Adoption of Conservation Agriculture in Europe.

Lessons of the KASSA project

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Abstract

According to KASSA findings, conservation agriculture is less adopted in Europe compared to other adopting regions and, reduced tillage is more common than no-tillage and cover crops. Currently, it is not popularised and it is less researched. It seems that the lack of knowledge on conservation agriculture systems and their management and, the absence of dynamic and effective innovation systems make it difficult and socio-economically risky for farmers to give up ploughing which is a paradigm rooted in their cultural backgrounds. In Norway and Germany the adoption of conservation agriculture has been encouraged and subsidised to mitigate soil erosion. In the other European countries the adoption process seems mainly farmers driven and the major driving force has been the cost reduction in machinery, fuel and labour saving. Soil and water conservation concerns did not appear as main drivers in the European farmers' decision to shift or not to conservation agriculture.

The conversion of European farmers to conservation agriculture is being achieved through a step by step attitude; large scale farms are the most adopters, probably due to their ability to absorb risks. The short term socio-economic benefits that conservation agriculture provides, the need to improve farms' competitiveness, market globalization and the steady increase of fuel cost are likely to be sufficient to boost the ongoing slow adoption trend of conservation agriculture in Europe.

Conservation agriculture is not equally suitable for all the European agroecosystems. The need of soil and water conservation in Europe requires anticipating the ongoing process in order to improve its ecological sustainability. Priority would be to define which regions in Europe are the most suitable for conservation agriculture taking into account climate and soil constraints, length of growing period, water availability and quality, erosion hazards and farming conditions. Policy and financial support favouring the use of cover crops and agronomically sound crop rotations as management strategies for weed, pest and diseases will certainly allow developing efficient and acceptable CA systems.

Key words: Adoption, conservation agriculture, reduced tillage, no-tillage, Soil and water conservation, erosion mitigation, Europe.

Introduction

Conservation agriculture (CA) refers to the simultaneous use of three main principles: (i)- less disturbance of the soil i.e. reduced tillage (RT) or (NT) no-tillage and direct seeding; (ii)- soil cover i.e. crop residue, cover crops, relay crops or intercrops to mitigate soil erosion and to improve soil fertility and soil functions and; (iii)- crop rotation to control weeds, pests and diseases (Derpsch, 2001). Other terms such as conservation tillage, zero-tillage and direct drilling apply to CA.

CA emerged historically as a response to soil erosion crises in USA, Brazil, Argentina and Australia where currently, it spans over million hectares. The most famous success story is that of Brazil, where conservation agriculture has been initiated by farmers. Afterwards, research, policy, NGOs, public and private sectors joined their efforts to farmers and farmers' societies and networks which led to effective and dynamic innovation systems that have strongly contributed to disseminate the technology.

Introduction of CA practices in Europe was mainly driven by economic considerations. According to Soanne and Ball (1998), reduced tillage and no-tillage practices as means of reducing crop production costs and allowing greater timeliness was intensively researched in many parts of Europe between 1960 and 1990. Despite this early interest, there still are few synthetic reviews of the research findings (Cannel, 1985; Soane and Ball, 1998; Rasmussen, 1999; Tebrügge and Düring, 1999; Holland, 2004, Deumlich *et al.*, 2006) and, the adoption of conservation agriculture by European farmers is still very weak compared to other regions of the world (Derpsch, 2005).

The rise of environmental concerns along with the questioning of the sustainability of agriculture in Europe in the past decade led the European Commission (EC) to support many research initiatives one of which was an appraisal of the applicability of no-till technology in the western European countries (Tebrügge and Böhrensen, 1997a-b). More recently, the EC has funded a specific support action called KASSA –Knowledge Assessment and Sharing on Sustainable Agriculture, which aimed at tacking stock of past research results on sustainable agriculture (http://kassa.cirad.fr).

This paper deals with the main findings and lessons of KASSA related to European countries. The potential of CA for soil and water conservation in Europe; the diverse practices of CA in Europe and their current extension in some European countries; then the main drivers and constraints for expansion of CA in Europe will be presented and discussed.

KASSA project

KASSA is a worldwide initiative assembling 28 partners from 18 countries in Europe, North Africa, South-East Asia and Latin America.

KASSA focussed mainly on conservation agriculture-CA; it worked simultaneously within 4 regional platforms: Europe, the Mediterranean, Latin America and Asia. The project was implemented through a step-by-step and iterative process. This process began with the development of comprehensive inventories and assessments of existing and validated knowledge on sustainable agriculture in the four different regional platforms. It continued with a comparative critical analysis across platforms, then the refinement of findings, and concluded with a final synthesis. Reports released at each step were submitted to the critical review of a panel of experts that validated KASSA results before its final delivery. The prospects for sustainable agriculture in Europe took an important part of the agenda of the KASSA closing conference.

19 European partners took part in KASSA. 11 partners from 8 countries participated within the European platform: Czech Republic, Denmark, Estonia, France, Germany, Norway, Ukraine, and United Kingdom. 8 partners from 3 countries participated within the Mediterranean platform: Greece, Italy and Spain (fig. 1).

Figure 1. European countries involved in KASSA

Main Results

1. CA practices and Soil and Water Conservation in Europe

The inventory and assessment of the results of past research on CA in Europe showed that research topics vary from country to country and from team to team within a country. According to Spanish teams' survey, until 1998: impact of CA practices on soil structure and soil organic matter (SOM) were subject matter of 40-48% of the studies; only 16% of the studies investigated soil erosion processes as affected by tillage practices and; studies focusing on soil biological activity under CA were insignificant. In northern Europe, soil physical properties, soil water and SOM were investigated in respectively 16%, 4% and 10% of the studies dealing with agronomic impact of CA; macrofauna was subject matter in 22% of the studies dealing with environmental impact of CA.

Thus, soil physical properties, soil water and SOM seem to have received more attention in Mediterranean Europe; macrofauna received more attention in Northern Europe and; erosion has been given nearly equal attention in both. In general, the impact of CA practices on soil properties affecting erosion i.e. soil structure and porosity; aggregates stability; soil infiltration and hydraulic conductivity; soil compaction; earthworm population; SOM; and the impact of CA practices on erosion processes have been less investigated in Europe compared to other matters like crop yield in CA or economics of CA. And, the investigations seldom focused on the whole subjects together.

From the results of KASSA, one can extract the main conclusions regarding soil and water conservation in Europe.

Soil physics and related water properties

Results available tend to ascertain that CA practices impact soil structure and porosity. However the magnitude and the significance of the changes seem to vary depending on soil texture, the climate, the CA practice i.e RT or NT and, the soil cover management. In many situations, CA practices led to: (i)- soil compaction of the upper layer (Gómez *et al.*, 1999; Hansen, 1996; Hernanz *et al.*, 2002; Munkohlm *et al.* 2003; Tebrügge and Düring, 1999); (ii)-decrease of soil porosity (Lampurlanés and Cantero-Martínez, 2006; Tebrügge and Düring, 1999); (iii)-as consequence, hydraulic conductivity decreases (Hallaire *et al.*, 2004; Lampurlanés and Cantero-Martínez, 2006; Moret and Arrúe, 200X; Rasmussen, 1999; Tebrügge and Düring, 1999). Under CA, evapotranspiration may be reduced and the soil water content may increase in the upper soil layer (Rasmussen, 1999; Josa and Hereter, 2005). The negative effect of NT on infiltration can be counteracted by the presence of residue on the soil surface, resulting in greater water storage (Lampurlanés and Cantero-Martínez, 2006). In Eastern European countries, especially in the case of degraded soils i.e. over-compacted or eroded soils, CA practices seems the regeneration and the improvement of soil physical properties (Čupa, 2000; Horáček *et al.*, 2001; Javůrek and Vach, 2002; Medvedev *et al.*, 2004).

Soil organic matter and aggregate stability

Change in soil organic matter (SOM) and Soil organic carbon (SOC) under CA is always reported in international literature. SOC generally increases and, the increase rate depends on the tillage practice and the crop rotation (West and Post, 2002).

NT systems always accumulate more organic matter on the soil surface than do RT systems. One particular feature of CA is that SOC accumulates in the very topsoil (Stockfish *et al.*, 1999; Tebrügge and Düring, 1999; Horáček *et al.*, 2001) which leads to carbon vertical stratification (Hernanz et al, 2002; Moreno *et al.*, 2006). This distribution of SOM and SOC impacts biological activity (Friebe & Henke, 1991; Dennis *et al.*, 1994), topsoil physical properties (Hallaire *et al.*, 2004; Balabane *et al.*, 2005; Riley *et al.*, 2005) and soil erosion (Puget *et al.*, 1995; Balabane *et al.,* 2005).

Soil surface crusting plays a key role in runoff and erosion (Tebrügge and Düring, 1999); low aggregate stability favours soil surface sealing and erosion. CA seems to improve aggregates stability; the improvement is higher in NT systems compared to RT systems (Tebrügge and Düring, 1999; Hernanz *et al.*, 2002). The increase of aggregate stability is correlated to the increase of SOC (Hernanz *et al.*, 2002). Nevertheless, soil sealing is a complex process involving many factors and; in regions where crusting is a significant problem soil cover plays a key role in preventing crust formation. In Mediterranean Europe, Usón and Poch (2000) showed that RT without soil cover didn't reduce crusting.

Impact of CA earthworms

Earthworms' activity has a decisive role in the formation of micro- and microaggregates (Six *et al.*, 2004). Results clearly indicate that abundance and fresh biomass of earthworms is higher when tillage intensity is reduced (Balabane *et al.*, 2005; Emmerling, 2001; Friebe & Hangen *et al.*, 2002; Pelosi *et al.*, 2006). Anecic and epigeic worms responsible for vertical biopores seem to be favoured by NT and soil cover (Pelosi *et al.*, 2006). It has been observed in Germany that the abundance of vertically oriented continuous earthworm burrows under NT increases soil infiltration rates (Tebrügge and Düring, 1999). Similarly, non-affected or increased hydraulic conductivity under RT in the Mediterranean has been attributed to the existence of preferential paths created by an increase of earthworm population (Moreno *et al.*, 1997). However, in the Mediterranean context, soil moisture conditions as influenced by climatic conditions of the year are determinant factor for the number of the earthworms during and between years (Ojeda *et al.*, 1997).

Erosion mitigation

There are few studies available on the topic in Europe, though in Germany and Norway CA practices have been encouraged to face soil erosion (Lundekvam and Skoien, 1998; Tebrügge and Düring, 1999; Borresen and Riley, 2003; Lundekvam *et al.*, 2003). The erosion mitigation results from the combined effect of the soil cover, the topsoil aggregates stability and the water infiltration rate which are closely linked to SOM and SOC and earthworms' activity (Friebe and Henke 1991; Puget *et al.,* 1995; Balabane *et al.,* 2005).

In northern Europe, erosion and run-off measurements showed that in NT erosion is reduced both during the cropping and the intercrop periods (Martin, 1999). Cover crops or catch crops play a major role in erosion mitigation (Breland, 1995; Frielinghaus, 2002). In some situations, modifying the time of tillage is sufficient to reduce the erosion risk; spring tillage in Norway results in little soil losses whereas autumn ploughing leads to higher erosion risk (Borresen and Njøs, 1990; Lundekvam and Skoien, 1998).

In Mediterranean Europe, research focused on both water and wind erosion. Water erosion has been studied in annual crops in Spain (De Alba *et al.*, 2001) and in perennial crops in Spain, Italy and Greece (olive orchards) (Gómez *at al.*, 1999, 2005). Wind erosion has been studied in semiarid Spanish cereal/fallow lands (López et al., 2001; López and Arrúe, 2005). In Andalusia several studies focused on the development of simulation models and expert systems to predict the effect of tillage systems on water erosion under different climatic conditions and to design site-specific agricultural implements (Simota *et al.*, 2005; De la Rosa *et al.*, 2005). As results, in dryland olive crops, reduced tillage and soil cover seem to be effective in reducing water erosion (De la Rosa *et al.*, 2005); in cereal/fallow lands, reduced tillage, with chiselling as primary tillage, could be a viable alternative to mouldboard ploughing for wind erosion control (López *et al.*, 1998, 2000).

From all these results, it is very clear, that the combination of soil cover and reduced or no tillage plays a key role in controlling soil erosion.

2. CA tentative adoption and current extension in Europe

In the diverse European agricultural contexts, the concept of CA gave rise to a wide variety of farming practices, ranging from non-inverting plough to reducing the depth of tillage and/or the number of passes, to the direct sowing within covered soil (fig. 2). Different practices may follow one another in time and may coexist within the same farmland. European farmers adapt their practices to the market opportunities and to the practical constraints they face.

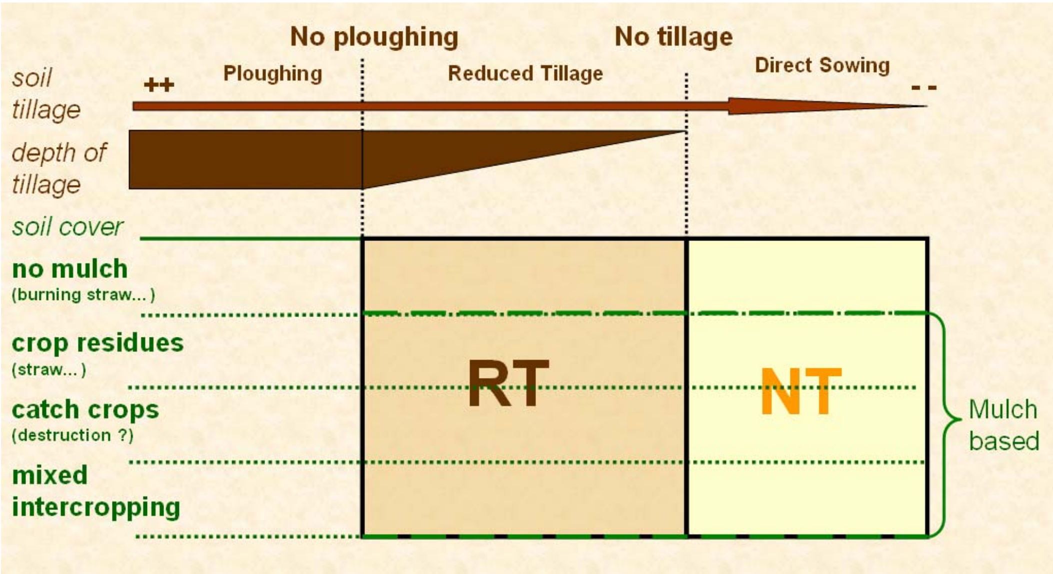

Figure 2. Description of the variety of practices of soil management in Europe
RT: reduced tillage; NT: no-tillage

Experience with CA in Europe varies from country to country and from region to region within a country. Farmers' interest in CA systems varies also with time. Farmers in UK and the Scandinavian countries seem to have been among the first adopters of CA practices. By 1978, 8-10% of the winter cereals in the UK were performed under NT or RT; however, by 1990, there was a strong move of farmers back to mouldboard ploughing because of a number of unforeseen problems of weed and crop residue management (Soane and Ball, 1998). The same scenario occurred in the Scandinavian countries between the 1970s and the late 1990s (Rasmussen, 1999); whereby the reasons given were residue management problems; grassy weeds infestations and excessive topsoil compaction (Munkholm *et al.*, 2003). According to Håkansson (1994) in Scandinavian areas where CA practices have been advocated without having previously carefully investigated all consequences, farmers who had started using these methods sometimes returned to traditional methods. In erosion risk area in Norway there is a clear tendency of shifting from RT with no ploughing to spring ploughing. In Italy the no-tillage trials started in 1968, but CA expansion began only in the 1990s; it was driven by the need to reduce crop costs and, the availability on the Italian market of sowing equipments and adequate herbicides (De Vita *et al.*, 2006). In France Farmers' interest in CA began in the

1970s, mainly driven by the need to reduce labour time but in the 1980s, this interest decreased due to favourable economic conditions and to the higher costs of herbicides. By the 1990s, the CAP reform and the international market conditions led farmers to seek again for reducing production costs and improved productivity (Goulet, 2004). This new interest in CA was helped by the availability of adapted implements and the decrease of herbicides prices (Barbier and Chevrier, 2002). CA is used by French farmers in many parts of the country but the most extended CA acreage is in southern France (Aquitaine, Midi-Pyrénées) and in Ile de France. In Spain, CA principles were introduced in the 1970s through knowledge acquired in USA (Fernández-Quintanilla, 1997) and later from Australia but, the real development of CA practices began by the 1980s with the involvement of technical advisers from agricultural services, farmers' cooperatives and multinational and national companies and scientists as well as the support provided to some regions (e.g. Castile-Leon) (Tamames, 2002). 11 farmers' societies and consortia have been created across the country; they played a key role in the development and adoption of CA by farmers (Tamames, 2002). The Spanish Conservation tillage Research Network created in 1996 has identified, between 1996 and 1998, 22 research groups across the Spanish territory collaborating with farmers adopters of CA and developing basic and applied researches linked to farmers' concerns including long-term experiments to assess and develop CA systems (Harnanz *et al.*, 1998). From 1985 to date, there have been many events organised by farmers' organisations and scientists on CA. It is worth to mention that the first world congress on CA took place in Madrid in 2001 (García-Torres *et al.*, 2001) and the third Mediterranean meeting on no-tillage took place in Zaragoza in 2006 (Arrúe and Cantero-Martínez, 2006); also, many publications targeting CA dissemination have been released (Gil-Ribes *et al.*, 2004). The main drivers that first influenced the development of CA in Spain were: the need for labour simplification; farmer time requirements for other activities as livestock or orchard intensive production and; savings of fuel and costs for machinery required for tillage and other inputs. According to farmers' surveys carried out periodically since the 1990s (Cantero-Martínez *et al.*, 1996; Pérez Berges, 1998, Hernanz *et al.*, 1998, Sisquella *et al.*, 2004a-b), acceptance of CA technologies in Spain is still low. In areas where the technology were not initially properly introduced the adoption level is very low. However in areas where the technologies were well introduced and adopted by some farmers, a swift spreading throughout the area occurred. The shift from plough-based systems to CA systems took place through 2 steps. The first step was the widespread adoption of RT techniques; the second step, ongoing but with lesser extent, is the adoption NT with more than 30% of the crop residue left on soil surface. Adoption of NT practices is facing many problems linked to soil compaction; straw and stubble management; higher incidence of weeds, pests, mice, rodents, slugs and diseases; lack of knowledge and technical advice which sometimes discouraged farmers. In Eastern European countries, many research trials have been carried out last decade (Čupa, 2000; Horáček *et al.*, 2001; Javůrek and Vach, 2006, 2002; Martyniuk *et al.*, 2006; Medvedev *et al.*, 2004; Dryšlová *et al.*, 2006; Smutný *et al.*, 2006; Winkler and Smutný, 2006); farmers' interest in CA practices is just beginning. In Baltic countries, some long-term experiments seem to have begun in the late 1980s (Jodaugiene *et al.*, 2006); farmers' adoption of CA practices is not yet clear.

Currently, there is no survey at EU or country level of CA coverage in Europe. Data available are scarce and may not apply to the whole cropping system (Table 1). For instance, most of the areas listed as "no-tillage" may correspond to fields managed in NT only for a part of a rotation, whereas the other crops of the rotation are managed using RT or ploughing. Indeed, cereals and rape can be grown under RT or NT while root or bulb crops are difficult to manage under these systems. Recent experiment showed that mulch and RT reduce yielding and quality of onion (Kęsik *et al.*, 2006). The figures in Table (1) show that CA practices are less adopted in Europe and that RT is more common than NT. Also, there is a large diversity of situations between the countries which entails diversity in the practices used. This diversity results from driving forces and constraints, which are different from country to country.

Table 1: Current extension of CA in the European countries participating in KASSA

Country	**Farming patterns**		**RT**		**NT**	
	number of farms	ha/farm	area (ha) (year)	% of the agricultural used area	area (ha) (date)	% of the agricultural used area
Czech Republic	54639	68	750 000 (2005)	18%	150 000 (2005)	3.5%
Denmark	48 750	53	150 000 (2004)	6.8%	~ 0 (2004)	-
Estonia	36 859	22	160 000	16%	10 000	1%
France	600 000	70	1 373 800 (2001)	4.6%	50 000 (2001)	0.2%
Germany	420 697	44	3 400 000 (2004)	20%	510 000 (2004)	3.0%
Norway	55 697	19	158 000 * (2004)	15%	6 000 (2004)	0.6%
Ukraine	53 000	800	9 400 000 (2005)	24%	50 000 (2005)	0.1%
United Kingdom	304 800	69	1 416 000** (2000)	7.7%	24 000 (2000)	0.1%

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

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

3. Future of CA in Europe: drivers and constraints

In Europe CA does not necessarily generate increase in yields. In northern Europe, on average, yields on poor and medium fertile soils do not change dramatically (+/- 10%); they slightly decrease on very fertile soils with a high-intensive level of production. In the Ukraine, however, yields are expected to increase by 5-10% on the chernozem. In Mediterranean Europe, according to Spanish team of KASSA, most of the studies carried out in Spain concluded that yields are generally 10-15% higher under no-tillage, especially in dry years. The change in yields does not appear critical in the decision of farmers whether to adopt CA or not.

Results of KASSA show clearly that RT and especially NT greatly reduce the cost of labour and fuel. However, the amount of the reduction depends on many factors i.e. the type of soil, crop and machinery; some of these results have been reported by Lahmar *et al.* (2006). Data on socio-economic aspects of CA at European level remain unfortunately scarce and do not allow drawing a comprehensive picture and a realistic comparison between the countries, cropping systems and the farming conditions. Labour saving in particular may allow developing other agricultural or non-agricultural activities generating additional benefits as emphasised by the Mediterranean team of KASSA. Also, the savings may be offset by additional costs induced by plant control; and it is reasonably arguable that the rise of the cost of pesticides and/or heavy infestations of weeds, pests and diseases may lead farmers to favour specific crops or to go back to conventional practices.

Scientific evidence of the long-term economic impacts of CA is rare at the European level (Tebrügge and Böhrnsen, 1997b; Kächele *et al.* 2001; Nielsen *et al.* 2004a-b). But it seems clearly that except for Norway and Germany where reduced tillage is subsidised (Lundekvam *et al.* 2003; Schmidt *et al.*, 2003), the reduction of production costs acts as a powerful driving force for CA adoption as it does in the whole other countries participating in KASSA. Soil and water protection and erosion reduction allowed by CA are recognised by Spanish farmers but they are not decisive in their decisions. The increased competition at the global and regional scale will certainly urge European farmers to seek for reduction of costs and improved productivity. CA may be a mean to reach these goals.

Hence, cost savings in fuel, labour and machinery remain the most important economic element of CA that drives its adoption in Europe. However, according to KASSA findings, development, dissemination and sustainability of CA-based systems are affected by many factors acting as drivers or constraints at farm and out of farm levels (Table 2). Most of drivers can become constraints and vice versa. Factors listed in table (2) make it clear that conservation agriculture is not equally appropriate for all European agroecosystems and, that shift from plough-based agriculture to CA-based agriculture is not a simple technical change.

4. Discussion

In most countries of the European participating in KASSA the adoption process is mainly farmer driven and the major driving force is the cost reduction and labour saving: two main farmers' objectives. The only clear exception is governmental subsidies put on RT in erosion risk area in Norway and Germany. Time saving and the improved timeliness of field operations allow developing other agricultural or non-agricultural activities generating additional benefits. The environmental concerns do not appear decisive in the decision of European farmers whether to shift to CA or not, but these concerns are likely to contribute more in the shifting towards CA when farmers get involved in innovation and learning processes. After years of CA practice, farmers perceive the effectiveness of CA systems in increasing SOM and earthworms' activity, reducing soil erosion, and improving water infiltration and productivity in dry areas which reinforce their choice.

CA is not equally suitable for the whole European agro-ecosystems; this confirms the "*Scandinavian viewpoint*" (Håkansson, 1994). The development of CA systems and their socio-economic and ecological sustainability are highly site specific. The fine tuning of CA systems require a continuous adjustment which calls for permanent knowledge generation and sharing among the stakeholders. In Europe, the use of cover crop and diversified crop rotations is still hardly practiced due to climate and soil limitations, short length of growing period in northern latitudes, lack of adapted crop varieties, difficult management of crop residue in wet conditions and, general market conditions. Thus, the mechanical control of weed provided by plough in conventional systems is replaced by a chemical control in CA systems, which is made easier by the availability of affordable and effective chemicals. As a result, in CA systems the number of herbicides treatments increases on average. The lack of knowledge and technical references on biological control of weed using the competition and allelopathy properties of intercrops and associated crops in CA systems makes the integrated management approach more risky for farmers.

The lack of scientific evidence on long term socio-economic and ecological impact of CA systems, the scatter of the available results, the diversity of CA practices used and the wide range of European contexts do not allow to draw a comprehensive picture on CA within Europe, or to anticipate its future development. Nevertheless, the conversion of European farmers to CA is being achieved through a step-by-step strategy; and large sized farms are the most adopters, probably due to their ability to absorb the risk and also to the lack of labour. The short term socio-economic benefits that CA provides through the reduction of costs of production, the need to improve farms' competitiveness, market globalization and the steady increase of fuel cost are likely sufficient to boost CA systems within Europe and to overcome the farmers' and societal possible reluctance due to socio-cultural barriers or environmental considerations. This conversion process is likely already ongoing.

Table 2. Drivers and constraints for CA

Drivers/constraints for conservation agriculture (not ranked)	
Farm and market conditions	Reduced/ increased production costs
	More/ less flexibility and improved timeliness of operations
	More/ less diversification and enterprise selection
	Use/ lack of cover crops
	Use/ lack of suitable rotations for integrated pest, weed, disease control
	Scarcity or excess/ suitable amounts of residues
	Strong/ weak crop-livestock interactions
	Reduced/ increased soil erosion and resource degradation
	Improved/ reduced water productivity (apply to water-scarce agroecosystems)
Biophysical conditions	Favourable/ unfavourable climate
	Favourable/ unfavourable soils
Social, cultural, technological, institutional, and policy environments	Presence/ absence of a crisis mentality
	Absence/ presence of socio-cultural barriers
	Leadership/ lack of leadership from farmers and farmer organisations
	Ready availability/ lack of conservation agriculture implements
	Presence/ absence of dynamic and effective innovation system
	Availability/ lack of knowledge regarding conservation agriculture
	Presence/ absence of policies for training, communication and support for farmers' initiatives
	Policies affecting farm size, agrarian structure and land tenure
	Appropriate/ inappropriate agricultural research policies
	Favourable/ unfavourable macroeconomic policies
	Favourable/ unfavourable agricultural sector policies
	Presence/ absence of suitable subsidies and credits to facilitate conservation agriculture
Impact of conservation agriculture on health and on the environment	Reduced/ increased pressure of weeds, pests and disease
	Reduced/ increased pollutions
	Impact of conservation agriculture on human health known/ not known

5. Conclusion

A wide range of facts tends to evidence a shifting of European agriculture, at least in the countries participating in KASSA, from plough-based systems to RT- and NT-based systems. The process is mainly farmer driven and the major driving force is the short-term benefits provided by CA systems through the reduction of the production costs. Farmers' surveys tend to ascertain that the change in yield induced by CA does not appear as a driver or a constraint in the development and the dissemination of CA in Europe. And, there is no scientific documentation of the long-term socio-economic and ecological impact of these systems.

Lessons of past and ongoing experiences lead to suggest that EU and country members' stakeholders, mainly policy and research, have to anticipate the conversion process in order to improve the long-term socio-economic and ecological sustainability of CA in Europe i.e. to reach a win/win situation between farmers' needs and societal expectations. Priorities would be: (i)- to define the recommendation domains for conservation agriculture within Europe taking into account climate and soil constraints, length of growing period, water availability and quality, erosion hazards and farming conditions; (ii)- to encourage the use of cover crops and agronomically sound crop rotations as management strategies for weed, pest and diseases; (iii)- to assess the actual ability of CA systems in conserving and improving soil, biodiversity and water quality in the diverse European contexts.

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