

Sustainable rapeseed production between science and politics*

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Abstract: The concept of sustainability, first developed in forestry, includes ecologic, economic and social aspects. In a number of international agreements almost all countries of the world have committed themselves to a sustainable development. The assessment of sustainability is normally done by using indicators. In the case of rapeseed special attention has to be placed on nitrogen balances and green house gas emission compared with other crops, however, a number of very positive effects of rapeseed occur if the scale of the crop rotation is considered. In recent years politics and administration have also used the term sustainability in the context of agricultural production, but only focussed on very few aspects and thus did not consider the complex system. This led to misconceptions and might cause disadvantages for rapeseed in the future. Based on the example of forestry, such a strong political influence might be avoided if the agricultural sector itself is able to establish assessment and certification systems.

Key words: sustainable production, indicators, biofuels, politics

Introduction

The concept of sustainability and sustainable development has a long tradition. The first ideas were developed in forestry well in the late 17th and early 18th century in different European countries. Based on the experience that wood was becoming increasingly scarce, the English author John Evelyn (1620-1706) suggested to managed forests in a way that only the re-growth should be harvested. Also the Jean-Baptist Colbert (1619-1683) made similar suggestions. However, it was until 1713 that a mining expert from Saxony named Hans Carl von Carlowitz (1645-1713) coined the term sustainability (German "Nachhaltigkeit") and postulated that the timber harvest should only equal the re-growth to secure a long-term existence (Christen, 1996). The reason for those early considerations was

merely an economic one, because all early concepts were developed to ensure the resource based for the industry and/or society of that time be it mining or housing.

In the following centuries the concept was further developed in forestry and forest sciences from a mere "harvest has to equal re-growth" approach to more complex systems including various environmental, economic and also social aspects of production. The focus was always with on the long-term existence of production systems. Surprisingly the ideas remained in the forest science and practical forest management communities until the early 1970th of the 20th century, when first international institutions like the World Bank, the United Nations, the OECD etc. used the term sustainability increasingly in their publications (Christen, 1996). It was only in 1987 based on the so-called Brundtland-Report from the than Norwegian Prime minister Gro Harlem Brundtland that the concept of sustainability entered the stage of international politics. In this report one of the famous definitions of

sustainability was coined: "Sustainable development is development that meets the needs of the present without comprising the ability of future generations to meet their own needs" (WCED, 1987).

The most important milestone in the discussion on sustainable development a few years later the so-called world summit in Rio de Janeiro (Brazil) in 1992, which lead to the Agenda 21, signed by 178 heads of states. In this agreement almost all countries of the world declared their commitment to a sustainable development. It is interesting to note, that already in the Agenda 21 a system of indicator was suggested to assess the sustainable development. This indicator-system already included a number of single indicators with a clear relation to land-use and agricultural production. The limitation from the perspective of sustainable rapeseed production (or any other single crop) is the fact, that the indicator-system of the Agenda 21 was developed to compare countries and assess the sustainable development at a very different scale compared with agricultural production on the field level.

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At the moment it looks as if this level will be again the focus on the 20+ summit in Rio this year.

An important lesson to be learned from the history of the discussion on sustainable development is the consequence for forestry and timber trade. Right after the Rio summit the Forest Stewardship Council (FSC) was established. In this council clear indicators for a sustainable forest management were agreed and now the FSC certification system is well known and is setting the agenda for sustainable forest management on an international scale. Another example much closer to rapeseed is the Round Table of Sustainable Palmoil (RSPO), which also has defined standards but not such a wide acceptance. Up to now, nothing with a comparable impact exists for agricultural crops, which makes communication and implementation still much more difficult compared with the timber industry.

Twenty years on following other agreements on sustainable development and establishing new institutions on national and international levels the concept of sustainability has reached almost all aspects of life, with the enormous problem, that the term sustainability is often used – especially in politics but also in the industry - without any knowledge of the underlying concept.

At this point, however, it is important to come back to the concept of sustainable development in order to distinguish it from too much political rhetoric and greenwashing from various industries (figure 1).

It is important to mention that agricultural production is notoriously complex and that this complexity should be included in assessment systems based on indicators. A great number of single indicators have been suggested to assess agricultural systems including rapeseed production. Based on the OECD concept of indicator categories, most single indicators are so called “pressure” or “driving force” type indicators. “State” indicators, which in an ideal world would be best suited to assess the actual situation of a resource are normally not considered given the high costs of direct measurements, however, in some cases the use of “state” indicators is included (OECD, 1998). Typical indicators to assess the environmental aspects of agricultural production systems are given in table 1.

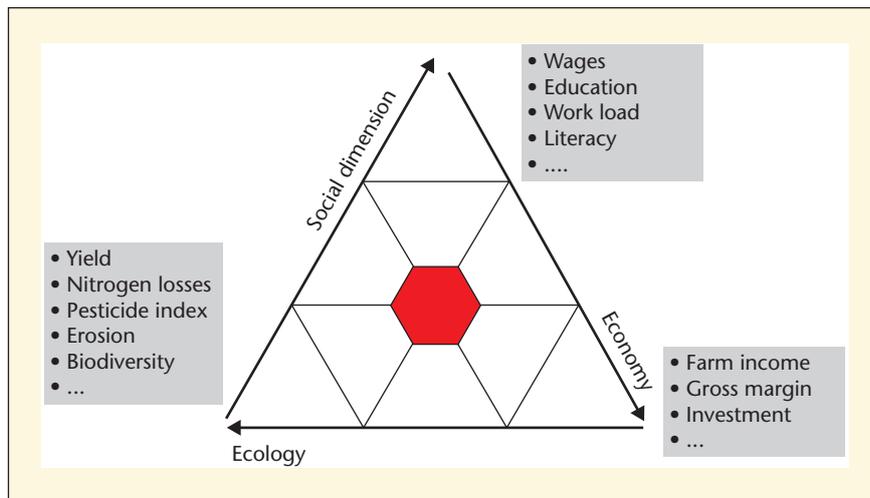


Figure 1. Triangle of sustainability.

Performance of rapeseed under sustainability criteria

The following section does not intend to provide a comprehensive presentation of all possible single indicators in rapeseed production. Neither is it possible to discuss single indicators in greater depth. The intention is simply to provide some examples of various indicators and results which include rapeseed either as a single crop or compared with other crops.

Given the concept of sustainability including e.g. long term effects on yields, soil fertility, biodiversity, pesticide application just to name a few it is necessary to broaden the scope of the analysis beyond the performance of a single crop to the level of a crop rotation or the farm level. Another important reason to consider a higher scale are all questions of the economic and the social dimensions. This is a clear and distinct difference to other crops, which are currently in the

focus of sustainability assessments especially in the area of renewable energy and biofuel production like palm oil (biodiesel) and sugar cane (ethanol), which are plantation crops and thus the scale of a crop rotation is not relevant.

In order to assess the effect of rapeseed on those long-term effects mentioned above it is thus necessary to include results from either long-term experiments or other long-term data with different proportions of rapeseed in a rotation. The theoretical problem, however, which occurs with this approach, is the question of the benchmark crop.

Applying the concept of green and blue water use Gerbens-Leenes *et al.* (2009) compared a number of crops, which are currently used for the production of biofuels and put that in relation to the energy gain in GJ. In their analysis rapeseed showed a very high figure of c. 400 m³ water per GJ. Also Soybeans and Sorghum showed comparable high figures, whereas other crops like sugar

Table 1. Sustainability indicators in the three different dimensions.

Ecology	Economy	Social Aspects
- Nitrogen balance	- Farm income	- Wages
- Phosphorus balance	- Investment	- Education
- Soil erosion	- Contribution of the rural sector to the economy	- Holidays
- Soil compaction	- Gross margin	- Social activities in the community
- Soil organic carbon		- Literacy
- Energy gain		
- Greenhouse gas emissions		
- Biodiversity		
- Pesticide index		

beet, sugar cane and potatoes only had figures between 60 and 110 m³ water per GJ.

Energy gain and/or energy efficiency are other indicators, which have been widely used in sustainability assessments on the crop and on the rotational level. *Figure 2* shows results from a long-term fertilizer experiment. The energy gain per ha increases up to 200 kg N/ha applied nitrogen fertilizer. However, due to the amount of energy used for the production of nitrogen fertilizer and the limited yield gain above 200 kg N/ha, the energy gain is reduced. This underlines the importance of such indicators especially in comparisons with other crops used for the production of biofuels. The effect of only small differences in yield caused by different application rates of nitrogen and the following consequences for the green house gas emissions – calculated as CO₂-equivalents – is given in *table 2*. Especially the last line is important, since it demonstrates the huge differences in CO₂eq per GJ. If such an indicator is used as an instrument in administration and politics, current production systems have to be adjusted accordingly. This is what is currently happening in Europe following the directive for the production of biofuels.

A major concern in relation to the production of rapeseed is the positive nitrogen balance. Data from more than 143 fields collected in mostly northern Germany collected in the years from 2000 to 2007 underline this observation (*figure 3*). Experimental results from Sieling und Kage (2011) show clearly that in the rotations of rapeseed –

Table 2. Effect of nitrogen fertilization on yield (t/ha), CO₂eq/ha energy output (GJ/ha) and CO₂eq / GJ.

Yield (t/ha)	3,9	4,1
N-Fertilization (kg N/ha)	160	240
CO ₂ eq/ha	1886	2401
Energy output (GJ/ha)	94,0	98,9
CO ₂ eq/GJ	32,8	39,8

winter wheat – winter wheat the highest positive nitrogen balances and thus the highest nitrate leaching is regularly measured in the winter after rapeseed. If only rapeseed is compared with other important crops under European conditions this would be an alarming situation, however, rapeseed has a number of very positive aspects in the short cereal based rotations currently used. Kirkegaard *et al.* (2008) have recently reviewed this aspect and emphasised the positive effect of rapeseed on the following cereals due to a lower incidence of root diseases and an improved soil structure. Higher yields achieved with a similar amount of nitrogen fertilization translate in a better nitrogen efficiency and a lower nitrogen balance and smaller nitrate leaching. A limiting factor of increasing rapeseed any further in the rotations apart from financial considerations, however, is the response of rapeseed itself to a higher proportion in rotation, which has been demonstrated by Sieling *et al.* (1997). Given those two effects of rapeseed in rotation the problem of high nitrogen balances is somewhat less crucial if the comparison is made on a rotational level.

The effect of the crop rotation and/or the preceding crops is similarly important for the calculation of green house gas emissions or the green house gas reduction potential Kage and Sieling (2011) recently calculated the green house gas reduction potential of rapeseed with different amounts of nitrogen fertilization following either barley or peas (*figure 4*). They could demonstrate that the positive effect of the preceding crop peas had quite an strong effect on the green house gas reduction potential making it much easier to achieve the guidelines of the renewable energy regulations for the production of biofuel. Another example of the strong effect of crop rotation and production intensity is given in *table 2*. In this field experiment rapeseed was either grown in a rapeseed – winter wheat – peas or a rapeseed – winter wheat – winter barley rotation. Additionally different levels of intensity in fertilization and fungicide application have been compared. If CO₂eq per GJ is taken as an object the results clearly underline the strong effect of the crop rotation. Additionally production systems with less nitrogen fertilization have advantages due to the high contribution of the nitrogen production to the greenhouse gas and energy balances (*table 3*).

Though the importance of a rotational view on rapeseed is, as demonstrated, essential for a correct assessment, a number of studies have neglected this aspect and tried to compare rapeseed with other crops on a crop to crop bases. Thamsiriroj and Murphy (2009) compared biodiesel produced from rapeseed in Ireland with palm oil from Thailand and come to the conclusion that CO₂ emission from palm oil are lower on a GJ bases. They calculate a greenhouse gas reduction of only 28.8% for Irish biodiesel vs. 55.1% for palm oil produced in Thailand.

Another example of a “crop to crop” comparison is given by Zah (2007). They compared the greenhouse gas emission with the total environment impact, which incorporates a number of different single indicators. Again in this study rapeseed does not perform very well compared with eg. ethanol produced from sugar cane or sugar beet.

As a conclusion from the examples give in this section it is important to stress that rapeseed has a number of positive

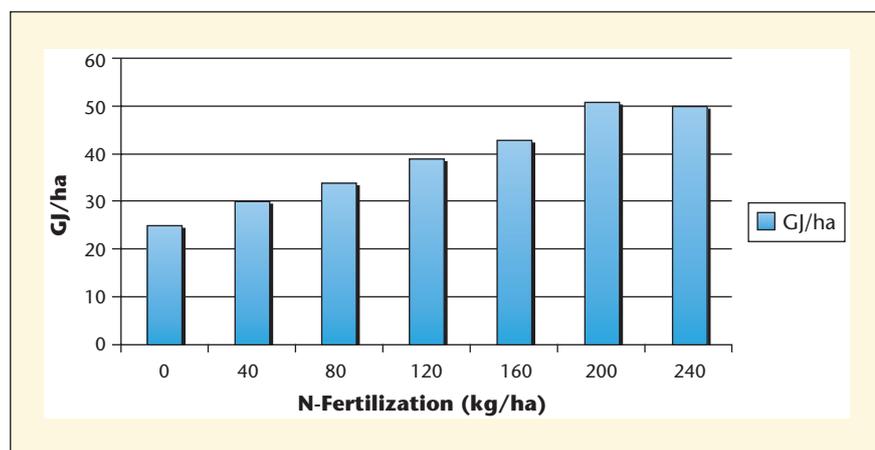


Figure 2. Effect of nitrogen fertilization (kg N/ha) in the energy gain of rapeseed (GJ/ha).

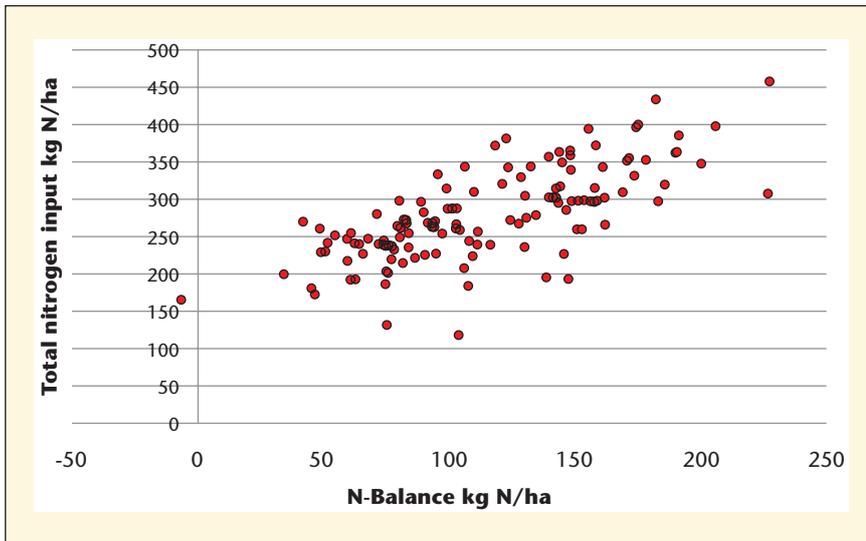


Figure 3. Effect of nitrogen input (kg N/ha) on nitrogen balances (kg N/ha) of 143 rapeseed fields in Germany (2000-2007).

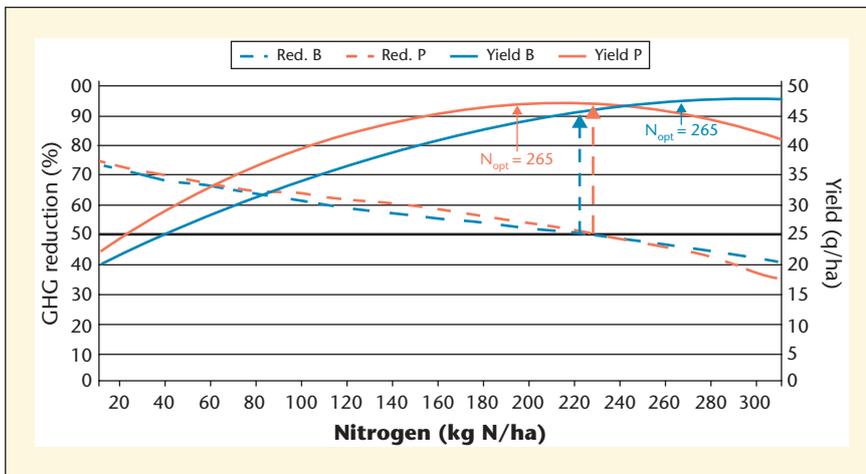


Figure 4. Effect of nitrogen fertilization (kg N/ha) and preceding crop (*b* = barley, *p* = peas) on the seed yield (q/ha) and greenhouse gas reduction potential (GHG,%) according to Sieling and Kage (2011, modified).

effects in the cereal based rotations in Europe. Some of them only become apparent if a rotational view is taken. There are, however, challenges for the future, which are mainly in the area of nitrogen efficiency and CO₂eq per GJ.

Influence of politics on sustainability assessments

Given the great complexity of the concept of sustainability it is important to come back to the influence of politics

Table 3. Effect of crop rotation and intensity on the greenhouse gas emissions (CO₂eq/GJ).

Crop rotation	Intensity		
	F+, N-	F+, N+	N+, F-
OSR – WW - Peas	39,8	41,6	44,5
OSR – WW - Barley	40,3	46,3	47,5

and what has politics and administration done in the last years. While in scientific studies a number of very diverse results on the environmental effect of rapeseed have been published and the debate on how to attribute affects of rotational crops continues, politics have taken decisions with a potential enormous impact on rapeseed production. The momentum comes at the moment mainly from the biofuel discussion and the blending mandates which are in place in the European countries. In order to have an argument in the discussion on the total CO₂eq balances of biofuels respective politics were put in place, which mainly focus on greenhouse gas reduction potential of the different biofuels. From the political side this is coined with the term “sustainable production” if certain levels of reduction potential are fulfilled. This approach has to be discussed very critical from at least two perspectives. On the one hand the very complex approach of sustainable production, looking at various ecological, economic and social aspects is reduced to only one indicator. Though greenhouse gas emission are important, without any doubt, however, it is by far not the only indicator to be measured. This limitation and the use of the term “sustainability” harms the entire concept and is misleading. On the other hand, the political approach has a methodological problem because it compares crops grown in rotation (rapeseed, sugar beet etc.) with crops, which are grown in plantations like palm or sugar cane. All positive effects of rotational crops, like the examples given in this paper in the case of nitrogen balances or greenhouse gas emission, are thus neglected. Examples in the case of rapeseed could easily be extended to soil structural effects, reduction of herbicide use in cereal rotations or better options to use conservation tillage and thus reduce soil erosions. All that could be demonstrated from scientific literature but is currently neglected and this is producing a very biased view on rotational crops like rapeseed with a lot of positive effects in the mid- and long term.

One must be sceptical if politics is able to deal with this complexity, especially when other options to produce renewable energy seem to be more suitable in such a crude analysis.

The main focus in this paper has been on the effects of misleading political decisions and benchmarks in the context of

growing rapeseed for biodiesel, however, one has to mention that also in the food sector similar developments are on the way. Again, it is not from within the agricultural sector but mainly from the food companies or the big retailers that "sustainability" standards are applied. Again, the standards normally focus on very few or only one indicator (carbon- or water food-prints) and rotational effects are neglected. How this will in the future effect rapeseed production is not clear, since such up to now standards have been quite weak, but it is possible that in the future the access to markets might be regulated with such standards.

Conclusion

The concept of sustainable agriculture is very complex and includes ecological, economic and social aspects. On the environmental side, rapeseed has some critical aspects especially when it comes to nitrogen efficiency, nitrate leaching and greenhouse gas emission which have to be clearly addressed in future

research projects. A lot of positive effects of rapeseed become obvious, if the entire crop rotation is taken into account. This will, however, not solve all problems for the future because from the political side the focus is very much on greenhouse gas emissions on a crop base. The rapeseed industry can not longer ignore this development. A lesson to be learned from other industries in the case of sustainable production is the pro-active approach of the timber industry, which has very early taken things in their own hands and is not with the forest stewardship council (FSC) setting the political agenda for sustainable timber production on a global scale.

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