Enhancing GHG balances in organic farms by integration of new bio-energy crop concepts

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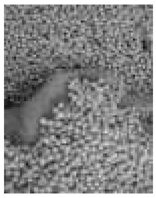
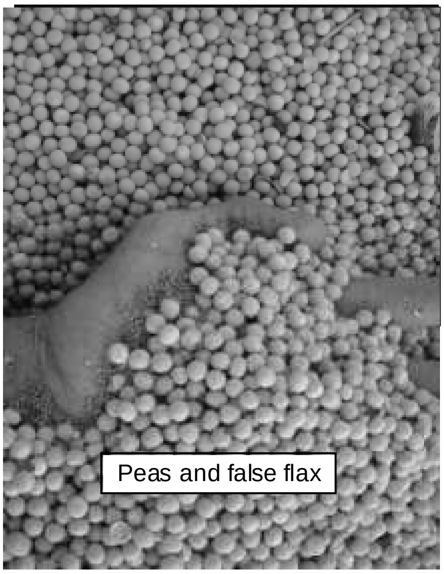



Fotos: metalerg.pl, Bundesverband Biogas, vTI

Mixed cropping with oil crops

Peas and false flax

Land equivalent ratio (LER)

Combined relative yield is higher than single yields in sole cropping e. g. 70 %+ 40 % = 110 %

2004	Safflower	False flax	LER
Mixed crop [t ha^{-1}]	**1.5**	**0.6**	
Sole crop [t ha^{-1}]	**2.3**	**1.3**	
RY [%]	**65**	**46**	**111**

2 ha single cropping: 2.3 t safflower + 1.3 t false flax

2 ha mixed cropping: 3.0 t safflower + 1.2 t false flax

Safflower/false flax, Trenthorst 2005

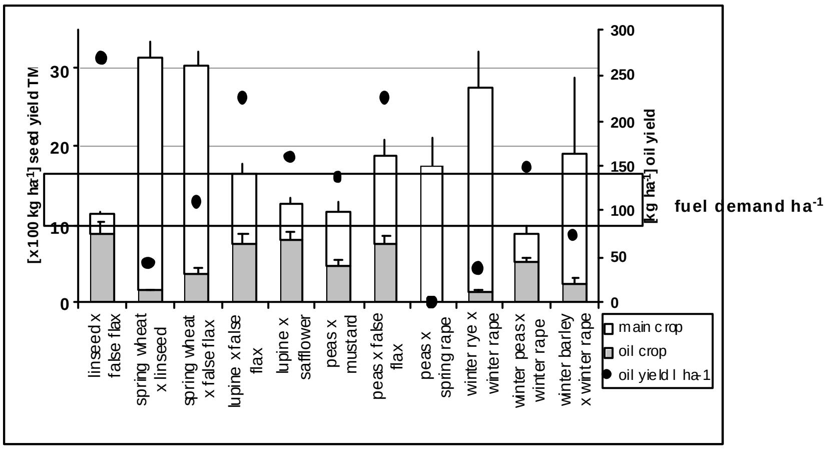
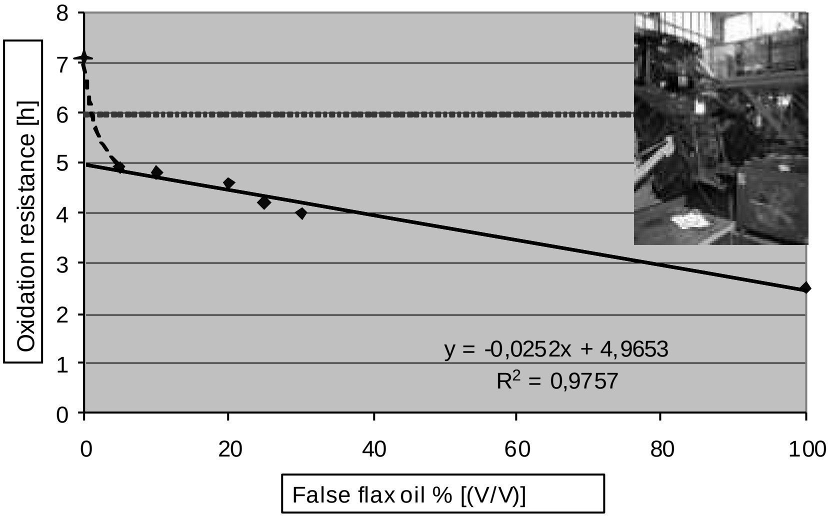
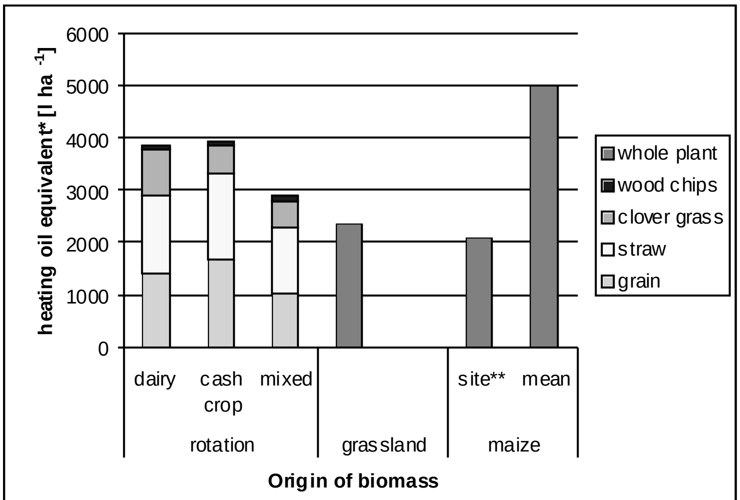


Fig. 1: Average grain yields of mixed cropping systems of different oilseeds with spring cereals and grain legumes [t ha^{-1}], oil yields of the oil crops in the mixtures



Oxidation resistance of different mixtures of pure oil of rapeseed and false flax (Schuemann et al., 2008, unpublished data)

Preserving the value of the preceding crop in rapeseed cultivation, establishment of intercrops for biogas use - winter rape intercropped with white clover *(Trifolium repens)***, Trenthorst, Autumn 2001**



* clover gras and maize after conversion to biogas)
** Mean yield in Trenthorst (7.5 t ha-1 DM)

Average yearly energy yield of plant materials grown in different organic crop rotations and in grassland in comparison to the energy yield gained in organic maize production

(yield data: Trenthorst 2003-2006, mean value for maize: varietytrials 2006, German Maize-Committee, Bonn)

Biogas slurry

Mobile pool for fertilisation

<u>Organic cash crop farm</u>	fermentation	kg ha^{-1}
Clover grass	3 cuts	300 N, 30 P
Winter wheat ⬅	straw	20 N, 4 P
Oats	straw	20 N, 4 P
Peas	straw	50 N, 10 P
Oilseed rape ⬅	straw	40 N, 8 P
Triticale	straw	20 N, 4 P
undersown clover gras	1 cut	50 N, 10 P

immobile 200 N

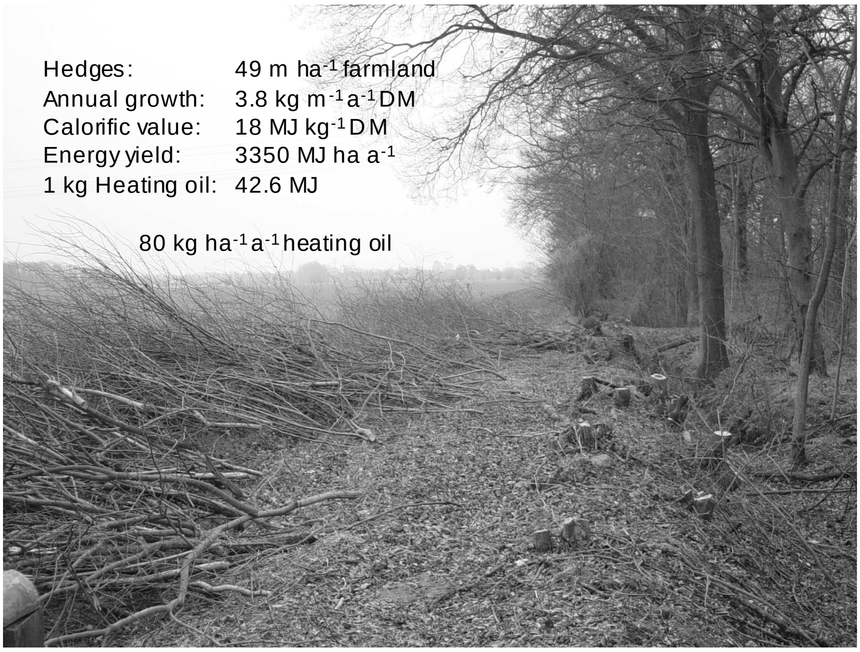
mobile fertiliser

500 N, 70 P

6 ha^{-1}

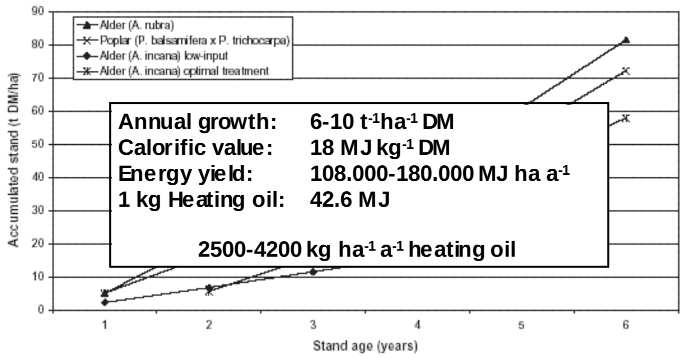
⬅ **= fertilisation**

rop rotation ‘ cash crop farm ‘ experimental farm Trenthorst



Hedges: 49 m ha^{-1} farmland
Annual growth: 3.8 kg m^{-1} a^{-1} DM
Calorific value: 18 MJ kg^{-1} DM
Energy yield: 3350 MJ ha a^{-1}
1 kg Heating oil: 42.6 MJ

80 kg ha^{-1} a^{-1} heating oil



Annual growth: **6-10 $t^{-1}ha^{-1}$ DM**
Calorific value: **18 MJ kg^{-1} DM**
Energy yield: **108.000-180.000 MJ ha a^{-1}**
1 kg Heating oil: **42.6 MJ**

2500-4200 kg ha^{-1} a^{-1} heating oil

Yields of short rotation coppices (Joergensen 2005)

A. rubra and poplar herbicide treated, not fertilized, *A. incana:* high input: irrigated and PK-fertilised, low input: not weeded not fertilised

Effects of wind breaking hedges on evaporation and soil erosion (Möndel, 2007)

Increase of LER values (Dupraz et al., 2005)

Effects on natural predators

Landscape element, enrichment of biodiversity

Diversification of production lines, simultaneous food production

Green house gas (GHG) emissions of different cropping systems with oil crops; GHG-reduction through the production of vegetable oil as a substitute for diesel; yield losses for food and forage caused by the cropping system, and/or the use of vegetable oil as fuel and remaining food and forage yield

	Yield losses for food and forage [kg ha^{-1}]	Food and forage yield [kg ha^{-1}]	Vegetable oil yield [kg ha^{-1}] Substitution of fossil fuel [kg]	[a]GHG emissions cropping system CO_2 eq. [t $ha^{-1}a^{-1}$]	[c]GHG reduction by substitution of fossil fuel CO_2 eq. [t $ha^{-1}a^{-1}$]
Clover x rapeseed	*	700-1000 oilcake	300-500	0.6 + 2.9	1.1-1.9
Rapeseed	300-500 oil	700-1000 oilcake	300-500	2.9	1.1-1.9
Peas x false flax	0-200 peas	1500-4000 peas	130-240	3.4 + 0.02[b]	0.5-0.9
Wheat x false flax	200-500 wheat	30-45 wheat	60-120	3.0[d] + 0.02[b]	0.2-0.4
Linseed	280-450 oil	540-900 oilcake	280-450	*	1.0-1.7

[a]data from Nemecek et al. 2005, [b]15.6 kg ha^{-1} CO_2 eq. for additional input for false flax in mixed cropping (Sergis-Christian and Browers 2005), [c]diesel fuel: CO_2 eq. 313,6 g kwh^{-1}, heating value 11,83 kwh kg^{-1}, together 3711 g kg^{-1} CO_2 eq. (Fritsche and Schmidt 2007), [d] estimation: Mean of values for winter wheat 3.4 and spring barley 2.7, * no data available

- In organic farms significant amounts of biomass are available as **by-products** of the farming system: clover grass and intercrops for **biogas** production, **straw** for burning
- The integration of **short rotation coppices** with possible synergistic effects on nature protection and landscape structure, and the intensified integration of **oil crops** for fuel purposes addresses the increasing demand for renewable energy sources.
- These new bio-energy crop concepts can additionally increase **resource efficiency** and reduce product bound GHG-emissions of organic farming.
- **Residues** of the farming system and products of **mixed cropping** systems for renewable energy purposes are not in full competition with food production.
- The **GHG-emissions** of the equivalent fossil fuel combusting could be avoided by their consistent use.
- Utilisation of at least parts of these energy resources could be **realistic goal** in organic agriculture.
- An open question is, whether organic farms can satisfy and replace the **nutrients** and **soil carbon** under intensified use of residues and the desired yield increase of new cropping concepts.
- Only concepts integrating both the **satisfaction of food demand** and of bio-energy production, are suitable to meet the demands of organic farming for the future.