# Soils and plant material in prestigious Bordeaux vineyards Impacts on yield and quAlity

# Les sols et le matériel végétal dans des crus prestigieux de Bordeaux. Effets sur le rendement et la qualité

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## Abstract

High resolution soil maps (scale : 1/3000) were created for seven of the most prestigious red wine producing estates in Bordeaux, covering in total approximately 400 ha. Soil type and grapevine variety were recorded for each vineyard block of these estates. A quality index was created by considering the destination of the grapes produced on each block, whether they were integrated in the first, the second or the third quality wine produced by the estate. Quality index was averaged over five vintages. Yield was measured for each vineyard block and averaged over five vintages. PEYROSOL (gravely soil) was the most frequent soil type in these estates (44% of the total mapped area). Soils with temporary water logging (REDOXISOL), heavy clay soils (PLANOSOL) and sandy-gravely soils (BRUNISOL) each covered 10% of the mapped area . Highest quality was obtained on PLANOSOLS, ARENOSOLS (sandy soils), BRUNISOLS and PEYROSOLS. Quality was low on COLLUVIOSOLS (deep soils on colluvium), LUVISOLS (leached soils) and REDUCTISOLS (soils with permanent water logging). Cabernet-Sauvignon was the dominant grapevine variety (59% of the mapped area), followed by Merlot (32%), Cabernet franc (8%) and Petit Verdot (1%). On average, the Quality Index was higher for Cabernet-Sauvignon and Merlot compared to Cabernet franc and Petit Verdot. Yield was dependent on soil type and cultivar. Comparison of soil type, cultivar and Quality Index can indicate which relationships between soil type / cultivar contribute to optimum quality performance in Bordeaux.

**Key words:** Soil type, Bordeaux, estate, quality, yield

## Introduction

A viticultural terroir is an ecosystem, in which the vine is in interaction with factors of the natural environment, like climate and soil (van Leeuwen and Seguin, 2006). Soil is considered as an important factor in terroir expression (van Leeuwen *et al.,* 2004). Bordeaux vineyard soils, and their impact on grape ripening, have been extensively studied (Duteau *et al.,* 1981; van Leeuwen et Seguin, 1994; Choné *et al.,* 2001; Trégoat et al., 2002). However, little data is published about their spatial distribution and their relative frequency in high quality wine producing estates. A wine producing estate in Bordeaux ("château viticole") is variable in size (from a few hectares to over 100 hectares) and generally comprises of several grapevine varieties and a variety of soil types. Grapes from different vineyard blocks are fermented separately. Quality potential varies from block to block, depending on soil type, topography, grapevine variety, vine age, root-stock and viticultural techniques. The wines marketed by the estate are a blend of wines produced from various blocks. In prestigious estates only the best wines are blended to be sold under the name of the estate. Second quality wine is blended into a wine sold under a second label, and third quality wine is in most cases sold anonymously. The destination of the crop (first, second or third quality wine) can thus be considered as an integrative indicator of the quality of the grapes produced on a given block. In this study, the soils of seven of the most prestigious red wine producing estates in Bordeaux were mapped at very high spatial resolution (scale: 1/3000), covering an area of approximately 400 ha. Soil type and grapevine variety were recorded for each vineyard block of these estates. A quality index was created and applied to each block. Yield was measured on each block and averaged over 5 vintages. Quality and yield were related to soil type and grapevine variety. This study gives an insight into the soil types in prestigious Bordeaux wine estates and allows classification of their potential for obtaining high quality wines. It also points out which grapevine variety best reveals the quality potential for each of these soil types in Bordeaux.

## Materials and methods

Soil maps were established for seven among the most prestigious red wine producing estates in Bordeaux at 1/3000 spatial resolution. Soil mapping techniques are described by van Leeuwen and Chéry (2001). Soils are classified according to the French Référentiel Pédologique (Baize *et al.*, 1995). The estates are located in the appellations Pauillac, Margaux, Pessac-Léognan, Saint-Emilion and Pomerol and cover approximately 400 ha of vines, in 500 individual vineyard blocks. According to the soil maps, the main soil type was determined for each block. Grapevine variety, root-stock and vine age were recorded for each block. A Quality Index is attributed to each block by the following scale: 4 points is given if the wine produced on the block is blended into first quality wine; 1.5 point is given if the wine produced is blended into second quality wine; 0 points are attributed if the wine is blended in the third quality wine. These coefficients are based on the assumption that the first quality wine in these estates is sold four times more expensively than the second quality wine and that third quality wine is sold for a price that just covers the production costs. This Quality Index is established for each vintage from 2002 to 2006 and an average in obtained over these years. Yields were recorded for each individual block and averaged for the same series of vintages. Hence, a database of approximately 2500 references (500 blocks over 5 years) was established, from which it is possible to trace how soil type and grapevine variety, as well as their interaction, affect grape quality potential and yield in these estates.

## Results

Soil type is highly variable in these estates, depending on the geological substrate (Tertiary or Quaternary), the quantity of stones, the level of weathering of the soil profile and possible temporary or permanent water logging. An inventory of the main soil types recorded in the seven estates, shows that gravely soils (PEYROSOL) are the dominant soil type (44%, figure 1). Soils with temporary water logging (REDOXISOL) cover 10% of the mapped area. In these soils, a temporary water table is present in the root zone during winter, but disappears during the summer.

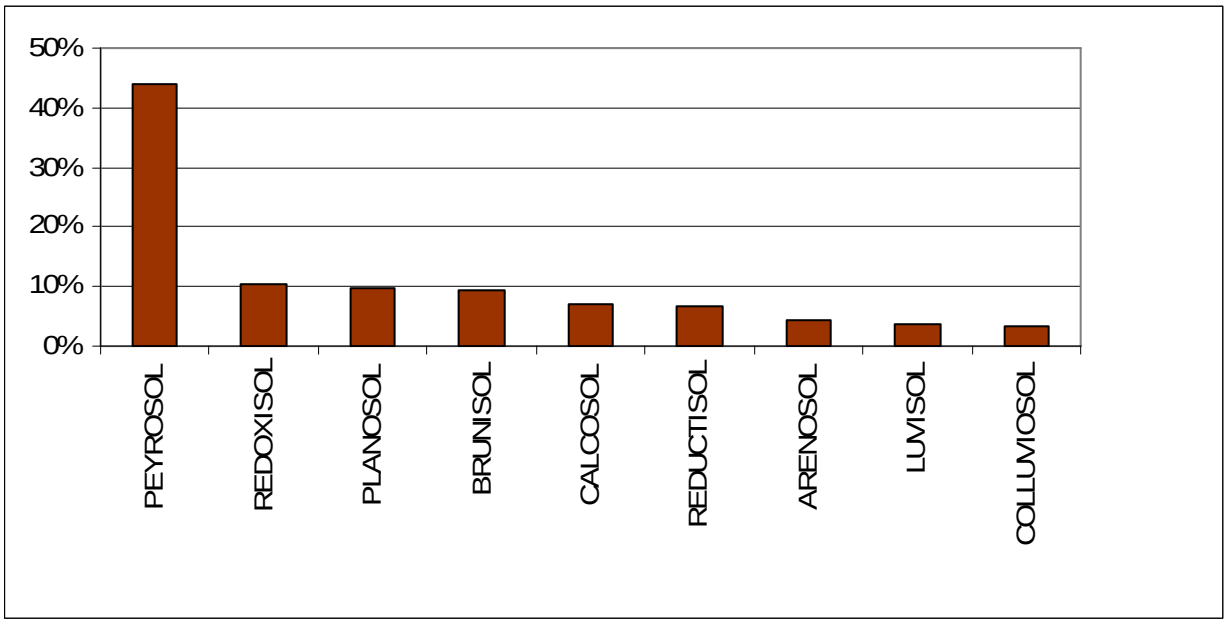


**Figure 1 Frequency of soil types in seven prestigious Bordeaux wine producing estates**

PLANOSOL (10% of the mapped area) is a soil type comprised of a sandy or gravely topsoil and a heavy clay sub-soil. BRUNISOL (10%) is a gravely-sandy or sandy-gravely textured soil. CALCOSOL (7%) is a lime holding, generally clayey textured soil. REDUCTISOL (7%) is a soil with a permanent water table that is always accessible by the roots ARENOSOL (4%) is a sandy soil. LUVISOL (4%) is a leached soil, often affected by some degree of water logging. COLLUVIOSOL (4%) is a deep soil developed on colluvium in a down hill position.

Quality Index is soil type related (figure 2). Mean quality is high on PLANOSOL, ARENOSOL, BRUNISOL and PEYROSOL. These soil types cover 67% of the mapped area. Mean quality is low on

COLLUVIOSOL, LUVISOL and REDUCTISOL (14% of the mapped area). Quality is intermediate on CALCOSOL and REDOXISOL.

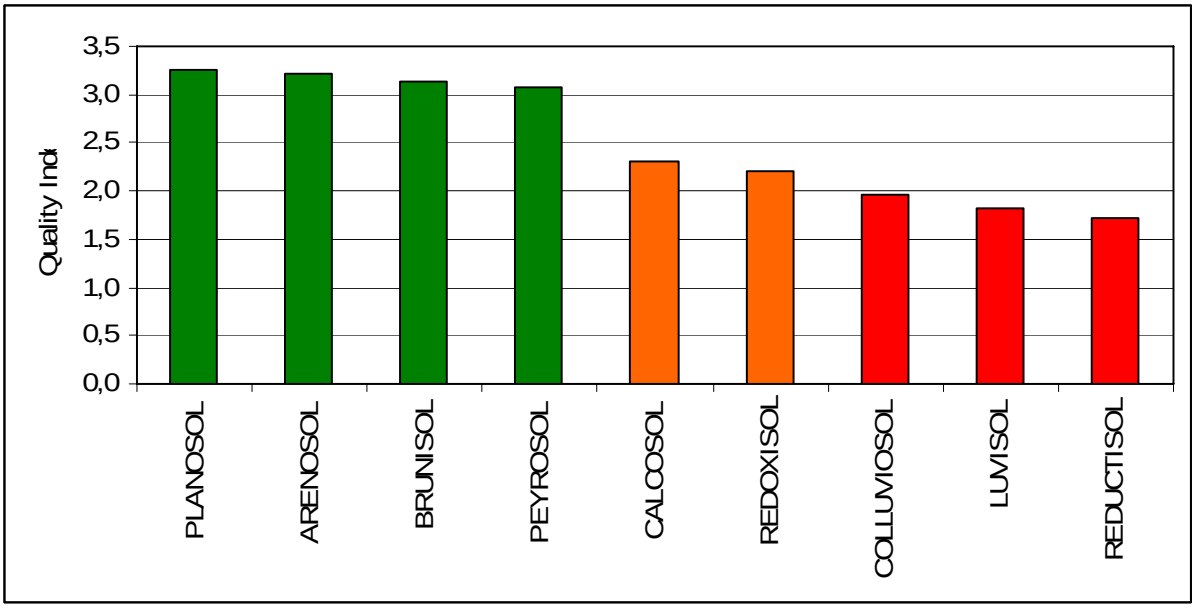


**Figure 2 Mean Quality Index (for vintages 2002-2006) for the main soil types of seven prestigious Bordeaux wine producing estates.**

Average yield is soil type related (figure 3). Yield is high on COLLUVIOSOL, LUVISOL, PLANOSOL and REDOXISOL. Yield is low on CALCOSOL and ARENOSOL. Yield is intermediate on PEYROSOL, BRUNISOL and REDUCTISOL.

In the seven estates selected for this survey, Cabernet-Sauvignon is the most widely planted variety (59%), followed by Merlot (32%). Cabernet franc (8%) and Petit Verdot (1%) are complementary varieties. Quality is variety dependant (figure 4). Average Quality Index is high for Cabernet-Sauvignon and Merlot, average for Cabernet franc and low for Petit Verdot.

Yield is also variety dependant (figure 5). Yield is highest for Merlot, followed by Cabernet-Sauvignon, Cabernet franc and Petit Verdot.

The Quality Index for a given variety can be further applied in assessing the combination of soil type and grapevine variety (figure 6). Using this Quality Index, it is possible to show whether a variety performs better on a given soil type than its average performance and hence to assess optimum soil – cultivar combinations. The major three varieties perform well on PEYROSOL and PLANOSOL. Merlot and Cabernet franc perform well on BRUNISOL and ARENOSOL; the performance of Cabernet-Sauvignon is average on these soil types. All grapevine varieties show poor results on REDOXISOL, REDUCTISOL, LUVISOL and COLLUVIOSOL, supporting the notion that these soils have lower quality potential for red wine production in Bordeaux. However, REDOXISOL and LUVISOL appear to contribute more to quality for Merlot, and COLLUVIOSOL for Cabernet-Sauvignon. On CALCOSOL, better quality results are obtained with Cabernet-Sauvignon than with Merlot.

## Discussion

In Bordeaux, estates are classified as a whole, unlikely Burgundy, where individual plots are classified. Bordeaux estates can cover over 100 ha and comprise of several soil types and a diversity of grapevine varieties. The Bordeaux classifications are mainly based on selling prices of the wines (Markham, 1997). To maintain the highest possible quality, and hence the highest possible selling prices and reputation, prestigious Bordeaux estates only use the best lots of wine produced on their estate for their first label.

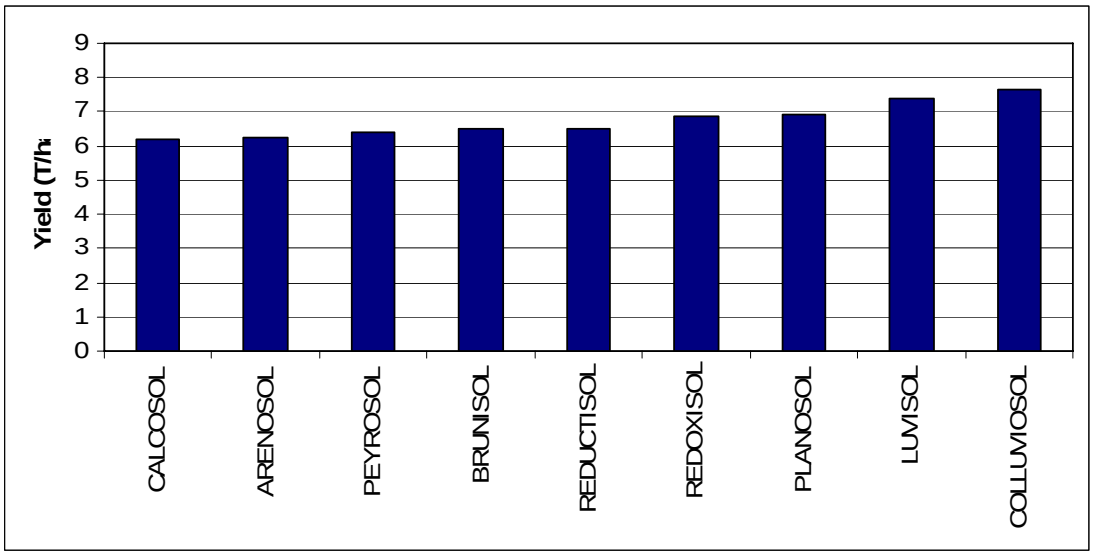


**Figure 3 Average yield for the main soil types of seven prestigious Bordeaux wine producing estates**

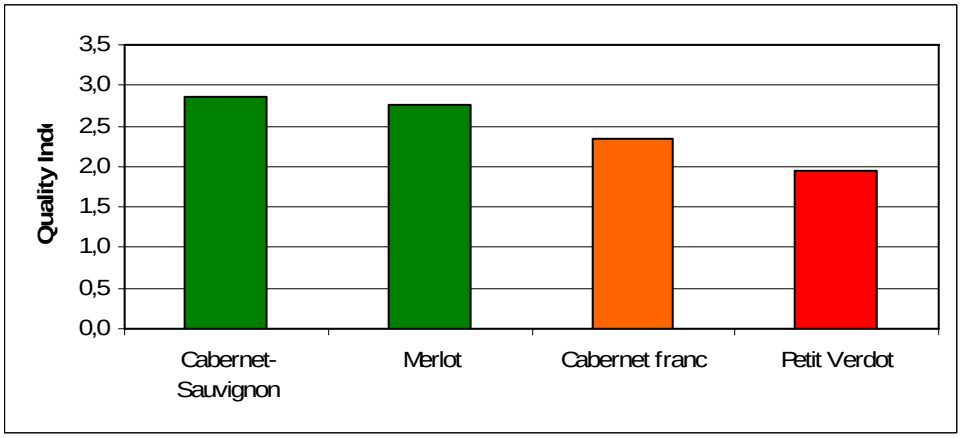


**Figure 4 Average Quality Index for the four grapevine varieties planted in seven prestigious Bordeaux wine producing estates**

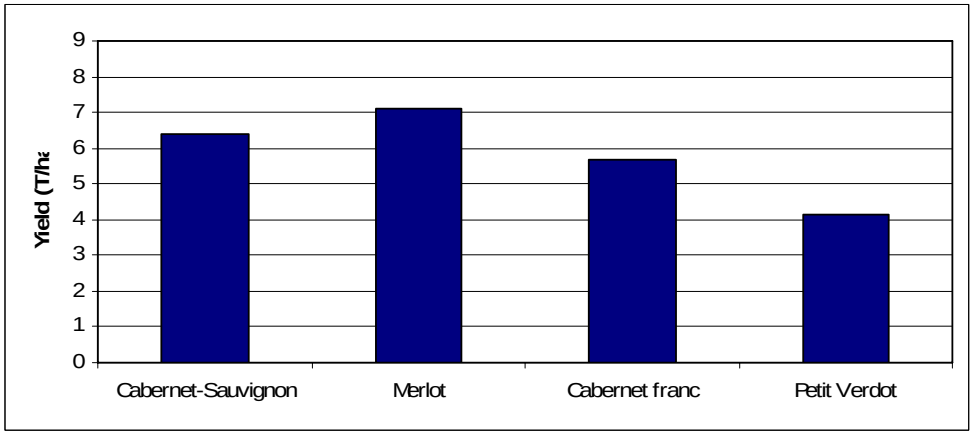


**Figure 5 Average yield for the four grapevine varieties planted in seven prestigious Bordeaux wine producing estates**

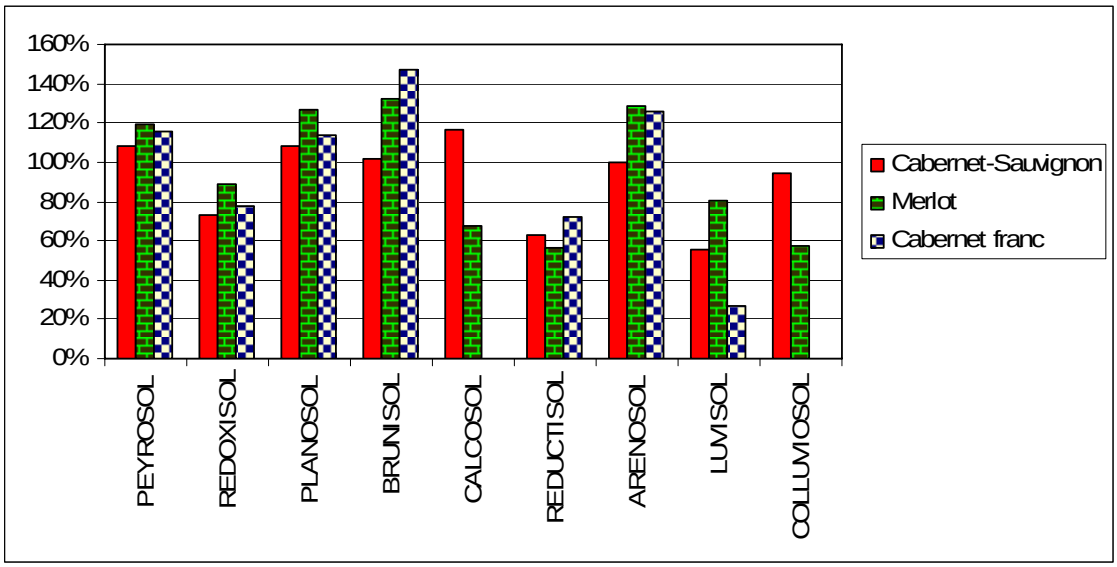


**Figure 6 Quality index for each association of soil type – grapevine variety, expressed in the percentage of the average performance of each variety**

The Quality Index created in this study is based on the frequency that wine produced from a given plot is used in the blend for the first wine. PEYROSOL, PLANOSOL, BRUNISOL and ARENOSOL (67% of the planted area of the seven prestigious estates used for this study) obtain a high Quality Index. Hence, quality potential in these estates is related to soil type. These estates also have plots with low quality potential soils (REDUCTISOL, LUVISOL, COLLUVIOSOL, 14% of the total area). Wine produced on these soil types is rarely used in the blend of the first wine as is shown by the low Quality Index they obtain in this study. It is widely acknowledged that great Bordeaux wines can be produced on gravely soils (PEYROSOL). It is less well known, that heavy clay soils can also obtain excellent quality performances in Bordeaux. PLANOSOL is a soil type that only covers very small acreages in the Bordeaux area as a whole. It might not be a coincidence that it is the third soil type in prestigious red wine producing estates. The soils defined as BRUNISOL in this study are similar to the soils qualified as PEYROSOL but they contain less stones (PEYROSOL > 50% stones; BRUNISOL < 50% stones). Hence, the high quality performance of BRUNISOL is not surprising. The high Quality Index obtained on the sandy ARENOSOL is a rather unexpected result.

Merlot is by far the most planted grapevine variety in Bordeaux and Cabernet-Sauvignon is planted on only 26% of the total wine producing area in Bordeaux. The high percentage of Cabernet-Sauvignon in this study (59%) is related to the high proportion of Médoc estates used for this survey (4 out of a total of 7 estates). On average, Merlot and Cabernet-Sauvignon obtain a similar Quality Index. It seems to be more difficult in Bordeaux to regularly produce first quality wine with Cabernet franc and Petit Verdot.

Yield is controlled in the estates used for this study by grape thinning prior to veraison. However, yield reduction is generally carried out as a percentage of the potential crop. Therefore, initial yield differences remain amongst plots. Yields are high for Merlot, followed by Cabernet-Sauvignon and Cabernet franc. Average yield is low for Petit Verdot. Surprisingly so, high volume producing varieties are also high quality potential varieties. Yield is also soil type related. High quality potential PEYROSOL and ARENOSOL have low average yield. Low quality potential COLLUVIOSOL and LUVISOL have high average yield. However, soil quality potential is not always negatively related to yield. Quality and yield are high for PLANOSOL and low for REDUCTISOL. On PLANOSOL, moderate water deficits induce early shoot growth cessation, while maintaining photosynthetic potential (van Leeuwen *et al.*, 2004). In these conditions, it is possible to combine high quality with moderately high yield. On REDUCTISOL, root asphyxiation induced by permanent water logging reduces vine vigour and crop yield. However, quality is low on this soil type because of unlimiting water uptake conditions.

The great majority of Cabernet-Sauvignon (57% of the total acreage of this variety) is planted on PEYROSOL. Only 22% of the total acreage of Merlot is planted on this soil type. However, both varieties obtain very good quality performances (Quality Index 3.27 for Merlot and 3.09 for Cabernet-Sauvignon). On the PLANOSOL excellent results are obtained with the three main varieties (figure 6). It is

acknowledged in Bordeaux that this soil type is suitable for Merlot (particularly so in Pomerol), but this study shows that is also matches very well with Cabernet-Sauvignon and Cabernet franc. On the ARENOSOL, high quality wine is produced with Merlot and Cabernet franc but Cabernet-Sauvignon also performs reasonably well. Merlot performs better than Cabernet-Sauvignon and Cabernet franc on REDOXISOL and LUVISOL. Grape ripening is delayed on these soil types, which explains that better maturity is obtained with an early ripening variety. Poor results are obtained on REDUCTISOL with all varieties because of permanent water logging. Some results are surprising and difficult to explain. Cabernet-Sauvignon obtains higher Quality Index scores on CALCOSOL and COLLUVIOSOL than Merlot. However, this observation might be biased by the fact that only very small acreages of Cabernet-Sauvignon are planted on these soil types.

## Conclusion

A survey of the relationship between soil type, grapevine variety, wine quality and yield in seven prestigious Bordeaux wine estates shows that yield and quality are both soil type and variety dependant. PEYROSOL (gravely soil) is the major soil type in prestigious estates in Bordeaux, but in these estates significant acreages of the equally high quality wine producing PLANOSOL (heavy clay soil) can be found. Wine quality is more irregular on deep soils with high water holding capacity (LUVISOL, COLLUVIOSOL) and on soils with permanent water logging (REDUCTISOL). Cabernet-Sauvignon is the dominant grapevine variety (59% of the mapped area), followed by Merlot (32%), Cabernet franc (8%) and Petit Verdot (1%). On average, Quality Index is higher for Cabernet-Sauvignon and Merlot compared to Cabernet franc and Petit Verdot. The highest yields are obtained with Merlot but this does not seem to alter the quality performances of this variety.

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