IMPACT OF DIFFERENT FARMING SYSTEMS ON EPIGEIC BENEFICIAL ARTHROPODS AND EARTHWORM FAUNA IN ARABLE CROPS

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SUMMARY

Effects of different traditional (conventional, integrated) and organic ('organic-biological' and bio-dynamic) farming systems on epigeic beneficial arthropods and earthworm fauna were investigated. All comparative investigations were performed in regular crop rotations on arable land. In Part A, the trials were performed within the DOC long-term trial at Therwil, Switzerland, and afterwards a paired farm approach was used to analyse on-farm situation including semi-natural habitats (Part B). Appropriate standard sampling methods were applied. Beneficial arthropods were sampled with funnel pitfall traps (live trapping in the DOC trial; on-farm trial with a killing trapping fluid) or with undisturbed soil cores using a hydraulic soil borer (overwintering study). Earthworms were analysed by handsorting with or without extraction with a mustard flour solution.

In general, the term *organic farming systems* include organic and bio-dynamic farming.

PART A: COMPARISON OF CONVENTIONAL WITH ORGANIC FARMING SYSTEMS IN SIMILAR SURROUNDINGS – RESULTS OF DOC LONG-TERM TRIAL

Beneficial arthropods were investigated in conventional, organic and bio-dynamic winter wheat plots. Earthworms were sampled in the unfertilised treatment and purely mineral fertilised treatment additionally and further crops such as beetroot, potatoes were included. The surroundings, the soil conditions and soil tillage were similar in all treatments with the same crop rotation and field history.

Chapter 1: Some farming related effects on the communities of beneficial arthropods were found: Acitivity density of carabids, staphylinids and spiders were in most cases higher in both organic farming systems than in the conventional system within a 3-year investigation period. The carabid communities found in organic systems were richer in species and species were more evenly distributed. Despite the close proximity and the small plot-size seven of 39 sampled species were found exclusively in the organic farming systems. Helio- and thermophilous species (e.g. *Brachinus explodens, Stenolophus teutonus*), phyto-zoophagous species of the genus *Amara* and *Harpalus*, and four species of the genus *Carabus* were more abundant in the organic plots. The higher activity-density of carabids in organic plots was most pronounced in spring compared to the conventional treatment. No significant differences were found between the two organic systems. Farming systems differed mainly in plant protection and fertilising management. Thus, direct and indirect effects of these practices are considered as most responsible driving forces.

Chapter 2 and 3: Eleven earthworm species were found at the site of the DOC-trial. *Nicodrilus longus, Nicodrilus nocturnus, Nicodrilus caliginosus* und *Allolobophora rosea* were the dominant species in all five treatments. The species diversity were lowest in the purely mineral fertilised and in the unfertilised treatment. Earthworm biomass, density, the occurrence of anecic, agroecolgically important species and the number of juvenile earthworms were significantly higher in both organic farming systems than in the two conventional and unfertilised treatments. The earthworm communities found in both conventional treatments were similar to the unfertilised treatment (no fertilizer for at least 12 years). Farm practices such as plant protection and the type and amount of fertilizers are considered as main driving factors.

PART B: SEMI-NATURAL HABITATS AND LOW-INPUT FARMING SYSTEMS - RESULTS OF COMPARATIVE STUDIES USING A PAIRED FARM APPROACH INCLUDING THE NEARBY SEMI-NATURAL HABITATS

The investigations were performed on representative integrated and organic farms in north-western Switzerland.

To assess the relative significance of semi-natural habitats to epigeic arthropods, the over-wintering was compared in arable crops with the adjacent semi-natural habitat on a integrated and a organic farm.

Chapter 4: The densities of arthropods found in arable fields were significant lower than in the semi-natural habitats. Ten fold higher densities of up to 1163 individuals per m^2 were measured in a semi-natural habitat (wild flower strip) than in the arable crops. With a total of 90 arthropod species in the semi-natural habitats, five times more species were found. Highest abundances and species diversities were found in a 3-year old wildflower strip, a hedge, a permanent meadow and a meadow under the cherry trees of an organic farm. Staphylinids, carabids, spiders and chilopods were the most abundant arthropod groups.
The data showed that undisturbed semi-natural habitats and low-input field margins play a key role as overwintering sites for many arthropods. This was encouraged by structural complexity, botanical diversity, the permanent vegetation layer and the temperature buffering soil litter in these more or less undisturbed habitats.

Effects of two different low-input farming systems (ICM and organic) on carabid, spider and earthworm fauna were investigated in 24 winter wheat fields on twelve farms. The study was performed in a 3-year field survey using a paired-farm approach in six different landscape units in northwestern Switzerland considering also the nearby semi-natural habitats. Eighteen elements were sampled within the study of arthropods and two field margins within the investigation of earthworms. Low-input ICM farming (ICM) within the State program 'Extenso cereal production' uses no insecticides, fungicides and growth regulators in the cereal production system, though herbicides are allowed and used.

Chapter 5: Considering all cereal sites, an extensive database of 82'298 carabids and spiders consisting of 237 species were generated. 36% fewer carabids and 8% fewer spider specimens were found in low-input ICM fields. In several cases, carabid populations of organic fields were significantly richer in species and abundance than in the low-input integrated crop management farmed plots. Spider communities differed less in mean number of species and abundance between the two low-input agricultural systems.
Multivariate analysis showed that farming method and weed abundance were significant factors altering the carabid fauna and weed diversity influenced spider fauna. Some farming system related effects could be detected on species level: Endangered, stenoceous carabids (e.g. *Carabus auratus*, *Diachromus germanus*) and top-predators (e.g. *Agonum* muelleri, *Poecilus* cupreus) were significantly more abundant in the organic fields. Wolfspiders such as *Pardosa agrestis*, *P. palustris* and *Trochosa ruricola* seem to be enhanced by organic management. Linyphiids (*Erigone atra*, *Oedothorax apicatus*) were more abundant in low-input ICM fields. Several carabid species and wolfspiders, which have their main biological distribution in semi-natural habitats were more abundant in organic fields.
As conclusion, there is some evidence that semi-natural habitats in combination with organic farming may play an important role in the conservation and enhancement of species-rich carabid and spider assemblages on arable land.

Chapter 6: Differences of earthworm communities were found between and within the farming systems. In 14 of 24 cases, earthworms of organic fields were significantly richer in abundance and biomass than in the integrated crop management farmed plots (ICM) with low-input; whereas the biomass resp. the abundances in ICM fields were significantly higher in 4 resp. 5 cases. The number of earthworm species and juveniles were mostly significantly lower in ICM fields. Anecic, deep burrowing species such as *Lumbricus terrestris, Nicodrilus longus* and *Nicodrilus nocturnus* as well as endogeic species such as *Nicodrilus caliginosus, Allolobophora rosea* were in two of three years significantly higher in the organic fields than in the low-input ICM fields.

Soil tillage, particularly a late ploughing at high earthworm activity, clearly had a major negative effect on earthworm abundance, irrespective of farming system. Using a cluster analysis dissimilarities of earthworm communities were detected between the two farming systems. The earthworm communities of organic fields were more similar to low-input grassy field margins. Redundance analysis (RDA) showed that the farming method, the cereal density and the soil potassium content were significant factors altering the earthworm fauna. Farming practices that may considerably influence earthworms within and between the farming systems were discussed.

These investigations have shown positive effects of organic farming systems on epigeic beneficial arthropods and earthworm populations in comparsion with conventional and integrated farming systems – this was found on a field plot-trial scale as well as on-farm investigations. If organic farming is linked with semi-natural habitats diverse communities of spiders and carabids can be conserved. This can fulfil multiple objectives in agroecology and nature conservation.

With higher farming intensity there is a higher risk that agro-ecologically important species (top predators, deep burrowing earthworm species) as well as nature conservation relevant species will be reduced. Such population changes have implications for pest control, soil fertility and other ecosystem functions.

ZUSAMMENFASSUNG

In dieser Arbeit wurden die Auswirkungen unterschiedlicher traditioneller (konventionell, integriert) und biologischer (organisch-biologisch, bio-dynamisch) Anbausysteme auf die epigäischen Nutzarthropoden und die Regenwurmfauna untersucht. Alle vergleichenden Erhebungen wurden in geregelten Ackerfruchtfolgen durchgeführt. Einerseits waren dies Untersuchungen im DOK-Langzeit-Exaktparzellenversuch in Therwil (Teil A), und andererseits stand danach die Analyse der Praxissituation im Rahmen von Paarbetriebsvergleichen unter Berücksichtigung des Umfeldes der Produktionsflächen (Teil B) im Vordergrund. Es wurden stets der Versuchsanlage angepasste Standardmethoden angewandt. Die Nutzarthropoden wurden mit Trichterbodenfallen (Lebendfang im DOK-Versuch; mit abtötender Fangflüssigkeit in Betriebsvergleichen) oder mit ungestörten Bodenproben (Überwinterungsstudie) erfasst. Die Regenwürmer wurden mit der Handauslese-Methode mit oder ohne vorgängiger Austreibung untersucht.

TEIL A: VERGLEICH KONVENTIONELLER MIT BIOLOGISCHEN ANBAUSYSTEMEN IN ÄHNLICHEM UMFELD - ERGEBNISSE AUS DEM DOK-LANGZEIT-EXAKTPARZELLENVERSUCH

Die Erhebungen der Nutzarthropodenfauna wurden im konventionellen, organisch-biologischen und bio-dynamischen Winterweizen durchgeführt. In der Untersuchung der Regenwürmer konnten zusätzlich das ungedüngte und das rein mineralisch gedüngte Verfahren und weitere Kulturarten (nach Randen, Kartoffeln) beprobt werden. Das Umfeld, die allgemeinen Bodenverhältnisse und die Bodenbearbeitung waren in allen Anbausystemen/Verfahren sehr ähnlich, die Fruchtfolge und Vorgeschichte der Parzellen waren identisch.

Kapitel 1: Verschiedene anbauspezifische Effekte auf die Gemeinschaften der Nutzarthropodenfauna wurden festgestellt: Die Aktivitätsdichten der Carabiden, Staphyliniden und Spinnen waren in den beiden Bioverfahren in den meisten Fällen der drei Untersuchungsjahre signifikant höher als im konventionellen Verfahren. Die Läufkäfergemeinschaft, die näher analysiert wurde, war in den Bioverfahren artenreicher und hinsichtlich artspezifischer Dominanzen ausgeglichener. Trotz direkter Nachbarschaft und kleinflächigen Parzellen wurden von den insgesamt 39 gefundenen Laufkäferarten sieben ausschliesslich in den Bioverfahren und eine exklusiv im konventionellen Anbausystem nachgewiesen. Helio- oder thermophile Arten (z.B. *Brachinus explodens*, *Stenolophus teutonus*), phyto-zoophage Arten der Gattungen *Amara* und *Harpalus* und vier Arten der Grosslaufkäfer der Gattung *Carabus* kamen am zahlreichsten in den Bioverfahren vor. Die in den Bioverfahren höheren Aktivitätsdichten unterschieden sich in der Frühlingsperiode am ausgeprägtesten vom konventionellen Verfahren. Zwischen den beiden Bioverfahren wurden keine signifikanten

Unterschiede gefunden. Die Anbausysteme unterschieden sich am stärksten im Pflanzenschutz und in der Pflanzenernährung. Die direkten und indirekten Effekte dieser zwei Faktoren wurden als hauptverantwortlich für die festgestellten Unterschieden diskutiert.

Kapitel 2 & 3: Im Rahmen der Untersuchung der Regenwurmfauna wurden elf Arten gefunden. Dabei waren *Nicodrilus longus, Nicodrilus nocturnus, Nicodrilus caliginosus* und *Allolobophora rosea* die dominanten Arten in allen fünf untersuchten Verfahren. Die Artendiversität war im rein mineralisch und ungedüngten Verfahren am tiefsten. Die Biomasse, die Dichte der Regenwürmer und das Vorkommen von agrarökologisch wichtigen, vertikalgrabenden Arten und die Anzahl der juvenilen Tiere waren in den beiden Bioverfahren signifikant höher als in den zwei konventionellen und dem ungedüngten Verfahren. Die beiden konventionellen Verfahren wiesen einen ähnlichen Regenwurmbesatz auf wie das seit mindestens 12 Jahren ungedüngte Verfahren. Die Massnahmen im Pflanzenschutz wurden abschliessend als Hauptfaktor für die festgestellten Unterschiede diskutiert und die Art und Menge der Düngung als sekundärer Faktor.

TEIL B: ÖKOLOGISCHER AUSGLEICH UND LOW-INPUT ANBAUSYSTEME - ERGEBNISSE AUS PAARBETRIEBSVERGLEICHEN UNTER BERÜCKSICHTIGUNG DES UMFELDES DER PRODUKTIONSFLÄCHEN

Die Erhebungen wurden auf repräsentativen Praxisbetrieben im Rahmen von Paarbetriebs-vergleichen durchgeführt.

Um die Bedeutung der ökologischen Ausgleichsflächen für die (Nutz-) Arthropodenfauna abzuschätzen, wurde die Überwinterung in verschiedenen Ausgleichsflächen mit den angrenzenden Ackerflächen auf einem integriert und biologisch bewirtschafteten Betrieb analysiert.

Kapitel 4: Die Abundanzen der Arthropoden in den Ackerflächen waren signifikant tiefer als in den ökologischen Ausgleichsflächen. Mit bis zu 1163 Individuen pro m^2 wurde mehr als eine 10-fach höhere Besatzdichte in ökologischen Ausgleichsflächen (Buntbrache) als in der Ackerfläche festgestellt. Mit ingesamt 90 nachgewiesenen Arthropodenarten in den Ausgleichsflächen wurden dort 5 Mal mehr Arten gefunden. Die höchsten Abundanzen und Diversitäten der Arthropoden wurden in einer Buntbrache, Hecke und in extensiv genutzten Dauergrünlandstreifen auf dem Biobetrieb festgestellt. Die Staphyliniden, Carabiden, Spinnen und Chilopoden stellten dabei die dominanten Tiergruppen dar.
Die Ergbebnisse haben deutlich aufgezeigt, dass diese ökologischen Ausgleichsflächen eine zentrale Rolle für die Überwinterung vieler Arthropodenarten im ackerbaulich geprägten Kulturland spielen. Die hohe strukturelle und botanische Diversität und die reichhaltige und

wärmeisolierende Streuschicht in diesen relativ ungestörten Flächen waren wahrscheinlich die wesentlichen, positiven Einflussfaktoren.

Auswirkungen von zwei low-input Anbausystemen (IP-Extenso- und Bioanbau) auf die Laufkäfer-, Spinnen- und Regenwurmfauna wurden in 24 Wintergetreideflächen untersucht. Sechs vergleichbare Paarbetriebe in sechs Landschaften der Nord-Westschweiz wurden dazu ausgewählt – in der Arthropoden-Untersuchung wurden die im Umfeld liegenden 18 ökologischen Ausgleichsflächen und bei den Regenwürmern zwei angrenzende Wieslandstreifen mitberücksichtigt. IP-Extenso-Anbau bedeutet im Getreidebau keine Anwendung von Fungiziden, Insektiziden und Wachstumsregulatoren – Herbizide sind zugelassen.

Kapitel 5: Über alle Untersuchungsflächen wurden mit insgesamt 82'298 Laufkäfern und Spinnen und 237 Arten ein umfangreicher Datensatz generiert. In den IP-Extenso bewirtschafteten Getreideflächen wurden dabei 36% weniger Laufkäfer und 8% weniger Spinnentiere gefunden. Auf der Ebene der Paarbetriebe waren in einigen Vergleichsfällen die Artenvielfalt und Aktivitätsdichte der Laufkäfer in den biologisch bewirtschafteten Wintergetreideflächen signifikant höher als in den IP-Extenso Flächen. Bei der Spinnenfauna ergaben sich weniger deutliche Unterschiede.
Multivariate Analysen ergaben, dass die Anbaumethode und die Dichte der Begleitflora die Laufkäfer und die Begleifloravielfalt die Spinnen signifikant beeinflusst haben. Verschiedene anbauspezifische Effekte auf gewisse Arten wurden festgestellt: Gefährdete, stenöke Laufkäferarten (z.B. *Carabus auratus*, *Diachromus germanus*) und agraökologisch wichtige Prädatoren (z.B. *Agonum* muelleri, *Poecilus* cupreus) waren in den biologisch bewirtschafteten Flächen signifikant zahlreicher. Wolfspinnen wie *Pardosa agrestis, P. palustris* und *Trochosa ruricola* wurden durch die biologische Bewirtschaftung gefördert. Linyphiiden hingegen wie *Erigone atra*, *Oedothorax apicatus* waren in den IP-Extenso Flächen zahlreicher. Verschiedene Laufkäfer- und Wolfspinnenarten, die biogeographisch hautpsächlich in ökologischen Ausgleichsflächen vorkommen, kamen in den Biogetreideflächen zahlreicher vor. Abschliessend erwies sich die Kombination von ökologischen Flächen mit biologischem Anbau als wichtige Einflussgrösse für die Erhaltung von artenreichen Laufkäfer- und Spinnengemeinschaften im ackerbaulich geprägten Kulturland.

Kapitel 6: Die Abundanz und Biomasse der Regenwürmer waren in 14 von 24 Fällen in den IP-Extenso Flächen signifikant tiefer als in den entsprechenden Bioflächen. In vier bzw. fünf Fällen war die Biomasse bzw. die Abundanz in den Bioflächen signifikant geringer. Die Diversität der Regenwürmer, die Anzahl der juvenilen Tiere und das Vorkommen vertikalgrabender, anözischer Arten wie *Lumbricus terrestris, Nicodrilus longus* und *Nicodrilus nocturnus* sowie dasjenige endogäischer Arten (*Nicodrilus caliginosus*, *Allolobophora rosea*) waren in zwei von drei Jahren in den Bioflächen signifikant zahlreicher. Der Bodenbearbeitung insbesondere ein später Pflugeinsatz im Herbst erwies sich, unabhängig vom Anbausystem, als stark Regenwurm reduzierend.

Multivariate Analysen ergaben, dass auf der Basis einer Clusteranalyse eine relative Ähnlichkeit zwischen den Regenwurm-Gemeinschaften in den Bioflächen und denjenigen in den extensiv genutzten Wieslandstreifen bestand. Eine Redundanz-Analyse (RDA) zeigte zudem auf, dass das Anbausystem, die Bestandesdichte und der Bodenkaliumgehalt wesentliche Einflussfaktoren waren, die die Gemeinschaften der Regenwürmer signifikant beeinflusst haben.

Aus den Untersuchungen im Exakt-Parzellenversuch sowie im Paarbetriebsvergleich ergibt sich, dass sich der biologische Ackerbau nachweislich positiv auf die Nutzarthropoden- und Regenwurmfauna im Vergleich zur konventionellen oder integrierten Anbaumethode auswirkt. Der biologische Anbau hat zudem ein interessantes Potential aufgezeigt, die Laufkäfer- und Spinnenfauna im Kulturland aus agrarökologischer sowie naturschutzfachlicher Sicht auf beachtlichem Niveau zu erhalten, sofern das Umfeld der Produktionsflächen mit verschiedenen ökologischen Ausgleichsflächen ausgestattet ist.

Je höher die Anbauintensität steigt, desto grösser wird die Wahrscheinlichkeit, dass Populationen agrarökologisch wichtiger Artengruppen (z.B. vertikalgrabende Regenwurmarten, Top-Prädatoren) und naturschutzrelevanter Arten (z.B. ‚Spezialisten' wie xero-thermophile, heliophile oder gefährdete Arten) empfindlich reduziert werden. Derartige Veränderungen der Populationen wirken sich auf die Schädlingskontrolle, Bodenfruchtbarkeit und weitere Ökosystemfunktionen aus.

General Introduction

For hundreds of years agriculture has contributed substantially to the diversity of species and habitats, and agriculture has formed many of today's landscapes. Over the last century, however, modern intensive agriculture with its high input of synthetic pesticides and fertilisers, monocrop specialisation has been detrimental to the diversity of genetic resources of crop varieties and livestock breeds, to the diversity of wild flora and fauna and to the diversity of ecosystems (Shiva 2001; Stanners & Bourdeau 1995). Especially with the intensification of arable land use over the last four decades, deterioration of soil fertility and biodiversity and increases in soil pollution have emerged as major issues. Maintenance of soil and water are fundamental for future agricultural production. Therefore, other farming systems are necessary, which exploit the natural biotic mechanisms that maintain soil structure, fertility and drainage, and help to regulate and control pests, diseases and weeds.

As a consequence, sustainable and low-input farming systems are of increasing public interest. Organic farming is a system in which many ecological restrictions have been fulfilled (e.g. IFOAM; EU or Biosuisse Guidelines), and it has been assessed to be environmentally benign. Benefits in abiotic as well as biotic aspects were found (Stolze et al. 2000). There is at present no European country that does not directly promote organic farming through agri-political measures (Lampkin et al. 1999).

Organic farming is dependent upon stabilising agro-ecosystems, maintaining ecological balances, developing biological processes to their optimum and linking agricultural activities with the conservation of biodiversity. Wild species perform a variety of ecological services within organic systems: pollination, pest control, and maintenance of soil fertility. Thus, higher levels of biodiversity can strengthen farming systems and practices. Enhancing functional biodiversity is a key ecological strategy to bring sustainability to production on farms. Organic systems also substantially reduce external inputs and do not use synthetic chemical fertilisers, pesticides, genetic modified organisms and pharmaceuticals. Instead, systems are designed to manage nature in order to determine agricultural yields and disease resistance. By respecting the natural capacity of plants, animals and the landscape, organic agriculture aims to optimise quality in all aspects of agriculture and the environment (Scialabba & Hattam 2002).

In this work, earthworms and polyphagous arthropods focussing on carabids and spiders were selected as indicator groups to compare arable cropping systems with different farming intensities: earthworms as endogeic animal group and arthropods as mainly epigeic group.

The role of earthworms in enhancing soil fertility is well known, and different farming practices have considerable effects on both earthworm abundance and species composition (e.g. Lee, 1985; Edwards & Bohlen 1996). Earthworms contribute to soil physical, chemical and biological processes such as soil structure formation, e.g. formation of stable aggregates (Schrader and Zhang 1997), and organic matter dynamics through nutrient cycling, decomposition of residues (Wolters and Ekschmitt 1995), and soil pore water dynamics through their burrowing activities, which provide soil pores for aeration and water infiltration (Edwards et al. 1990; Pitkänen and Nuutinen 1997).

Carabids, staphylinids and spiders are polyphagous arthropods that live above ground and belong to the most abundant arthropod groups in arable fields. Many species feed on a wide range of food items. Thus, they are important predators and play an important role in the regulation of various pests in arable crops (e.g. Nyffeler and Benz 1988; Kromp 1999; Sunderland and Samu 2000). In addition, certain arthropods, especially carabids, are considered as sensitive indicators of habitat quality (Steinborn & Heydemann 1990). Monitoring them yields useful information on the sustainability of different agricultural farming systems.

COMPARATIVE INVESTIGATIONS OF CONVENTIONAL AND ORGANIC FARMING ON BENEFICIAL FAUNA

Numerous comparative investigations have studied effects of conventional and organic farming on carabids (Dritschilo & Wanner 1980; Kromp 1990; Booij & Noorlander 1992; Steinborn & Meyer 1994), spiders (Ingrisch et al. 1989; Glück & Ingrisch 1990; Steinberger & Kromp 1993), other beneficial arthropods (Moreby et al. 1994), and earthworms (Bauchhenss 1991; Scullion et al. 2002). In many cases higher diversity and abundance in arable crops was found under organic farming. A few studies performed in perennial crops such as orchards (Paoletti et al. 1995) or vegetable crops (Hokkanen & Holopainen 1986; Clark 1999) found similar differences. Due to the lack of detailed information of farm practices and site conditions the main driving factors often remain unclear.

Furthermore, to get ‚hard‘ data on the effects of organic farming systems on arthropods and earthworms, it is relevant to perform investigations after a transition period of at least 5-7 years (a mean duration of a crop rotation on organic farms) after the change from conventional farming. The time of transition period necessary is depending on field history respectively on the farming intensity in the past. Spurious results may otherwise result (Moreby et al. 1994; Armstrong 1995), if organic farms were selected with a too short transition period of two or three years.

In the DOC long-term trial, the organic plots were managed as such for more than 10 years. Moreover, detailed information about the farm practices since 1978 was available, as well as extensive information of site conditions. Under these more or less controlled conditions and partly similar farm practices (soil tillage, identical crop rotation in all treatments), the main question was: Which are the main driving forces influencing arthropod and earthworm populations in the different intensive farming systems?

ROLE OF SEMI-NATURAL HABITATS – OVERWINTERING OF ARTHROPODS

Field margins are important refuges for many plants and animals and thus play a key role in maintaining biological diversity on arable farmland (Fry 1994). The size and type of field margins and associated semi-natural habitats play an essential role in the survival of many invertebrates during winter. This has been shown for polyphagous pest predators, such as carabids, staphylinids and spiders (Sotherton 1984; Wiedemeier & Duelli 1993; Andersen 1997). However, there is a lack of information about appropriate overwintering sites and the effects of different field margins (e.g. wild flower strip) on several further groups of arthropods.

LOW-INPUT ARABLE CROPPING SYSTEMS AND SEMI-NATURAL HABITATS

Since 1993, the Swiss government has subsidised low-input farming methods (e.g. low-input ICM, organic farming) and the establishment of field margins and semi-natural habitats. According to these new agro-politics, direct payments are made only if farmers fulfil the minimum guidelines (ecological performance). For example, farmers have to use at least 7% of the land area as semi-natural habitat or field margins (Anonym 2000). In this context, agri-environmental schemes need an evaluation of effects of low-input farming systems on flora and fauna (Pfiffner et al. 2000). There is a lack of data from on-farm trials comparing low-input arable farming systems, which are currently promoted by state programs. Furthermore, the question was, how useful it is to combine semi-natural habitats and valuable field margins with low-input agriculture to enhance diversity of generalist predators and to improve natural pest control through a higher abundance of top predators?

OUTLINE OF THIS THESIS

This thesis is organised in five chapters analysing two investigation scales. On the one hand the scale of the randomized DOC-long-term trial has been considered, on the other hand the farm scale, using a paired farm approach.

Chapter 1, 2 and 3 investigate effects of bio-dynamic, organic and conventional farming systems on polyphagous arthropods and earthworm populations in a 7-year crop rotation. The investigations were performed within the 'DOC' long-term trial, in which two conventional and two organic farming systems were compared since 1978. In chapters 4 to 6, investigations were done on farm level, using a paired farm approach including semi-natural habitats. Chapter 4 concerns the overwintering of arthropods in soils of arable fields and adjacent semi-natural habitats on an integrated and an organic farm. Chapter 5 analyses the impact of low-input farming systems on carabids and epigeic spiders in winter cereal fields, considering also the nearby semi-natural habitats altering these polyphagous arthropods in space and time. Chapter 6 analyses the effects of low-input farming systems on earthworm populations in cereal crops within the same trial design as used in chapter 5.

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