ICROFS news

4/2009 November

Newsletter from the International Centre for Research in Organic Food Systems

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Your input to *ICROFSnews*

We listen to our readers's response with pleasure, as we are here for you!
Therefore, any responses are more than welcome, be it about the new format, suggestions to improvements, changes, content or anything you can think of.

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International Workshop in China
The ICROFS Board of Directors held their 5th meeting back-to-back with the International Workshop on Organic Farming and Development in China, held in Beijing, 21-23 October 2009.

The workshop in Beijing was a collaboration between China Agricultural University (CAU), ICROFS and ISOFAR, and aimed at creating an overview of present research in organic agriculture and giving suggestions for future topics to support development of organic agriculture in China.

As the two events had several overlapping interest they were successfully merged with a joint programme on the first workshop day focused on organic agriculture as a policy instrument and overview of global organic research.

At the separate sessions on the second workshop day, the International Workshop focused on

» Organic agriculture - research and practice
» Research efforts to support development of organic food and agriculture
» Future research activities.

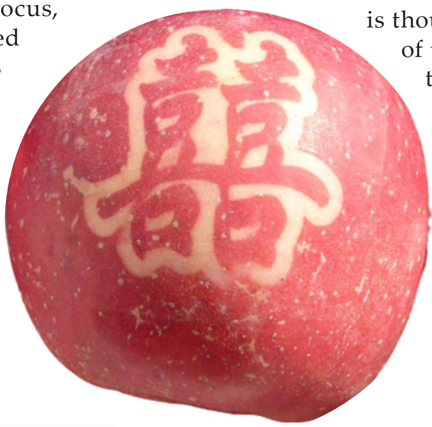
Future research activities were addressed through roundtable discussions on potential topics for future research in organic agriculture in China. This took place in three groups with each their focus, and then followed by presentations in plenum and further discussions.

The three roundtable discussions focused on:

» Policy and rules
» Production and Processing
» Marketing and Rural Development.

Read more about the workshop, its programme and get the presentations from the part of the workshop co-organized by ICROFS at www.icrofs.org.

Professor Louise Jackson, chairman of ICROFS' international Board, Thomas Harttung, head of ICROFS, Niels Halberg, and chairman of the Programme Committee, Michael Stevns, all climbing the Great Wall of China.



ØkoForskPLUS: Improved international synergy
The creation of a new national research programme on organic food systems, ØkoforskPLUS, is under way by ICROFS' Programme Committee. On 16. November, 2009, the national committee met to discuss a draft of a future call for applications for the next research programme. The programme has been named ØkoForskPLUS and is thought of as a continuation of the whole research effort that has been made in the three research programmes, DARCOF I-III (DARCOF III runs out in 2010).

The programme will focus on a strategy for the Danish organic research, but with a strengthened synergy from international collaboration.

A new future research programme can further develop organic agriculture to play a still more important role in fulfilling political goals of creating a synergy between a market-based and growth-oriented food production. At the same time, the programme will meet the green objectives of bio-diversity, pesticides, water protection, and climate.

DARCOF III programme status
ICROFS' national Programme Committee met in mid-November also to discuss the status of the current research programme, DARCOF III, which runs from 2006-2010.

The committee thoroughly examined the projects' status reports and the project managers will soon receive the committee's evaluations. All-in-all, the 15 projects run successfully and according to plan.

CERTCOST

CERTCOST workshop at BioFach
In October, the ten CERTCOST partners met in Izmir, Turkey, to discuss present progress and research results. A considerable amount of planning was also on the agenda, and an effective, slightly revised plan for the next vital parts of the project is now in place.

There will be a CERTCOST workshop on occasion of the World Organic Fair, BioFach 2010. Partners from the European project will present recent research results on organic certification and costs.

Read more at www.certcost.org

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Greenhouse gas emissions from cultivation of energy crops – is it important?

By Mette S. Carter, research scientist, and Per Ambus, professor, Risø National Laboratory for Sustainable Energy, Technical University of Denmark, Roskilde, Denmark

Replacing fossil fuel-derived energy with biomass-derived energy is commonly emphasized as a means to reduce CO_2 emissions. However, our study highlights the risk of large greenhouse gas emissions when wastes from bioenergy production are recycled as fertilizer for energy crops.

Crop management affects the magnitude of these emissions, which in some cases negate a considerable fraction of the global warming savings associated with biofuels.

Figure 1. Simulated injection of waste-stream material from a biogas plant after sowing of maize.

A future goal within organic farming is to reduce the reliance of fossil fuels and reduce greenhouse gas emissions via local production of renewable energy.

Biofuels for self-sufficiency

This could include bioethanol and biogas produced from energy crops and animal manure. Currently CO_2 from fossil fuel combustion accounts for 57% of the global greenhouse gas emissions, whereas the strong greenhouse gases nitrous oxide (N_2O) contributes with 8% (IPCC, 2007). Agricultural activity is the dominant source of N_2O, which is mainly associated with the use of nitrogen based fertilizers in agricultural production.

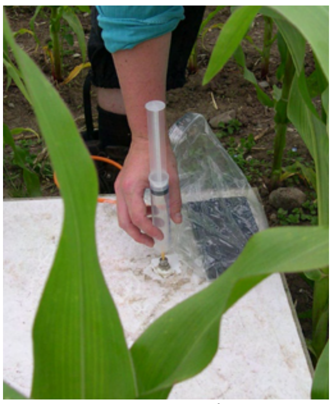


Figure 2. Emission of N_2O was measured by manual gas sampling in gas-flux chambers.

Field emissions are uncertain

Agro-biofuels are expected to reduce the emissions of greenhouse gases because CO_2 emitted during the combustion of the biofuels has recently been taken from the atmosphere by the fodder or energy crop, thus CO_2 is recycled between atmosphere, crop and biofuel. By changing from fossil fuels to biofuels the organic farmer avoids emitting fossil fuel-derived CO_2 into the atmosphere. However, a recent analysis of global emission data proposes that accelerated emissions of N_2O associated with the production of biomass for biofuel purposes will outweigh the avoided emissions of fossil fuel-derived CO_2 (Crutzen et al., 2008).

Objective: Greenhouse gas balances

In the present study we examined the effects on N_2O emissions when waste-stream material from a biogas plant is recycled as fertilizer for a maize energy crop within an organic cropping system. Furthermore, we assessed sustainability in terms of greenhouse gas balances for co-production of bioethanol and biogas from maize. This is compared to the greenhouse gas balance for winter rye as an alternative energy crop.

N_2O measurements in field experiment

The maize crop was sown on the 14th of May 2008, and on the same day anaerobic digested cattle slurry + maize residue was applied as organic fertilizer via simulated injection (Fig. 1).

For comparison untreated cattle slurry was included in the experiment and both fertilizers were applied at a rate of 150 kg plant available N/ha. Emissions of N_2O were monitored regularly using two-part static chambers (Fig. 2). We found elevated emissions that persisted for almost two months, quite often at very high rates.

The cumulative N_2O emissions during the two months amounted to 895, 583 and 46 mg N_2O-N /m^2 in the digested slurry + maize, untreated slurry and control treatments, respectively. Thus, more N_2O was emitted from anaerobic digested slurry as compared to untreated slurry.

The experiment was replicated in 2009, but here we found the opposite effect of anaerobic digestion on the N_2O flux. We believe that the fermentation process needs to be completely finalized in the biogas plant in order to obtain a reducing effect of anaerobic digestion on field emissions of N_2O related to the application of slurry-based fertilizers. The N_2O emission factor varied between 2.3 and 5.7% of the applied nitrogen (Table 1), which is substantial higher than the 1%-loss proposed by the Intergovernmental Panel on Climate Change (IPCC) for direct losses of N_2O from organic residues.

No advantage of fertilizing maize

The maize biomass was used for co-production of bioethanol and biogas. A greenhouse gas balance was made in order to highlight how much the field emissions of N_2O accounted for in comparison to the fossil fuel-derived CO_2, which was avoided by producing the biofuels.

In general, there was no greenhouse gas advantage of fertilizing the maize crop, because the extra crop yield - and thereby biofuel production - was offset by increased field emissions of N_2O (Fig. 3A).

This balance does not include fuels used by farm

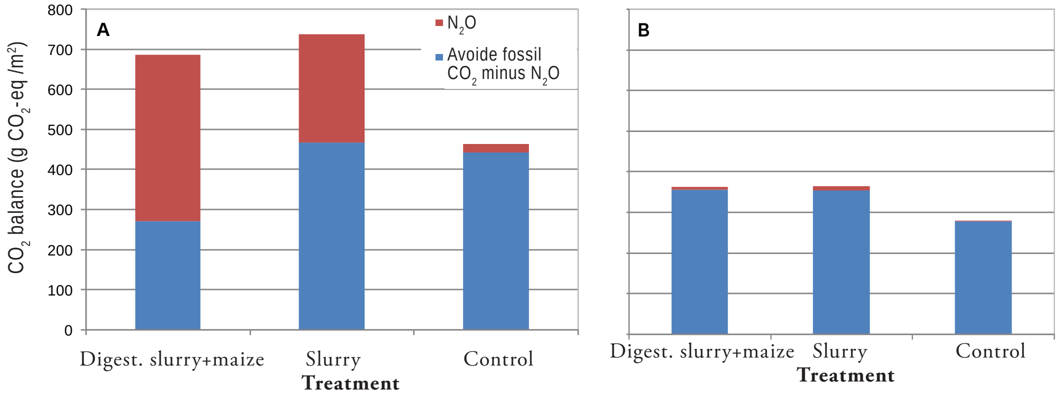


Figure 3. Greenhouse gas balance, expressed as CO_2-equivalent (CO_2-eq.), for biofuels produced from maize (A) or winter rye (B) fertilized with either anaerobic digested slurry + maize residue or raw slurry compared to unfertilized control. The blue part of the bars indicate the net CO_2 reduction when emissions of N_2O (red part) is taken into consideration.

References

Crutzen, P.J. et al. (2008) "N_2O release from agro-biofuel production negates global warming reduction by replacing fossil fuels." *Atmos. Chem. Phys.* 8, 389-395.

IPCC (2007) *Climate Change 2007*: Synthesis Report.

machinery and fuels used during the production of the biofuels, thus the actual net CO_2 reduction was lower than illustrated in Figure 3A, which means that the blue part of the column should be reduced even further.

Winter rye is a potential energy crop

The reason for the high N_2O emission after simulated injection of slurry-based fertilizers is partly that the fertilizers were applied before the maize crop was present to take up the nitrogen.

Furthermore, injection of the liquid materials produced anaerobic zones in the soil with high availability of nitrogen and labile carbon compounds, which is favorable conditions for denitrification and thereby N_2O production.

Finally, the maize was sown late in spring to ensure high soil temperatures, which also stimulates the microbial turnover of nitrogen. In comparison, a similar experiment was carried out in a winter rye energy crop in March 2009, but under different conditions regarding three important aspects:

Photo of winter rye: Our study showed that winter rye is a potential alternative to maize as an energy crop.

1) The crop was present when the materials were applied,

2) materials were applied on the soil surface simulating application by trail hoses and

3) soil temperatures were predominantly in the range 0 to 5 °C.

The greenhouse gas balance for bioethanol and biogas produced from the winter rye crop shows that application of the slurry-based fertilizers increased the crop yield without increasing the N_2O emissions to the same extent (Fig. 3B).

The rye yield was similar to the maize yield, but the conversion of rye biomass into bioethanol and biogas was less efficient. Despite the slightly lower net CO_2 reduction we find that winter rye is a potential alternative to maize as an energy crop.

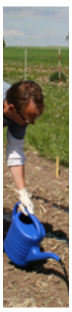
It is important that the organic farmers have several options for energy crops as a high biodiversity in the agricultural landscape reduces the spread of pests and diseases between fields.

Crop and management specific emission factors

The N_2O emission factors were significantly lower when the slurry-based fertilizers were applied to winter rye as compared to maize (Table 1). In the literature, greenhouse gas balances for agro-biofuels are very often based on the IPCC emission factor of 1% to estimate field emissions of N_2O.

For some crops and fertilizer managements this factor may underestimate N_2O as a greenhouse gas source. Maize is the most common energy crop grown in Europe and USA, and we found emission factors of 2.3-5.7% when waste-stream material from a biogas plant was used to fertilize maize energy crops.

We therefore advocate for the use of crop and management specific N_2O emission factors in greenhouse gas balances in order to focus on growing the energy crops with the highest greenhouse gas reduction potential.



	Fertilizer	
Energy crop - year	**Slurry**	**Digested slurry + maize**
Maize - 2008	2,7	5,7
Maize - 2009	2,9	2,3
Winter rye - 2009	0,1	0,1

Table 1. N_2O emission factor for unsaturated slurry and anaerobica digested slurry + maize applied as fertilizer to maize and winter rye energy crops (N_2O-N emission in % of applied N)

Read more

You can find more information about the DARCOF III research project BioConsens on biomass and production of bio-energy in organic farming on the following webpage:

www.icrofs.org/Pages/Research/darcofIII_bioconcens.html

Article

Nitrate leaching from silage maize


By Elly M. Hansen and Jørgen Eriksen. Aarhus University. Faculty of Agricultural Sciences, Department of Agroecology and Environment, Research Centre Foulum

A maize experiment on coarse sandy soil demonstrates that it is no easy matter to establish an effective catch crop of perennial ryegrass in high-yielding maize.

The catch crop did not reduce nitrate leaching from the soil but tended to reduce maize yields, while the application of slurry increased both yield and nitrate leaching.

During the last 20 years the area with maize in Denmark has increased dramatically and reached 163,000 ha in 2008. Silage maize is easy to grow, is a suitable fodder for cows and goes well with grass-clover in the diet. This means that silage maize is often found in crop rotations with grass-clover on sandy soils in western Denmark.

The ploughing in of grass-clover fields poses a serious risk of increased nitrate leaching on a coarse sandy soil, even when carried out in spring. With increased maize cropping, there is therefore a need for strategies to reduce nitrate leaching after ploughing of grass-clover.

In the ICROFS project, OrgGrass, we examined the effect of catch crop and slurry application on nitrate leaching from maize after a spring-ploughed grass-clover.

The experiment

The maize experiment was initiated in spring 2008 after ploughing a 6-year-old grass-clover field on a commercial organic farm on a coarse sandy soil in the southern part of Denmark.

Four maize treatments were established (Table 1). The fertilized treatments received 135 kg per ha total N including 78 kg per ha ammonium-N in cattle slurry. As a reference to the maize treatments there was an unfertilized green barley treatment where spring barley and Italian ryegrass were grown for silage (Table 1).

The grass-clover field was ploughed on 14 May 2008 and maize was sown the following day. Spring barley was sown on 16 May, which was relatively late under the prevailing weather conditions.

Cattle slurry was placed on both sides of the rows of maize in the fertilized treatments. The Italian ryegrass catch crop was sown late (8 June) in the green barley plots due to very dry soil condition. Due to continuous drought the Italian ryegrass was re-sown on 17 June where also perennial ryegrass was sown in maize. On 19 June the field was irrigated with 25 mm.

Before the maize experiment was started, the grass-clover field had been part of an experiment with three different grazing strategies from spring 2006 to autumn 2007. As there were no significant effects of grazing strategy or interaction between previous grazing strategies and maize treatment, the presented values are therefore averaged across the previous grazing strategies.

Yields

Maize benefited from the warm weather in spring 2008. A dry matter production of 16.0 t per ha in

An overview of the experiment on 24 June, spring barley in front and maize to the right. Photo: Henning Thomsen.

Treatment	Leaching N kg/ha		Yield dm kg/ha		N uptake kg/ha	
Unfertilized maize	86	b	13,157	b	141	b
Unfertilized maize with a catch crop[1]	74	b	12,888	b	136	bc
Fertilized maize	136	a	15,976	a	181	a
Fertilized maize with a catch crop1	115	a	15,379	a	173	a
Unfertilized green barley with a catch crop[2]	27	c	5,884	c	127	c
LSD.95	-		741		11	

Table 1. Leaching from 1 April 2008 to 30 March 2009, yields and N uptake. Percolation 562 mm. [1] Perennial ryegrass (12 kg ha-1 seeds). [2] Italian ryegrass (25 kg ha-1 seeds). Yield and N-uptake including grass cuts (specified in Table 2).

Perennial ryegrass (variety: Mikado) was sown in maize on 17 June. Photo: 16 July, Henning Thomsen.

The maize variety Rosalie gave a better soil cover than several other maize varieties (Danish Agricultural Advisory Service, 2008), which is an important factor in relation to competition against weed, but it probably also affects the growth of the catch crop. Photo: 26 July, Henning Thomsen.

The warm weather seemed to benefit maize more than barley and Italian ryegrass in green barley plots (in front and to the right). On 26 July the height of maize was approximately 180 cm. The green barley plots were harvested on 16 July. Photo: Henning Thomsen.

fertilized maize was on level with conventionally grown Rosalie maize in 2008 (Danish Agricultural Advisory Service, 2008).

Maize responded positively to fertilization. With an application of 78 kg per ha ammonium-N it yielded 2.8 t per ha more than unfertilized maize.

In both fertilized and unfertilized maize, yields were not significantly different whether perennial ryegrass was grown as a catch crop or not. However, the trend was that yields were lower with a catch crop than without.

This was not expected since the ryegrass showed a poor development during autumn, maybe due to the competition from maize. In spring 2009 the perennial ryegrass had almost disappeared from the plots, showing that it is no easy matter to establish perennial ryegrass as an effective catch crop in vigorously growing maize.

	Date	Yield kg/ha	N uptake kg/ha
Green barley	15 July	3,375	65
1st cut of Ital. ryegrass	25 August	1,402	37
2nd cut of Ital. ryegrass	28 October	1,107	25

Table 2. Yield and N in green barley and Italian ryegrass.

The yield of the green barley plus two Italian ryegrass cuts was less than half of the maize yields. This yield was low compared with a green barley harvest in a previous DARCOF experiment in 2003. The green barley itself only yielded 3.4 t per ha (Table 1) compared with 6.1 t ha-1 after a 5-year-old grass-clover fertilized with 60 kg ammonium-N in the 2003 experiment.

The late sowing of the barley and the Italian ryegrass in 2008 probably contributed to the yield reduction, but the two Italian ryegrass cuts did not come up to expectations either. The yield for the two cuts was 2.5 t per ha (Table 2) compared with 6.2 t ha-1 in the previous experiment. It was noticed that during the summer period Italian ryegrass grew less vigorously than in the previous experiment, probably due to the warmer and drier weather in 2008. This might have influenced the autumn growth of the ryegrass.

An overview of the experiment on 30 October. Plots with a catch crop in the foreground. Plots without a catch crop were treated with a rotary cultivator just before the photo was taken. Plots with Italian ryegrass in green barley plots in the background. Photo: Henning Thomsen

Nitrate leaching

Leaching in all the maize treatments was significantly higher than the reference treatment level in green barley of 27 kg N ha per ha (Table 1). The lowest leaching level in maize was in unfertilized maize with a catch crop (74 kg N/ha), and the highest level was found in fertilized maize without a catch crop (136 kg N/ha).

Slurry application to maize increased leaching significantly in comparison to unfertilized maize. The application of 78 kg N per ha in slurry increased leaching by 50 kg N ha-1 and in the same treatment the N uptake in maize was increased by 40 kg N ha-1. This indicates that even though maize increased dry matter yield and N uptake after slurry application, it could not increase the N uptake by an amount corresponding to the ammonium-N in slurry. From an environmental point of view the results suggest that maize grown after a long-established grass-clover field should receive less fertilizer.

Catch crops are often suggested as a measure to reduce nitrate leaching. In the maize experiment leaching tended to be less (12 kg N/ha) in unfertilized maize when a perennial ryegrass catch crop was included rather than leaving the soil bare after harvest (Table 1). In fertilized maize, leaching also tended to be less (21 kg N/ha) with a catch crop, but the difference between the two fertilized treatments with or without a catch crop was not significant.

The result demonstrates the challenge of establishing a catch crop in maize, where the catch crop is able to reduce nitrate leaching satisfactorily in autumn while not reducing the yield of maize.

Read more

You can find more information about the DARCOF III research project OrgGrass on grass-clover in organic dairy farming on the following webpage: www.icrofs.org/Pages/Research/darcofIII_orggrass.html

Nitrogen dynamics in organic crop rotations


By Søren O. Petersen, senior scientist, and Michal A. Brozyna, PhD student, Faculty of Agricultural Sciences, Aarhus University, Department of Agroecology and Environment

The content of "active" nitrogen in the soil is influenced by crop rotation and soil type. Ongoing projects investigate the availability of these pools for better nitrogen self-sufficiency on organic farms.

Despite the fact that green manure, catch crops and livestock manure help maintain soil fertility in organic cropping systems, the self-sufficiency with respect to nitrogen (N) remains a great challenge. Nitrogen inputs will be allocated to plant uptake, lost to the surroundings, or enter one of several pools of N in the soil. The turnover of some organic N is very fast and could play an important role in the nitrogen supply of the crop.

The so-called active nitrogen consists mainly of mineral N and N that is incorporated in soil microorganisms. Most of the nitrogen that is supplied to the soil in crop residues or livestock manure will pass through these pools.

Four crop rotations

At the Faculty of Agricultural Sciences, Aarhus University, several projects currently examine nitrogen dynamics in organic crop rotations. These investigations are conducted in a long-term crop rotation experiment, which was established at three different sites in Denmark in 1997. They represent three soil types, that is, a coarse sandy soil (Jyndevad), a loamy sand (Foulum) and a sandy loam (Flakkebjerg).

In 2007 and 2008 the amount of active N was quantified in soil under the winter wheat crop of four different crop rotations. Two of the organic rotations involved include catch crops, while a third system is conventional (and identical to the fourth rotation, which is also organic).

Figure 1b. The study focused on accumulated N in the different cropping systems. Therefore the rings were covered during slurry application in spring. Photo: Henning Thomsen.

Figure 1a. A total of 72 100-cm3 rings were installed at each site in November, shortly after seeding of winter wheat. They were randomly sampled in April, May, June and August the following year. Photo: Søren O. Petersen.

In the two experimental years a number of 100 cm^3 rings were placed in the soil in November of the previous year, after sowing of the winter wheat (Fig. 1A).

Enough rings were installed to enable four samplings during the growth season. The rings were covered during manure application to avoid the "noise" that would result from the high concentrations of N in the manure (Fig. 1B). In this way we hoped to emphasize the long-term effects of cropping system on pools of active N in the soil.

Differences in soil fertility

Dramatic effects of crop rotation and soil type on the amounts of active N were observed. The plough layer contained 80-100 kg/ha active N at Jyndevad, 150-200 kg N/ha at Foulum, and 100-250 kg N/ha at Flakkebjerg (Fig. 2).

The differences within each soil type could be related to crop rotation, and the same pattern was seen on all three soil types:

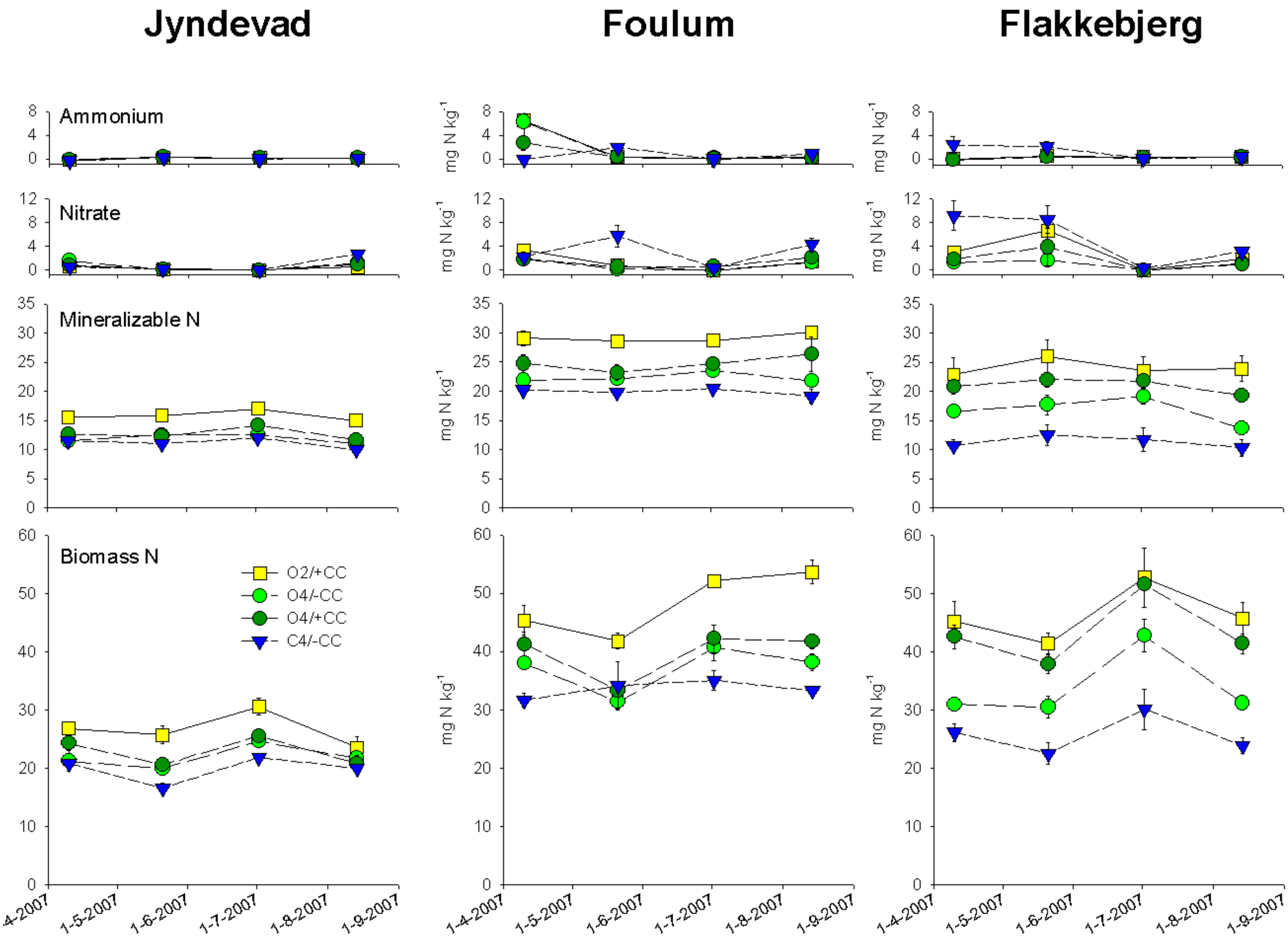
Catch crops increased the content of active N in the soil. Green manure had an independent (positive) effect on the concentration of active N. Finally, there was always least active N in the conventional system (although it should be stressed that until 2005 this system was grown for several years without any manure N supplements).

At Flakkebjerg the differences between crop rotations were much more pronounced than at the other two sites (Fig. 2). One reason could be the higher clay content in Flakkebjerg soil (15.5%) compared to Jyndevad (4.5%) or Foulum soil (8.8%).

Clay minerals are small and "edgy", which results in a structure with many small pores where a part of soil microorganisms are protected against predators, and clay-organic matter complexes may also give protection against decay.

The amount of mine-

Figure 2. The observed concentrations of ammonium, nitrate, mineralizable N and biomass N were quantified in soil under winter wheat during the growth season. The effects of crop rotation were similar at all sites, but pool sizes were very different. Key to crop rotations: O2 was a forage crop rotation, O4 a cash crop rotation. +CC and –CC indicates whether catch crops were included in the crop rotations.



ralizable clay was up to 2 times higher at Flakkebjerg than at Jyndevad. This is no doubt one reason for the lower crop yields observed at Jyndevad in these rotations.

Can green manure and catch crops be used more efficiently?

Another, on-going study looks at nitrogen balances and losses of the potent greenhouse gas nitrous oxide (N_2O) in one of the organic crop rotations.

It is a great challenge to mobilize the active N of the soil at the right time. Green manure collects nitrogen in competition with soil microorganisms, but this is of limited value to subsequent crops if this plant biomass is degraded and the nitrogen partly lost to the surroundings via ammonia volatilization, denitrification or leaching before the next growing season.

In this project biogas treatment of grass-clover as a strategy to reallocate nitrogen within the crop rotation is examined. Two different strategies are compared: After cuts the grass-clover is either left to decompose on the ground, or the grass-clover is harvested and digested in a biogas reactor together with livestock slurry.

This has several advantages: Harvesting the plant biomass reduces the risk for ammonia losses to the atmosphere. Biogas treatment can reduce the risk for N_2O emissions, although this effect appears to depend on weather conditions and soil properties.

What is certain is that "green" energy is produced that will improve the overall greenhouse gas balance of the farm, and a source of nitrogen is produced that may be used elsewhere in the crop rotation, and at the optimal time.

Biogas treatment of grass-clover involves some technical challenges. And if the digestion takes place in centralized facilities, it is likely to become mixed with slurry from conventional farms, at least currently.

On the other hand, the perspectives in this strategy appear promising in view of the two-fold benefits of improving the greenhouse gas balance while also improving nitrogen self-sufficiency on the farm.

Article

Organic farming effects on clay dispersion in carbon-exhausted soils

By Per Schjønning, Lis W. de Jonge, Jørgen E. Olesen and Mogens H. Greve,
Aarhus University, Faculty of Agricultural Sciences,
Department of Agroecology and Environment

Figure 1. Clay particles dispersed in water (a), edge-to-edge flocculated in interaction with organic matter (b) or face-to-face cemented in lack of organic matter (c).

In this paper we show that clay particles in soils that are low in organic matter content are easily dispersed in the soil water. This has has important effects on soil ecosystem functions and services.

Many Danish soils are depleted in organic matter (OM) after decades of intensive cereal cultivation (ref. 7). This paper shows that clay particles (colloids) in soils that are low in OM content are easily dispersed in the soil water, which in turn has important effects on soil ecosystem functions and services.

Organic farming systems generally tend to increase soil OM contents and may thus mitigate the negative effects.

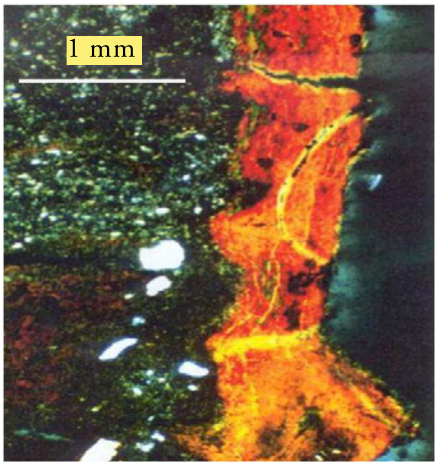


Figure 2. Micromorphology image of the wall of a macropore at 100-150 cm depth of a loamy soil on Sjælland. Deposits of laminated clay particles extend from the pore wall (reproduced from ref. 3).

Clay dispersion and potential consequences

Clay particles can be dispersed to soil water by the mechanical energy in traffic and tillage (Figure 1a). This is especially pronounced in soils with low OM content.

Dispersed clay particles may be leached to deeper soil horizons, where they can be deposited as clay skins in macropores (Figure 2).

Another potential fate of dispersed clay particles is transportation to the aquatic environment, potentially carrying strongly sorbing pollutants such as pesticides, PAHs or phosphorus. When dispersed clay particles re-assemble in the topsoil drying process, this may include flocculation with OM (first step in soil aggregation, Figure 1b).

Alternatively, for low-OM soils the drying process may induce cementation / internal crusting (Figure 1c), which may seriously reduce soil friability and hence the ease of soil fragmentation during seedbed preparation.

A vicious circle may hence be initiated because crusted, hard clods may then need an even higher energy input to fragment during tillage (potentially inducing more dispersion of clay particles).

In a previous ICROFS project, we collected soil from two neighbouring fields at Sjællands Odde that had the same geological origin and soil texture (refs. 2, 4, & 6).

One of the fields had grown forage crops in an organic cropping system for half a century (labelled High-C in Table 1). This included frequent application of animal manure in a crop rotation including grass leys.

In contrast, the other field had been used for continuous growing of small-grain cereal crops with only mineral fertilizers and with no return of organic residues to the soil for at least 25 years prior to the investigation (labelled Low-C in Table 1).

The contrasting management gave significant differences in soil OM content (Table 1). The dispersion of clay-sized colloids was higher for the Low-C soil than the High-C soil when field-moist soil was shaken in water for two minutes (Table 1).

Interestingly, however, when air-dried soil aggregates were treated similarly, the amount of dispersible clay was significantly lower for the Low-C than the High-C soil. This may be interpreted as a cementation of dispersed clay in the Low-C soil upon drying (ref. 2).

In accordance with this, the tensile strength of dry macro-aggregates (the energy needed to crush an aggregate) was highest for that soil. In essence, the high dispersion of clay in the soil with a low content of soil OM may cause the creation of inconveniently strong clods in dry conditions.

Threshold soil organic matter content?

Despite decades of research, it has not been possible to set a universal soil OM threshold for satisfactory tilth conditions for all soil types. As an example, we found a loamy sand soil at Askov with 2.2% OM to have an acceptable soil structure (ref. 5), while we observed severe soil degradation for the loamy Low-C soil at Sjælland with 2.5%

Soil characteristics	Management system	
	High-C	Low-C
Soil organic matter (g 100 /g soil)	3.4b	2.5a
Water-dispersible-colloids of wet soil (mg /g clay)	98a	134b
Water-dispersible-colloids of dry aggregates[1] (mg /g clay)	20.6b	18.0a
Tensile strength of dry aggregates[2] (kPa)	215a	267b

[1]Averaged across three aggregate sizes, 0.063-0.25, 0.5-1, 4-8 mm
[2]Averaged across four aggregate sizes, 1-2, 2-4, 4-8 and 8-16 mm

Table 1. Soil characteristics measured in two neighbouring soils with contrasting cropping and fertilization management. Figures labelled with different letters are significantly different (P=0.05). Please consult text for details. Data from refs 2, 4 & 6.

Crop rotation	Sampling year	
	2008	2009
Organic, including grass ley (O2)	0.95a	0.64a
Organic, annual crops (O4)	0.93a	0.61a
Conventional, annual crops (C4)	0.87a	0.57b

Table 2. Ratio between dispersed clay from dry & wet 1-2 mm aggregates when shaken in water for 2 minutes. Averages across fertilization and catch crop treatments for each crop rotation. Numbers of replicate plots for each rotation are 6, 6 and 4 for the O2, O4 and C4 rotations, respectively. Figures followed by the same letter within a specific year are not significantly different (P=0.05).

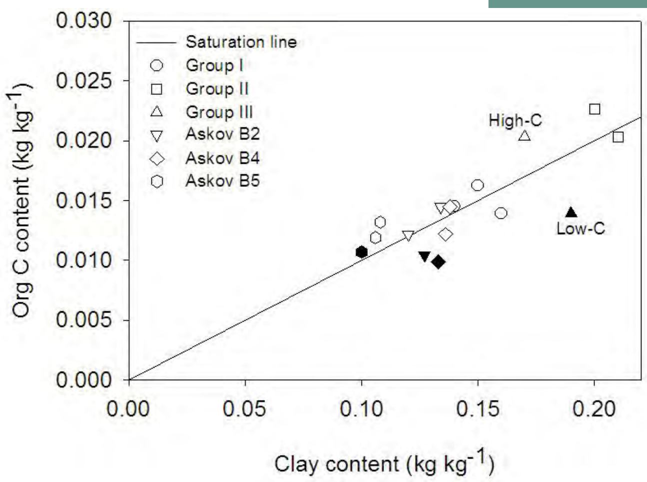


Figure 3. Relation between the content of clay and OC for a range of Danish soils with different soil management. Results on soil physical characteristics were reported for the Groups I-III soils by ref. 4 and 6, the Askov B2 and B4 fields were studied by ref. 5, and the Askov B5 soil by Per Schjønning in 1994. Soils with poor tilth are identified by closed symbols. The soils labelled "Low-C" and "High-C" are those discussed in relation to Table 1.

OM (Table 1).

However, recently Dexter et al. (2008) showed that many arable soils display a soil clay content and organic carbon (OC) ratio, n, of close to 10. Soils with higher ratios were 'unsaturated' with OM and were characterized by a high dispersibility of clay.

Clay definitions

Dexter et al. (2008) defined complexed clay (CC) as CC = (nOC) if (nOC < clay) else CC = clay, while non-complexed clay (NCC) in turn was defined as NCC = (clay - CC) if (clay - CC) > 0 else NCC = 0.

Figure 3 shows the relation between clay and organic C for a range of Danish soils studied in previous ICROFS projects. Soils shown as closed symbols were characterized by tilth problems, while soils with open symbols displayed a satisfactory soil structure.

The results in the Figure support the finding by Dexter et al. (2008) that soils below the 'saturation' line (clay/OC>10; NCC>0) have a critically low OM content.

Results from the CROPSYS project at Flakkebjerg

The ongoing CROPSYS project under ICROFS compares different arable crop rotations at three locations. The experiment was initiated in 1997, and the crop rotations differ in proportion of grass-clover in the rotation, use of catch crops and use of manure and fertilisers.

At Research Centre Flakkebjerg, the soil is generally severely depleted in OM. In a recent investigation of soil structural characteristics we found that all the 64 plots studied had soil OM contents below the Dexter 'saturation' line (Figure 4).

According to the Dexter terminology, points above the line are 'saturated' with OC and hence the soil in the CROPSYS plots at Research Centre Foulum is in good shape with respect to soil tilth.

This is in accordance with previous measurements at Foulum (ref. 8). Figure 4 also shows that the experimental field at Research Centre Flakkebjerg is very heterogeneous with clay content ranging from about 10 to 22%.

We also measured clay dispersibility of field-moist soil as well as of 1-2 mm aggregates either in air-dried conditions or at a water content corresponding to field capacity. Figure 5 shows results from the plots investigated in 2009.

We note that the amount of water-dispersible clay increases with the content of non-complexed clay (NCC). In this presentation the effect of the three cropping systems is embedded in the NCC-term that a management-induced increase in soil OM will decrease the amount of NCC. We have previously measured an additional increase in soil OC of the 'best' compared to the 'poorest' crop rotation in the Flakkebjerg CROPSYS site through 6 years of 0.0013 kg OC per kg soil.

This is equivalent to a decrease in NCC of 0.013 kg per kg soil, which should

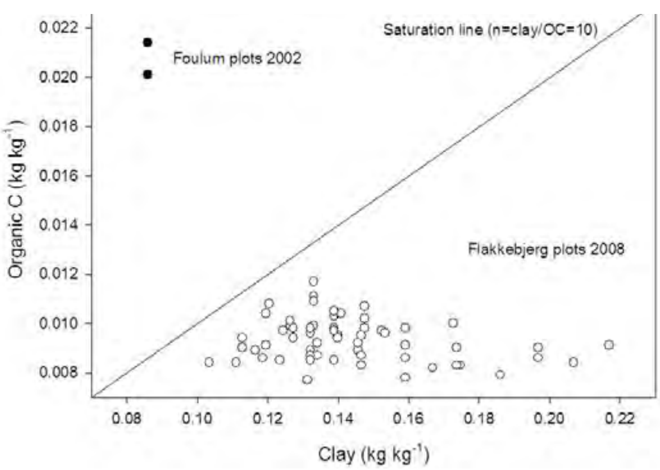


Figure 4. Relation between the content of clay and OC for the 64 experimental CROPSYS plots at Flakkebjerg and two selected plots at Foulum (the latter measured by ref. 8).

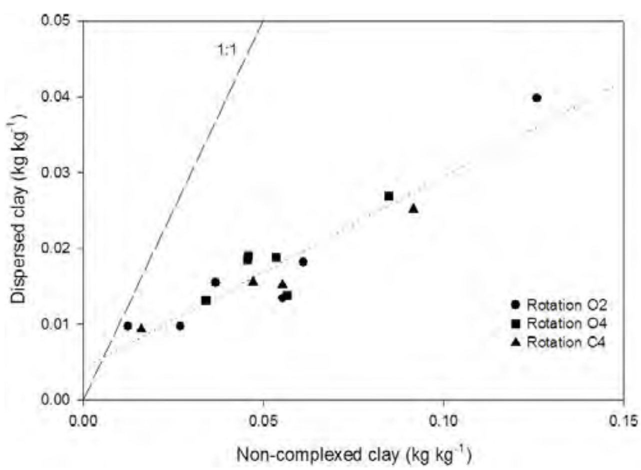


Figure 5. Relation between amount of soil non-complexed clay (NCC) and clay dispersed in soil samples taken from CROPSYS-Flakkebjerg plough layer (2009) and shaken in water for two minutes. Method according to ref. 1. Please consult text for details.

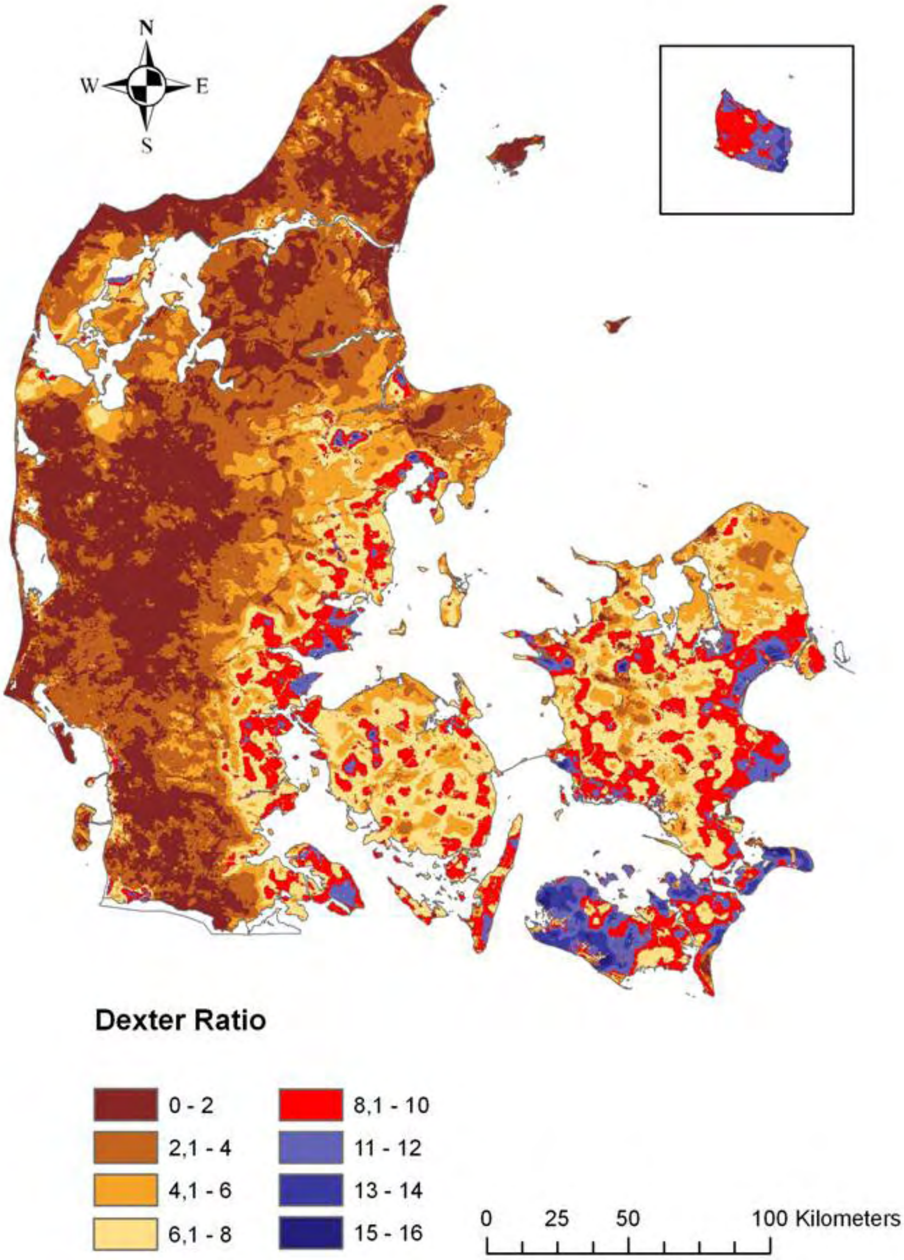


Figure 6. The 'Dexter-ratio' calculated as n=clay/OC, where OC is organic C for the plough layer of Danish soils. A value of n>10 indicates potential tilth problems due to critically low contents of OC. Created from the Danish Soil Database, www.djfgeodata.dk, at Aarhus University.

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be compared to measured values of 0.01-0.13 kg per kg soil. This indicates that (re-) saturation of the clay with OC at this Flakkebjerg field is a very slow process.

In Table 2 we have tabulated the ratio between the clay dispersed from the air-dried aggregates and field-moist aggregates, respectively. A low ratio indicates a high degree of cementation of clay particles at dry conditions. In both years, the highest ratio was observed for the organic O2 crop rotation with the highest input of OM to the soil, while the lowest was observed for the conventional C4 system.

This effect was significantly different for the 2009 plots. In accordance with the results shown in Table 1, the low ratios observed for the conventional plots indicate that more cementation and internal crusting is found here than for the organic crop rotations.

Figure 6 shows the 'Dexter-ratio' for Danish soils. It appears that for a range of the clay-holding soils in the eastern part of Denmark, the soil OM content is critically low. Following more studies, we anticipate the 'Dexter-ratio' to be a potential tool to identify soils that are critically low in soil OM.

Conclusions

Many Danish soils are exhausted in organic matter content, which affects key soil functions including their suitability for crop production.

The new Dexter-index is promising for identification of soils with critical low organic matter contents.

Organic crop rotations tend to increase soil organic matter and may mitigate the negative effects of low organic matter contents.

Our results show that it is a long-term task to re-establish satisfactory tilth conditions for carbon-exhausted soils.

Read more

You can find more information about the DARCOF III research project CROPSYS on the effect of cropping systems on production and environment on the following webpage: www.icrofs.org/Pages/Research/darcofIII_cropsys.html

Organisation

Global Meeting of the Farmers' Forum (IFAD)
[February 15-16, 2010]

The International Fund for Agricultural Development, IFAD, holds it third meeting of the Farmers' Forum.

The second global meeting of the Farmers' Forum took place on 11 and 12 February 2008 in conjunction with the Thirty-first session of IFAD's Governing Council. The Forum brought together about 80 farmers' leaders from around the world

For more information on the meeting, contact Christine Grandi by E-mail: c.grandi@ifoam.org.

The Farmers' Forum is a bottom-up process of consultation and dialogue between small farmers' and rural producers' organizations, IFAD and governments, focused on rural development and poverty reduction. Fully aligned with IFAD's strategic objectives, the Forum is rooted in concrete partnership and collaboration at the country and regional levels.

Publications

Ecology and Farming: Research Special Edition

The latest issue of IFOAM's E-magazine, Ecology and Farming, focuses on "Knowledge for an organic future" by means of a special research edition.

IFOAM's executive director Markus Arbenz introduces the issue like this:

"Too often organic agriculture is portrayed as a mysterious process of muck and magic. In this issue of Ecology and Farming we have set out to show that in many ways organic production is just as "high tech" and well researched as the rest of world agriculture."

Among numerous articles by high profile researchers in the field of research in organic food systems, the director of ICROFS, Niels Halberg, has written an article entitled: "Securing Food and Ecosystems by Eco-Functional Intensification."

Read more on IFOAM's website: www.ifoam.org/press/magazine.html

Congresses

Organic Horticulture (28th IHC): Productivity and sustainability
[22-27 August 2010, Lisbon, Portugal]

Call for abstracts, deadline: 31.12.2009. The 28th International Horticultural Congress (28thIHC) calls for papers is a world conference on horticultural sciences, under the patronage of the International Society for Horticultural Science (ISHS) and will be held in Lisbon, Portugal, at 22-27 August, 2010.

The 28thIHC programme includes the relevant and opportune event considering the rising consumption, production and marketing of organic food, all over the world.

For further information, go to www.ihc2010.org

International Conference on OA in Scope of Environmental Problems
[3-7 Feb. 2010, Famagusta, Cyprus]

The International Conference on Organic Agriculture in Scope of Environmental Problems will be organized between 03-07 February 2010 on the island of Cyprus under the auspices of local authorities.

Read more at the conference website: http://organic.emccinstitute.org

Creativity and Innovation

***Greening Human Capital:* International Conference on Human Capital for Sustainable Economics**

[27-28 May 2010, Karlsruhe, Germany]

A two-day International Conference on Developing Human Capital for Sustainable Economies is held in the "green" city of Karlsruhe, Germany. Here, a diverse group of participants will discuss issues of global warming and the emergence of the green economies; how is the transformation from high to low carbon economies impacting human capital management; and effective initiatives needed to develop and manage human capital for sustainable economies.

For further information and registration, go to: www.etechgermany.com/HCConference.pdf

Fairs

Bio Vak organic trade fair
[20-21 Jan. 2010, Zwolle, Netherlands]

One of the themes of the BioVak 2010 in the Netherlands will be the emancipation of organic farming. Women visitors will benefit from a target campaign emphasizing women as entrepreneurs in the organic sector.

Various workshops will focus on the role of women in the organic market; BioVak 2010 will strive to serve as a knowledge base for this emerging group.

More information at www.biovak.nl

BioFach 2010 theme: Organic + Fair
[February 17-20, 2010, Nuremberg]

The arrangers of the international organic world fair, BioFach 2010, have replaced pointing out a "Country of the year" with the theme: "Organic + Fair."

Thus, the world fair focuses on organic and fair trade labelled products.

In 2009, Denmark enjoyed the title of "Organic contry of the year," which meant a great export push for Danish organic enterprises.

BioFach 2010 runs from Wednesday 17. to Saturday 20. February 2010 in Nuremberg Messezentrum.

Read more at the BioFach website: www.biofach.de/uk.