Improving green-house gas balances of organic farms by the use of vegetable oil from mixed cropping as farm own fuel and its competition to food production

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The special situation of organic farming

Organic farming aims at the use of local resources and tries to establish local material flows and in- farm circles.

Organic farming needs concepts to increase their overall efficiency in plant production and needs concepts to supply high quality products for an efficient livestock production.

Only by this product related green house gas emissions can be reduced further.

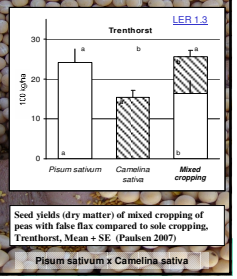
Due to heavy yield risks in organic oil crop production in organic farming cropping concepts for oil crops are needed.

The concept of mixed cropping with oil crops addresses these demands.

Mixed cropping systems in organic farming – Why?

Minimizing risks	Yield buffer Weed management Lodging resistance Pest and diseases
Increasing productivity	Nutrient efficiency Yield increase
With oil crops	Organic cultivation possible Farms with fuel self reliance

Yield goal: 100-200 l vegetable oil per hectare without yield losses in the main crop



Seed yields (dry matter) of mixed cropping of peas with false flax compared to sole cropping, Trenthorst, Mean + SE (Paulsen 2007)

Triticum aestivum x Linum ustitatissivum

Pisum sativum x Camelina sativa

Competetive interference <competetive facilitation = higher productivity per area

Controlled competition

High plant density in mixed cropping systems with linseed and false flax or lupines and safflower, Trenthorst 2004

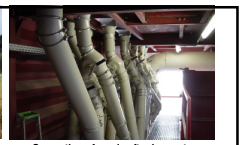
Technique

Bouncing plate for broadcast seeding of fine seeds, vTI, Trenthorst

Controlled depth by different drill coulters for each seed type, 2 x 24 rows Kramerbräu-Naturland Hof, Pfaffenhofen

Seed drills for mixed cropping with additional seed hoppers

Harvesting of peas in mixture with false flax



Separation of seeds after harvest

Peas kept upright in mixture with false flax

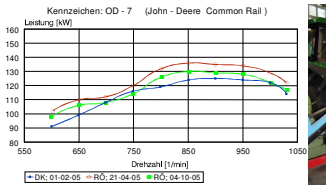
Farm scale oil mill

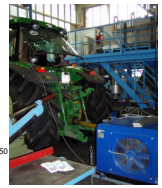
Oil crops
Brassica napus
Linum ustitatissivum
Camelina sativa
Carthamus tinctorius
Sinapis alba

Main crops
Hordeum vulgare
Secale cereale
Lupinus angustifolius
Pisum sativum
Triticum aestivum

Secale cereale x Brassica napus

Use



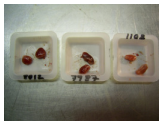


Power of a 125 kW-tractor fueled with diesel or rapeseed oil, Trenthorst/Rostock 2005

	G. max oil cake	*C. sativa* oil cake
Fattening performance, n=	44	48
Slaughtering weight, g	3741 [b]	3883 [ab]
Daily weight gain, g	44.0 [a]	45.8 [a]
Feed intake, g/d	100.7 [bc]	107.6 [ab]
Feed conversion, g/g	2.38	2.35
Organ weights, n=12		
Thyroid, g	0.341 [b]	0.351 [b]
Liver, g	70.8 [ab]	74.3 [ab]
Carcass yield, %	69.4 [ab]	69.5 [ab]
Sensoric: meat quality (leg) (1= bad, 6=very good)		
Tenderness	4.3	4.2
Juiciness	4.3	4.5
Aroma	4.1	3.9
Fatty acid composition of intramuscular fat		
SFA[1], %	28.2 [a]	28.0 [a]
MUFA[2], %	38.5	40.5
PUFA[3], %	33.1	31.3
Rest, %	0.2	0.2

[a,b,c] different letters indicate significant differences ($p \leq 0.05$),
[1] Saturated Fatty Acids: C14:0 , C16:0, C18:0; [2] Mono Unsaturated Fatty Acids: C16:1, C18:1, C20:1, C22:1; [3] Poly Unsaturated Fatty Acids: C18:2, C18:3, C20:4

Oil cakes as source of protein and of essential amino acids in organic animal nutrition

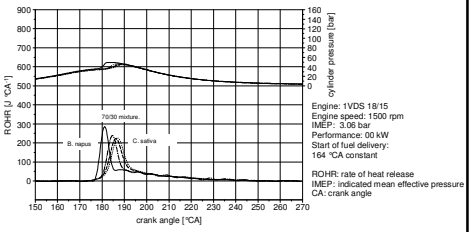


Effects of the complete replacement of oil cake of *G. max* (5 %-content) by oilcake of *C. sativa* in feeding ratios for chickens on performance and meat quality (Weissmann et al. 2007)

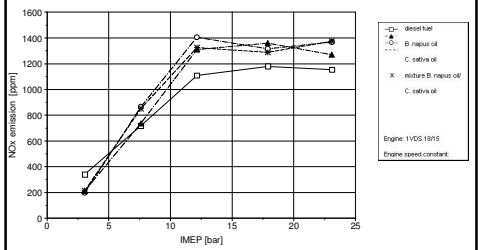
Parameters of fuel characteristics of a 70%/30% mixture of *B. napus* oil and *C. sativa* oil

Parameter	Unit	Threshold DIN V 51605	Oil mixture
CCR*	%(*m/m*)	≤ 0.40	0.46
Iodine number	g $100g^{-1}$	95 - 125	125
Acid value	mg KOH g^{-1}	≤ 2.0	1.59
Oxidation stability	h	≥ 6.0	4.0
P-content	mg kg^{-1}	≤ 12	11
S-content	mg kg^{-1}	≤10	3
Σ Ca + Mg	mg kg^{-1}	≤ 20	20.9

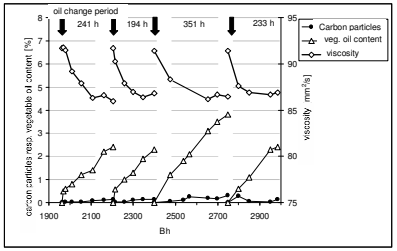
* Conradson Carbon Residue



Burning characteristics of diesel fuel, *B. napus* oil, *C. sativa* oil and a mixture of 70 % *B. napus* and 30 % *C. sativa* at idle load (IMEP 3.06 bar)



NO_x-emissions a different engine loads



Changes in motor oil quality in four oil change periods during 1000 h work of a tractor with a fuel mixture of 30% *Camelina sativa* and 70% *B. napus* oil (Trenthorst 2007

Average grain yields of mixed and sole cropping systems of various main crops and oil crops in organic farms [kg/ha dry matter] and land equivalent ratio of mixed cropping (LER) (4 German sites in 2004 and 2005)

crop combination*	oil crops sole	oil crops mixed	main crops sole	main crops mixed	mixed cropping total	LER
P. sativum./C.sativa	1100	750	1470[b]	1120	1870[a]	1.44
T.aestivum/L.ustitatissivum	740	140	3660[a]	2990	3140[b]	1.01

Yields and yield gains or losses by mixed cropping compared to sole cropping at equal land use [kg/ha dry matter]

crop combination*	farm yield 2 ha mixed cropping / 2 ha oil crop	mixed cropping / 2 ha main crop	sole cropping 1 ha/1 ha oil crop	sole cropping 1 ha/1 ha main crop	Additional farm yield by mixed cropping /1 ha oil crop	Additional farm yield by mixed cropping /1 ha main crop
P. sativum./C sativa	1500	2240	1100	1470	+200	+385
T. aest./L. ustitatissivum	280	5980	740	3660	-230	+1160

Gains (+) and losses (-) of different parameters when mixed cropping with oil crops is introduced in an organic farm

a) grain yields
b) additional oil
c) additional oil cake
d) raw protein (XP)
e) energy
f) reduction of green house gas emissions by the substitution of diesel fuel by vegetable oil

Crop combination*	(a) +/- main crops	(b) + veg. oil	(c) + oil-cake	(d) +/- XP	(e) +/- heating value	(f) - CO_{2eq}
	kg/ha				[e]MWh/ha	kg/ha
P. sativum/C. sativa	-350	285	465	+116	+3.6	-893
T. aest./L. ustitatissivum	-670	53	87	-55	-2.2	-166

Conclusions

Mixed cropping can enable organic farmers to introduce oil crops in their crop rotation, inner farm yield increases can lower the product related green house gas emissions

If mixed cropping is introduced as measure to reach fuel self reliance this has complex effects on the green house gas balances.
- yields of the main crops will normally be lower as before (yield security might increase)
- oil cake is produced as by product and can increase livestock productivity and replace feedstuff import with indifferent climate load
- per ha mixed cropping between 15 and 300 (max. 900 kg) diesel fuel can be directly replaced. This means a reduction of green house gases between 50 and 893 kg/ha (max. 2900 kg/ha) CO_2-equivalents depending on the culture

- Additional loads in production have to be expected for additional mechanization for seeding and seed separation.

- Mixed cropping with oil crops helps to minimize area-competition of bio-fuel and food production

Triticum aestivum x Camelina sativa | **Lupinus angustifolius x Carthamus tinctorius**