WINETWORK

European Knowledge Transfer

TECHNICAL DATA SHEET

Global vineyard strategy to prevent GTDs

Vineyard management practices to prevent GTDs

Network for the exchange and transfer of innovative knowledge between European wine growing regions

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Global vineyard strategy to prevent GTDs

Planting phase

1. Planting a new vineyard

The first step for a healthy vineyard is to **choose varieties that are less susceptible to develop trunk diseases**. Several studies demonstrated that the incidence of Esca is lower in Montepulciano and Merlot and higher in Sangiovese, Cabernet sauvignon, Chardonnay, Sauvignon Blanc, Riesling, Semillon, Trebbiano (Figure 1).

Rootstocks as well plays a role in susceptibility to GTDs: *Vitis riparia* 039-16 and Freedom have a good degree of tolerance, like *Vitis riparia* X *Vitis berlandieri*. Similar degree of susceptibility is reported between not grafted and grafted vines, on European or American rootstocks. Some authors refer the **positive influence of certain rootstocks**, such as Rupestris, in the resistance to Esca, probably due to the high tannin content in the plant that reduces the potential of infection. Since 2016 in Galicia the susceptibility of rootstocks and autochthonous cultivars to Esca, Eytypa dieback and Botryosphaeria dieback is under study. A 4-year study made in France assessed the different rootstocks impact on Esca foliar symptoms expression: *Riparia* Gloire de Montpellier was the rootstock leading to less Esca foliar symptoms. Other rootstocks, as the "101-14", the "3309" and "Gravesac" tended to be more sensitive, but **effects could be reversed depending on meteorological conditions.** Evaluation trials of grapevine rootstocks against GTDs soilborne pathogens attested that the rootstock 110R was the most susceptible to both black-foot and Petri diseases while the 161-49C rootstock resulted the most tolerant to Petri disease infection.

Choice of the location, which will condition all subsequent vineyard grow and development, is also relevant to minimize the damage caused by the GTDs. So, whenever possible, we must proceed the grading that get slopes lower than 10%. If the slopes are higher, between 10% and 20% earthmoving works would be important, so we must think about the possibility of planting along the contour lines. With slopes higher than 20%, we already have to consider the need to make terraces.
Overall the sites where vines grow easier, meaning exposition to South, preference to higher part of the hills where winds keep moisture level low, have a positive impact on vine health status and consequently reduce GTDs risk.

The **planting period** must be chosen carefully avoiding too late planting. The best period of time is from late Autumn to early Spring, during the dormant plant season. In areas with cold winters, March planting is preferable.

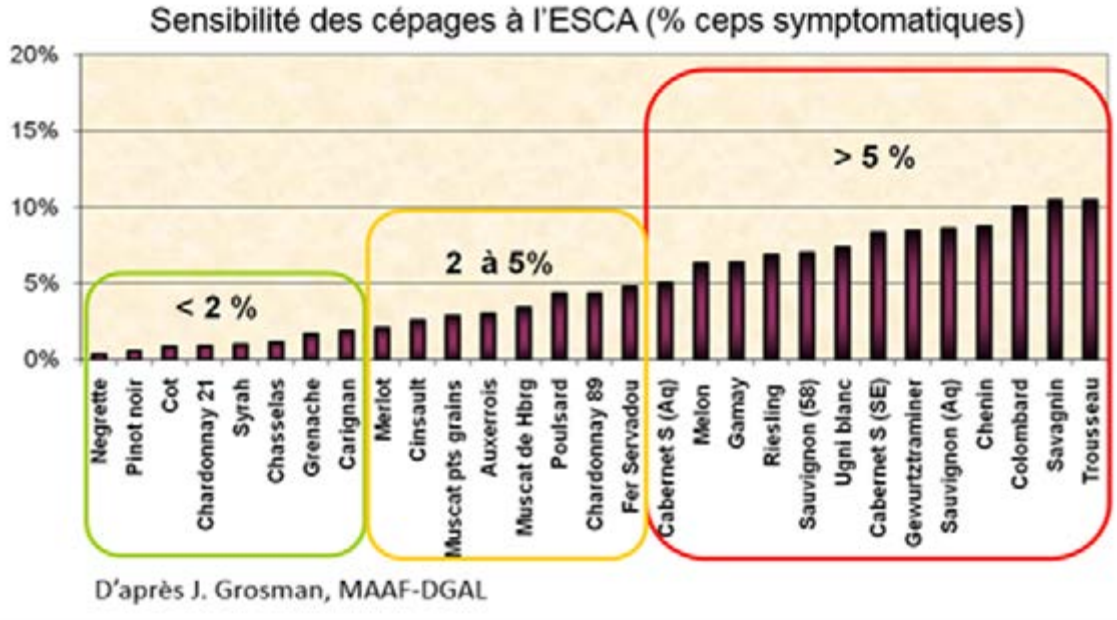

Figure 1: sensitivity degree of most common grape varieties(MAAF-DGAL)

How to handle vines is also crucial: avoid leaving roots soaked in water over 24 hours before planting and carefully water newly planted cuttings in order to **avoid water stress** (in both senses). At planting pay attention not to break the roots and be careful that the **root system is not be folded but well stretched** in all the available space in order to facilitate the best root development. In general is important to avoid soil compaction. For this purpose don't entry in the field with heavy machine when the soil is soaked and prefer a double-layer cultivation.
It is shown an example of a tool designed by Ribeiro's own grower, consisting of a metal tube with a channel for introducing the plant and thus being able to conduct it in depth without bending the roots and in a straight way (Figure 2).

Figure 2: Planting with special homemade tool (courtesy of Ángel González of Beade winery in Ribeiro D.O. Galicia, Spain)

At planting time the **inoculation with *Trichoderma*-based products** (*T. harzianum, T. atroviride, T. asperellum, T. gamsii*) could be recommended. Before planting, vines roots are **soaked for an hour in a solution containing *Trichoderma***. *Trichoderma* improves root growth and stress resistance in colonized plants, which would possibly make plants less sensitive to wood diseases. Vines can also be soaked for 50 minutes in a water solution containing cyprodinil and fludioxonil or metiram and pyraclostrobin*. These mixtures reduces incidence and severity of black foot disease and Botryosphaeria dieback.
The best period of the year for **field grafting** is spring, or at the flowering time for the Northern regions, when the vines are starting to push new growth. Try to graft when the vines are dry (days with no rain) to reduce the risk of disease's infection.

The choice of the **training system** should avoid over simplification and favor a physiologically sound pruning, allowing a **smooth sap circulation**. It is to prefer less severe pruning, with **small pruning wounds** and a reduced interference with vessels development. Long pruning systems should be preferred and several evidences support that "alberello" and Guyot systems should be preferred. When planting a new vineyard it is extremely important to p**romote a right vertical growing of the trunk**, binding the new plant to a good stake: a vertical trunk is less sensitive to machinery damage used for weed-control under-row.

Pruning in the formation phase

It is important to adopt pruning preventive measures since the beginning of the vineyard life. In general, all practices that cause stress in plants should be avoided. A reasonable pace to establish the definitive structure of the plant, **avoiding big pruning wounds, and respecting sap flow paths** is essential.

High density plantation systems increase GTDs risks, so the balance among production, quality and health needs a compromise, considering the forecasted life span of the vineyard.

2. Soil preparation

The first areas of the vineyard where symptoms of GTDs appear are identified as particularly dry or areas where water-logging persists for long periods, combined with poor nutritional conditions. Before planting it is advisable to make soil analyses to know the mineral and organic substance content and then compare the data with the mean values of the territory. **Improvement of general soil conditions**, starting from the physical structure down to nutrients availability it is recommended if poor nutritional conditions exist. Moreover, it must be verified that the soil is not infected by analysis in an authorized laboratory. The fundamental problems in soil come mainly from the fungi that cause root rot such as *Armillaria mellea* and *Rosellinia necatrix* and from the nematodes.
Before planting it is important to r**emove all the previous pruning debris**, especially if GTDs were detected. In the case of previously existing plantations, it is advisable to wait before replanting at least 3-4 year, (better 6 or 7). A useful practice, supporting the residues degradation and the related pathogens is the green manuring, as it adds organic matter that facilitates microbial activity. Furthermore, the green manure roots development helps the soil structuring. Specific crops may be used, such as species from Brassicaceae, rape (*Brassica napus L.*), mustard (*Brassica juncea L.*) rapeseed (*Brassica rapa*) etc, that produce allelopatic substances (volatile isothiocyanates) able to suppress/reduce pathogenic fungi. (figure.3) As an alternative, mustard meal can be incorporated into the soil, leading to comparable results.

Planting is also the phase in which future management possibilities are set and their potential to reduce wood diseases out-break should be taken into account.

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Figure 3: Use of *brassica rapa* in the vineyard (IFV South-West)

These practices are:

- **soil erosion reduction** through appropriate orientation of the vineyard rows and soil protection by cover crops
- **an effective drainage system**
- **improvement of soil structure** by increasing or maintaining a good level organic matter through green manuring, addition of compost and other organic materials
- **increase of phosphorus and potassium availability**, linked to the previous point and to soil structure.

If the previous use was shrub must be carried out a deep ploughing or subsoiling preferably that will fragment the horizons of the soil in a vertical way facilitating water's drainage and allowing the proliferation of depth roots of vines.

3. How to check and to handle nursery materials

The use of **certified planting materials** is always recommended. A healthy vine has a higher potential to react to infections, granting an easier start of the crop and a more sustainable management of the vineyard. When receiving the vines from nursery, a visual check for necrosis in the wood is advisable and, if found, a microbiological analysis is recommended. However, when rooted vines show very large necrosis, even if they are not colonized by pathogenic fungi, they have unpredictable performances over time, for instance irregular sprouting and/or a stunted vigor. In young vineyards wood decay frequently starts from the grafting point, especially if grafted in the splitting of green shoots and the graft is just above the ground-level. The omega grafting is the most extensively used but it leads to a 30-50% of dead wood. The best choice for GTDs prevention is the bud grafting. Be aware that grafting cause wounds that increase the possibility for the pathogenic fungi to enter into the plant. **Wounds should be protected** with sprayed or painted formulations.

Growing phase

1. Pruning

Pruning time is important since it could influence the vine sensitivity to pathogens and abiotic disorders. Pruning should be trimmed according to vine physiology and be implemented during **dry and non-windy periods**. Regarding the best pruning moment there is no agreement. Late pruning in the dormant season (as close as possible to bud-break) was a recommended cultural practice, since the wounds heal faster with high degree-day temperatures. Nevertheless, recent studies revealed that the rate of natural infection of pruning wounds was lower in early pruning (Autumn) than in late pruning (Winter). Nevertheless, experiences report different outcomes on the topic and in some areas early pruning is preferred. The susceptibility of the wound is mostly **influenced by relative humidity and rainfall**. Double pruning or pre-pruning is enhanced by growers to speed up final pruning and to reduce disease incidence in spur-pruned vineyards, also considering that spores need only up to 5 hours of wetness (rain) to infect wounds. **Sanitation methods are often complemented with pruning wounds protection** from frost or biotic attacks through the application of fungicides, biological formulations

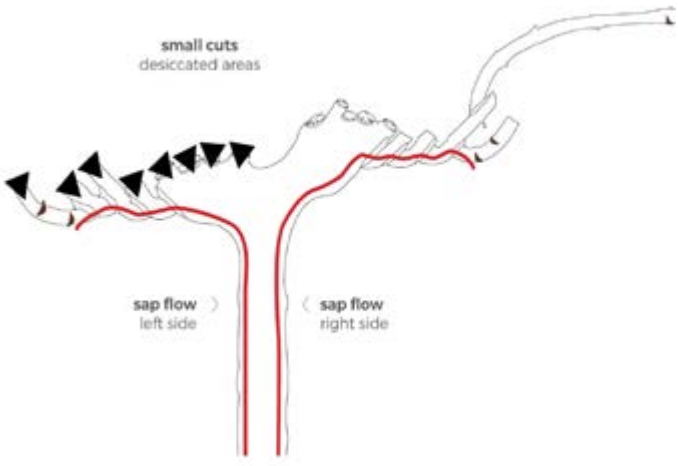

Figure 4 : The best pruning technique assure a continuity of the flow and respect of the vascular system. With kind permission of «I preparatori d'uva» www.simonitesirch.it

or both in alternation. Some studies demonstrated that the infections after pruning can be significantly reduced by using a single paste application with a mixture of benomyl, pyraclostrobin, tebuconazole or thiophanate-methyl. Anyway, in order to be effective, the products must be applied directly into the wounds. Some other studies demonstrate that paste application were no effective for Esca or Botryosphaeria species but only for Eutypa.
Cuts close to the perennial wood (clear-cuts) (usually produced by electric pruning scissors) should be avoided in order to reduce the formation of wood drying up cones. Pruning systems that allow a better sap flow circulation over the years (e.g. Guyot-Poussard) should be preferred (Figure 4).

Mechanization vs hand-made operations

The excessive simplification of training system (mechanical pruning, harvest, etc.) is probably, at present, one of the most harmful reasons that involve GTDs, as each operation risks to open wounds and give way to infections.
For the sake of plant health, hand-made operations should be preferred. Nevertheless, economic and organizational aspects should be taken into account, leading to prefer a shorter vineyard life-span than a longer and healthier one.

2. Weed control in the under-row: respect the trunk

The increasing use of equipment for under-row tillage, replacing herbicides, may cause injury to the trunk if it is not carried out with the right attention, facilitating GTD's infections. In order to reduce this risk, the right equipment should be chosen and carefully tuned to the specific vineyard. The feeler sensitivity commanding the movement back from the row must be quite high: it's better to have some grass left back than an injured trunk. In the case of working in absence of a feeler system (circular or multi-petal working heads) profiles that could cause injury should be avoided. For the same reasons, de-suckering machines should not peel the vines bark (decorticate).

Topping, canopy thinning, leaf removal machines (green canopy management) do not seem to impact as operating on still green shoots, while the risk may arise in case of too late interventions on woody branches. Anyway, there is currently no evidence about it.

3. Soil management

Plant stress caused by unbalanced nutrition, poor drainage, soil compaction, heavy crop loads on young plants, planting of vines in poorly prepared soil and improper plant holes play an important part in the development of GTDs especially on the foliar symptoms expression. Since the soil is the main source of inoculum for soilborne fungi, disease management practices based on soil correct management is key in the prevention of GTDs diseases.
In general a well-structured soil, where air and water easily circulate and is never water logged or saturated is a key aspect in prevention.

In the first five years it is essential to **prevent an excessive plant vigor**, allowing the plant to exploit most of its resources for the development of a good and deep root and vascular system. As a consequence, application of high doses of nitrogen should be avoided. A high C/N ratio of soil organic matter reduces plant vigor and favors secondary metabolism, increasing the production, among others, of polyphenols that increase plant natural resilience towards pathogens. A reduced vigor (and the consequent delayed production), allowing a more balanced vine growth, could help the plant to be less susceptible to GTDs.

In general the use of cover crops (not only leguminous species) and, even better, permanent coverage of the area between the rows with herbaceous species **balances nutrients availability and improves soil structure**. In the choice of the mixture composing the coverage it is important to include **deep rooting species** (i.e. lucerne) as it improves lower layers structure and air circulation. Moreover, lucerne increases phosphorus availability and it avoids soil compaction due to mechanical means circulation. In case of lack of nitrogen, green manures rich in leguminous species can be preferred for a period of time, since balance is set.
In any case, a good availability of organic matter should always be a goal. Besides green manures, compost and organic fertilizers should be added to balance yearly mineralization. Compost can be produced with manure, mowed grass, wine-making residues and pruning residues. In the latter case, care should be payed in avoiding infected materials or to run a long fermentation process able to inactivate pathogens.

Soil tillage must avoid soil compaction. **Over-watering and water-logging should be avoided as well as water stress**, which in particular conditions can lead to a wood efficiency and functionality impairment and to an increased susceptibility to fungal infections. Moreover, ground fractures just below the surface due to drought periods, can cause root breaking and desiccation but also fresh wounds that are the main infection routes.

Global vineyard strategy to prevent GTDs

4. Water management and irrigation

High humidity level in the soil (and in the air), together with warm climate, provides the **optimal condition for fungi propagation and development**, especially for soil-borne pathogens.
On the other side, **severe water stress could cause a higher expression level of GTDs symptoms**.
Drip irrigation must be regulated to avoid both critical conditions. The daytime is more advisable than nighttime in summer irrigation. The so called "mild stress", applied to promote a good ripening is reasonable, but too extreme in"thirst" of the vineyard may lead to the GTDs symptoms appearance in affected vineyards.
In case of excess vigor and/or an excess yield, due to high nitrogen fertilization, use of vigorous rootstocks and continuous soil tilling is always dangerous for GTDs risk but mostly in case of dry-land farming, because in a dry season this excess increases the water stress establishment and the explosion of GTDs symptoms.

5. Biological control to prevent infections

Trichoderma exhibits **antagonistic activity** towards other microorganisms, especially soil-borne ones. Healthy vines can be inoculated with these fungi to **colonize the woody tissues** of the cordon and the trunk up to few centimeter under the treated wounds. *Trichoderma* is applied on the vegetation and competes with pathogenic fungi, so improving the protection towards GTDs. The treatment must be repeated every year. The use of various species of the fungal genera *Trichoderma* (*T. harzianum, T. gamsii, T. atroviride, T. asperellum*) to protect pruning wounds came into use with various commercial preparations. The fungus colonizes the pruning wounds forming a barrier to the pathogens penetration. Its action is only preventive and it is linked to a various number of variables affecting the biological habit of the fungus and its capacity for colonization. Complete colonization require a certain time, during which the grapevine is sensible to infections and *Trichoderma* may be washed off in case of rainfall. The ideal is to spray *Trichoderma* as soon as possible after pruning.

Recommendation: prune by plots or sectors and as soon as one plot is completed, spray *Trichoderma*.

Production phase

1. Annual pruning

Same concepts reported for the growing phase worth true in the production phase.

2. Debris management

In order to reduce diseases spreading, **infected wood should be removed from the field**, either burned or composted. It is particularly important in the case of old wood (branches, trunks), while one-year wood is less dangerous.
Chopping and burying the debries could create a dangerous inoculum in the soil.
Some practices to reduce the inoculum are suggested:

- **Remove dead vines, diseased vines or dead parts of alive vines (dead shoots).**
- **Remove or burn them or protect them away from rain. GTDs inocula are found at surface of the wood in all part of grapevine (arms, trunk).**
- **Remove debris before pruning, better if together with observe diseased vines at stage of 8-12 leaves for Eutypa dieback and before harvest for Esca and Botryosphaeria dieback**
- **Consider that some pathogens as Botryosphaeriaceae could resist in pruning debris for more than 3 years.**

Another positive practice is the composting,useful also to soil organic matter increase. Its management should consider the following:

- peak temperature of 64-70°C and 21 days of fermentation in general ensure the reduction of pathogens below detection limits, but this practice is not tested on GTDs pathogens
- the long term composting of pruning debris, sheep manure, leaves and grass residues (fermenting at temperatures around 50-60°C for at least 3 years) allow to eradicate GTDs pathogens by limiting mycelial development. Composted material can be reintroduced in vineyard with no risk of contamination.

3. Fertilization

During the production phase a balanced nutrition to assure a balanced growth and a limited vigor is the goal. Thus, incidence of wood diseases can be reduced by a moderate fertilization that grants the plant the resources for production but also for self-defense. Indeed, an excessive vegetative growth affects both the plant lignification and the ability of the plant to self- protect. Moreover, **an increased plant vigor needs more severe pruning that causes large wounds facilitates infections**. A moderate nitrogen availability and limited irrigation are advisable.

It is demonstrated that foliar applications of nutrients influence the development of GTDs foliar symptoms. For example, foliar application of a mixture of calcium chloride, magnesium nitrate and Fucales seaweed extract during three years led to a significant reduction of symptoms development in the vine treated with the full mixture. Both quantity and quality of grapes from the treated vines increased, while no phytotoxic or other unwanted effects on grape growth were detected.

4. The use of *Trichoderma* and other biocontrol agents

For the prevention of GTDs, *Trichoderma* species as *Trichoderma harzianum* and *T. atroviride* treatments during the whole plant life can be recommended (figure 5.). Another possibility is the induction of grapevine self-defence systems using other biocontrol agents. A scientific study ascertained that necrosis, produced by Phaemoniella chlamydospora (one of the Esca disease pathogens), were reduced up to 50% when *Pythium oligandrum* colonized the root system of grapevine cuttings. Commercial products containing this biocontrol agent are currently available.

Other products, based on a mix of arbuscular-mycorrhizal fungi, if inoculated in vines could reduce the susceptibility to GTDs.

Fig 5: Aspersion of trichoderma-based product to protect pruning wounds (EKU, Eger, Hungary)

5. Soil management and Weed management in the under-row

The same concepts reported for the growing phase worth true in the production phase.

6. Water management and irrigation

It has been evidenced that a **water-stressed vineyard in a warm, dry environment may be more susceptible to infections** through pruning wounds by Eutypa lata than vines receiving regular irrigation. Internal wood symptoms are not related to foliar symptoms severity or to the temperature and moisture combination. Water-stressed vines have significantly lower photosynthetic rates and lower levels of stomatal conductance compared to those receiving optimal irrigation, indicating that these plants experienced significantly higher levels of physiological stress. Fungal diseases which enter the plants from the pruning wounds produced some external symptoms and the lesion length are significantly longer in pruning wounds of stems from plants in the lowest irrigation regime, with lesion length declining linearly with the increasing irrigation volume. These results clearly indicate that when a **grapevine is exposed to water stress, colonization and disease expression by Botryosphaeriaceae spp. are much more severe**. Practical recommendations reported in 2.5 for the growing phase worth true also in the production phase.

7. Trunk renewal practices

The decision to replace vines is not only based on economic factors, since there are agronomic ones (establishment of new vines, yield, uniformity quality of grape, etc.) which could affect the viability of the new plants. Some practices, such as **trunk renewal, re-grafting and trunk cleaning** (surgery) could be also considered. **An inspection to identify symptomatic vines in early stages is recommended**. The inspection time depends on the predominant trunk diseases in the vineyard. Foliar symptoms of Eutypa dieback and Botryosphaeria dieback are visible in spring while the Esca ones develop starting approximately in mid-June. Dead spurs and stunted shoots are best observed later in the growing season, when vegetative growth stops.

Symptomatic vines must be marked in order to **evaluate the degree of infection in a plot, to prune infected plants separately from others or to follow up and evaluate implemented actions.**

The trunk renewal practice consists in the recovering of a diseased vine by replacing the infected trunk with a new one, utilizing a sucker at its base (figure 6 and 7.). Scientific studies have shown successful results when applied against Eutypa dieback and other trunk diseases.

The experience in many countries shows that **the sooner the trunk renewal begins, the more successful** it

will be in controlling the disease spread and yield loss. This practice allows recovering the plant and taking advantage of the root system of the damaged vine, thus **mitigating the losses by damages of wood disease and maintaining the productivity** of vineyard. Two suckers can be used to form two trunks, a helpful insurance against new infections, or an extra possibility in case of damage. If suckers sprout from rootstock they can be used to recover vine, through a graft between an herbaceous sucker and new scion, or either reestablish the vine through grafting directly on rootstock.

Figure 6: Suckers kept to renew the trunk (Photo courtesy of Lucía & Manolo Vilerma.)

Figure 7: A vine after trunk renewal (Photo courtesy of Lucía & Manolo Vilerma.)

Trunk cleaning removes from trunk or arms the rotten wood that disturbs the circulation of sap. It means to **open the trunk** or arms, to **remove the affected wood**, keeping only the external part of the wood or cambium. The cut is always made above the graft point and about 20 cm below the any wood staining. **Early implementation, as soon as first symptoms appear, is recommended**, if done in june it allows to harvest in the current year. Trunk cleaning is only effective on Esca and Botryosphaeria dieback (figure 8).

Figure 8: Appereance of the trunk after trunk cleaning (IFV Alsace)

Re-grafting or **over grafting** is another way to recover plant vine by removing the damaged part and recovering a new part by **grafting a new scion**. This grafting will be carried out in rising sap by a herbaceous grafting on a **rootstock sucker** that has sprouted in spring, **or directly on the trunk** usually by slit grafting. The upper part of plant could be removed in a reasonable time after grafting has taken place or after the crop cycle in pruning of the next year. Both cases, the root system of old vine is also used, which means that production loss is lower. More precisely, the re-grafted vines could reach the productive level of the older ones in three years and with the same grape quality level (important for the wine quality). However, this practice require more time consuming and therefore is more expensive than the renewal of the trunk.

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http://www.maladie-du-bois-vigne.fr/Maladies-du-bois/L-esca/Protection-au-vignoble

More information

www.winetwork-data.eu

Technical datasheets:

- Good pruning practices
- Pruning in regard with sap flux
- *Trichoderma* spp. application to prevent GTDs infection

Video seminars:

- Scientific overview of grapevine trunk diseases (Dr. Vincenzo Mondello, URCA)
- Symptomatology and epidemiology of GTDs (Dr. Vincenzo Mondello, URCA)

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