Genetic diversity for agroecology and adaptation to climate change in a mixed crop-dairy system

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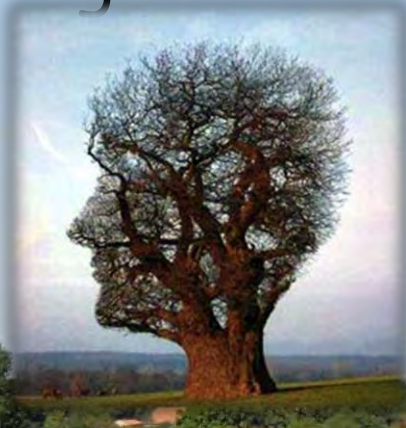
Oasys

an agroecological dairy system adapted to climate change

An innovative system, breaking from existing systems

experimented at the farm-scale = system experiment



Main objectives of this new dairy cattle system:

- to permit farmers to live from their dairy system
- in a context of climate change
- 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

Plant ⟷ Animal

Diversified forage resources ⟷ **Productive and robust herd**

Diversification of plants
species, cultivars, mixtures

Multilayer cropping
agroforestry

Long crop rotations

Drought-adapted crops

Large use of legumes

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

Main innovations of the system

To diversify

species, cultivars, mixtures

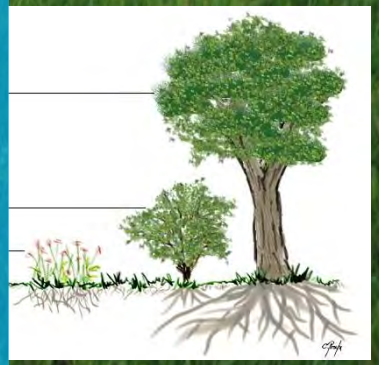
breeds, calving periods

functions

Hypothesis: 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

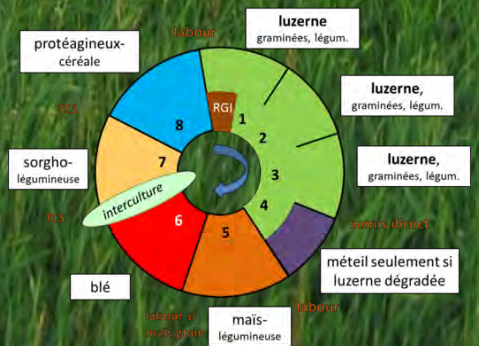
To valorise all dimensions

vertical 3D



Time 4D

crop rotation



cow lifetime

Oasys

A long-term system experiment

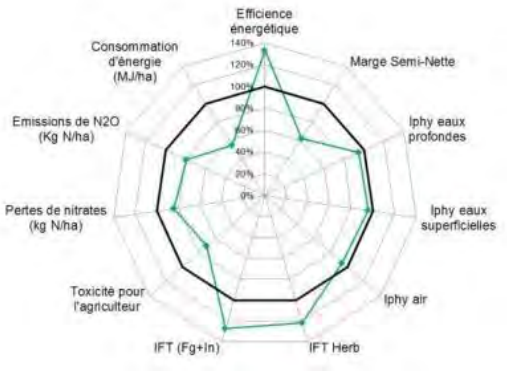
- implemented since June 2013 at an INRAE facility
- 90 ha of temporary grasslands and annual crops
- 72 dairy cows (+ heifers)
- oceanic climate with summer droughts
- deep soils (loamy clay)

A low-input system

- No irrigation
- < 350 kg concentrates/cow/year
- < 5 kg mineral N /ha
- Pesticide treatment frequency index < 0.5 (out of grasslands)
- Forage self-suffiency

Multicriteria assessment at the farm level

A lot of data available regarding:



- **weather and agricultural practices**
- **agronomic** and **zootechnical performances**
  - crops yield and quality
  - grazing practices
  - daily feeding amount and individual milk production and quality
  - cattle conformation, reproduction, health
- **environment:**
  - water and energy consumptions,
  - biodiversity (pollinators, flora, weeds, avifauna, lepidoptera, odonata, amphibians, reptiles)
  - soil fertility (physico-chemical properties, earthworms, nematodes, enzymes)
- **economic** data: costs, incomes, subsidies

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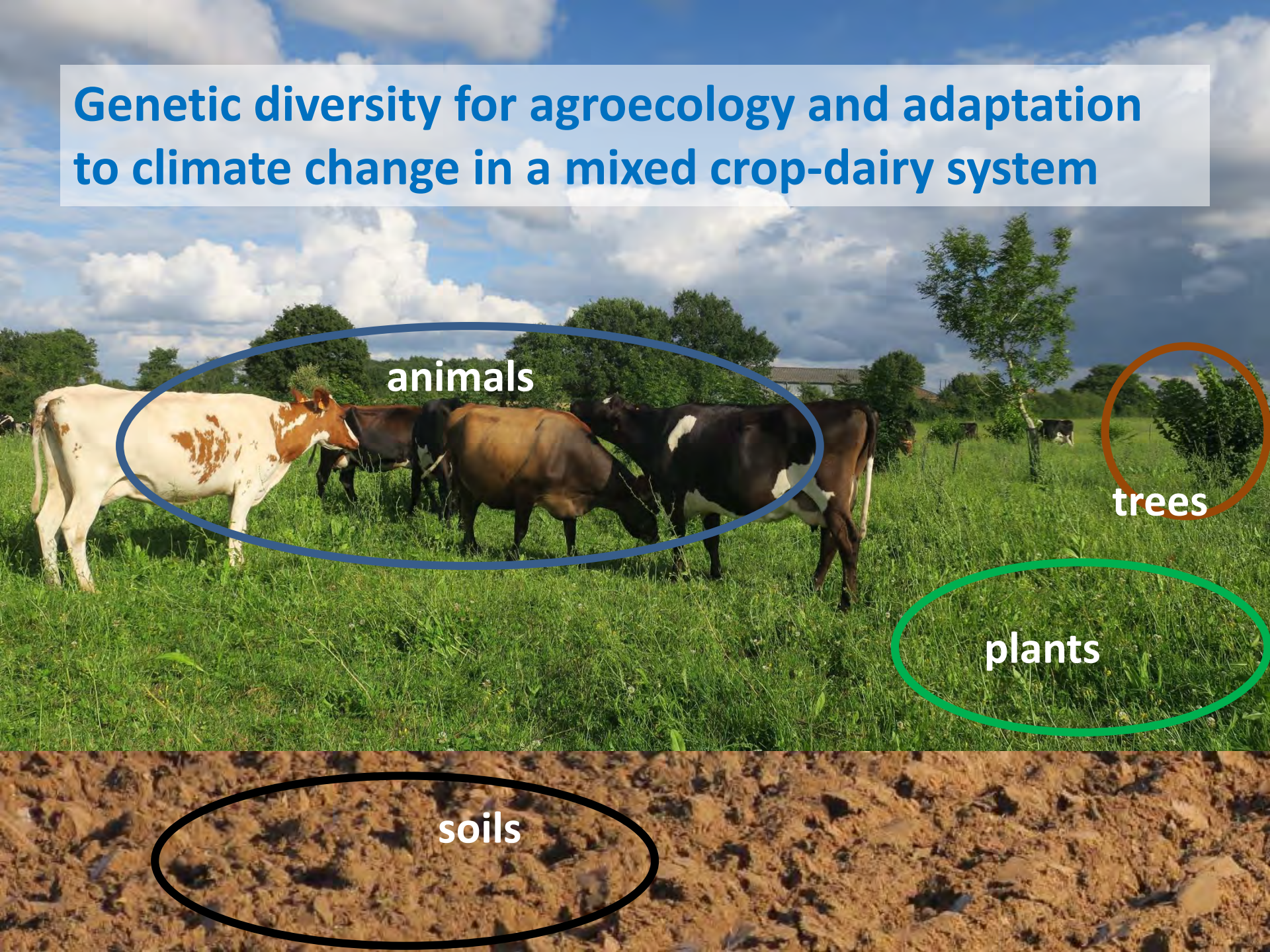


Genetic diversity in the dairy herd

3-breed rotational crossing to valorise heterosis

- Ho = **Holstein**	production, sensitivity
- SR = **Scandinavian Red**	reproduction, production
- Je = **Jersey**	reproduction, robustness, size, heat stress, solid content

Crossbreeding in OasYs

2013

2014

2016

2018

Holstein ♀

♂ SR ♂ Je

F1 Ho x SR ♀ Ho x Je

♂ Je ♂ SR

G2 (Ho x SR) x Je ♀ (Ho x Je) x SR

♂ Ho ♂ Ho

G3 ((Ho x SR) x Je) x Ho ♀ ((Ho x Je) x SR) x Ho

Ho = Holstein

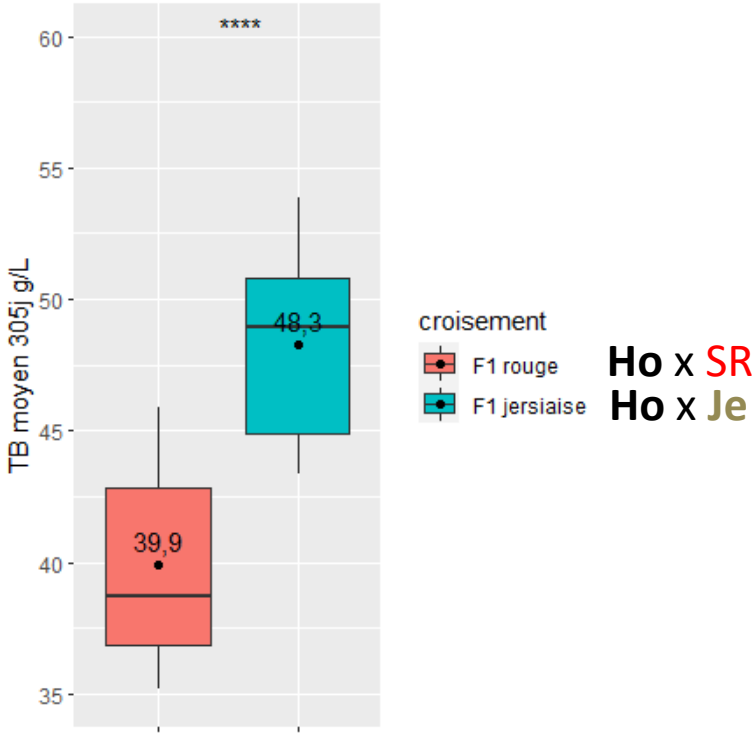
Je = Jersey

SR = Scandinavian Red

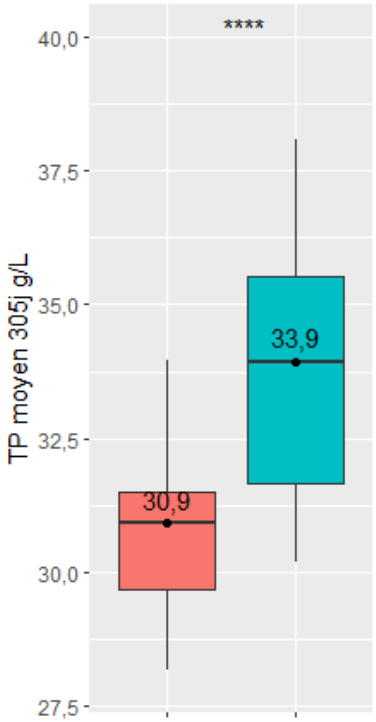
A dairy herd more adapted to the grazing of diversified resources and to climate change, less sensitive to diseases and with a good reproduction to limit unproductive animals.

First results on milk production (F1)

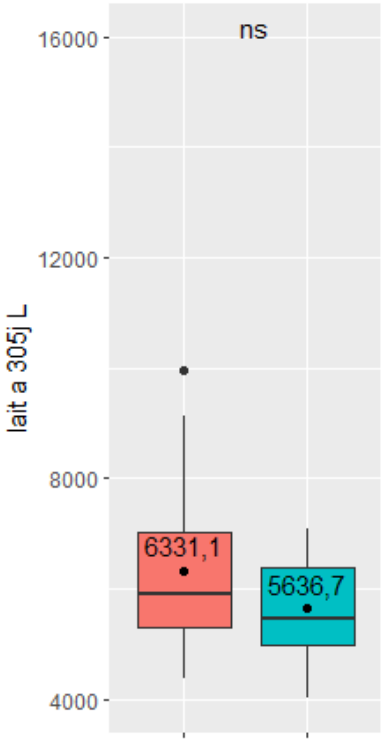
Mean fat content (g/L) on 305 d



Mean protein content (g/L) on 305 d)



Milk produced (L) on 305 d



Link with the @BRIDGe platform (INRAE): Animal Biological Resources for Integrated and Digital Genomics

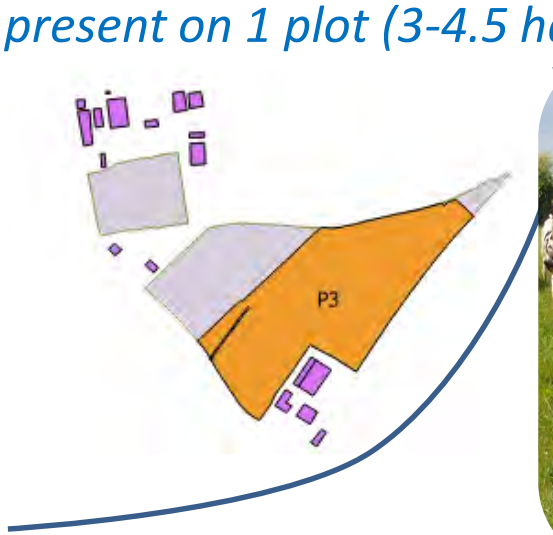
Storage of DNA from all our crossed dairy cows

Long-term storage, available to scientists

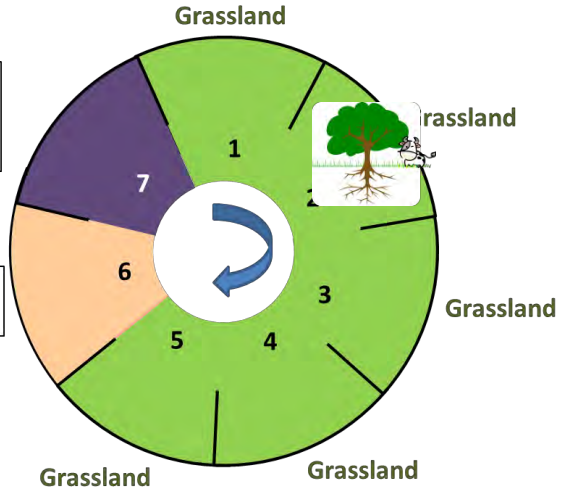
Genetic diversity in crops and grasslands

Each year of the rotation is present on 1 plot (3-4.5 ha)

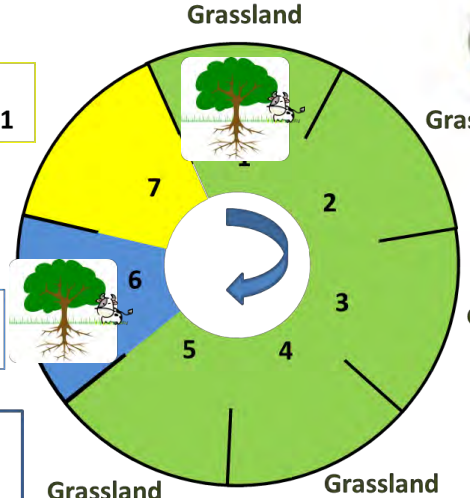
OasYs : 90 ha



Mainly grazed crop rotation



Totally grazed crop rotation



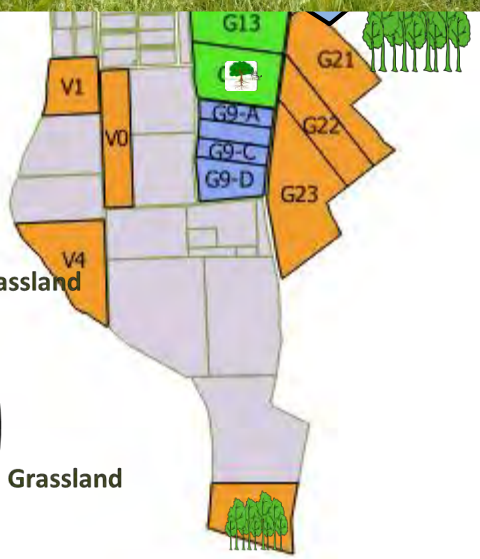
Grazed annual forage crop 1

to address the shortage of grass in summer and winter

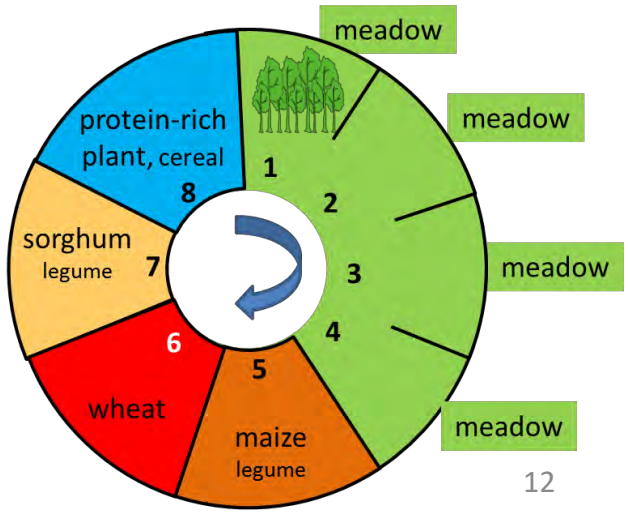
Grazed annual forage crop 2

Millet +
Alexandrian clover
Chicory

Fodder beet
Cereal-legume mixtures



Ungrazed crop rotation



Other rotations

Genetic diversity in crops and grasslands

to be less sensitive to hazards or diseases

5 cultivars of *Sorghum bicolor* differing by their height and earliness.
Phoenix, Arigato, Master, Little Giant, Big Dragoon

2 cultivars of tall fescue (*Festuca arundinacea*) *Romie and Iliade*
in a multispecies grassland of lucerne, white clover, plantain + oat

No link with BRC:
use of commercial seeds
no design of new cultivars?

Genetic diversity of trees

Genetic diversity of trees fodder trees (pollarded)

not been chosen

White mulberry *Morus alba*

Seedlings came from a commercial tree nursery.
We observed a great variability in the shape of leaves and production levels.
We do not know / study their genetic diversity.
This could influence their palatability, nutritive value.

No link with BRC, because no BRC exists on this thematic

Genetic diversity of trees timber trees

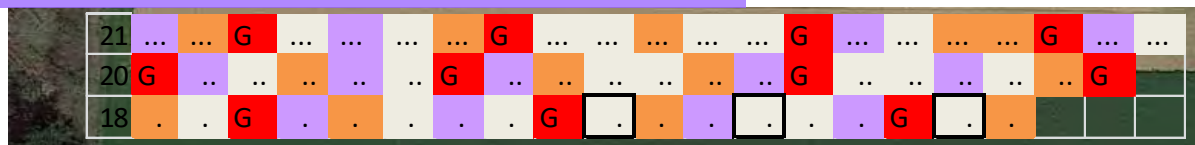
Merisier Triploïdes 295 ... .. .
Merisier Triploïdes 287 .
Cormier ... .. .
Alisier ... .. .
G
Control merisier Gardeline

Wild cherry *Prunus avium* (2 progenies)

Service tree *Sorbus domestica*

Wild service tree *Sorbus torminalis*

300 trees planted in Feb. 2014 on 3 ha



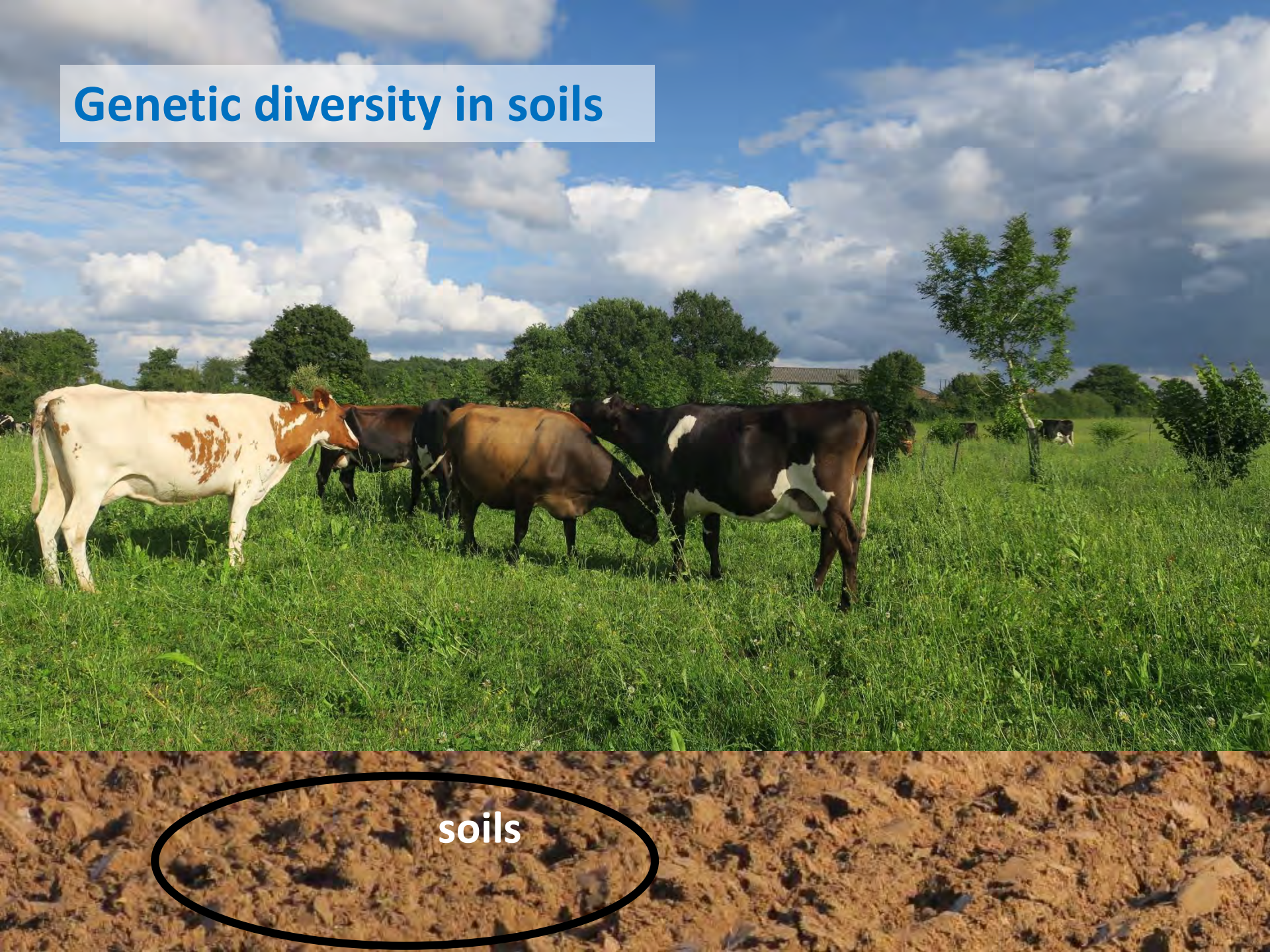
1, 2 or 3 seedling per planting location

control without trees

forestry control plot

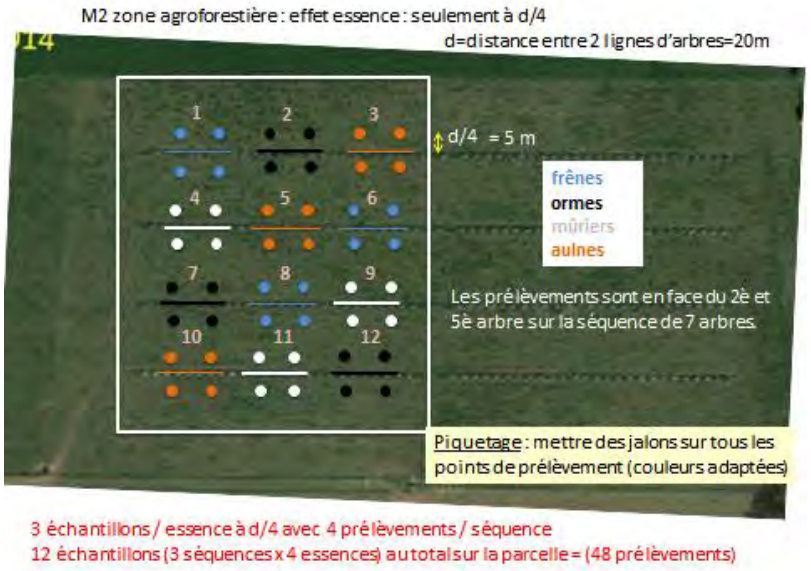
Link with BRC ? cf Frédérique Santi presentation !

Genetic diversity in soils



Genetic diversity of soil microorganisms

Soil samples from 3 grazed paddocks and 3 plots from the ungrazed crop rotation
Include 2 agroforestry plots / 6
Collected in 2016 and 2021.



Link with the **Platform GenoSol** (INRAE) : **conservation** of Microbial Genetic Resources, *a Technical Platform for molecular characterization of the microbial meta genome and an Information System on soil and environmental microbial diversity*
Long-term storage, available to scientists.

Conclusion and perspectives

- Genetic diversity is used in OasYs to **enhance resilience to hazards** (diseases, pests, climate events, …) in the context of a **low-input farming system** (less pesticides, concentrates, N fertilisers and veterinary products).

- Our **long-term** agroecological system potentially generates genetic diversity in soils (microorganisms) and in grass species.

- Our **actual links with BRC**s are:
  - mainly relative to animal and soil microorganisms genetics
  - to **store on the long-term** the biological ressources generated by our system

- These resources are **available for scientists** to better study the processes linking genetic variability, agroecology and adaptation to climate change.

Oasys

Many thanks for your attention !

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