GOOD PRACTICES FOR THE CONTROL OF "LA SECA" (ROOT ROT) ADVANCE IN MEDITERRANEAN SILVOPASTURE SYSTEMS

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Good practices for the control of "la seca" (root rot) advance in Mediterranean Silvopasture systems

Aim of this manual

The decay process that is causing serious damage to Mediterranean Silvopasture systems, such as dehesas, montados and meriagos, must be approached from a realistic and practical point of view. For this reason, the objective of this publication is to provide practical solutions that every owner can apply on their land in order to avoid the advance of "la seca" (root rot) with all its consequences. With this realistic vision, this publication presents well-defined treatments aimed at improving the state of trees and worsening the state of pathogens, which cause the death of large numbers of trees. Therefore, it is a manual that allows land owners to follow the proposed methodologies in a simple way and that is published with the sole intention of being useful.

What is "la seca"?

"La seca" (root rot) is a progressive deterioration and death of holm oaks and cork oaks in the Mediterranean silvopasture systems (such as dehesas, montados and meriagos) that has been observed especially in the Iberian Peninsula since the 80s of the 20th century (Pérez-Sierra *et al.*, 2013).

The decay of these silvopasture systems has a complex etiology and is the result of the action of numerous factors, both abiotic and biotic (Casas et al., 2006). However, the importance of the oomycete *Phytophthora cinnamomi* in the death of trees has been recognized as one of the main causes by the scientific community (Brasier et al, 1993; Sánchez et al., 2002).

Figure 1: Holm oaks with root rot symptoms. Own source

What is *Phytophthora cinnamommi* life cycle?

Phytophthora cinnamomi is widely distributed worldwide and is capable of colonizing a large number of hosts, which makes its control extremely difficult (Serrano Moral 2012).

This pathogen carries out its entire life cycle in the soil, where humidity is a fundamental factor in its development and spread (Zentmyer, 1980). There, it is found in the form of survival structures (oospores and chlamydospores) that can survive latent for long periods of time and usually at low densities (Sanchez et al., 2002). When the germination conditions are adequate

(high temperatures and high humidity in the soil), these spores germinate producing sporangia, which also germinate producing flagellated (mobile) zoospores (Serrano Moral 2012). Zoospores are capable of actively moving in the water film that surrounds the soil particles, and they are chemically attracted by the radical exudates of the plant species susceptible to being infected. Once inside the roots, the microorganism produces mycelium that grows inside them rapidly, producing new sporangia and zoospores and rapidly increasing the population of the pathogen. The infected plants therefore act as a source of inoculum as long as the conditions of soil water saturation are maintained (Serrano Moral 2012). At the moment in which the environmental conditions are no longer favorable, the oomycete will form new chlamydospores that will remain in the soil as survival structures, starting the cycle again.

The great capacity to produce infective spores of *P. cinnamomi* together with the high susceptibility of younger plants with many absorbent roots is a lethal combination for these ecosystems in soils with high water saturation (Sánchez et al. 2010).

What are the symptoms?

Destruction of the tree's uptake system due to necrosis of fine roots causes water and nutritional deficiencies in plants (Trindade et al 2020).

The symptoms observed in the aerial part of the tree are similar to those that would produce a situation of weakness due to water deficit:

- ✓ yellowing or wilting of the leaves,
- ✓ defoliation (loss of leaves that causes more transparent canopies),
- ✓ drying of the tips of shoots and twigs (regressive dieback).

In addition, at root level can be observed:

- ✓ absence of absorbent secondary roots
- ✓ necrosis in existent rootlet.

Figure 2: wilting of the leaves. Own source

The appearance of evident symptoms in the canopy of the trees is indicative of the existence of an important affectation at the root level.

The death of the trees due to the action of this pathogen can develop suddenly, collapsing in a short period of time (a few months or even weeks) or during a slower process, and can last several years. Whether it occurs one way or another depends both on the susceptibility of the tree and on environmental conditions. Slow death is more frequent in cool and humid climates (Sánchez et al. 2006).

How can it be detected?

The airborne symptoms of "la seca" are very nonspecific, which makes the diagnosis of the disease difficult. For an accurate diagnosis, it is necessary to isolate the pathogen in the infected rootlets or in the soil of the rhizosphere using specific laboratory techniques. There are also *Phythopthora* detection kits on the market that can be used by any user directly in the field. It is necessary to take into account that, although these tests may be useful as a first approximation, they are not entirely specific, and should be complemented by sending samples to specialist laboratories.

Figure 3: Phytophthora tests are easy to use by any user and can be performed directly in the field. Own source

What can we do to control its progress?

Lines on which the proposed techniques are based

As indicated above, in recent years the causes that have allowed root rot to advance both in holm oak and cork oak, especially in southern Spain, have been studied. It is known that the process by which large trees with great natural resistance die, is due to several accumulated causes.

We can summarize these factors in three:

1. Long periods of drought and irregular rains that weaken the tree.
2. Aggressive cultural practices that generate a greater weakness to the tree in the long term.
3. Advancement of an aggressive pathogen such as *Phytophthora*, capable of causing serious damage to weakened plants.

Knowing these determining factors, it is proposed to work on two fundamental strategic lines that allow to control to a great extent the progress of this pathology:

1. Improve the vigor of the trees.
2. Make it difficult for *Phytophthora* to develop.

With this vision, the tasks to be carried out to achieve these ends are shown below.

It is noteworthy that these measures should not be taken independently, but **should all be applied together**. The concept is that each of these tasks increases the probability of survival by a low percentage, but all of them integrated into a set of management measures allow to obtain satisfactory results.

Measures aimed at improving the state and vigor of the trees.

- **Mycorrhizal fungi application**. A cocktail of mycorrhizal fungi capable of developing rapidly in an environment such as dehesas, both in acidic and basic pH, has been selected. These species are *Pisolithus arhizus* (also known as *Pisolithus tinctorius*), *Scleroderma meridionale*, and Hebeloma spp. The spores of these fungi will be applied in a liquid medium with a minimum of $1x10^5$ spores / ml. This sporal suspension will be applied together with the two products detailed below (Bacteria + Trichodermas).

- **Mycorrhizal helper bacteria application**. These bacteria perform a double function. In the first place, they help the plant and the fungus to achieve mycorrhization more efficiently. In addition, these bacteria are capable of solubilizing soil nutrients (especially phosphorous) so that the plant has them available and achieves better nutrition and therefore greater vigor. The bacteria will be applied in a liquid medium with a minimum of $1x10^6$ spores / ml

- **Biological agents (*Trichodermas*) application**. These fungi are capable of limiting the advancement of various pathogenic fungi by having a biological control effect. Its effect is twofold: on the one hand it limits the growth of pathogens by competition in the soil and secondly due to the elicitor effect that enables the plant damage prevention system to be activated. *Trichoderma* spores will be applied in a liquid medium with a minimum of $1x10^4$ spores / ml.

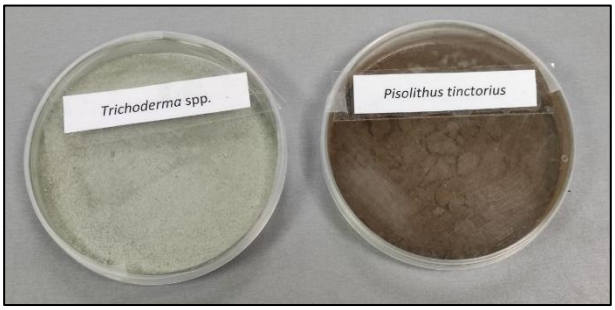

Figure 4: Inocula of Trichodermas and Pisolithus tinctorius (P. arhizus) in powder ready to dilute in water for application.

Application: A shaking tank of phytosanitary products will be used and an injection will be made into the soil at 10 points if the tree is adult (10 m crown diameter), 5 points if it is of medium age (5 m crown diameter) and 3 points in young holm oaks or cork oaks (1-3 m crown diameter). These points will be selected on the edge of the crown projection. With the tool in the image, the injector will be inserted to a depth of between 5 and 15 cm, making sure that all the product remains on the ground and not on the surface.

- **Moderate pruning and cleaning of work tools.** It is very important not to cause pruning wounds that limit the vigor of the plant. This occurs with the cutting of branches of more than 15 cm that it will be important to avoid. In addition, an excess of pruning also damages the vigor of the tree when the balance between biomass and photosynthesis is unbalanced. Never remove more than 30% of the tree's foliar mass. Cleaning of tools will always be done when changing from one tree to another by using 10% hydrogen peroxide.

- **New plantations.** They are the future of the dehesas and in many cases, due to the presence of livestock, regeneration is difficult. Thus, new plantations will always be carried out with a protector for the livestock. The same microorganisms mentioned above (mycorrhizal fungi, mycorrhizal helper bacteria and Trichodermas) will be applied in the planting hole. This allows the plant to develop by overcoming the effect of *Phytophthora*. It is advisable to diversify plantations with other species that are not susceptible to *Phytophthora* (hackberry, ash, gall oak, wild olive, even stone pine, depending on soil moisture conditions) and be attentive to genetics selection programs for holm oaks and cork oaks resistant to this sickness.

- **Avoid damage to the roots**: ensure that plowing or tilling does not damage the roots to avoid weakening the trees. Prioritize the use of brush cutters over tillage for scrub control.

Measures aimed at difficulting *Phytophthora´s* development.

- **Application of calcium carbonate or calcium sulfate.** Calcium carbonate powder is a very cheap and easy to apply product. Three tons per hectare will be applied with a centrifugal spreader coupled to a tractor. It is important to make sure that the product settles in the environment of the trees. It is also possible to apply calcium sulfate (agricultural gypsum), with greater solubility and therefore with greater potential to reach the depths at which *Phytophthora* is found.

Figure 5: Calcium carbonate powder application by tractor and centrifugal fertilizer spreader. Own source

- **Application of antagonistic microorganisms.** Although this application has been mentioned in the previous section (measures aimed at improving the state and vigor of the trees), the aforementioned microorganisms have an important effect in limiting the development of Phytophthora. Mycorrhizal fungi have an antibiosis effect against the pathogen at the same time that they generate a physical barrier in the mycorrhizae with the tissue called "mantle". The form of application as you have mentioned and it is advised to do it annually.

- **Water management:** Whenever possible it is necessary to carry out measures aimed at avoiding the flooding of the affected areas that favor the advance of the disease. It is recommended to create a drainage network that channels part of the runoff water out of the affected area. It must be done upstream, before reaching the affected area.

- **Tillage of the soil:** Due to the characteristics of *Phytophthora*, the way in which the soil is managed is crucial to control its progress. The dissemination of *P. cinnamomi* is greater in heavy and compact soils, with low infiltration capacity, since these favor the appearance of waterlogging and surface runoff. Thus, the following recommendations should be followed:

- ✓ **Avoid compaction:** Do not work on damp or flooded soils.
- ✓ **Favor infiltration:** Maintain species of scrub that are not susceptible to the disease on slopes and along water courses to favor infiltration and avoid runoff.
- ✓ **Planning:** Try to plan the work, always starting with the unaffected areas and ending with the affected ones.
- ✓ **Vehicle cleaning:** Have cleaning pools (wheel dip) for vehicle wheels or ensure exhaustive cleaning of the same between the different areas.
- ✓ **Cleaning of agricultural implements:** Like pruning tools and vehicle wheels, agricultural implements can carry spores or mycelium of pathogenic fungi and especially *Phytophthora*. For this reason, whenever a tillage is carried out, the implement will be thoroughly cleaned, first with soap and water and later with 10% hydrogen peroxide. Leave to act for 10 minutes and clean with water to avoid corrosion.

- **Livestock management:**

- ✓ Avoid over-exploitation of livestock that produces greater soil compaction.
- ✓ Clean the animals' legs (using footbaths) when moving from one area to another.

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