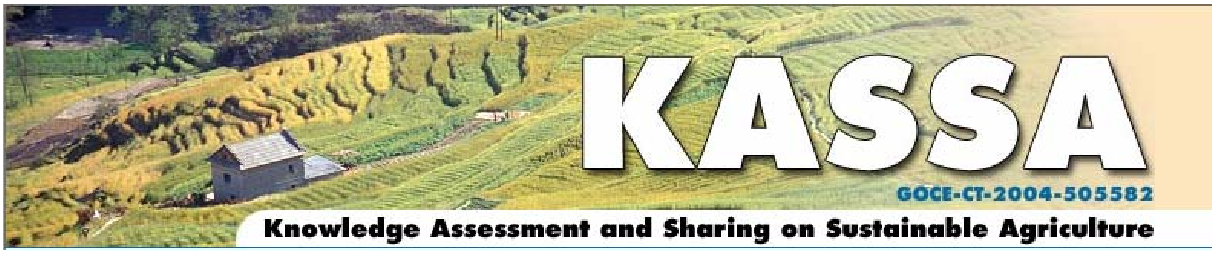

Comprehensive inventory and assessment of existing knowledge on sustainable agriculture in the European platform of KASSA

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2- INRA, France;
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Introduction

The objective of this report is to present a comprehensive inventory, a critical analysis and an assessment of existing knowledge on sustainable agriculture in the European Platform of KASSA (WP 1.1.). According to the CMU decisions, the inventory has been focused on Conservation Agriculture (reduced tillage, no-till, soil cover), Organic Farming and Genetically Modified Organisms, depending on the availability of the results in the participant countries. In the European Platform, we have emphasized the inventory and the assessment of the results on Conservation Agriculture, owing to the low level of any state of art on that topic (contrarily to Organic Farming) and the low development of GMOs (moratorium).

The methodology followed to achieve this work is split in several steps:

- Inventory of the results generated in the different countries, carried out by each participant. The references of the publications collected have been entered in the KASSA database, with the description of the conditions of obtaining results and the synthesis of the results obtained, in order to share this knowledge (353 publications from the 11 participants of the European Platform in early April).

- Critical analysis and synthesis of the results obtained in each participant country. The report of each country can be found in appendix.

- Synthesis and assessment of driving forces, constraints and impacts of alternative practices (Conservation Agriculture and Organic Farming), at the whole platform level. The writing of the different sections has been distributed among the partners, the draft report was discussed during the meeting, improved taking into account the decisions drawn up and validated by the partners. The validated report is presented in part I and II.

- Conclusion and proposals drawn up thanks to the brainstorming done during the meeting and finalized by the PF coordinator. This work is presented in part III.

I- Driving forces and constraints to dissemination of alternatives to conventional agriculture (e.g. Conservation Agriculture and Organic Farming)

(partners 2 and 5)

I-1- Conservation Agriculture: from concept to practices

The exchanges between the partners of the European platform have underlined the necessity to draw a common scheme for the description of the practices related to Conservation Agriculture, concept which appears rather vague for many people.

The first question we should try to answer is: ***How to make operational the concept of Conservation Agriculture?***

According to European Conservation Agriculture Forum (ECAF), *Conservation Agriculture refers to several practices which permit the management of the soil agrarian uses, altering its composition, structure and natural biodiversity as little as possible and defending it from degradation process (e.g. soil erosion and compaction).*

This definition of Conservation Agriculture is focused on the **objective to reach.** Nevertheless, the concept seems difficult to implement concretely and it appears necessary to go to a definition based on **the practices performed** to reach the results expected.

During the first World Congress of Conservation Agriculture held in Madrid in 2001, the single concept of Conservation Agriculture was refined leading to three main points:

- Minimum soil disturbance: i.e. minimum tillage
- Permanent soil cover
- Adapted crop rotation

This **single concept** of Conservation Agriculture is declined on the farm by a **wide variety of practices**. It seems crucial to describe all the practices used and to reach an agreement on what we are talking about when we say "Conservation Agriculture".

The following scheme (***Figure1***) presents a categorization of the two main factors involved in the definition of Conservation Agriculture:

1. <u>The type of soil tillage</u>: practices can be classified according to a gradient of soil tillage: from deep tillage without soil over-turning, to the total absence of soil tillage. Quantitative indicators can be defined, that permit to rank tillage practices along this gradient (e.g. depth of tillage, number of tillage operations). These indicators are sometimes used to characterize the practices (e.g.: in some publications "Superficial Tillage" corresponds to practices when the depth of tillage is < 10 cm, or in other publications, "Direct Sowing" corresponds to practices when the tillage depth is < 5 cm). This sort of classification may give rise to two main issues:
   - Lack of homogeneity in the limits fixed according to different authors;
   - The quantitative limits mentioned doesn't correspond to drastic changes in the functioning of the cropping system and are difficult to pick out (for

instance, some authors fix a limit at the depth of 10 cm, but no drastic change occurs between the depths of 9 cm and 11 cm).

In order to avoid ambiguousness, it seems crucial to emphasize the qualitative changes in soil tillage. Two main changes are distinguishable:

1) No ploughing,
2) No tillage.

These two limits allow one to classify the practices used for crop management without ambiguity. Nevertheless, when the cropping system scale is considered, another issue may appear: the practices used in a given field are often implemented intermittently. For example, ploughing may be introduced every 5 years, or, over the crop rotation, winter crops may be managed using direct sowing whereas spring crops are cropped using reduced tillage. That's why it is important to take into account alternation of the practices over the time.

2. The type of soil cover:
   - *no mulch*: in that case, there is no permanent soil cover. Crop residues are exported, burned or incorporated.
   - *crop residues*: mulch is provided by crop residues left on soil surface, that break down slowly enough to make a permanent cover.
   - *green manure*: catch crop is sown during the intercrop and broken down using various means (chemical, mechanical, frost), before sowing the next crop, providing additional biomass to make a permanent cover.
   - *mixed intercropping:* the catch crop is grown during the intercrop and left alive during the cash crop, which lead to a system of mixed intercropping.

When the two factors are crossed, twelve types of practices can be distinguished, with three main groups:

- **Reduced tillage**: it represents all the practices whose soil tillage is situated between no-ploughing and no-tillage, whatever the soil cover management.
- **No-tillage**: it represents all the practices without any soil tillage, whatever the soil cover management.
- **Mulch based**: represents all the practices without ploughing (minimum tillage or no tillage) and involving a soil cover (crop residues, catch crops or mixed intercropping)

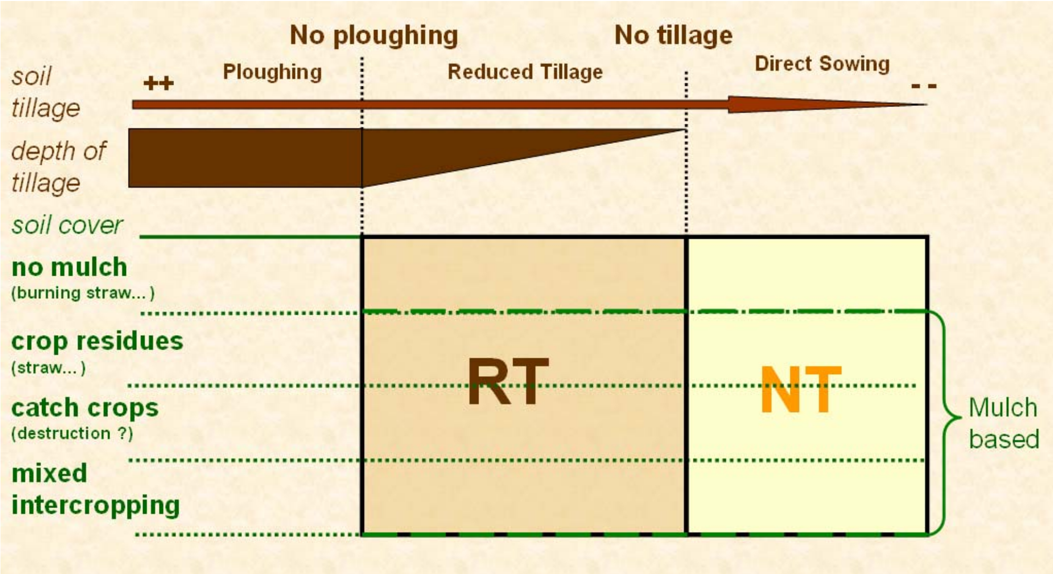

Figure 1: *Description of the variety of practices of soil management*

We decided to include into **the concept of Conservation Agriculture** all the practices involving **Reduced Tillage** or **No tillage**.

I-2- Extension of CA and OF in the European platform

According to the available data in the country reports and in the Description of Work document, the estimated extension of the CA (RT and NT) and OF practices in the European Platform is presented in the following table:

	RT		**NT**		**OF**	
	Area (ha) (date)	% of the agricultural used area	Area (ha) (date)	% of the agricultural used area	Area (ha) (date)	% of the agricultural used area
France	1 373 800 (2001)	4.6%	50 000 (2001)	0.2%	540 000 (2004)	1.8%
Germany	3 400 000 (2004)	20%	510 000 (2004)	3.0%	734 027 (2004)	4.3%
Denmark	150 000 (2004)	6.8%	~ 0 (2004)		147 400 (2003)	6.7%
Norway	158 000 * (2004)	15%	6 000 (2004)	0.6%	35 000 (2005)	3.4%
United Kingdom	1 416 000** (2000)	7.7%	24 000 (2000)	0.1%	688 000 (2004)	3.7%
Estonia	160 000	16%	10 000	1%	46 015	0.5%
Czech Republic	750 000 (2005)	18%	150 000 (2005)	3.5%	252 000 (2003)	5.9%
Ukraine	9 400 000 (2005)	24%	50 000 (2005)	0.1%	239 542 (2004)	0.6%

Table 1: *Extension of CA and OF in the European Platform*

** In Norway, acreage in RT also comprises the area ploughed in spring.*

***: The area under conservation tillage given for the UK the appears implausible as that type of farming is only now entering recognition amongst farmers in this country and it is thought that this figure includes the grazing areas that traditionally represent a very large segment of UK farming and are either never tilled or only ploughed to renew the ley, i.e. once every 4-10 years.*

It was roughly difficult to collect reliable data because:

- There is no official statistical data available in some countries;
- Data often refer to tillage practices implemented for each crop and not for the entire cropping system. For instance, most of the areas inventoried as “No Tillage” may correspond to fields managed in No Tillage only for a certain period of the rotation, whereas the other crops of the rotation are managed using reduced tillage or ploughing.

A qualitative assessment of the extension of each type of practices presented in ***Figure 1*** has been performed by each partner (Table 2 and Table 3)

Table 2: *Assessment of the importance of Reduced Tillage practices by each partner*
0: not used + : low level of use ++ : medium level of use +++ : high level of use

Soil tillage / Soil cover	Reduced tillage							
	France	Denmark	Germany West/East[1)]	Norway	UK	Estonia	CZ.Rep	Ukraine
No mulch	++	+++	+ / ++	0	0	++	++	+++
Crop residues	++	+	+++ / ++	+++	0	++	++	+
Catch crops	++	+	+ / ++	++	0	+	++	+
Mixed intercropping	0	0	+ / 0	0	0	0	0	0

[1)] The conditions of agriculture, the agro- climatic conditions in particular, differ significantly between both regions

Table 3: *Assessment of the importance of No Tillage practices by each partner*
0: not used + : low level of use ++ : medium level of use +++ : high level of use

Soil tillage / Soil cover	No tillage							
	France	Denmark	Germany West/East	Norway	UK	Estonia	CZ.Rep	Ukraine
No mulch	+/0	0	+ / ++	0	+	+	++	+
Crop residues	+	0	+ / +	+	+	+	++	+
Catch crops	+	+	+ / +	0	0	+	++	+
Mixed intercropping	0/+	0	+ / 0	0	0	0	0	0

It appears that No Tillage is very little used in Europe. There is a large diversity of situations between the countries, which also implies diversity in the practices used. This diversity results from driving forces and constraints, which are different from country to country.

I-3- Driving forces and constraints

Dissemination of innovative practices is submitted to many factors that act as driving forces or constraints. Five main conditions are able to affect the extension of innovative practices:

1. Pedo-climatic conditions
2. Agronomic conditions
3. Sociologic conditions
4. Economic conditions
5. Political conditions

I-3-1- Pedo-climatic conditions[1]

Driving forces:

➢ Soil erosion is a crucial issue highlighted in Northern Europe, able to induce changes in agricultural practices. The issue was mentioned in 7 countries out of 8 (France, Germany, Norway, Czech Republic, Ukraine, United Kingdom and Estonia]. **Water erosion** is the main issue noticed, but **wind erosion** has also been highlighted in Czech Republic and Ukraine.

Nevertheless, the importance of this factor differs from one country to another: for instance, in Estonia, the intensity of natural erosion is not high, whereas, in Czech Republic, erosion is the most significant degradation process.

➢ Soil crusting: in the loamy lands of the North of Europe, soils are very sensitive to crusting. One way able to limit crusting is to keep a permanent cover on the soil (France).

➢ Pebble rising: soil turn-over causes the rising of the deep stones. Giving up ploughing is a method limiting stone rising (Ukraine, France).

Table 4: *Assessment of the qualitative importance of pedo-climatic driving forces by each partner*
0: not used + : low level of use ++ : medium level of use +++ : high level of use

	Driving Forces	France	Denmark	Germany West/East	Norway	UK	Estonia	CZ.Rep	Ukraine
CA	Soil erosion	++	0	+++ / ++	+++	++	+	++	+++
	Soil crusting	++	0	+ / +	0	++	++	+	+
	Pebble rising	+	0	+ / ++	+	++	++	+	+
	Soil degradation *(compaction…)*	0	0	++ / +++		++	++	0	++

[1] Appendix 1, France partner 2, section 1.2.1 page 5 ; Appendix 4 , Denmark partner 7, section 2.1., page 8 ; Appendix 5, Germany partner 9, *Context of development*, page 3 ; Appendix 7, Norway partner 11, section 1.2.1, page 5 ; Appendix 10, Czech Republic partner 14, section A, page 7 ; Appendix 9, Estonia partner 13, page 7-8-9 ; Appendix 11, Ukraine report partner 15, *Description* section 1 page 3-4 /*Brief analysis* section 4 page 20 ;

Constraints:

➢ Soil characteristics: texture and water-logging: the characteristics of soils must be taken into account in order to succeed in performing RT practices. In fact, RT is mostly suitable to soils with good structure. For instance, RT is an interesting alternative to conventional agriculture for heavy clay soils where ploughing can be difficult and often provides better results. On the contrary, in sandy soils, RT practices are difficult to perform: compaction can occur and prevent roots development. In these soils, occasional loosening of soil is often necessary (Denmark, Germany).

In addition, poorly drained soils are not suitable for RT. The constraints linked to soil characteristics limit the extension of the areas (France, Ukraine).

➢ Soil humidity and temperature: reduced tillage often induces an increase in soil humidity and a decrease in soil temperature. This may be an advantage in the areas where the hydric deficiency is high (in some areas of Germany or Czech Republic for instance). Nevertheless, the changes in soil temperature and humidity mainly represents a constraint in North Europe, especially in northern countries (Norway, Denmark) for many reasons:

- Delay in emergence and development of spring crops (Norway);
- Slow down of mineralization, which affects nitrogen availability (Norway).

This process makes very difficult the development of reduced tillage practices for spring crops. This explains that RT is mainly performed for winter crops in northern Europe.

Table 5: *Assessment of the qualitative importance of pedo-climatic constraints by each partner*
0: not used + : low level of use ++ : medium level of use +++ : high level of use

	Constraints	France	Denmark	Germany West/East	Norway	UK	Estonia	CZ.Rep	Ukraine
CA	Soil characteristics (*texture / water-logging)*	+++	+	+++ / +	++	++	+++	0	++
	Soil humidity and temperature	++	++	+ /	+++	+++	+++	0	+

I-3-2- Agronomic conditions[2]

Driving forces:

➢ Necessity to increase the soil organic matter content: the crucial role of organic matter in soil properties and dynamics leads to try to restore it when damaged (Estonia). RT is a method which permits to reach a new equilibrium in the soil (France).

[2] Appendix 2, France partner 5, section 2 ; Appendix 3, Denmark partner 6, section 1.3; Appendix 4, Denmark partner 7, Step 3 section 1.2 ; Appendix 6, Germany partner 10, section 1, page 7; Appendix 7, Norway partner 11, section 1.2.4 ; Appendix 9, Estonia partner 13, page 5-6 ; Appendix 10, Czech Republic partner 14, page 10 ; Appendix 11, Ukraine partner 15, *Brief analysis* section 1 ;

➢ Higher trafficability: in RT, trafficability is improved, which induces an increase in the number of suitable days for soil tillage, without high risk of compaction [France (5)]. In addition, reducing the number of passages of the agricultural machines is able to limit compaction and improve soil structure in some areas where soils are mechanically damaged due to the use of heavy agricultural machinery (Estonia, Ukraine).

➢ Development of technologies required for implementing RT or SD (especially machinery and herbicides): it is (or it has been) a major force driving the development of CA (Germany). This process was mainly boosted by private companies which play a more or less important role depending on the countries. On the contrary, in some countries, the absence of suitable technology for RT management is a strong constraint, which retards the extension of the practice (Ukraine).

➢ Concerning organic farming extension, the process of control and certification of seeds has largely promoted the development of OF practices but may become a constraint (new rules for certification give problems because there is a lack of organic seeds varieties) (Denmark). The right choice of seed is the first step to perform sustainable and efficient crop.

Table 6: *Assessment of the qualitative importance of agronomic driving forces by each partner*
0: not used + : low level of use ++ : medium level of use +++ : high level of use

	Driving Forces	France	Denmark	Germany West/East	Norway	UK	Estonia	CZ.Rep	Ukraine
CA	Need to increase the soil organic matter	++	0	+ / 0	+	++	+++	++	++
CA	Trafficability	+	0	++ / +	+	++	++	+	+
CA	Technology development *(herbicide efficiency, material quality)*	++	0	+ / +++	++	+	+++	+	+++
OF	Control and certification of seeds	0	++	+ / +	0	0	++	0	+

Constraints:

➢ Difficulties for agronomic management:

The thorough changes in the functioning of the agro-system induced by Conservation Agriculture lead to totally revise the practices implemented, in order to control some issues that are more or less crucial depending on the situations:

- ✓ Weed infestation (see § II-2-6)
- ✓ Slugs and mice infestation (see § II-1-4)
- ✓ Crop residue management (see § II-2-5)
- ✓ Disease and pest increase (see § II-2-7)
- ✓ Soil structure (see § II-2-1)

Farmers can be led to completely change the cropping system (catch crop, rotation).
Now, there are only few references available and we have little experience, due to:

- ✓ The novelty of these systems (especially SD);
- ✓ The difficulty to transfer results and solutions obtained in other contexts (pedo-climatic, socio-economic);
- ✓ The need to change many practices in coherence, in order to suit to the context and to reach some objectives, which may be very different from case to case.

Though the improvement of agricultural technologies (see above), there are still many agronomic issues that are not solved. The agronomic management constraint remains one of the main constraints explaining the low expansion of RT practices in Northern Europe.

➢ <u>Concerning organic farming extension:</u> some issues pointed out in CA are also considered as constraints in OF: weeds, slugs, crop rotation… Nevertheless, more references and more experience are available on OF systems. Besides, the farming system play a crucial role, as for instance, the difficulty for implementing stockless OF in some areas (Norway).

Table 7: *Assessment of the qualitative importance of agronomic constraints by each partner*
0: not used + : low level of use ++ : medium level of use +++ : high level of use

	Constraints		France	Denmark	Germany West/East	Norway	UK	Estonia	CZ.Rep	Ukraine
CA	Management issues	weeds	+++	++	+++ / ++	+++	+++	+++	+	+++
		diseases	++	+	+++ / ++	+++	++	++	+	++
		slugs&mice	++	0	++ / ++	+	0	+	+	?
		straw residues	++	0	++ / +++	++	+	++	0	+++
		soil structure	+++	0	0 / +	+	+++	+++	0	++
		rotation	++	0	++ / +	+++	+++	+++	0	+++
		catch crops	++	0	+ / +	+	+++	+	0	++
	Lack of references		+++		+ /	+	+++	+	++	+++
OF	Management issues *(weeds, nutrients…)*		++	++	+++ / +++	+++	+++	+++	0	++
	Farming system *(livestock)*		++	+++	++ / ++	+++	+++	+++	0	?

<u>I-3-3- Sociological conditions[3]</u>

<u>Driving forces:</u>

➢ <u>Improvement of labour organization:</u> as RT reduces labour time, it leads to improve the work organization on farm (France). It is an important sociological factor, which is linked to the necessity to increase productivity (see *I-3-4- Economic conditions*).

[3] Appendix 1, France partner 2, section 1.2.4 ; Appendix 2, France partner 5, section 3.2 ; Appendix 4, Denmark partner 7, step 2, section 3 ; Appendix 7, Norway partner 11, section 1.2.2

➢ Association promoting alternative practices: farmers performing RT practices usually bring together in order to exchange experiences and practices. The membership feeling is strong in the group and members need to meet other farmers performing similar practices in order to be confirmed into their choices and their convictions. Such associations exist in several countries in the platform, for instance FNACS in France or FRDK in Denmark (Denmark, France). These associations are driving forces to motivate investigations and to develop the practices on farm.

Table 8: *Assessment of the qualitative importance of sociological driving forces by each partner*
0: not used + : low level of use ++ : medium level of use +++ : high level of use

	Driving Forces	France	Denmark	Germany West/East	Norway	UK	Estonia	CZ.Rep	Ukraine
CA	Labour organization	+++	+++	+++ / +++	+	0	+	+	++
	Association of farmers	++	+++	+ / ++	+++	+	+	0	+++

Constraints:

➢ Psychological changes: ploughing is a traditional technique in the North Europe and is considered as a symbolic practice in many countries (France, Ukraine). Adopting an innovative technique requires first of all changes in farmers' mind and questions the traditional conception of agriculture (France). In Europe, regarding the traditional heritage of agricultural society, some farmers are not psychologically prepared to launch into new ways of cropping.

➢ Marginalization: in some countries of the platform, farmers who practice reduced tillage practices may be marginalized:

✓ *Of the neighbourhood*: giving up ploughing represents a cultural revolution and often is not accepted by their neighbours and the fear to become marginalized can prevent farmers from changing (France).

✓ *Of the development networks:* in some countries the lack of references on CA appears through the difficulty of the development networks to answers farmers' requests. This process leads some farmers to become marginalized of these networks and to turn towards associations of farmers or private companies in order to satisfy their expectations.

➢ Technical investment and education: adopting RT requires high technical investment and additional knowledge on the functioning of the cropping system (France). Farmers should put appropriate themselves new techniques in order to succeed in agronomic management.

Table 9: *Assessment of the qualitative importance of sociological constraints by each partner*

0: not used + : low level of use ++ : medium level of use +++ : high level of use

	Constraints	France	Denmark	Germany West/East	Norway	UK	Estonia	CZ.Rep	Ukraine
CA	Traditional conception of ploughing *(psychologic change)*	+++	++	++ / +	++	+++	+++	0	+++
	Marginalization *(neighbours, development networks)*	+++	0	0 / 0	++	0	++	0	++
	Investment to gain specific knowledge	++	0?	++ / ++	++	+++	++	+	+++

I-3-4- Economic conditions[4]

Driving forces

➢ Reduction of the costs and labour time: it seems to be a major factor inducing the change at the platform scale. In all the countries, the increase of competition at the global scale as at the European scale leads many farmers to tend to reduce the costs and to increase productivity. CA may be a mean to achieve this requirement, involving the reduction of the input costs (fuel) and of the labour time devoted to soil tillage (Germany, France, Denmark, Czech Republic).

These factors are able to explain the fact that reduced tillage practices are mainly performed in large size farms in which the financial benefit of full capacity machinery use and the increase in labour productivity are higher than in small size farms (Germany, France, Denmark).

➢ Increase or stabilization of yields: in some areas, CA may lead to increase or stabilize yields. This process is mainly observed in the areas with low or medium level of yield potential (France, Czech Republic).

➢ Concerning organic farming extension, the three main driving forces noticed are:

- ✓ Increase in the demand of products of quality and the increase in prices;
- ✓ Proximity of urban markets (Denmark);
- ✓ Export (Denmark).

[4] Appendix 1, France partner 2, section 1.2.2 ; Appendix 2, France partner 5, section 2; Appendix 3, Denmark partner 6, section 1.3; Appendix 4, Denmark partner 7, Step 2 section 2.3; Appendix 5, Germany partner 9, page 8 and 16; Appendix 6, Germany partner 10, page 7; Appendix 10, Czech Republic partner 14, section B;

Table 10: *Assessment of the qualitative importance of economic driving forces by each partner*
0: not used + : low level of use ++ : medium level of use +++ : high level of use

	Driving Forces	France	Denmark	Germany West/East	Norway	UK	Estonia	CZ.Rep	Ukraine
CA	Cost reduction *(fuel consumption, machinery costs)*	+++	+++	+++ / +++	++	+++	+++	++	+++
	Labour time	+++	+++	+++ / +++	+	+++	+	++	+++
	Increase or stabilization of yields *(in areas with medium level of yields)*	++	0?	0 / 0	++	+	++	++	+
OF	Increase in the demand and in the prices	+++	+++	+++ / +++	+++	+++	+++	+	+
	Proximity of urban markets	++	++	++ / ++	+++	+	+	++	+
	Export	+	+	+ / +	0	+	+	0	+

Constraints:

➢ Expensive equipment: the necessary investment at the beginning of the implementation of RT practices is high: equipment (specific sowing machines) is very expensive and many farmers hesitate buying such machines which will be profitable only after several years.

➢ Transition period: it is very risky regarding yields until finding new system equilibrium and farmers have to appropriate themselves the knowledge necessary to implement RT practices. The economic risk during this transition period (high investment and potentially low yields) may discourage farmers to launch into RT. The issues of the transition period are also observed when conversion to Organic Farming, but in that case, farmers can receive subsidies from the government (Denmark).

➢ Decrease in yields: in the areas with high level of yields, the reduced tillage practices may induce a decrease in yields compared to intensive conventional tillage (France).

Table 11: *Assessment of the qualitative importance of economic constraints by each partner*

0: not used + : low level of use ++ : medium level of use +++ : high level of use

	Constraints	France	Denmark	Germany West/East	Norway	UK	Estonia	CZ.Rep	Ukraine
CA	Material investment	+++	+++	++ / ++	++	+++	++	+++	+++
CA	Diminution of yields *(in areas with high level of yields)*	+++	+	+++ / +++	+	0	+	++	+
CA	Transition period	+++	+	+ / ++	+++	+	+	+	+
OF	Transition period	+	+	+ / ++	+++	++	+	+	+

I-3-5- Political conditions[5]

Driving forces:

In all the countries of the platform, it is possible to find legislations directly or indirectly related to soil conservation and OF.
There are three main types of political measures that can affect the development of CA and OF.

- Political decision that induces economic consequences, which acts indirectly in favour of RT development. For instance, the Common Agricultural Policy (1992) aims to reduce the costs, to enlarge farm areas and to diversify farm activities. These objectives can be reached by performing reduced tillage. That's why indirectly, CAP favours RT (France).

- Regulation measures: governments may bring compulsory measures aiming at reducing environmental impact of agriculture and promoting sustainable practices. In some countries, these measures are in favour of CA (erosion control (Norway, Czech Republic), compulsory catch crops (France), fertilizers and manure use and storage (Czech Republic)

- Subsidies: in some areas, financial incentives are distributed to promote CA practices (Norway, Germany) or OF practices (Denmark, Germany, France). Subsidies often act as a strong mechanism in order to extend CA areas.

Political measures highly vary depending on the countries of the platform (action or subsidies), but in all them, they generally strongly act to drive the extension of sustainable agriculture. Policy seems to be the major factor of extension, in front of all the other ones.

[5] Appendix 1, France partner 2, section 1.2.3 ; Appendix 3, Denmark partner 6, section 1.3 ; Appendix 4, Denmark partner 7, page 4; Appendix 5, Germany partner 9, page 8-9 ; Appendix 7, Norway partner 11, section 1.2.3 ; Appendix 10, Czech Republic partner 14, page 7 ;

***Table 12**: Assessment of the qualitative importance of political driving forces by each partner*
0: not used + : low level of use ++ : medium level of use +++ : high level of use

	Driving Forces	France	Denmark	Germany West/East	Norway	UK	Estonia	CZ.Rep	Ukraine
CA	Political decision induces economic consequences	++	0	++ / ++	++	+++	+	+	++
	Regulation measures	+	0	+ / +	+	+++	++	0	++
	Subsidies	0	0	++ / ++	+++	+++	+++	0	+++

Constraints

- Restriction measures: burning straws (Denmark), application date of N fertilizers (France): they can act as constraints for CA development, if no other technical solution is found (concerning crop residue management for instance).

***Table 13:** Assessment of the qualitative importance of political constraints by each partner*
0: not used + : low level of use ++ : medium level of use +++ : high level of use

	Constraints	France	Denmark	Germany West/East	Norway	UK	Estonia	CZ.Rep	Ukraine
CA	Restriction *(e.g. restriction of burning straws, date of application of N fertilizers)*	++	++	+ / +	++	++	++	+	+
	Pesticide use reduction	+++	0	++ / ++	+++	0	++	0	++
OF	Absence of legislative grounds	0	0	0 / 0	+	+++	+++	0	++

Conclusion:

As far as public supports to CA are concerned, the results show a trade-off between erosion and pesticides: in the areas where erosion is the major concern, subsidies are allotted to practices favouring erosion mitigation (Norway). On the contrary, in the areas where pesticides are the main issue, there is no support for CA (France).

II- Impact of Conservation Agriculture and Organic Farming in Europe: assessment and significance of the knowledge generated

II-1- Environmental impacts

II-1-1- Carbon cycle and greenhouse gas emissions (partners 13 and 14)

II-1-1-1- Soil organic matter content and carbon cycle

There is little information available on soil organic matter and carbon cycle. The majority of the results come from French long term experiments: soil organic matter characteristics and dynamics in no-till systems are studied in comparison with conventional systems. Moreover, qualitative observations are made on-farm[6]. A Czech experiment is also mentioned on that topic (Horáček et al., 2001). Besides, in Germany, soil organic matter characteristics are studied in relation with soil ecology[7].

Reducing soil tillage affects soil organic matter and carbon cycle on four aspects:

- distribution in the profile layer,
- stocks,
- quality
- dynamics.

Reducing soil tillage leads to an evolution of the distribution of soil organic matter in the profile layer (Balesdent *et al*, 1990; Friebe, 1992a +b; Ahrens et al., 1994; Stockfish et al., 1999; Tebrügge, 2000; Horáček et al., 2001). In conventional tillage, organic carbon distribution is uniform over the first 30 centimetres, resulting of soil turn-over by ploughing (SOM rate is about 2% in the French long term experiment (*in:* Labreuche et Bodet, 2001)). When giving up ploughing, soil organic matter provided by crop residues is not buried and accumulates in topsoil (75% of the organic carbon returned from the crop can be found in the uppermost 5 cm (Balesdent *et al*, 1990)). A decreasing gradient of organic carbon is established from the surface to the deeper layers. This gradient depends on:

- The duration of the implementation of reduced tillage practices;
- The type of practice used: the less the soil is disturbed, the more the gradient is marked. French studies show that the increase in organic matter rate between the depth and the superficial layer is by 2% in NT whereas it is 1% in RT (from 1.6% to 3.6% in NT and 1.6% to 2.6% in RT) (*in:* Labreuche et Bodet, 2001).

Concerning **organic carbon and nitrogen stocks**, German studies show that they were **higher in no ploughed systems**. In a superficially tilled system (12 cm), the increase in organic carbon is about 5 Mg/ha and the increase in total nitrogen is about 1 Mg/ha (Stockfish et al., 1999). French results confirm that observation. The average storage of carbon in reduced tillage systems was estimated by 0.2 ± 0.13 tC/ha/year (Arrouays *et al*,

[6] Appendix 1, France partner 5, section 2.1, page 5
[7] Appendix 5, Germany partner 9, *Conservation Tillage* section III-3, page 17

2002). Nevertheless, it is crucial to keep in mind that carbon storage strongly depends on the technique used and the duration of implementation. From case to case, the value of average carbon storage fluctuates between 0.1 and 0.3 tC/ha/year (Thevenet *et al*, 2002). The type of soil cover is important in that process: for instance, in a direct drilling system with a permanent soil cover, carbon stocks significantly increase by 8% in comparison with the conventional system (Balabane *et al*., 2005).

Concerning **soil organic matter quality**, there is very few data available in Europe. The main results come from French studies and highlight that only cropping systems with a permanent cover differ from conventional systems in the distribution between particulate (> 50 µm) and humified (< 50 µm) organic matter. There is no differences between no till without cover crop and conventional plot, whereas there is an increase by 23% in POM-C% Total C in a permanent cover and zero tillage system in comparison with a conventional system. Consequently, POM-C could not constitute a reliable indicator of the effects of different till management on soil functioning and the use of POM-N as indicator could be more relevant (Balabane *et al*., 2005).

When reducing soil tillage, the functioning of the soil is affected, and **dynamics of soil organic matter is modified**:

- Return of organic matter from the crop is lower in no-till;
- Organic carbon mineralization is also lower in no-till. In French long term experiment, the amount of original soil organic matter mineralized in 17 years is divided by 2 in no-till in comparison with the conventional system (0.45 kgC/m² in no-till versus 0.95 kgC/m² in conventional system, (Balesdent *et al*, 1990)). The slow down of mineralization speed can be partly explained by the association between organic matter and mineral particles. Ploughing break down this association and release organic matter which is exposed to mineralization. On the contrary, when the soil is less disturbed (in RT and NT), the aggregates remain stable and mineral particles prevent organic carbon from mineralization (Balesdent *et al*, 1990). In addition, the modifications of air-providing and microbial activity that occur when reducing soil tillage are also liable to affect mineralization speed.

II-1-1-2- Greenhouse gas emissions

There are few results on greenhouse gas emissions due to:

- The novelty of that issue;
- The difficulty to implement methods of measurement of gas emissions *in situ* (in particular N2O emissions).

One on-going study is mentioned in France about CO_2 and N_2O emissions and two studies are mentioned in Germany, dealing with N_2O emissions and CH_4 oxidation .

CO_2 emissions were very variable and **no significant differences** appeared between no-till and conventional tillage (Nicolardot *et* al, proceedings, 2004). Nevertheless, cumulated emissions over a year tend to be slightly higher in no-till than in conventional (4068± 221 kgC/ha versus 3162± 453 kgC/ha). More studies are required to compare these results and to draw up reliable conclusions.

Concerning **N_2O emissions**, French and German results are coherent. German studies showed that **emissions were significantly higher** in no-till systems. The gas was supposed to be produced during nitrification and not denitrification, because the ratio N_2O/N_2 remained low (1,2) (Hütsch & Mengel, 1991; Motz, 2003). The same trend was observed in French experiments (Nicolardot *et* al, proceedings, 2004). Nevertheless, these observations have to be carefully considered: methods of measurement only permit to collect emissions during a short period of time (3 hours) and the extrapolation to a longer period (day, month, year) can not be easily done.

CH_4 oxidation was observed to be higher in undisturbed soils (Hütsch, 1998).

II-1-2- Erosion mitigation (partners 13 and 14)

Even if it is commonly accepted that CA is a mean permitting to reduce erosion (see *I- Driving forces and constraints*), there are few studies mentioned on that topic by the KASSA partners. The results presented in this section mainly come from French experiments, which are carried out both on-farm and in experimental stations[8] and from German experiments[9]. Moreover, some studies carried out in Norway deal with the effects of the period of tillage on erosion, but they are focused on ploughing[10].

Erosion and runoff measurements show that, in no-till, erosion is reduced both during the cropping period and the intercrop (during the intercrop, sediment losses are reduced by 4,5 times : 182kg sediment/ha in the ploughed treatment versus 40 kg/ha in the no-till treatment) (Martin, 1999). No-tillage effects on erosion increase over a long duration. In a long term project, calculation of sediment losses of 6400 kg/ha (CT) and 900 kg/ha (NT) highlighted the soil protective impact of no-tillage system in the long term (Fischer et al., 1995). Regarding runoff, it is also reduced during the cropping period, but during the intercrop, it can increase in some situations (no-till without a cover crop, superficial tillage in humid conditions…). In order to avoid run-off during the intercrop, it is advised to sow a cover crop (mustard, fescue, ray grass…). Results on experimental stations showed that runoff was reduced by 4 times when a mustard intercrop was sown: 6.1 mm in no-till system to 1.5 mm in the system with the cover crop (Martin, 1999). On farms results confirm this observation: sowing a mustard intercrop permits to reduce runoff by 1.5 to 15 times from case to case (Seine Maritime CA *et al*, study report, 2004).

Time of tillage is important to be taken into account in order to reduce erosion. The information available on that topic concern ploughing: Norwegian studies showed that autumn ploughing leads to a high risk of erosion, whereas spring tillage results in little soil loss when the soil is protected by plant residues after the growing season. In this long-term trial, they found that spring tillage reduced the annual soil losses by 90%, compared to autumn ploughing (Lundekvam and Skoien, 1998). There is no study available in Europe concerning RT systems, but similarly, it seems that the date of tillage should be carefully considered regarding erosion and runoff issues.

The process of erosion mitigation results from the increase in topsoil stability. The stability is improved in no-till in the upper 3 centimetres of the profile layer whereas it is unchanged in the deeper layers (Monnier et al, 1976). This trend was first observed in the 70s, and new methods permitted to refine the results and to evaluate the stability in

[8] Appendix 1, France partner 2, section III-2, page 14
[9] Appendix 5, Germany partner 9, *Conservation Tillage* section III-4, page 21
[10] Appendix 7, Norway partner 11, section 3.3.3, page 13

comparison to different mechanics of desegregation. It was observed that no till leads to an increase in topsoil stability mainly in case of heavy rains (tested by explosion of aggregates), or in case of repeated moderate rains (tested by slow humidifying of the aggregates). In addition, the stability seemed to be more efficiently improved in case of permanent soil cover (Balabane *et al*, 2005).

Soil stability is closely linked to soil organic carbon content. Especially, young organic matter accumulated in surface would be responsible for macroaggregate stability (>2µ) (Puget *et al*, 1995).

II-1-3- Pollutants in soil and water
(Partners 2 and 9)

II-1-3-1- Studies available on pollutants

The interest and therefore the knowledge on the fate and reactivity of pollutants in conservation tillage and organic farming seem to be **very individual in the different partner countries** involved in the KASSA Project. While in western countries the fate of pesticides is one major issue in agricultural and environmental research, this subject is of less importance in eastern European countries. This is due to the fact, that the input of pesticides in eastern EC is usually very low because of high market prices.

Most partners mainly mention studies and results on **nutrient leaching**. Few of them are concerned with the interrelation of reduced tillage and nutrient leaching in a narrower sense. Other studies on this subject are often embedded in studies on nutrient cycle and nutrient management in general.

Very little is known on the **fate of pesticides under reduced tillage (RT) situations**, though it is broadly accepted, that RT and especially no-tillage (NT) may lead to an increased use of herbicides and an increased number of treatments for weed control (several studies[11]). When changing the tillage system, it is a challenge to adapt weed control to the new situation. Several experiences and studies are described that pronounce the importance of adapted crop rotations and cover crops (Brandsaeter et al., 1998; Breland, 1996a; Bräutigam, 1993). However, no exact results are described on this subject.
Though some results of other studies concerning glyphosate (Stenrød et al., 2005a; Stenrød et al., 2005b; Stenrød et al., 2005c; Stenrød et al., 2005d) may be carefully extrapolated to RT systems, only very few studies are mentioned that focus on the impact of RT on the fate of pesticides (Düring et al., 2002a; Düring et al., 2002b, Real *et al*, 2005).
Furthermore, some studies point at a higher need for **fungicide use** because of a higher infestation risk under reduced tillage conditions[12]. However, there are also contradictory experiences[13].

[11] Appendix 4, Denmark partner 7, section 2.4., page 9 ; Appendix 7, Denmark partner 11, section 3.3.2, page 12 ; Appendix 1, France partner 2, section III-7-2, page 25 ; Appendix 5, Germany partner 9, *Conservation Tillage* section III-1, page 15

[12] Appendix 5, Germany partner 9, *Conservation Tillage* section III-1, page 15; Appendix 7, Norway partner 11, section 3.5.5, page 19

[13] Appendix 2, France partner 5, section 2.2, page 7

Only very few studies are available on the **fate of other pollutants in RT systems**, as for example heavy metals and organic pollutants originating from agricultural use of sludge and composts (Ellingsen, 2005; Jensen, 2005; Düring et al., 2002a; Tebrügge & Düring, 1999).

While especially the N-management is a subject of great interest of research in organic farming, little results are mentioned on the **leaching and groundwater pollution in organic farming systems**[14]. This is also true for other pollutants originating from organic farming, because prohibition of application of chemical pesticides and mineral fertilizers as well as limitation of livestock intensity generally leads to less environmental pollution. This may be the reason, why there are only very few results on the fate of pesticides, accepted for the use in organic farming (Neem-products, Pyrethrin, Copper-agents etc.). Most of these studies focus the plant protective impact rather than environmental effects.
As a matter of fact, recycling is a major principle in organic farming. However, legal or voluntary regulations often restrict the use of sludge and wastes in organic farming. Nevertheless is the fate of pollutants originating from these materials a subject to some studies.
However, in some European Partner Countries of the KASSA Project organic farming has just been introduced for a few years and therefore only few studies and rather less reliable data are available at present (Estonia, Czech Republic, Ukraine).

II-1-3-2- Leaching of nutrients (especially N)

The results of several studies indicate a significant **decrease of nutrient (N, P, K) losses under reduced tillage intensity** when compared to conventional plough tillage (Tebrügge, 2000; www.lr.dk, 2004, Eltun, 1995; Eltun and Fugleberg, 1996; Korsaeth and Eltun, 2000).
A **peak of mineralization** without sufficient plant cover **is avoided** when ploughing is abandoned (Kohl & Harrach, 1991; Riley, 1998).
One major fact to **reduce N losses** in conventional tillage systems was found to be the **time of ploughing**. Norwegian modelling results confirm field experimental data where ploughing in early autumn resulted in high N losses and should therefore be avoided. As a result of the model studies autumn ploughing as late as possible was recommended as an alternative to spring ploughing (Korsæth et al., 2002a). However, no European results are mentioned concerning the impact of the time of tillage in RT systems on nutrient fluxes.

Especially **leaching of nitrate seems to be reduced** along with reduced tillage intensity (www.lr.dk, 2004, Tebrügge, 2000). Nutrients are accumulated in the upper soil layer under NT. However, a higher susceptibility of macropore flow is described for NT soils due to more (permanent) earthworm channels which in German studies resulted in water by-passing the soil matrix and preventing nutrients from leaching (Kohl & Harrach, 1994). On the other hand, in no-till soils nutrients may be subject to fast depth transfer under unfavourable conditions (heavy rainfall in short time interval after application) (Tebrügge & Düring, 1999). However, better infiltration capacity of RT soils results in a decrease of lateral surface flow and therefore in a decrease of soil erosion, decreasing also nutrient losses via the lateral path.

[14] Appendix 7, Norway partner 11, section 3.3.1., page 10;

An important fact regarded in several studies is the **benefits of catch crops**. Results from Norwegian studies point out that especially Ryegrass efficiently traps nitrogen that otherwise would be leached from the soil (Molteberg et al., 2004). Furthermore, in Czech experiments it could be shown that catch crops could even support the yield formation by means of better time distribution and higher efficiency of nitrogen nutrition (Javůrek and Vach, 2002). To avoid nutrient losses and aligned water pollution a plant cover over the whole year is recommended (Breland, 1995). However, nutrient management should be geared to synchronize plant available nutrients and demand of the plants.

In organic farming systems, the risk of nutrient losses is generally lower due to lower input and lower stocking rates (Hansen et al., 2001; Korsaeth and Eltun, 2000). Nevertheless, there are various studies especially on N management in organic farming. German results indicate that for example appropriate grass-clover management and date of ploughing can reduce N-leaching, even in stockless farms. However, efforts to manage stockless farms in organic agriculture are subject to Norwegian studies, too.

II-1-3-3- Fate of other pollutants: pesticides, heavy metals and organic pollutants

As mentioned above, the studies on other pollutants mainly focus on the fate of pesticides and heavy metals in soils under different management.

The **fate of pesticides in various tillage systems** was intensively studied in Germany. The results clearly show that transfer of pesticides is related to the **distribution of soil organic matter**. As soil organic matter is enriched in the upper layer of NT soils, pesticides susceptible to sorption on organic matter also accumulate near the surface and show less availability to depth transfer (Düring et al., 2002a; Düring et al., 2002b). Similar results may be extrapolated from Norwegian studies, that however did not take into account different tillage systems but nevertheless describe increased binding and degradation of glyphosate with increasing organic matter content in upper soil layers. In these projects, it was found that glyphosate degradation increases with increasing temperature and decreases with increasing soil depth due to decreasing soil organic matter content (Stenrød et al., 2005a; Stenrød et al., 2005b; Stenrød et al., 2005c; Stenrød et al., 2005d).
However, **pesticides are generally faster broken down in NT soils due to higher microbial activity** (Düring et al., 2002a; Düring et al., 2002b), which may be confirmed by extrapolating the Norwegian studies mentioned above.

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 (Tebrügge & Düring, 1999). Further research is needed in this field through the cooperation of soil tillage experts and those who study the fate of the various pesticides.

As described for pesticides, the fate of other pollutants is similarly related to the depth distribution of soil organic matter. **Higher sorption rates of heavy metals under NT** were detected in German studies 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). The soil-plant interactions and the behaviour of heavy metals in soil is a major subject to many KASSA Partners and is studied actively. Nevertheless, studies on the impact of different tillage systems on the fate of these pollutants are rare.

Studies on **persistent organic pollutants** (POP) are rarely mentioned [only in German report]. Due to their partition behaviour, these lipophilic compounds are **strongly absorbed 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 of polychlorinated biphenyls (PCB) among soil depths. The main route for vertical transport of PCBs in arable soils would be mechanical mixing or, in case of NT, bioturbation via earthworm activity (Düring et al., 2002a). Erosion, which should be limited under RT, may be regarded as a possible path of pollution for those compounds. It showed to be very important to take into account different congeners as well as metabolites of organic pollutants that might reveal a different behaviour in the environment. It will be an important future task of research to investigate the fate and reactivity of multiple organic compounds that are in use today and pose potential health and environmental risks. Far too little is known yet about the behaviour of these substances in the environment, whereas the recycling of organic wastes containing these will probably increase in terms of conservation of natural resources.

II-1-4- Biodiversity
(Partners 2 and 9)

II-1-4-1- Studies available on biodiversity

The **knowledge and results of studies** on impacts of conservation agriculture and organic farming on biodiversity **are various** in the different partner countries of the KASSA Project. All partners signalise a great interest in the interrelations of conservative agriculture and biodiversity. In some countries, where for example organic farming is just developing and is practised to a little extent today, research on this issue has been started recently and only few results are available at present. Other countries have focused on this subject for several years, though.

Although it is accepted that organic farming generally supports biodiversity by abandoning the use of chemical fertilizers and pesticides as well as generally lower input, only few partners describe distinct results on changes in biodiversity[15]. From these projects, it is concluded that in an environmental point of view **organic farming is superior to conventional agriculture as the support of biodiversity**, ecosystem functioning and nature quality is a central and system immanent goal of organic farming practices. Nevertheless, these results are not well documented.

II-1-4-2- Impact of organic farming on biodiversity

An important research topic is the **conversion phase from conventional agriculture to organic farming**.

Danish studies mention an increase of flora species after only 3-4 years after conversion and relate this increase to the **cessation of herbicide use (**Petersen et al., 2004).

[15] Appendix 3, Denmark partner 6, section 3.3, page 20; Appendix 5, Germany partner 9, *Organic Farming* section III, page 28; Appendix7, Norway partner 11, section 3.4, page 14.

Besides cessation of herbicides, other studies describe **beneficial effects of cover/ inter crops**, which protect the soil surface and support the overwintering of arthropods. Norwegian results showed that lowest winter survival of arthropods was observed on bare soil (Dennis et al., 1994). Another positive effect of organic farming on biodiversity seems to be the **necessity of balanced crop rotations**, whereas conventional agriculture often favour rotations with little variation or monocultures (Anon. 2002b).

Other studies focus on the **positive effect of hedgerows and field boundaries** which are more common in organic farming practices and generally support biodiversity of flora and fauna (Murcia, 1995; Anon. 2002b). Most often, results are derived from studies working on a field scale or even smaller scale. Few studies focus on a larger scale to obtain results on the development of biodiversity across field borders. A project recently initiated in the UK tries to find out a more effective way of biodiversity conservation on a landscape scale. A similar landscape scale approach is pursued in Germany, where an interdisciplinary Collaborative Research Centre (SFB 299) investigates "Land Use Options for Peripheral Regions"[16]. In Denmark, it was shown that when borders and hedges were established, there was an increase in the number of skylarks (Topping, 2004, 2005; Jepsen et al., 2004).

II-2-4-3- Impact of reduced tillage on biodiversity

Various results are described concerning **the impact of reduced tillage intensities on biodiversity**. As a matter of fact, the mentioned studies mainly focus on soil biology and weed diversity.

As a general result **weed infestation** is described **to increase** under reduced tillage (RT)[17].

Furthermore, **diversity and abundance of biennial and perennial species increased**, where the latter was especially observed under no-till (NT) conditions, whereas conventional plough tillage (CT) induced the development of annual species (Torresen and Skuterud, 2002; Sandal, 2004; Verdier *et al*, proceedings, 1990; Rameau *et al*, proceedings, 1992). Due to higher infestation rates in RT systems efforts in weed control usually increase again influencing biodiversity and abundance of weed species themselves. In French experiments, it was observed that especially for annual species, the effects of tillage and weed control depend on the longevity of the seed stock (Debaeke, 1994).

A possible problem of weed infestation under RT conditions may pose perennial weed species with vegetative propagation and rhizomes, which are usually well controlled under CT.

Other studies mentioned describe that the **weed seed bank increased in the upper soil layer** under RT conditions (Torresen and Skuterud, 2002; Debaeke, 1987). Besides, seed stock evolution was slower in untilled soils (Debaeke, 1987), although other studies indicate contradictory results (Torresen and Skuterud, 2002). Norwegian results point out that an increase in the soil seed bank does not always correlate with an increase in weed emergence.

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[16] Germany, partner 9

[17] Appendix 5, Germany partner 9, *Conservation Tillage* section III-3, page 15; Appendix 7, Norway partner 11, section 3.4.1., page 14; Appendix 1, France partner 2, section III-4-3, page 20; Appendix 2, France partner 5, section 2.1, page 4; Appendix 4, Denmark, partner 7, section 2.5, page 10; Appendix 10, Czech Republic partner 14,section B, page 10.

The **benefits** of reduced tillage intensity on **soil fauna seem obvious**: ploughing may be regarded as an elementary catastrophe for soil fauna because of the destruction of the habitat. The more stable the system (and the habitat) the more individuals and species are usually observed. Furthermore, mulch, plant residues or cover crops protect the soil surface and deliver food for soil organisms (Dennis et al., 1994; Friebe & Henke, 1992). As a result, **mulch covering the soil surface seemed to favour proliferation by slugs** (Bout, study report, 2004; Sandal, 2004] but on the other hand protected crops from slug consumption (Bout, study report, 2004). Moreover, **mulch had generally positive effects on density and diversity of Carabidae, spiders and nematodes** (Rougon et al, 2001; Bout, study report, 2004; Andersen, 1999). Vertical distribution of nematodes was found to increase in upper soil layers and to be aligned with increasing microbial activity and concentration of soil organic matter (Overhoff et al., 1991; Assheuer et al., 1992; Rössner et al., 1994).

A couple of studies clearly indicate, that **abundance and fresh biomass of earthworms were higher when tillage intensity was reduced** (Balabane *et al*, 2005; Friebe, 1992a; Friebe & Henke, 1992; Emmerling, 2001; Hangen et al., 2002), although one French study describes contradictory results (Topoliantz *et al*, 2000). Abandonment of ploughing and application of layer cultivation (chisel-plough) led to an increase of earthworm species from 4 to 7 in a German experiment (Emmerling, 2001). In addition, there is a modification in the balance of earthworm communities: anecic species became predominant in NT (Balabane *et al*, 2005; Alletto, study report, 2002).

Surface cover by mulch or plant residues (food and protection), **undisturbed habitat** and vertical **distribution of soil organic matter** and aligned **microbial activity** may be considered as the key factors promoting soil biology and biodiversity.

II-2- Agronomic impacts

II-2-1- Soil physical properties

(Partner 11 and 15)

Degraded physical properties by the conventional intensive loosening of soil by deep annual ploughing are reported in Ukraine studies[18]. It shows in destruction of structure, formation of plough pan, over-compacting of subsoil down to 0,65-0,80 m, according to decrease in fertility due to excessive humus mineralization or by mixing the arable soil layer with illuvial, podsolic horizons or gravelly materials[19]. However, **replacement of conventional tillage by alternatives should be implemented selectively, according to condition of the same physical properties**. The loamy soils with good structure are suitable first of all for minimal and no-till (Sandal, 2004). Reduced tillage should also be applied on soils with equilibrium bulk density that does not exceed optimum, areas with erosion risk and on arid locales. For example, in Ukraine, where chernozem soils with favorable physical properties, but with limited humidity, constitute 60 % of arable area (about 18 mill. ha), the suitable area for minimal tillage is estimated to 11 mill. ha, including no-till (5,5 mill. Ha)[18]. At the same time UK does not show large

[18] Appendix 11, Ukraine, *Brief Analysis* section 1, page 10
[19] Appendix 9, Estonia, *Features of soil and their functions degradation*, page 7

interest in no-till because of an overwetting. On sandy soils (because of their cementing), gleyic and solonetzic soils (because of poor air-providing and increased bulk density) the application of minimal tillage technologies is limited (Sandal, 2004; [20]).

As **the winter wheat is least demanding regarding the bulk density of soils, it is the best crop for minimal tillage**. The winter and summer barley is most susceptible, and oat and winter rye take an intermediate position (Sandal, 2004). As far as spring crops are considered, one of the main constraints for performing conservation tillage is to be able to sow in good conditions of soil humidity. If it is not possible, the resulting degradations of soil properties are liable to strongly penalize the yield (Caneill et al, 1994; Hansen, 1996).

The alternative methods of tillage influence on the physical properties, but the end result depends on humidity at the moment of tillage and contents of clay in soil**.** For NT **the porosity decreases in the upper layer down to 28 cm**, but in deeper layer, no differences compared to conventional technologies were found in a French experiment (Stengel, 1986 *in* Guérif, 1994; Foy, study report, 2004; Alletto, study report, 2002). In no-till, the large pores decrease first of all (Hallaire *et al,* 2004). In the majority of no-till experiments, the improvement of structure investigated by a complex of methods was identified (Monnier *et al*, 1976; Balabane et al, 2005). The accumulation of organic matter inside of soil aggregates that promotes their stability is important feature of NT.

With alternative tillage**, bulk density of top layer as a rule increases a little**; however, it does not exceed the limits for optimal condition for the majority of crops in some situations [19]. On not ploughed fields, **penetrometer resistance also increases**, especially on sandy soils. However, in Norwegian trials with reduced tillage on silty loam, an increase in porosity in surface horizon due to increase of the contents of organic matter was observed (Riley et al, 2005). Similar finding were reported from Germany (Beisecker, 1994*)*. A decrease of penetrometer resistance at >30 cm depth was also observed, indicating that the plough pan may have diminished. Excessive bulk density is eliminated with the help of deep loosening by chisel tiller. In summary papers, the positive effect of non conventional technologies of tillage on improvement of structure, penetrometer resistance and other physical properties of soils were observed[21].

At continuous application of ploughless tillage, the tilled layer is differentiated on main physical properties: bulk density, penetrometer resistance, porosity and also on the distribution of the roots. For **grain crops such differentiation has no large value**. For **sugar beet and peas, however, the differentiation is negative**. The periodic turnover of surface layer or deep entering of mineral fertilizers appears in this case indispensable. To counteract increase in bulk density in the arable layer, surface mulching and inside loosening of this layer has proved useful[22]. Also entering of manure at the first phases of development of minimum tillage, and promoting colonization by earthworms and enchytraeids have positive effect on bulk density. The physical properties of soils are improved by moving routing of machine-tractor units at cultivation of crops, decrease of machines weight and observance of the permissible pressure standard of machines on soil[23]. The direct drilling with mulching essentially reduced maximum and increased

[20] Appendix 11, Ukraine partner 15, *Brief Analysis*, Section 4, page 22
[21] Appendix 11, Ukraine partner 15, *Brief Analysis*, Section 1, page 10 ; Appendix 10, Czech Republic partner 14, section B, page 11 ;
[22] Appendix 11, Ukraine partner 15, *Brief Analysis*, Section 1, page 11
[23] Appendix 11, Ukraine partner 15, *Brief Analysis*, Section 1, page 13

minimum temperature, heat capacity, thermal conductivity and thermal diffusivity of top soil layer (Rasmussen, 1999).
Trafficability on no tilled area is better than on conventional tillage (Guérif, 1994).

So, the data collected about change of physical properties of soils at application of different agricultural technologies demonstrate that **the effects of tillage practices on soil physical properties highly vary depending on the pedo-climatic context**: conservation tillage may constrain the negative process of physical degradation in some cases (Ukraine, Estonia), but in other cases, it is able to cause a degradation of physical properties in the medium term, whose effects on yields depends on the culture cropped. To achieve a large diversification of soil-climatic and economic conditions, different condition of physical properties of soils, complex of tillage effects, it is necessary to prolong the research in order to gain references in various contexts: the setting up of maps of suitability for conservation tillage, depending on the pedo-climatic conditions, is probably a direction for further research programs. This process has already started in some countries (Ukraine, Czech Republic) but a more systematic approach is needed.

II-2-2- Soil water fluxes and content
(Partner 11 and 15)

Most partners report that reduced tillage systems tend to reduce soil porosity and increase bulk density near the soil surface. This may **reduce hydraulic conductivity in some cases** (Rasmussen, 1999; Alletto, study report, 2002; Hallaire *et al*, 2004), but **in other cases, higher infiltration** and **by-pass flow** during heavy rains was observed due to the increase in the number of macropores (Friebe & Henke, 1992). Besides, **evapotranspiration may be reduced and content of soil water may increase in the upper soil layer** (Rasmussen, 1999). This is an issue in Norway, with its short growing season, as wet soils result in later seeding and cooler soils. The effective shortening of the growing season can have both quality and yield costs. This issue is also mentioned in the report from partner 9[24] . Excessive soil water is mentioned as an important reason for low interest of zero tillage in UK. The increased water content in the top soil is also recognized in France, but ongoing experiments indicate that this trait is reversed in deeper layer (Carof, on-going thesis).
On the other hand, reduced hydraulic conductivity and evapotranspiration is an important beneficial trait of conservation tillage in dry area, conserving the soil water [25].

II-2-3- Soil chemical properties
(Partner 11 and 15)

In the majority of long-term experiences conducted on alternative systems of tillage, and entering of fertilizer, an **accumulation of mobile nutrition elements** (N,P,K and some other) **in top layers of the soils is observed** (Langlet and Remy, 1976; Balland, 1982; Riley, 1998; Friebe, 1992a +b; Ahrens et al., 1994; Stockfish et al., 1999; Tebrügge, 2000; Horacek et al, 2001). In light soils, the accumulation is marked besides in subsoil

[24] Appendix 5, Germany partner 9, *Conservation Tillage* section III-4, page 22
[25] Appendix 6, Germany partner 10, section II page 12; Appendix 11, Ukraine partner 15, *Brief analysis* section 1, page 12

layers. The accumulation of elements can be accompanied by some acidification of soil solution and decreasing CEC. Without fertilizer, the minimum tillage technology slightly affects N and P, but may strengthen emission of N_2O, especially if the tillage was conducted to shallow depths (see *II-1-1-2- Greenhouse gas emissions*). On a background of minimal tillage without turnover of soil surface, a clear differentiation of nutrition elements in profile is observed.

In **organic agriculture,** a saturation of crop rotation by faba- and faba-grain crops or the seeding of cultures in inter-row **strengthens fixation N_2 and increases the quantity of the accessible forms of nitrogen in soil** (Knudsen et al, submitted). The efficiency of nitrogen can be improved also by late sowing of cultures, the mineralization of remnants that promotes accumulation of nitrogen for the subsequent crops. **Conservation tillage is likely to affect the mineralization of organic nitrogen** owing to environmental conditions (temperature and humidity) and soil organic matter distribution. Nevertheless, very few studies are available, and results seems sometimes contradictory (Laurent *et al*, proceedings, 2004; Riley, 1998). The process of a denitrification seemed to be higher in a no-tillage system also (Germon *et al*, 1994; Hütsch & Mengel, 1991; Motz, 2003).

Typical for P and K changes are the established capability of their maintenance in rather stable state in soils, their enrichment in natural condition or as a result of long-term application of fertilizer. **The minimal tillage essentially reduced losses of P** (Tebrügge, 2000*)*. Besides the maintenance of a definite level of the content of mobile nutrition elements is reached by the application of fertilizer prepared with usage of clean raw of phosphorites, sapropels, waste products, organic-mineral fertilizers[26].

So, the effects of reduced tillage on chemical properties mainly appear through the establishment of a vertical gradient of the distribution of chemical compounds. The chemical properties strongly interact with the biological and physical properties, that's why there is a demand for more detailed analysis of the changes depending on structure of crop rotation, texture and entering of fertilizer.

II-2-4- Crop yields
(partners 6 and 7)

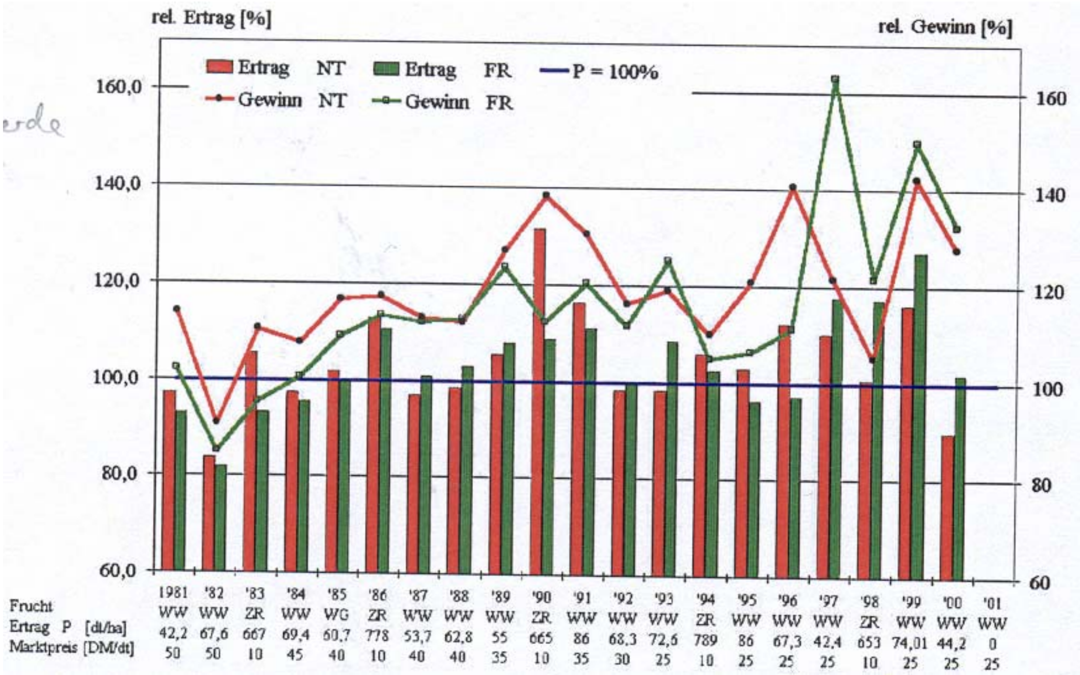
II-2-4-1- Conservation Agriculture

Results obtained in the European Platform indicate that the impact of soil tillage on crop yields is variable, depending on climate and soil conditions and characteristics of the cropping system.

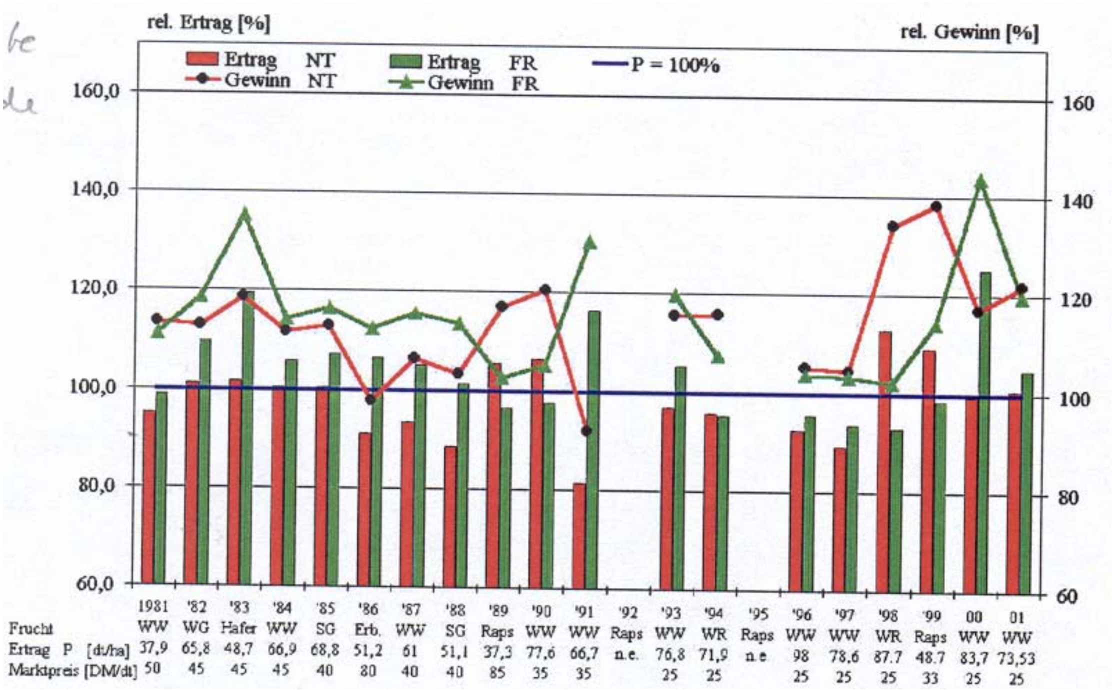
Figure 2, a. b c d e: *Yield results from five locations in Germany in the period 1981 to 2001.*
Source: „Evaluation of conservation tillage systems for the cultivation of peripheral fieldsites", Diss. Uni Giessen, Grube, J., 2002. Partner 9, Germany
Additional information:

[26] Appendix 11, Ukraine partner 15, *Brief Analysis* section 2, page 14

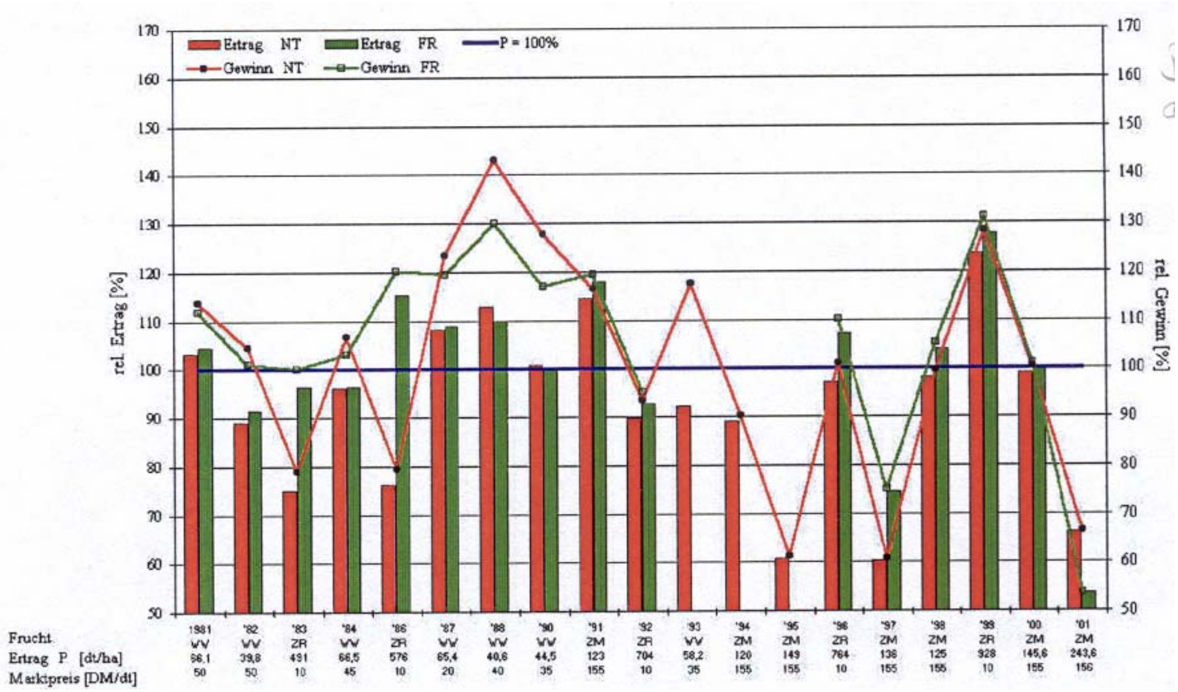
- Yield of plough site is set 100%, other yields are shown as relative yields (left axis) and same is true for profit (right axis). X-axis are years from the beginning of the experiment.
- NT is No Tillage (Direct drilling), FR is reduced Tillage (no plough but rotovator or else).
- „Frucht“ is crop, „Ertrag P“ is yield on plough site, „Marktpreis“ is market price for crop
- crops: Mais = maize, WW = winter wheat, Hafer = oat, WG = winter barley, ZR = sugar beet, Raps = rape seed, ZM = maize (corn, sweet corn), Erb = peats



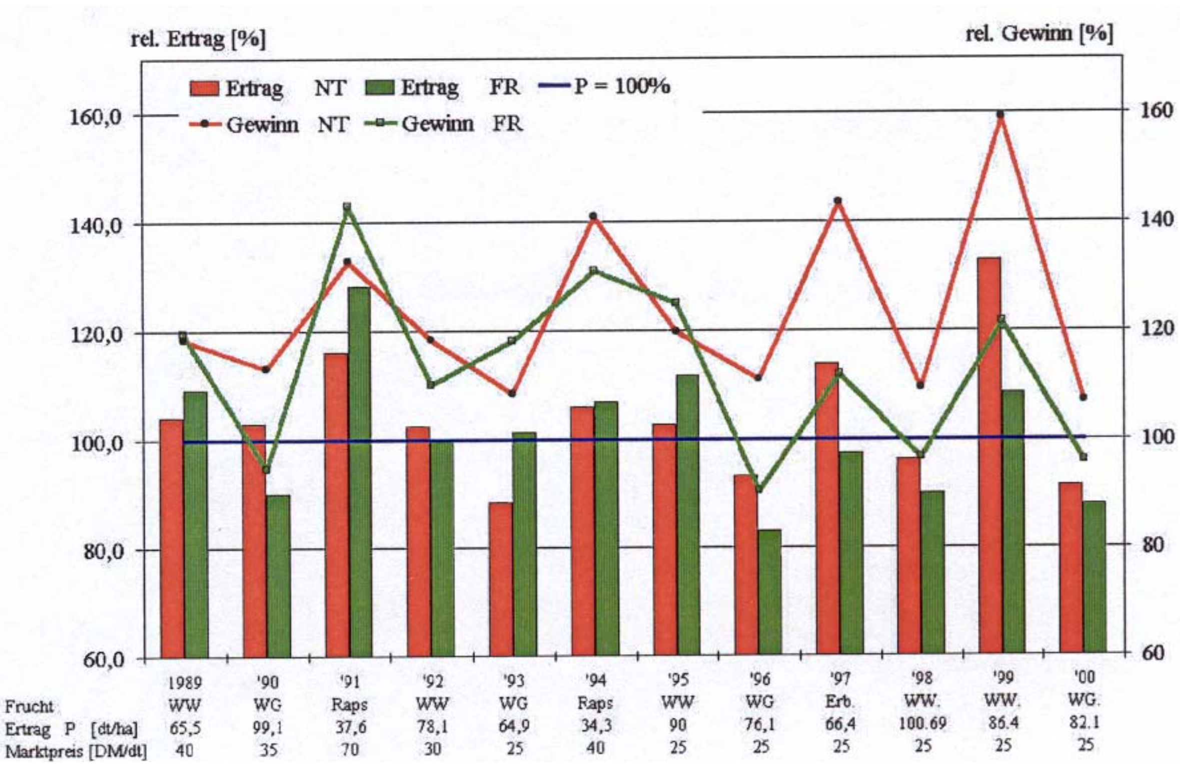
2 a: Location: Ossenheim Soil: Luvic Phaeozem



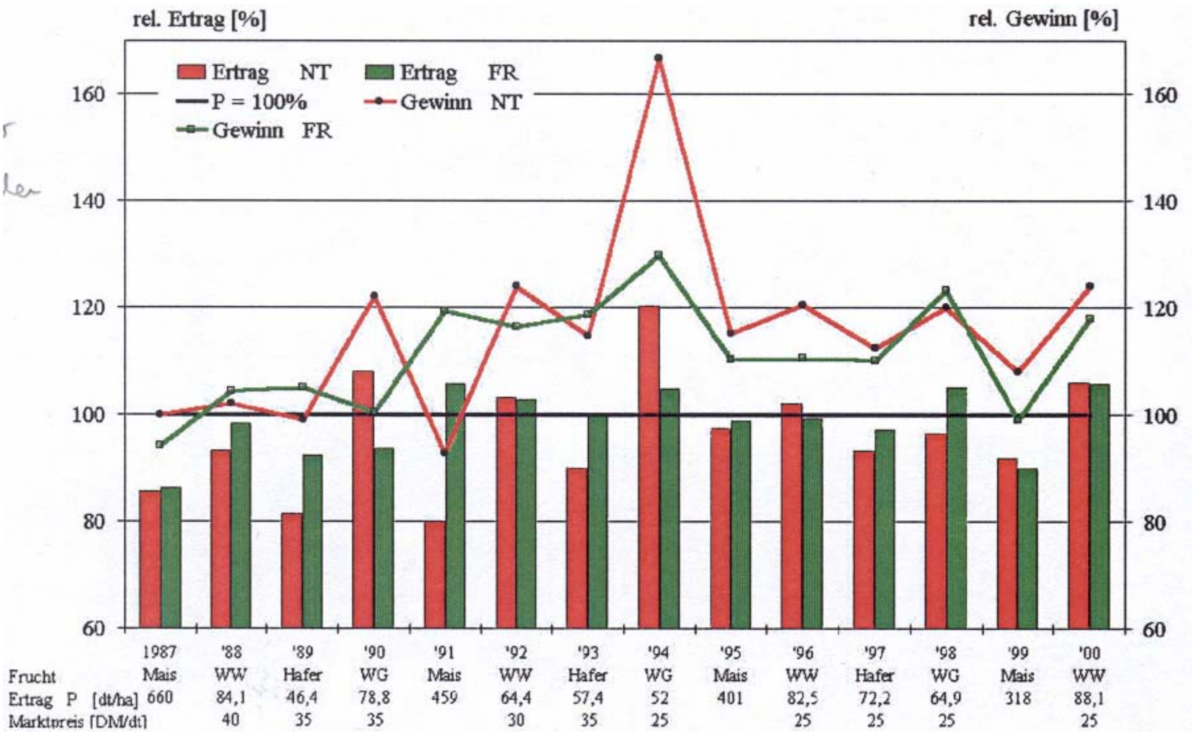
2 b: Location: Wernborn Soil: Stagnic Luvisol



2 c: Location: Bruchköbel Soil: Eutric Cambisol



2 d: Location: Hassenhausen Soil: Luvisol



2 e: Location: Gießen Soil: Eutric Fluvisol

Major results indicate that reducing tillage generally has **no strong effect on yields** (except during the transition phase) if sowing is performed under good conditions and if weeds, pests and diseases control is efficient (Grube, 2003; Viaux, 1999, Le Garrec, study report, 2003; [27]). The risks of yield losses are likely to be higher under direct drilling than under reduced tillage (Boiffin *et al*, 1976; Grube, 2003; Figure 2).

The effects of conservation agriculture on yields are resulting from the modifications of physical, chemical and biological properties, which are complex and highly sensitive to pedo-climatic conditions, and from the characteristics of the cropping system. Nevertheless, some major effects can be point out from the results[28]:

- **Climate:** dry conditions (rainfall deficiency) generally favours yield increase under RT, whereas high level of precipitation can lower yields drastically. Low temperature in the early season can limit yields of spring crops (especially maize) under ploughless tillage.
- **Soil**: when the soil is not well drained, the yields tend to be higher in the ploughed system than in the RT one.
- **Crop**: yields of wheat, oat, rape and barley are generally not strongly affected by RT practices (Figure 2), whereas the RT systems (and especially the direct drilling ones), have often penalized the yields of maize (Figure 2c & 2e). Yields of maize under RT are closely linked to soil compaction, soil drainage and the sowing machine used. The response of sugar beet yields to tillage practices appears highly variable from case to case (figure 2a &2c) and linked to sowing conditions.

[27] Appendix 7, Norway partner 11, section 3.5.3, page 17; Appendix 10, Czech Republic partner 14, section B, page 10); Appendix 6, Germany partner 10, section II, page 10

[28] Appendix 7, Norway partner 11, section 3.5.3, page 17; Appendix 10, Czech Republic partner 14, section B, page 10); Appendix 1, France partner 2, section III-7-1, page 25; Appendix 6, Germany partner 10, section II, page 10; Appendix 5, Germany partner 9, *Conservation Tillage* section III-1, page 15; Appendix 11, Ukraine partner 15, section 1, page 12

II-2-4-2- Organic farming

After six years of organic vegetable production using catch crops, green manure crops and crop sequences aimed at a high utilisation of precrop effects. Results from Danish trials indicate that **it is possible to maintain good crop yields** even without livestock manure, and hence that farming with less domestic livestock is potentially possible.

Also in Denmark, where four-course rotations with or without one year of grass-clover as a green manure/catch crop were trialled and cumulative rotational grain yields of cereal and grain legume crops were calculated, results showed that **rotations without a green manure crop produced the greatest total grain yields, dry matter and N yield**, being about 10% higher compared to rotations with a grass-clover ley in one year of four. Even though the grass-clover ley positively enhanced subsequent cereal grain yields and N uptake, these yield benefits simply cannot compensate for the yield reduction resulting from leaving 25% of the rotation out of production over the four-year period.

II-2-5- Cover crop and residue management (partners 6 and 7)

The main purpose of cover crops is generally to provide a good ground cover to decrease rainfall runoff and soil erosion, as well as assisting to smother weeds. However, cover crops can also be used as catch crops to prevent nutrient leaching, and as green manure crops if they fix or accumulate N, for example. However, the main problem with cover crops is of course, the need to control them, so that they do not compete too strongly against main crops or prevent main crop establishment through cover crop or residue mulch. In particular, **the fairly slow breaking down of straw residues can be problematic to succeed in sowing the following crop**. This issue often leads farmers to favour RT (which permits to partially incorporate straws) in comparison with direct drilling after a cereal crop. The effect of straw management in RT depends on climate, and especially on rainfall (Borresen, 1999). An important issue of cover crop and residue management is the risk to enhance the development of diseases and parasites that find a favourable environment in the soil cover (see *II-2-7 Pest and disease management*)

Research programs were carried out to find cover crops suitable to use in combination with row crops in order to control weed and pests and able to grow synchronized with the main crop in order to avoid competition for nutrients, water and light (Ghiloufi *et al*, proceedings, 2001; Carof, study report, 2003).

In terms of functioning as a catch crop and preventing N leaching, results show the **efficiency of cover crops to decrease the amount of mineral nitrogen remaining in the soil and to reduce the risk of leaching**. In the subsequent spring, **mineralization of N from the crop residues leads to increased N availability for the succeeding crop**. This additional mineralization has to be taken into account for the management of N fertilization of the succeeding crop, in order to avoid N leaching at the whole cropping system level.

II-2-6- Weed management
(partners 6 and 7)

II-2-6-1- Conservation agriculture

Learning to deal with new weed situations in RT and direct sowing systems (see *II-1-4- Biodiversity*) is a challenge in all the countries of the European Platform. This issue leads farmers to find solutions in terms of herbicides, cover crops and rotation management.

It is generally accepted that especially no-till systems may lead to an **increase of pesticide use,** even if it is not systematic. Especially perennial weed species and species with root propagation and rhizomes may pose a problem under reduced tillage (Verdier *et al*, proceedings, 1990; Torresen and Skuterud, 2002). Increasing weed control may be necessary in monocultures (no adapted crop rotation) and under wet conditions (Torresen and Skuterud, 2002).

In a French study at the Grignon site, the need of pesticide use was approximately doubled (Debaeke, 1994). Norwegian results describe a need for glyphosate use in autumn and an additional need for selective herbicides in the growing season (Torresen and Skuterud, 2002). No further results are mentioned concerning a direct comparison between conventional and reduced tillage systems. However, German studies confirm French experiences of farmers that underline the need for a change of weed management strategy aligned with the necessity of education[29]. On the other hand plant residues and mulch prevent a fast pesticide movement into soil (Düring et al., 2002a; Düring et al., 2002b). This result means that pollution risks do not systematically increase (see *III- Conclusions and Proposals*)

French studies indicate that pesticide fluxes depend on their application period. In various French studies the pesticides atrazine, epoxiconazole, isoproturon and sulcotrione were studied. Transfer was higher for autumn application due to higher first rainfall amounts and erosion (Real et al, 2005). Similarly, in Norway, results on glyphosate showed the importance of the date of herbicide application: after autumn spraying, deep transfers occurred, whereas when spraying after the harvest of barley, glyphosate was barely detected in deeper layers (Stenrød et al., 2005a; Stenrød et al., 2005b; Stenrød et al., 2005c; Stenrød et al., 2005d).

The **effects of covered cropping systems that suppress weed population** have been shown in many studies (Brandsaeter et al., 1998; Breland, 1996a; [25]). Living mulches have also been shown to have control weed more efficiently compared to dead plant mulch.

The **crop rotation has a strong effect on weed infestation in RT systems** (Mamarot *et al*, proceedings, 1992; Chauvel *et al*, 2001; Bräutigam, 1993; [30]). This result enhances the necessity to carry out long term studies on the evolution of weed populations in RT, in order to propose alternative methods to herbicides for weed control.

[29] Appendix 5, Germany partner 9, Conservation tillage section III-1, page 16-17 ; Appendix 2, France partner 5, section 2.1., page 4

[30] Appendix 2, France partner 2, section 2, Page 5

II-2-6-2- Organic agriculture

In the first two years of a crop rotation experiment in Denmark, there were **no differences in weed flora (species, numbers and biomass) pertaining to crop rotation**, but a **tendency towards lower weed infestation** in cereals without catch crops, where weed harrowing or hoeing had been performed, became evident. In order to circumnavigate this problem, a technique, where the underseed is placed in the same row as the crop plants, thereby making mechanical weed control possible, may be a solution.

Apart from ploughing, **mechanical forms of weed control suitable for organic agriculture** i**nclude steaming of the topsoil** (effective method of reducing weed seed germination, but high energy consumption) and **punch planting** (as a new method to reduce weeds within rows in organically grown crops). In this method, a hole is punched in the soil, and a seed is dropped into it, without any other seedbed preparation and soil disturbance outside the hole. Over two year trials, punch planting with flame weeding, normal planting with flame weeding and normal planting without flame weeding were compared in fodder beet. Punch planting with flame weeding reduced intra-row weed densities by 30% at the 2-4 leaves stage of fodder beet compared to normal drilling with flame weeding, and even by 50% compared to normal drilling without flame weeding.

Furthermore, **crop competition against weeds can be improved by the choice of more competitive crop cultivars**, and differences in weed infestation can vary by as much as 25% among different winter wheat as well as spring barley cultivars. In addition, **the date of sowing is important to consider**: delaying the sowing time of winter cereals by 3 weeks has also been proven to decrease the density and biomass of weeds by 30 to 75%, depending on the weed species composition, etc. Since crop yield penalties incurred by this delay amounted to 10% under weed free conditions, however, this method is only appropriate where high weed pressure would otherwise cause a larger yield loss. **Placement of slurry in the soil close to the crop rows in spring cereals improved the competitiveness of the cereals against weeds**. Without additional weed control, weed biomass was reduced by up to 50% in barley and crop yield increased by 15-35% in barley and oats by astute placement of the manure. **Crop rotation influences the weed infestation**, i.e. the amount of weeds was lowest in cereals grown the first year after ploughing a clover-grass field, and increased to twice the amount three years after clover-grass. Very good weed control in cereals can be achieved through a strategy combining pre- and post-emergence harrowing, if necessary augmented by selective harrowing at a later stage, with slurry application close to the crop rows.

In Norway and France, research on an alternative method of weed control, with the use of living mulches and mulches is carried out, besides trials with cover crops suitable to use in combination with row crops to control weed and pests.

II-2-7- Pest and disease management
(partners 6 and 7)

II-2-7-1- Conservation agriculture

Permanent vegetal cover remaining on unploughed soils **favours the proliferation various pest**, such as slugs and snails, but also that of their natural enemies.

Furthermore, pests may not cause damage to crops as long as sufficient vegetal soil cover for them to feed on is around.

Numerous diseases, especially fungal diseases, have been reported to increase under CA compared to conventional plough systems (Elen, 2003; Henriksen et al, 1999; www.lr.dk, 2004). Also special disease problems in RT had been observed such as problems with: Leaf Blotch, Net Blotch, rust and Powdery mildew in barley and in wheat Yellow Rust, Tan Spot/Yellow Leaf Spot (DTR) and Powdery Mildew gives problems (Jørgensen, L. N., 2004). The diseases Take-all (*Gaeumannomyces graminis* var. *graminis*) and Eyespot (*Pseudocercosporella herpotrichoides*) diseases seems not to be influenced by the soil treatment method. In Norway *Erysiphe graminis, Rhynchosporium secalis* and *Ramularia colly-cigny* gives problems in spring cereals rotation (1994-1997). Fusarium diseases and mycotoxins also give problems in Norway.

The increase in pests and diseases under CA often results in **higher pesticide use**, or even sometime forcing farmers to revert back to ploughing. In 2004 and 2005, an increase of problems with Fusarium has been observed in Denmark and can lead to ploughing of area with RT for prevention of diseases, because non effective fungicides can be used.

Additionally, **soil type also appears to play a role**, at least where slugs are concerned, and Danish observations indicate that on heavy clay soils, slugs pose less of a problem in unploughed compared to ploughed soils.

In Norway and France, **the effects of field boundaries and grassy banks on the dispersal and over wintering of beneficial arthropods** have been explored (Andersen, 1999; Rougon et al, 2001). Research on pest control of weeds and pests in vegetable systems using cabbage-living mulch systems and has shown the importance of multiple criteria when developing improved systems.

II-2-7-2- Organic agriculture

Most research into disease management in OF **focuses on using resistant varieties**, particularly in vegetable, fruit and berry production systems, where product quality demands are high and pests and diseases pose a considerable challenge. **Other research has focussed on biological control**: for example, antagonistic micro-organism such as *Trichoderma,* neem seed extracts, control by *Bacillus thuringiensis*, variations in crop rotations in order to break pest and disease cycles, treatments of the seeds (acetic or citric acid, milk powder, mustard, brushing and cleaning, high temperature drying, etc., to prevent disease spread through contaminated seed). Danish research into catch crops for vegetable and arable crop cultivation furthermore also addresses aspects of soil biology relevant for crop protection, such as improved living conditions for soil organisms, which may serve as predators for pests. In horticulture crops biological control of fungi and pests has been used in Denmark for many years and research is comprehensive in this field. In Danish organic grown greenhouse cucumber research in using solarization against the soil borne fungi *Pythium* has shown good effect.

II-2-8- Selection of varieties

(partners 6 and 7)

The right choice of seeds is the first step to sustainable and efficient crops. As mentioned above, **the use of disease and pest resistant crop varieties in CA and OF is often more important** than in conventional systems, where the spread of such can be controlled through pesticides and/or the removal of potential habitats and food sources by ploughing. Higher competitive power against weeds is also often sought after in the selection of appropriate crop varieties in CA or OF, and consequently, especially in fruit, berry and higher value vegetable production, many varietals screening programmes exist, which often also, where these are admissible, include GMO crops.

Since January 2004, the EU directive appointment for the new certification of organic seed has been effective. The **main problem is seed-borne diseases**, which make the production very vulnerable and expensive, and screening for varieties with high tolerance for use in organic farming is required. In addition, **lack of organic seeds is a reality**. The problem is that varieties resistant to crop current disease are not always available to the farmers. Also problems with **different toxin producing fungi on seeds** had to be solved.

The new EU- rules for use of organic seeds have brought up some new aspects:

1) Lack of certificated varieties of organic seed with the most suitable characters;
2) Increase in prices of organic seed because of low yield and low quality of the seeds;
3) Lack of certificated seed varieties can cause the growers to use own non certificated seeds of low quality;
4) Demand for new seed treatment methods in organic seed.

II-3- Socio-economic impacts

(partners 10 and 12)

II-3-1- General context

The available data do not allow a comprehensive comparison between the countries of the European platform and only support general statements. Based on the pattern of data submitted, it appears that, in general, data availability in the various countries varies greatly. As expected, conventional farming is usually covered well by statistical and economic analyses, but also organic farming appears to receive more detailed attention, particularly in countries such as the Czech Republic, Denmark, Germany, Norway and the UK. Data on conservation tillage are available at much less detail and hardly go beyond a figure for area under cultivation, with the exception of France and Norway where more detail is available on crops, nutrient input, costs and labour.

Table 14 shows the number of farms and the average farm size. On average the biggest farms are located in Ukraine, in France and in Great Britain. Figures on number and size of farms using conservation tillage are not specified. The use of average farm size appears a somewhat meaningless figure as actual farm sizes vary from minute plots to very large farms, e.g. in Ukraine, the former East Germany and in the Czech Republic. Differences in farm sizes have historical reasons, but the background of the agro- climatic conditions is also significant.

Much agricultural (with low inputs) produce would be grown for self-sufficiency purposes on small private plots that often escape statistical analysis (e.g. in the UK).

Table 14: *Number of farms and average size of farms: for the whole country, for conservation tillage and for organic farming*

Country	**General**		**Conservation Agriculture**		**Organic farming**	
	No of Farms	ha/Farm	No of Farms	ha/Farm	No of Farms	ha/Farm
Czech Republic	-	-	-	-	-	-
Denmark	48,750	53	-	-	3,510	48
Estonia	36,859	22	-	-	810	57
France	600,000	70	-	-	-	-
Germany[31]	420,697	44	-	-	16,476	45
Norway	55,697	19	-	-	2,484	-
Ukraine	53,000	800	-	-	-	-
UK	304,800	69	-	-	3,995[32]	174

The growth of the number of organic farms has decreased (e.g. Denmark, UK) as the market matures and, for example, supply problems due to climatic conditions are offset by increasing imports. A similar trend has been observed in the UK.

Table 15 shows average nitrogen application and use of pesticides in the countries of the KASSA-Partners. The nitrogen input in the eastern European countries is with max. 61 kg/ha much lower compared to those of western Europe. Highest nitrogen inputs are reported for Great Britain and France. The nitrogen input on fields and grassland is an indicator of the intensity of agricultural land use. But it is not allowed to conclude from this indicator alone to estimation of environmental pollution, like leaching of nitrate into the groundwater. Therefore the nitrogen balance is the necessary indicator.

[31] Average farm size in the former West Germany and East Germany differ greatly, i.e. 31.7ha and 198.7 ha, respectively

[32] Total producers is 3,995 which could give a near estimate for holding numbers

Table 15*: Average nitrogen application and use of pesticides aggregated by country.*

Country	**N**	**Pesticides**
	kg/ha	€/ha
Denmark	144	-
Czech Republic	61	-
Estonia	33	13
France	180 (166)	32 (34)
Germany	105	117
UK	183	43
Norway	132	-
Ukraine	15	-

In brackets () conservation tillage

Table 16 shows yields for selected crops, aggregated as averages for each country

Table 16: *Yields of selected crops by country*

Country	***Yearly average***	**Winter wheat**	**Winter barley**	**Sugar beet**	**Rape**	**Potatoes**
		t/ha	t/ha	t/ha	t/ha	t/ha
Denmark		-	-	-	-	-
Czech Republic		4.07	3.76	45.2	1,55	18.97
Estonia	*average 1993-2003*	2	-		1,3	13.5
France	*2004*	7	6.5	62	3	45
Germany	*2003*	8.21	7.06	58.2	4.13	43.07
Norway	*2004*	5		-	3	23.4
Ukraine	*2004*	3.16	-	23. 61	-	13.84
UK[33]	*2004*	6-10	6-9	46-60	1.6-4	12-50

Clearly, **the most important aspect of the impact of conservation and organic farming will be determined by the new Common Agricultural Policy** (CAP) that up to the end of 2004 has focussed on subsidising production – i.e. in terms of quantity – not quality. As of 1.January 2005, however, a changed CAP has come into existence promising a 'long-term perspective for sustainable agriculture'[34]. The key elements of the reformed CAP are:

- A single farm payment for EU farmers, independent from production; limited coupled elements may be maintained to avoid abandonment of production,

[33] Figures for the UK are expected ranges (SAC Farm Management Handbook 2004/5)
[34] http://europa.eu.int/comm/agriculture/capreform/index_en.htm

- this payment will be linked to the respect of environmental, food safety, animal and plant health and animal welfare standards, as well as the requirement to keep all farmland in good agricultural and environmental condition ("cross-compliance"),
- a strengthened rural development policy with more EU money, new measures to promote the environment, quality and animal welfare and to help farmers to meet EU production standards starting in 2005,
- a reduction in direct payments ("modulation") for bigger farms to finance the new rural development policy,
- a mechanism for financial discipline to ensure that the farm budget fixed until 2013 is not overshot,
- revisions to the market policy of the CAP:
    - ✓ asymmetric price cuts in the milk sector: The intervention price for butter will be reduced by 25% over four years, which is an additional price cut of 10% compared to Agenda 2000, for skimmed milk powder a 15% reduction over three years, as agreed in Agenda 2000, is retained,
    - ✓ reduction of the monthly increments in the cereals sector by half, the current intervention price will be maintained,
    - ✓ reform in the rice, durum wheat, nuts, starch potatoes and dried fodder sectors.

There is **little research conducted to date solely on sociological factors** concerning the evolution and the social impact of organic farming, conservation agriculture and GM crops and various authors state the need for more research into the social implications of these 'new' agricultural systems.

Through consultation with stakeholders, for example in the UK, its has been established that **the most important aspects for the future are considered to be lifestyle changes, health and dietary needs** of an ageing population and **the economic, social and environmental drivers** for business decisions of land managers such as new opportunities for farmers to become stewards of the rural environment and engage in new service businesses concerned with nature conservation, recreation and tourism (see *I- Driving forces and constraints*).

II-3-2- Socio-economic impacts of Conservation Agriculture

Even if economical impact of CA is an important issue, there are very few studies mentioned on that topic in the European platform. The results presented in this section mainly come from Germany, France and Denmark.

The impact of CA has mainly be assessed through **direct margins**, which results from the difference between gross production (directly linked to the yield, see *II-3-4 Yields*) and costs. In general, **economical interest of CA mainly comes from cost reduction**:

- Fuel costs
- Labour costs
- Machinery costs

The results obtained (***Table 17***) show that RT and especially DS permits to highly reduce labour costs and fuel costs[35]. However, this effect depends on the type of machinery used and the type of soil.

Table 17: *Fuel costs and labour costs in Ploughing, RT, DS in Germany, Denmark and France*

		Ploughing	RT	DS
Fuel consumption (L/ha)	Germany	35	14 to 25	6
	Denmark	40/50	18 to 35	
	France	*Clayey soil*: 75 to 105 *Clay/loam soil:* 26 to 38	*Clayey soil*: 18 to 29 *Clay/loam soil:* 12 to 25	12 to 24
Labour (h/ha)	Germany	2	0.8 to 1	0.4
	Denmark	2/3	1.1 to 1.7	0.8 to 1
	France	2	1.5	0.5 to 1

The **reduction of the costs is variable from case to case**. This should be illustrated with two examples on a loess region (site conditions see above) and on a loamy soil in northern Germany (Mecklenburg-Western Pomerania). On loess soil in Saxony the cost reduction amounts to 100 – 120 €/ha and are higher than on loamy soils in northern Germany with about 40 to 50 €/ha (***Table 18***).

Table 18: *Reduction of costs for conservation tillage and additional expenses for plant control compared with conventional plant production in different farms of the state Saxony with loess soils. Average 1994 – 2003.*

Crop	**reduction of costs at soil tillage (€ / ha)**	**additional expenses at plant control (€ / ha)**		
		herbicides	**fungicides**	**control of slugs/ mice**
winter wheat	100 – 120	+ 25	no	+ 20
winter barley	100 – 120	+ 50 bis +70	no	no
winter rye	110	no	no	no
triticale	110	+70	no	no
spring barley	110	+70	no	no
winter rape	100 – 120	+ 50 bis +70	no	+ 20 bis 40
sugar beet	100	+ 50	no	no
potatoes	250	no	no	no
corn	100 – 150	+ 50	no	no
grass for food	120	no	no	no
grass for reproduction	120	no	no	no

Agrarbericht Sachsen, 2003

Table 19: *Crop specific cost reduction on a large scale experiment on loamy soils in Mecklenburg-Western Pomerania, Northern Germany*

[35] Appendix 5, Germany partner 9, *Conservation Tillage* section III-1, page 16 ; Appendix 4, Denmark partner 7, section 2.3, page 9 ; Appendix 6, Germany partner 10, section II, page 12-13 ; Le Garrec, study report, 2003.

crop	crop specific cost reduction	time reduction
	€/ha incl. wages	h/ha
Winter wheat	53	1.1
Winter barley	41	0.7
Sugar beet	41	0.5

Neubauer, 2003

Costs reduction affects direct margins (that increase by 0 to 65 €/ha according to a French study (Le Garrec, study report, 2003)). Nevertheless, the data obtained on several cases have to be carefully considered, and do not represent the diversity of the situations that can occur on farm. Many cases can be found where RT or DS is given up, due to economic reasons that are not included in the studies mentioned.

The **socio-economic impact of conservation agriculture may appear to be contradictory**. At the outset there exist the problems of lack of knowledge, extension and training that can overcome the views held by farmers on traditional forms of farming. While returns from crops are expected to rise, yields may be unpredictable during the transition period. While in the long-term machine costs are expected to be reduced, an initial investment for new machinery will be necessary. While a saving may be obtained from reduced labour costs, an increase in pesticide costs is likely. Farmers with adequate financial support and forecasting abilities and given suitable agronomic conditions may well see increased overall returns over a relatively short-term time period. Others may find a change to this new farming system too unfamiliar and risky. If conservation agriculture does achieve a reduction in input costs and thus an increase in profits, increased uptake of this new farming systems and increasing competition would be expected to erode these profits – at least by the medium term. On the surface, reduced labour costs on the farm represent a direct financial gain to the farming business – but require alternative employment opportunities. For farmers managing large units this may well be a decisive factor in favour of conservation agriculture – but for many family farmers that operate under marginal conditions this would mean they would have to supplement their own incomes through finding alternative ways of employment in their own locality.

Socio-economic impact of CA in Europe remains an issue difficult to judge, on which very few data is available for the moment.

II-3-2- Socio-economic impacts of Organic Farming

Research into the socio-economic impact of organic farming is presently being conducted, which explores the key hypothesis that organic farming provides an additional benefit to the development of the rural economy, its employment patterns and social networks over and above conventional agriculture.

The **demand for organic products** due to new lifestyle demands that often focus on human and environmental health **has created new market opportunities in Europe**. Typically, organic imports are bought at a premium when compared to identical products produced on non-organic farms. However, markets for organic food are more sensitive, for example due to the nature of the produce itself and local oversupplies lead to a loss in market premiums. These unsettled market conditions create problems for organic farmers who have difficulties obtaining reliable market information and clearing their products at harvest time as they are facing decreasing prices. Particularly in climatically less favoured regions and countries where the diversity of crops is limited such troubles are compounded (e.g. organic potatoes in the UK losing their premiums due to temporal oversupply).

While some consumers express a preference for locally-grown organic foods, the demand for a wide variety of food stuffs year-round makes it impossible for any country to source organic food entirely within its own borders. As a result, many countries in Europe have – apart from boosting their own indigenous production - begun to **import organic farm products in increasing quantities**. The ultimate profitability of an organic farm therefore varies, and few studies have assessed the long-term potential for the market premiums obtained for organic products.

A further important feature of organic agriculture is **the support it gives to old breeds of plants of cultivation and farm animals** – many of which have been adapted to local conditions over very long time periods. This fact not only benefits genetic diversity (biodiversity) it also represents an **important economic benefit** for organic farming as the ongoing dispute about the introduction of GMOs exemplifies

As *Table 20* shows, the allocation of production costs in organic farming is different in contrast to other farming systems such as conventional agriculture: **Costs for plant protection products and fertiliser are very low while yields are lower**, too. In Germany yields are generally 1/3 less than conventional produced yields. For some crops, e. g. wheat and potatoes, yields are only 1/2 of conventional farming methods.

Table 20: *Comparison of some economic figures for organic farming and conventional farming in Germany*

	Conventional agriculture	**Organic farming**
	€/ha	***€/ha***
plant protection	62	1
fertiliser	72	10
labour	27	135
Profit per farm	33,500	33,400

Bauernverband (2005)

Most studies find that **organic agriculture requires significantly greater labour input** than conventional farms. This is especially true in areas of low ecological potential. However, when labour is not a constraint, organic agriculture can benefit underemployed labour in rural communities. This, however, crucially depends on the availability of suitable housing for farm labourers, as rapidly increasing property prices have already created a serious shortfall in many rural areas. Increased employment on organic farms, although a considerable cost factor for the farmer, represents an important social gain for farming and rural communities – provided these communities still have the necessary suitable housing available.

For many family farmers that operate under marginal conditions **organic agriculture combined with rural stewardship functions may well be a way to remain on their land** and continue their business – and particularly so if they can find ways of marketing their products again locally – which in turn would mean a boost for both local economies and communities. In this way organic farming could well represent the driver for a return to the farming communities that were wiped out through production-centred policies since WW2. Nevertheless, land tenure can be also critical to the adoption of organic agriculture. It is highly unlikely that tenant farmers would invest the necessary labour and sustain the difficult conversion period without some guarantee of access to the land in later years when the benefits of organic production are attainable.

It seems that, similar to conservation agriculture, t**he overall socio-economic impact of organic agriculture does not appear to be either wholly beneficial or adverse**. At the outset there exist the problems of lack of knowledge, extension and training that can overcome the views held by farmers on traditional forms of farming. While organic products usually obtain a premium in the market place, returns from crops are not always assured due to seasonal fluctuations and growing local, national and international competition. Furthermore, yields are less predictable than in conventional farming and there are no real savings to be obtained from reduced machine requirements. The considerable savings on nutrients and pesticides may well be offset against increased labour costs and/or reduced yields. Farmers with adequate financial support and forecasting abilities and given suitable agronomic conditions may well see increased overall returns in the medium term. Moreover, it is assumed that, as organic farmers also rely on natural pest controls, the overall reduction in the use of toxic synthetic pesticides in rural areas should lead to improved health of farm families and their neighbours. Nevertheless, the benefit of organic products on human health is not obviously proved yet

As is exemplified by the diverse positive and negative influences on organic agriculture, and the most recent research proposals concerning its socio-economic impact, it is difficult to judge the overall socio-economic impact of organic agriculture in Europe at this time.

III- Conclusions and proposals

III-1- Technical changes

Conservation agriculture (CA) induces thorough changes in the functioning of the cropping system, leading to the modification of many practices (soil tillage, fertilization, pesticide management…) and the adaptation of the entire cropping system (rotation, intercrop) in order to avoid unfavourable effects in the long run (weeds, soil structure degradation). In addition, interactions between the practices implemented have to be taken into account: the suitable combination of different techniques is crucial to succeed in the management of the cropping system (for instance, soil tillage*suitable herbicide strategy*suitable rotation is required for successful weed management). Conservation agriculture adoption leads to the **necessity to revise the whole management process**.

Monitoring is a key point of these technical changes since farmers have to adapt their practices to the new states of the system. It requires development of indicators characterizing CA systems, which can not be the same ones than in conventional agriculture. That’s why **suitable indicators for CA monitoring are required**. It is compulsory to build relevant tools in order to characterize the state of the system and to adapt the management process (for instance, is the “number of earthworms” a reliable indicator to consider that soil structure is satisfactory?).

“I should change what I can change”: in order to change the management process and to find indicators for monitoring, three points are required:

- **New technology**: machinery, chemistry, plant material adapted to CA. Pesticides are generally available in European Platform, but specific machinery may be difficult to find and is often costly. The selection of plant material (cash crop and intercrop) adapted to CA has not yet begun.
- **Validated references and decision support tools**: i.e.: “How does the system function? How to look at it? How to act?” The transfer of knowledge on management process acquired in other areas is often difficult, because the objectives, the pedo climatic and economic context and the impacts of the techniques used are generally different from case to case (due to the sensitivity of the interactions between processes in the context). So, there is a strong need of references and decision tools adapted to the European context.
- **Training and exchange of experiences**.

III-2- Innovation process

The innovation process is achieved by various partners:

The pioneer farmers adopting innovative practices have a crucial role: they are faced with a lack of references which lead them to bring together. These associations of farmers aim to take advantage of the existent knowledge in the areas where the technique is already implemented (trips), carry out on-farm experiments in order to produce proper references, share their experiences, and set up training programs.

Private companies are involved in four processes:

- Technology development (machinery, chemistry, plant material): advises and demonstrations (machines). For the moment, companies of selection of plant variety are slightly involved (due to the moratorium on GMOs?).
- Advises: development of suitable indicators (biological activity for instance) and methods of measurement;
- Communication: press for specialized public and general public, brochures;
- Developing the ideas and proposals of research outcomes.

The role held by **extensionists and researchers** is made difficult by:

- the novelty of these systems, which implies the lack of references;
- the necessity to take into account the whole system (coherent management of various practices), from a multidisciplinary point of view (in order to assess the impacts) and to consider various scales (from the specific practice to the long-term effect of the cropping system).

Farmers’ strong expectations lead to an evolution of Research and Development activities. Nevertheless, this evolution is on-going, and breaking off can occur, because farmers have the impression that researchers and extensionists do not answer their requests.

For conventional farmers, **it may be difficult to launch into conservation agriculture**, due to:

- the lack of references on the way to implement the practices and the impacts of these practices, especially in terms of agronomic and economic impacts;
- the change of paradigm: psychological and sociologic aspects are crucial in the change (see *III-7- Sociological aspects*).

These difficulties can lead to a breaking off between conservation agriculture and conventional agriculture.

As far as the main lines of the innovation process are concerned, a **parallelism can be made between organic farming (OF) and conservation agriculture**. Nevertheless, organic farming innovation process is a little more advanced than the conservation agriculture one, and some lessons drawn up in OF might be applied to CA.

It appears necessary **to think about a system of governing** in order to precise the role played by each actor in the innovation process. Some aspects of the different roles are summed up in the following scheme (***Figure 3***).

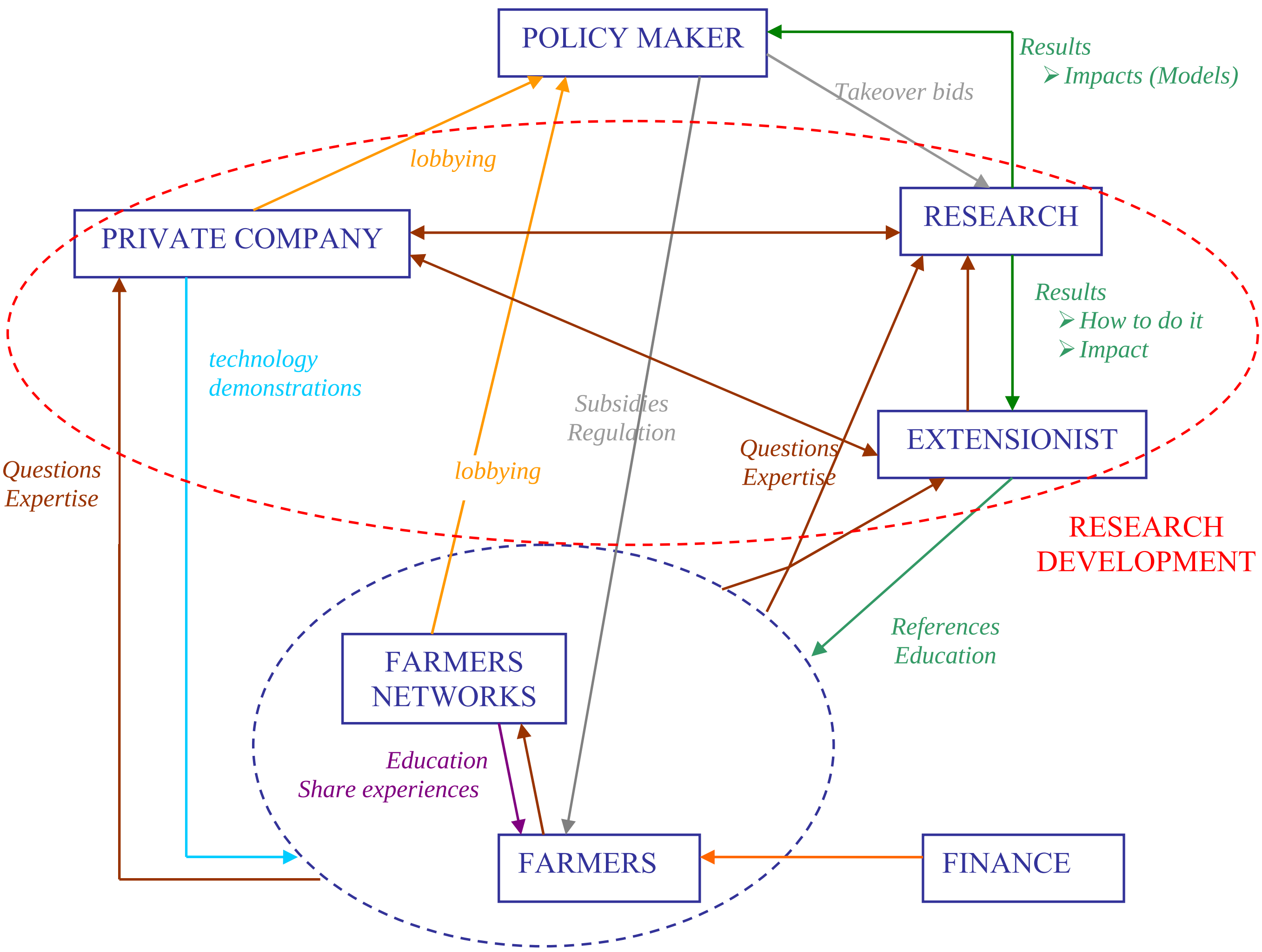


Figure 3: *System of governing: several aspects of the actors' role in the innovation process*

III-3- Economic viability

In Europe, conservation agriculture rarely induces an increase in yields and does not permit to sell products more expensive. Moreover, there is no specific market: products from CA are mixed with products from conventional agriculture, and thus, are very sensitive to market pressure (globalization). This point is different from OF: certification process (label) permits to sell the products at higher price. That's why **economic viability in conservation agriculture largely depends on cost reduction**. Three aspects have to be underlined:

- Labour costs strongly decrease in general;
- Machinery costs: CA permits to reduce machinery pool and tractors' power. Nevertheless, this effect appears in the medium term, depending on the time required for machinery depreciation. In the short term, farmers need to buy specific and expensive machines (sowing machines), and the costs of these machines depend on the possibilities to buy material in common.
- Input costs may increase (herbicides, seeds for cover crops) or decrease (fuel). They highly vary from case to case, and closely depend on the level of practice mastery of the farmer.

Farm size is an important factor of economic viability: CA appears more economically interesting in the case of large farms, where labour is limited. In order to minimise costs it should be taken into consideration to share machines in a farmer network, especially when reduced tillage is not used for all crops grown in the rotation.

Transition period is precarious because:

- The system evolves towards a new equilibrium. Some positive aspects appear several years after the conversion (biodiversity and organic matter effects on structure and ravagers' control), whereas some negative aspects quickly appears (weed and slug proliferation).
- Farmers have to acquire new know-how.

The transition period is unstable and risky: yield losses can occur. In that case, economic viability is broken down.

The **possibility to receive subsidies**, especially during the transition period, appears to be a major factor for economic viability (see *III-6- Policy*).

III-4- Environmental impacts

Environmental impacts are not always positive. In the European Platform, this observation led to a trade off between the positive impact (erosion mitigation) and the negative one (pesticides increase) of CA.

The **increase in the number of herbicides treatments in CA**, which is observed in many countries of the European platform, is a hotly debated topic. Three main points have to be underlined:

1. The increase in the number of herbicide treatments is not compulsory in CA, even if it is generally observed. Weeds can be controlled using another means, the two main ones being: 1) suitable rotation and 2) intercrop use.

2. The increase in the number of treatments does not always lead to increase the quantity of active substances spread. Some farmers use reduced doses or low volumes, which permits to decrease the doses of herbicides put in.
3. The increase in the number of treatments does not always lead to increase the pollution risk in RT. Two main factors can be involved in the mitigation of the pollution risk:
    - accumulation of organic matter in topsoil, which favours absorption and break down of the products in topsoil;
    - cover crops which avoid to directly apply the product on the soil, in which case it is very sensitive to leaching by runoff.

Research is asked and needed to provide knowledge to assess the trade-off between beneficial and negative impacts. Too less is known on the fate and environmental behaviour of specific pesticides used in CA.

Soil cover plays a crucial role on the environmental impact (pesticides, recycling, nutrients, biodiversity, carbon storage…). That's why it is relevant to cross the two factors, soil tillage and soil cover (see *I- Driving forces and constraints*), in order to assess environmental impacts. In the European platform, there are few results on these impacts at the moment. Some topics are favoured (erosion), but many gaps still remain (biodiversity, pollution,…).

In order to study many of these impacts, it appears important to **consider larger scale:**
- space scale: go from the field scale to the regional scale (biodiversity, erosion,…);
- time scale: long term effects (carbon storage, biodiversity,…).

Several long term experiments are being carried out, which have given some results about these issues, but they are still partial.

Global environmental impacts have to be considered: climate change, resource management, fuel consumption.

III-5- Multipurpose role of agriculture

Impact of conservation agriculture on multipurpose role of agriculture is potentially important even if little information is available for the moment. This impact can be assessed regarding the three main roles of agriculture:

1. **<u>Production</u>**: In Europe, CA should have low impacts on quantity and quality of production (except if it permits to restore degraded areas and increase the yields). However, **conservation agriculture strongly affects means of production**: it develops many innovation processes (products, tools, methods of reasoning) and enhance some traditional know-how (cover crop, associated crops, old varieties), even if it leads to give up other traditional know-how (ploughing).

2. **<u>Environment:</u>** (see *III-4- Environmental impact*). CA induces a potentially beneficial impact on biodiversity, landscape diversity (rotation and cover crop), recreation (attractive landscape for tourism and hunting), erosion (on-farm and off-farm impacts) and carbon sequestration. Negative effects can be noticed regarding pollution (pesticides, N_2O emissions), but this topic is very little documented and hotly debated.

3. **Rural development**: the impact of CA on rural development is not well documented. Nevertheless, three points have to be underlined, which have both positive and negative effects:

- **Employment**: CA leads to reduce on-farm labour need, inducing a decrease in the number of farm workers. However, innovation process may increase employment in the other sectors of the production channel.
- **Structure of the rural space**: CA may favour the increase in farm size, leading to the decrease of farmers' density in the rural space. On the contrary, CA may be a mean to maintain farmers in intermediate areas through the increase of competitiveness.
- **Animation**: CA favours farmers' exchanges (machinery and experience) and create networks in rural areas (see *III-7- Sociological aspects*).

III-6- Policy

Policies seem to play a major role affecting the extension of conservation agriculture through three aspects:

- **Political decision** that induces economic consequences, which acts indirectly in favour of CA development. For instance, the Common Agricultural Policy favours CA, while encouraging farmers to increase cultivated areas per person and to reduce the costs.
- **Regulation**: compulsory measures can favour CA (e.g. catch crops obligation) or disadvantage it (e.g. prohibition of burning straws).
- **Subsidies**: CA extension appears larger in countries where subsidies have been targeted on reduced tillage practices.

Policies on CA are very heterogeneous from one country to another. This observation raises the question of the need to harmonize laws on soil protection in Europe (Soil Protection Act). Moreover, a major trend was highlighted: in Europe, there is a trade-off between erosion mitigation and pesticides. Countries (or regions) where erosion is the main concern support conservation agriculture, whereas countries where pesticides are the major problem do not support it.

Faced with the difficulty to assess pesticide risks on pollution and health, policy makers are focusing on pesticides uses. Nevertheless, there is no direct link between pesticide applications and pollution and health risks (see *III-4- Environmental impacts*). That's why **references, indicators and decision support tools are needed** in order to assess risks induced by pesticides in CA. These tools are of great interest to help policy makers (targeted incentives and compliance) and farmers (self risk calculation).

III-7- Sociological aspects

In Europe, there is little information on social impact of CA. Nevertheless, several trends can be drawn up out of this study:

Work place: farmers can take advantage of the reduction of labour time in order to enlarge their farm, to diversify farming activities or to invest in non-agricultural occupation, leading to a change in social relationships.

New form of farmers networks: relationships that are established between farmers using CA or OF favours social stability but sometimes, may lead to marginalization (with regards to the neighbourhood especially). Farmers establish some contacts from one region to another and even from country to country (e.g. trip to Brazil for farmers performing CA). These networks constitute a meeting place for the farmers interested in the alternative practices and create social animation, which provide new dynamism to rural populations (public debate participation, dynamic actions).

Identity: conservation agriculture and organic farming often lead farmers to develop or assert their proper identity. They are deeply rooted in a specific conception of the relationship existing between farming and nature. This identity affects the way that farmers perceive their profession ("I have got the impression to do a new job") and their place in the society ("I have got the impression to contribute to nature conservation").

Education: conservation agriculture and organic farming require personal training and permanent questioning of practices, which contribute to farmers' personal education.

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Appendices

WP1.1. Country reports by each partner

Appendix 1: WP 1.1 report – FRANCE - Partner 2 - INRA

Appendix 2: WP 1.1 report – FRANCE - Partner 5 - FNACS

Appendix 3: WP 1.1 report – DENMARK - Partner 6 - KVL

Appendix 4: WP 1.1 report – DENMARK - Partner 7 - FIU

Appendix 5: WP 1.1 report – GERMANY - Partner 9 – JLU

Appendix 6: WP 1.1 report – GERMANY - Partner 10 – ZALF e.V.

Appendix 7: WP 1.1 report – NORWAY - Partner 11 – NCRI

Appendix 8: WP 1.1 report – UNITED KINGDOM - Partner 12 – ENL

Appendix 9: WP 1.1 report – ESTONIA - Partner 13 – EESTI

Appendix 10: WP 1.1 report – CZECH REPUBLIC - Partner 14 – VURV

Appendix 11: WP 1.1 report – UKRAINE - Partner 15 – NSC ISSAR