae (and some families). Haughton et al: Numbers and densities of bees, butterflies, Aranea, Collembola, Carabidae, Heteroptera Hawes et al: Analysis for groups of herbivores, predators, detrivores and pollinators.

* Champion et al. 2003. Phil. Trans. R. Soc. Lond. B 358:1801-1818
** Firbank et al. 2003 Phil. Trans. R. Soc. Lond. B 358: 2-16

APPENDIX 3: Literature overview of data on non-target arthropods in potato

Figures on species or groups have been retrieved from graphs and tables.

Kromp	**1990 Austria Potato**
Carabid beetles (Coleoptera, Carabidae) as bioindicators in biological and conventional farming in Austrian potato fields **In:** **Biol. Fertil. Soils** Volume: 9 Pages: 182-187	
Agricultural practice:	Two biological and two conventional potato field were studied. Conventionally managed fields were surrounded by maize, clover, woodland and pastures. Conventionally managed fields were ploughed in autumn, harrowed, ploughed and harrowed in spring, 4 x ridged + 2 x flexible harrowed and fertilised in autumn (stable manure) and spring (stable and semi-liquid manure, NPK)
Chemical sprayed:	Terbuthylazine and terbutryn was applied on one of the conventionally managed fields. This is **NOT** on the list of permitted chemicals in The Netherlands.
Arthropod catching method:	pitfalls Ø = 85 mm, depth 80 mm, filled with 4% formaline with a some detergent, covered with 20 x 20 cm plate. Three groups of four traps in 10m^2; between groups 80 m, at least 15 meter from field edge. 7-14 days sampling periods from late May - early September
Data recorded in database:	Numbers of dominant (>2%) carabid species per field Total species per field: 32

Species name	**Nr. of ind.**
Platynus dorsalis	93
Trechus quadristriatus	108
Poecilus cupreus	9
Bembidion quadrimaculatum	34
Loricera pilicornis	11
Pterostichus melanarius	811
Carabus scheidleri	50
Amara consularis	15
Carabus cancellatus	16
Harpalus rufipes	20
Calathus melanocephalus	12
Poecilus versicolor	49
Bembidion lampros	70
Calathus fuscipes	58
Dyschirius globosus	6
other species/individuals	17/78

Other usabledata:	No other data available
Other data in article; not directly relevant for the project:	Data of ind. of mentioned species biologically managed fields and of maize field with terbuthylazine applied

Kromp	**1999 Austria Potato**
Carabid beetles in sustainable agriculture: a review on pest control efficacy, cultivation impacts and enhancement **In:** **Agriculture, Ecosystems and Environment** Volume: 74 Pages: 187-228	
Agricultural practice:	For Upper Austria (see Kromp 1990): Two biological and two conventional potato field were studied. Conventionally managed fields were surrounded by maize, clover, woodland and pastures. Conventionally managed fields were ploughed in autumn, harrowed, ploughed and harrowed in spring, 4 x ridged + 2 x flexible harrowed and fertilised in autumn (stable manure) and spring (stable and semi-liquid manure, NPK) For Carinthia see Kromp (1985): unknown
Chemical sprayed:	See Kromp 1990; Kromp 1985
Arthropod catching method:	Data for Upper Austria: pitfalls Ø = 85 mm, depth 80 mm, filled with 4% formaline with a some detergent, covered with 20 x 20 cm plate. Three groups of four traps in $10m^2$; between groups 80 m, at least 15 meter from field edge. 7-14 days sampling periods from late May - early September Data for Carinthia: catching method unknown
Data recorded in database:	Average number of Carabidae per trap per day in 1980 Total number of carabid species caught in 1980
Other usable data:	No other data available
Other data in article; not directly relevant for the project:	Comparable data for winter and dinkle wheat

Sites	**Avg. nr. Carabidae per trap per day**	**Total number of carabid species**
Upper Austria P1	1.8	26
Upper Austria P2	1.4	32
Carinthia P3	0.8	27

* Kromp (1985) Zur Laufkäfer (Coleoptera, Carabidae) von Ackern in drei Gegenden Osterreichs unter besonderer Berücksichtigung der Bewirtschaftungsweise, Ph.D. Thesis, University of Vienna; 218 p.

O'sullivan and Gormally	**2002 Ireland Potato**
A comparison of ground beetle (Carabidae: Coleoptera) communities in an organic and conventional potato crop **In:** **Biological Agriculture and Horticulture** Volume: 20 Pages: 99-110	
Agricultural practice:	Conventional grown potato followed rape Ploughed in October, rotivated twice, fertilised and sown on 30 April 1999 Cultivars Kerrs Pink and Golden Wonder
Chemical sprayed:	Roundup was sprayed in autumn 1998 Sencorex, Ridomil, Breston 60 and Fentin flow were applied. Of these chemicals only Ridomil is permitted; the other chemicals are **NOT** on list of permitted chemicals in The Netherlands
Arthropod catching method:	Pitfalls Ø = 11 cm, depth 12 mm, filled with 20% ethylene glycol-solution with some detergent and covered with 15 x 15 cm board. Pitfalls placed at 4 and 15 meter from edges in conventionally managed crops Continuous 14-days sampling during growing season of maize (June – September 1999, no sampling from 7-21 July)
Data recorded in database:	No data usable data for this project due to non-permitted chemicals used
Other usable data:	Number of individuals (abundance) of carabid species during whole sampling period. Total carabid individuals and number of carabid species per sampling period
Other data in article; not directly relevant for the project:	Comparable data for organic managed fields

Lang	**2000 Germany Maize, Potato**
The pitfalls of pitfalls: a comparison of pitfall trap catches ad absolute density estimates of epigeal invertebrate predators in arable land **In:** **Anzeiger fur schadlingslingskunde - Journal of Pest Science** Volume: 73 Pages: 99-106	
Agricultural practice:	Crops on the field: 1994: maize 1995: winter wheat 1996: potato Detailed information on management activities only available for winter wheat cultivation
Chemical sprayed:	Detailed information during winter wheat cultivation, not for potato and maize Prior to potato cultivation 'Round-up' (herbicide) was sprayed
Arthropod catching method:	5 photoeclectors height 25 cm (5 cm in soil), covering 0.25 m^2 soil surface, with 2 pitfalls (Ø = 7 cm, depth ? mm, containing ethylene glycol + detergent) inside. A roof covered the traps; one unfenced pitfall (description see above) was placed at 1m from each photoeclector A at random in each plot Eight 7-days sampling periods (at about six-weeks intervals) during winter wheat cultivation
Data recorded in database:	No usable data for this project since data have mainly been collected for winter wheat cultivation. Data published only cover winter wheat cultivation
Other usable data:	-
Other data in article; not directly relevant for the project:	-

Andersen and Eltun	**2000 Norway Potato**
Long-term developments in the carabid and staphylinid (Col. Carabidae and Staphylinidae) fauna during conversion from conventional to biological farming **In:** **Journal of Applied Entomology** Volume: 124 Pages: 51-56	
Agricultural practice:	8-crop rotation in conventional managed fields: early potato/winter wheat, winter wheat, oats, barley, late potatoes, spring wheat, oats, barley. for whole cropping system see Eltun (1994) and Eltun and Riley (1994)
Chemical sprayed:	Unknown see Eltun (1994) and Eltun and Riley (1994)
Arthropod catching method:	5 Pitfalls (Ø = 7 cm, depth ?, filled with water and some detergent) in Barley-plots. Emptied twice a week from mid May to mid August.
Data recorded in database:	No data usable data since pitfalls were situated in Barley plots, not in the potato plots of the rotation cycle.
Other usable data:	-
Other data in article; not directly relevant for the project:	Data on numbers of carabids and staphylinids at Apelsvoll barley fields Shannon-Weaver diversity numbers in barley plots at Apelsvoll

Booij	**1994 The Netherlands Potato**
Diversity patterns in carabid assemblages in relation to crops and farming systems **In:** **Carabid beetles: Ecology and Evolution** ***(eds. Desender et al)*** Pages: 425-431	
Agricultural practice:	Six crops (wheat, pea, potato, beet, onion, carrot) in conventional, integrated and organic farming systems over three consecutive years For details on the farming system see Vereijken (1986)*
Chemical sprayed:	Unknown during growing season; dichlorepropene was used in nematode fumigation after each potato drop. This is **NOT** on the list of permitted chemicals in The Netherlands. See Vereijken (1986).
Arthropod catching method:	4 Pitfalls (Ø = 10 cm, depth ?, filled with 4% formaline solution. Sampling period during growing season (May- half August), emptied weekly.
Data recorded in database:	No data usable data since either data for all systems (conventional, integrated and organic) or for all crops are pooled.
Other usable data:	-
Other data in article; not directly relevant for the project:	Data on species numbers per trap per year expressed per crop, but pooled per farming system, or expressed per farming system, but pooled for all crops

* Vereijken (1986) Netherlands Journal of Agricultural Science 34 (387-393)

Booij and Noorlander	**1992 The Netherlands Potato**
Farming systems and insect predators **In:** **Agriculture, Ecosystems and Environment** Volume: 40 Pages: 125-135	
Agricultural practice:	Six crops (wheat, pea, potato, beet, onion, carrot) in conventional, integrated and organic farming systems over three consecutive years For details on the farming system see Vereijken (1986)*
Chemical sprayed:	Unknown during growing season; dichlorepropene was used in nematode fumigation after each potato drop. This is **NOT** on the list of permitted chemicals in The Netherlands. See Vereijken (1986).
Arthropod catching method:	4 Pitfalls (Ø = 10 cm, depth ?, filled with 4% formaline solution. Sampling period during growing season (May- half August), emptied weekly.
Data recorded in database:	Data on carabid, staphylinids and liniphylids numbers pooled per crop and farming system over three years.
Other usable data:	Data on nr. of species per trap per year pooled per crop per farming system over three years (species/trap per year) for carabids and spiders
Other data in article; not directly relevant for the project:	-

Group	**Total numbers from 1985-1987**
Carabidae	277
Staphylinidae	90
Linyphiidae	119

* Vereijken (1986) Netherlands Journal of Agricultural Science 34 (387-393)

de Snoo, van der Poll and de Leeuw	**1995 The Netherlands Potato**
Carabids in sprayed and unsprayed crop edges of winter wheat, sugar beet and potatoes **In:** **Arthropod natural enemies in arable land I Densities, spatial heterogeneity and dispersal** ***(eds. Toft and Riedel)*** Pages: 199-211	
Agricultural practice:	7 farms; avg. field size: 5.2 ha (500 x 100 m); from which 5 potato fields most common rotation: winter wheat, potatoes, winter wheat, sugar beet. conventional fertilisation and tillage regimes maintained
Chemical sprayed:	sprayed edge sprayed with methribuzin, parathion, dimethoate, menab; from which parathion is **NOT** on the list of permitted chemicals in The Netherlands unsprayed edge: no herbicides or insecticides were allowed, fungicide application was allowed
Arthropod catching method:	6 pitfalls (Ø = 11.3 cm, depth ? mm, filled with 4% formalin in 1990 and with 50% ethylene glycol in 1991). A plastic roof covered the traps. 4 or 5 traps were placed 15 m along crop edge; 1.5 m from field edge Weekly sampling in 1990 13 weeks and in 1991 12 weeks from May to end of July.
Data recorded in database:	No usable data on conventionally managed field edges since parathion is not on the list of permitted chemicals in The Netherlands.
Other usable data:	Data from sprayed and unsprayed zone: Total avg.nr. of carabid individuals and species per trap per year for 1990 and 1991 Avg. nr. of carabid individuals per trap per week from May to end of July in 1990 and 1991 Total avg. nr. of some selected carabid species per trap per year
Other data in article; not directly relevant for the project:	Comparable data available for winter wheat and sugar beet

Armstrong	**1995 United Kingdom Potato**
Carabid beetle (Coleoptera: Carabidae) diversity and abundance in organic potatoes and conventionally grown seed potatoes in the north of Scotland **In:** **Pedobiologia** Volume: 39 Pages: 231-237	
Agricultural practice:	At two sites organic and conventional potatoes were grown. Potatoes were planted in mid-April and mid-May. In conventionally grown potatoes Liquid fertiliser was Applied after planting the potatoes.
Chemical sprayed:	Decisquick was applied as aphicide and is **NOT** on the list of permitted chemicals in The Netherlands
Arthropod catching method:	6 pitfalls (Ø = 7.5 cm, depth 9.5 mm, filled with ethylene glycol). A roof covered the traps. weekly sampling from 12th June till 7th August; but only 5 were processed.
Data recorded in database:	No usable data for this project since applied chemical is NOT on the list of permitted chemicals in The Netherlands.
Other usable data:	Cumulative average numbers of individuals per carabid species per trap ± se for whole sampling period total numbers of pitfall catches per sampling period.
Other data in article; not directly relevant for the project:	Comparable data available for organic fields

Cole et al.	**2005 United Kingdom Potato**
Comparing the effects of farming practices on ground beetle (Coleoptera: Carabidae) and spider (Aranae) assemblages of Scottish farmland **In:** **Biodiversity and Conservation** Volume: 14 Pages: 441-460	
Agricultural practice:	Unknown
Chemical sprayed:	Unknown
Arthropod catching method:	9 pitfalls (Ø = 7.5 cm, depth 10 cm, filled with monopropylene glycol). A 15mm mesh grid prevented life stock and small animals entering the pitfalls. 16 m transect; data collected and pooled at monthly intervals from 1998-2000; only first year of recorded data were used
Data recorded in database:	Number of carabid and spider species
Other usable data:	no additional data
Other data in article; not directly relevant for the project:	Comparable data available for 72 other sites (a.o. rye, cereal, mixed crop fields etc.)

Site nr.		**Number of Carabid species**	**Number of Spider species**
29	1998	18	16
30	1999	18	18
31	2000	13	13

Holland et al.	**1998 United Kingdom Potato**
The impact on non-target arthropods of integrated compared to conventional farming: results from the LINK integrated farming systems project **In:** **The 1998 Brighton conference - Pests & Diseases** Pages: 625-630	
Agricultural practice:	6 farms, with 7 plots (1/2 conventional practice) 5-coarse rotation (cereals and break crops); each rotation coarse present at each site each year. Management followed local practice (details unknown)
Chemical sprayed:	herbicides were applied, but unknown what herbicides (Ogilvy et al. 1994)
Arthropod catching method:	5 pitfalls (Ø = ? cm, depth ? mm, filled with water and some detergent) 2 transects with sampling every 10 meter, starting 30 meter from edge 5-days periods at monthly intervals through crop growing season
Data recorded in database:	Data on Carabidae and Linyphiidae over 5 years (1992-1997) per pitfall trap per day in June at three sites (Sacrewell, Lower Hope and High MowThorpe)
Other usable data:	No data available
Other data in article; not directly relevant for the project:	Comparable data for winter wheat, peas, oil seed rape, etc.

Site	**Avg. nr. of Carabidae/ pitfall trap/ day**	**Avg. nr. of Linyphiidae/ pitfall trap/ day**
Sacrewell	0.6	1.0
Hope Mowthorpe	0.3	0.5
Lower Hope	0.7	3.8

[*] Ogilvy et al. (1994) Aspects of applied biology 40: 53-60

<table>
<tr><td colspan="2">Holland et al. 2002 United Kingdom Potato</td></tr>
<tr><td colspan="2">Carabids as indicators within temperate arable farming systems: Implications from SCARAB and LINK integrated farming systems projects
In:
The agroecology of carabid beetles (ed. Holland) Pages: 251-277</td></tr>
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2 transects with sampling every 10 meter, starting 30 meter from edge
5-days periods at monthly intervals through crop growing season</td></tr>
<tr><td>Data available on arthropod groups:</td><td>Data on Pterostichus melanarius in July

The average number of Pterostichus melanarius individuals per pitfall per day in July
<table>
<tr><th>Site</th><th>Avg. nr. of ind./pitfall/day</th></tr>
<tr><td>High Mowthorpe</td><td>0.71</td></tr>
<tr><td>Lower Hope</td><td>0.17</td></tr>
</table></td></tr>
<tr><td>Other data available</td><td>Pooled data from April-July over 5 years (1992-1997) of carabid individuals per trap per day at three sites (Sacrewell, Lower Hope and High MowThorpe)
Pooled data from April-July over 5 years (1992-1997) of carabid species per trap per day at three sites (Sacrewell, Lower Hope and High MowThorpe)</td></tr>
<tr><td>Not usable data</td><td>Comparable data for other crops: a.o. winter wheat, peas, etc.
Totals of carabids trapped in all crops over the sampling period</td></tr>
</table>

*Ogilvy et al. (1994) Aspects of applied biology 40: 53-60