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Organic seed, conservation agriculture and GM crops in Denmark

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STEP 2: Description of context and extension organic seed, GMO and conservation agriculture (reduced tillage) in Denmark

1. Organic seed

The potentials and constraints to development of sustainable agriculture is a multifaceted activity where many different factors had to be taken into account. There is a need to formulating measures and activities for promote such development. In order to achieve this, an integrated approach is required and attention is to be given to all aspects that play a significant part in the process. The right choice of seed is the first step to sustainable and efficient crop.
In this preliminary KASSA draft report, some crops had not been mentioned for instance horticulture crops will not be treated with details and the forestry will be left out.
Denmark produced nearly 50% of the world market for seeds and 90% is exported (Ministry of Science, 2004: www.workindenmark.dk).
Denmark was one of the first countries in the world where control and certification of seeds was established. The first organisation "The Danish Field Seed Control" was private and founded by E. Møller-Holst in 1871. The name was "The Danish Field Seed Control" and they only controlled the seeds. In 1891 it was taken over by the Danish State under the name Danish name "Statsfrøkontrollen" and from 1990 it was unite with Danish Plant Directory.
All seeds sold in Denmark had to be certificated and this certification following the ISTA rules and all EU regulations.
Since the nineties organic farming has increased and covered 147.400 hectare (ha) in 2003 representing about seven percent of the total cultivated area in Denmark. Organic agriculture increased and in 2001 a need for production of organic seed appeared. Research on production of organic seed was started with the main crops cereals, grass and clove (Danmark Statistik, Anon. 2004).

2. Use of genetically modified plants and seeds in Denmark

Since 1998 experiments with GM crops had been possible in Denmark, but first in 2004 the new EU regulative, which allows the commercial cultivation of these types of seed, came into force. EU directives No. 2001/18/EC on deliberate release of GMOs into the environment, had made it legal to ask for permission to grow GM crops in Denmark (www.plantedir.dk Danish Plant Directory, S. Pedersen, 2004).
In Denmark we are just waiting for the first permission for conventional use. But consequences of GM in Denmark for organic farming had been subject for investigations, including the problematic of co-existence between use of GM in conventional and organic farming for some years (Boelt, 2003;Boelt and Bertelsen, 2002 a,b; Boelt, 2004; Kjellsson and Boelt, 2002; Kjellsson and Damgaard, 2003; Rasmussen et al., 2003).

Regulation of GMOs in the European Union was changed in 2004 (www.plantedir.dk 2004). In January 2005 only one GM seed source got permission for cultivation in Denmark and this is Bt-maize MON810 (Monsanto Europe SA, France), which has a Bt toxin and is resistance to European Corn Borer in maize, which is not a problem in Denmark. Maize Bt176 (Syngenta) has an environmental permission (environmental risk assessment) to be grown in EU. It is resistant to herbicides and could be of interest for some growers, but it still missing the last permission for

cultivation in Denmark, which is to be obtained on the national variety list. In 2003 DLF-Trifolium, Danisco and Monsanto applied EU for permission for cultivation of a GM fodder beet with Roundup resistance, but they are still waiting for a response (www.plantedir.dk -S. Pedersen, 2004).

3. Reduced tillage (RT) crop production systems in Denmark

Reduced tillage in Denmark comprises many different growing strategies, but common for all of them is that no ploughing is used.
RT includes direct sowing (DS), where the soil is treated in depths of 5 cm before sowing and RT where the soil is treated in depths from 5 to 20 cm before sowing (Sandal, 2004). In Denmark, DS is of limited application in Denmark (Sandal, personal communication 2004).

From the beginning of the 1970s and until mid-1980s, RT and DS were topics of great interest and was the subject for several studies in Denmark (Nielsen et al., 2004). This interest gradually declined, and one of the main reasons was attributed to the restriction of burning of straw after harvesting. RT investigations were very limited to nearly non-existence in the late1990's, but experiencing a dramatic increase in recent years.

It is estimated that an area of about 400.000 ha (17% of the area in rotation) could be used for RT (Olesen et al, 2002) in Denmark, but currently no statistical data of the extent of RT in country has been registered. The adviser for the RT growers, Erik Sandal from the Danish Agricultural Advisory Centre (www.lr.dk), indicated that a noticeable increase has been experienced and the area with RT is estimated to be about 150.000 ha in 2004.

According to the Danish Statistical Institute figures (Danmarks Statistik, 2004a), the total area with cereals in 2003 was 1.487.312 ha. In 2003, the winter wheat area made up 652.000 ha this is 43.8 % of the cereals area. This means that the area with RF constitutes 23-31 % of the total area of cereals under cultivation and the total grown/cultivated area in Denmark with RT is of about 7 %.

Execution of RT requires expensive equipment and therefore farmers with large area of cereal production have mostly applied it. Many pig producers have also practiced RT for reduction of costs and winter wheat is the preferred crop nearly without crop rotation.

Farmer practicing RT founded the Danish growers organisation for reduced tillage and its name is FRDK (Foreningen for Reduceret Jordbearbejdning i Danmark). FRDK is a member of European Conservation Agriculture Federation (ECAF).
The main reason for the farmers to use RT is the lower costs of labour and fuel. This makes the crop production more sustainable for the farmers.

STEP 3: Analysis and synthesis of the information collected in each country

1 Organic seed in Denmark

1.1 Seed production

In 2003 the cultivated area of Denmark was about 2.672.727 ha, cereals made up 1.487.000 ha (55.6 percent) (Danmarks Statistik, 2004). During 2004 the total area with production of field seeds in 2004 was 87.554 ha, 87.932 tons grass seeds were produced on 83.175 ha (Danmarks Statistik, 2004). The area with clover was 4304 ha and the yield 1.690 tons in 2004 (Anon. 2004).

Denmark has some advances for seed production, and the main reasons for this are our suitable climate, research efforts and our expertise in seed control. Denmark produced nearly 50 percent of the world market for seeds, and 90 percentages of our production are exported. The biggest seed company in Denmark is DLF Trifolium A/S, which is the world-leading producer of clover and grass seeds (Ministry of Science 2005: www.workindenmark.dk).

Research in production of organic seed able for certification is required. The main problems faced plant diseases and pests, which make the production very vulnerable and expensive. Denmark is the first and nearly only producer of organic clover and grass seed on the world market, and a large number of research projects are carried out by the Danish Research Centre for Organic Farming (DARCOF), and the results have been published (Boelt and Deleuran, 2000; Boelt, 2002; Boelt, 2003 a,b; Boelt et al., 2002; Borgen, 2002; Borgen et al, 2002a; Hansen and Boelt, 2004).
There has been an increased interest in production of organic seed. Today Denmark is nearly self-sufficient in organic seeds of cereals, grass and clover (Anon., 2004a). In 2005 export of organic grass and clover seed to USA can be a reality (Danish Plant Directory, personal communication L. Tinghus, 2005).
Denmark has no production of organic horticultural seeds yet, but research projects under FØJO/DARCOF had started, in which investigations in the production of carrot, leek and cauliflower seeds are included (Boelt, 2002;Boelt, 2004a; Boelt et al., 2004). The area with conventional seeds is 5.000 ha and 25 species are produced. Spinach constituted 4.000 ha of this area (Bondesen, 2005).

1.2 Certification of organic seed and database

Danish Plant Directory controls organic seeds and follows rules for certification. The rules for organic seeds are exactly the same as for conventional seeds – the ISTA Rules. Organic seed is analysed for seed infestations and can, in practice, only be sold as organic seed in Denmark if the level of pathogens is below the defined threshold levels. This often results in lack of certificated organic seed on the market and dispensation for use of conventional seed has to be given (Kristensen and Jespersen, 2004).
Therefore, production of organic seed can be very difficult and expensive, and research in this field is required (Boelt and Gislum, 2004; Borgen, 2002).
Seed-borne diseases cause problems, and in 2005 a five-year project on organic seed supported by DARCOF (FØJO Forskningscenter for Økologisk Jordbrug) will examine the thresholds in field

trials for all relevant diseases in peas and small cereals for use under organic farming conditions (Nielsen and Kristensen, 2002; Nielsen, B. J., 2004a).
From January 2004, the EU directive appointment for the new certification of organic seed was effective. In the beginning of 2004, the Danish Organic Seed Database was started by Danish Plant Directory, and information about organic seed available for sale can be found on the Internet address: Danish Organic Seed Database: www.lr.dk/applikationer/oekosortsdb
Currently (January 2005), the Danish Database contains about 80 different field crops (species) and 90 different horticultural crops. When no organic seeds are available for the growers, it is possible to apply for dispensation using the Danish organic Seed Database. Dispensation can be granted generally or individually.
In 2004, general dispensation was granted for 72 species of agricultural crop and their names can be seen in the Annual Report 2004 on the Internet (Anon. 2005a; www.Plantedir.dk -Årlige rapport 2004).
In 2004 individual dispensations was granted for eight species (22 varieties) of agricultural crops: oat (*Avena sativa*), winter rape (*Brassica napus*), cooksfoot (*Dactylis glomerata*), winter barley (*Hordeum vulgare*), grass (*Lolium perenne*), lucerne (*Medicago sativa*), pea (*Pisum sativum*), white clover (*Trifolium repens*), wheat (*Triticum durum, T. turgidum subsp. durum*) and Grassmi. In 2004, the number of horticultural crops with general dispensations included 41 for general dispensation and 69 species for individual dispensation. The names of species and varieties are given in the same report as mentioned above (Anon. 2005a).
In 2005, it will be necessary to grant a special dispensation for the level of leaf, stem and pod spot in pea seeds. This means that the threshold of the disease will be changed from 5 percent instead of 20 percent (Nielsen, G. C., 2005). A research project to solve this specific disease problem in pea has just started (Nielsen, 2005).
The main problem is seed-borne diseases, which make the production very vulnerable and expensive, and lack of organic seeds is a reality.
In order to achieve more effective control, molecular diagnostic methods for prevention of unnecessary rejection of organic seed has been developed, especially for estimating the threshold in barley of *Pyrenophora teres* and *P. graminiea* (Justesen et al., 2004).

1.3 Disease problems and resistance

When organic seed are used, it is very important to make the right choice of variety to prevent diseases. Varieties have to be resistant to diseases, which is common in the crop. The problem is that such varieties are not always available to the farmers. Seed-borne diseases cause problems in organic farming (Nielsen et al, 1998) and screening for varieties with high tolerance for use in organic farming is required (Nielsen, 2004b; Nielsen et al., 2002; Pinnschmidt et al, 2004).
Also problems with different toxin producing fungi on seeds had to be solved (Elmholt, 2002; Hestbjerg et al, 2002).

1.4 Seed treatment

To control seed-borne pathogens on organic seeds, one may only use mechanical and physical seed treatment methods; seed treatment with chemicals or micro-organisms are not allowed. Products will be listed in a catalogue of organic products on the homepage: www.lr.dk/okokatalog when permission is given.

In 2001, a research project under DARCOF (FØJO) with the title:" Healthy seed propagation for organic production of cereals and legume seed" was initiated (www.organiceprints.org). Experiments with treatment of seed with e.g. acetic acid, citric acid, bio-preparation Cedomon and cleaning by brushing are part of this project, but also treatment with milk powder and mustard flour has been carried out in cereals (Borgen, 2004; Borgen and Nielsen, 2001; Borgen and Kristensen, 2001; Nielsen et al. 2000). Use of high-temperature drying of organic grown cereals can reduced the amount of mycotoxines (Kristensen and Elmholt, 2002). In the Danish organic horticultural sector, growers sometimes use hot water seed treatments for reduction of seed-borne diseases in vegetable crops (Bjørn and Thinggaard, 1999).

1.5 Conclusion on organic seed

Production of organic seed has been a success for some crops, e.g. different species of grass and red clover. Problems on other seed species in the production appeared and had to be solved.
The new EU certification 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.
It is, therefore, apparent that the problems present to organic seeds sources could result in a reduction of organic farming in Denmark.

2. Reduced tillage (RT) crop production systems in Denmark

2.1. Introduction

During the last years, several trials/experiments on RT have been conducted in Denmark in collaboration with farmers and the Danish Agricultural Advisory Centre. Results and findings from much of these publications can be found on the homepage of Danish Agricultural Advisory Centre (Landscentret - www.lr.dk) and in annual reports. Unfortunately many of the publications on RT are written in Danish. Some of the research publications from the Danish Institute of Agricultural Sciences (DIAS; www.agrsci.dk) and The Royal Veterinary and Agricultural University (KVL;www.kvl.dk) are written in English or have English summaries.

2.2 Selection of suitable areas and crops for implementation of RT

RF practices are mostly suitable for clay soils with a good structure and for heavy clay soils where ploughing can be difficult, RF can even produce better results. In sandy soils, RF can lead to soil cementation, and loosening of soil can be necessary. Winter wheat is the best crop for RF in Denmark, and starting with RT it is best if winter rape is followed by winter wheat. Winter wheat is the easiest and most successful crop for RT on clay and sandy soils. Winter- and spring barley are more difficult, and oat and winter rye are in between (Sandal, 2004).
New discount trials started in 2001 with spring barley grown with direct sowing (DS) and the results had shown that costs can be reduced with 50 to 75% (Sandal, 2004a; Anon., 2004c).

Winter and spring rape present demands to soil structure. Pea and other leguminous fruit are less suitable than rape, and production of grass seed leads to many problems. Production of maize without yield loss can only be done on sandy soil because it needs a high soil temperature during spring. Root crops such as beet, turnip and sugar beet need a good soil structure, and loosening of clay soil in the autumn is necessary (Sandal, 2004). Liquid manure can be used in RT without problems (Sandal, 2004). During 2004, good results were obtained with RT in fodder beet production (www.FRDK.dk).

In a research report from five-consecutive-year experiments (starting in 1999), RT was compared with ploughing at three locations and results revealed no significant differences or changes in yield during the period between the two systems (Høy, 2004).

Execution of RT requires expensive machinery, and farmers mostly practise it with large areas for cereal production. Many big pig farmers practises RT, and winter wheat is the preferred crop. The farms using RT are rather big. In Denmark 65% of the winter wheat is produced by pig farmers, where the main crop is winter wheat, often with winter wheat followed by winter wheat.

Many aspects of the influences of different growing methods in RT had been treated and many experiments carried out (Grossmann, 2002; Henriksen et al., 2004; Schjønning et al., 1999; Schjønning and Rasmussen, 2000; Schjønning et al., 1999, 2002a,b; Sørensen and Mortensen, 2004; Van den Akker and Schjønning, 2004).

2.3 Yield and production costs (cost reduction of energy, CO_2, labour)

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New discount trials started in 2001 with spring barley grown with direct sowing (DS) and the results had shown that costs can be reduced with 50 to 75% (Sandal, 2004a; Anon., 2004c). Yields were 50 hkg/ha with ploughing and 43 hkg/ha with direct sowing, but the costs were more than 50% lower (Sandal, 2004a).

In 2001 experiments with reduction of energy requirement using wheat and rape as crops were started. In the experiments, fuel consumption, labour requirement and capacity on reduced tillage and direct seeding were investigated (Nielsen et al., 2004), and the results are presented in the following:

1. Fuel consumption using traditional tillage was 40-50 l/ha, with reduced tillage 18-35 l/ha and with direct drilling 12-14 l/ha. In reduced tillage the fuel consumption was reduced by 33-64 %, depending on the method and technique.

2. Labour requirement: With traditional tillage, 2.0-3.1 /ha was used, with reduced tillage with ploughing, 2.0-2.2 hours/ha, with reduced tillage without ploughing, 1.1-1.7 hours/ha and with direct drilling, 0.8-1.0 hours/ha.

3. When stubble harrowing was carried out in the same working depth, there were no significant differences in fuel consumption on sandy and clay soil.

4. The most significant savings on reduced tillage can be achieved if ploughing is avoided.

5. When cereal followed cereal, a need for intensification of use of pesticides was observed.

The results from this report showed that the growers were able to reduce the costs of production in a considerable manner. Information from FRDK in 2004 tells us that the labour in spring barley under RT systems was only the half of the labour used in ploughing systems and in winter wheat where 1.25 more labour was used in ploughing systems (www.frdk.dk).

2.4 Environmental effects

When RT was used in the 1980s, experiments investigated only the yield and not the effects on the environment, and therefore, such experiments are needed (Olesen et al., 2002). RT has influence on the consumption of energy, pesticides, deposition of carbon in soil, nitrogen pollution to groundwater, N_2O, erosion, but we know very little about P, N and pesticides as well as growth- and environmental problems (Olesen et al., 2002). Right now, only very few results about the environmental effects from using RT are available.
In the 1980s, crop rotation was normally used, but this has changed, and in RT systems, cereal can be grown as the only crop year after year and often with winter wheat. This practice can lead to an increased use of pesticides (herbicides and fungicides) with a negative effect to the environment.

We may expect to find less depletion of N and P in RT cultivation, depending on how deep harrowing is done. It has also been observed that lack of manganese is less common in RT crop production systems (www.lr.dk, 2004).
RT can cause changes in the soil structure and content of soil organic matter (SOM), which can increase fertility of the soil, but RT on sandy soil can cause problems when cementation of soil occurs and has to be ploughed up to avoid drainage problems.

After a high content of organic matter is built up in the RT system, weed and disease problems can make it necessary to practise ploughing of the soil at frequent intervals (www.lr.dk, 2004). Reduction of erosion due to the increase in organic matter is to be expected, but this is of relatively poor importance in a low land like Denmark.

The effects of run-off of pesticides and nutrition to watercourses from RT systems are still unknown. Danish drinking water (groundwater) is under surveillance by the GEUS (Danmarks og Grønlands Geologiske Undersøgelser) for pollution, e.g. content of pesticides and NO_2 (GEUS, 2004).

The report "Land use and landscape development perspectives for nature, agriculture, environment and land management" is a conclusion on the project "Land use and landscape development illustrated by scenario" (Hansen, 2004). This report can be a tool for future research on the evaluation of the interaction between nature, agriculture, environment and land management practices.

An investigation conducted by the Ministry of Environment of Denmark (Miljøstyrelsen) (www.mst.dk MST) on the diversity of birds in different growing systems was carried out from 1976 to 1996 (Anon. 2002a). Investigations of RT influences on the biodiversity have shown that no changes in the natural flora and fauna (biodiversity) were observed between different growing systems, but more differences appeared from looking on soil preparation, establishment of non-grown borders (edges), hedges, crop rotation and others (Anon. 2002b).

Evaluations by the Danmarks Miljøundersøgelser (www.dmu.dk DMU) on the effects of different growing systems on the number of skylarks have just been published, and the result showed that green fields did not lead to an increase in the population of skylarks, but this was the case when non-grown borders and hedges was established (Topping, 2004, 2005; Jepsen et al., 2004). Influences of RT and other agriculture growing systems on biodiversity need to be further investigated because of negative changes had been observed in the biodiversity (2004 www.DMU.dk).

2.5 Weed, disease and pest problems

The way to control weeds, diseases and pests in RT systems is different from systems with ploughing. Problems due to weed in RT systems are a great challenge. Attempts to solve these problems by using glyphosat before seeding and later by applying herbicides to the fields have been carried out. Increased problems are observed in RT systems, especially with root weed, such as creeping thistle (*Cirsium arvense*) (Sandal, 2004). Sustainable control methods had to be developed and research has started (Melander, 2002; Rasmussen and Jensen, 2002).

Special weed problems are observed in RT systems as common cleavers, Apera spica-vent, Alopecurus myosoides and Bromus sterilis (Melander and Holst, 2004).
Also speciale 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 RT systems, the following fungi have been noticed to cause disease problems too: In wheat: *Fusarium avenaceum* (Ear Blight), *Septoria avenae* (Septoria Leaf Blotch), *Erysiphe graminis* (Powdery Mildew- meldug), *Puccinia striiformis* (Yellow Rust), *Drechslera tritici-repentis* (Yellow Leaf spot), *Tilletia tritici* (Stinking Bunt), *Pyrenophora graminea* (Leaf stripe), *Septoria nodorum* (Leaf and Glume Blotch). In rye: *Claviceps purpurea* (Ergot), in barley: *Typhula incarnata* (Snow Rot), *Puccinia hordei* (Brown Rust), *Drechslera teres* (Net Blotch), and *Ustilago* (www.lr.dk, 2004).

In 2004 and 2005, an increase of problems with *Fusarium* has been found and can lead to ploughing of area with RT for prevention of diseases (Nielsen, G. C., 2005, Sandal personal communication 2005).

The amount of pesticides used in agricultural crops according to Danmarks Statistik was 2.868 tons (active amount chemicals) in 2002/03. Split up into four groups: herbicides 2105 tons, fungicides 574, insecticides 43 tons and grow regulators 146 tons. From 2001 to 2003, the cultured area was reduced by 6.7 %, and the total consumption of pesticides was decreased by 3 % (Anon. 2004). Concerning consumption of herbicides and fungicides, an increase on herbicides on 1.5 % was recorded with a fall of only 2.4 % of fungicides. Increased use of RT systems does not seem to have an effect in reduced utilisation of pesticides. It has been observed that when wheat after wheat is practised in RT, the demand for pesticides will increase (Nielsen et al., 2004).
The bio-preparation Cedomon (*Pseudomonas chlororaphis*) has been registered in Denmark for use as seed treatment in conventional barley grains against *Drechsler teres* (Net Blotch) and *Drechslera graminea* (Leaf Stripe) (Nielsen, 2004).

In RT, the greatest pest problem right now is field slug (*Agriolimax agrestis*), but on heavy clay soils, the problem appears to be less on RT than on soils where ploughing has been used (Sandal, 2004).
In the following Table is a review over the consumption of pesticides in the 8 countries participating in North European Platform of KASSA given.

Tons active substance		2001	2002	2003	2004	Database/ references
Czech Republic	Herbicide Fungicide Insecticide		na	na	na	
Denmark	Herbicide Fungicide Insecticide	2364 654 87	2369 683 89	2390 665 92		Danmark Statistik P706,P707
Estonia	Herbicide			268		Statistcal

	Fungicide Insecticide			24 6		office of Estonia Enviroment 2003
France	Herbicide Fungicide Insecticide					
Germany	Herbicide Fungicide Insecticide			15.350 10.033 6370		
Norway	Herbicide Fungicide Insecticide				191 124 5	
UK	Herbicide Fungicide Insecticide					
Ukraine*	Herbicide Fungicide Insecticide			7200 200 140	8600 190 150	

na = not available * physical weight

2.6 Selection of varieties

Use of seed of resistant varieties in RF is more important than in conventional systems if increase of pesticide treatments is to be avoided. Because the amount of fungal diseases seem to increase in RT systems, there is an increase of demand of varieties with fungal resistance in RT (Sandal et al. 2004), and this has led to a special advice of seed varieties for RT, which can be found on www.Sortinfo.dk (Sandal et al., 2004).
Examples of selection of varieties with resistance /tolerance to diseases are given as follows:

- Winter wheat: Against *Septoria avenae* (Septoria Leaf Blotch): Use the varieties Kris, Galicia and Ritmo (is very susceptible to *Fusarium*). Against *Fusarium avenaceum* (Ear Blight) you can find good resistance in Robigus, Skalmeje, Terre, Hattrick, Bill, Opus and Biscay.
- Winter barley: against *Rhyncosporium secalis* (Rhynchosporiun Leaf Blootch) and *Drechslera teres* (Net Blotch). Any of the most used varieties have resistance to both diseases, and Carola is very susceptible.

A need of varieties with resistance to *Pyrenophora graminea* (Leaf stripe) in barley had resulted in a screening program has started (Nielsen, BJ, 2004).
Special weed problems in RT systems, makes seed choice important and special advises are offered e.g. demands for varieties with high competition against weed are recommended. For example the wheat varieties Galicia and Kris with low competition ability for weeds should be avoided (Sandal et al., 2004).

2.7 Recent experiments

Danish Adviser Organisation for Agriculture (Landbrugscenctret, www.lr.dk) (Anon, 2003, 2004c and 2005b), DIAS (DJF publications, www.agrsci.dk) and FRDK (www.frdk.dk) had in the last years made investigation in RT and DS. Reviews of literature on experiments carried out from 2002 to 2004 can be seen (in Danish) in KASSA DATABASE www.kassa.cirad.fr

2.8 Conclusions

In Denmark, use of RT has increased from nearly non-existence in the late nineties to comprise about 200,000 ha in 2004-2005, and nearly half of the area estimated by Olesen et al. (2002) was found suitable for the use of RT.

Globally, the main reasons for using RT are prevention of erosion caused by sand drift, precipitation or drought. These factors are not the reason for using RT in the lowland Denmark (highest elevation point is 173 m) with very little erosion and sand drift. The main reasons for the farmers to practise RT in Denmark are lower costs of labour and fuel consumption. This makes the agriculture more sustainable for the farmers, but the question remains: Will it be sustainable for the society and environment too? At present, the main questions that have to be answered in connection with use of RT systems are those on soil nutrition, use of pesticides against weeds, fungal diseases and pests. This had to be evaluated in relation to the Danish plan for water environment no. 3 for agriculture (Vandmiljøplan III). The two main subjects are reduction of N and pesticides (especially herbicides) consumption.
Health problems had increased in Denmark concerning fertility of man is going down in the last decade. Especially sex alike hormones are under review

It is also of importance to gain knowledge on the effects of RT on the environment where we need a better understanding of influence of the RT on e.g. pollution of under-ground water, biodiversity, weeds, soil organic matter, soil fertility, soil texture and soil moisture. This means that there is an urgent need for more investigation to evaluate the sustainability of the RT systems in Denmark.

Taking this into consideration, it is logical to conclude that there is a need for further analysis of all the different factors of RT systems which distinguish reduced tillage systems from traditional system with ploughing and organic farming, for making an evaluation if any of the systems is more sustainable than the others.

Up to now the Danish organic farming system is the most sustainable growing system for the environment in Denmark, because no pesticides are used. But the there is a high consumption of fuel and also the N consumption should (catch- and cover crops) be improved with new strategy of using catch- and cover crop in the future.

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