Decay and Low Sustainability Of Fruit Trees

Because of high-frequency irrigation under drip and microsprinkler

Antonio Lobato
Consultant
Decay of Vines in Copiapó Valley

Decay of vines in Aconcagua Valley
Aerial Analysis of Plantations in Punitaqui Limarí Valley
Aerial Analysis of Table Grape Parronal Limarí Valley (Chlorophyll Degradation)
Old Avocado Tree (Age 60 years), Mexícola Variety
San Esteban County, Aconcagua Valley
New Avocado Plantations (Age 1-3 years)
On sloping hills
Avocado Plantations (Age 3-5 years)
On sloping hills
New Avocado Plantations (Age 5-7 years) On sloping hills
New Avocado Plantations (Age 7-10 years)
On sloping hills
Result after 10 years of high-frequency irrigation

Is this a good practice in fruit tree production?
Symptoms and Indicators of Decay and Low Sustainability

In fruit trees

1. Symptoms of foliage with low vigor and low vegetative development

2. High Concentration of foliar Manganese as an indicator of flooding and lack of oxygen on root zones.

3. Coloration and abnormal growth of primary roots and fine roots.

4. Varying Levels of Salinity at Different Soil Depths, and the Presence of Reductive Conditions of Grey Color.

5. Presence of Indicator Plants.
Symptoms of Lack of Oxygen on Canes of Vines
Vine with Few Canes and Buds
(Approx. 37% of normal)
Decreasing Cane Thickness as a Sign of Decay in Vines Due To Lack of Oxygen in Roots
Lower Foliage Density in Avocado Trees As a Sign of Decay Due to Lack of Oxygen in Roots
Simptoms and Indicators of Decay and Low Sustainability

In fruit trees

1. Symptoms of foliage with low vigor and low vegetative development

2. High Concentration of foliar Manganese as an indicator of flooding and lack of oxygen on root zone.

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4. Varying Levels of Salinity at Different Soil Depths, and the Presence of Reductive Conditions of Grey Color.

5. Presence of Indicator Plants.
Typical Foliar Analysis of Decayed Grape Vines

<table>
<thead>
<tr>
<th>VARIEDAD</th>
<th>Thompson 1</th>
<th>Flame seedless</th>
<th>Red Globe</th>
<th>Superior</th>
<th>RANGO ADECUADO</th>
</tr>
</thead>
<tbody>
<tr>
<td>N-TOTAL (N) %</td>
<td>3.48</td>
<td>3.04</td>
<td>3.10</td>
<td>3.05</td>
<td>2.00 - 2.40</td>
</tr>
<tr>
<td>FOSFORO (P) %</td>
<td>0.33</td>
<td>0.37</td>
<td>0.34</td>
<td>0.34</td>
<td>0.14 - 0.45</td>
</tr>
<tr>
<td>POTASIO (K) %</td>
<td>1.06</td>
<td>0.67</td>
<td>0.97</td>
<td>0.97</td>
<td>0.95 - 1.20</td>
</tr>
<tr>
<td>CALCIO (Ca) %</td>
<td>1.96</td>
<td>2.50</td>
<td>1.43</td>
<td>1.54</td>
<td>1.50 - 2.40</td>
</tr>
<tr>
<td>MAGNESIO (Mg) %</td>
<td>0.28</td>
<td>0.31</td>
<td>0.24</td>
<td>0.22</td>
<td>0.25 - 0.60</td>
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<tr>
<td>ZINC (Zn) ppm</td>
<td>24</td>
<td>23</td>
<td>25</td>
<td>23</td>
<td>30 - 50</td>
</tr>
<tr>
<td>MANGANESO (Mn) ppm</td>
<td>305</td>
<td>405</td>
<td>425</td>
<td>450</td>
<td>20 - 300</td>
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<tr>
<td>FIERRO (Fe) ppm</td>
<td>151</td>
<td>177</td>
<td>170</td>
<td>133</td>
<td>60 - 100</td>
</tr>
<tr>
<td>COBRE (Cu) ppm</td>
<td>9</td>
<td>6</td>
<td>9</td>
<td>7</td>
<td>3 - 20</td>
</tr>
<tr>
<td>BORO (B) ppm</td>
<td>26</td>
<td>34</td>
<td>28</td>
<td>23</td>
<td>35 - 100</td>
</tr>
</tbody>
</table>
Foliar Manganese Concentration on Petiols of Table Grapes in Full Bloom Stage
(Each Bar represents an average of about 20 growers)

Optimal Range of Oxygen in Roots (150-200 ppm)

Regiones

III  IV  V  VI  VII  RM
Foliar Manganese Concentration on Petiols of Grape Vines in Full Bloom Stage
(Each Bar represents an average of about 20 growers)

Out of Range: WHY?

Optimal Range of Oxygen in Roots (150-200 ppm)
Foliar Magnesium Concentration on leaf Blade of Table Grapes in Veraison Stage (Each Bar represents an average of about 20 growers)

Optimal Range of Oxygen in Roots (150-200 ppm)
Foliar Manganese Concentration on Leaf Blades of Grape Vines in Veraison Stage (Each Bar represents an average of about 20 growers)

Out of Range AGAIN: WHY?

Optimal Range of Oxygen in Roots (150-200 ppm)
High Concentration of foliar Manganese as an indicator of flooding and lack of oxygen on root zones in Avocado Trees.

**Caso 1**

**Localidad:** La Ligua

**Especie:** Paltó Hass  
**Tejido:** Hoja

**Fecha muestreo:** 20-03-2006  
**F.Ingreso:** 24-03-2006  
**F.del informe:** 03-04-2006

<table>
<thead>
<tr>
<th>Identificación Cuartel</th>
<th>Sector 5</th>
<th>Rango Adecuado*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variedad</td>
<td>Hass</td>
<td></td>
</tr>
<tr>
<td>Edad</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Nº de Laboratorio</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nitrógeno total (N)</th>
<th>%</th>
<th>1.89</th>
<th>2.00 - 2.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fósforo (P)</td>
<td>%</td>
<td>0.19</td>
<td>0.10 - 0.25</td>
</tr>
<tr>
<td>Potasio (K)</td>
<td>%</td>
<td>0.55</td>
<td>0.75 - 2.00</td>
</tr>
<tr>
<td>Calcio (Ca)</td>
<td>%</td>
<td>1.13</td>
<td>1.00 - 3.00</td>
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<tr>
<td>Magnesio (Mg)</td>
<td>%</td>
<td>0.51</td>
<td>0.25 - 0.80</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>ppm</td>
<td>95</td>
<td>30 - 150</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>ppm</td>
<td>770</td>
<td>30 - 500</td>
</tr>
<tr>
<td>Hierro (Fe)</td>
<td>ppm</td>
<td>75</td>
<td>50 - 200</td>
</tr>
<tr>
<td>Cobre (Cu)</td>
<td>ppm</td>
<td>9</td>
<td>5 - 15</td>
</tr>
<tr>
<td>Boro (B)</td>
<td>ppm</td>
<td>18</td>
<td>40 - 100</td>
</tr>
</tbody>
</table>


Plants with Severe Decay
**CASO 2**

Localidad: Combarbala  
Especie: Palto Hass  
Tejido: Hoja

Fecha muestreo: 24-03-2006  
F.Ingreso: 24-03-2006  
F.del informe: 03-04-2006

<table>
<thead>
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<th>Sector 4</th>
<th>Rango Adecuado*</th>
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<td>Hass</td>
<td>Hass</td>
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</tr>
<tr>
<td>Edad</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>N° de Laboratorio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrógeno total (N) %</td>
<td>2,31</td>
<td>2,02</td>
<td>2,00 - 2,50</td>
</tr>
<tr>
<td>Fósforo (P) %</td>
<td>0,16</td>
<td>0,18</td>
<td>0,10 - 0,25</td>
</tr>
<tr>
<td>Potasio (K) %</td>
<td>0,98</td>
<td>1,09</td>
<td>0,75 - 2,00</td>
</tr>
<tr>
<td>Calcio (Ca) %</td>
<td>1,81</td>
<td>1,40</td>
<td>1,00 - 3,00</td>
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<tr>
<td>Magnesio (Mg) %</td>
<td>0,47</td>
<td>0,33</td>
<td>0,25 - 0,80</td>
</tr>
<tr>
<td>Zinc (Zn) ppm</td>
<td>59</td>
<td>73</td>
<td>30 - 150</td>
</tr>
<tr>
<td>Manganoso (Mn) ppm</td>
<td></td>
<td></td>
<td>30 - 500</td>
</tr>
<tr>
<td>Hierro (Fe) ppm</td>
<td>67</td>
<td>66</td>
<td>50 - 200</td>
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<tr>
<td>Cobre (Cu) ppm</td>
<td>7</td>
<td>9</td>
<td>5 - 15</td>
</tr>
<tr>
<td>Borro (B) ppm</td>
<td>37</td>
<td>35</td>
<td>40 - 100</td>
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</table>

Plants About to Die

Foliar Analysis of Plants with Normal Levels of Manganese Concentration as a Result of Very Good aereation in the Root System

**CASO 3**

<table>
<thead>
<tr>
<th>Localidad</th>
<th>La Ligua</th>
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<tbody>
<tr>
<td>Especie</td>
<td>Palto Hass</td>
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<tr>
<td>Tejido</td>
<td>Hoja</td>
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<tr>
<td>Fecha muestreo</td>
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<tr>
<td>F.Ingreso</td>
<td>24-03-2006</td>
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<tr>
<td>F.del informe</td>
<td>03-04-2006</td>
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<table>
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<th>Sector 4</th>
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</thead>
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<tr>
<td>Variedad</td>
<td>Hass</td>
</tr>
<tr>
<td>Edad</td>
<td>7</td>
</tr>
<tr>
<td>N° de Laboratorio</td>
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<table>
<thead>
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<th>Analítese</th>
<th>Rango</th>
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<tr>
<td>Nitrógeno total</td>
<td>2,10</td>
</tr>
<tr>
<td>(N) %</td>
<td></td>
</tr>
<tr>
<td>Fósforo</td>
<td>0,22</td>
</tr>
<tr>
<td>(P) %</td>
<td></td>
</tr>
<tr>
<td>Potasio</td>
<td>1,40</td>
</tr>
<tr>
<td>(K) %</td>
<td></td>
</tr>
<tr>
<td>Calcio</td>
<td>1,89</td>
</tr>
<tr>
<td>(Ca) %</td>
<td></td>
</tr>
<tr>
<td>Magnesio</td>
<td>0,60</td>
</tr>
<tr>
<td>(Mg) %</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>55</td>
</tr>
<tr>
<td>(Zn) ppm</td>
<td></td>
</tr>
<tr>
<td>Manganeso</td>
<td>210</td>
</tr>
<tr>
<td>(Mn) ppm</td>
<td></td>
</tr>
<tr>
<td>Hierro</td>
<td>110</td>
</tr>
<tr>
<td>(Fe) ppm</td>
<td></td>
</tr>
<tr>
<td>Cobre</td>
<td>9</td>
</tr>
<tr>
<td>(Cu) ppm</td>
<td></td>
</tr>
<tr>
<td>Boro</td>
<td>49</td>
</tr>
<tr>
<td>(B) ppm</td>
<td></td>
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</tbody>
</table>

Optimal Range of Oxygen in Roots (150–250 ppm)
Symptoms and Indicators of Decay and Low Sustainability

In fruit trees

1. Symptoms of foliage with low vigor and low vegetative development
2. High Concentration of foliar Manganese as an indicator of flooding and lack of oxygen on root zone.
3. Coloration and abnormal growth of primary roots and fine roots.
4. Varying Levels of Salinity at Different Soil Depths, and the Presence of Reductive Conditions of Grey Color.
5. Presence of Indicator Plants.
What is happening under the soil of these decayed plants?
Washing away soil particles to expose the root system
Typical root system of a decayed plant
(NOTICE: No feeder roots present)
So, What is happening with nutrients applied through fertigation?
Typical Red Color of roots affected by severe lack of oxygen for long periods of time.
Typical Red Color of wine grape roots affected by severe flooding and lack of oxygen for long periods of time

Abnormal upward growing pattern
Next Step: Beginning of Necrotic Tissue on secondary roots because of diseases
Damage on the inner part of the grape crown as a result of long periods of flooding and lack of oxygen
Typical Red Color of roots affected by severe lack of oxygen for long periods of time

Plum Tree Root System
What happened in avocado trees?
Fine roots with weak cuticle
Typical Red Color of roots affected by severe lack of oxygen for long periods of time
Typical Red Color of roots affected by severe flooding and lack of oxygen for long periods of time

Abnormal upward growing pattern
Damage on the inner part of the avocado crown as a result of long periods of lack of oxygen.
Normal Root System
Typical Red Color of roots affected by severe lack of oxygen for long periods of time
Gradients of red coloration throughout time affected by lack of oxygen
Simptoms and Indicators of Decay and Low Sustainability

In fruit trees

1. Simptoms of foliage with low vigor and low vegetative development
2. High Concentration of foliar Manganese as an indicator of flooding and lack of oxygen on root zone.
3. Coloration and abnormal growth of primary roots and fine roots.
4. Varying Levels of Salinity at Different Soil Depths, and the Presence of Reductive Conditions of Grey Color.
5. Presence of Indicator Plants.
Symptoms of tip burn as a result of high salinity levels in a non-saline soil
3 different colors in a uniform soil profile as a result of different water contents.
Blueberries
Symptoms and Indicators of Decay and Low Sustainability

In fruit trees

1. Symptoms of foliage with low vigor and low vegetative development

2. High Concentration of foliar Manganese as an indicator of flooding and lack of oxygen on root zone.

3. Coloration and abnormal growth of primary roots and fine roots.

4. Varying Levels of Salinity at Different Soil Depths, and the Presence of Reductive Conditions of Grey Color.

5. Presence of Indicator Plants.
Reasons for decay and low sustainability

1. Irrigation technique
2. Physical and chemical fertility of the soil
3. Physiological response of roots
4. Agronomic quality of irrigation water
5. Diseases and plantation problems
6. Abnormal wetting patterns of soils under drip irrigation
Short and frequent irrigation
The paradigm of irrigation and its effect on the mid and long term.

Anoxia    Soil crusting

Soil crusting
Soil saturation
Upward-growing roots
Saline Zone
Dry soil, Low salt content
Reasons for decay and low sustainability

1. Irrigation technique
2. Physical and chemical fertility of the soil
3. Physiological response of roots
4. Agronomic quality of irrigation water
5. Diseases and plantation problems
6. Abnormal wetting patterns of soils under drip irrigation
Volume and specific surface relationship

Surface: \(2 \times 2 \times 6 = 24 \text{ cm}^2\)

\(1 \times 1 \times 6 \times 8 = 48 \text{ cm}^2\)
This soil was prepared at too low soil water levels. The structures seen here are the direct result. Roots do not penetrate these structures.
A well prepared soil.
Loss of volume of soil and physical fertility
Soil crusting as impediment for water infiltration
Calcium carbonate crystals
Citrus
Standing Water in a Severely Compacted Field
Reasons for decay and low sustainability

1. Irrigation technique
2. Physical and chemical fertility of the soil
3. **Physiological response of roots**
4. Agronomic quality of irrigation water
5. Diseases and plantation problems
6. Abnormal wetting patterns of soils under drip irrigation
Señales de las raíces profundas

Señales de las raíces superficiales

Cierre estomático

Síntesis de etileno

Ácido Abcisico

Zona saturada de humedad, suelo sin estructura

Zona seca

Asfixia

Sequedad

Precursor de etileno

Sello superficial

Sello del perfil de riego

Ácido Abcisico
Pattern of growth in grape vine roots

Soil Profile
Saint-Julien
Grape vine roots up to 6 meters depth
Reasons for decay and low sustainability

1. Irrigation technique
2. Physical and chemical fertility of the soil
3. Physiological response of roots
4. Agronomic quality of irrigation water
5. Diseases and plantation problems
6. Abnormal wetting patterns of soils under drip irrigation
Infiltration reduction of irrigation water depending on salt content

*RHOADES (1977) & ÖSTER Y SCHÖER (1979)*
Effect of gypsum as amendment applied through water irrigation in Lontué river because of low salt contents (VII Region, Chile)
Reasons for decay and low sustainability

1. Irrigation technique
2. Physical and chemical fertility of the soil
3. Physiological response of roots
4. Agronomic quality of irrigation water
5. **Diseases and plantation problems**
6. Abnormal wetting patterns of soils under drip irrigation
What is the evolution of these plants in the future?
Wine grape: severe attack of crown galls
Wine grape: severe attack of nematodes.
Grape Vine: Severe attack of Philoxera
Reasons for decay and low sustainability

1. Irrigation technique
2. Physical and chemical fertility of the soil
3. Physiological response of roots
4. Agronomic quality of irrigation water
5. Diseases and plantation problems
6. Abnormal wetting patterns of soils under drip irrigation
Wetting pattern of Chilean soils
The great paradox
Well irrigated soil
Clay loam soil with a narrow wetting pattern under drip irrigation
Symptoms on foliage because of dry root zones in a full irrigated orchard
Grape Vines Planted in a sandy soil with 100% of wet soil
Under drip irrigation
Soil profile
San Julián, Ovalle. Chile
Method for the Recuperation of Decayed Agricultural Plantations

(M.R.P.D.F.)

US Patent Granted 2005

Authors

Antonio Lobato
Eduardo Alonso
**Basic principles of Method for the Recuperation of Decayed Agricultural Plantations**

**Irrigation**

1. “Irrigation period is for soils, and should be enough to reach the deepest roots. This is a fundamental tool in order to introduce oxygen to the soil profile.”

2. “Irrigation frequency is for plants, and depends on the species, age, and the phenological stage.”

3. “Water distribution should be applied sufficiently so as not to leave the roots in dry zones.”

**Ammendments**

1. Sulfuric acid as a chemical tool to eliminate soil crusting and improve water infiltration.

2. Calcium sulfate as a tool to improve porosity and physical fertility of soils.

**Stimulation of New Root Growth**

Use of Chitosan (poli-D-glucosamina) as a molecule which inducts SAR responses in plants such as an increase in the volume of roots.
Validation Experiment of the Method for the Recuperation of Decayed Agricultural Plantations
Experiment: Two methods of water application in grape vines. Muscat of Alexandria variety. Ovalle, 1996

Soil Profile
San Julián, Ovalle
Daily irrigation according to the ETc
14 continuous hours of irrigation every 3 days
Both methods use the same amount of water but with absolutely different results !!!
Effect of Two methods of water application in grape vines. Muscat of Alexandria variety. Ovalle, 1996

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Shoot growth (cm)</th>
<th>Yield/plant (kg)</th>
<th>Bunches/plant (N°)</th>
<th>Bunch Weight (kg)</th>
<th>Sugar content (°Brix)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily irrigation</td>
<td>47,11 a</td>
<td>19,76 a</td>
<td>73 a</td>
<td>270 a</td>
<td>21,2 a</td>
</tr>
<tr>
<td>Non daily irrigation</td>
<td>68,31 b</td>
<td>42,13 b</td>
<td>92 b</td>
<td>456 b</td>
<td>20,0 a</td>
</tr>
</tbody>
</table>

Letras iguales no difieren estadísticamente entre sí. Duncan p<0.05
Training of personnel in soil characteristics and root conditions during the irrigation period using the method analysis of Soil pit
Deep Soil Pit in order to observe wetting patterns, root growth, under the new method.
Radio Logger

Antenna

DataTrac Mobile

Radio Receiver

DataTrac Graphing Software

Rain Gauge

Temperature Probe

Moisture Sensors
Fluctuation of water content at three depths using two different methods of irrigation

Maipo Valley, Chile

30 cm depth Moisture sensor

60 cm depth Moisture sensor

90 cm depth Moisture sensor

High frequency of irrigation

Low frequency irrigation, long periods
Fluctuation of water content at three depths using *Method for the Recuperation of Decayed Agricultural Plantations* Maipo Valley, Chile

Perfect synchronicity between periods of irrigation
Increased porosity after calcium sulfate application
New roots growing in a damaged secondary root as a result of new method of irrigation
Condition of roots prior to treatment

Generation of new roots after treatment
Thank you very much!