Integrating agroforestry into an innovative mixed crop-dairy system

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• context: the OasYs system
• agroforestry practices tested in OasYs
• conclusion and perspectives
OasYS: an innovative mixed crop-dairy system based on agroecological principles

designed through a collaborative approach

Main objectives of this new dairy cattle system:
• to permit farmers to live from milk production
• in a context of climatic hazards
• while saving water and fossil energy resources
• and contributing to a sustainable agriculture
An agroecological approach to valorise natural resources all the spatial and temporal dimensions

**Vegetal**

Diversified forage resources

- Diversification of plants species, cultivars, mixtures
- Multilayer cropping agroforestry
- Long crop rotations
- Drought-adapted crops
- Large use of legumes

**Animal**

Productive and robust herd

- Priority to grazing 1 entirely grazed crop rotation
- 2 calving periods
- Extension of lactation length + of cow lifetime performance
- 3-way cross-breeding Holstein Scandinavian Red Jersey

**Recycling of effluents**

Dual purpose crops
the increase of diversity in a dairy production system allows to conciliate good production levels and high environmental performance and to improve the resilience of the whole system.

OasYS

A long-term system experiment

• implemented since June 2013 at an INRA facility
• 90 ha of temporary grasslands and annual crops
• 72 dairy cows (+ heifers)
• oceanic climate with summer droughts

The hypothesis tested
Why to integrate agroforestry into dairy farming?

To diversify forage resources
To contribute to fodder autonomy and cattle welfare in a context of climate change

To mitigate climate change
To valorise and protect natural resources (soil, biodiversity, water)

To strengthen the financial capital of the
To create an original landscape
How to integrate agroforestry into dairy farming?

**Alley cropping agroforestry**
- High stem trees
- Pollards to be browsed
- Fodder liana

**Boundary hedgerows**
- Wood or groves of trees
How to integrate agroforestry into dairy farming?

**Alley cropping agroforestry**

- High stem trees
- Pollards to be browsed
- Fodder liana

**Objectives:**
- to test and evaluate AF practices at field scale and on the long term
- to determine coherent ways of integrating AF in a productive dairy cattle farm.
How to integrate agroforestry into dairy farming?

Alley cropping agroforestry on 3 grazed paddocks
Focus on paddocks with fodder trees and lianas

In 2015-16

Totally grazed crop rotation

to address the shortage of grass in summer and winter

Millet + Alexandrian clover
Chicory
Fodder beet
Cereal-legume mixtures
Trees are protected against livestock by an electric fence (single line).

Effect of:
• tree species (4)
• management mode: extensive vs intensive browsing of trees

Fodder trees: future pollards to be browsed
Fodder trees: future pollards to be browsed

M2: a paddock of 3.1 ha, 204 trees planted in Feb. 2014

Control without trees 0.9 ha

Block 1

Block 2

36 m

20 m

200 m

302 m

82 m

96 m

2 m high pollard

1 m high pollard
Fodder trees: future pollards to be browsed

pollarded to increase the foliar biomass

Objectives: to be browsed during periods of low grassland production (summer and autumn).

Objective: to provide shade

Alnus cordata  Ulmus minor  Morus alba  Fraxinus excelsior  Quercus ilex
Fodder trees: future pollards to be browsed

Control without trees

Row 1: Fe, Fe, Fe, Fe, Fe, Fe, Fe, Fe, Qi, Qi, Um, Um, Um, Um, Um, Um, Fe, Fe, Ac, Ac, Ac, Ac, Ac, Ac, Ac, Qi
Row 2: Qi, Ma, Ma, Ma, Ma, Ma, Ma, Ma, Fe, Ac, Ac, Ac, Ac, Ac, Ac, Ac, Qi, Fe, Fe, Fe, Fe, Fe, Fe, Fe, Fe, Fe
Row 3: Fe, Um, Um, Um, Um, Um, Um, Um, Qi, Fe, Fe, Fe, Fe, Fe, Fe, Fe, Fe, Fe, Fe, Fe, Fe, Fe, Fe, Fe, Fe, Fe
Row 4: Qi, Ac, Ac, Ac, Ac, Ac, Ac, Ac, Qi, Fe, Ma, Ma, Ma, Ma, Ma, Ma, Ma, Qi, Um, Um, Um, Um, Um, Um, Um, Fe

2-m pollard: ash (Fe), evergreen oak (Qi)
1-m pollard: ash (Fe), field elm (Um), Italian alder (Ac), white mulberry (Ma)
Fodder trees: future pollards to be browsed

Trees planted in February 2014 => pollarded in 2019?

Study of:
- tree growth
- pasture production
- soil fertility
- biodiversity

Species:
- Alnus cordata
- Ulmus minor
- Morus alba
- Fraxinus excelsior
- Quercus ilex
Fodder lianas: vine rootstocks

Effect of:
• vine rootstock: Paulsen 1103 or Gravessac
• support structure: 2 modes of trellis (partial or total)
• management mode: extensive vs intensive browsing of vine

Vine rootstocks are protected from livestock by an electric fence (single line).
Fodder lianas: vine rootstocks

M3: a paddock of 3.3 ha
1160 vine seedlings planted in April 2015

Block 1
104 m

Block 2
104 m

84 m

3 replicates of each module

Gravessac - partial trellis
Gravessac - total trellis
Paulsen 1103 - partial trellis
Paulsen 1103 - total trellis

Control without vine 0.9 ha
**Fodder lianas: vine rootstocks**

1 module: a double row of vine (1 rootstock)
- 48 vine seedlings
- 15 wood poles

**Partial trellis:** 1 m high metal trellis + 1 wire
**Fodder lianas: vine rootstocks**

1 module: a double row of vine (1 rootstock)
- 48 vine seedlings
- 15 wood poles

**total trellis**: 1 m high metal trellis x 2
Fodder lianas: vine rootstocks

Browsing of the vine in 2017 or 2018?
Focus on a plot with multipurpose trees

• an agroforestry demonstration plot for dairy farmers
• resulting from a collaborative design with stakeholders
• AgForward FP7 research project

How in practice to establish a profitable AF system with ruminants?

Nutritive value of trees and shrubs?

How to protect young trees from livestock?

Which spatial organization of trees:

to optimise forage production, tree production and animal welfare
while limiting the load and complexity of work
Focus on a plot with multipurpose trees

Mainly grazed crop rotation

In 2015-16
Focus on a plot with multipurpose trees

**Effect of spatial organization**

- **S** single row set
- **D** double row set
- **T** triple row set

**G14**: a paddock of 3 ha
598 trees planted in Feb. 2015

North

control without trees
0.9 ha

Grazed

Ungrazed
Focus on a plot with multipurpose trees

Diversification of tree uses

High stem trees: pear, honey locust, service tree
*Pyrus communis, Gleditsia triacanthos, Sorbus domestica*

To provide: timber, fuelwood, wood chips (litter - soil amendment), shade, fodder

Pollards: white mulberry, Italian alder
*Morus alba, Alnus cordata*

To provide: fodder, wood chips (litter - soil amendment), timber, fuelwood

Coppiced trees: goat willow, field elm, black locust, grey alder
*Salix caprea, Ulmus minor, Robinia pseudoacacia, Alnus incana*

+ liana, fodder hedge: to be determined

To provide: fodder, wood chips (litter - soil amendment)
Focus on a plot with multipurpose trees

High stem tree
Pollard
Coppiced tree

S  single row set  2 m  4 m  1.3 m
D  double row set  6 m
T  triple row set  10 m

Effect of spatial organization

Pollard
Coppiced tree

M  s  s  P  o  o  M  r  r  M  b  b  M  s  o  F  s  s  A  o  o  A  r  r  A  b  b  A

A  A  P  A  A  M  F  M  M  M
A  A  A  A  C  M  M  M  M  P  M
A  A  A  A  C  M  M  M  M  P  M

M  s  s  o  o  M  r  r  b  b  b  b  r  b  s  s  s  C  o  o  o  r  r  b  b  b

s  s  s  o  o  r  r  b  b  b  b  b  P  s  s  s  g  o  o  o  s  o  r  r  s  o  F  b  b  b

A  A  A  A  C  M  M  M  M  P  M
A  A  A  A  C  M  M  M  M  P  M
A  A  A  A  C  M  M  M  M  P  M

M  s  s  o  o  r  r  b  b  b  b  s  o  r  b  s  s  s  o  o  o  s  o  r  r  b  b  b

s  s  s  o  o  o  r  r  b  b  b  b  P  s  s  s  o  o  o  r  r  r  s  o  F  b  b  b

A  A  A  A  C  M  M  M  M  P  M
A  A  A  A  C  M  M  M  M  P  M
A  A  A  A  C  M  M  M  M  P  M

M  s  s  o  o  r  r  b  b  b  b  s  o  r  b  s  s  s  o  o  o  s  o  r  r  b  b  b

s  s  s  o  o  r  r  b  b  b  b  b  P  s  s  s  o  o  o  r  r  r  s  o  F  b  b  b

M  s  s  o  o  r  r  b  b  b  b  s  o  r  b  s  s  s  o  o  o  s  o  r  r  b  b  b

M  P  M  M  M  M  F  A  A  A  A

s  s  s  o  o  r  r  b  b  b  b  s  o  r  b  s  s  s  o  o  o  s  o  r  r  b  b  b

s  s  s  o  o  o  r  r  b  b  b  b  P  s  s  s  o  o  o  r  r  r  s  o  F  b  b  b

M  P  M  M  M  M  F  A  A  A  A

fodder&hedge  fodder&hedge  fodder&hedge  fodder&hedge  fodder&hedge
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Focus on a plot with multipurpose trees

Six types of protection from cattle:

- No protection: ungrazed
- Electric fence
- Electric fencing tape
- Metal fence
- Olfactory repellent:
- Plastic fence
Nutritive value of fodder trees

protein and fibre content

in vitro digestibility

effective ruminal degradability
Conclusion and perspectives

• agroforestry is a very new practice for dairy farmers offers many promising possibilities

• several agroforestry systems can be profitable for dairy cattle farmers, depending on their objectives
• they need to be documented and evaluated at field and farm scale with a multicriteria assessment