



ClieNFarms
Climate Neutral Farms

D6.3 First batch of 20 EIP-AGRI Practice Abstract

Due date of deliverable: M18 – 30 June 2023

Actual submission date: M18 – 30 June 2023



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036822

D6.3 First batch of 20 EIP-AGRI Practice Abstract

Author(s)/Organisation(s)	Dina Lopes, Joana Anjos (CONSULAI)
Contributor(s)	CRAW; BFH-HAFL; AGACAL; IDELE; IDELE; ACTA; Teagasc; UCSC; WR; AgResearch; NutriFarms; IBNA; GWCT; University of Leeds; Danone
Work Package	WP6
Due date of deliverable (DoA)	30 th June 2023
Actual Submission Date	30 th June 2023
Type of deliverable	R (Report)

Dissemination Level		
PU	Public	X
CO	Confidential, only for members of the consortium (including the EC)	

LEGAL NOTICE

The information and views set out in this application form are those of the author(s) and do not necessarily reflect the official opinion of the European Union. Neither the European Union institutions and bodies nor any person acting on their behalf may be held responsible for the use which may be made of the information contained therein.

Funding Scheme: Innovation Action (IA) • Topic: LC-GD-6-1-2020

Start date of project: 01 January 2022 • Duration: 48 months

© ClieNFarms Consortium, 2022.

How to cite this report:

D6.3 First batch of 20 EIP-AGRI Practice Abstract, ClieNFarms Consortium (EU-H2020 project GA n°101036822), 2023

Table of Contents

1	Introduction.....	5
1.1.	Purpose of the document.....	5
1.2.	Structure of the document.....	5
2	EIP-AGRI Practice Abstracts.....	7
2.1.	Reducing fertiliser application with a localised nitrogen fertilizer injection at seeding for arable crops	7
2.2.	Optimization of grassland management	8
2.3.	Pregnancy test in dairy cows to increase feed efficiency.....	9
2.4.	Reducing the age at first calving on beef farms	10
2.5.	Reducing the age at first calving.....	11
2.6.	Introducing cover crops in loamy soils	12
2.7.	Introducing grain legumes, such as pea crop, in the cropping systems to reduce the net greenhouse gas emissions.....	13
2.8.	Protected urea in the Irish pasture-based system	14
2.9.	White clover in the Irish pasture-based system.....	15
2.10.	Strip tillage combined with slurry/digestate fertilization	16
2.11.	Feed efficiency and N use efficiency of the herd are important key indicators on dairy farms	17
2.12.	Lower footprint farming at the Southern Dairy Hub.....	18
2.13.	Use of improved interrows on olive groves, as a solution to increase carbon sequestration .	19
2.14.	Double-purpose feeding strategy, by using local oilseeds by-products in order to mitigate GHG small ruminants' diets while gaining side-advantages.....	20
2.15.	Application of Biochar	21
2.16.	N2 slurry processing (a method of acidification)	22
2.17.	Crop rotation - Corn and mix of cereals (including legumes).....	24
2.18.	Innovative Systemic Solutions Space for Climate-Neutral Farms	25
2.19.	The Creative Arena Methodology	26
2.20.	Catalogue of farm-level solutions that can reduce climate impact of agricultural production systems in Europe.....	27
3	Conclusions and next steps	28

List of figures

Figure 1 : Banded nitrogen fertilization at seeding on sugar beets	7
Figure 2 : the frame with disks for the banded fertilization system assembled on an existing single seed drill.....	7
Figure 3: AGACAL staff taking samples in farm	9
Figure 4: Pregnancy test equipment	9
Figure 5 – Demonstration farm of the I3S in Lauragais, South of France.	12
Figure 6: Pea in vegetative period – to follow the agronomic key characteristic to ensure pea production. (B. Remurier, Terres Inovia ©)	13
Figure 7: Harvest of pea crops. (Terres Inovia ©)	13
Figure 8: Protected urea being spread on farm. Source: Teagasc.	14
Figure 9: Close up of protected urea. Source: Teagasc.....	14
Figure 10: White clover swards on an Irish pasture-based dairy farm. Source: Teagasc.....	15
Figure 11: Soybean sown under strip tillage after durum wheat.....	Erro! Marcador não definido.
Figure 12: Strip tillage with slurry injection and planting.	Erro! Marcador não definido.
Figure 13: Improved interrow on olive groves in the Demonstration Farm of the Portuguese I3S.....	19
Figure 14 – Biochar application.	21
Figure 15: The N2 unit at the University of Leeds farm showing from right to left: the raw slurry tank, separator, separated slurry tank, N2 unit and NEO storage tank.	22
Figure 16: Slurry application to winter wheat using dribble bars on the University of Leeds arable farm.	22
Figure 17: Mix of cereals including leguminous (AVEX).	24
Figure 18: Soil sampling with AGACAL.	24
Figure 19: Map of the I3S networks, its pedoclimatic regions and the partners in charge.	25

1 Introduction

1.1. About the ClieNFarms Innovation Action

Supporting the Farm to Fork (F2F) strategy, contributing to the achievement of its objectives, the ClieNFarms project aims to demonstrate, evaluate and improve technical, organisational and financial solutions at the farm level that will contribute to achieving climate-neutrality of European agriculture by 2050. This will be done by a multi-actor approach, interactively integrating and improving existing solutions to achieve economically viable business models in farming systems by involving farmers, extension services, agri-food business, policymakers, finance and citizens. These solutions will be disseminated, and young farmers will be targeted through capacity building.

The central operational focus of ClieNFarms is the case-study structure that will allow a strong empowerment of farmers and supply chain accompanied by a smooth dissemination and replication of the tested innovations. Called I3S (Innovative Systemic Solutions Space) the demonstration structure is based on demonstration farms, lead commercial farms, outreach farms and replicate farms working all together with the supply chain in a living-lab like structure approach.

ClieNFarms also intends to pave the way for combined biogeochemical (reduction in GHG missions, increase C storage) and biogeophysical effects (increase in surface albedo, reduction in sensible heat flux and infrared radiation) in order to mitigate climate change more efficiently, without any negative impacts for food security or yield/product quality.

The project is vastly innovative as aims to: (1) integrate different solutions to embrace mixed crop farming systems and animal production; (2) account for biogeophysical effects associated with changes in management practices in order to promote the synergies between the biogeochemical effects and the biogeophysical effects; (3) move from farm level to (eco)system level either through farm networks or by involving supply chains in a multi-actor designed process; (4) validate integrative solutions and to develop the required financial incentives to engage farmers in the required transition.

1.2. Purpose of the document

It is first important to explain what an EIP-AGRI Practice Abstract is. It's a summary in a common format to provide farmers, foresters, advisers or whoever is interested with short and concise practical information. As according to its website, *"The EIP-AGRI common format facilitates knowledge flows on innovative and practice-oriented projects from the start till the end of the project. The use of this format also enables farmers, advisors, researchers and all other actors across the EU to contact each other."*

In the case of the ClieNFarms project, the 18 of the 20 Practice Abstracts (PAs) presented below are about the solutions that are going to be tested in each I3S network. More specifically, explaining the solution, why it needs to be tested and what are the main benefits for the end-user if that solution is implemented.

The last three PAs that the ClieNFarms project has produced in this first batch are about three of the main outputs of the project, of which external stakeholders such as farmers, advisors, industry players, etc, can take part and benefit from. The concepts introduced are of the I3S networks, the Creative Arena methodology and the Catalogue of Solutions that is now available on the ClieNFarms [website](#).

1.3. Structure of the document

This document is structured in three major sections.

Section 1 introduces the objective of this document, as well as explaining the purpose of producing and disseminating EIP-AGRI Practice Abstracts.

Section 2 presents the 20 Practice Abstracts developed in the ClieNFarms project.

Section 3 is dedicated to the next steps of disseminating these PAs.

2 EIP-AGRI Practice Abstracts

2.1. Reducing fertiliser application with a localised nitrogen fertilizer injection at seeding for arable crops

Authors: Didier Stilman; Marie Collard

In terms of GHG emissions (both direct and indirect) and environmental impacts, reducing and optimizing nitrogen (N) fertilization is a key lever. To reach such a target, a localised injection of N under soil surface with or near the seed at sowing is a promising alternative commonly used in no-till or reduced-tillage systems. This technique has the advantages of securing N supply by avoiding loss through volatilization as well as through leaching and no runoff losses.

Moreover, it also has an impact on weeds management by fertilizing specifically the crop without fertilizing the whole soil, and thus feeding and strengthening weeds.

The N fertilizers 'placement is a trade-off between the best efficiency, the limitation of the risks of N toxicity, the N's form (liquid or solid) but also of mechanical and technical feasibility. Thus, different N fertilizers placements strategies exist in the same furrow as the seed; just below the seed line, between two lines either next to each line (6-8 cm depending on line spacing); or above the seed line.

Most of the single seed drills manufacturers have nowadays the equipment for this kind of fertilization. It represents an investment compensated by the savings in fertilizers. For localized fertilization with liquid N, the equipment can be limited to coulters or discs, the purchase of a tank and a distribution system.

On figure 1 and 2, a test of localised N fertilisation at seeding is being tested for sugar beets. Here, liquid nitrogen is injected near the seed line (6-7cm) at a narrow depth (4-5 cm). The frame with the discs (in red) for the fertilization system was assembled on an existing single seed drill (in blue). On sugar beets, this technique allows a reduction of N applied by 30% to 50% compared to the standard fertilization scheme (Legrand, G., & Vanstallen, M. 2000).



Figure 1 : Banded nitrogen fertilization at seeding on sugar beets



Figure 2 : the frame with disks for the banded fertilization system assembled on an existing single seed drill.

2.2. Optimization of grassland management

Authors: Jan Grenz, Anna Braun, Lin Bautze

Grassland-based dairy production is a mainstay of Swiss agriculture, as in other parts of Europe. Dairy farmers have since long been under economic pressure and now face political pressure to reduce methane and nitrous oxide emissions associated with milk production. This can lead them to abandon dairy production altogether and, depending on site conditions, convert grassland into arable land. Yet, grasslands have a high ecological value. They contribute to biodiversity preservation and water filtration. Carbon stocks under Swiss grassland sites were shown to amount to an average 80 tons C/ha in the top 20 cm alone, much more than under arable land¹.

Grassland management is now increasingly being optimized by measures such as (i) choosing site-adapted grass-legume mixtures, (ii) synchronising grazing with vegetation stages, (iii) judicious use of compensatory feed and (iv) keeping dual-purpose cows with high pasture suitability. Site-adapted packages of measures were shown to contribute to reduced greenhouse gas emissions and increased environmental efficiency. Several farms in the Swiss I3S have adopted some or all these measures, at different levels of intensity, from an organic mountain farm to intensive valley farms. Under suitable conditions (e. g. pasture areas close to the stable) and with appropriate processing and marketing, workload was reduced while economic revenue increased.

¹ Moll-Mielewicz J, Keel S and Gubler A. (2023). Organic carbon contents of mineral grassland soils in Switzerland over the last 30 years. *Agriculture, Ecosystems & Environment* 342. [108258. 10.1016/j.agee.2022.108258](https://doi.org/10.1016/j.agee.2022.108258).

2.3. Pregnancy test in dairy cows to increase feed efficiency

Authors: César Resch Zafra, Marcos Veiga, Adrián Botana, Laura González

Between 10 and 15% of dairy cows positive to pregnancy lose their calf between diagnosis and day 100 after positive fecundation day, this means in economics terms over 4,5 euros per cow and day lost.

Milk Pregnancy Test offers to farmers the possibility to check through milk if cows are in calf or not, this analyse is based on pregnancy associated glycoproteins in milk.

Every four months eleven lead commercial farms in Spain are visited and milk samples are taken in those cows that after veterinary revision are in calf (positives) and have less than 100 days after positive insemination. It is estimated that around 15% of dairy cows in milk fulfil these requirements.

In 24/48 hours, information of this no invasive pregnancy test is delivered to farmers and no intentionally open days on cows are avoided, with this information days in milk of herd are going to be shortened and feeding efficiency of herd improved².

Efficiency is key when regard to carbon emissions, when cows are beyond 300 days in milk their efficiency in terms of transforming dry matter into milk drops dramatically as show in graph.

Two visits were rendered so far, November 22 and March 23, 541 samples were taken and after being analysed 4.8% of cows that were supposed to be in calf were empty. Between these eleven farms dispersion of results is quite high in terms of results gap, with three farms where no empty cows were detected and two farms where empty cows were almost 20%.



Figure 3: AGACAL staff taking samples in farm



Figure 4: Pregnancy test equipment

² WCDS Advances in Dairy Technology (2006) Volume 18:19-28

2.4. Reducing the age at first calving on beef farms

Authors: Thomas Gontier, Jérémy Douhay

Reducing the age at first calving of heifers reduces the number of unproductive animals on the farm and thus reduces enteric methane emissions, which represent the main emissions on a beef farm.

In addition, the area freed up by less unproductive animals can increase the forage security of the farm, which is particularly interesting in a context of drought.

To succeed with this early calving, you must be careful to:

- adapting the feeding of young animals: having quality fodder and adapted LSU on grazing, but also adapting the intake of concentrates. The key point is to reserve for heifers the best forages and to the regrowth fields during grazing periods. Winter rations should have slightly higher energy densities than for calving at 36 months.
- monitoring the growth of the heifers: measuring the weight of the animals to reach a sufficient weight for breeding (70 % of adult weight),
- detection of heat and control of reproduction
- in beef system, the reduction of the age can be limited by the single period of calving in many farms.

And the classic age of calving at 36 months can only significantly be reduce to 30 months if there are two period of calving in the farm, with in that case one part a part of the herd with autumn calving season, and one part with spring calving season. And heifers of 30 months from one system are calving in the other one.

For example, Jalogny demonstration farm reduce the age at first calving by 6 months in 2024. There was until then two herds, on calving in autumn and one calving in spring, heifers of each one calving at 36 months. From 2024, heifers will calve at 30 months and heifers will switch from the autumn system to the spring system and vice versa.

2.5. Reducing the age at first calving

Author: Pauline Lambert

Reducing the age at first calving of heifers reduces the number of unproductive animals on the farm and thus reduces enteric methane emissions, which represent the main emissions on a dairy farm. In addition, the area freed up by less unproductive animals can increase the forage security of the farm, which is particularly interesting in a context of drought.

To succeed with this early calving, you must be careful to:

- adapting the feeding of young animals: having quality fodder and adapted LSU on grazing, but also adapting the intake of concentrates
- monitoring the growth of the heifers: measuring the weight of the animals
- detection of heat and control of reproduction

For example, Trevarez demonstration farm reduced the age at first calving by 2 months between the periods 2015-2017 and 2018-2020 thanks to a better growth of the heifers but also a better choice of the renewal heifers. Indeed, on this experimental farm, the age at first calving has been reduced from 27 to 25 months thanks to a ration consisting of unlimited hay, water and a concentrate based on faba bean and a barley pellet. The heifers are weaned at 100kg, which corresponds to 75 days of age in 2018. At the age of 6 months, the heifers weigh 200kg and it is from this moment that the grazing is maximized.

During the implementation of this action, the consumption of concentrates was certainly increased by 100kg, but this increase is compensated by a decrease of 660kg of dry matter of fodder needed thanks to 2 months of unproductive period less.

The implementation of this practice on experimental farm can be an example for commercial farms.

2.6. Introducing cover crops in loamy soils

Authors: Oscar Godin, Marie Estienne

In Lauragais (South-West of France), soils are often very loamy (with sometimes more than 40 % of loam). Therefore, there is no obligation to grow cover crops between two cash crops. However, cover crops are identified as an efficient way to store carbon in soils. Hence, their introduction can be complex as there is very few days during which the machines can work in the fields as they can easily become moist during autumn.

Depending on the choice of the grown species, it is possible to reduce the fertilizers doses of the cash crop following the cover crop: legumes like faba beans or phacelia are likely to spare about 40 units of nitrogen with a biomass of 2.5 tDM/ha.

In the demonstration farm of the I3S Lauragais, we experiment nearly permanent soil cover to reduce erosion and improve soil fertility. During long intercropping, between durum wheat et sunflower for example, we use 2 type of cover crop: a summer one with sorghum and moha and a winter one with faba bean and phacelia. The main achievement of this succession is that the covercrop is destroyed mechanically, without glyphosate. The summer crop is sown directly just after wheat harvest. The biomass is really depending on the weather. If it is more than 3 tDM/ha, the cover can be harvest as Energy catch crop. This opportunist summer catch crop come in replacement of the winter catch crop initially present in the rotation and which produce some negative effect on weed pest management without glyphosate and on water availability for the sorghum after.

In a similar situation, the introduction of cover crops on 77 ha in a farm of 177 ha involves an increase of costs of about 50 €/ha/year mainly because of the purchase of inputs and the cost of the machinery. As a result, the GHG emissions decrease of about 0.7 t CO₂ eq/ha due to the reduction of fertilisation and the storage of carbon in the soil.



Figure 5 – Demonstration farm of the I3S in Lauragais, South of France.

2.7. Introducing grain legumes, such as pea crop, in the cropping systems to reduce the net greenhouse gas emissions

Authors: Hugo Darombozi, Bastien Remurier, Mathieu Dulot, Anne Schneider

Growing more annual harvested grain legumes is one of the promising solutions for the arable sector for targeting to both the contribution to climate mitigation and local protein production.

In 2022, mitigation studies in the French systems of “Grand Est” have shown that this solution is a guaranteed improvement of farm carbon balance with an increase of 15 or 20% of areas in pea, faba bean or soya. The effect is higher when it is combined with an increase in cover crops proportion (before spring type legume or in short intercrop periods).

Legumes produce their own constitutive proteins thanks to the unique ability to fix atmospheric nitrogen through a symbiotic relationship with soil bacteria. The presence of harvested grain legumes in crop successions enables to reduce the application of nitrogen fertilizers, which are energy-intensive to produce and contribute to greenhouse gas emissions. There is indeed no application during the grain legume campaign and the absence of N₂O emissions has been confirmed in field measurements in French conditions under pea crop. Moreover, the following crop requests a reduced nitrogen application and have an increased yield.

This practice consists in the following steps, here in the case of pea for example:

- (i) Defining the best way to modify the initial crop succession for getting at least 15% increase for pea area in the system.
- (ii) Ensuring the best conditions for the pea sowing and cycle: to get the highest entry of renewable nitrogen and highest pea yield.
- (iii) Defining optimal technical practices for the following crop.

By including peas in crop rotations, farmers can reduce reliance on synthetic nitrogen fertilizers and make cost savings, improve soil health and biodiversity, diversify their crop production for system robustness over years and market opportunities.



Figure 6: Pea in vegetative period – to follow the agronomic key characteristic to ensure pea production. (B. Remurier, Terres Inovia ©)



Figure 7: Harvest of pea crops. (Terres Inovia ©)

2.8. Protected urea in the Irish pasture-based system

Authors: Deirdre Hennessy, Natasha Browne, Susan Moloney

In Ireland, the agriculture sector has been set a clear target in the Climate Action Plan to reduce greenhouse gas emissions by 25% by 2030, with the overall goal to be climate neutral by 2050. Protected urea has the potential to give the greatest and fastest reduction in greenhouse gas and ammonia emissions within grass-based agriculture. Protected urea fertiliser is urea that has been treated with a urease inhibitor, which can be coated on the outside of the fertiliser granule or incorporated into the urea granule melt during manufacturing. Both urea and protected urea fertilisers have 71% lower nitrous oxide emissions relative to calcium ammonium nitrate (CAN) fertiliser, however, protected urea fertiliser also reduces ammonia emissions by 78% compared to standard urea fertiliser. Reducing both ammonia and nitrous oxide losses, helps to reduce the impact of grass-based ruminant production systems on water and air quality. In Ireland, traditionally urea was used in spring, and CAN in summer and autumn.

An additional advantage of protected urea is that it can be spread at any time of the year. It works as effectively as standard urea fertiliser in damp spring conditions due to the inclusion of the urease inhibitor. In the summer protected urea releases nitrogen at a slower rate and more effectively than CAN.

Protected urea is cheaper than CAN on a per kg of N basis. Protected urea is still more expensive than standard urea on a per tonne basis, however, there is significantly greater N losses from standard urea. Protected urea will give the same effective N to the plant as standard urea at a 12% lower spreading rate.



Figure 8: Protected urea being spread on farm. Source: Teagasc.



Figure 9: Close up of protected urea. Source: Teagasc.

2.9. White clover in the Irish pasture-based system

Authors: Deirdre Hennessy, Natasha Browne, Susan Moloney

The first steps to mitigating nitrous oxide emissions from pasture-based ruminant production systems are establishing there are tools and options to reduce the amount of chemical nitrogen (N) used to produce herbage for livestock to graze. In Ireland, there are targets in place to reduce N fertilizer use by 25% by 2030. White clover is a legume species that fixes N from the atmosphere through biological nitrogen fixation making it available to the plant. This means that the quantity of chemical N required can be reduced and consequently nitrous oxide emissions can be reduced. Irish research shows that chemical N fertiliser application can be reduced by up to 40% in grass-white clover swards that have an average sward clover content of 20%, without negatively affecting herbage production. Reducing chemical N fertiliser application will reduce the carbon footprint of milk and meat products, as well as absolute emissions.

Compared to grass-only swards, Irish and international research shows that white clover leads to increased herbage quality, dairy cow dry matter intake, nitrogen use efficiency, milk production and live weight-gain. On dairy farms, grass-white clover swards have been reported to have increased net profit by €108-404/ha compared to grass-only swards due to reduced chemical N fertiliser use and increased milk solids production per cow. Therefore, clover is not only important for reducing emissions but also for increasing animal performance and profitability.

Establishment and persistency of white clover within the sward can be a challenge on farm. Farmers should have a plan in place to establish white clover in all paddocks over a five-year period using both re-seeding and over-sowing. Average annual sward clover content in each paddock should be at least 20%. To improve establishment, soil pH should be greater than 6.5 and a minimum soil index of 3 for P and K. Grazing management is also key for establishing white clover, the sward must be grazed tight in the first year to allow light to reach the base of the sward for stolon production. Care must also be taken to minimise the risk of bloat in paddocks with high clover content.



Figure 10: White clover swards on an Irish pasture-based dairy farm. Source: Teagasc.

2.10. Strip tillage combined with slurry/digestate fertilization

Author: Andrea Ferrarini

Strip Tillage is a tillage technology which works only on well-defined strips of soil. While the inter-row spacing remain nearly unchanged (Figure 11). The tilled strip is 20-25 cm wide and 8-30 cm depth while the inter-row spacing can vary from 45 to 75 cm. This tillage technology is suitable either for main row summer crops or for second crops in summer after winter crops. When to apply strip tillage depends on soil type. On fine-textured soils is advisable to apply strip tillage before winter while on coarse-textured soil in spring.

To get the best results with strip tillage it is necessary to combine fertilization with tillage. Fertilizing under the planting row has several agronomic, climate and economic advantages. Strip stillage is combined with slurry/digestate or mineral fertilizer injection before crop sowing.

Within ClieNFarms will be demonstrated with targeted strip till machineries that it is possible to plant and fertilizer with no yield losses by injecting liquid (biogas digestate) or slurry many cereal and horticultural crops (Figure 12). There are many options to combine the strip till machinery with fertilizer distribution (front fertilizer hopper, rear fertilizer hopper, self-propelled slurry tanker or umbilical drag hose system). To reduce processing times, it is also possible to combine strip tillage with planting (via trailed machine or via hydraulic lifter).

The economic and climate advantages of strip tillage are:



Figure 11: Soybean sown under strip tillage after durum wheat.

Less working Time -30/40% (compared to traditional processing: ploughing + harrowing + seedbed preparation);

1. Fuel consumptions reduced up to -60/70% (compared to traditional processing);
2. Reduced carbon footprint (GHG emissions relative to field operation);
3. Less machinery needed;
4. Reduction of maintenance operations;
5. Lower economic investment;
6. Efficient fertilizations (less fertilizer needed: - 20/30% N-P-K);
7. Faster execution (just one pass at 7-12 km/h).

The agronomic advantages are instead:

1. Soil structure improved (70% of soil untouched);
2. Less soil compaction (due to the less passes);
3. Increased soil organic matter and carbon;
4. Less surface evaporation;
5. More surface infiltration;
6. Less surface erosion (2/3 of the soil untouched);
7. More effective fertilization (precision farming);
8. Less soil degradation (fewer passages).



Figure 12: Strip tillage with slurry injection and planting.

2.11. Feed efficiency and N use efficiency of the herd are important key indicators on dairy farms

Authors: Jouke Oenema, Koos Verloop

For most dairy farms, feed efficiency (kg FPCM/kg DM intake) and N use efficiency of the herd (%) can provide useful information on the performance of the herd and as a basis for the gross margin (the market value of milk minus the cost of purchased feed). Therefore, it is important to include feed efficiency and N use efficiency of the herd in the analysis and discussion of the results with farmers. Milk yield per cow, number of young animals per cow, energy content of grass silage, proportion of maize in the ration and proportion of concentrated feed in the ration explain to a large extent the variation among farms in feed efficiency. These indicators are also important for the N use efficiency of the herd, together with the crude protein content of the feed ration.

A management that supports high N use efficiency of the herd is highly correlated with feed efficiency. Thus, the amount of feed taken up per litre of milk is higher on farms with a high N use efficiency. CH₄ emission not only depends on the characteristics of the feeds taken up but also from the amount of feed taken up by the cattle. The more feed passes the rumen of a cow the more CH₄ emission or the fewer feed is needed to produce a litre of milk the lower the CH₄ emission. Therefore, a management that focusses on an efficient turnover of feed (energy) into milk (products) also contributes to low CH₄ emission.

Improving feed efficiency reduces the methane emissions from enteric fermentation and improving N use efficiency of the herd reduces ammonia emission from stable and storage. In conclusion, feed efficiency and N use efficiencies of the herd are key indicator for the profitability and environmental performance of dairy farms.

2.12. Lower footprint farming at the Southern Dairy Hub

Author: Cecile de Klein

New Zealand dairy systems are characterised by year-round grazing, with Southern systems commonly wintering animals on a forage crop. The target outcomes of the farm systems' trials at the Southern Dairy Hub in New Zealand are to provide a range of farm system options that meet the future environmental (greenhouse gases and nutrient loss to water), animal welfare, public perception and profitability requirements for New Zealand Southern farmers³.

The farm systems' trial is funded and led by Dairy NZ⁴ and one of the proposed approaches being implemented is to optimise a **lower** intensity farming system with wintering on fodder beet and compare this with a standard intensity system with wintering on fodder beet. The **lower intensity** system has annual N fertiliser use reduced from ~180 kg N/ha to ~50 kg N/ha, and stocking rate reduced from 3 to 2.5 cows/ha, while the target per-cow milk production is increased from ~450 kg milk solids/cow to ~480 kg milk solids/cow.

The hypothesis is that, compared with the standard intensity system, the **lower intensity** system has a lower environmental footprint, while maintaining profitability. To test this hypothesis the following impacts will be assessed: animal performance and welfare, forage production and utilisation, profit, GHG emissions and losses to water.

³ https://www.southerndairyhub.co.nz/site_files/35476/upload_files/blog/SDHMarch2022handout.pdf?dl=1

⁴ <https://www.dairynz.co.nz/>

2.13. Use of improved interrows on olive groves, as a solution to increase carbon sequestration

Authors: Isabel Ribeiro, Ana Seabra

The maintenance of permanent inter-row cover with spontaneous vegetation is a common practice in modern olive groves in the Alentejo. However, the quantity and diversity of vegetation between the rows tends to degrade over the years. This is due to soil compaction by the repeated passage of machinery and actions of cutting the vegetation and destroying pruning wood before or during the flowering season. It is believed that maintaining cover vegetation between the rows of the olive grove can support soil and water conservation. As such, we decided to sow a biodiverse meadow in the inter-row to improve the quantity and quality of vegetation present and to support soil functions.

In a parcel of the Demonstration Farm Outeiro, it was sowed a seed mixture of legumes, grasses, umbelliferous and crucifers adapted to the soil and climate conditions of the site. Before sowing, the soil was tilled with disc harrow and chisel passes. The evolution of the improved inter-row will be compared with a control plot where the spontaneous inter-row is maintained. It's expected that implementing this measure will contribute to an increase in Carbon sequestration, improved soil structure and fertility and reduced losses by mineralization and erosion. Another expected outcome is the improvement of water infiltration into the soil, which consequently improves the transactability of machinery at times of the year when there is more humidity in the soil as well as improved biodiversity in the inter-row.



Figure 13: Improved interrow on olive groves in the Demonstration Farm of the Portuguese I3S.

2.14. Double-purpose feeding strategy, by using local oilseeds by-products in order to mitigate GHG small ruminants' diets while gaining side-advantages

Author: Catalin Dragomir

Increasing the proportion of dietary lipids has been reported to decrease the GHG emissions in ruminants (Alvarez-Hess et al, 2019; Vargas et al 2020). On the other hand, this feeding strategy is more specific to high productive animals, with high energy requirements and is less used within low-input production systems.

A common feed resource in some areas are the cakes resulting from the mechanical extraction of oils from various oilseeds, which contains various amounts of residual lipids, depending on the efficiency of the mechanical extraction. On the other hand, the farmers are reluctant using this feed resource, especially in case of minor oilseeds, which may contain active substances / plant secondary metabolites that can influence rumen metabolism of the milk production. On the other hand, addition of certain lipids in the diets is known to have the potential of altering the milk fatty acids profile.

Also, such feed resources are available on the feedstuffs market or can be cultivated by the farmers themselves. Situations where the oil processors retain the oils and deliver the cakes back to the farmers are not uncommon.

In this context there is a potential of promoting the use of oilseed cakes as a tool to reduce GHG emissions, based on the following drivers:

- they are available locally;
- they can replace a part of the dietary starch, thus compensating partly for their higher costs;
- they have the capacity to induce beneficial changes in milk composition, which is a base for the production of premium dairy products (which can be valorised in case of short-chain production systems);
- easiness of application (inclusion in goats' diets²²⁶ / multiplication.

The solution has to be tested in order to demonstrate the effects on the milk composition and the fact that the additional costs implied by the new feeding strategy can be recovered. It is a matter of optimisation between costs, GHG mitigation and targeted changes in fatty acids composition. A potential barrier is the rumen biohydrogenation of the unsaturated fatty acids and the less known side-effects of the use of minor oilseeds. Also, a too high proportion of dietary fats may impair the rumen fermentations.

2.15. Application of Biochar

Authors: Alastair Leake, Joe Stanley

Agriculture sits in a unique position in the economy, being not only an historic and current source of warming greenhouse gas emissions (GHGs) but also with the potential to act as a **GHG sink**, therefore acting as part of the solution to anthropogenic climate change. Such **greenhouse gas reduction (GGR) practices** come in both natural and novel forms. Natural forms include **carbon sequestration** via afforestation and the building of soil organic matter. Novel, technologically based forms include the application of biochar to farmed land.

Biochar is a carbon-rich substance produced from biomass (plant matter) which can be used to store carbon dioxide taken up from the air by plants. Biochar is created by a process called pyrolysis, where the biomass is heated to very high temperatures under low oxygen conditions.

Biochar can be produced from a wide range of feedstock materials, including some **waste materials** that have no other use, such as domestic green waste, agricultural and forestry residues. Biochar can potentially be applied to soils to sequester carbon for centuries, **removing carbon dioxide from the atmosphere**, and thereby not only helping achieve national climate & GGR targets but also potentially rapidly raising the **soil organic carbon** level of agricultural soils. It can also **improve the soil** by increasing pH of acidic soils, improving water and nutrient retention, and improving soil structure and workability. These can benefit a crop by improving productivity and **reducing carbon footprint**.

As part of the ClieNFarms project we will be assessing the impact of applying 10t/ha of biochar to direct drilled winter wheat. We will be assessing yield, soil emissions, herbicide efficacy and soil biology. If proven, this practice stands to be particularly beneficial where farmers can produce their own biochar on-site utilising their own organic materials, especially elements such as waste timber, hedge cuttings or crop residues which would otherwise be left to rot down. There is the added potential of generating valuable carbon credits in the pyrolysis process.



Figure 14 – Biochar application.

2.16. N2 slurry processing (a method of acidification)

Author: Judith Ford

The N2 slurry processor uses an electrically powered plasma torch to ionise air which is then passed through raw slurry where nitrogen is absorbed. The treated slurry (known as Nitrogen Enriched Organic fertiliser or NEO) has more available nitrogen and is more acidic than raw slurry. The ammonia and methane emissions from storing and spreading the slurry are reduced by the acidification. This also reduces the odour from slurry spreading which is an advantage for farm workers and neighbours.

Less NEO is needed than raw slurry to treat the same area of land thus reducing the cost of chemical fertiliser and reducing the GHG emissions from producing and transporting fertiliser to the farm.

A farm with a supply of renewable energy (from wind, solar or anaerobic digestion) could reduce fertiliser costs and reduce GHG emissions. However, the unit consumes a lot of electricity and without local renewable generation the process is unlikely to be cost effective, or to result in a net reduction of GHG emissions.

This solution is already used for cattle slurry and needs to be tested on a pig farm to understand: the technical performance of the N2 unit processing pig slurry, the energy use, the emissions from the slurry (methane and nitrous oxide), the reduction of chemical fertiliser use, the impact on crop yields, and the net impact on GHG emissions.

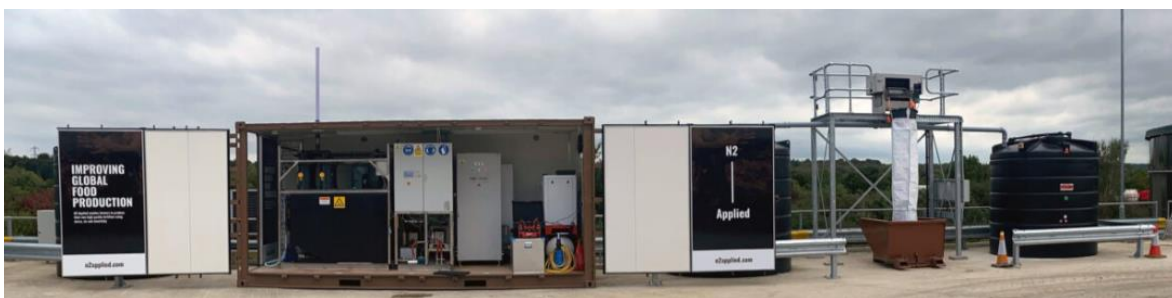


Figure 15: The N2 unit at the University of Leeds farm showing from right to left: the raw slurry tank, separator, separated slurry tank, N2 unit and NEO storage tank.



Figure 16: Slurry application to winter wheat using dribble bars on the University of Leeds arable farm.

2.17. Crop rotation - Corn and mix of cereals (including legumes).

Author: Jose Yagüe

Crop rotation is a key agriculture best practice that can have multiple benefits on farm, such as, improved soil health, biodiversity, and when combined with other practices such as no-till or low-till can improve soil carbon sequestration and reduce the farm's carbon footprint.

A farmer in the Spain I3S was originally rotating two types of crops, starting with a summer crop and later with a winter crop, usually rotating corn seeds and barley. The farmer then fertilised the land using their cows' manure and adding a considerable quantity of inorganic fertilisers every year.

The farmer's approach was assessed by external experts in crop solutions, who proposed cultivating the crops using a new approach. The farm is now sowing 2 types of seeds mix, instead of just sowing barley. The farmer now has 105 ha with a mix called AVEX (Oat strigose or Black Oat, Annual Clovers, Vetches and Ray-grass) and 30 ha with a second mix of seeds called CMIX (Hybrid Barley, Annual Clovers, Vetches and Ray-grass) and is rotating both with corn.

The weather conditions in Catalonia (North-East of Spain) are becoming increasingly challenging and are characterised by intensive heat waves in the summer, very cold winters and droughts, which were the regular conditions for the last two to three years. Additionally, the crops on this farm are grown without irrigation, and are dependent on erratic rainfall. Therefore, it was important to select a resistant combination of seeds and to improve soil health.

Adopting this approach, using these 2 mixes of seeds with legumes, had multiple benefits:

- Reduced the need for using inorganic fertilisation;
- The forage obtained is more digestible;
- The later corn planting is done in better soil conditions, due to the presence of additional Nitrogen fixed by the previous crop.

We also expect to see a progressive increase in the soil organic matter content, and we will assess this at the end of the project.



Figure 17: Mix of cereals including leguminous (AVEX).



Figure 18: Soil sampling with AGACAL.

2.18. Innovative Systemic Solutions Space for Climate-Neutral Farms

Author: Joana Anjos

ClieNFarms is an EU-funded project supporting the European Green Deal, focused on developing climate-neutral and climate-resilient sustainable farms.

Through the use of its demonstrative approach, ClieNFarms aims to boost the adoption of sustainable practices and agricultural knowledge transfer. This case-study structure will empower farmers and support the smooth dissemination and replication of tested innovations. These are called the I3S (Innovative Systemic Solutions Space), a network of twenty case-studies (crops, cattle, dairy, special crop productions, sheep, and pigs) where systemic innovative solutions will be tested and evaluated using up-to-date modelling approaches and multicriteria assessment tools. By being part of this network, farmers can assess the feasibility and effectiveness of different innovative solutions specific to their production systems and geographical areas. This enables them to make well-informed choices regarding organizational, technical, and financial aspects, fostering the development of sustainable farming practices.

Over the course of the project, different events in each I3S will be organised, facilitating the adoption of the chosen solutions by a wider network of practitioners in each region, and fostering knowledge exchange within the agricultural sector.

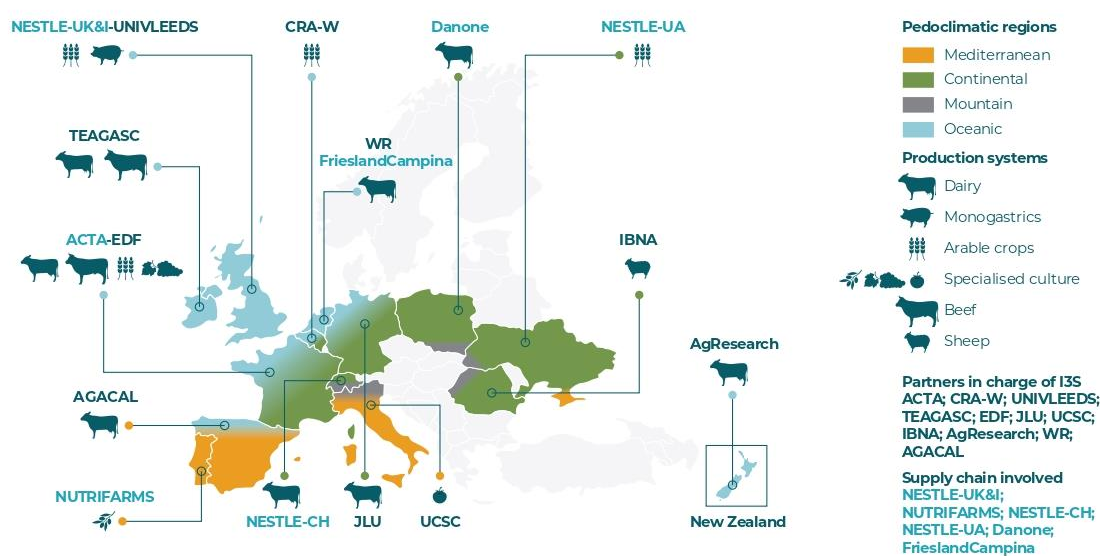


Figure 19: Map of the I3S networks, its pedoclimatic regions and the partners in charge.

2.19. The Creative Arena Methodology

Author: Joana Anjos

The Creative Arena methodology developed by the ClieNFarms project is an innovative approach that aims to co-develop and scale systemic solutions for climate-neutral, climate-resilient farms in Europe. It follows the Innovative Systemic Solution Space (I3S) concept, integrating components to test and disseminate tailored multi-actor solutions.



Through a set of steps, the methodology ensures shared solutions and empowerment of farmers towards the concept of climate-neutral farming. Furthermore, it benefits practitioners, offering added value by identifying technical, organizational, and financial solutions for climate neutrality, guiding economically viable business models, while considering pedoclimatic conditions, resource availability, and constraints specific to each farm. It also fosters engagement and collaboration among the value-chain ecosystem, providing opportunities for networking, knowledge exchange, and capacity building. The results obtained through the Creative Arena methodology can be utilized by practitioners to make informed decisions regarding investments in specific equipment, strengthen collaborative proposals, and improve the overall efficiency and resilience of their farming systems.

Figure 20: the first creative arena in Ireland

2.20. Catalogue of farm-level solutions that can reduce climate impact of agricultural production systems in Europe

Author: Joana Anjos

For which type of agricultural system would like to search climate solutions?



Figure 21: snapshot of the catalog on the website of the project

The Catalogue of solutions by the ClieNFarms project, an Innovation Action funded by the EU, is a practical repository supporting the transition to climate-neutral farming. It offers a range of solutions that are being tested and evaluated through the project's I3S networks.

By utilizing the Catalogue, end-users such as farmer and advisors, gain valuable information and resources. It provides solutions addressing organizational, technical, and financial aspects,

empowering farmers to make informed decisions that can reduce emissions and enhance climate resilience.

Additionally, the catalogue serves as a knowledge-sharing platform, fostering knowledge exchange and facilitating collaboration among stakeholders in the agricultural sector. Practitioners can explore and learn from the experiences and successes of others who have implemented the solutions documented in the catalogue. This promotes the dissemination of best practices and encourages the adoption of innovative approaches to farming.

In summary, the ClieNFarms project's Solutions Catalogue offers a valuable resource for practitioners seeking innovative approaches to climate-neutral farming. It provides systemic solutions, fosters knowledge exchange, and promotes collaboration. Utilizing this catalogue enhances decision-making, explores entrepreneurial opportunities, and contributes to sustainable and resilient practices.

3 Conclusions and next steps

In the current timing, the [EIP-AGRI platform](#) as it was formerly known is no longer available, due to now being a part of the [EU CAP Network](#). Because of this, the new platform is still under construction and therefore it will not be possible for the PAs to be readily available in this platform. CONSULAI, as the responsible partner for the production of the PAs, has already contact the entity responsible to streamline its publication. Furthermore, and to ensure a wider dissemination of this abstracts, they will also be added to the ClieNFarms website in a dedicated section.

The next batch of Practice Abstracts is due in M42, as part of the D6.4 Second batch of 20 EIP-AGRI Practice Abstracts and will present the latest outputs of the project.