TRUFFLES CULTIVATION : HISTORY, TECHNOLOGY, CHALENGES

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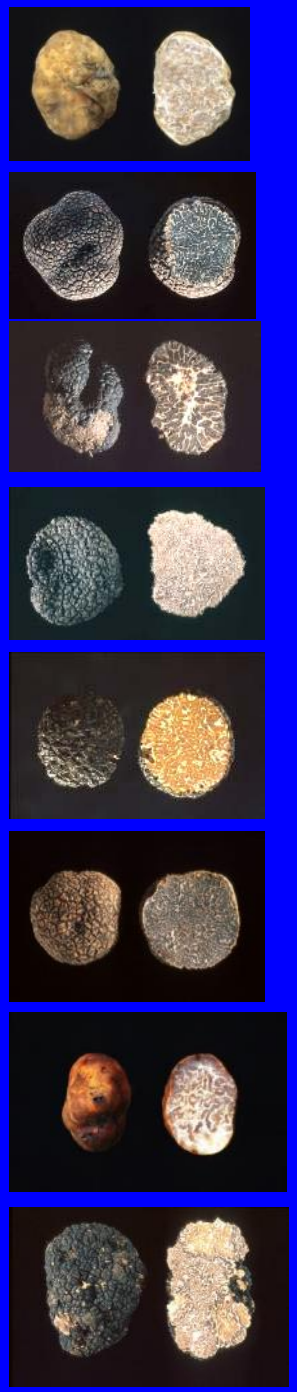
Applying Old World Research and Knowledge to New World Truffle Production.

I added knowledge to research. Indeed, we cannot understand the needs of research if we do not have an idea of the state of knowledge. The history of truffle production in France is very important to know. In fact, a century ago we had at least 10 times more Tuber melanosporum truffles than today. Why so many truffles in the past and such a significant decline? Despite the efforts of research, we cannot explain everything.

Main valuable species in Europe

Prices paid at the growers



Tuber magnatum :
2000 Euros / kg

Tuber melanosporum :
800 Euros / kg

Tuber brumale :
200 Euros / kg

Tuber aestivum :
100 Euros / kg

Tuber uncinatum :
250 Euros / kg

Tuber indicum :
100 Euros / kg
at the super market

Tuber borchii :
50 Euros / kg

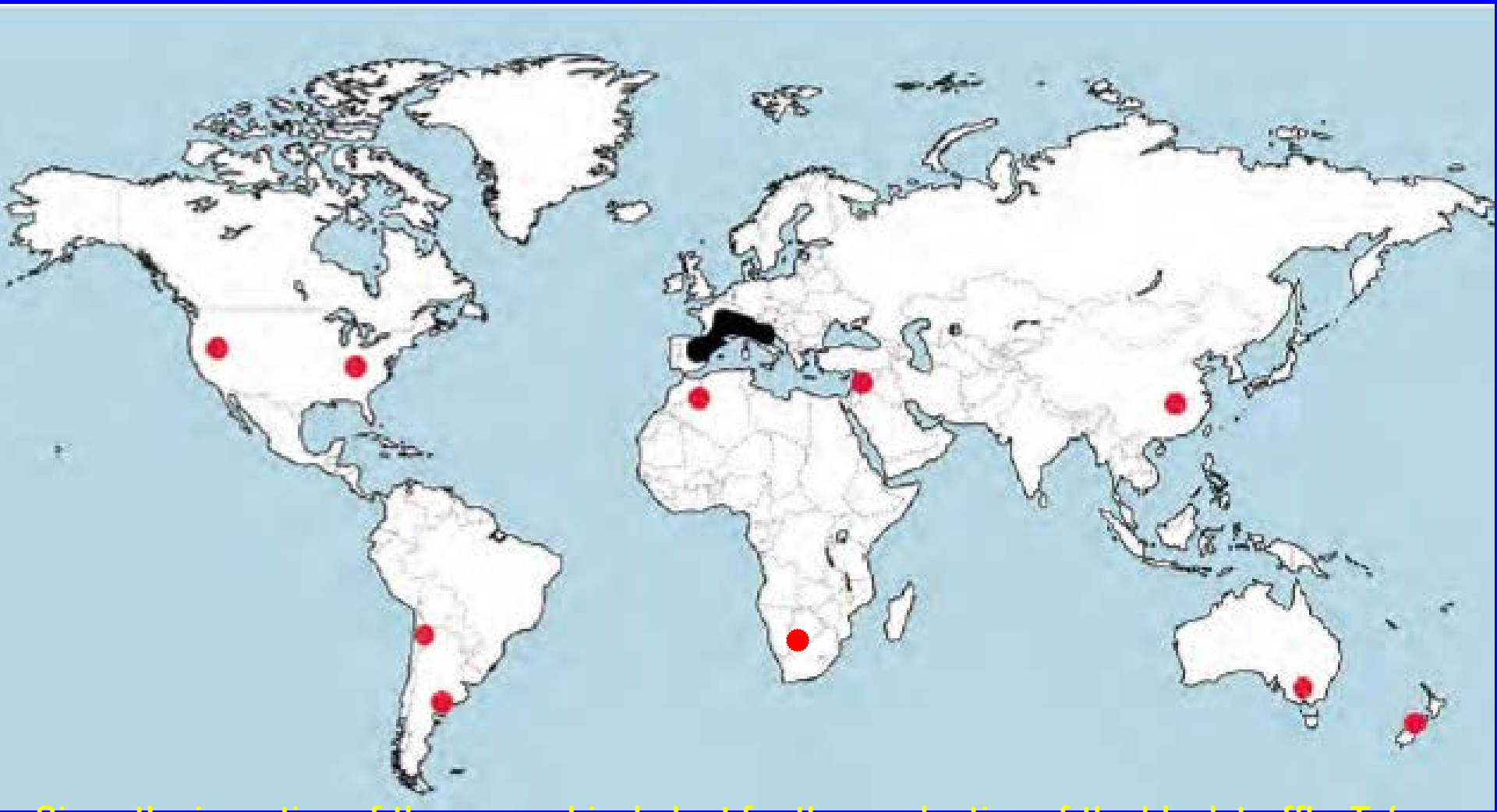
Tuber mesentericum :
50 Euros / kg

Tuber melanosporum area in Europe

Black truffle in Europe is mostly in Spain, France and Italy.

The cradle of the black truffle and its cultivation in Europe is located in Spain, France and Italy.

Black truffle in the world



Since the invention of the mycorrhizal plant for the production of the black truffle *Tuber melanosporum* (in the early 1970s), the cultivation of truffles has spread all over the world. The cultivation of truffles was first introduced in New Zealand and North Carolina.

Warning about the ecology of the black truffle

Tuber melanosporum is the fungus of the calcareous shallow soils in Mediterranean climate.

But it's possible to adapt the environment in different areas and countries for its cultivation

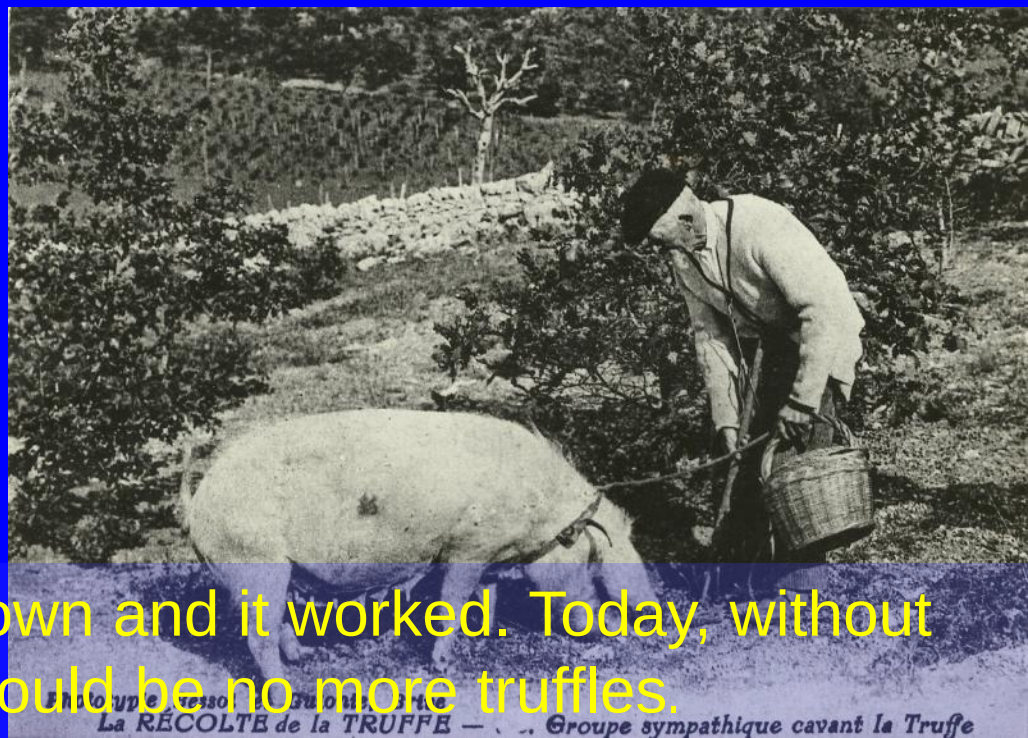
It is very important to know that the black truffle is above all the fungus of superficial limestone soils in a Mediterranean climate. This will determine the balance to be search for between tree growth, soil fertility and water management.

HISTORY

Tuber melanosporum truffle was abundantly harvested in France in the nineteenth century. We harvested around 2000 tons compared to 100 tons today.

The Truffle cultivation was invented at the beginning of the XIXth century by sowing acorns in suitable calcareous soils.

1914



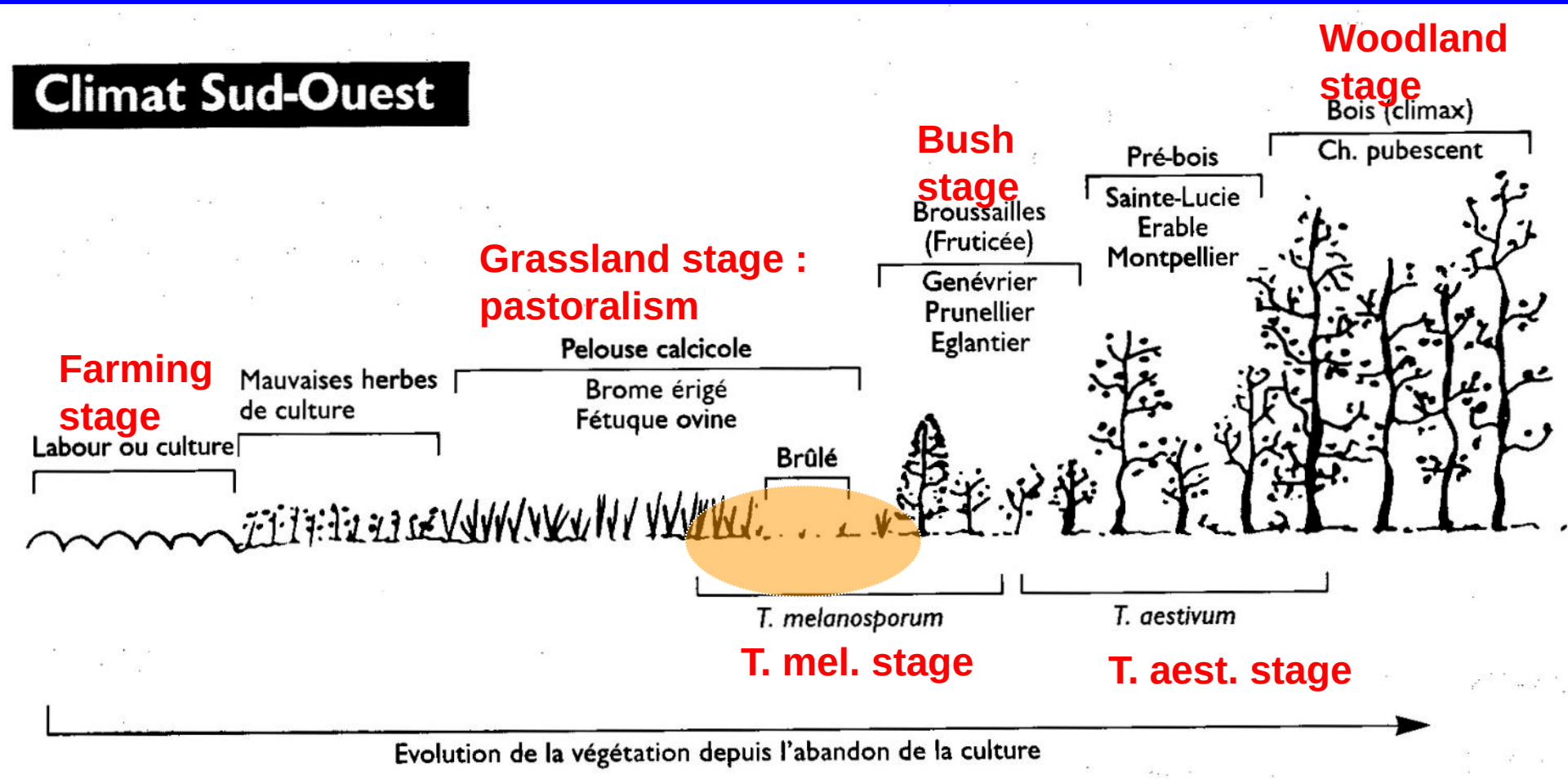
In the old days, acorns were sown and it worked. Today, without the mycorrhizal plants, there would be no more truffles.

In front of decline of the truffle production, the French Institute INRA invented the mycorrhizal controlled plant checked with the black truffle *Tuber melanosporum*, marketed from 1974.

With the mycorrhizal plant, we saved the truffle in the old world and introduced its cultivation in the new world.

Tuber melanosporum is a early stage fungus or a pionner fungus.

Tuber melanosporum truffle appears naturally at a certain stage in the evolution of the limestone environment when it is no longer cultivated

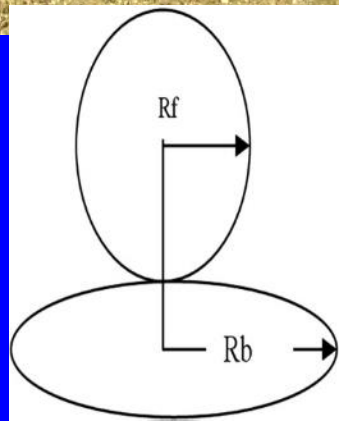


The *Tuber aestivum* (or white summer truffle) truffle has less strict ecological requirements. It is more flexible, more adaptable.

Main factors

The principal conditions for successful truffle production are :

1. using well mycorrhized plants,
2. suitable soil
3. Mediterranean or Atlantic climate,
4. Cultivation practices designed to maintain an equilibrium which favours the fructification of a pioneering type of fungus.



Choice of the mycorrhizal host trees

1. environmental conditions (soil, climate, habitat)
2. planting density
3. cultivation equipment.

Soils qualities

Soils are generally :

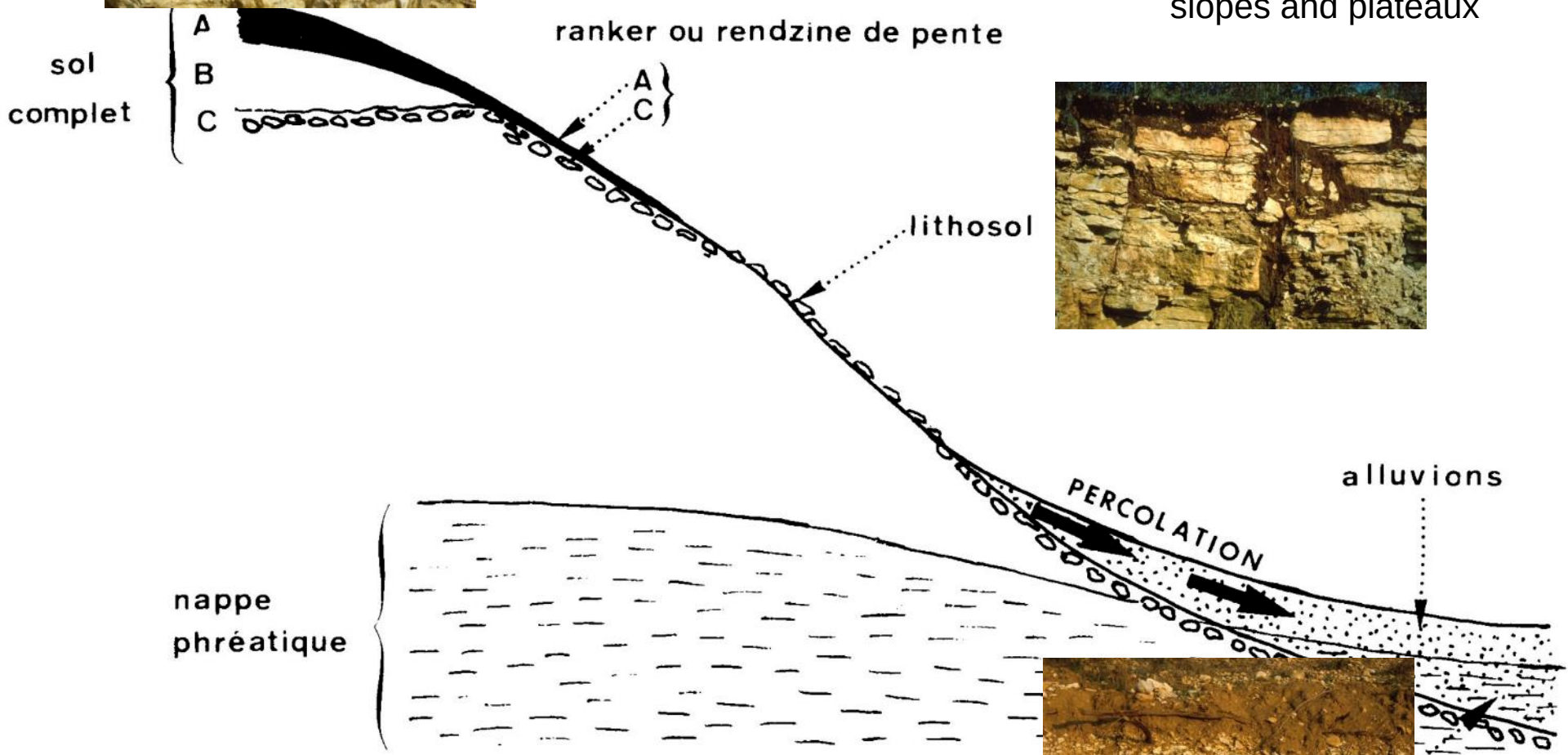
1. Calcareous,
2. well aerated,
3. well drained,
4. highly biologically active.

The pH of the soil depends on the presence of calcium carbonate. So you need a calcareous soil.

Pedology : different types of soils

Rendosol
Rendzina ; plateaux

Lithosol :
slopes and plateaux



Fluviosol : river valley

Fungal characteristics

It is necessary to take into account

1. presence of spores
2. or mycelium of other mycorrhizal fungi likely to enter into competition with the black truffle.



Biodiversity is very important even if can't explain all the interactions with soil and fungus.

Persistence of pastoral tradition in some areas is adapted to black truffle ecosystem.

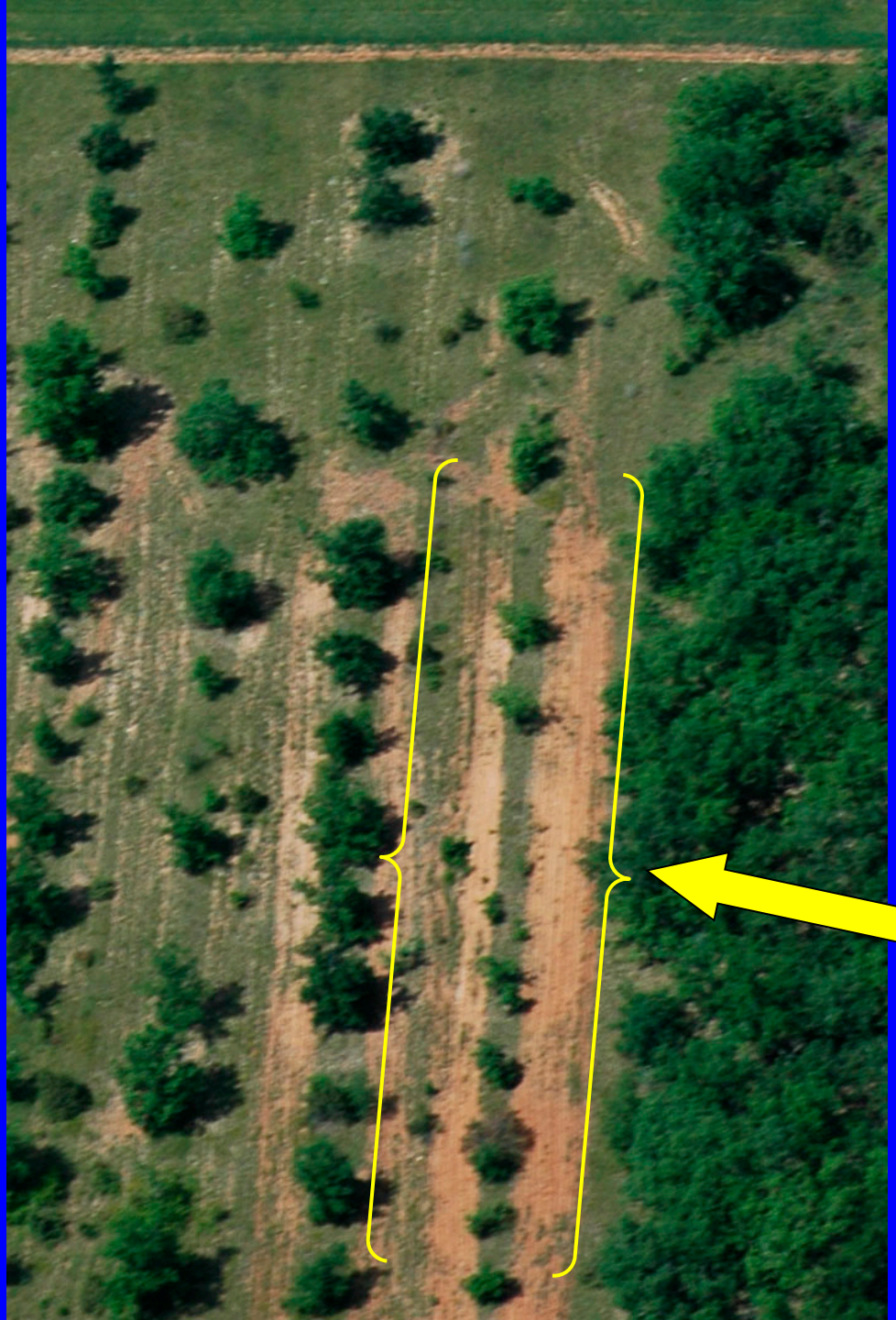
Rabbit

Hare

Cernuella virgata

Protection or biodiversity

Messor Structor



Pressure of contamination is dangerous for *Tuber melanosporum* trees when there is a wooded environment.

Burnt area provoked by different mycorrhized fungi on old oaks roots.

Climate

Climate is a limiting factors :

1. summer drought during the critical growth period (or indeed when the primordia are formed)
2. freezing of the truffles at the start of winter or right in the full harvesting season.

Truffle is born mainly in May and June

This very small truffle has been photographed at the end of June. Its weigh is about few tenth milligrams. We have never seen connection between small truffle and root system.

One truffle *Tuber melanosporum* the 27th of June 2008

Cultivation techniques

Cultivation techniques aim to control :

1. tree growth and the propagation of their initial mycorrhizal inoculation,
2. aeration of the soil in spring
3. possible physico-chemical or biological adjustments in the soils
4. managing climatic problems.

Cultivation techniques

Lot (South-West)

Cultivation techniques

Dordogne (South-West)

Cultivation techniques

Var (South-Est)

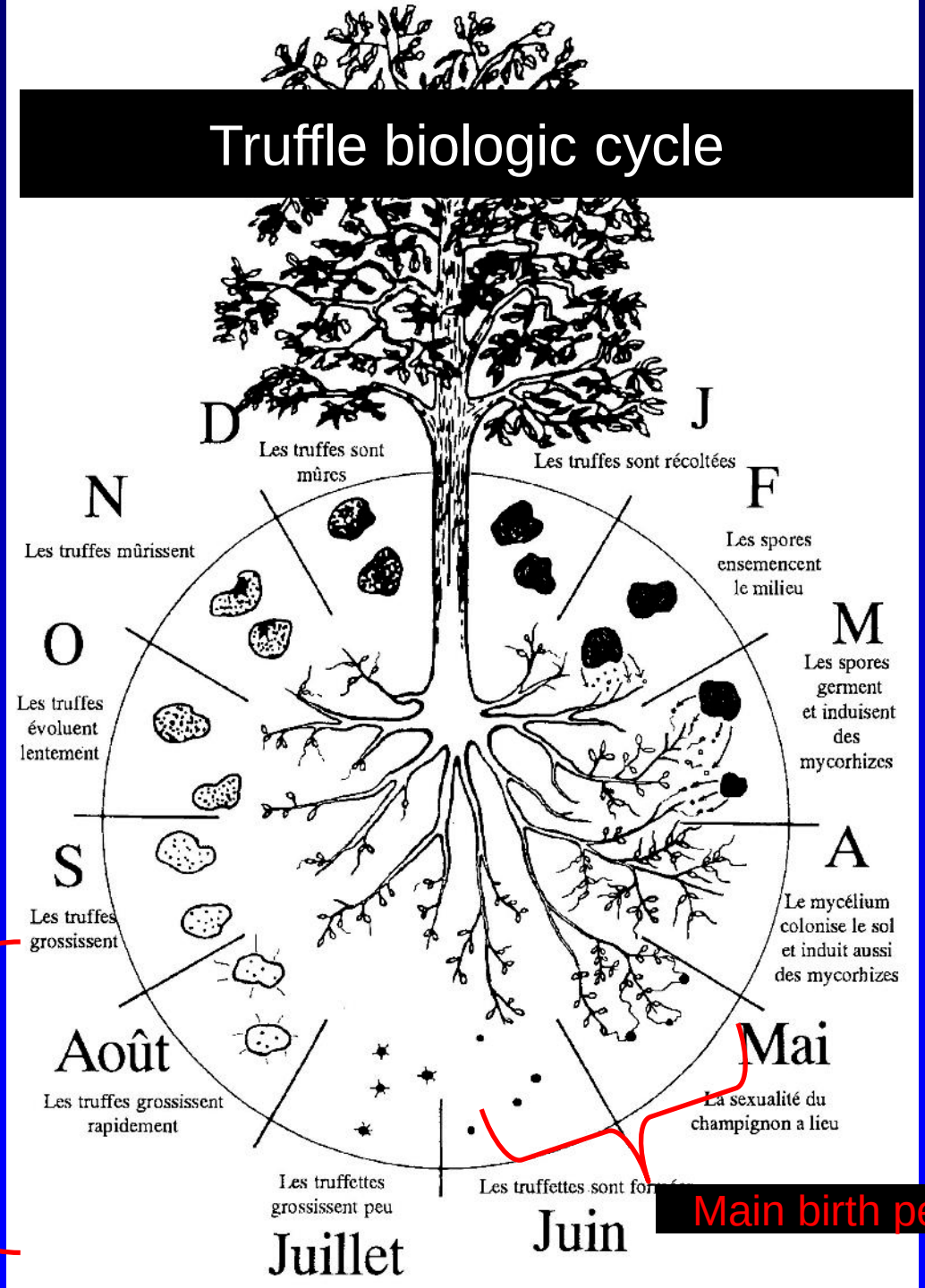
How is the tilling?

1. Very shallow (5 to 8 cm)
2. Soil not to much dry, not too much wet
3. In March or April (spring, before the growth of the mycelium)
4. Machine with discs or teeth

Truffle irrigation

Managing the water for the truffle production

Truffle biologic cycle



Critical period for the growth of the fruit body

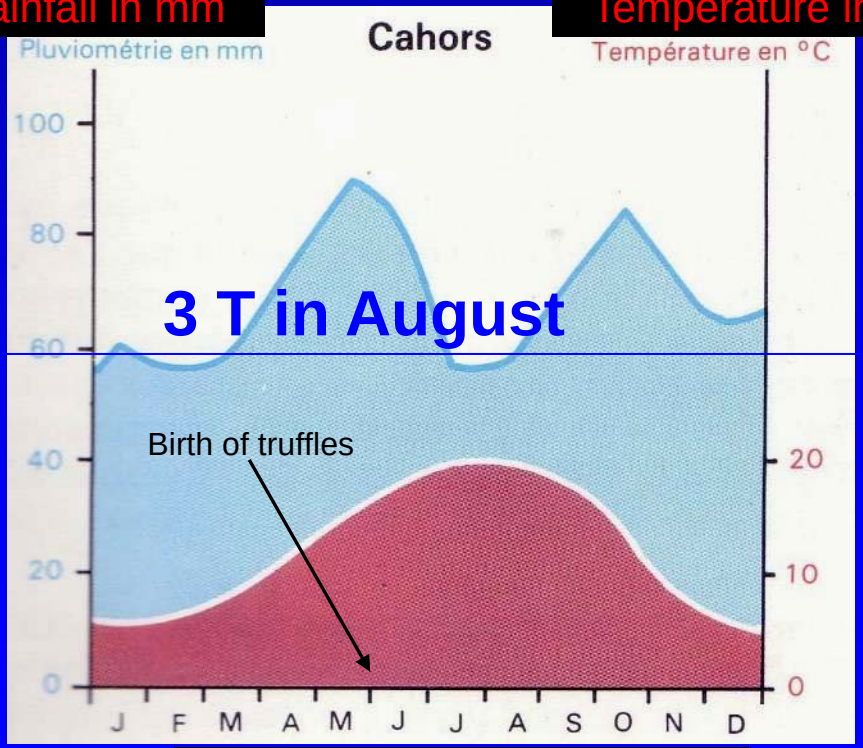
Main birth period

Requirements to manage watering :

- Threshold or limit of resistance at the drought
- Critical period of growth (August)
- We get the best results whens 3T < P < 4 T (rainfall between 80 à 90 mm per month).

Rainfall in mm

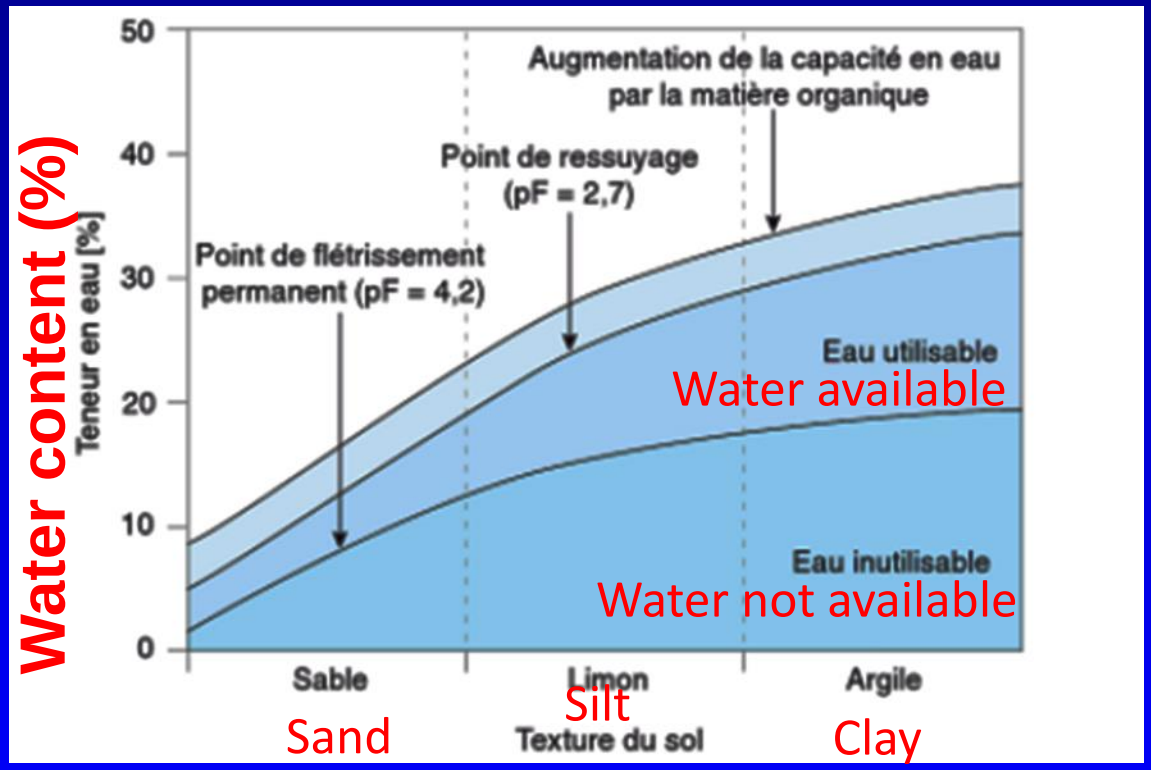
Temperature in °C



Ombro-thermic diagram

Truffle is protected against drought by its skin or peridium.This protection can be effective for 15 to 20 days.

Sands retain less water than clays.However, the water is more easily available.



pF Tracer One
by WETRUF for measuring the water potential or pF

Work on the water requirements of the truffle has shown that it can survive better than plants like vine or sunflower.

How we manage water requirements of the truffle in France?

1. Irrigating the good (producing) burnt areas
2. Mulching the soil with branches or other materials

Classical method in France

Roles of irrigation :

1. 20 mm every 15 to 20 days in June, jolly, September
2. 20 mm every 10 to 15 days in August

Despite new technology, truffle growers get good results by following simple rules.

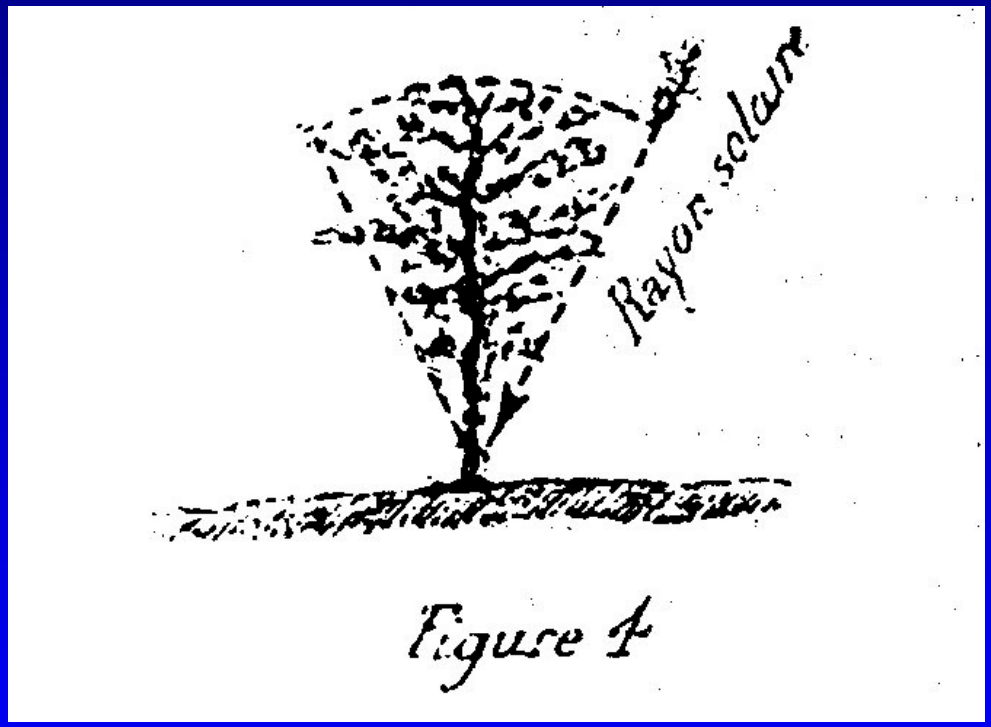
THE PRUNING

We will consider the pruning of trees in two ways

- Old method (Borredon 1887)
- Modern method (my conception)

De Bosredon method (1887)

Reversed conical shape

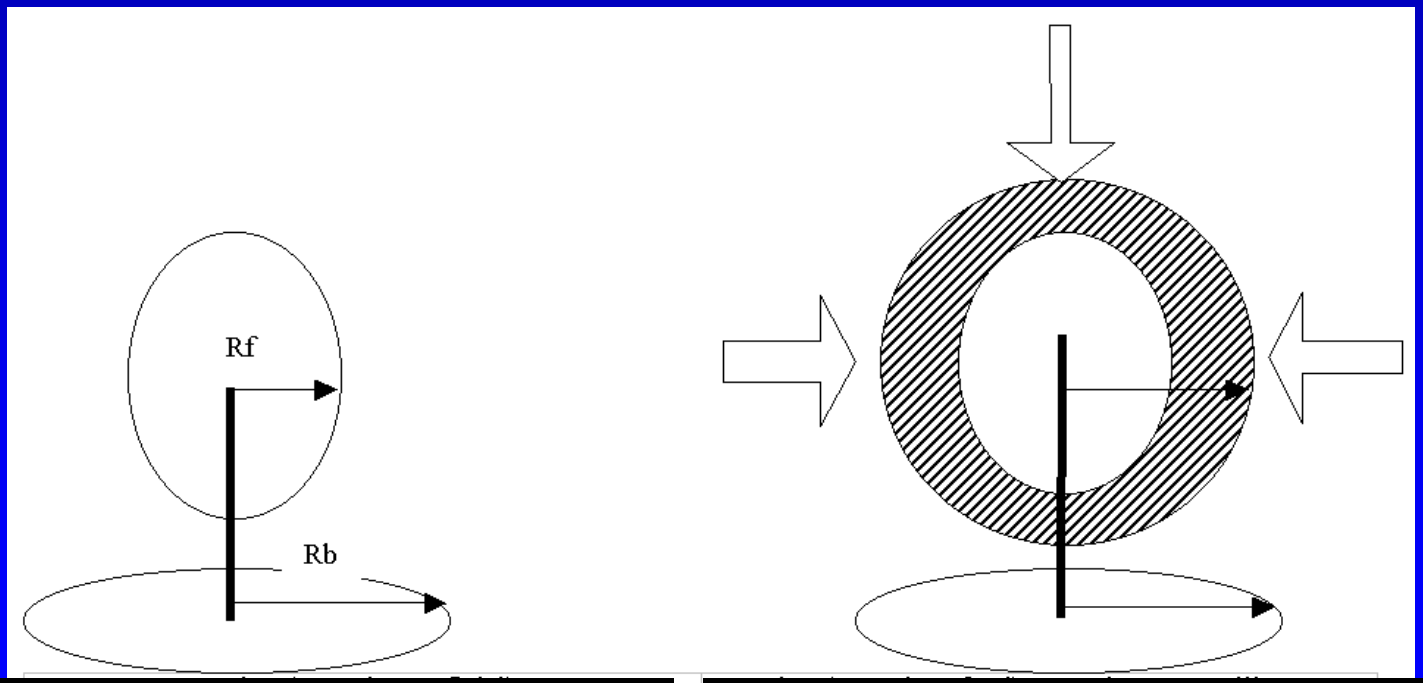


Aim : protect the burnt area from the sun at noon and warm the soil in the morning and in the evening

Modern conception

Why to prune, in my opinion ?

1. Give a shape at the young tree to make easier its growth
2. Preserve the balance between the vigor of the tree and the virulence of the black truffle
3. Economize the conquest space of the truffle plantation.



Truffle virulence on shallow soil.
We don't need to prune

Weak virulence on deep soil.
We need to prune

Pruning in truffle cultivation

1. Give a shape
2. Manage the vigor of the tree

Give a shape on young tree

Manage the vigor

Fertilizing and liming

Managing the fertility and the Calcium level of the truffle plantation

Fertilizing trials affect truffle production permanence

Spores inoculation

This is to provide spores that will strengthen the production potential.

The truffle farmer digs a hole with an auger which he fills with a mixture of vermiculite, disinfected potting soil, limestone and spores.

Add spores on truffle trees when the brûlé appear to do « snow ball » effect

Bringing spores to the young brûlés ones stimulated their extension and favored the entry into production of truffles.

The best results in Franc

pictures from Roger Ribes

These results are exceptional and are not systematic. We do not know why.

Biological cycle according to François Le Tacon (France)

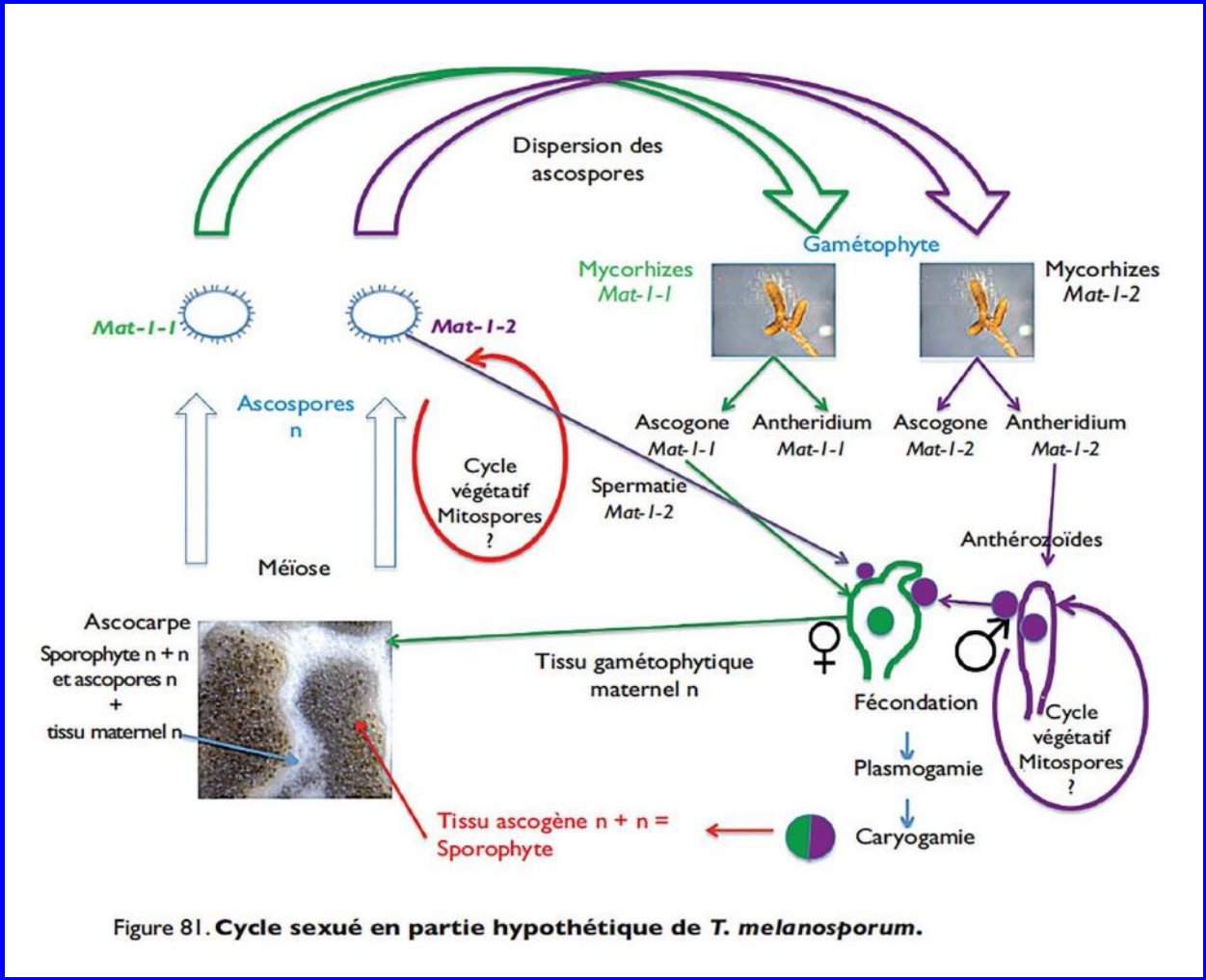


Figure 81. **Cycle sexué en partie hypothétique de *T. melanosporum*.**

The spores could be the male form of the truffle. This would justify the interest of providing spores in the brûlé of mycorrhizal trees.

Challenges

Several questions arise for the cultivation of the truffle and its biology.

On cultivation : how to control the contaminating fungi? How to improve the domination or the virulence of the truffle on the other fungi ?

On biology :

How is the feeding of the fruitbody ?

How is the mating or sexual reproduction ?

Studies with SYSTRUF on the recent years

How is the feeding of the fruitbody with the carbon?
How is the mating or sexual reproduction

Scientific research in recent years has led to work on the nutrition of the truffle (with the help of the tree) and the sexuality of the truffle.

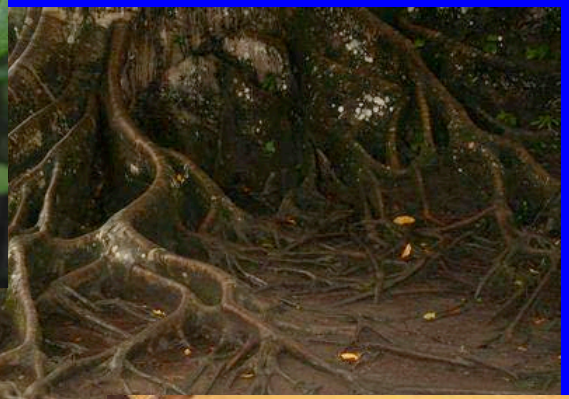
M.-A. Sellosse presentation

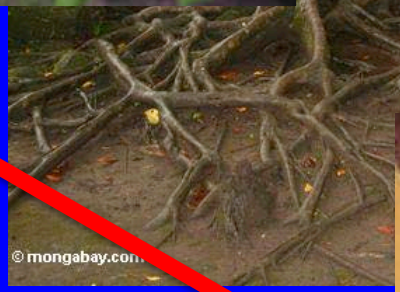
In this device, they have enclosed the foliage of a tree.
The tree breathed CO2 labeled with a carbon 13 isotope.

Truffle fruitbody has feed this type of carbon.

A connection between tree and the fruitbody should exist.

M.-A. Sellosse presentation





Carbon from photosynthesis

SOIL ?

Conclusion

Truffle cultivation is economically viable if we take into account the difficulties from the environment (fungi contaminations from woodland in France, climate changement everywhere, etc.) and the new scientific knowledge.




Thanks to the continued efforts of the scientists, technicians, truffle growers, and the public subsidies, we can believe in the future of the truffle cultivation,

in the old world and the new world.

Thank you for your attention