



“Compost benefits and quality for viticultural soils”

By: Alfred Cass and Megan McGrath

In: Proceedings of the Soil Environment and Vine Mineral Nutrition Symposium. P. Christensen and D.R. Smart (Eds.), pp 135-143. 2005. American Society of Enology and Viticulture, Davis, CA.

In this very interesting and well-organized paper the authors explain the process by which intense tillage and high vineyard traffic destroy soil structure, and how applications of compost can reverse that. They also discuss how to assess compost quality.

- Soil physical properties have more impact than we think. Just because the soil does not go away does not mean that it has not lost the structure it once had. To illustrate this, the authors note how the loss of pore structure can cause: increased soil strength, increased anoxia (loss of oxygen), lower infiltration, lower hydraulic conductance, and poorer drainage. These would cause, in turn, reduced root growth and reduced microbial activity. It is no surprise that the vines would suffer too!

- **Soil physical deterioration.** The authors describe in detail the different soil breakdown processes. Even though they all lead to the same negative place, you might want to get acquainted with each.

- 1) *Coalescence*: Slow deposit of fine soil particles between individual aggregates, welding them together into a massive structure. Soils that have been tilled in a very dry state are particularly prone to coalescence.

- 2) *Slaking*: Structural collapse when dry soil aggregates are wetted rapidly by rain or irrigation. Soils with low organic carbon (<2%) are subject to rapid slaking.

- 3) *Dispersion*: Disintegration of the slaking products into individual particles due to high forces of repulsion between clay particles. These high forces are promoted by high concentrations of exchangeable sodium. This condition is rare in North Coast vineyards, but can occur in more arid areas.

- 4) *Compaction*: Reduction of soil volume by destruction of pore space, mainly large pores. Soils with low organic carbon (<2%) are particularly prone to compaction, but soils high in organic matter exhibit elastic resilience that makes them rebound.

- 5) *Aggregate pulverization*: This happens when soils that are too dry are tilled, which destroys aggregates into fine powder. On the other hand, tilling when soil is too wet destroys aggregates by smearing, because soil strength is at a minimum. Tillage should ideally happen when soil moisture is at a point called “Lower Plastic Limit”. At this water content, soil is just changing from “brittle” to “plastic”, and tillage creates aggregates of optimum sizes (5 to 25 mm) (one inch is 25 mm).

- **Effects of compost on soil structure** . Even though applying compost as mulch has benefits for moisture conservation and weed control, the following benefits are not realized unless compost is mixed with the soil.

- 1) *Pore-size distribution*. Incorporating compost by careful tillage produces long-lasting, heterogeneous pore-sizes. Large pores allow O₂ and CO₂ flow. Very large pores (biopores) enhance water infiltration and drainage.

- 2) *Water-holding capacity*. Soil water available for plants is stored in small (microspores) and medium pores. Compost improves water-holding capacity by enhancing this porosity and ensuring pore continuity.

- 3) *Infiltration and Hydraulic conductivity*. Soils with a large proportion of macropores have higher infiltration rates and higher hydraulic conductivity (less resistance to water flow). After tillage, soil tends to

have a large proportion of unstable macropores (“tillage voids”). But if the soil has been treated with compost prior to tillage, a larger proportion of these pores will persist through wetting/drying cycles.

4) *Aggregate stability*. This is the strength of the interactions within the soil aggregate in relation to outside forces. If aggregates are stable they will last even when subject to stresses. And compost, because of the microbial activity it generates, is responsible for reinforcing the stability of these aggregates.

5) *Biological activity*. An increased porosity leads to increased biological activity. Fungi and bacteria are the leading soil organic matter decomposers through the action of their enzymes. *Humus* refers to any organic matter which has reached a point of stability, and it will not break down further. It is an amorphous, colloidal, polymorphic, dark-brown group of compounds which represent the end result of microbial decomposition. *Humic acid* is an example of these compounds.

· **Compost quality**. Half of most commercial compost is carbon. The other half is mostly oxygen and hydrogen, along with nitrogen, phosphorus, and many other constituents. These constituents can include heavy metals, plastic waste, wood chips, sawdust, metal, and rock. Because compost composition is highly variable and cannot be controlled by the user, the USDA and the US Composting Council are working toward the publication of a set of standards for compost analysis. Next the authors describe the criteria they use to select the best compost possible.

1) *Maturity*. A mature compost has reached enough humification to provide a certain degree of physical, chemical, and biological stability. At this point, C:N ratio, ammonium levels, and salt concentrations are within specific ranges. Application of immature compost is detrimental to vines, as compost starts decomposing rapidly in the soil, inducing 1) anoxia, 2) N draw, particularly in high C:N compost (nitrogen deficiency due to microbial growth flush), and 3) phytotoxicity due to the presence of organic acids, the intermediate by-products of decomposition. Even though several indices of compost maturity have been established, the authors use a **C:N ratio <20** as an initial reference of good compost maturity.

2) *Salinity, Boron, and Sodidity*. High salinity, boron (B), and sodium (Na) are toxic for grapevines. Boron in compost should be <100 mg/l. Sodium should be <1%. Salinity is measured by electrical conductivity (EC). There is a sliding scale for the amount of compost recommended based on EC: the higher the electrical conductivity, the less compost should be used. Most commercial compost in northern California has **EC values <20 dS/m**, so applications of 11 tons/ha (5 tons/acre) are safe. Leaching of compost before application can be a solution to eliminate high salts.

3) *Soluble nitrogen*. The concern here is to avoid excessive nitrogen that would induce excessive vegetation unfit for premium wine production. At maturity, compost should have **<300 mg/kg ammonium-N, and <42 mg/l nitrate-N**.

4) *Heavy metals*. Some compost –for example, municipal solid waste- tends to have higher concentration of heavy metals, such as zinc (Zn), copper (Cu), nickel (Ni), lead (Pb), cadmium (Cd), and chromium (Cr). The risk is contamination of the fruit, and of the environment! Critical levels have not been established.

5) *Pathogens*. Contaminates in compost can include: pesticides, herbicides, fecal coliforms, pathogens and weed seeds. Even though the high temperatures reached during composting are sufficient to kill enteric pathogens and weed seeds, composting is not a sterilization process, so some pathogens could potentially re-grow. There are no specific criteria developed here.

In summary, compost has many beneficial effects on physically degraded soil, improving: *pore-size distribution, water-holding capacity, infiltration, aggregate stability, and biological activity*. The factors dictating compost quality include: *maturity, salinity, nitrogen, heavy metals, and pathogens*. Adding compost which meets the criteria of the USDA and the US Composting Council before vineyard establishment is particularly beneficial for early plant growth.

Author: Bibiana Guerra, Editor: Kay Bogart. This summary series funded by J. Lohr Vineyards & Wines.