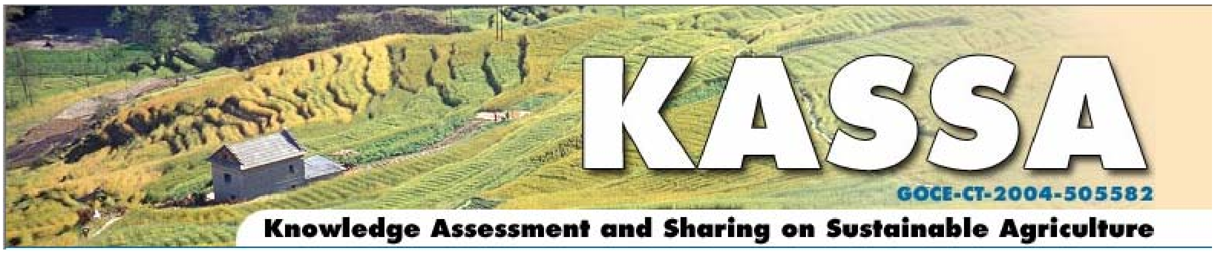

Deliverable 1.1 – Appendix A5

Conservation agriculture, organic farming and GM crops in Germany

Main focus: Western Germany

R-A. Düring and A. Michels

Justus-Liebig-Universität Giessen (JLU), Heinrich Buff-Ring 26, D-35392 Giessen, Germany

Centre de coopération internationale en recherche agronomique pour le développement
Avenue Agropolis, 34398 Montpellier, France

www.cirad.fr

ACKNOWLEDGMENTS

The research reported here has been carried out in the context of KASSA project (Knowledge Assessment and Sharing on Sustainable Agriculture) a European Commission – funded project (DG-Research - Contract no. GOCE-CT-2004-505582) under the FP6 programme: "*Integrating and strengthening the European Research Area*"; Thematic priority "Sustainable Development, Global Change and Ecosystems", Sub-priority "Global Change and ecosystems".

Disclaimer

This publication reflects only the authors' views. It should not be construed as representing the views of the European Commission. The European Commission is not liable for any use that may be made of the information contained therein.

KASSA has been coordinated by CIRAD.
It worked between 1 September 2004 and 28 February 2006.
The KASSA Consortium assembled 28 contractors from 18 countries.
KASSA has been implemented through four regional "platforms": Europe, the Mediterranean, Asia and Latin America.
http://kassa.cirad.fr

Partners of the European platform:

2- INRA, France;
5- FNACS, France;
6- KVL, Denmark;
7- FIU, Denmark;
9- JLU, Germany;
10- Zalf e.V, Germany;
11- NCRI, Norway;
12- ENL, United Kingdom;
13- EAU, Estonia;
14- VURV, Czech Republic;
15- NSC-ISSAR, Ukraine.

Scientific advice has been provided by:

Michel Griffon (CIRAD, France);
Ren Wang (IRRI, Philippines);
Jaromir Kubat (VURV, Czech Republic);
Roberto Peiretti (AAPRESID, Argentina).

This document is the workpackage 1.1 report of the partner JLU, Germany

Table of contents

Context of development of sustainable agriculture

Pedo-ecological and climatic conditions for agriculture in Germany

The Federal Republic of Germany is a country of western Central Europe with atlantic warm-moderate climate and rainfall at all seasons. Due to geology and relief Germany (total area 357,000 km²) can be subdivided into four large natural regions: north German low lands and coast, low mountain ranges, alpine foreland and alps, where the low mountain ranges have the greatest importance (54 % of the total area). The annual average temperature is between 8 and 10°C, with lower temperatures only in the mountain ranges and higher averages at favourable locations, e. g. the basins of the Rhine Valley. Temperature´s yearly variation differs from the atlantic north and west with mild winters and cool summers to the rather continental east of the republic, where warm summers change with cold winters. The regional precipitation amounts to 837 mm per year, with higher amounts on the altitudes of low mountain ranges and lower amounts in the lee-wards located lowlands of these ridges. Highest annual precipitation reaches over 2000 mm, while the annual precipitation between the Thueringer Basin and the Magdeburger Boerde partially is less than 500 mm.

German soils show a high spatial variability. Soils of the low mountain ranges are dominated by Cambisols that are associated with Gleysols and Stagnosols due to humid climate and that are of different thickness according to the relief position. On alkaline volcanic substrates Eutric Cambisols are prevalent, whereas Dystric Cambisols predominate sandy areas. The most fertile arable soils are found in the Leipziger Bucht, the Magdeburger and Hildesheimer Boerde, the Kölner Bucht, the Mainzer Becken, the Wetterau and in Kraichgau, where Chernozems and Luvisols have developed from periglacial dust deposits (Loess). Today, most of these soils are slightly degraded due to erosion and intensive agriculture. Substrates of soils of the alpine foreland are predominantly influenced by ice-age glacier activity. Out of moraine substrates stagnic and/ or dystric Luvisols have formed, which are often associated with sandy soils of former river sediments.

Land use

Of the agriculturally used 17 million ha in Germany, almost unchanged 11.9 million ha (70 %) were arable land in 2003. Given in figure 1, 58 % of the arable land was cultivated with grain, 15 % with forage crops, 12 % with oil seeds and 6 % with root crops. Almost 7 % or 782,000 ha are fallow lands in the context of EU agricultural politics. From 6.9 million ha area of grain, in 2004 45 % (3.1 mio. ha) were wheat, the

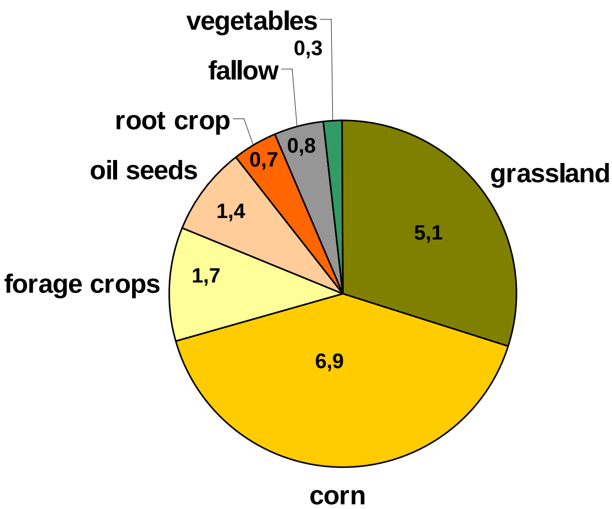

Fig. 1: Land use in Germany (numbers are hectares in million)

most important crop in Germany, followed by barley (2 mio. ha). Approximately 5.3 million ha were grassland, 30 % of the agricultural area in use. Wine production only used 0.1 million ha (approx. 0.6 % of the agricultural area in use).

Farm structure, sizes and management

In 2003 388,100 German farms (> 2 ha) managed 17 million ha agricultural area in use. The average farm size was 43.8 ha, revealing notable differences between the western and eastern (after reunification of the former FRG and the GDR in 1989, “Neue Bundesländer”) federal states of the republic. While farm size in the western states lay clearly below average with 19.7 ha, farms were clearly larger (184.5 ha) in the eastern federal states due to historical structure development before reunification. In comparison with the European Union (Eu-15 (2000): 18.7 ha average farm size) Germany was above average. Approximately 28,500 (7 %) farms larger than 100 ha managed an area of 48 % of the entire agricultural area in use.

Classified according to main focus of production, 47 % of the farms were producing forage crops (most with cattle and milk production), 31 % specialized on cash crops, 10 % managed permanent crops (wine, fruit, vegetables, hop), 6 % were intensive livestock farms (pigs, poultry, eggs) and 5 % had mixed production.

Tab. 1: farm sizes and land use

farm size classes	farms		area	
hectares (from…to…)	**number (x1000)**	**%**	**hectares (x1000)**	**%**
2-10	132.8	34.2	686.3	4.0
10-20	77.5	20.0	1150.2	6.8
20-50	94.3	24.3	3115.9	18.4
50-100	54.9	14.2	3823.2	22.5
> 100	28.5	7.3	8206.0	48.3
total	388.1	100.0	16981.8	100.0

Almost 46 % of the agricultural enterprises in the western federal states were managed as main income source (full-time farms), whereas 54 % were subsidiary farms. For the eastern federal states this ratio was 36 % to 64 % respectively.

Socio-economic conditions

In 2003, German agriculture had an economic share (incl. forestry and fishery) of 1.2 % of Germany´s gross value added (production value 47 billion Euro) and gave employment to 2.4 % (962,000) of all employed people. The whole “agribusiness” (agriculture, forestry, fishery and pre- and post-operating business) employed 4.3 million (11.1 %) people and had a share of 6.8 % of Germany´s gross value added (553 billion production value; last available data from 2000).

About 73 % of Germany´s agricultural budget (total 5.2 billion Euro) accounted for social expenditures (3.78 billion euro). The means of the “Joint Task for the Improvement of Agricultural Structures and Coastal Protection (GAK)” were 729 million Euro in 2004. Together with complementary means of the federal states a total volume of 1.2 billion

Euro subsidies results. The ratio of expenditures of federal government and states governments is 60 to 40 (coastal protection 70 to 30).
After reduction of EU compensation payments, modulation measures (as agri-environmental tasks according to EU “cross compliance”) were added in 2003.

Organic farming

At the beginning of 2004, 16,476 farms (4.3 %) managed 734,027 ha (4.3 % of the total agricultural area in use; EU average: 3.4 %) according to the EU Regulation on Organic Farming. Highest portion of area is reached in the federal states of Brandenburg, Hesse, Mecklenburg-Vorpommern and Baden-Württemberg. Especially the eastern states show high percentages of organic farms (average 5.7 %). Average farm sizes of organic farms are above average (53 ha and 40.5 ha resp.). About 82 % of all organic farms have animal husbandry with a great emphasis on cattle production (77 %). Therefore permanent grassland is the most important land use (51 %) in German organic farming, followed by arable land (48 %). Approximately 1 % of the organically used acreage are permanent cultures (mainly fruit).
About 60 % of all organic farms are aligned with one of the organic producer associations. There are nine German producer associations, all of them have minimum requirements that exceed those of the EU Regulation on Organic Farming.

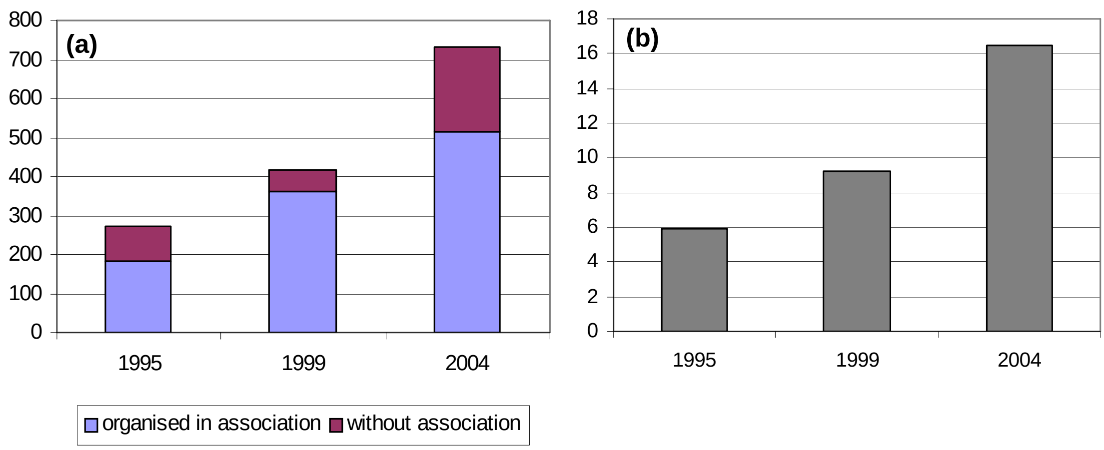

Fig. 2: Development of organic farming in Germany. (a) Total area of organic farming, (b) number of organic farms

In order to promote organic products in food retailing industry, the German government introduced the “Bio-Siegel” (national organic seal) in autumn of 2001, which is based on the fulfilment of the EU Regulation requirements. Furthermore, since 2002 there are higher grants for implementing and keeping organic production systems. These grants can be adjusted individually by the federal states.

Since 2004, the “Federal Scheme for Organic Farming” (“Bundesprogramm ökologischer Landbau”) expends 20 million Euro per year for supporting measures, which will be continued until 2007. In total, organic farms realised higher earnings in 2002/03 marketing season than conventional producing farms (20,600 Euro per labour force and 18,000 Euro per labour force resp.). The earnings of organic farms were stabilised by higher subsidies (470 Euro/ha and 357 Euro/ha resp.).

Demand for organic products has been constantly growing in recent years, while turnover growth rates clearly decreased. Turnover growth rate for organic products was approximately 4 % in 2003, turnover totalled 3.1 billion Euro and accounted for 2.4 % of the food retailing industry´s total turnover.

Genetically modified crops (GMO)

The use of genetic modifying methods in agriculture is discussed more intensively and more critically in Germany and other European states than in most other countries of the world. Mostly, the often expressed rejection is due to fear of ecological and health risks and ethic concerns.

Germany only grows transgenic crops for experimental reasons. In 2004 transgenic crop growing was limited to 300 ha with almost exclusively herbicide-resistant maize. In 2003, 13 applications were realized in 307 releases of GMOs. Until July 2004, a total of 139 applications were put into practice on 686 locations in Germany.

In November 2004, the German government implemented the EU Directive for the deliberate release of GMO into the environment in the Genetic Modification Act, regulating especially the co-existence of different growing systems. In the now applicable law version, farmers growing GM crops will be liable to pay compensation if material negative effects are claimed by other farmers. This poses a substantial risk to these farmers and limits the cultivation of GM crops. The EU commission has asked the

German government for revision.

Conservation Agriculture

The proportion of areas treated with CT amounts to roughly 20% of the total arable land of Germany, characterised by a significant growth within the past 20 years.

However, the use of CT in Germany is regionally differentiated. In the eastern part, conservation tillage is most significant followed by the north and at least with minor importance by Southern Germany. This differentiation is shown in figure 3.

The region-specific proportion of CT is clearly related to farm sizes. As illustrated in figure 4, broadest use of conservation tillage systems applies for farms larger than 500 ha.

Single federal states such as Saxony do have some higher proportions of CT due to special support programmes, resulting in 30 – 40% ploughless tilled soils.

No-tillage is not a relevant opportunity in Germany as only 3% of the total arable land is cultivated by NT.

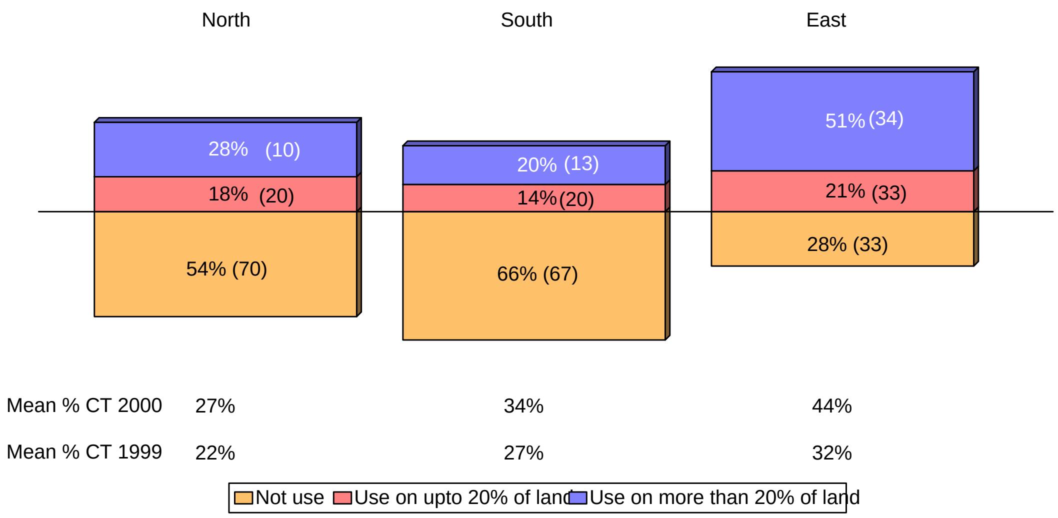

Fig. 3: Use of conservation tillage in different regions within Germany (produce studies research).

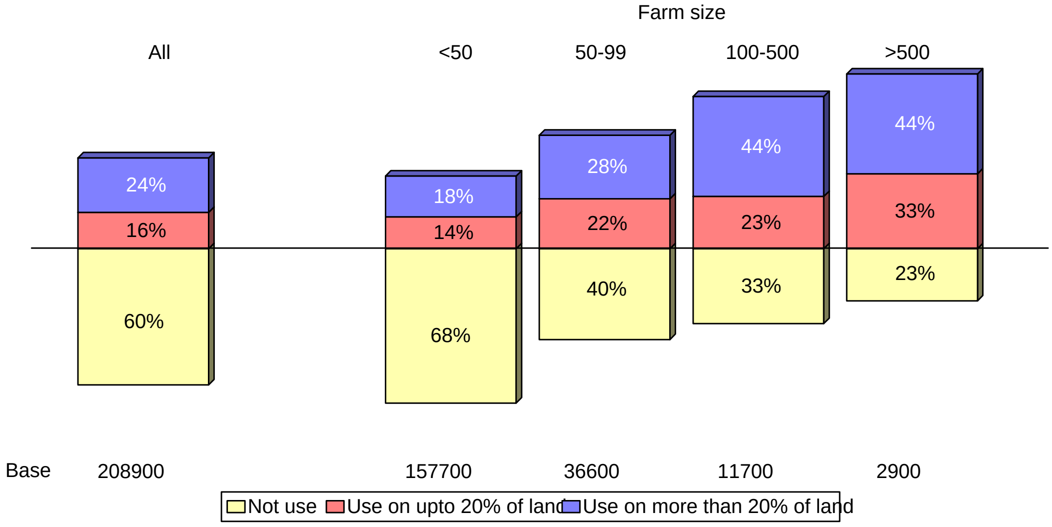

Fig. 4: Use of conservation tillage with respect to different farm sizes within Germany (produce studies research).

As the benefits of reduced tillage systems are well known for many years, conservation tillage has become a subject to legislation (e. g. Soil protection Act) and a subject of cross-compliance. Almost all federal states support reduced tillage intensities with financial incentives of 25 €/ha and year to 120 €/ha and year. The support is granted following various requirements, e. g. application of no-tillage, mulch tillage, often referred to as measures for prevention of erosion.

The following parts of the report refer exclusively to West-Germany and the studies and experiments carried out there. A similar consideration is done by Partner No. 10 (ZALF, Müncheberg, Frielinghaus) for the eastern part of Germany. This division is reasonable, because there are many mainly structural differences in agriculture and land use between western Germany and the former GDR.

Conservation Tillage

II - Conditions of obtaining of results

II-1-Partners

Different institutions and associations work to improve knowledge in conservation tillage practices. They can mainly be subdivided into universities and universities of applied sciences, research institutes, governmental research institutions and organisations and non-governmental associations. Universities, Research Institutes as well as non-governmental and private associations are generally supported by state funding. The support is for distinct projects or for the organisation as a whole.

Universities: Univ. of Kiel, Univ. of Göttingen, Univ. of Bonn, Univ. of Giessen, Univ. of Kassel/ Univ. of Applied Sciences Witzenhausen, Univ. of applied sciences Osnabrück, Univ. of applied sciences Weihenstephan, Humboldt-Univ. of Berlin, TU Munich, Univ. of Hohenheim, Univ. of applied sciences Flensburg, Univ. of applied sciences Oldenburg

Research institutes: National Research Center for Environment and Health (GSF), Research Centre Jülich (FZJ)

Governmental research institutes and organisations:

State level:

BMVEL (Federal Ministry of Consumer Protection, Food and Agriculture – funding of research),

BMBF (Federal Ministry of Education and Research – funding of research)

BLE (Federal Agency for Agriculture and Food – organisation and funding of research),

FAL (Federal Agricultural Research Centre – active research institution),

UBA (Federal Environmental Agency – organisation and funding of research)

VDLUFA (Association of the German agricultural research and analytic institutes)

Federal states level:

Agricultural chambers of the federal-states (one per federal state)

LUFA (Agricultural research and analytic institutes) – chambers are in charge of these active research institutions

Associations:

DLG (German Agricultural Society)

KTBL (Association for Technology and Structures in Agriculture)

GKB (German Association for Conservation Agriculture)

II-2-Main experiments in Germany

The presented results are mainly the outcomes of university research. Especially state level research institutions support university projects.

Various results on diverse issues in conservation tillage were studied in a long-term interdisciplinary research approach supported by the BMBF (former BMFT – Federal Ministry of research and technology) at the university of Giessen between 1986 to 1994 (see Fig. 5). Major results are summarized in a final report (*Tebrügge & Dreier, 1994*).

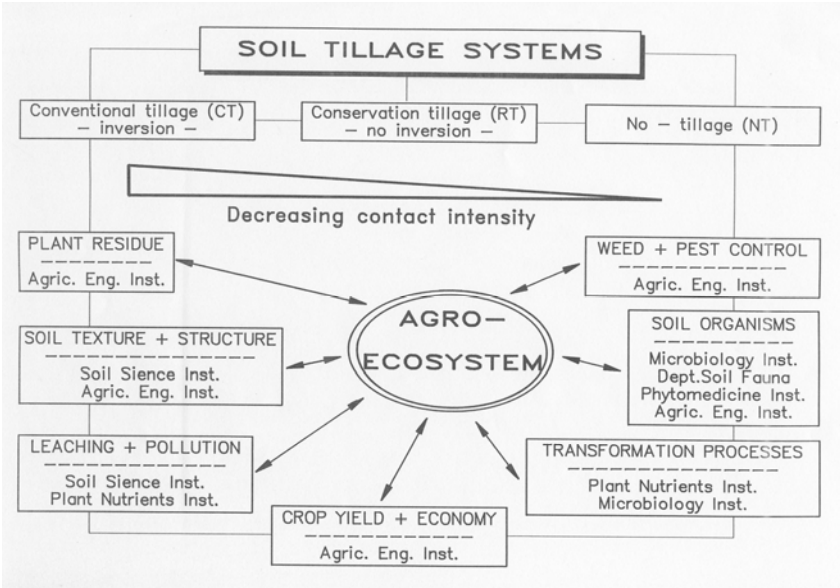

Fig. 5: Institutes and research subjects involved in the joint project on the interrelations of soil tillage systems and the soil ecosystem.

The locations and fields used in these experiments were subject to different tillage practices for some years before and are still today as described below. Five locations were chosen to represent different soil types and climatic conditions. Full-sized plots (200 m long, 12 m wide) in two replicated experiments were used to compare the tillage treatments on these sites. The tillage treatments were mainly applied to cereal crops, sugar beet (*Beta saccharifera L.*), maize (*Zea mays L.*), or rape (*Brassica sp.*).

The tillage systems had been applied consecutively to the same plots for several years. The different tillage methods used in the investigations and the decreasing impact of the implements to the soil (from CT to NT) as well as their influence on agrotechnical aspects are illustrated in Fig. 6.

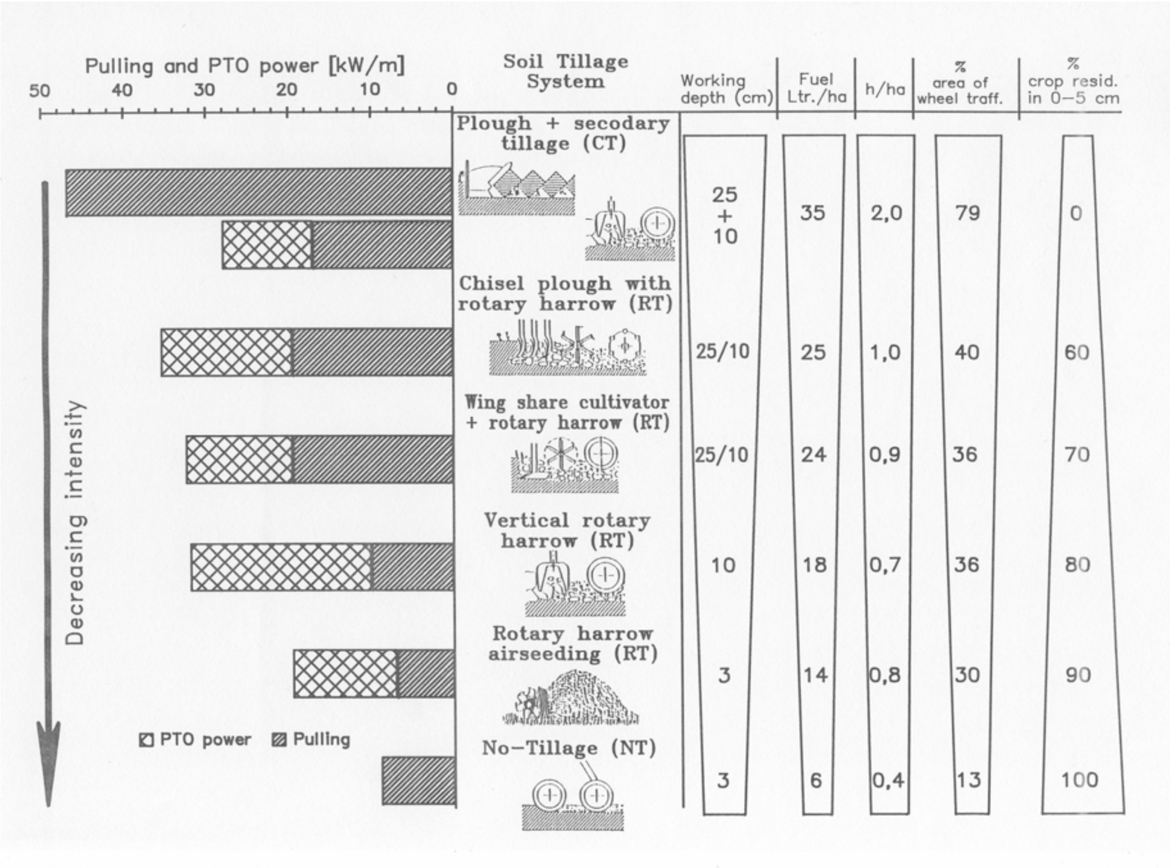

Fig. 6: ***Applied tillage systems and their effects on performance and requirements. Impact on soil depth and soil surface.***

After finalization of the mentioned research, various other studies and projects were and are still carried out on these fields.

II-2-1-Field experiments:

Main features of the experimental sites are given in Table 2. All fields are managed by or in cooperation with the Institute of Agricultural Engineering of Giessen University.

Giessen: Site is situated on and managed by a university farm and research station in Giessen, Middle Hesse.

Ossenheim: Site is owned and managed by a farmer in cooperation with the university of Giessen. It is located in the Wetterau, a favourable region for intensive agriculture.

Bruchköbel: Site is owned and managed by a federal farm in cooperation with university of Giessen. It is located in the Main lowlands in southern Hesse.

Hassenhausen: Site is owned and managed by a farmer in cooperation with the university of Giessen. It is located 20 km north of Giessen.
Wernborn: Site is managed by a farmer in cooperation with the university of Giessen. It is located in western Taunus in southern Hesse.

Table 2: Characteristics of the field sites under investigation

Site	Soil	Texture [g kg^{-1}]			Soil type	Precip. [mm year^{-1}]	Mean temp. [°C]	Crop rotation	Beginning year
		Clay	Silt	Sand					
Giessen	sL	310	530	160	Eutric-Fluvisol	600	8	cereal (8 yr.) silage maize (3 yr.)	1986
Wernborn	L	265	559	176	Stagnic Luvisol	625	7.6	Cereal (14 yr.) Rape (3 yr.)	1980
Ossenheim	L	212	673	115	Luvic Phaeozem	575	9	Cereal (13 yr.) sugar beet (4 yr.)	1980
Hassen-hausen	L	138	667	195	Luvisol	630	8	Cereal (7 yr.) Rape (2 yr.)	1988
Bruchköbel	S	57	293	650	Eutric Cambisol	600	9	Cereal (8 yr.) sweet maize (4 yr.) sugar beet (5 yr.)	1980

Further sites:
Liebenau: Located at Lake Constance; different tillage systems applied since 1982
Ullrichstein: Located in Vogelsberg, Middle Hesse

Other German experimental sites are mostly managed in cooperation with university institutes or research institutes within the scope of distinct projects. For this purpose whether cooperation with practical farmers are searched for or fields of university research farms are used.

II-2-2-On farm

There are numerous projects initiated by farmers, associations and / or companies especially regarding new techniques in sowing and residue management. These initiatives are mainly supported by the state and/ or by companies if involved and private fields of farmers are used.

II-2-3-Laboratory

Laboratory studies regarding transport behaviour of various substances (pollutants, nutrients, microorganisms etc.) mainly with undisturbed lysimeters taken from experimental sites are carried out at different universities and at National Research Centres (FAL, GSF, FZ Jülich).

III – Significance and impact of the results obtained

Strong efforts in studying effects and impacts of different tillage systems from various points of view were made in the beginning and the mid nineties. Recent research is mainly focused on optimising technology and assessing environmental impacts.

Results of studies can mainly be subdivided into five categories:

1. General agronomic impacts (yields, cost-/labour-saving, pest-management etc.)
2. Technical aspects of conservation tillage (machines and technology)
3. Impacts on soil ecology (biomass, carbon-cycle, microbiology, fauna, root-zone)
4. Impacts on soil physics (compaction, erosion, infiltration etc.)
5. Impacts on soil chemistry and behaviour of pollutants

III – 1 General agronomic impacts

Effect on yields of different crops is a major subject of investigation. Very important is to study the impact of various tillage systems in long-term approaches especially regarding the time of conversion from conventional tillage to reduced tillage systems.

Major results indicate a little decrease of yields during conversion phase and a balancing or even higher yields with application of reduced tillage systems in the long run (*Dumbeck, 1986; Vorderbrügge, 1989; Tebrügge & Eichhorn, 1992; Tebrügge, 1994; Grube, 2003*). Different intensities of reduced tillage systems have to be considered:

Whereas no-till systems showed generally same or slightly lower yields of wheat than conventional tilled fields, chisel-plough systems showed most often higher yields (*Grube, 2003*).

Studies concerning yields should always have an integrated point of view. Cost savings by reduced work intensities are to be accounted for when discussing the monetary effects of different tillage systems.

Major cost- / and labour-saving points of reduced tillage systems are (*Tebrügge, 2000*):

- machinery cost prices (less machines needed for reduced tillage)
- machinery maintenance
- fuel
- labour time

Tebrügge & Böhrnsen (1997a) calculated cost savings for no-tillage of about 150,- Euro/ha when compared to conventional tillage. An integrated approach regarding yields as well as cost-savings from experiments running for more than 20 years indicate clearly, that farms applying no-tillage systems have economic advantages between 7 % to 23 % compared to conventional tillage (*Tebrügge & Böhrnsen, 1997a & b*).

Plant protection and weed control has to be adjusted to reduced tillage. Especially in no-till systems the use of a total-herbicide (e. g. glyphosate products) is normally necessary. It has been shown, that in the time of conversion from conventional tillage to no-tillage more weeds where able to arise. In the long run, weed abundance was strongly related to the management and crop rotation (*Bräutigam, 1993*). The 20 year average herbicide costs were about 20-30 Euro per ha and year higher for no-tillage systems than for conventional tillage systems (*Tebrügge, 2000*).

Higher damages by fusarium in reduced tillage systems couldn´t be approved in field nor in laboratory experiments (*Bräutigam, 1994*). Lowest rates of fusarium infestations are described for no-till systems and explained by highest concurrence and antagonism in the upper soil centimetres and a higher microbiological activity (*Bräutigam, 1994; Grocholl, 1991*).

Major results for agronomic and economic impacts of conservation tillage are:

- similar yields compared to conventional tillage
- cost savings by lower input (esp. fuel, labour time, machinery costs and maintenance)
- higher contribution margin in the long run
- new management for weed control and plant protection necessary
- faster rising of weeds with decreasing tillage intensities
- lower fusarium infestation rates for no-till systems
- higher average costs for weed control and plant protection
- new management for fertilization

III-2-Technical aspects of conservation tillage

Many studies were conducted regarding the technical aspects of different tillage systems. Main focus of these studies is sowing as well as stubble and straw treatment.

Main results:

- straw should be chopped smaller with reduction of tillage
- straw spreading should be more uniformly with reduction of tillage
- highest requirements of residue management for no-tillage, because of straw accumulation on surface and surface soil layer
- plant rising is usually better after shallow harrowing than with no-tillage or ploughing
- no-tillage needs distinct techniques for seed deposition (e. g. cutting discs)

On-going studies are working on these questions. New research areas are: seeding techniques for vegetables, no-tillage (low input) cultivation of maize, optimising seeding times of different crops in mulch tillage systems, optimised seed deposition in no-tillage systems.

III-3-Impacts of conservation tillage on soil ecology

Many impacts on soil ecology especially regarding microbiology, abundance and biodiversity of soil fauna are strongly related to the vertical distribution of soil organic matter. Plant residues and soil organic matter were found to accumulate in the soil top layer in relation to tillage intensity. Intensive accumulation in top 5 cm were described from no-till fields (*Friebe, 1992a +b; Ahrens et al., 1994; Stockfish et al., 1999; Tebrügge, 2000*). Corg and Nt were described to show higher average contents in non-turning tillage systems with strong enhancement in the upper soil centimetres according to tillage depth (*Ahrens et al., 1994*). Stockfish et al. (1999) calculated an increase of about 5 Mg ha^{-1} of Corg and about 1 Mg ha^{-1} soil nitrogen under shallow cultivation compared to conventional ploughing.

These differences in vertical distribution of soil organic matter are the pre-condition for soil fauna and microbiology. For the latter it was found, that microbial activity shifted along with organic matter to the upper soil centimetres under reduced tillage intensities and increased in intensity (*Grocholl, 1991; Ahrens et al., 1994*). Under conventional tillage microbial activity was distributed over the whole plough horizon and slightly concentrated in the deeper layers where organic matter and plant residues eventually accumulated (*Böhm et al., 1991*). The litter left on the surface of non-ploughed soils can be considered as a key factor for promoting microbial activity, improving aggregate stability, protecting against erosive water forces, and herbicide behavior (*Tebrügge & Düring, 1999*).

Similar patterns for vertical distribution were described for nematodes (*Overhoff et al., 1991; Assheuer et al., 1992; Rössner et al., 1994*). Generally counts for nematodes in no-till systems were lowest for non-phytopathogeneous as well as for pathogeneous species.

A couple of studies clearly indicate, that abundance and fresh biomass of earthworms was higher when tillage intensity was reduced (*Friebe, 1992a; Friebe & Henke, 1992; Emmerling, 2001; Hangen et al., 2002*). Ploughing is described as an elementary catastrophe for soil fauna because of the destruction of the habitat. The more stable the system (and the habitat) the more earthworms, species and earthworm channels were observed. Abandonment of ploughing and application of layer cultivation (chisel-plough) led to an increase of earthworm species from 4 to 7 (*Emmerling, 2001*). Plant and harvest residues on the surface or in the top soil layer increase the number of species feeding on these materials (e. g. Lumbricus terrestris) and therefore increase the number of vertical channels resulting in higher infiltration rates and better air capacity in deeper layers (*Friebe & Henke, 1992*). Furthermore the conversion of organic matter by earthworms leads to an increase of aggregate and structure stability resulting in better trafficability (*Gruber, 1992*). After few years of non-turning tillage, soil fauna is able to break up tillage induced vertical horizontation and to decrease effects of plough layers (*Friebe & Henke, 1992*).

Biodiversity of the soil fauna and microbial society was generally higher in reduced tillage systems due to less disturbance of the habitat, protection of the soil surface from rain splash effect by plant residues and mulch, higher complexity of fauna society and interdependent growth of populations and balanced concurrence.

Related with microbial activity, different tilled soils show different gas emissions. Few studies were carried out concerning greenhouse gas emissions. However, results are consistent. N2O emissions were higher in soils with reduced tillage and N2 and total N losses were higher in conventional tilled soils due to better conditions for fast denitrification (*Hütsch & Mengel, 1991; Motz, 2003*). Higher N2O losses were explained by high mineralisation rates in the surface layer and formation of N2O during nitrification rather than during denitrification. Recent projects try to model N2O losses in relation to land-use (*Szyska, University Giessen, on-going*).

Furthermore, CH4 Oxidation was observed to be higher in undisturbed soils and significant lower in continuously ploughed soils (*Hütsch, 1998*).

Main results on impacts of conservation tillage on soil ecology:

- accumulation of plant residues and organic matter on or near the soil surface according to depth of interference
- strong relation between vertical distribution of soil organic matter/ plant residues and microbial activity, microbial biomass and vertical distribution of soil mikro- and mesofauna
- therefore strong relation between Corg/ Nt depth distribution with vertical distribution of soil organic matter
- increasing average Corg and Nt contents with decreasing tillage intensity
- increasing biodiversity and abundance of various fauna species in relation to

decreasing soil disturbance

- increasing aggregate and structure stability due to increasing abundance of soil fauna and therefore better trafficability and infiltration capacity under reduced tillage intensities
- plant residues and mulch protect soil fauna, offer food and especially enhance vertical movement of earthworms leading to an increase of vertical channels
- reduced tilled soils show higher N2O emissions but less N2 and total N losses
- reduced tilled and undisturbed soils may act as a sink for CH4 while this function is limited for continuously ploughed soils

III-4-Impacts of conservation tillage on soil physics

Major effects of lower tillage intensities on soil physics are often strongly related to changes in soil fauna and ecology as described above. However, some effects are basically due to the abandonment of repeated loosening by ploughing.

Dynamics of bulk density and penetration resistance

Decreasing tillage intensity from the conventional system to no-tillage generally resulted in an increase in bulk density of the upper soil (*Beisecker, 1994; Richter, 1996*). However, non-tilled soils show significantly decreased bulk densities directly (0-3 cm depth) at the surface. This would be related to the existing mulch layer on top of non-tilled soils (*Beisecker, 1994*) that provides organic matter and food for soil fauna, which loosens surface soil by burrowing activities.

Compaction of NT soil was found especially at the 0-10 cm soil depth. However, directly below the sub-surface layer (25 - 30 cm soil depth), bulk density of the tilled soils usually was higher than in non-tilled plots.

Penetration resistance [MPa] of the soil can be regarded as a factor determining the quality of its structure. No change in resistance with increasing soil depth under no-tillage contrasted with lower resistance under ploughing in the upper soil zone. At 25 - 30 cm depth, where the tractor wheels compact the soil during ploughing, compaction of the soil (bulk density, 1.51 $Mg \cdot m^{-3}$) could be confirmed, whereas NT did not show this compaction (1.41 $Mg \cdot m^{-3}$).

Pore volume, pore size distribution and trafficability

The recurring tillage of CT creates an artificial inter-aggregate pore system in the topsoil, which contains nearly 50 % of the total pore volume with pores >120 µm. However, these macropores are unstable as indicated by their volume-reduction over the winter time. NT plots showed lower total pore volume over the same period with relatively constant values of pore size >10 µm.

Because of natural settlement of soil without repeated loosening a shift of pore size distribution from wider pores (>50 µm) to smaller, medium sized pores occurs. Total pore volume decreases with decreasing tillage intensity. However, water capacity increases due to higher water tension in smaller pores while air capacity is satisfactory due to increase of vertical bio-pores (*Frede et al., 1994*). Higher water contents in no-till soils lead to a balanced temperature fluctuation which may result in slower warming of these soils in spring (*Frede & Gäth, 1993*).

The increase in soil stress after wheeling showed lowest amounts in non-tilled plots. Highest pressure was recorded on the ploughed soil at 20 cm soil depth (*Gruber*, 1993) whereas reduced tillage plots showed better trafficability even under wetter conditions.

Aggregate stability and surface sealing

Aggregate stability on different soils was lowest in CT treatments. With increasing clay contents of the soils, differences in aggregate stability between the treatments decreased. However, increased aggregate stability from CT to RT to NT was clearly observable at all times.

Strongly related to aggregate stability, surface sealing decreased with decreasing tillage intensity. Besides aggregate stability, this was due to cover and hence protection of the soil surface by plant residue and mulch layer. This effect was clearly observable especially on non-tilled plots.

Runoff, soil erosion

Water erosion causes severe problems in Germany, especially on silty soils. The factors responsible for this are as follows: decreased infiltration caused by hampered percolation due to subsoil compaction, a lack of pore continuity and buffer capacity of the soil during heavy showers, and surface sealing due to poor aggregate stability.

The rainfall simulation experiments revealed the strong influence of tillage intensity on erosion as numerous authors have shown (i.e., *Packer et al., 1982; van Doren et al., 1984; Radcliffe et al., 1988*). The soil protective effect of the no-tillage system could be confirmed by significantly lower amounts of both runoff, and more pronounced sediment loss for this silty soil. Calculation of sediment losses of 6400 kg ha^{-1} (CT) and 900 kg ha^{-1} (NT) in a long-term project highlighted the soil protective potential of the no-tillage system (*Fischer et al., 1995*).

In an integrated view, off-site damages by erosion and sediment deposition should be taken into account which can be minimized by the application of conservation tillage systems.

Main results on impacts of conservation tillage on soil physics:

- bulk density and general compaction increases with decreasing tillage intensity
- bulk density is usually higher in sub-surface layers for ploughed plots
- a shift of pore size distribution from larger pores to smaller pores occurs when repeated ploughing is abandoned due to natural reconsolidation
- unstable interaggregate macropores of conventional tilled soils are substituted by continuous biopores and worm channels
- increased numbers of biopores result in higher infiltration rates and increase of macropore and by-pass flow during heavy rainfall
- higher water contents due to higher water tension in smaller pores may result in slower warming of no-till soils in spring
- aggregate and structure stability increases with decreasing tillage intensity resulting in better trafficability
- decreasing soil disturbance leads to decrease of surface sealing due to increased aggregate stability and surface cover
- therefore soils under reduced tillage are better protected against erosion
- erosion protection leads to socio-economic welfare regarding protection of valuable arable soils and off-site damage by sediment losses

III-5-Impacts of conservation tillage on soil chemistry and behavior of pollutants in soil

Studies on tillage effects on soil chemistry usually deal with two aspects: fertilization and mineralisation of plant nutrients as well as behavior of organic and inorganic pollutants.

It is generally accepted that plough tillage results in higher NO3 concentrations in autumn as well as in spring due to higher mineralisation rates at higher temperature (higher air volume → faster warming in spring) and higher O2-availability (*Kohl & Harrach, 1991*). After long-term application of no-tillage mineralistion rates may balance in comparison to tilled soils (*Harrach & Richter, 1994; Richter, 1995*).

Nitrate and phosphate losses may occur in no-till soils when significant macropore flow relocates the nutrients into subsurface soil (*Kohl & Harrach, 1994*). However, phosphate and nitrate leaching may be limited in no-till soils due to infiltrating water by-passing the soil matrix in macropores and channels without intensive exchange with soil solution (*Tebrügge, 2000*).

Recent studies often deal with the behavior of pollutants in soils under different management. Long-term tillage treatments resulted in characteristic enrichment patterns of soil organic C and some air-borne and fertilizer-carried pollutants. Accumulation of humus in the surface layer of NT soils altered the behavior of reactive substances in soil due to its strong sorption capacity. Elevated pollutant concentrations were found in the surface of NT soils and this could be attributed mainly to higher sorption capacity compared to plowed soils (*Düring et al., 2002a; Düring et al., 2002b*).

Higher sorption rates of heavy metals under NT were detected by different extractabilities especially of Zn and Cd. This suggests that the availability of those heavy metals for transport should be reduced under NT or RT, which benefit from the supply of organic C from plant residues left on the surface (*Düring et al., 2002a*).

Correlation of PCB concentrations with organic C suggests approximation to thermodynamic equilibrium within the investigated field sites. Due to their partition behavior, these compounds are strongly sorbed to the soil matrix and are not suspected to be transported freely dissolved with the water flow. This was also supported by the uniform ratios of different congeners among soil depths. The main route for vertical

transport of PCBs in arable soils would be mechanical mixing or, in case of NT, bioperturbation via earthworm activity (*Düring et al., 2002a*).
Susceptibility of various pollutants, especially organic contaminants, for movement in and from soil would be directly dependent on the organic C, which may be controlled by tillage intensity (*Düring et al., 2002a*).
Moreover, losses of agrochemicals via the lateral path may be clearly reduced under no-till conditions. However, under certain conditions, such as short time intervals between application and a heavy shower event, the downward movement of plant protection agents may be increased. Further research is needed in this field through the cooperation of soil tillage experts and those who study the fate of the various pesticides (*Tebrügge & Düring, 1999*).

Main results on impacts of conservation tillage on soil chemistry and behavior of pollutants in soil:

- N-mineralisation is usually higher in ploughed soil
- nutrients losses may occur in reduced tilled soils due to higher impact of macropore flow
- infiltrating water can by-pass soil matrix in channels and biopores and therefore prevent nutrients leaching in no-till soils
- same effect is significant for the leaching of soluble pollutants
- some pollutants, especially organic pollutants show high sorption on soil organic matter and are therefore accumulated in the upper layer of reduced tilled soils
- sorption may make pollutants less available in reduced tilled soils
- losses of agrochemicals via the lateral path are significantly reduced with decreasing tillage intensity
- rapid downward movement of nutrients, agrochemicals and pollutants may occur under unfavourable conditions (e. g. heavy rainfall and short time interval between application and rainfall) in no-till soils.

Organic Farming

II - Conditions of obtaining of results

II – 1- Partners

Organic farming is a major issue in German agricultural politics, therefore improvement of scientific and practical knowledge on organic farming is supported and funded in various ways.

To step up research activities in organic farming, a Research Institute of Organic Farming, located in Trenthorst in Schleswig-Holstein, was established at the Federal Agricultural Research Center (FAL). The Institute is also charged with interdisciplinary co-ordination apart from pursuing its own research activities.

Under the Federal Organic Farming Scheme, the Federal Ministry of Consumer Protection, Food and Agriculture established a scheme to promote research and development projects as well as measures for technology and knowledge transfer in organic farming.

Agricultural faculties at different universities have set up distinct institutes for organic farming and operate organically managed research farms. One university (Kassel/Witzenhausen) even conducts a distinct program of study.

Furthermore, in Germany there are currently eight organic producer organisations. They unite around 60 % of Germany's organic farmers. The organic producers’ organisations all own legally protected seals with which certified farms and certified processors can be labelled. These seals are familiar to German consumers, especially those of Demeter, Bioland and Naturland.

AGOEL - ArbeitsGemeinschaft Oekologischer Landbau (Association for Organic Farming) was the umbrella association of the German organic producer organisations until 2002. It had had been founded in 1988. In July 2002 it ceased its activities.

In June 2002 representatives of organic farming groups, processors and traders announced the creation of a common "union of the organic food industry" (Bund der Oekologischen Lebensmittelwirtschaft (BOEL). The members of BOELW are listed at the central Internetportal www.oekolandbau.de. Specifically the union aims to become active in the following fields:

- advancement in quality assurance systems for organic food production through purposeful
- industry-wide co-operation between member's groups and the food trade
- improvement in the communication structure among the members, with authorities and with consumers for a faster exchange of information
- Organization of common initiatives to influence policy in areas such as food law, the EC-organic regulations and the EU Common Agricultural Policy
- Initiation of and support for research and development in production and processing in organic farming.

There are numerous other organisations related to organic agriculture in Germany, some of which are presented below.

- IFOAM and the IFOAM Regional Group of German-speaking Countries (Austria, Germany, Luxembourg, Switzerland)
- Stiftung Ökologie & Landbau (SÖL)" ("Foundation Ecology & Agriculture")
- FiBL Berlin e.V.
- Schweisfurth Stiftung" (Schweisfurth Foundation)
- Gregor-Louisoder Umweltstiftung
- Zukunftstiftung Landwirtschaft

All of these associations generally support and fund research projects in different ways. The internet portal http://forschung.oekolandbau.de/adressen-institutionen.php gives an overview over the main German scientific institutions with focus on organic farming.

Main research partners are (number of reports and documents in the database of http://orgprints.org in brackets):

Centre for Agricultural Landscape / Land Use Research (ZALF) (11)

Cereal Breeding Research Darzau (15)

Federal Agricultural Research Centre FAL (92)

Federal Biol. Research Centre BBA (63)

Federal Centre for Breeding Research BAZ (5)

Federal Centre Meat Research BAFF (2)

Federal Dairy Research BAfM (1)

Federal Research Centre for Nutrition and Food (BEFL), Detmold (6)

Federal Research Centre for Nutrition BFE (3)

Federal Scheme BÖL (84)

Federal States (171)

FH Hamburg (4)

FH Nuertingen (3)

FH Osnabrück (4)

FH Soest (1)

FH Weihenstephan (2)

FH Wiesbaden (3)

FiBL (30)

Foundation Ecology & Agriculture (SÖL) (30)

Institute for Biodynamic Research (IBDF) (63)

Institute of Soil Conservation and Sustainable Agriculture (6)

KÖN (9)

Landwirtschaftskammern (65)

Oeko-Institut (11)

Other organizations (106)

Univ. Berlin (FU) (2)

Univ. Berlin (HU) (19)

Univ. Bonn (77)

Univ. Frankfurt (2)

Univ. Göttingen (27)

Univ. Giessen (25)

Univ. Hannover (23)

Univ. Hohenheim; Faculty of Agriculture (59)

Univ. Kassel, Ecol. Agricultural Sciences (178)

Univ. Kiel (49)

Univ. Munich (TUM) (21)

Univ. Rostock, Agro-Ecology (5)

Univ. Trier (4)

ZSL (1)

III – Significance and impact of the results obtained on Organic Farming

The projects and scientific literature on organic farming in Germany has grown to such an extent, that it is almost impossible to give a brief overview. On the internet portal http://forschung.oekolandbau.de/ (especially on http://orgprints.org/view/subjects/) there are mentioned over 2500 studies and reports on organic farming issues, with over 1200 studies and reports concerning the subject of crop production (without studies on soil, ecology, economy and socio-economic impacts, that are separate topics). Most of the studies can be downloaded as .pdf-files.

Major research areas are (number of reports and documents on the subject in the database of http://orgprints.org in brackets):

- Soil and environment (518)
    - soil quality and soil biology (247)
    - biodiversity (115)

    - emissions (92)
    - nutrient management and turnover (218)
- crop production (1248)
    - production systems (868)
        - cereals, pulses and oil seeds (355)
        - composting and fertilization (142)
        - plant protection, plant quality, weed management (501)
        - breeding and propagation (149)
- socio-economics and food systems (628)
    - politics and socio-economics (148)
    - market and trade (141)
    - food security and food quality (190)
    - values, standards and certification (136)

GMO

II - Conditions of obtaining of results

Use of genetically modified organisms in agriculture is strongly regulated in Germany by the novel "Gentechnik-Gesetz" (Act on gen-technology), which is more severe than the EU-Regulations on GMO.

II – 1- Partners

Currently there are about 300 ha in test cultivation ("Erprobungsanbau"), involved are 30 farms and federal institutions. All experiments are accompanied by a scientific program ("wissenschaftliches Begleitprogramm") funded by the government.

Most important partners are state and federal institutions and companies (most of them acting internationally, e. g. Monsanto, Pioneer, KWS, Syngenta).

Main research partners:

- Bundessortenamt
- Robert-Koch-Institute
- Federal institute of consumer protection and food security (BVL)

- Federal institute of risk assessment (BfR)
- Federal Agency for nature conservation
- Federal Agricultural Research Centre (FAL)
- Federal Biol. Research Centre BBA
- Federal Centre for Breeding Research BAZ
- Federal Ministry for the Environment, nature conservation and nuclear safety
- Federal Ministry of consumer protection, food and agriculture
- Federal Ministry of education and research
- DECHEMA (Society for Chemical Engineering and Biotechnology)
- Verband deutscher Ölmühlen e.V. (association of German oil mills)
- Bundesverband Deutscher Pflanzenzüchter e.V (German association of plant breeders)
- German section of the International Association of Plant Tissue Culture & Biotechnology (IAPTC & B)
- BIO biotechnology industry organization
- consumer associations
- environmental associations
- Companies in association with farmers
- Universities (leader of the scientific program: Institute of plant breeding and plant protection at the Martin-Luther- University Halle- Wittenberg)

III – Significance and impact of the results obtained on GMO

All studies and projects are centrally coordinated and are focussed on cultivation of Bt-maize. Main subjects of all experimental set-ups are environmental aspects and cross-pollination with regard to co-existence of GMO and conventional crop production.

Main results of first research experiments (published on http://www.transgen.de/erprobungsanbau/begleitforschung/516.doku.html):

- cross-pollination decreases rapidly with increasing distance to Bt-plot
- GMO-fraction of above 0.9 % (threshold for labelling by law) can be observed in non-Bt-plots up to 10 m distance from Bt-plots

- therefore, non-Bt-maize cultivated in direct proximity presumably has to be labelled
- as practical measure for preventing cross-pollination, an at least 20 meter distance is proposed
- measure of parallel cultivation of early and late blossom species is no practical way of preventing cross-pollination

Annex I

Considered studies

A - Conservation tillage

Title	Year	Instution
Assessment of new soil management systems in crop rotations with rape seed and leguminoses	2004	University Paderborn
Characterizing the transport behaviour of microorganisms in soils under different management	2005	University Gießen
Assessment of new soil management systems in crop rotations with rape seed and leguminoses	2004	TU Munich
Assessment of new soil management systems in crop rotations with rape seed and leguminoses	2004	Institut für Acker- und Pflanzenbau der Landesforschungsanstalt für Landwirtschaft und Fischerei Mecklenburg-Vorpommern
Studies to reduce aphid infestation by mulch seeding in beans and lupine	2000	TU Braunschweig
Comparison of different soil management systems with regard to recycling of organic municipal wastes	2000	University Gießen
Soil conservation and cost saving - introduction of technical concepts to reduce and prevent soil problems in crop cultivation	1999	Kuratorium für Technik und Bauwesen in der Landwirtschaft e. V.
No-tillage and late tillage of maize after winter peas to reduce environmental impacts and cultivation problems while optimzing yields	2004	Haußecker, M. und Müller-Stöcker, T. GbR
No-tillage and late tillage of maize after winter peas to reduce environmental impacts and cultivation problems while optimzing yields	2004	Biohof Bakenhus des Oldenburgisch-Ostfriesischen Wasserverbandes (OOWV)
Improvement of straw management with regard to seed bedding in mulch and no-tillage systems	2000	Meyfarth, Frank (Investor)
Improvement of straw management with regard to seed bedding in mulch and no-tillage systems	2000	Busse, Erich (Investor)
Improvement of straw management with regard to seed bedding in mulch and no-tillage systems	2000	Stadler Dr.,Thomas (Investor)
Technique for seeding rape before harvesting ripe corn crops under consideration of technical aspects, cultivation and soil protection	2001	University Gießen

Soil protection and agriculture - environmental impacts of conservation tillage	2003	GKB, UBA, FAL
Measures of soil conserving agriculture	2000	Umweltbundesamt
Response of earthworm communities to different types of soil tillage	2001	Trier University
Stress/strain processes in a structured unsaturated silty loam Luvisol under different tillage treatments in Germany	2000	Kiel University
Tillage and land use effects on methane oxidation rates and their vertical profiles in soil	1998	University Gießen
Ploughing effects on soil organic matter after twenty years of conservation tillage in Lower Saxony, Germany	1999	Inst. of Sugar Beet Research and University Göttingen
Reducing tillage intensity - a review of results from a long-term study in Germany	1999	University Gießen
Tillage effects on the accumulation of polychlorinated bephenyls in biosolid-amended soils	2002	University Gießen
Indications for soil organic matter quality in soils under different management	2002	GSF-National Research Center of Environment and Health, Federal Research Station for Agroecology and Agriculture FAL (Switzerland), Technical University Munich
Influence of long-term conservation tillage on soil and rhizosphere microorganisms	1999	Leibniz-Centre for Agricultural Landscape and Land use Research
Possibilities of conservation tillage on sandy soils - analysis of a long-term experiment	1997	Leibniz-Centre for Agricultural Landscape and Land use Research
Soil mechanical properties of a partly reloosened (ditch plow system) and a conventionally tilled overconsolidated gleyic luvisol derived from glacial till	1998	Kiel University
No Tillage and recovery of soil structure?	1999	Kiel University
Agritechnical, economic and environmental assessment of differentiated tillage intensities on five pedogenetic different sites with common crop rotations	on going	University Gießen
Assessment of conservation tillage in points of reduction of erosion and enrichment of soil organic matter	on going	University Gießen
Measures of Stoppelbearbeitungsverfahren under consideration of energy requirements, fuel consumption, aggregate structures, mixing of plant residues and growing of residue crops	on going	University Gießen
Ecological impacts of different tillage systems	1997	University Hohenheim
Optimizing no-tillage cultivation of maize	1999	University Hohenheim

Optimizing corn distribution of no-tillage machines	1999	University Hohenheim
Studies on fertilizer injection in no-tillage cultivation	on going	University Hohenheim
Development of a mulch seeding technique for vegetables	2004	University Hohenheim

Annex I

Considered studies

B – Organic farming

Title	Year	Instution
Introdution of wet hot air treatment to reduce seed-borne pathogens on organically produced vegetable seeds	2005	HILD Samen GmbH,
Seed treatment in organic vegetable cultivation	2000	Allerleirauch GmbH
Seed treatment in organic vegetable cultivation	2001	PADENA, University Hohenheim
Impacts of sulfur fertilizing of wheat on sulfur poor locations in organic farming systems on yields and quality	1999	Institut für Biologisch-Dynamische Forschung e.V.
Genetic engineering and organic farming	2003	Umweltbundesamt
Soil studies in context of the conversion from conventional to organic farming	on going	Kiel University, Gut Ritzerau
Optimizing of cropping systems in organic farming	on going	Kiel University, Gut Ritzerau
Bicropping-Experiment on Lindhof (University Farm)	on going	Kiel University, Lindhof
Bicropping - an alternative in organic wheat cultivation	2002	Kiel University
Better baking qualities by no-tillgae in organic farming	2004	Kiel University
Influence of different crop rotation systems on pathogens in organic farming	on going	University Göttingen, Gut Ritzerau
CONBALE-Project Lindhof (converting to organic farming consequences to N-balance and N-leaching)	on going	Kiel University, Lindhof
Yield and N2-Fixation of different leguminoses and their impact on yield potential of winter wheat with varied organic fertilizing	2002	Kiel University, Lindhof
N-fluxes in conventional and organic crop rotations - results from the CONBALE-Project Lindhof	2002	Kiel University, Lindhof
Establishment of a central platform for testing lead gene function in crops based on the TILLING technology (GABI-TILL)	on going	Kiel University
Mapping of resistance genes to clubroot in Brassica species	on going	Kiel University
Nitrogen supply of white cabage and maize after winter-leguminous as green manure	on going	University Bonn
Characterizing winter wheat varieties suitable for organic agriculture by comparing varieties derived from conventional and organic breeding programs	on going	University Bonn
Strategies of Weed Control in Organic Farming - WECOF	on going	University Bonn
Indirect (non-mechanical) weed control in organic farming	on going	University Bonn
Problematic weeds in organic farming: Development of strategies for a sustainable control of Cirsium arvense and Vicia hirsuta	on going	University Bonn

Modelling environmental impacts of an increase in organically farmed area in Northrhine-Westphalia	on going	University Bonn
Organic Agriculture in North-Rhine-Westphalia: Influence of land productivity, economy, crop and animal production intensity of mainstream agriculture	on going	University Bonn
Possibilities and limits of non-live stock operations and reduced tillage in organic farming	on going	University Giessen, Gladbacherhof
Practical introduction and optimizing of the "Weite Reihe"-concept for the aim of high baking quality of organically produced winter wheat	on going	University Giessen, Gladbacherhof
Long-term impacts of organic farming on soil, plant and environment	on going	University Giessen, Gladbacherhof
Gas balances (CO2, N2O, CH4) for soils of the Gäulandschaften under conventional and organic farming	2000	University Hohenheim
Influence of soil management in organic farming systems on soil organic matter, soil billogical properties and especially N-dynamics	on going	University Hohenheim
Influence of soil management in organic farming systems on N-mineralization-immobilization-dynamics, soil organic matter and soil microbiological properties under special consideration of the conversion phase	on going	University Hohenheim
Optimizing N-management in organic vegetables farming	on going	University Hohenheim
Contribution of mykorrhiza for the uptake of anorganic on organic N in wheat	on going	University Hohenheim
Variation of chemical nutrients availability and root intesity during conversion phase	on going	University Hohenheim
Micro-N-Fix: Microbial fixation of atmospheric nitrogen for staple food crops	on going	University Hohenheim
Cultivation of oil seeds in organic farming systems: Influence of seeding time and N-supply of the plants from organic fertilizer on yield, product quality, pests and N, C, and energy balances	on going	University Hohenheim
Variation of pests during the conversion phase from conventional to organic farming	on going	University Hohenheim
Appearance and development of plant deseases in organic farming	on going	University Hohenheim
Effects of the CAP-reform and possible further developement on organic farming	on going	University Hohenheim
Further Development of organic farming policy in Europe, with particular emphasis on EU enlargement (EU-CEEOFP)	on going	University Hohenheim

Annex I

Considered studies

C – Genetically manipulated organisms

Title	Year	Instution
Interrelation of genetic diversity and the abundance auf resistence genes in Malus sieversii (Ledeb.) M. ROEM.-Populations from Middle Asia	2004	Genbank Obst, AG Molekulare Marker des Institut für Pflanzengenetik und Kulturpflanzen
Improvement of winter rape resistence against BWYV by classical and biotechnological methods	1998	Institut für Pflanzenbau und Pflanzenzüchtung der Georg-August-Universität Göttingen
Improvement of winter rape resistence against BWYV by classical and biotechnological methods	1998	Gemeinschaft zur Förderung der privaten deutschen Pflanzenzüchtung e.V. (GFP)
Development of Environmental Indicators for Monitoring of Genetically Modified Plants		R. Brauner, B.x Tappeser, A. Hilbeck, M. Meier
"Gene Farming": State of the art, possible risks and management strategies	2001	André de Kathen, Verbraucher-Zentrale NRW
Assessment of the impact of genetically manipulated crops on soil, especially on soil organic matter	1999	Umweltbundesamt
Agronomic and Environmental Aspects of the Cultivation of Transgenic Herbicide Resistant Plants	2004	Umweltbundesamt
Alternatives to genetically modified crops	2003	Umweltbundesamt
Genetic engineering and organic farming	2003	Umweltbundesamt
Studies of gene transfer by composting of genetically modified (herbicide resistant) maize	2000	Umweltbundesamt
Conceptional development of a monitoring system on environmental impacts of genetically modified crops	2003	Umweltbundesamt
Improvement of drought and heat tolerance of summer barley by AB-QTL-Analysis	on going	University Bonn
AB-QTL Analysis in winter wheat: detection of benificial genes for pathogen resistence from wild forms	on going	University Bonn
Development and analytical determination of novel rapeseed with genetically modified tocopherol composition	on going	Giessen University
Development and analytic differentiation of novel rapeseed oil varieties	on going	Giessen University
Development and molecular characterisation of rape seed oils	on going	Giessen University
Mapping of the sunflower Pl2 locus for resistance to Plasmopara halstedii race 2 and construction of a BAC library	on going	Giessen University

Annex II

General information about German agriculture:

http://www.verbraucherministerium.de/

http://www.bauernverband.de/ (only available in German)

Information about organic farming in Germany:

http://www.bundesprogramm-oekolandbau.de/

http://www.soel.de/

http://www.organic-europe.net

Information about GMOs in agriculture:

http://www.gruene-gentechnik.de (mostly German)

http://www.rki.de/GENTEC/GENTEC.HTM

Information about conservation agriculture:

http://www.pfluglos.de/ (only available in German)

http://www.gkb-ev.de/index.html (only available in German)

References

Ahrens, E. et al. (1994): Mikrobiologische Beurteilung von Bodenbearbeitungssystemen unter besonderer Berücksichtigung der C- und N-Umsetzungen sowie der Einflüsse von Herbizidanwendungen. In: Tebrügge, F. & M. Dreier (Hrsg.) (1994): Beurteilung von Bodenbearbeitungssystemen hinsichtlich ihrer Arbeitseffekte und deren langfristige Auswirkungen auf den Boden, S. 41-64.

Assheuer, T. et al. (1992): Vertikalverteilung von Nematoden im Boden unter dem Einfluß verschiedener Bodenbearbeitungssysteme. In: Friebe, B. (1992): Wechselwirkungen von Bodenbearbeitungssystemen auf das Ökosystem Boden. Beiträge zum 3. Symposium vom 12.-13. Mai 1992 in Gießen. Wiss. Fachverlag Dr. Fleck, Giessen, ISBN 3-928563-30-0: 147-164.

Beisecker, R. (1994): Einfluß langjährig unterschiedlicher Bodenbearbeitungssysteme auf das Bodengefüge, die Wasserinfiltration und die Stoffverlagerung eines Löß- und eines Sandbodens. Diss. Uni Giessen, Inst. f. Landeskultur.

Böhm, H. et al. (1991): Mikrobiologische Beurteilung von Bodenbearbeitungssystemen am Beispiel dreier Bodentypen. Z. f. Kulturtechnik und Landentwicklung 32 (2), S. 114-120.

Bräutigam, V. (1993): Einfluß verschiedener Bodenbearbeitungssysteme auf Halmbasiskrankheiten des Getreides, die Unkrautentwicklung und –bekämpfung. MEG 231. Diss. Uni Giessen, Inst. f. Landtechnik.

Bräutigam, V. (1994): Einfluß verschiedener Bodenbearbeitungssysteme auf Halmbasiskrankheiten des Getreides und die Unkrautentwicklung. In: Tebrügge, F. & M. Dreier (Hrsg.) (1994): Beurteilung von Bodenbearbeitungssystemen hinsichtlich ihrer Arbeitseffekte und deren langfristige Auswirkungen auf den Boden. S. 225-232.

Deutscher Bauernverband (2005): Situationsbericht 2005 – Trends und Fakten zur Landwirtschaft, 304 S.

van Doren, D.M. et al. (1984) : Influence of long-term tillage and crop rotation on water erosion. Soil Sci. Soc. Am. J. 48: 636-640.

Düring, R.-A., T. Hoß und S. Gäth (2002a): Depth distribution and accumulation behavior of pollutants in long-term differently tilled soils. Soil Till. Res., 66: 183-195.

Düring, R.-A., T. Hoß und S. Gäth (2003): Sorption and bioavailability of heavy metals in long-term differently tilled and biosolid-amended soils. Sci. Tot. Environ. 313,. 227-234.

Dumbeck, G. (1986): Bodenphysikalische und funktionelle Aspekte des Packungsdichte von Böden. Diss. Uni Giessen, Inst. f. Bodenkunde.

Emmerling, Ch. (2001): Response of earthworm communities to different types of soil tillage. Applied Soil Ecology 17: 91-96.

Epperlein, J. (2005): personal communication.

Fischer, P. et al. (1995): Geringere Herbizideinträge in Oberflächengewässer durch reduzierte Bodenbearbeitung? Mitt. Dtsch. Bodenkundl. Gesellsch. 76: 253-256.

Frede, H.-G. et al. (1994): Auswirkungen langfristig differenzierter Bodenbearbeitung auf die Porenraumstruktur und den Wasser- und Stofftransport eines Löß- und eines Sandbodens. In: Tebrügge, F. & M. Dreier (Hrsg.) (1994): Beurteilung von Bodenbearbeitungssystemen hinsichtlich ihrer Arbeitseffekte und deren langfristige Auswirkungen auf den Boden. S. 91-116

Frede, H.-G. & Gäth, S. (1993): Bewertungskriterien für Bodenbearbeitungssysteme. BL-Journal 3, 119-122.

Friebe, B. (1992a): Entwicklung der Makro- und Mesofauna unter dem Einfluß langfristig differenzierter Bodenbearbeitung. In: Friebe, B. (1992): Wechselwirkungen von Bodenbearbeitungssystemen auf das Ökosystem Boden. Beiträge zum 3. Symposium vom 12.-13. Mai 1992 in Gießen. Wiss. Fachverlag Dr. Fleck, Giessen, ISBN 3-928563-30-0: 117-130.

Friebe, B. (1992b): Wechselwirkungen von Bodenbearbeitungssystemen auf das Ökosystem Boden. Beiträge zum 3. Symposium vom 12.-13. Mai 1992 in Gießen. Wiss. Fachverlag Dr. Fleck, Giessen, ISBN 3-928563-30-0.

Friebe, B. & **W. Henke** (1992): Bodentiere und deren Strohabbauleistungen bei reduzierter Bodenbearbeitung. Z. f. Kulturtechnik und Landentwicklung 32(2), S. 121-126.

Gesellschaft f. konservierende Bodenbearbeitung (2005): **personal communication.**

Grocholl, J. (1991): Der Einfluß verschiedener Bodenbearbeitungssysteme auf den mikrobiologischen Status von Böden verschiedener Standorte unter besonderer Berücksichtigung der C-Umsetzung. Wissenschaftlicher Fachverlag Dr. Fleck Niederkleen, Diss. Uni Giessen, Inst. f. Mikrobiologie.

Grube, J. (2003): Beurteilung von konservierenden Bodenbearbeitungssystemen zur Bewirtschaftung peripherer Ackerbaustandorte. Diss. Uni Giessen, Cuvillier Verlag, Göttingen 2003.

Gruber, W. (1992): Die Gefahr der Bodenverdichtung bei unterschiedlicher Bodenbearbeitung. In: Friebe, B. (1992): Wechselwirkungen von Bodenbearbeitungssystemen auf das Ökosystem Boden. Beiträge zum 3. Symposium vom 12.-13. Mai 1992 in Gießen. Wiss. Fachverlag Dr. Fleck, Giessen, ISBN 3-928563-30-0: 117-130.

Gruber, W. (1993):Auswirkungen der Bodenbelastung mit landwirtschaftlichen Arbeitsmaschinen und der Bodenbearbeitung auf das Bodengefüge. MEG 232. Diss. Uni Giessen, Inst. f. Landtechnik.

Harrach, T. & **U. Richter** (1994): Einfluß langjährig differenzierter Bodenbearbeitungssysteme auf die Durchwurzelbarkeit des Bodens und die Stickstoffverlagerung mit dem Sickerwasser. In: Tebrügge, F. & M. Dreier (Hrsg.) (1994): Beurteilung von Bodenbearbeitungssystemen hinsichtlich ihrer Arbeitseffekte und deren langfristige Auswirkungen auf den Boden. S. 129-176.

Hütsch, B. & K. Mengel (1990): Einfluß unterschiedlicher Bodenbearbeitungssysteme auf Stickstoffumsatz im Boden und Nitratverlagerung. Symposiumsband „Wechselwirkungen von Bodenbearbeitungssystemen auf das Ökosystem Boden", Gießen (1989), S. 119-133.

Hütsch, B. & Mengel, K. (1991): Messung von Denitrifikationsverlusten bei Pflugbearbeitung und Direktsaat. Z. f. Kulturtechnik und Landentwicklung 32: 70-79.

Kohl, R. & T. Harrach (1991): Zeitliche und räumliche Variabilität der Nitratkonzentration in der Bodenlösung in einem langjährigen Bodenbearbeitungsversuch. Z. f. Kulturtechnik und Landentwicklung 32(2), S. 80-87.

Motz, I. (2003): Einfluss von Bodenbearbeitung, Düngung und Fruchtfolge auf die Lachgasemissionen aus Ackerflächen. Forschungsbericht Agrartechnik AG Forschung und Lehre der Max Eyth Gesellschaft im VDI 410. Diss. Uni Hohenheim.

Overhoff, A. et al. (1991):Einfluß der Bodenbearbeitung auf die Populationsdichte von Nematoden. Z. f. Kulturtechnik und Landentwicklung 32(2), S.106-113.

Packer, J.C. et al. (1992): Infiltration and soil erodibility benefits of conservation tillage. In: Normann, M.J.T.(ed.): Proceedings of the 2nd Australian agronomy conference: 192.

Radcliffe, D.E. et al. (1988): Effect of tillage practices on infiltration and soil strength of a typic Hapludult soil after ten years . Soil Sci. Soc. Am. J. 52: 798-804.

Richter, U. (1995): Einfluß langjährig differenzierter Bodenbearbeitungssysteme auf das Bodengefüge und den Stickstoffhaushalt. Diss. Uni Giessen, Inst. f. Bodenkunde.

Rössner, J. et al. (1994): Auswirkungen verschiedener Bodenbearbeitungssysteme auf die Abundanz phytoparasitärer und nicht-phytoparasitärer Nematoden. In: Tebrügge, F. & Dreier, M. (Hrsg.) (1994): Beurteilung von Bodenbearbeitungssystemen hinsichtlich ihrer Arbeitseffekte und deren langfristige Auswirkungen auf den Boden. S. 205-224.

Stockfisch, N. et al. (1999): Ploughing effects on soil organic matter after twenty years of conservation tillage in Lower Saxony, Germany. Soil & Tillage Research 52: 91-101.

Szyska, B. (on going): Schätzung von N-Emissionen aus der Pflanzenproduktion. on-going Diss. Uni Giessen.

Tebrügge, F. & H. Eichhorn (1992): Die ökologischen und ökonomischen Aspekte von Bodenbearbeitungssystemen. In: Friebe B. (Hsrg): Wechselwirkungen von Bodenbearbeitunssystemen auf das Ökosystem Boden; Beiträge zum 3. Symposiium 1992 Gießen. Wissenschaftl. Fachverlag Dr. Fleck.

Tebrügge, F. (1994): Beurteilung von Bodenbearbeitungssystemen unter den Aspekten von Bodenschutz und Ökonomie. In: Tebrügge, F. & M. Dreier, (Hrsg.) : Beurteilung von Bodenbearbeitungssystemen hinsichtlich ihrer Arbeitseffekte und deren langfristige Auswirkungen auf den Boden. S. 5-16.

Tebrügge, F. & **Dreier, M.** (Hrsg.) (1994): Beurteilung von Bodenbearbeitungssystemen hinsichtlich ihrer Arbeitseffekte und deren langfristige Auswirkungen auf den Boden. Wissenschaftlicher Fachverlag Dr. Fleck, Gießen (1994), 252 S.

Tebrügge, F. & **A. Böhrnsen** (1997a): Crop yields and economic aspects of no-tillage compared to plough tillage: Results of long-term field experiments in Germany. In: Tebrügge, F. & A. Böhrnsen (eds.) Proceedings of the 2nd workshop 15-17 May, Silsoe, UK: Experience with the applicability of no-tillage crop production in the West-European countries. Wissenschaftl. Fachverlag Gießen, p. 25-44.

Tebrügge, F. & **A. Böhrnsen** (1997b): Results and conclusions of the surveys on No-Tillage. In: Tebrügge, F. & A. Böhrnsen (eds.) Proceedings of the 4th Workshop 12-14 May, Boigneville, France: Experience with the applicability of no-tillage crop production in the West-European countries. Wissenschaftl. Fachverlag Gießen, S. 54-153.

Tebrügge, F. & R.-A. Düring (1999**)**: Reducing tillage intensity- a review of results from long-term study in Germany. Soil & Tillage Research 53; 15-28.

Tebrügge, F. (2000**)**: Comparison of soil machine interactions by intensiv tillage and no-tillage 22 pp.. Poceedings 4th Inten. Conf. on Soil Dynamics, CD-ROM. Adelaide, Australia.

Tebrügge, F. (2000): Visionen für die Direktsaat und ihr Beitrag zum Boden-, Wasser- und Klimaschutz. Vortrag, Zollikofen-Bern, 28.06.2000.

Vorderbrügge, T. (1989): Einfluß des Bodengefüges auf Durchwurzelung und Ertrag bei Getreide – Untersuchungen an rekultivierten Böden und einem langjährigen Bodenbearbeitungsversuch. Wissenschaftlicher Fachverlag Dr. Fleck, Niederkleen. Diss. Uni Giessen, Inst. f. Bodenkunde.