Resilience for Dairy (R4D) has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000770

Resilience4Dairy: Eco-efficient low cost dairy production on a mixed farm in Northern Germany

Ralf Loges and Friedhelm Taube

Grass and Forage Science/ Organic Agriculture, University of Kiel, Germany
rloges@email.uni-kiel.de

LYON 30/8/2023

Introduction: Challenges of spezialized farming

Recent intensification in European agricultural production is accompanied by serious environmental trade-offs questioning the sustainability of current specialized production systems for both all arable cash crops and animal products.

Current challenges in intensive agriculture:

a) High demand for external resources
b) Reduced biodiversity
c) High N- and P-surpluses
d) Increasing social demands with respect to animal welfare
e) Climatic impacts

Introduction: Challenges of spezialized farming

On top of this there is a bunch of other challenges farmers are faced with

f) Fluctuating product prices
g) Increased production costs (often not covered by revenue)
h) Decreasing acceptance of modern farming by the society
i) Greenhouse gas emissions
j) Climatic change (farmers have to cope with more extreme weather situations)
k) Difficulties to recruit co workers
l) Unattractive work – live - balances
m) Serious stress symptoms have been observed at many farmers
n) Difficulties to persuade the next generation to become farmers

Promising Solutions

In cooperation with farmers and advisors the R4D-project as identified a large number of solutions to help to make dairy farmers more resilient

Here some of these solutions as examples:

Mixed-farming (real or virtual)
Cooperation between complementary farms (sharing machines and workers)
Reintroduction of grazing (to reduce forage costs and increase acceptance)
Crossbreeding (for more robust cows and better marketing of excess calves)
Homegrown proteins (pulses and grass clover), self sufficiency
Multispecies swards (to increase drought tolerance and biodiversity)
Decrease input of expensive mineral N-fertilsers and concentrates
Reduced first calving age
Increased longevity of cows
Consideration of organic farming (Farm to fork strategy)

Promising Solutions

Many of the mentioned solutions are present on several of the 120 Pilot-farms of the R4D-project

But what will it look like when all of the on the last slide mentioned solutions are applied on the same pilote farm?

How will On-Farm Eco-Efficiency and Economy of Dairy Farm in Northern Germany look like in contrast to the average farm of the region of Schleswig-Holstein when adopting these soloutions





The interdisciplinary project: "Eco-efficient pasture-based milk production" started 2016 at Kiel University's organic research farm Lindhof in Northern Germany.

The project focusses on a whole-farm approach to analyse the potential of pasture-based milk production on grass-clover leys with the aim to strengthen sustainability of an organic arable crop rotation.

In 2015 Lindhof's low input herd of suckler cows + followers (0,4 LU/ha) was replaced by a spring calving herd of dairy cows (0,9 LU/ha).

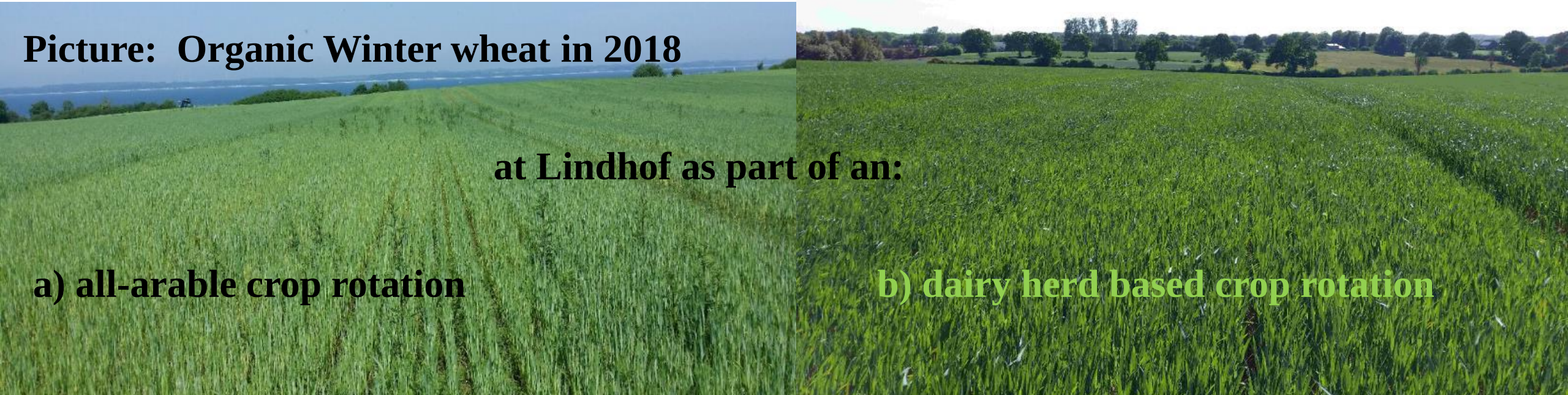
The share of grass clover in the crop rotation was increased from 20% to 40%

The interdisciplinary project: "Eco-efficient pasture-based milk production" started 2016 at Kiel University's organic research farm Lindhof in Northern Germany.

The project focusses on a whole-farm approach to analyse the potential of pasture-based milk production on grass-clover leys with the aim to strengthen sustainability of an organic arable crop rotation.

In 2015 Lindhof's low input herd of suckler cows + followers (0,4 LU/ha) was replaced by a spring calving herd of dairy cows (0,9 LU/ha).

The share of grass clover in the crop rotation was increased from 20% to 40%



Picture: Organic Winter wheat in 2018

at Lindhof as part of an:

a) all-arable crop rotation

b) dairy herd based crop rotation

Aim of the here presented project carried out on farm level:

Can the reintroduction of a dairy herd on a former specialized all arable farm also reduce future challenges of a typical dairy farm and produce milk profitably in a climatic friendly way?

Picture: Organic Winter wheat in 2018

at Lindhof as part of an:

a) all-arable crop rotation

b) dairy herd based crop rotation

“Eco-efficient milk production” Lindhof

Aim: Maximization of milk production from grazing at a reduced input of concentrates: 770 kg/cow/year at an actual milk yield of 7600 kg ECM/cow

What we do:

Grazing of 2year lasting multi species grass clover leys (perennial rye-grass + white + red clover + **birdsfoot trefoil + chicory + lancelot plantain** + carravay)

Rotational grazing, after each milking allowance of very young fresh grass/clover, at a growing height of 8 cm based on platemeter readings

Grazing from beginning of March – to mid November (Grazing period: 275 days/year)

Seasonal-calving from end of January - mid April

Herdsize: 100 Jerseys and Crossbreeds with EBI and Red Angeln Cattle

First calving at an age of 23.5 month and a replacement rate of only 18.3 %

No additional N-fertilisation to the grass clover,
all manure is transferred to arable crops)

Selfsufficiant with concentrates (Triticale + Faba beans)

Forages cooperation with an organic all-arable (swapping forage against manure)

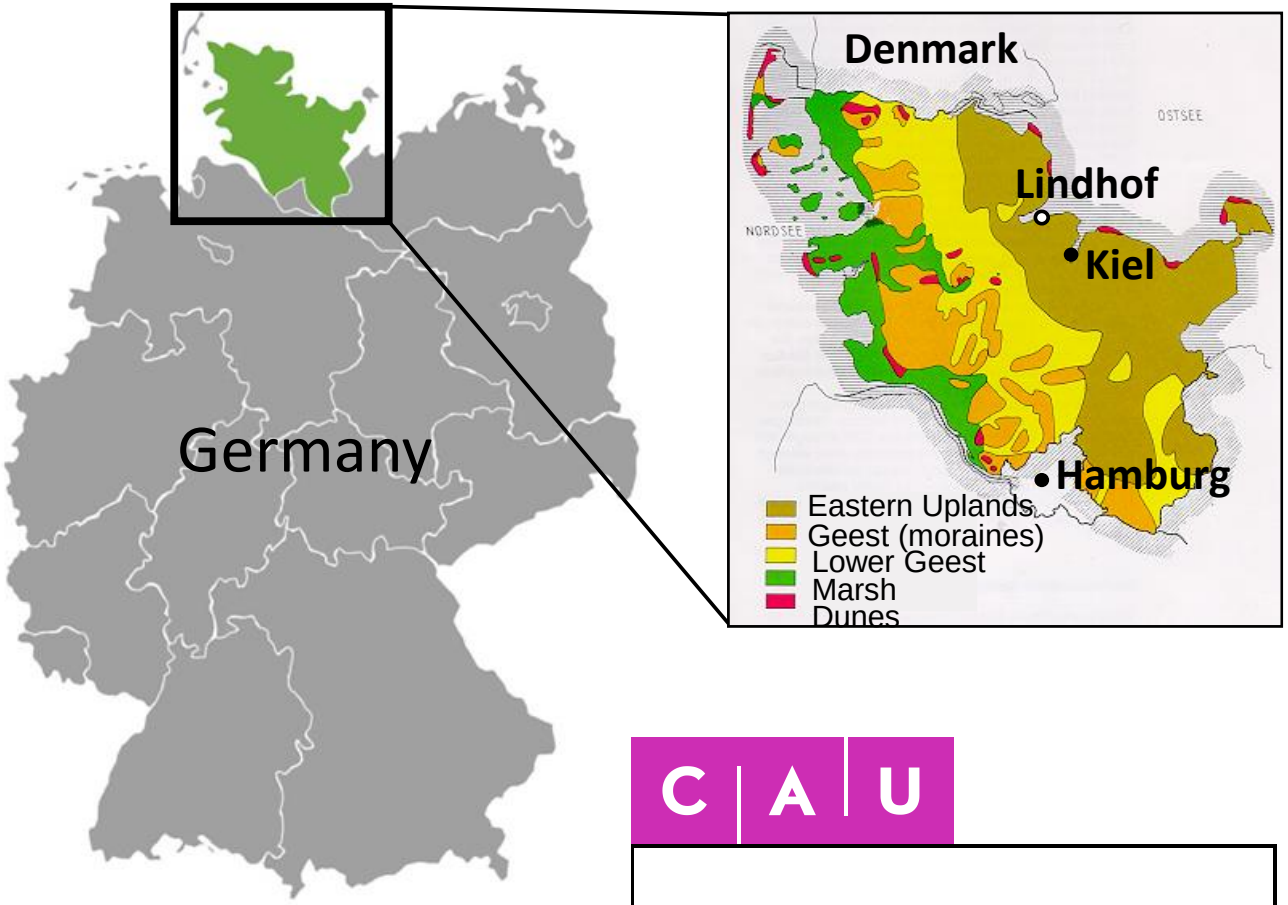
Machine and workforce cooperation with a conventional all-arable farm

“Eco-efficient milk production” Lindhof

Reintroduction of grazing for dairy cows on an organic mixed farm in Northern Germany

Farm Area: 182.0 ha
production area: 159.3 ha
arable land 110.9 ha
perm. grassland (intens.) 6.9 ha
wet perm. grassland with management-restrictions 41.5 ha

100 Dairy cows on 52 ha grass clover leys
2 x 20 replacement heifers
+ 2 x 30 beef heifers (crossbreeds with Angus on nature protected permanent grassland
Precipitation: 785 mm p.a.
Temperature: average: 8.7 °C
Soil type: sandy loam, loamy sand



Christian-Albrechts-Universität zu Kiel
Faculty of Agricultural and Nutritional Sciences

Results

a) The main agronomic and environmental performance indicators at Lindhof are compared to those of the average of 356 dairy farms of the north German federal state of Schleswig-Holstein (S-H) as reported by the advisory service (BZA) *Landwirtschaftskammer S-H* (2020).

b) Measured N2O emissions and Nitrate leaching to the groundwater as well as Product Carbon Footprint (PCF) for milk production (including production of replacement heiffers) of Lindhof is compared to 3 contrasting specialised dairy farms from the same region:

1) Conventional: all year indoors: 11170 kg ECM cow^{-1} $year^{-1}$
2) Conventional: restricted grazing: 9484 kg ECM cow^{-1} $year^{-1}$
3) Organic: low input / full grazing 6060 kg ECM cow^{-1} $year^{-1}$

Table 1: Tab 1 Economic results and nitrogen balance (2019/20) of the experimental farm Lindhof compared to the average of 356 dairy farms consulted by the chamber of agriculture of Schleswig-Holstein

Milk production including Heifer rearing	**Unit**	**Lindhof**	**Average of 356 BZA full evaluated establishments in SH.**
Production technology			
Cow herd	number	94	166
Live weight	kg/cow	470	670*
Milk yield ECM	kg ECM/cow	7,007	9,433
Milk production natural	kg/cow	5,728	9,257
Milk per kg live weight	kg ECM/kg LG	14.90	14.08
Fat plus protein	kg/cow	592	702
Fat	%	5.59	4.2
Protein	%	3.99	3.45
Concentrates/cow/year	t/cow	0.80	2.81
Concentrated feed/kg ECM milk	g/kg ECM	120	295
Milk production per ha MFA on farm**	kg ECM/ha FA	10,946	14,866
Calculated forage performance according to BZA, ((maintenance covered by forage)	kg ECM/cow	5,284	3,767
Forage performance according (maintenance shared by all fodder sources	kg ECM/cow	5,865	5,519
Forage performance, proportion of total ration	%	75.41	39.93
Adjusted reproduction rate	%	18.20	33.40
First calving age (LKV annual report 2020)	Months	23.9	28.4[a]
Calving interval (LKV annual report 2020)	days	362	400[a]
Costs for vet, medicines + hoof care	ct/kg ECM	1.48	1.64
Feed costs per kg ECM milk produced***	ct/kg ECM	16.81	22.12
Forage costs (pro rata)	ct/kg ECM	12.17	13.35
Concentrated feed costs (pro rata)	ct/kg ECM	3.83[α]	8.77
More metrics			
Mineral N fertilizer input (kg/ha HFF)	kg N/ha HFF	0	99
N balance[b] (sub-farm milk produced)	kg N/ha HFF	88	149

* Estimated value based on the average of the breeds, **without area requirements for imported feed;
*** incl. rearing replacement heifers, [a]Farms in the same region, [b]Farm-gate N balance of the sub-farm milk production, [α]from organic production at a 63% higher price
Abbreviations: SH = Schleswig-Holstein, ECM = energy-corrected milk, MFA = main forage area, BZA = branch accounting, source: LK SH 2020

Table 1: Tab 1 Economic results and nitrogen balance (2019/20) of the experimental farm Lindhof compared to the average of 356 dairy farms consulted by the chamber of agriculture of Schleswig-Holstein

Milk production including Heifer rearing	**Unit**	**Lindhof**	**Average of 356 BZA full evaluated establishments in SH.**
Production technology			
Cow herd	number	94	166
Live weight	kg/cow	470	670*
Milk yield ECM	kg ECM/cow	7,007	9,433
Milk production natural	kg/cow	5,728	9,257
Milk per kg live weight	kg ECM/kg LG	14.90	14.08
Fat plus protein	kg/cow	592	702
Fat	%	5.59	4.2
Protein	%	3.99	3.45
Concentrates/cow/year	t/cow	0.80	2.81
Concentrated feed/kg ECM milk	g/kg ECM	120	295
Milk production per ha MFA on farm**	kg ECM/ha FA	10,946	14,866
Calculated forage performance according to BZA, ((maintenance covered by forage)	kg ECM/cow	5,284	3,767
Forage performance according (maintenance shared by all fodder sources	kg ECM/cow	5,865	5,519

Table 1: Tab 1 Economic results and nitrogen balance (2019/20) of the experimental farm Lindhof compared to the average of 356 dairy farms consulted by the chamber of agriculture of Schleswig-Holstein

Milk production including Heifer rearing	**Unit**	**Lindhof**	**Average of 356 BZA full evaluated establishments in SH**
Production technology			
Forage performance, proportion of total ration	%	75.41	39.93
Adjusted reproduction rate	%	18.20	33.40
First calving age (LKV annual report 2020)	Months	23.9	28.4[a]
Calving interval (LKV annual report 2020)	days	362	400[a]

Table 1: Tab 1 Economic results and nitrogen balance (2019/20) of the experimental farm Lindhof compared to the average of 356 dairy farms consulted by the chamber of agriculture of Schleswig-Holstein

Milk production including Heifer rearing	**Unit**	**Lindhof**	**Average of 356 BZA full evaluated establishments in SH.**
Production technology			
Costs for vet, medicines + hoof care	ct/kg ECM	1.48	1.64
Feed costs per kg ECM milk produced***	ct/kg ECM	16.81	22.12
Forage costs (pro rata)	ct/kg ECM	12.17	13.35
Concentrated feed costs (pro rata)	ct/kg ECM	3.83[α]	8.77
More metrics			
Mineral N fertilizer input (kg/ha HFF)	kg N/ha HFF	0	99
N balance[b] (sub-farm milk produced)	kg N/ha HFF	88	149

* Estimated value based on the average of the breeds, **without area requirements for imported feed;
*** incl. rearing replacement heifers, [a]Farms in the same region, [b]Farm-gate N balance of the sub-farm milk production, [α]from organic production at a 63% higher price
Abbreviations: SH = Schleswig-Holstein, ECM = energy-corrected milk, MFA = main forage area, BZA = branch accounting, source: LK SH 2020

Results

Table 2: Full costs in the 2019/2020 financial year*

Full cost evaluation for basic feed 2019/20	**Mowed pasture Lindhof**	**BZA 2019/20 grass silage**	**BZA 2019/20 corn silage**
Energy yield, MJ NEL/ha	57,228	57,593*	84,746*
Crude Protein Yield, kg CP/ha	1, 275	1, 456	907
Total costs, €/ha	943.75	1,865.98*	2,039.44*
Total cost, ct/10 MJ NEL	16.47	32.40*	24.07*
Total cost, ct/kg CP	0.74	1.28	2.25

* Mowed pasture on the Lindhof in comparison to grass and maize silage as the most important staple feed of the 356 cattle advisory services in Schleswig-Holstein in 2019/2020; Source: LK SH 2020)

Results

Tab 2: Chosen Parameters with relevance to environment of the organic mixed-farm Lindhof in comparison to 3 different specialized dairy-farms of the same region (average of 2 years. abreviations ECM = Energiecorrected Milk. FA= Forage area on farm)

Parameter Dairy production including replacement	Unit	Organic mixed farm Lindhof	organic-low-input full grazing on permanent pasture	Intensive 80 days of grazing (conventional)	Intensive all year housed (conventionell)
Milk yield ECM	kg ECM/cow	6867	6060	9484	11817
Concentrates/cow/year	kg/cow	900	200	2400	3100
Milkproduktion per ha Forage Area on farm**	kg ECM/ha FA	10394	7420	11512	15817
Fodder Area needed to produce 1 kg ECM including production of concentrates	m^2/ kg ECM	1.3	1.4	1.2	1.2
N_2O -Emissiones per ha FA	kg N_2O/ha	1.5	2.3	7.8	6.2
Nitrat-N-leaching to the groundwater per ha FA	kg NO_3^--N/ha	9	16	48	25
Methane-Emission Manure storage	kg CO_2/ha FA	777	889	2491	3225
Soil-carbon sequestration	kg CO_2/ha FA	-2063	-1725	-1327	-891
N-Balance per ha FA (Milk + Heiffers)	kg N/ha	50	94	190	220
Carbon-Footprint (PCF) per kg ECM-h	kg CO_2 / kg ECM	0.63	0.92	1.22	1.08

(Source: Reinsch T. Loza C. Malisch CS. Vogeler I. Kluß C. Loges R. Taube F 2021. Toward Specialized or Integrated Systems in Northwest Europe: On-Farm Eco-Efficiency of Dairy Farming in Germany. Front. Sustain. Food Syst. 5. 614348. https://doi.org/10/gj68j4)

Conclusions

High milk yields at very low costs and almost no nitrate losses combined with increased yields of succeeding cereal crops show the capability of a rotational ley grazing systems to be economically competitive exhibiting simultaneously reduced environmental burdens.

The findings underline the strength of ruminant-based crop-livestock systems as a tool towards ecological intensification under the temperate conditions of Northern Germany.

(More results see last slide)

Thank you for your attention

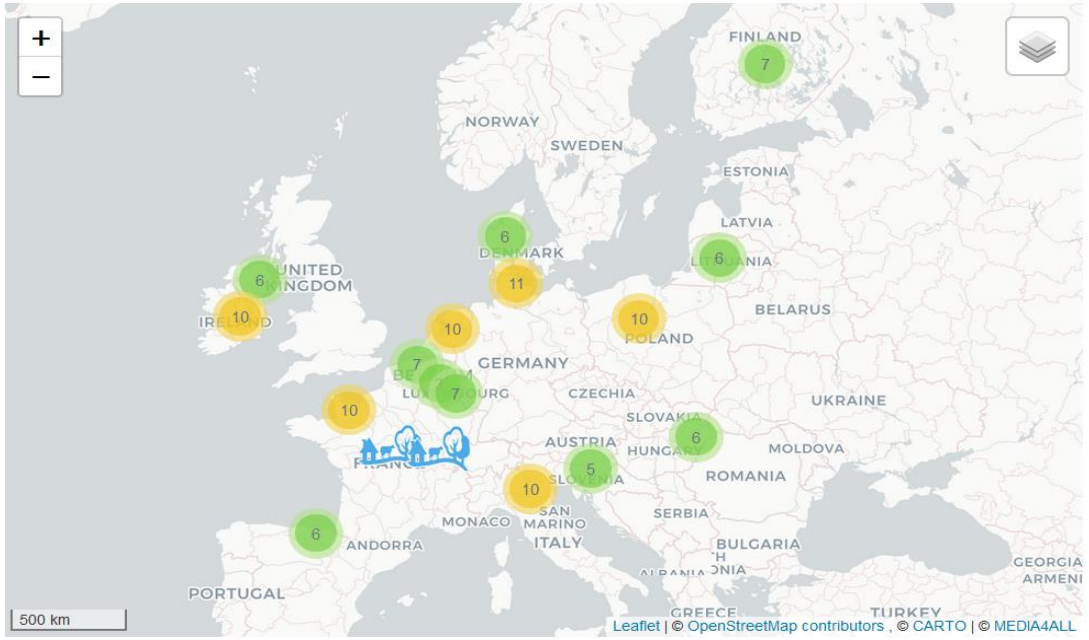
Fist day out on grass in early march 2022

Acknowledgements:

The authors like to thank the EU-Horizon-2020 Project: R4D: Resilience for Dairy (Grant agreement ID: 101000770) for supporting this study

R4D: The European network for sustainable milk production

R4D is an international network funded by the EU as part of the Horizon 2020 program that aims to promote the economic, social and environmental sustainability of the dairy industry in Europe. (https://resilience4dairy.eu/)



• Loza, C., Davis, H., Malisch, C., Taube, F., **Loges, R**., Magistrali, A., Butler, G., 2023. Milk Fatty Acids: The Impact of Grazing Diverse Pasture and the Potential to Predict Rumen-Derived Methane. Agriculture 13, 181. https://doi.org/10.3390/agriculture13010181
• Beye H, Taube F, Lange K, Hasler M, Kluß C, Loges R, Diekötter T 2022. Species-Enriched Grass-Clover Mixtures Can Promote Bumblebee Abundance Compared with Intensively Managed Conventional Pastures. *Agronomy*, 12 https://doi.org/10.3390/agronomy12051080
• Lorenz H, Reinsch T, Hess S, Taube F 2019. Is low-input dairy farming more climate friendly? A meta-analysis of the carbon footprints of different production systems *Journal of Cleaner Production* 211, 161–170. https://doi.org/10.1016/j.jclepro.2018.11.113
• Smit HPJ, Reinsch T, Kluß C, Loges R, Taube F 2021. Very Low Nitrogen Leaching in Grazed Ley-Arable-Systems n Northwest Europe. Agronomy. 11, 2155. https://doi.org/10.3390/agronomy11112155
• Reinsch T, Loza C, Malisch CS, Vogeler I, Kluß C, Loges R, Taube F 2021. Toward Specialized or Integrated Systems in Northwest Europe: On-Farm Eco-Efficiency of Dairy Farming in Germany. Front. Sustain. Food Syst. 5, 614348. https://doi.org/10/gj68j4
• Loza C, Reinsch T, Loges R, Taube F, Gere JI, Kluß C, Hasler M, Malisch CS 2021. Methane Emission and Milk Production from Jersey Cows Grazing Perennial Ryegrass–White Clover and Multispecies Forage Mixtures. Agriculture 11, 175. https://doi.org/10/gh4n97
• Nyameasem JK, Malisch CS, Loges R, Taube F, Kluß C, Vogeler I, Reinsch T, 2021. Nitrous Oxide Emission from Grazing Is Low across a Gradient of Plant Functional Diversity and Soil Conditions. Atmosphere 12, 223. https://doi.org/10.3390/atmos12020223
• Lorenz H, Reinsch T, Kluß C, Taube F, Loges R 2020. Does the Admixture of Forage Herbs Affect the Yield Performance, Yield Stability and Forage Quality of a Grass Clover Ley? Sustainability 12, 5842https://doi.org/10.3390/s
•Loges R, Bunne I, Reinsch T, Malisch CS, Kluß C, Herrmann A, Taube F. 2018. Forage production in rotational systems generates similar yields compared to maize monocultures but improves soil carbon stocks. European Journal of Agronomy 97, 11-19 10.1016/j.eja.2018.04.010

Resilience for Dairy (R4D) has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000770

Thank you for your attention