Grapevine yield-gap: identification of environmental limitations by soil and climate zoning in Languedoc -Roussillon region (south of France)

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Context

In Languedoc-Roussillon region, many ***IGP Pays d'Oc*** producers are far from the label yield quality threshold, *i.e.* **90 wine hl·ha^{-1}·year^{-1}** for red and white wine. These **yield-gaps** are weakening the profitability and durability of many vineyards (Touzard et al., 2017). Yield-gaps at the regional level have been widely studied in arable crops, but very little in perennial crops, such as grapevine. Understanding **environmental factors** involved in yield-gaps, such as climate and soil limitations, is the first step for the grapevine yield-gap analysis. **At the regional scale**, numerous studies of the 'terroir' involved in wine quality exist. However, there have not been studies to classify environmental factors concerning grapevine yield-gaps yet.

Data used

1. Wine yield dataset

IGP Pays d'Oc label (~1100 cellars, ~80-120.000 ha, ~50% of Languedoc-Roussillon viticultural area)
96 667 individual yield data aggregated into 606 municipalities
4 456 average yield in municipalities from 2010 to 2018
58 grapevine varieties

2. Climate Data

MétéoFrance *SAFRAN* reanalysis with grids of 8km by 8km
Extraction of Languedoc Roussillon region from 2010 to 2018

3. Soil data

Soil Available Water Capacity (SAWC) regional map (Styc and Lagacherie, 2021)
Soil pH *GlobalSoilMap* cartography regional map (Vaysse and Lagacherie, 2015)

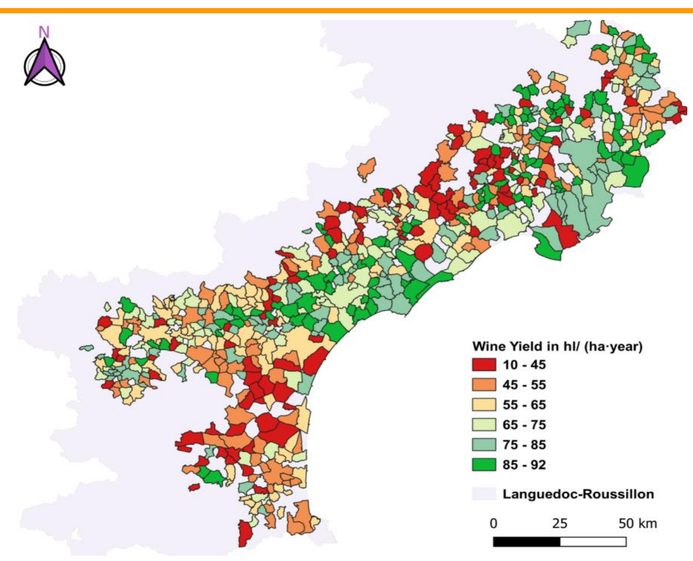
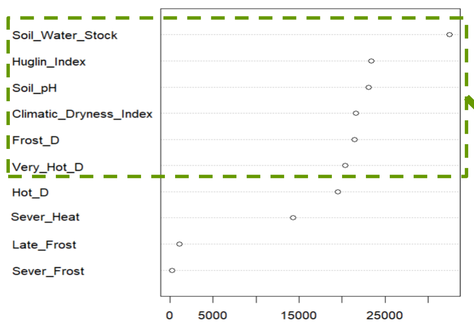


Fig. 1. Average wine yield in the municipalities (2010-2018)

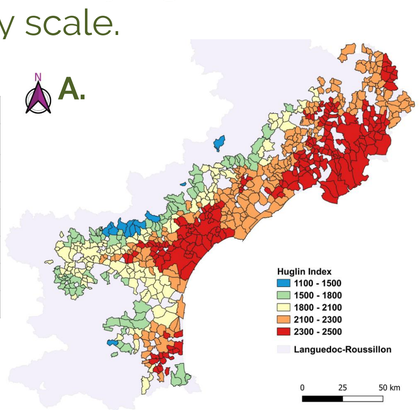
Selection of relevant soil and climate indicators at the municipality scale

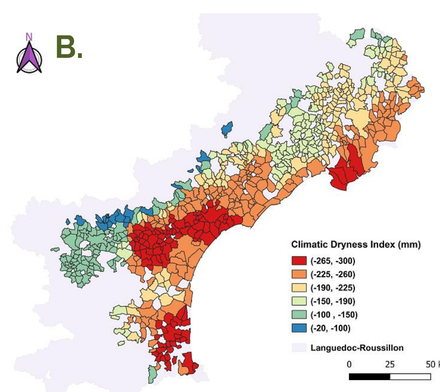
We used a **backward stepwise model selection** process using **linear mixed-effects models** (with the '*nlme*' R package) to discriminate and **select** the **statistically significant** indicators capable to estimate grapevine yield at the municipality scale.



Indicator selected	Units (units/year)
Soil Available Water Capacity	mm
Soil pH	-
Climatic Dryness Index	mm
Huglin Index	Degree Celsius
Days of Frost	days
Very Hot Days	days
Severity of Heat Stress	Degree Celsius

Fig 2. Random forest partial dependence plot of variable importance





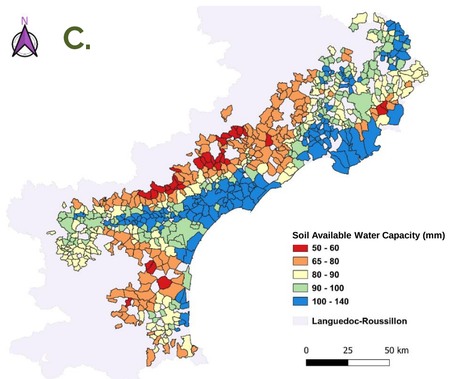


Fig. 3. A. Huglin index (°C from 1 April to 30 September);
B. Climatic Dryness Index (P-ET from 1st April to 30th August); and
C. Soil Available Water Capacity (mm/ 2m depth)

Zones clustering and assessment

We **clustered** the municipalities with similar soil and climate using a combination of **principal components analysis** (PCA) and **ascendant hierarchical classification** (with '*FactomineR*' R package).

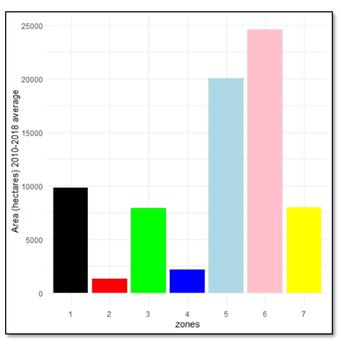


Fig 4. Map of the clustered zones presenting similar soil and climate indicators

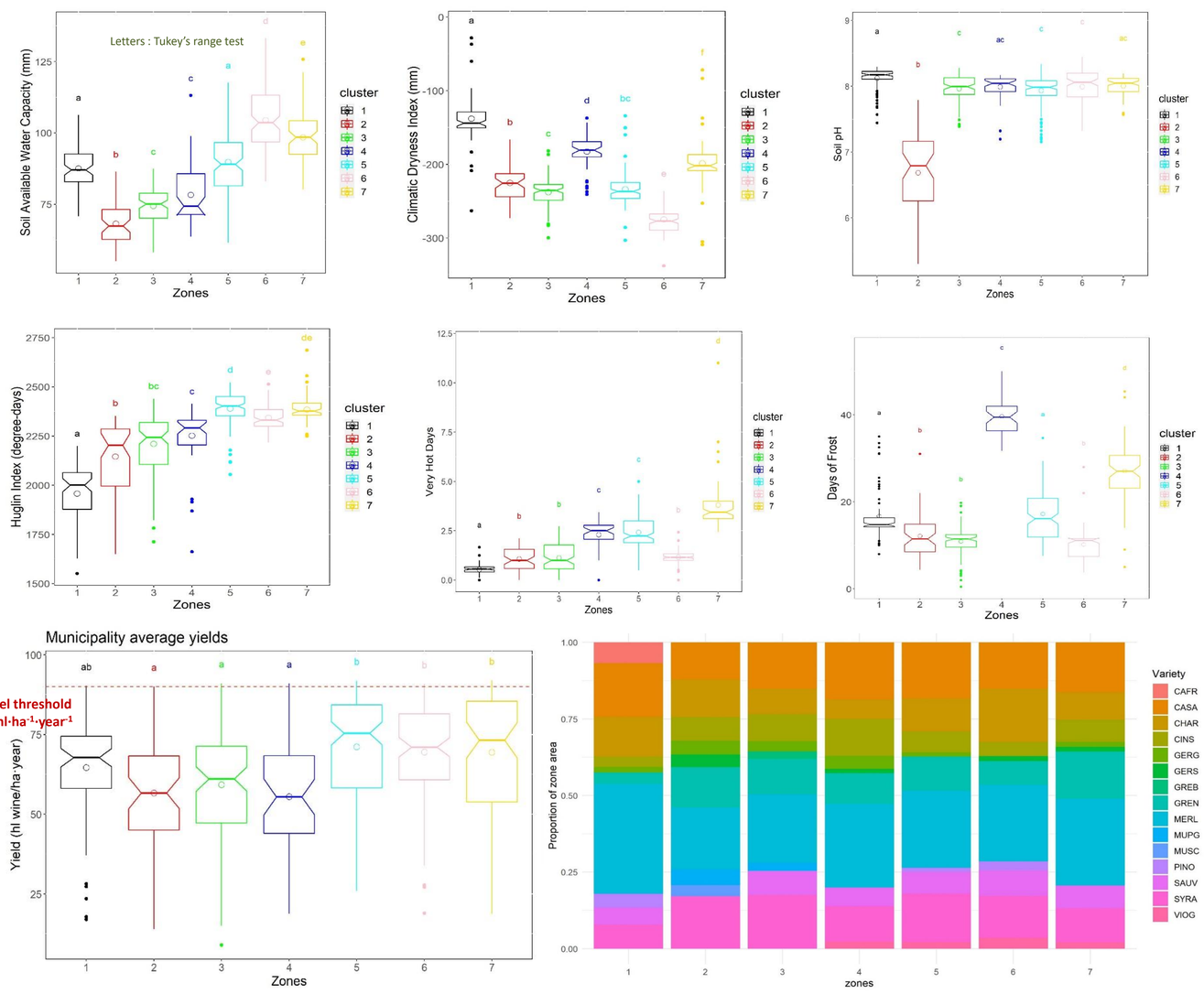


Fig 5. Boxplots of yield, soil and climate indicators in the municipalities of each zone and barplot of 10 most grown grapevine varieties.
CAFR for Cabernet Franc; CASA for Cabernet Sauvignon; CHAR for Chardonnay; CINS for Cinsault; GERG for Générique Rouge (several red wine varieties mixed); GERS for Générique Rosé (several rosé wine varieties mixed); GREB for Grenache Blanc; GREN for Grenache Noir; MERL for Merlot; MUPG for Muscat Petit Grain; MUSC for Muscat; PINO for Pinot Noir; SAUV for Sauvignon Blanc; SYRA for Syrah and VIOG for Viognier.

Conclusions & Perspectives

The zones identified had similar yield-gap **levels** but because of **different** environmental **factors**. This work helped to identify the **environmental factors** involved in grapevine yield-gaps at the **regional** scale. Further research needs to be done concerning the plant material and the farming practices involved in the vineyards to understand the best ***Genotype x Environment x Management*** interactions (Van Ittersum et al., 2013)

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