Legumes Translated Report 3

An application of life-cycle assessment (LCA) to legume cropping

Leonardo Amthauer Gallardo
Heinz Stichnothe
Jens Dauber

Thünen Institute of Biodiversity &
Thünen Institute of Agricultural Technology

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Legumes Translated

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Introduction

The literature on environmental effects of cropping systems with and without legumes using LCA was analysed. The most comprehensive work was the results of the Legumes Futures project ("Legumes Futures Report 1.6 - Effects of legume cropping on farming and food systems"). The data gathered in the Legume Futures report was reanalysed and synthesised in order to make it suitable to the practice audience.

Another task accomplished within the project was data gathering of suitable crop sequences from the actor groups. A data plausibility and quality check was performed before the data were further processed. This task is just completed. LCA of relevant environmental impacts was performed for those cropping systems of the actor groups for which the necessary data quality could be compiled. Due to the corona situation there were delays in the return of data and quality control. Streamlined LCA of crop sequences with and without legumes were conducted. TI also searched for cropping system assessment tools including biodiversity and environmental performance and assessed those tools for their applicability within Legumes Translated.

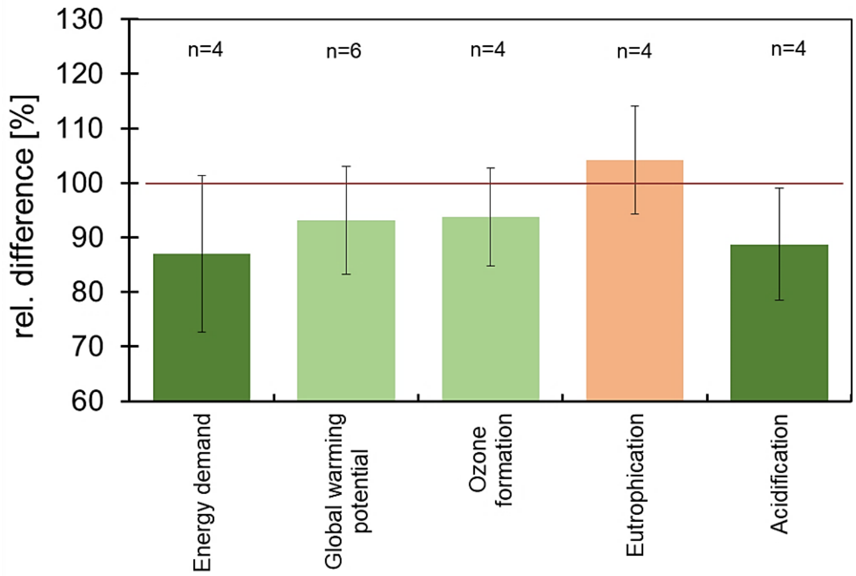
Life-cycle assessment

We focused our analysis of environmental effects using LCA in two contexts: for comparing area-related impacts of crop sequences with grain legumes to those without, and for comparing European-grown grain legumes with imported soya on the basis of protein produced. A total of four sources were available for the area-related comparisons based on experimental areas located in Sweden, France and Austria. For the protein-related comparison, we found a two sources with investigations carried out in four countries, Germany, France, Switzerland, and Spain.

Taking land as the functional unit, the introduction of a grain legume crop into a cropping sequence resulted in slight decrease (between 8 and 13%) in primary energy use, global warming potential, ozone formation and acidification. Only eutrophication was slightly increased when the sequence included a grain legume. For comparison based on feed-based functional unit (the functional unit was the nutritional equivalent of one kg of soybean meal), replacing standard imported soybean meal with grain legumes of European origin resulted in decreases in environmental impacts. The decrease ranged between 37% (eutrophication) to 71% (primary energy imput). It must be noted that a comparison of LCA studies from different regions in different years using different LCI modelling approaches and different LCIA-methods has limitations. This concerns especially the models to calculate reactive nitrogen emissions, particularly nitrate (e.g., STANK or SALCA-NO_3).

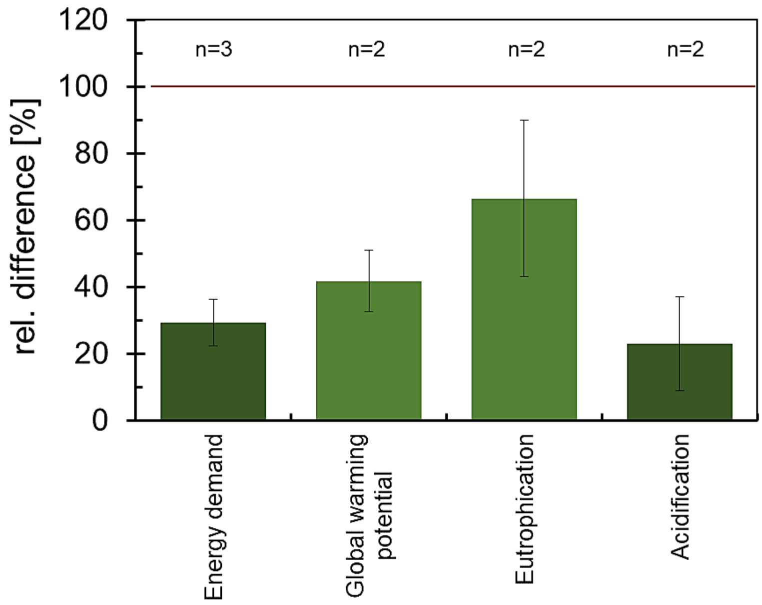
We selected two crop sequences from Bulgaria that fulfilled all data quality criteria from the actor groups' crop sequences. We calculated the environmental impacts per ha. Environmental impacts were also expressed per unit dietary energy, cereal unit, crude protein, and the usable protein (relevant for dairy feed) make comparisons based on the same function (bioenergy, feed/fodder and dairy fodder). For each function, the land area demand of the crop sequence with legumes was higher than the crop sequence without legumes. To get the same amount of crude protein as is obtained from cropping sequences without legumes, 1.14 ha of crop sequence with legumes is needed. The corresponding amount for cereal units is 1.37. The disbenefits of increased land use are off-set by up to 50% reductions in mineral N-fertiliser use both for area used and kg protein produced as the functional unit. The main reason for the lower environmental impacts of crop sequences with legumes compared to the sequences without is the reduced amount of mineral nitrogen fertiliser needed. In the following months, further crop rotations after the improvement of data quality will be analyzed with an harmonised approach so that the results are fully comparable.

Methodological approaches to quantify biodiversity and ecosystem services in LCA are still under development and not harmonized yet. Therefore, LCA might be used to identify potential risks regarding biodiversity and ecosystem services, but it is currently not ready for robust decision support concerning biodiversity and ecosystem services at farm level.



Data from Nemecek and Baumgartner (2006) and Hayer et al. (2012) compiled in Reckling et al. (2014)

Figure 1. Relative comparison between crop sequences with and crop sequences without for the LCA categories energy demand, global warming potential, ozone formation, eutrophication and acidification (green bars show lower values in crop sequences with pea than in crop sequences without legumes, red bars show the opposite. Error bars represent standard deviation; raw data was related to the unit [ha land])



Data from Cederberg and Flysiö (2004), Eriksson et al. (2004) and van der Werf et al. (2005), Hörtenhuber and Zollitsch (2010), compiled in Reckling et al. (2014)

Figure 2. Relative comparison between pea from European production compared with imported soy meal for the LCA categories energy demand, global warming potential, eutrophication and acidification (green bars show lower values in pea than in imported soycake; red bars show show the opposite; error bars represent standard deviation; raw data was related to the unit [kg produce])

Table 1. Functional performance per hectare for crop sequence without (CS1) and with legumes (CS2)

Functional performance	CS1	CS2	Ratio CS1:CS2
LVC [MJ ha^{-1}]	397628.0	296920.0	1.34:1
Cereal Unit [kg ha^{-1}]	21940.9	16023.5	1.37:1
Raw protein [kg ha^{-1}]	2844.2	2489.0	1.14:1
Usable protein [kg ha^{-1}]	2753.1	2228.5	1.24:1

Table 2. Environmental impacts of crop sequence without (CS1) and with legumes (CS2) per hectare and per kg UP

Environmental impacts	CS1 [per ha]	CS2	CS1 [per kg UP]	CS2	Ratio CS1:CS2 per kg UP
Metal depletion [kg Cu eq.]	1.3E+02	4.6E+01	4.7E-02	2.1E-02	2.3:1
Fossil depletion [kg oil eq.]	2.2 E+03	1.1E+03	8.0E-01	4.9E-01	1.6:1
Marine eutrophication [kg N eq.]	1.1E+00	1.7E+01	4.0E-02	7.6E-04	0.5:1
Freshwater eutrophication [kg P eq.]	2.5E+00	1.0E+00	9.1E-04	4.5E-04	2.0:1
Global warming potential (GWP 100y) [kg CO2 eq.]	8.9E+03	5.5E+03	3.2E+00	2.5E+00	1.3:1
Photochemical ozone Formation [kg NOx eq.]	6.7E+01	3.3E+01	2.4E-02	1.5E-02	1.6:1
Stratospheric O_3 Depletion [kg CFC-11 eq.]	1.3E-01	9.3E-02	4.7E-05	4.2E-05	1.1:1
Terrestrial acidification [kg SO2 eq.]	8.3E+01	4.1E+01	3.0E-02	1.8E-02	1.6:1

Literature

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About this report

Authors: Leoanardo Amthauer Gallardo, Heinz Stichnothe and Jens Dauber Thünen-Institut: Biodiversity (thuenen.de) and Thünen-Institut: Agricultural Technology (thuenen.de)

Contact: Leonardo Amthauer Gallardo leonardo.amthauer@thuenen.de,

Heinz Stichnothe heinz.stichnothe@thuenen.de

and Jens Dauber jens.dauber@thuenen.de

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Cover photograph: Flowering field pea in farmers field in Germany. Photograph: Moritz Reckling

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