Sustainability of winter oilseed rape cropping systems in NW Germany

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Abstract

The assessment of oilseed rape cropping systems according to the principles of sustainable farming requires a comprehensive approach taking into account environmental, economic and social aspects of production. We used the REPRO model to assess different farms in the northern part of Germany.

Compared with average figures in the region, the farms included in the project showed a moderate use of pesticides and only little improvement seems possible at the moment. Given the rotations of mainly winter oilseed rape (*Brassica napus*), winter wheat (*Triticum aestivum*) and winter barley (*Hordeum vulgare*), the balance for organic substance on the farm and on the field level are stable. From an energetic point of view, the farms had an above average performance. The major critical point from an environmental point of view has been the nitrogen balance, however, differences between the farms showed the range for possible improvements.

Key words: Oilseed rape, *Brassica napus*, nitrogen balance, biodiversity, indicators, sustainability

Introduction

Sustainability assessment requires the integration of various indicators. Our approach to assess the sustainability on the farm level is based on the computer model REPRO, which has been developed at the University of Halle-Wittenberg. With this model it is possible to quantify all major energy and material flows on the farm and on the field level as well as incorporate information on economic effects of the different decisions taken on the farm. The project covers the assessment of sustainability of any farms over a period of 5 years. The REPRO model allows the use of a great number of indicators. We have chosen three indicators for this publication. We focus on the farm level, because this is the lowest level, which allows the integration of social indicators. Additionally, the farm level is especially important because all major decisions regarding varieties, input, crop rotation etc. are made on this level.

Materials and Methods

Nitrogen: The calculation of the nitrogen balance according to REPRO is given in figure 1. All different pools are included in the calculation.

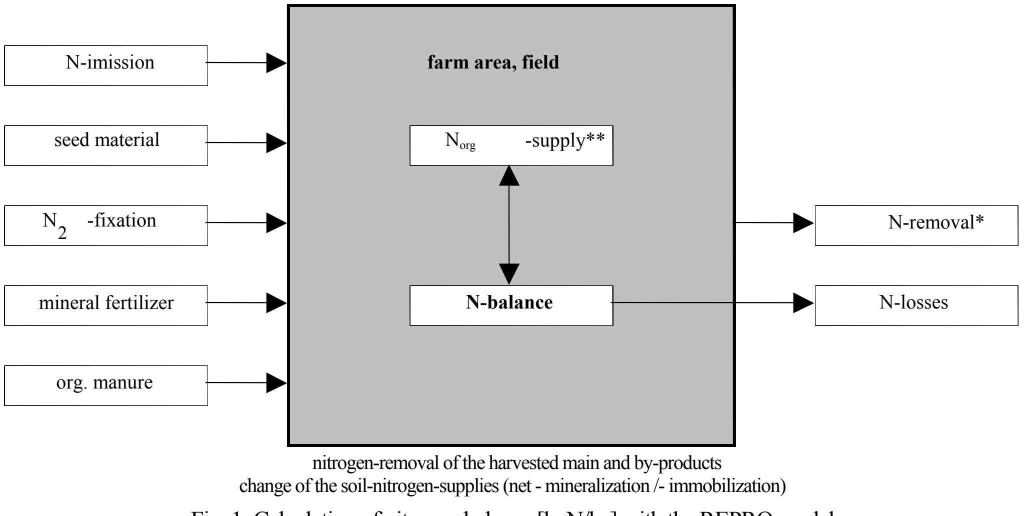

Fig. 1: Calculation of nitrogen balance [kgN/ha] with the REPRO model

Energy

The energy flows on the farm and on the field level are based on the approach to include all fossil fuel consumption on the field level. The energy gain with the products and the use of the by-products is calculated according to Hülsbergen et al., (2001). Drying and transport on the farm and from the farm to the retailer is not include.

Biodiversity

The calculation of biodiversity is a complex calculation as a pressure indicators with the single indicators given in table 1. (Heyer et al., 2003).

Tab. 1: Assessment level, data availability and additional information for the calculation of biodiversity in the REPRO model

Level	Data availability	Background
Primary Landscape structure		
Proportion of natural landscape (%)	Data is available from National Agriculture. Statistics	
Secondary landscape structure		
Crop diversity index	Farm data and Shannon Weaver index	In total, the different single indicators provide a comprehensive assessment of the potential number of niches on a farm.
Proportion of green fallow (%)	Farm data	
Pesticide free area (%)	Farm data	
Field size and variability	Farm data	
Pesticide index	Farm data calculated in REPRO	These indicators give information about the quality of the ecological niches.
N-balance(kg/ha)	Farm data calculated in REPRO	

Results

A comparison of the nitrogen balances for three practical farms in northern Germany shows a great variability between the farms and between the three experimental years. The lowest balance was realized in 2005 on farm 3 with only 74 kg/ha, whereas the highest balances occurred in 2001 on farm 2 with a nitrogen surplus of 176 kgN/ha.

Tab. 2. Comparison of nitrogen balances of winter oilseed rape [kgN/ha] of three practical farm in northern Germany.

	year	a	b	c	d	e	f	g	h	i	j	k	l
Farm 1	2001	192	144	48	21	0	123	48	75	178	321	8	121
	2002	159	119	40	21	0	129	40	89	166	315	14	142
	2003	183	137	46	21	0	133	46	87	192	346	2	161
	2004	216	162	54	21	0	112	54	58	210	344	5	123
	2005	206	155	52	21	0	136	52	85	203	360	6	148
	mean	**190**	**143**	**48**	**21**	**0**	**126**	**48**	**79**	**190**	**337**	**7**	**140**
Farm 2	2001	205	154	51	23	0	224	51	172	153	400	19	176
	2002	160	120	40	23	0	192	40	152	138	353	22	171
	2003	199	149	49	23	0	199	49	150	130	353	6	148
	2004	208	157	51	23	0	229	51	177	115	367	12	147
	2005	225	169	56	23	0	235	56	179	139	397	13	158
	mean	**200**	**151**	**50**	**23**	**0**	**217**	**50**	**167**	**134**	**374**	**14**	**160**
Farm 3	2001	193	145	48	33	0	48	48	0	220	301	4	104
	2002	145	109	36	33	0	36	36	0	223	292	8	140
	2003	138	104	34	33	0	34	34	0	230	298	8	152
	2004	224	169	56	33	0	56	56	0	239	328	1	103
	2005	216	162	54	33	0	54	54	0	206	290	0	74
	mean	**183**	**137**	**46**	**33**	**0**	**46**	**46**	**0**	**224**	**302**	**4**	**114**

a = nutrient removal total; b = nutrient removal by main product; c = nutrient removal by by-product; d = N- imission; e = nitrogen input with seed; f = organic fertilizer; g = straw manuring; h = liquid manure; I = mineral fertilizer; j = total nitrogen input; k = nitrogen soil-N change; l = nitrogen surplus

The table 3 shows nitrogen balances of complete crop rotations winter oilseed rape, winter wheat and winter barley on one of the practical farms included in the survey. The nitrogen balances showed a variation from 104 to 116 kgN/ha in the years compared.

Energy

The various energy indicators give in table 3 showed also a great variation between the farms and the different experimental years. Most important are the results for the energy output (j) and the output/input relation (m). All systems compared in this collection showed a considerable energy gain and a positive output/input relation.

Biodiversity

The calculation of the pressure on biodiversity showed a considerable differentiation between the three practical farms. Farm 1 and farm 3 produced fairly high figures, whereas farm 2 showed only under average effect on the biotic environment. Differences between the years, however, where small and it was not possible to establish a clear trend for positive or negative development on the farms with respect to the pressure on biotic environment.

Tab. 3: Nitrogen balances [kgN/ha] on a farm a northern Germany with the crop rotation winter oilseed rape (WR), winter wheat (WW) and winter barley (WB) in the years 2001 to2005.

	2001	2002	2003	means over the years
main crop	WR	WW	WB	
nitrogen removal total (kg/ha)	194	202	189	**195**
organic fertilizer (kg/ha)	123	70	88	**94**
mineral fertilizer (kg/ha)	160	233	158	**185**
total nitrogen (kg/ha)	304	327	270	**302**
nitrogen surplus (kg/ha)	102	149	90	**116**
	2002	2003	2004	means over the years
main crop	WR	WW	WB	
nitrogen removal total (kg/ha)	162	229	177	**189**
organic fertilizer (kg/ha)	139	65	64	**89**
mineral fertilizer (kg/ha)	157	204	187	**182**
total nitrogen (kg/ha)	317	293	274	**295**
nitrogen surplus (kg/ha)	138	107	78	**108**
	2003	2004	2005	means over the years
main crop	WR	WW	WB	
nitrogen removal total (kg/ha)	181	190	247	**206**
organic fertilizer (kg/ha)	136	52	41	**76**
mineral fertilizer (kg/ha)	188	187	193	**189**
total nitrogen (kg/ha)	345	262	257	**288**
nitrogen surplus (kg/ha)	161	93	59	**104**

Tab. 3. Comparison of energy balances of winter oilseed rape of three practical farms in northern Germany.

	year	a	b	c	d	e	f	g	h	i	j	k	l	m
farm 1	2001	112	3	3	7	0	1	3	1	15	112	97	175	7
	2002	93	3	3	6	0	1	3	1	15	93	77	213	6
	2003	107	3	3	7	0	1	4	1	17	107	90	203	6
	2004	126	2	2	8	0	2	4	2	18	126	108	184	7
	2005	121	3	3	8	0	1	4	1	17	120	103	186	7
	means	**111**	**3**	**3**	**7**	**0**	**1**	**4**	**1**	**17**	**111**	**95**	**192**	**7**
farm 2	2001	120	8	8	6	0	1	4	1	20	120	100	212	6
	2002	93	7	7	5	0	1	3	1	18	93	75	247	5
	2003	117	7	7	5	0	1	4	2	18	117	99	201	6
	2004	124	7	7	4	0	1	4	2	18	124	106	187	7
	2005	133	7	7	5	0	1	5	2	19	133	114	184	7
	means	**118**	**7**	**7**	**5**	**0**	**1**	**4**	**2**	**19**	**118**	**100**	**203**	**6**

energy output: a = energy fixation yield (GJ/ha);
energy input: b = organic fertilizer (GJ/ha); c = liquid manure (GJ/ha); d = mineral fertilizer (GJ/ha); e = seed material (GJ/ha); f = plant protection product input (GJ/ha); g = fuel power (GJ/ha); h = machines (GJ/ha); i = input fossil energy (GJ/ha);
energy results: j = energy-output (GJ/ha); k = energy-win (GJ/ha); l = energy-intensity (MJ/GE); m = output/input-relationship

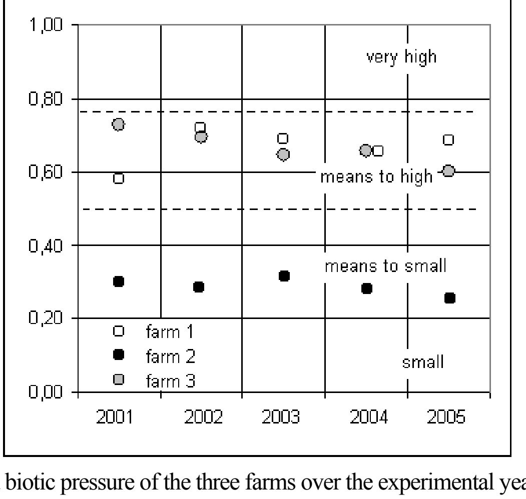

Fig. 1: Calculated biotic pressure of the three farms over the experimental years 2001 to 2005.

Discussion

The results of the different practical farms included in this evaluation are in accordance with the range of results for single indicators nitrogen balance, energy balance and pressure on biodiversity in the literature in similar environments (Hülsbergen et al., 2001; Heyer et al., 2003; Sieling et al. 2006). A detailed comparison is possible with experiments dealing with nitrogen balances and nitrate leaching. Given the range of nitrogen balances of oilseed rape on the practical farms our results underline the importance of a calculation of nitrogen balances on a rotational level. The different farms, however, showed no clear trend in all indicators. Low nitrogen balances were achieved with small impact on the biotic environment and vice verse.

A comprehensive evaluation of the sustainability of the systems requires an analysis of a range of indicators. A focus on only one indicator is not appropriate and will inevitable lead to wrong management decisions on a farm as well as on a political and administrative level.

Aknowledgement

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