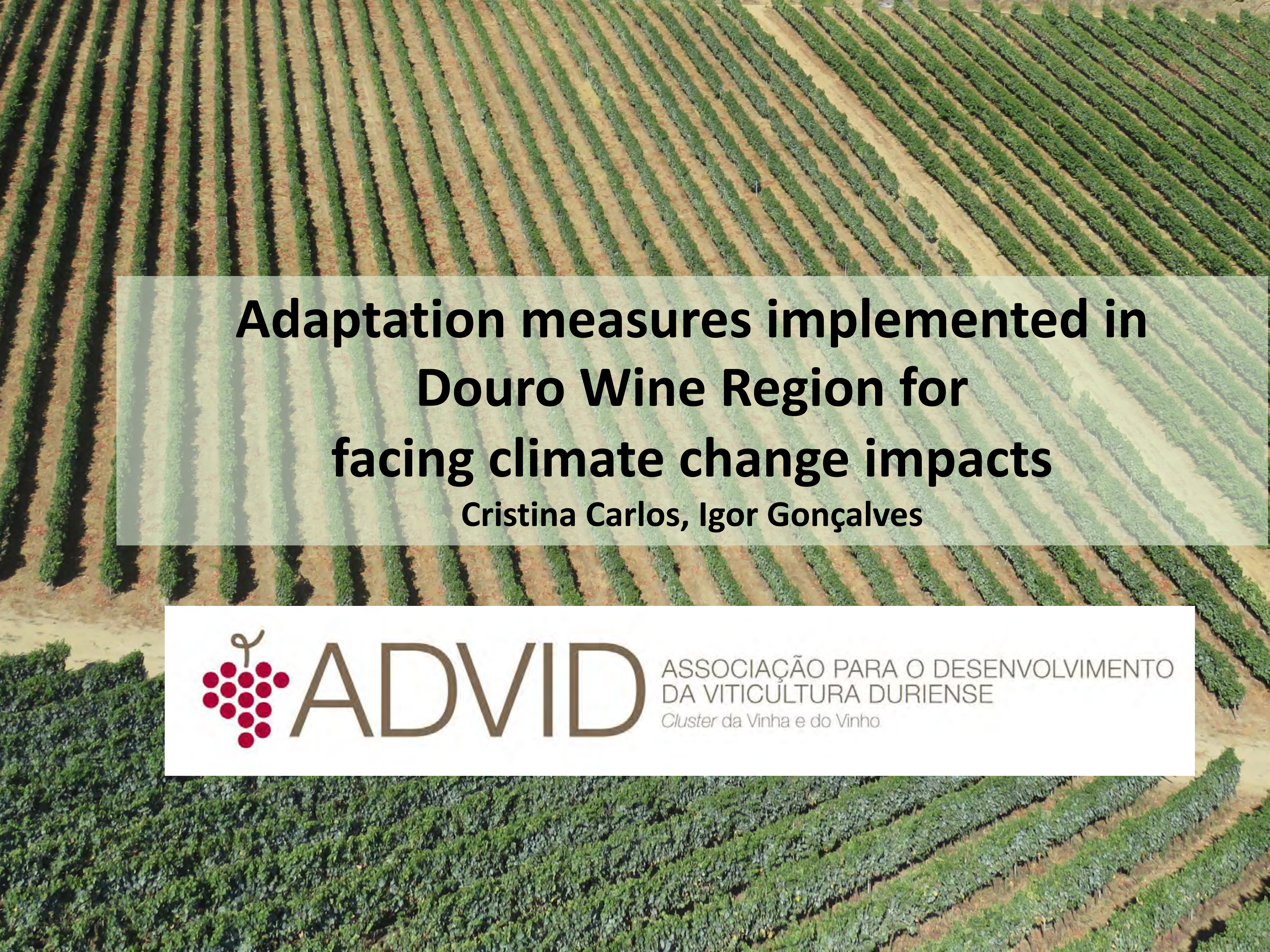


Adaptation measures implemented in Douro Wine Region for facing climate change impacts

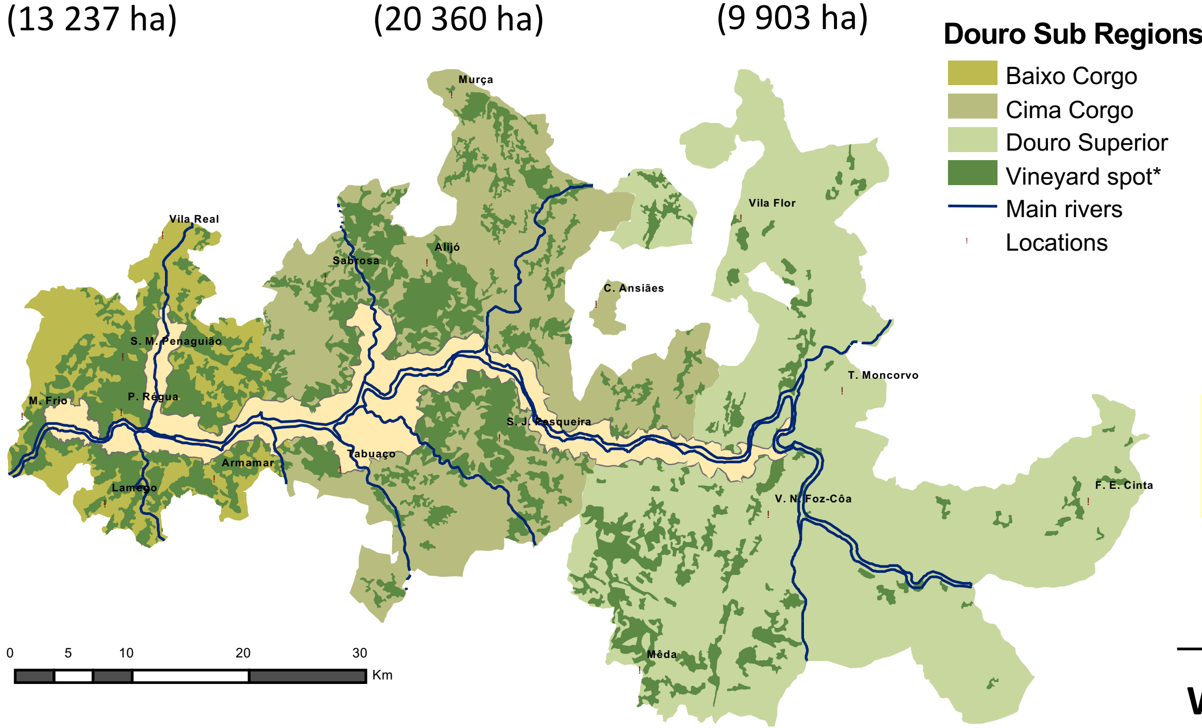
Cristina Carlos, Igor Gonçalves

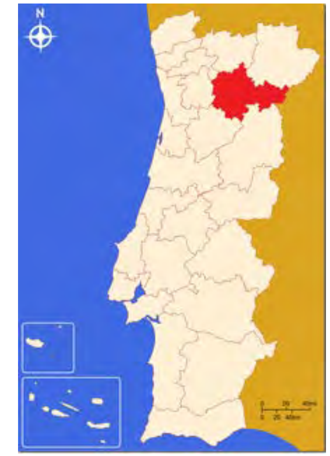
ADVID
ASSOCIAÇÃO PARA O DESENVOLVIMENTO
DA VITICULTURA DURIENSE
Cluster da Vinha e do Vinho

Douro Demarcated Region

One of the biggest steep slope viticulture regions of world

Baixo Corgo	Cima Corgo	Douro Superior
(13 237 ha)	(20 360 ha)	(9 903 ha)





Surface vineyards (Ha)	**43 500**
Winegrowers (nº)	20 370

Surface / winegrower: **2.14 ha**
(5 parcels)

Source: IVDP, 2019

Winegrowers ADVID	**166**
Surface vineyards (ha)	**6 337.0**
IPM	**5.916**
Organic	**421**

Alto Douro Vinhateiro (ADV) classified by UNESCO in 2001

Portuguese viticulture facts & figures

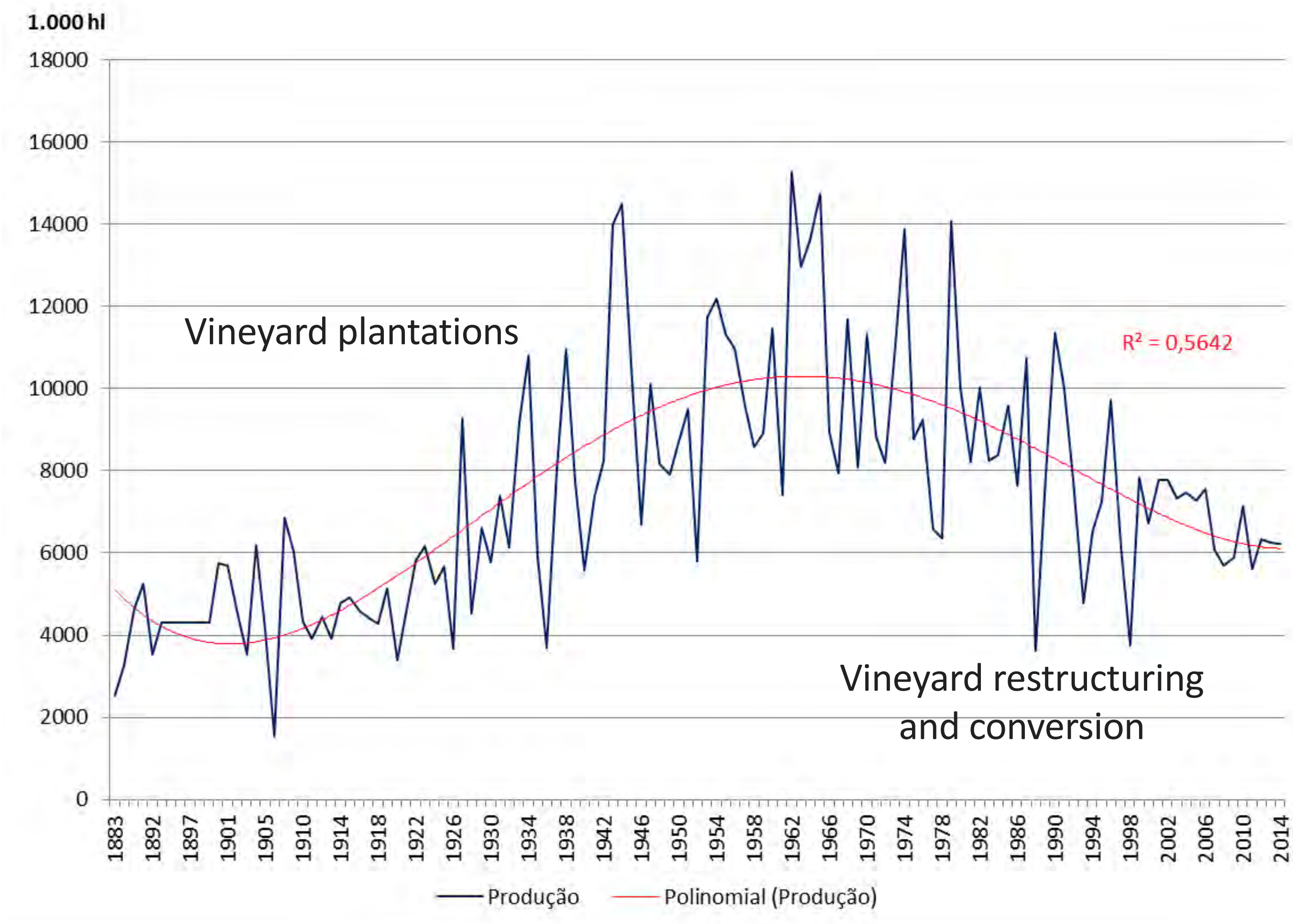
11th wine producer (5th Europe);
9th position in surface with vineyard but with very low productivity (~4 ton/ha)
One of the lowest prodution / ha

Source: OIV, 2019 STATISTICAL REPORT ON WORLD VITIVINICULTURE

Country	Wine Prod. (10^6 Hl)	Area (10^3 Ha)	L / Ha	Tones / Ha
Germany	10,3	103	10,0	13,6
Australia	12,9	146	8,8	12,0
Italy	54,8	705	7,8	10,6
South Africa	9,5	126	7,5	10,3
Argentina	14,5	218	6,7	9,1
France	48,6	793	6,1	8,4
Chile	12,9	212	6,1	8,3
USA	23,9	439	5,4	7,4
Spain	44,4	969	4,6	6,2
Portugal	**6,1**	**192**	**3,2**	**4,3**
China	9,1	875	1,0	1,4

Wine production time series in Portugal

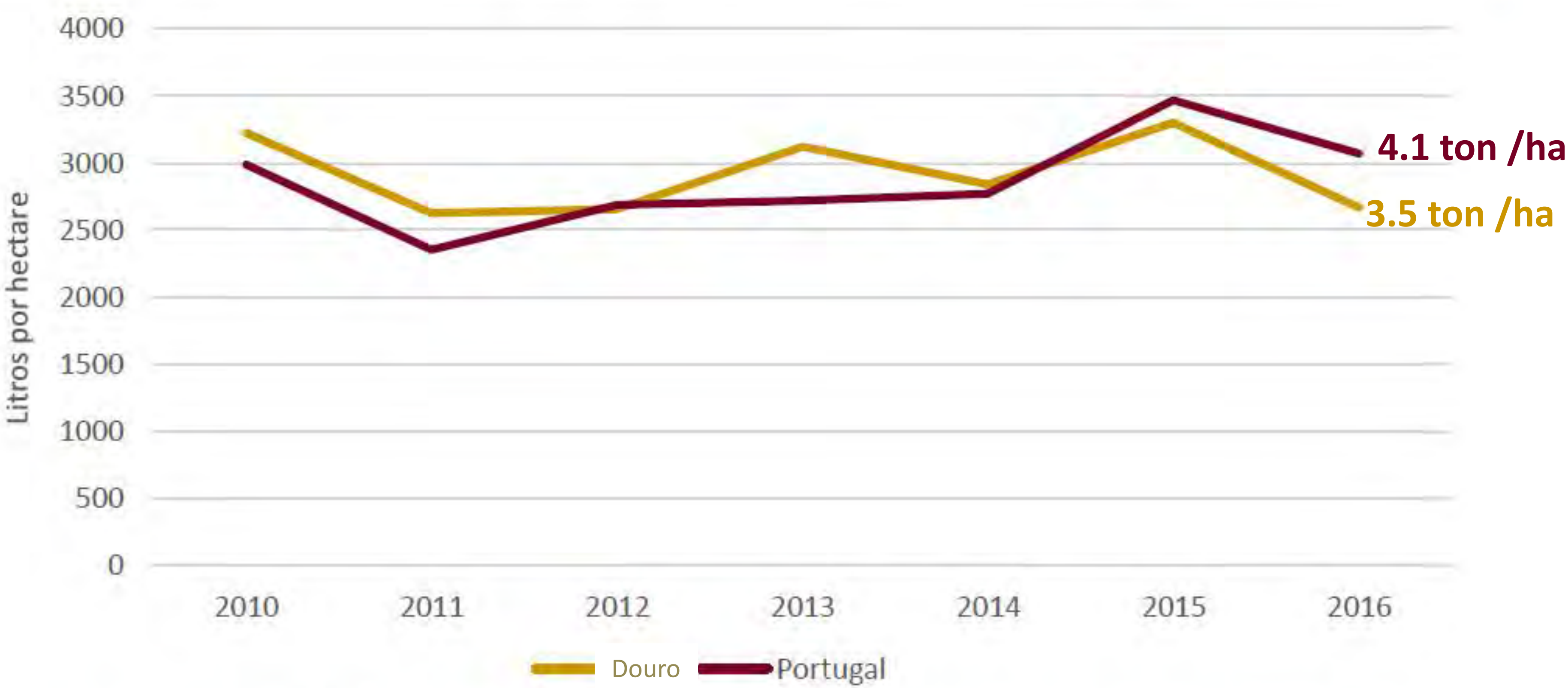
The Douro wine sector is extremely vulnerable to climate conditions



Strong interannual variability forced by **weather conditions**

Source: João Santos (UTAD), according IVV 2017 data

Evolution of wine production in Douro Demarcated Region



The productivity is extremely low, when compared with the maximum allowed in DOC) (**7.5 ton/ha** for red wines; **8.8 ton/ha** for withe wines)

Source: IVDP (2017) RUMO ESTRATÉGICO PARA O SETOR DOS VINHOS DO PORTO E DOURO

ADVID – Research and Experimental Development main areas

Flagship Projects

Research and Experimental Development - R&ED

- Impact of climate changes on the Douro
- Zoning wine production potential
- Functional biodiversity
- Assessment of grapes quality potential
- Preservation of genetic diversity
- Sustainable production in viticulture
- Maximizing efficiency of hillside vines
- Training and dissemination

Goals of ADVID under climate change strategic line of research

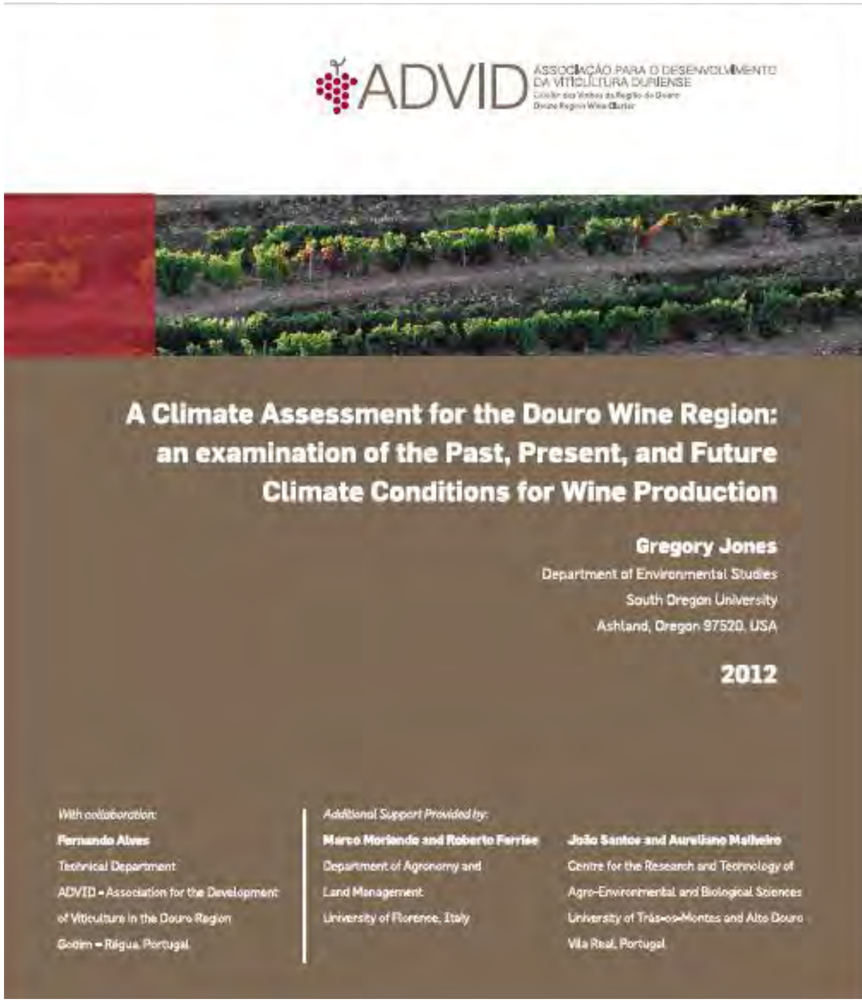
- **To identify impacts of climate change in viticulture and needs of wine sector**

- To promote **studies to analyze evolution of climate conditions and evaluate the application of adaptation measures**, in close collaboration with the wine sector and scientific partners at national and international level

- **To recommend to winegrowers the best management practices to reduce their vulnerability to climate change impacts**, promoting the **stability of production, high quality of wines,** enhancing the **resilience of wine sector**

Study conducted in Douro about Climate projections (Jones 2012)

A climate assessment for the Douro wine region: an examination for the past, present and future climate conditions for wine production


ADVID ASSOCIAÇÃO PARA O DESENVOLVIMENTO DA VITICULTURA DURIENSE

A Climate Assessment for the Douro Wine Region: an examination of the Past, Present, and Future Climate Conditions for Wine Production

Gregory Jones
Department of Environmental Studies
Southern Oregon University
Ashland, Oregon 97520, USA

2012

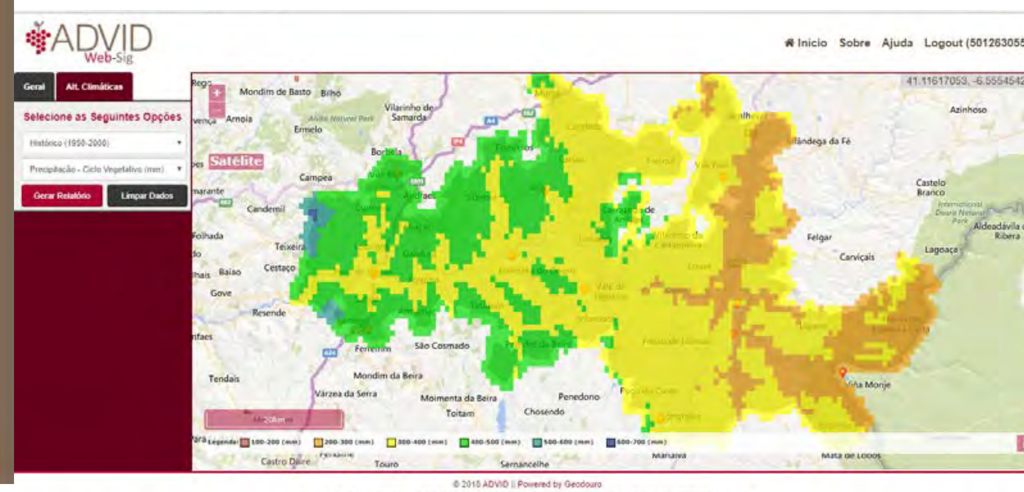
With collaboration:
Fernando Alves
Technical Department
ADVID – Association for the Development of Viticulture in the Douro Region
Godim – Régua, Portugal

Additional Support Provided by:
Marco Moriondo and Roberto Ferrise
Department of Agronomy and Land Management
University of Florence, Italy

João Santos and Aureliano Malheiro
Centre for the Research and Technology of Agro-Environmental and Biological Sciences
University of Trás-os-Montes and Alto Douro
Vila Real, Portugal

ADVID developed a webtool that allow growers to have access to this information in order to **support management decisions**

ADVID Web-Sig



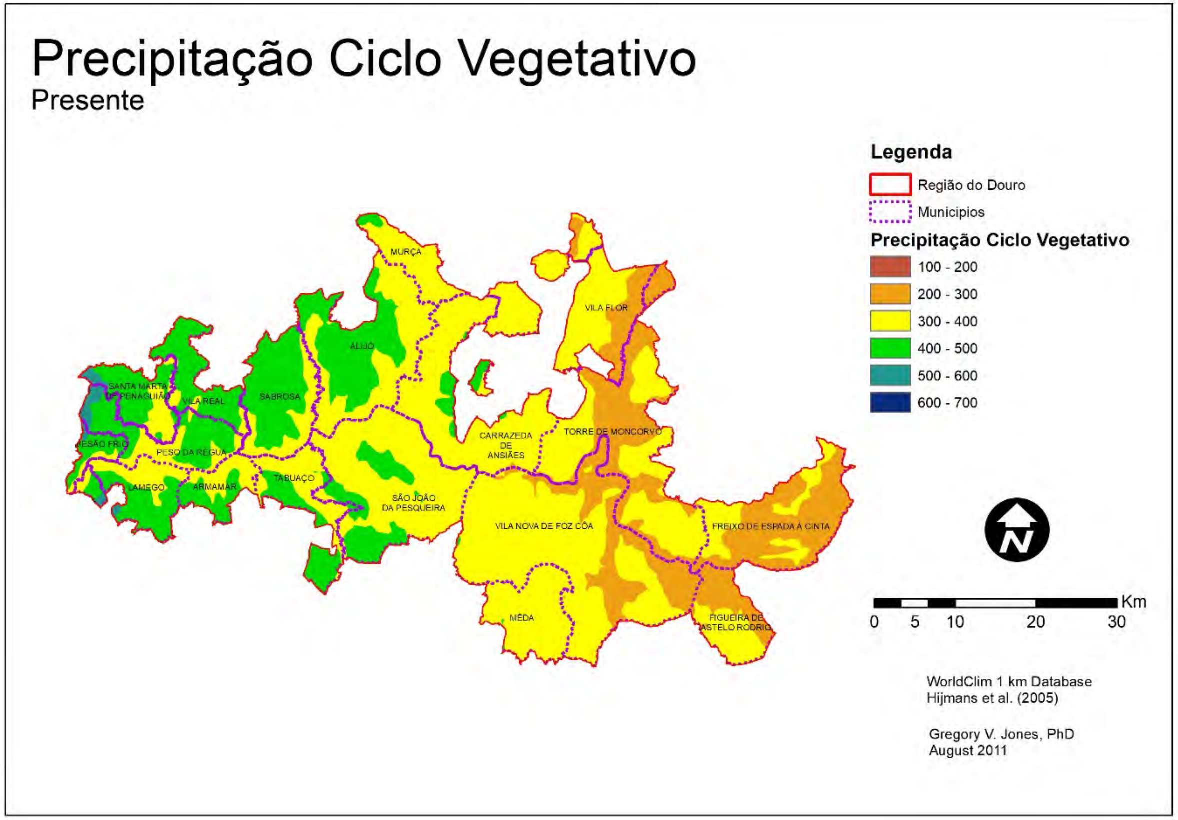
A climate assessment for the Douro wine region - Study Description

- **11 climate parameters analized**
- 3 greenhouse gas emission scenarios (B2, A1B, A2)
- Spatial Climate: Historic Data **(1950-2000)**
- Three future time periods (2020, 2050, and 2080)
- Spacial Resolution: **1 km2 (100 ha) .**

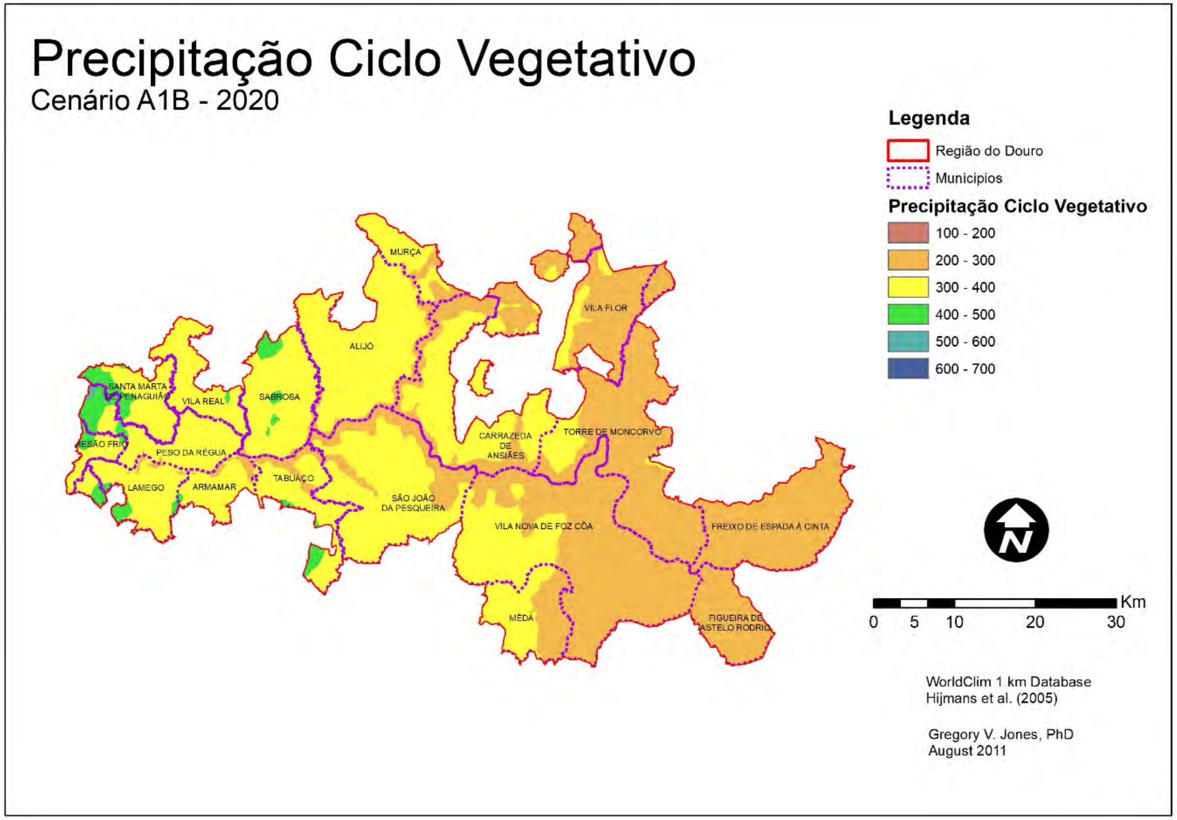
Climate Parameters
Annual Precipitation (mm)
Average Annual Temperature (ºC)
Growing Season Active Temperatures (∑TA, ºC)
Growing Season precipitation(mm) – April to October
Growing Season Average temperature (ºC) – April to October
Growing Season Maximum Temperature (ºC) – April to October
Growing Season Minimum Temperature (ºC) – April to October
Huglin Index
Winter Precipitation (mm) – November to March
Winter Maximum Temperature (ºC) – November to March
Winter Minimum Temperature (ºC) – November to March

- Future climate conditions in the Douro Wine Region were examined using IPCC SRES projections.

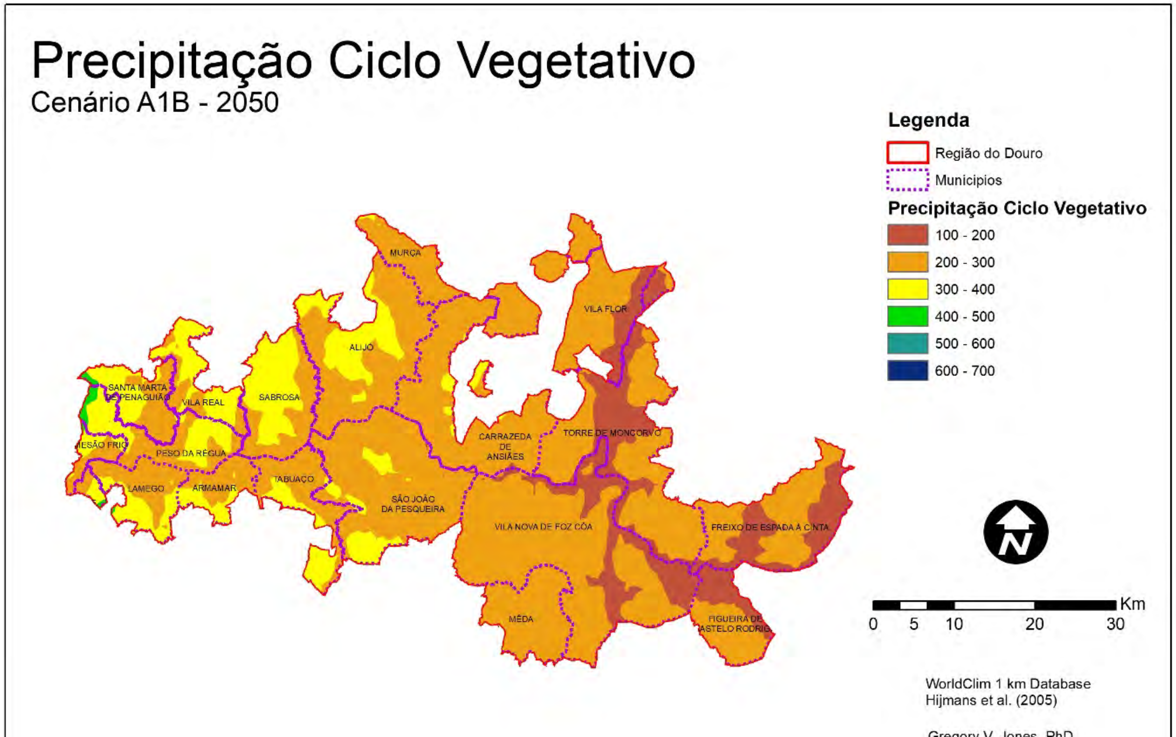
■ Growing Season precipitation (mm) - Historic (1950-2000)



Growing Season precipitation (mm) - A1B Scenario 2020

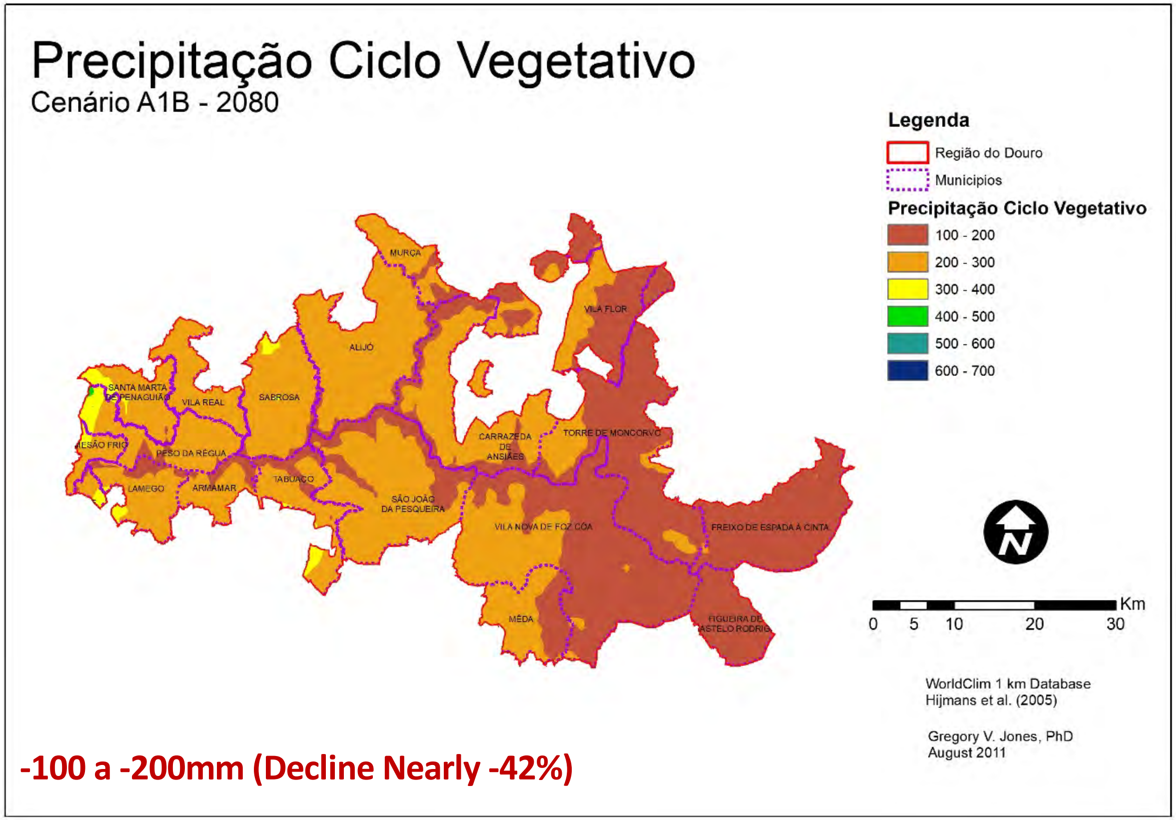


Growing Season precipitation (mm) - A1B Scenario 2050



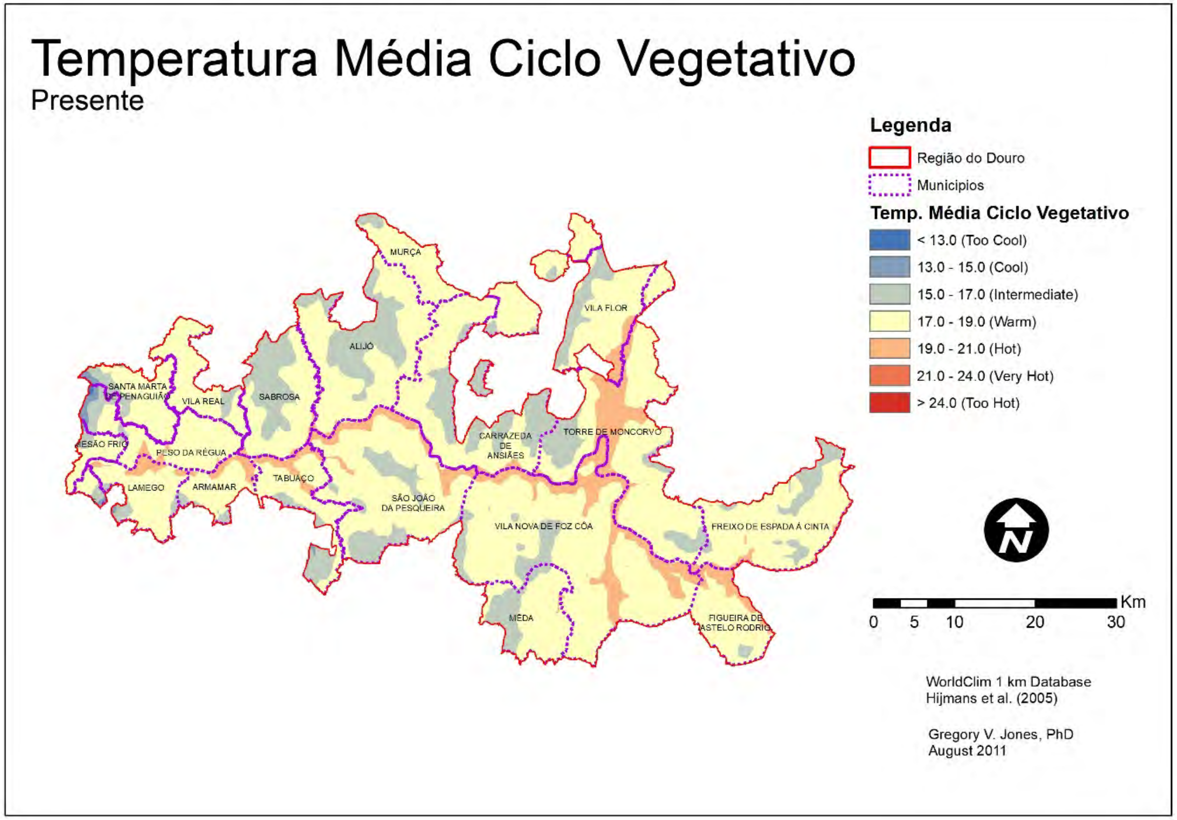
Decline Up To **-100 mm**

■ Growing Season precipitation (mm) - A1B Scenario 2080

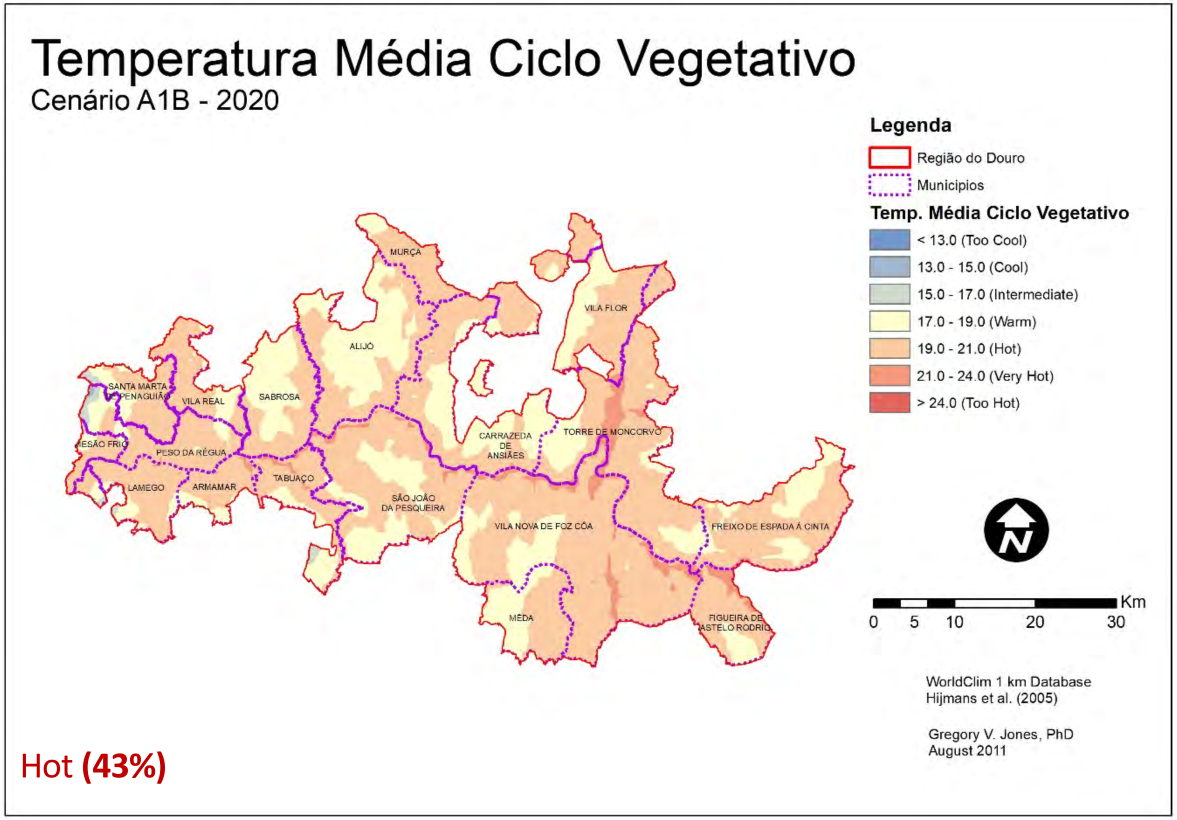


-100 a -200mm (Decline Nearly -42%)

Growing Season Average temperature (ºC) - Historic (1950-200)

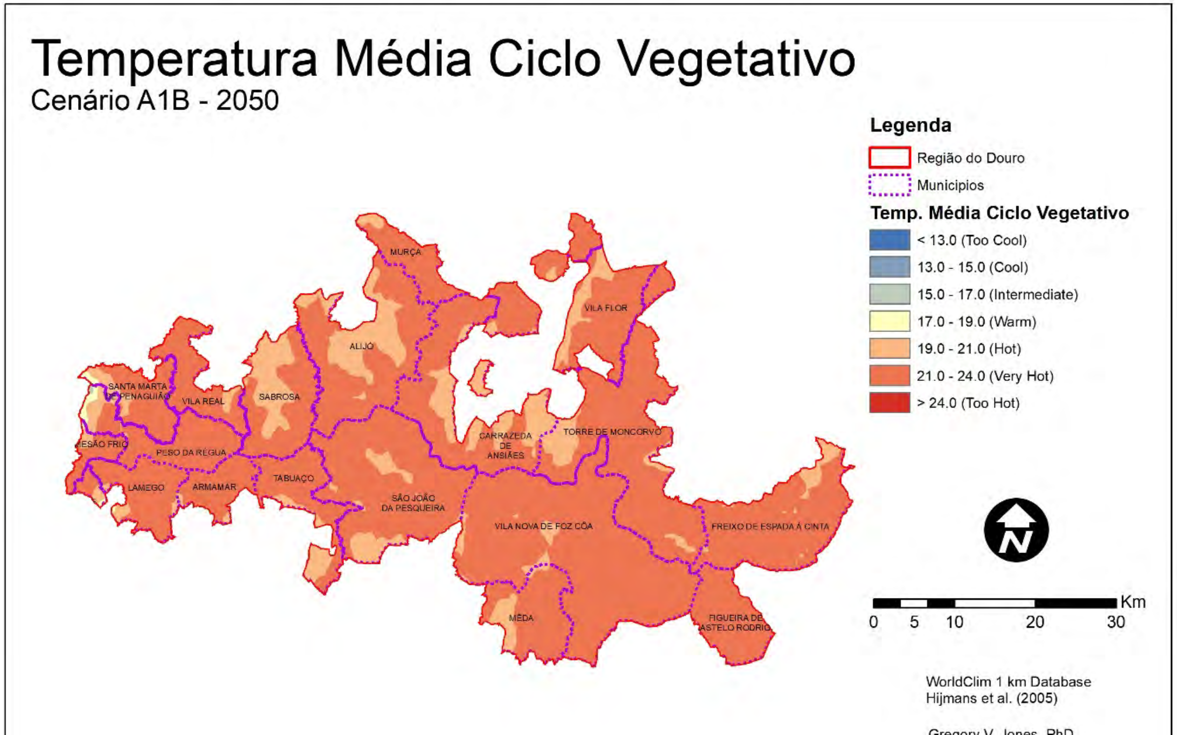


Growing Season Average temperature (ºC) - A1B Scenario 2020



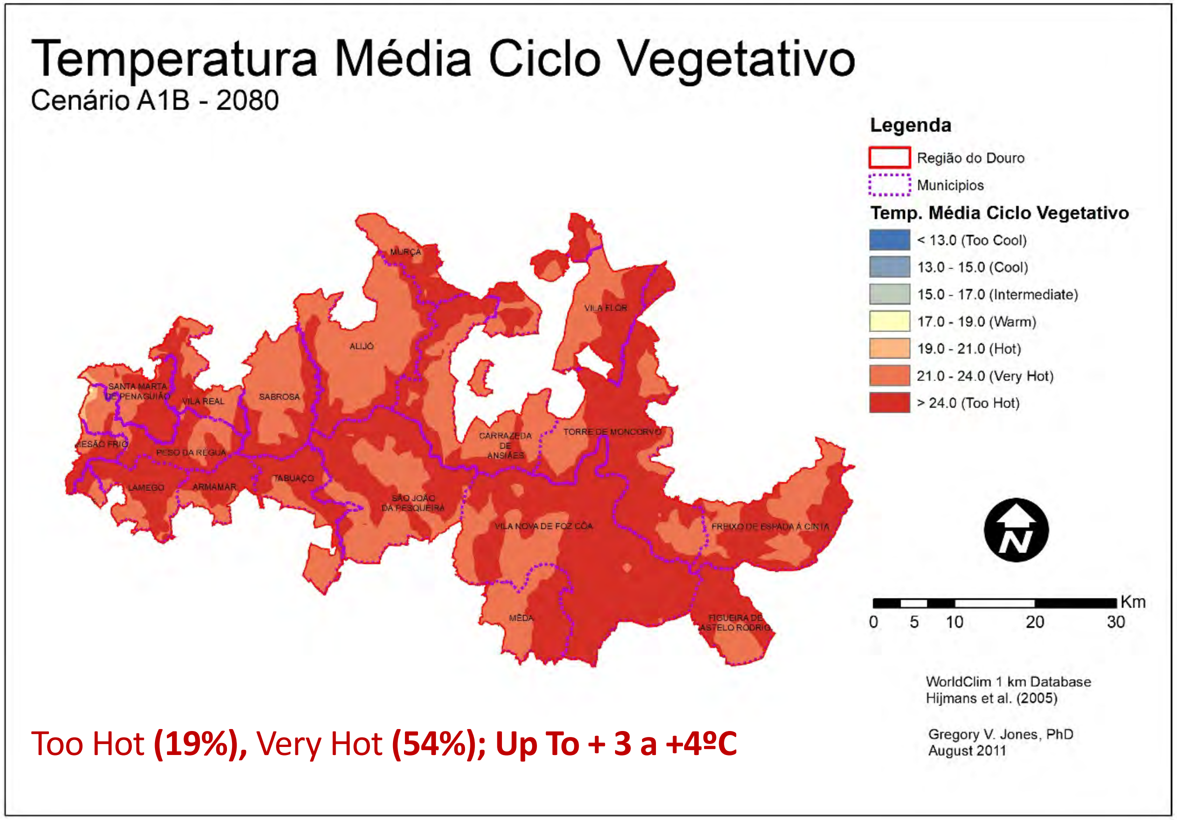
Hot **(43%)**

■ Growing Season Average temperature (ºC) - A1B Scenario 2050



Very Hot **(36%); up To + 3ºC**

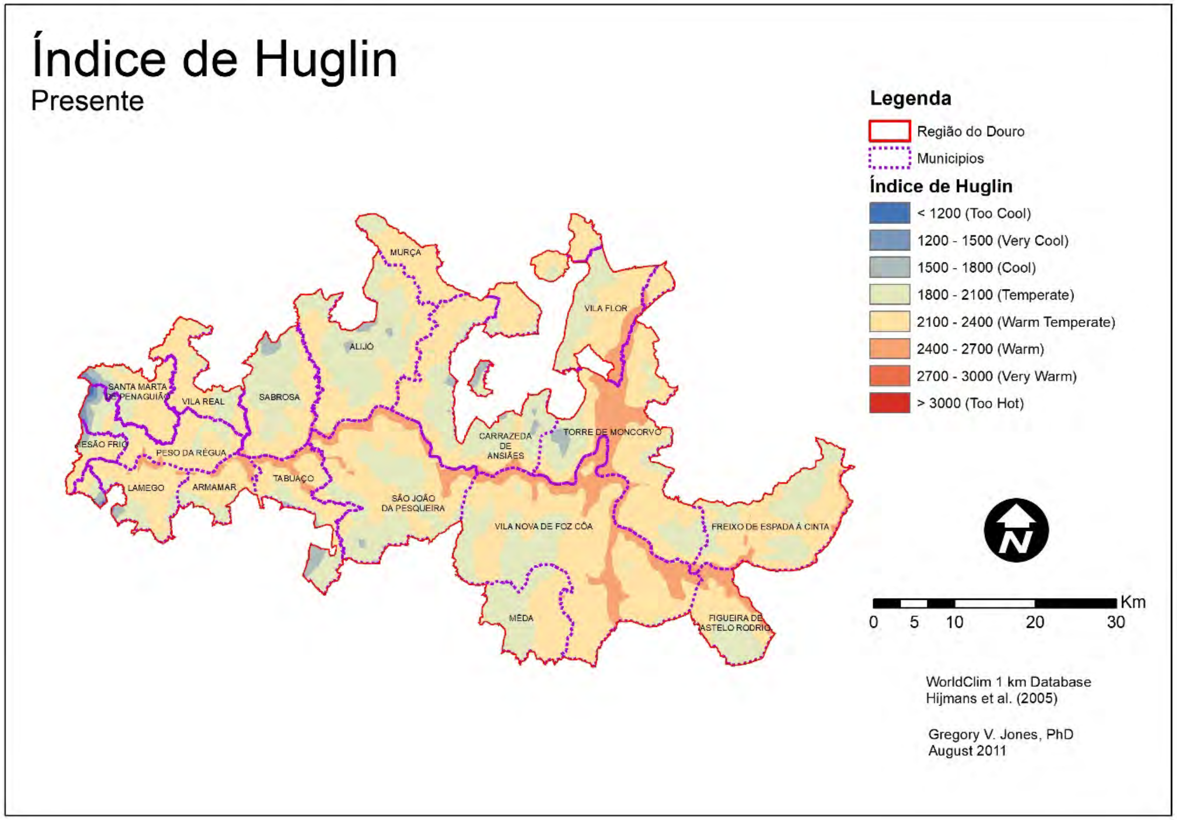
■ Growing Season Average temperature (ºC) - A1B Scenario 2080



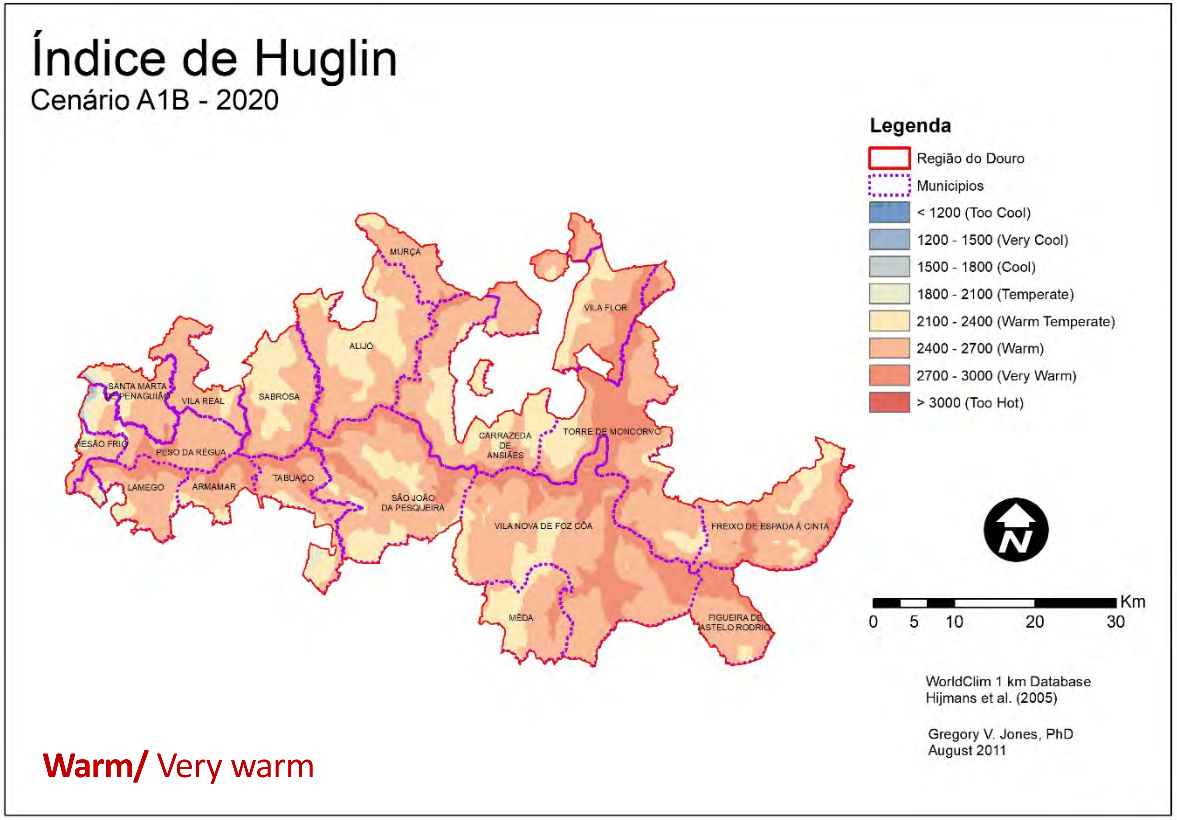
Too Hot **(19%),** Very Hot **(54%); Up To + 3 a +4ºC**

Huglin Index - Historic (1950-2000)

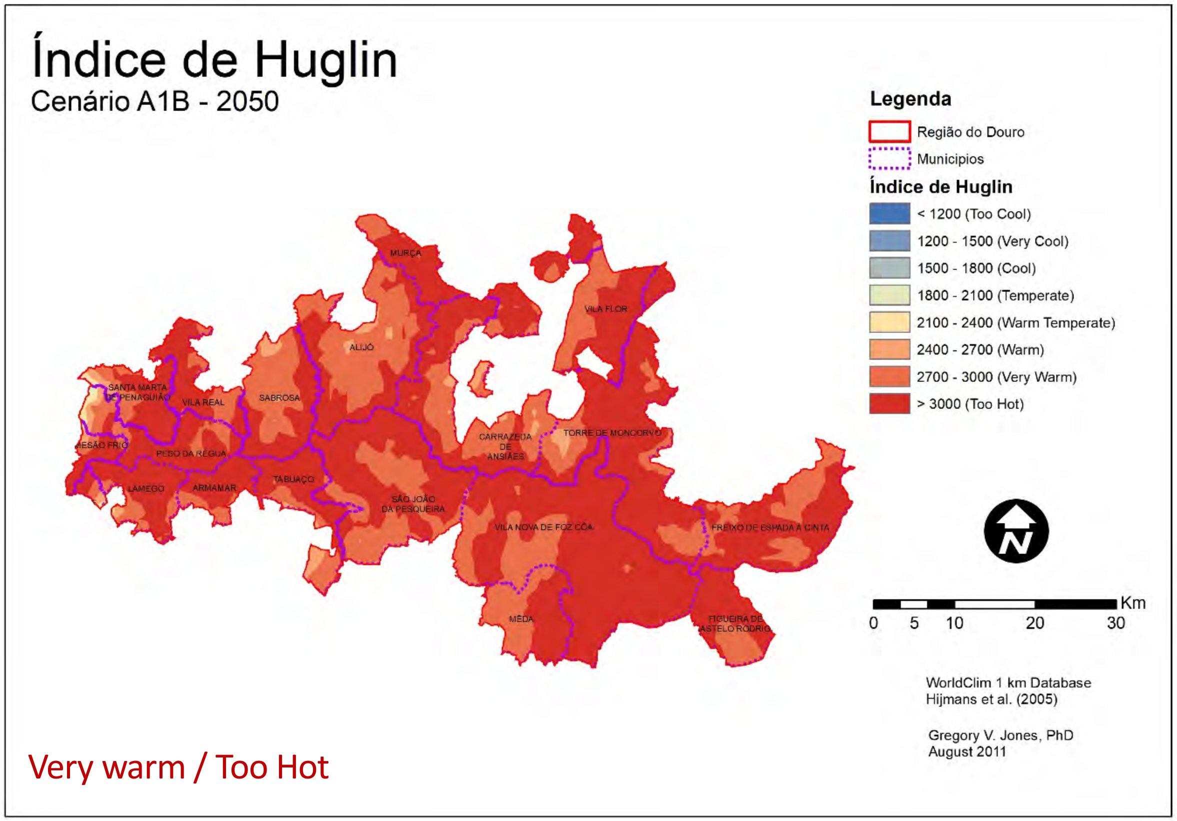
Bioclimatic Index used in viticulture that indicates suitability of an area for vine cultivation



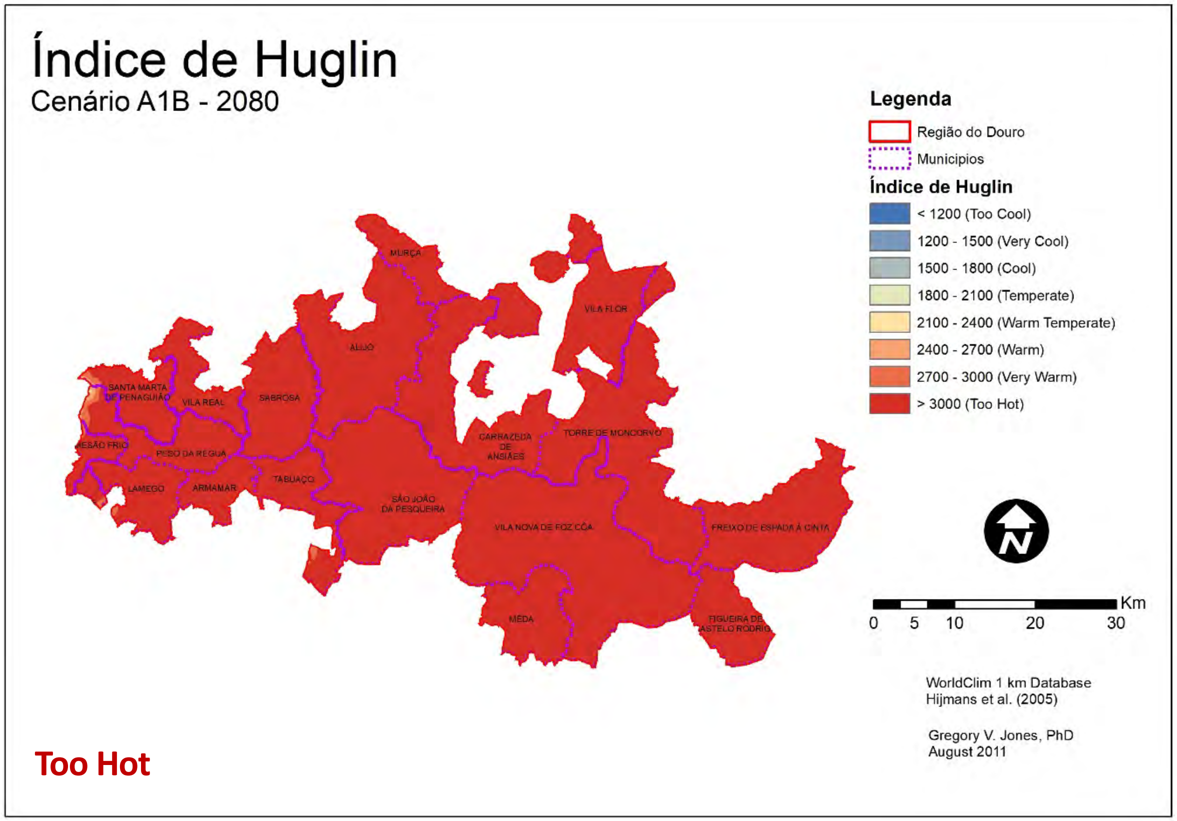
■ Huglin Index - A1B Scenário 2020



Huglin Index - A1B Scenário 2050



■ Huglin Index - A1B Scenário 2080



Impacts (risks) of climate changes in viticulture

- **Anticipation of grape ripening / Reduction in time window for harvest** (ex. 2017)
- Changes in **grape characteristics and wine profiles**
- **Physiological impacts** in vineyards (higher water, heat and radiative stresses)
- **Reduction in vineyards longevity**
- **Changes in pests and diseases complex** (ex. More trunk diseases, mealybugs, mites)
- **Impacts on soil quality (reduction in organic matter)** with **higher risk of erosion**
- **Lower productivity** with impacts on **economic sustainability**
- **Risk of abandonment of vineyards in drier zones**

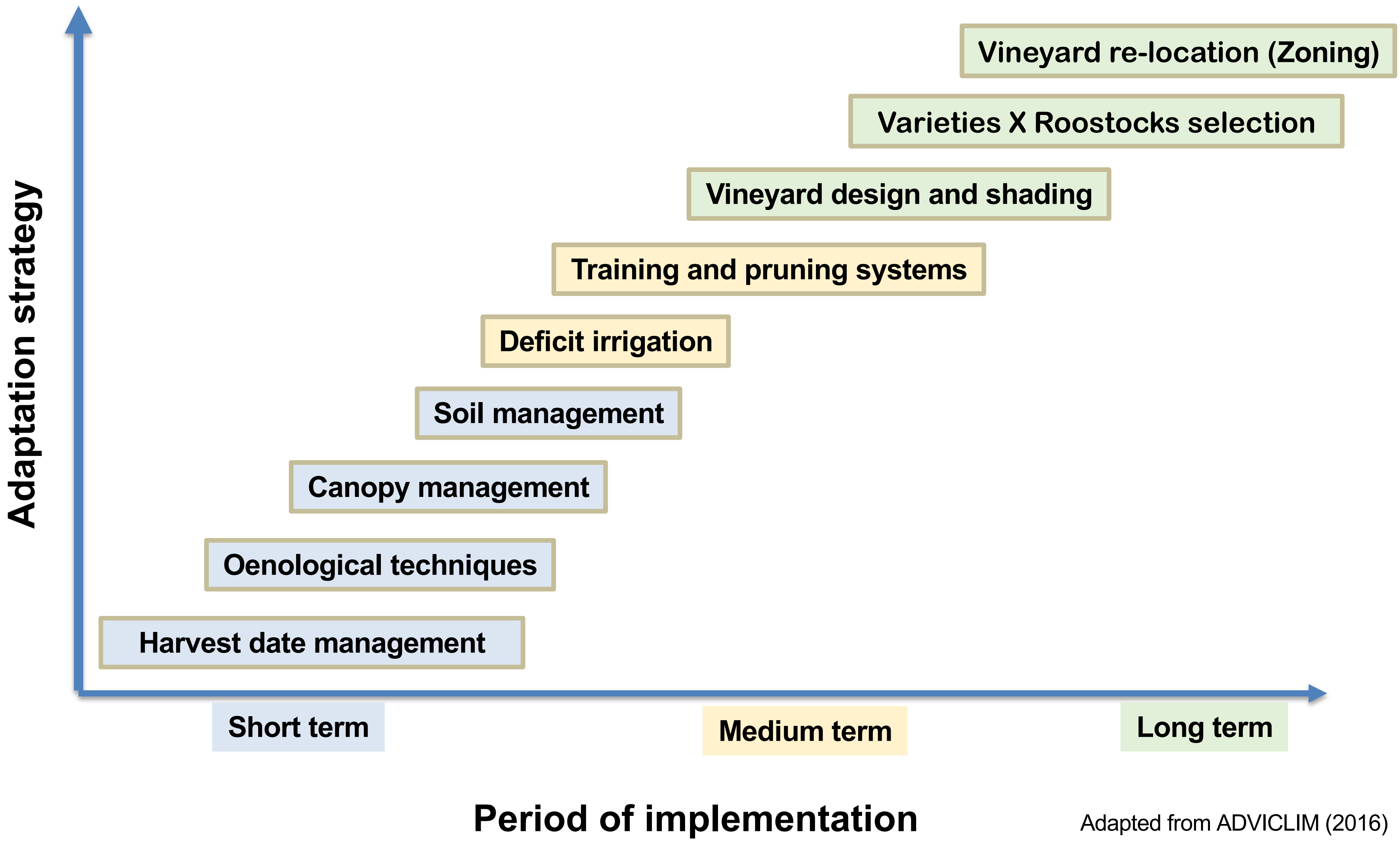
Source: Carlos Lopes (ISA)

Measures to be implemented on news vineyards

Avoiding unfavourable exposition (south) to prevent sun burn events

▪ Water, heat and radiative stresses in August / September 2017

Adaptation measures to climate change and period of implementation



Adapted from ADVICLIM (2016)

Adaptation measures to climate change under study in Douro Region

a) Preservation and study of **genetic diversity** of Portuguese varieties

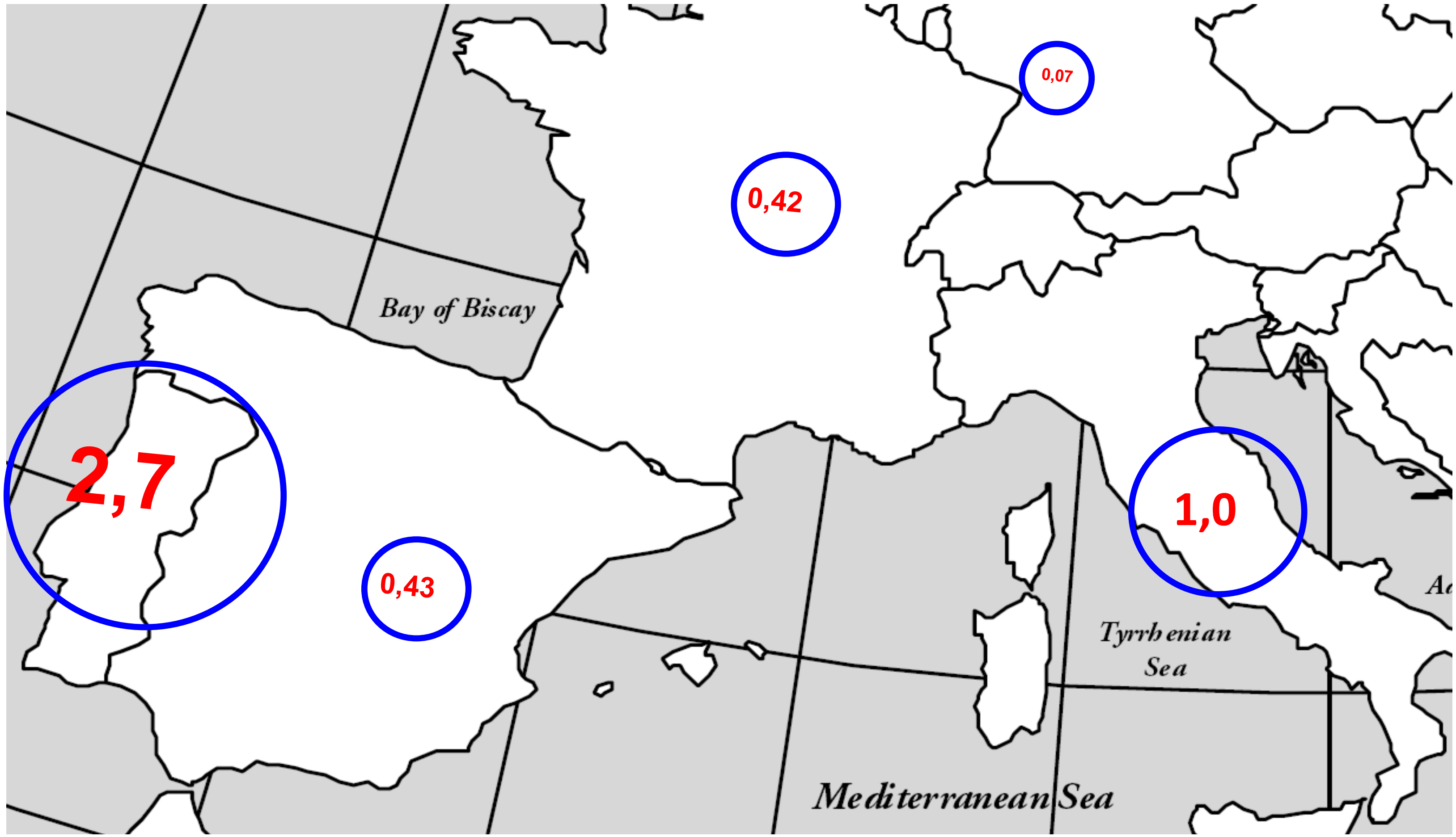
b) **Application of kaolin** as a leaf protector against thermal and light stress

c) Management of **Deficit Irrigation** (RD)

d) Other studies ongoing (**application of biochar to soil**; **shadow nets**; **precision viticulture techniques)**

Genetic diversity in Portugal

Number of authoctonous varieties cultivated / km2 in Europe
according to national official lists



A. Martins, 2010

Douro region – a genetic diversity reservoir

Fonte: António Graça, 2011

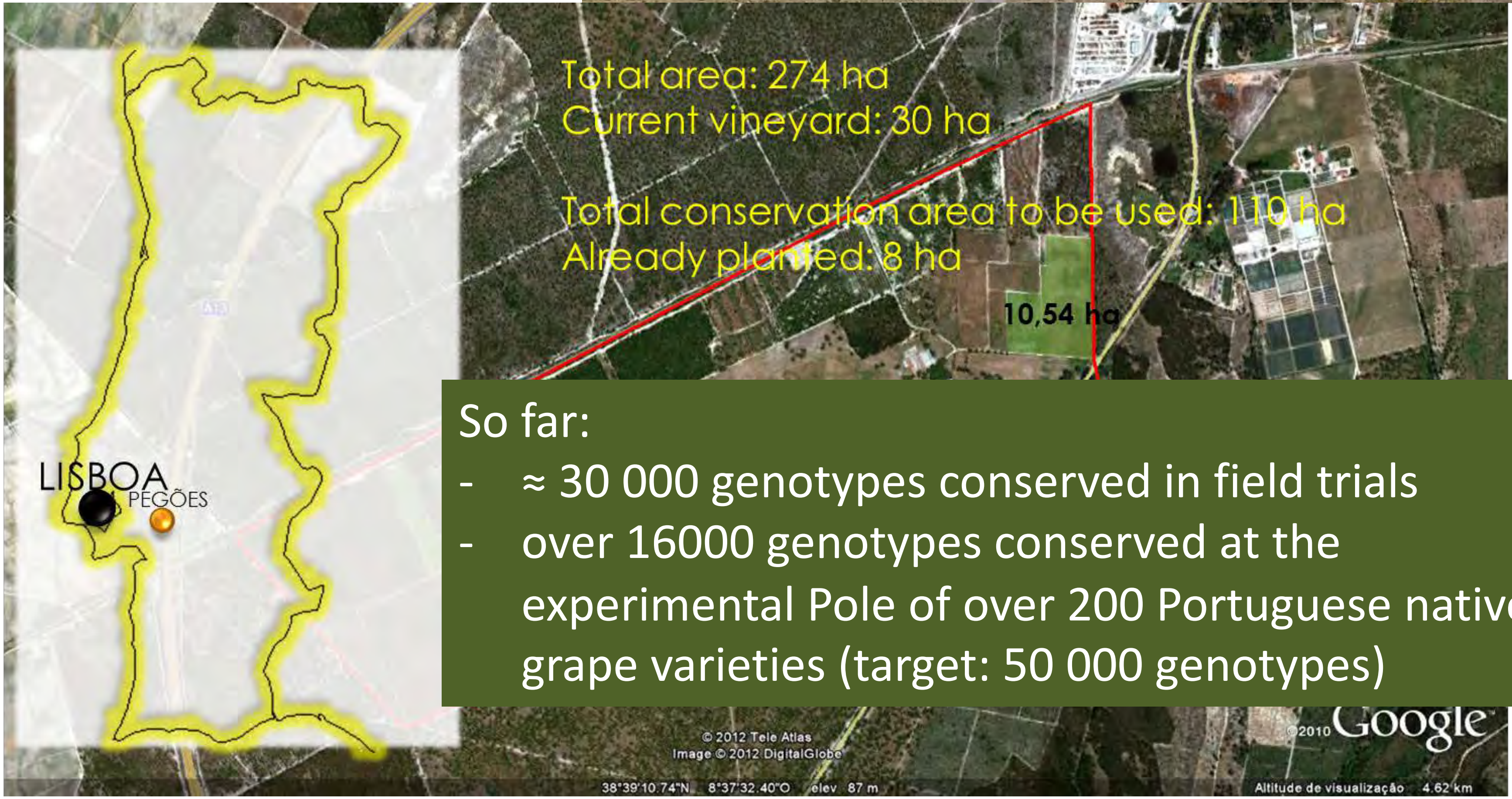
Alfrocheiro	Borraçal	Dedo de Dama	Granho	Moscatel Galego Branco	Ratinho	Tinta Penajoia
Almafra	Bragão	Diagalves	Grossa	Moscatel Galego Roxo	Ricoca	Tinta Pereira
Almenhaca	Branca de Anadia	Doçal	Jaen	Moscatel Galego Tinto	Roal	Tinta Pomar
Alvadurão	Branco Desconhecido	Doce	Jampal	Moscatel Graúdo	Rodo	Tinta Tabuaço
Alvar	Branco Especial	Dona Branca	Labrusco	Moscatel Nunes	Roseira	Tintinha
Alvar Roxo	Branco Gouvães	Dona Joaquina	Lameiro	Mourisco	Roupeiro Branco	Tinto Cão
Alvarelhão	Branco Guimarães	Donzelinho Branco	Larião	Mourisco Branco	Roxo Flor	Tinto Sem Nome
Alvarelhão Branco	Branco João	Donzelinho Roxo	Leira	Mourisco de Semente	Roxo Rei	Touriga Branca
Alvarelhão Ceitão	Branda	Donzelinho Tinto	Listrão	Mourisco de Trevões	Rufete	Touriga Fêmea
Alvarinho	Branjo	Dorinto	Loureiro	Mourisco Roxo	Sabro	Touriga Franca
Amaral	Cainho	Encruzado	Lourela	Negra Mole	Samarrinho	Touriga Nacional
Amor-Não-Me-Deixes	Calrão	Engomada	Luzidio	Nevoeira	Santareno	Trajadura
Amostrinha	Camarate	Esgana Cão Tinto	Malandra	Padeiro	Santoal	Transâncora
Antão Vaz	Caracol	F…	M…	… Matias	São Mamede	Trigueira
Aragonez	Caramela	…anoso	M…	Pato…	São Saul	Trincadeira
Arinto	Carrasquenho	Espadeiro	M…asia Bianca	Pé Co…	…rigo	Trincadeira Branca
Arinto do Interior	Carrega Branco	Espadeir…	M…	Pedra…	…milão	Trincadeira das Pratas
Arinto do Pico	Carrega Burros	Estre…cio	Malvasia …e S. …	Perigo		Triunfo
Arinto Roxo	Cascal	Fa…ra	Malvasia Ca…	Pero F…	…vilhão	Uva Cão
Arjunção	Casculho		…asia Cã…	Perru…	…a	Uva Cavaco
Avesso	Castelã	…ado	…a Roxa		…usão	Uva Salsa
Azal	Castelão	Ferral	Malvasia Fina	Pical	Tália	Valdosa
Babosa	Castelão Branco	Folgasão	Malvasia Fina Roxa	Pilongo	Tamarez	Valente
Baga	Castelino	Folgasão Roxo	Malvasia Preta	Pinheira Branca	Terrantez	Valveirinho
Barca	Casteloa	Folha de Figueira	Malvasia Rei	Pinheira Roxa	Terrantez da Terceira	Varejoa
Barcelo	Cercial	Fonte Cal	Malvasia Romana	Pintosa	Terrantez do Pico	Vencedor
Bastardo	Cercial Branco	Galego	Malvia	Praça	Tinta	Verdelho
Bastardo Branco	Cidadelhe	Galego Dourado	Malvoeira	Preto Cardana	Tinta Aguiar	Verdelho Roxo
Bastardo Roxo	Cidreiro	Galego Rosado	Manteúdo	Preto Martinho	Tinta Aurélio	Verdelho Tinto
Bastardo Tinto	Códega do Larinho	Gonçalo Pires	Manteúdo Preto	Promissão	Tinta Barroca	Verdial Branco
Batoca	Concieira	Gorda	Marufo	Rabigato	Tinta Caiada	Verdial Tinto
Beba	Coração de Galo	Gouveio	Melhorio	Rabigato Franco	Tinta Carvalha	Vinhão
Bical	Cornifesto	Gouveio Estimado	Melra	Rabigato Moreno	Tinta Fontes	Viosinho
Boal Barreiro	Corropio	Gouveio Preto	Molar	Rabo de Anho	Tinta Francisca	Vital
Boal Branco	Corval	Gouveio Real	Molinha	Rabo de Lobo	Tinta Martins	Xara
Boal Espinho	Corvo	Gouveio Roxo	Monvedro	Rabo de Ovelha	Tinta Mesquita	Zé do Telheiro
Bonvedro	Crato Espanhol	Grangeal	Moreto	Ramisco	Tinta Miúda	

Associação Portuguesa para a Diversidade da Videira – PORVID

- **Public-private association founded 2009 with the following goals:**
  - **Conservation of INTRAVARIETAL genetic variability in pots and field trials**
  - **Promote studies on growing and winemaking attributes of 200 autochthonous varieties**

Stop genetic loss of Portuguese varieties

The conservation park



So far:

- ≈ 30 000 genotypes conserved in field trials
- over 16000 genotypes conserved at the experimental Pole of over 200 Portuguese native grape varieties (target: 50 000 genotypes)

■ Intervarietal diversity as a climate change adaptation measure

Associação Portuguesa para a Diversidade da Videira – PORVID

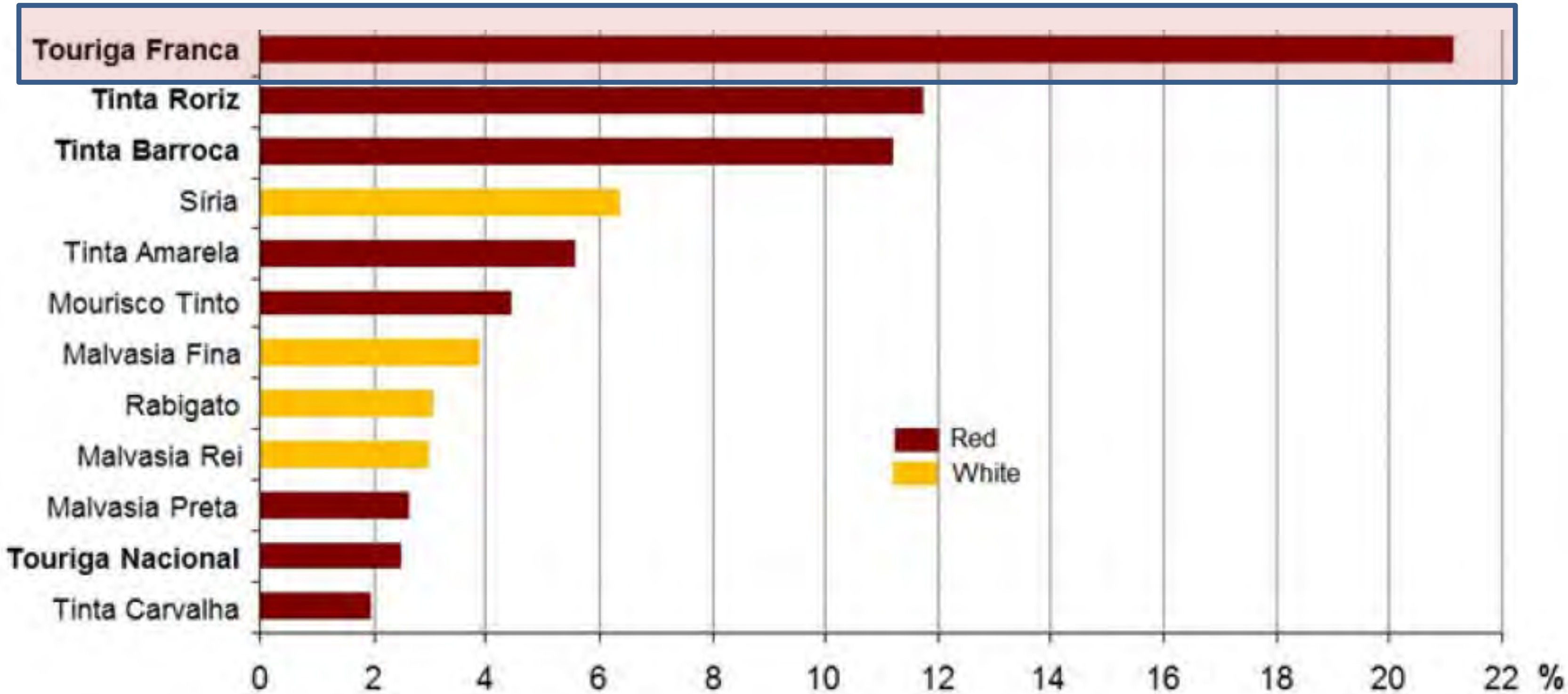
- Possibility to perform polyclonal selection, with different goals
- **Select varieties with higher stress resistance**

Ex: **Tempranillo** (*Tinta Roriz in Douro*) **variety**

- **30 selected genotypes with priority to anthocyanins** are now in a second cycle of comparison in 6 trials (4 in the Douro, 1 in Dão, 1 in Alentejo);

- Selection of **more heat tolerant genotypes** is ongoing in a trial in Alentejo

Most used varieties in Douro region



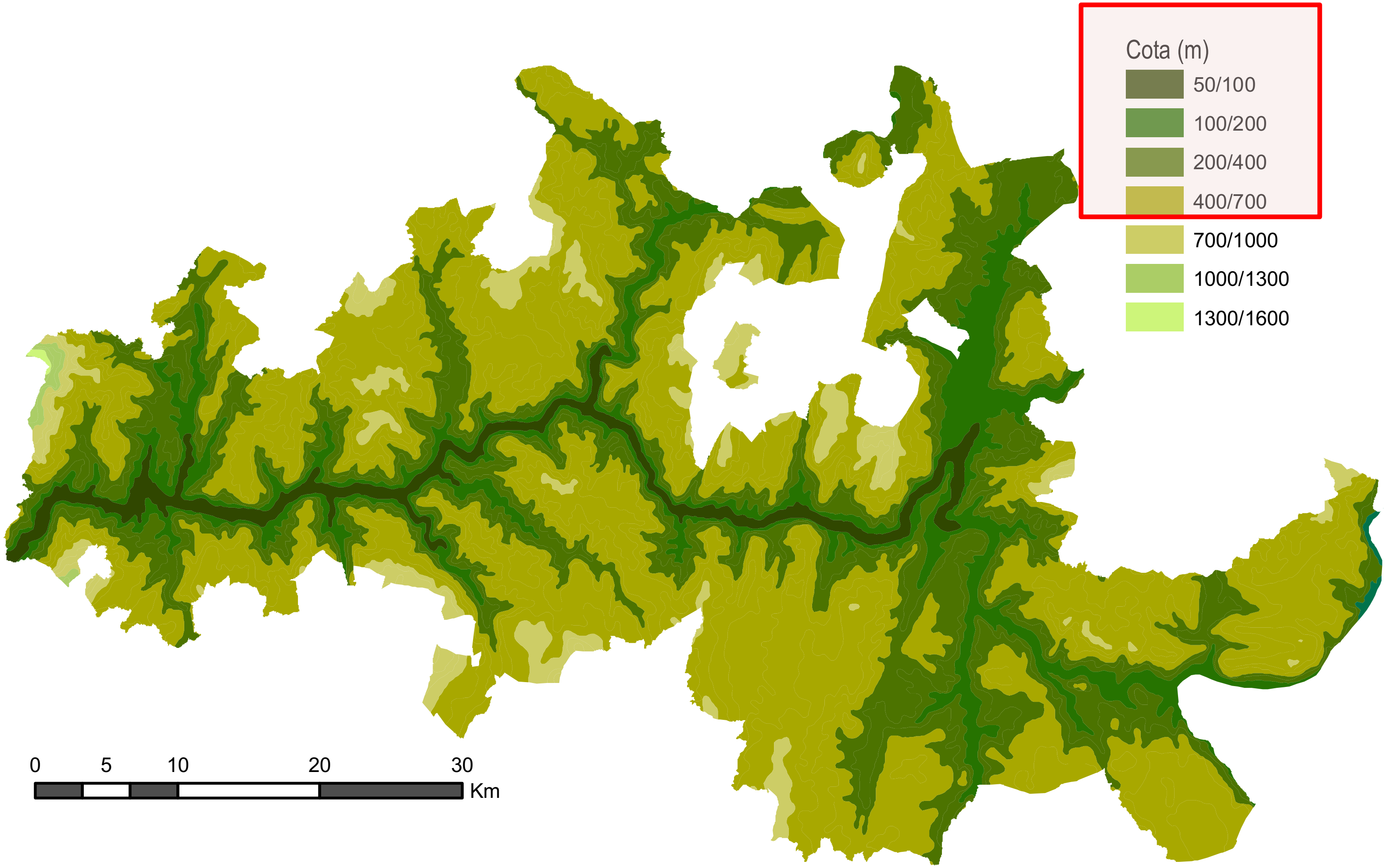
Casa do Douro, 2002

Touriga Franca, one of the most used variety, exibit a higher resistence to climate impacts

Studies are going at Insituto superior de Agronomia (Lisbon) about its leaf anatomy

INSTITUTO SUPERIOR DE AGRONOMIA
Universidade de Lisboa
Hinc Patriam Sustinet

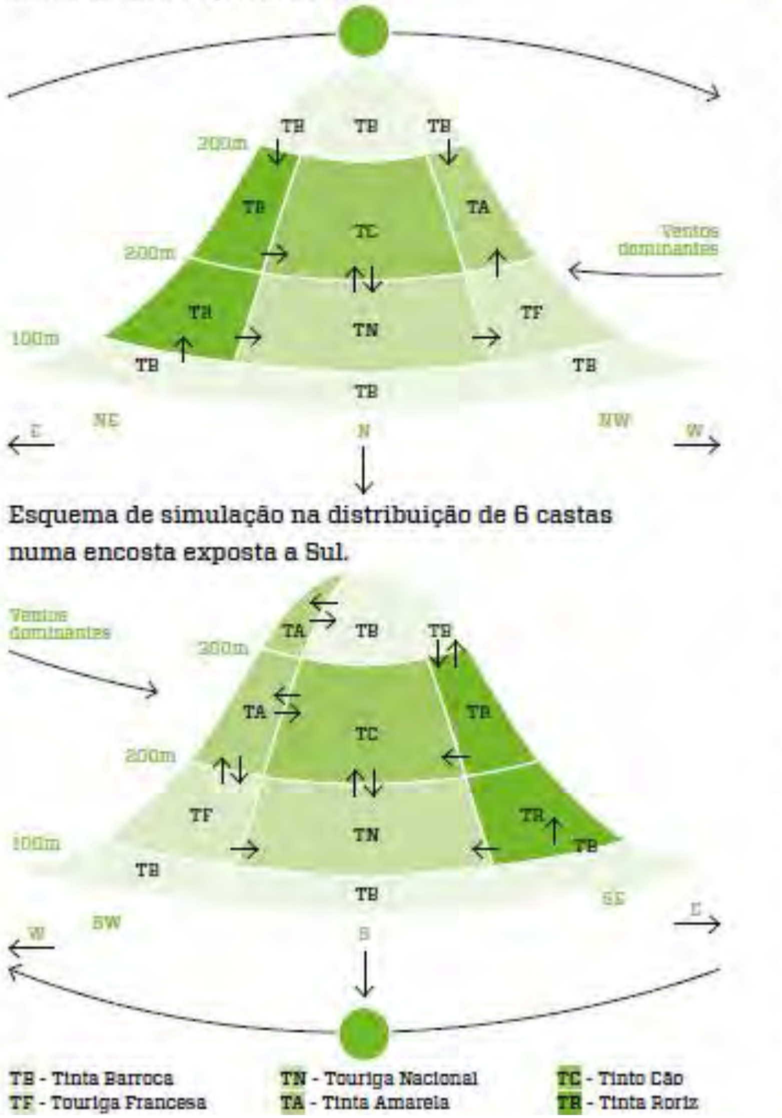
■ Classes of altitude in Douro region



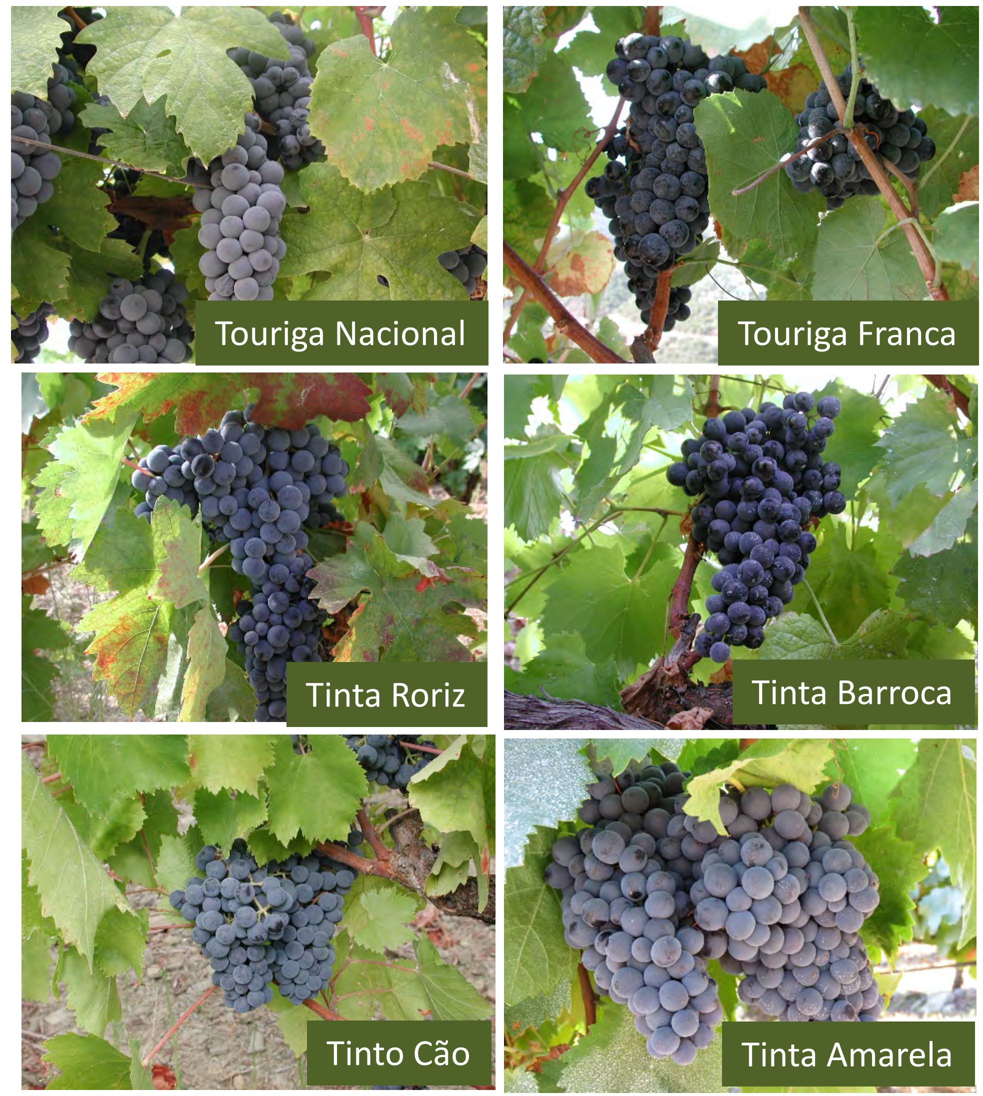
Topographic and geographical conditions allow to relocate grape varieties (zoning)

Fonte CAOP e Instituto do Ambiente.

■ Zoning strategy was studied for main red varieties used in Douro



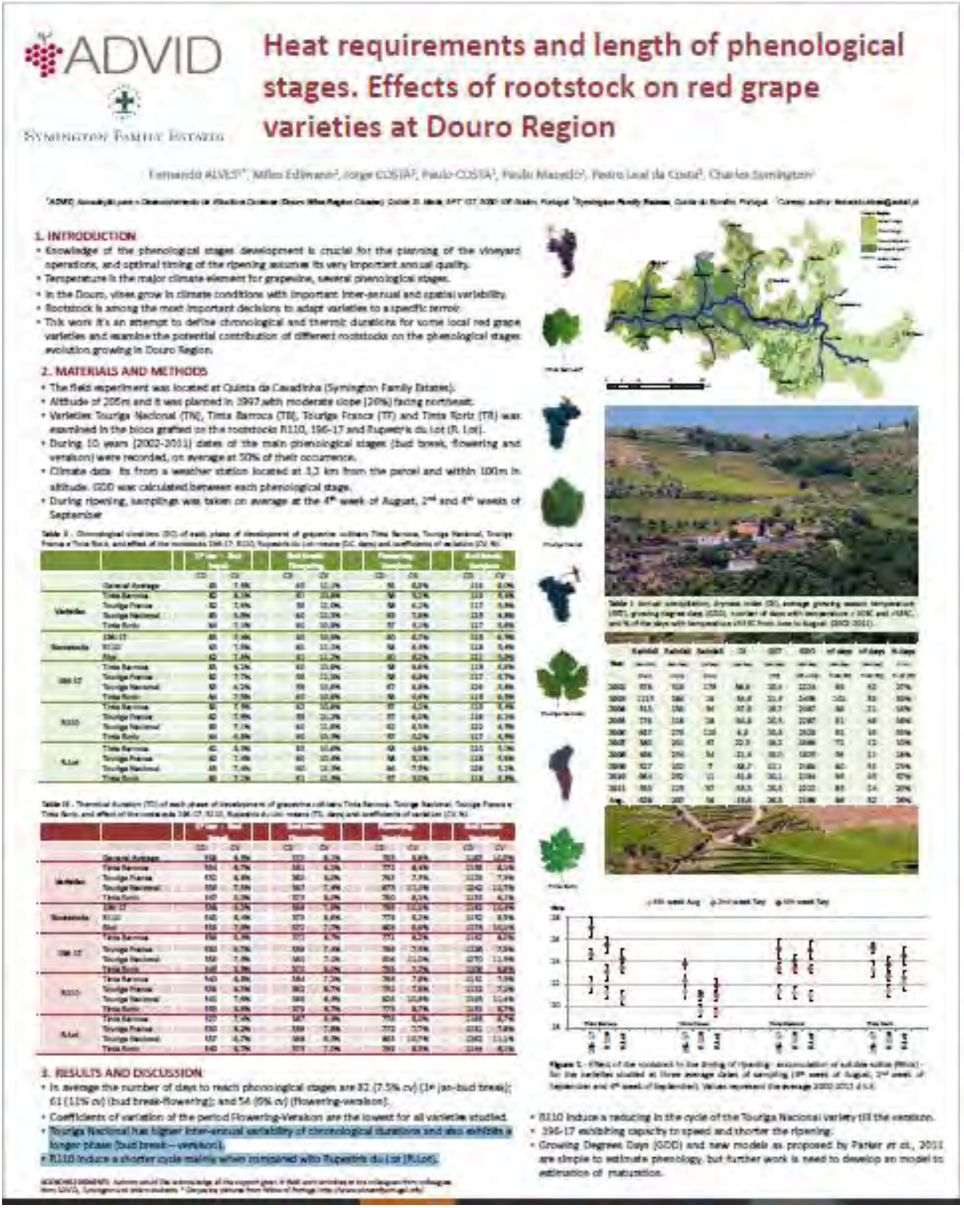
Source: Oliveira, A.A (2001)

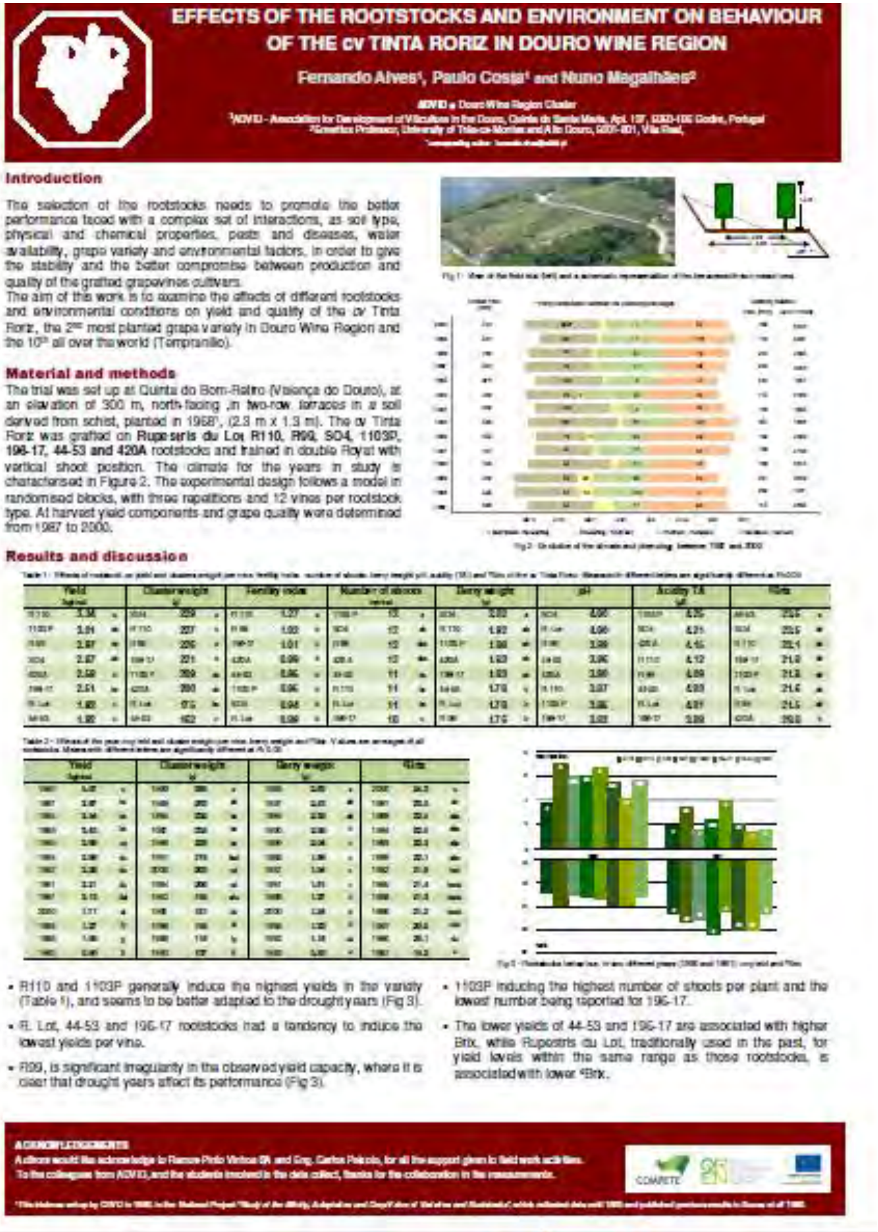


Source: Paulo Costa

utad

Understanding which are the best combinations of rootstocks X Varieties to face climate change…





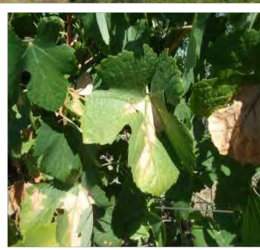
Application of sunscreen protection (Kaolin) to vineyards

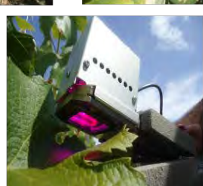
utad

Application of sunscreen protection (Kaolin) to vineyards

This technique result in:

- Reflection of part of radiation
- Reduction in internal temp. of leafs and grapes
- Reduction in transpiration rate
- Higher efficience of photossynthesis
- High stomate condutance
- Reduction of leaf and grape sun burn phenomena





PHYSIOLOGICAL AND YIELD RESPONSES OF GRAPEVINES TO KAOLIN UNDER SUMMER STRESS

José MOUTINHO-PEREIRA[1*], Lia-Tânia DINIS[1*], Hélder FRAGA[1], Rafael PINHEIRO[1], Helena FERREIRA[1], Jorge COSTA[2], Igor GONÇALVES[2], Ana OLIVEIRA[1], Glória PINTO[3], João A. SANTOS[1], Aureliano C. MALHEIRO[1], Carlos CORREIA[1]

[1] CITAB, Universidade de Trás-os-Montes e Alto Douro, UTAD, 5000-801 Vila Real, Portugal
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[3] CESAM, Universidade de Aveiro, 3810-193, Aveiro, Portugal

*Author for correspondence: moutinho@utad.pt

Xth International Terroir Congress - 7/10 July 2014

Introduction

Winegrape production in Mediterranean regions, especially in the Douro Demarcated Region (DDR, Northeast Portugal), is subject to warm and dry summer climate conditions, that may irreversibly impair some physiological processes, leading to poor grape yields and quality. Previous work by our team in the region clearly showed that grapevines growing under severe summer stress experienced significant decline in yield due to stomatal and mesophyll limitations to photosynthesis. Frequently, some of these leaves, particularly those lower on the canes and more directly exposed to sunlight, displayed irreversible photoinhibition and chlorosis followed by necrosis, unprotecting the cluster zone and leading to a decrease in grapevine water use efficiency. Consequently, in low vigour vines, yield, berry weight and sugar concentration are significantly reduced. Furthermore, other berry characteristics, such as colour, flavour and aroma components are suppressed by excessive solar exposure of grapes and low water availability. Related with adaptation and mitigation practices, we wish to reinforce the knowledge of the effect of particle film applications, i.e. spraying canopies with a aqueous suspension of kaolin. Hence, the aim of the present study is to investigate the main effects of a foliar application with a kaolin particle film in the physiological behaviour of the "Touriga Nacional" variety.

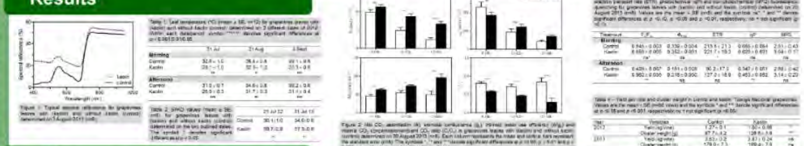
Material and methods

Experimental trial: The experiment was undertaken in 2012 and 2013 in the commercial vineyard "Quinta do Vallado", located at Peso da Régua in the DDR, northern Portugal.

Plant material: *Vitis vinifera* L. "Touriga Nacional", grafted onto 110 R. Three vineyard lines, located on a steep hill, with N-S orientated rows and with 20 plants each one, were pulverized soon after veraison, with 5% (w/v) kaolin (Surround WP; Engelhard Corp., Iselin, NJ). Three additional vineyard lines, with 20 plants each one, were maintained as control, i.e. without kaolin application.

Physiological and agronomical measurements: Leaf gas exchange rates were measured with an infrared gas analyser (LCA-3, ADC, England). Chlorophyll a fluorescence features were measured in situ with a pulse-amplitude-modulated fluorimeter (FMS 2, Hansatech Instruments, Norfolk, England). Total chlorophylls and total carotenoids were determined according to Lichenthaler (1987). Chlorophyll concentration per area was also estimated non-destructively using a SPAD-502 meter (Minolta, Japan). Leaf temperature was measured with an infrared thermometer (Infratrace KM800S, England) with a 15° field view. Leaf reflectance was measured from 200 to 1100 nm, using a leaf clip with a bifurcated fiber-optic cable attached to both HR2000 Spectrometer (Ocean Optics, Inc., Dunedin, USA) and to an Ocean Optics LS-1 tungsten halogen light source. At harvest, yield per vine was determined in 60 vines per treatment. Values were compared by a one-way ANOVA test. All means were compared at the 0.05 (*), 0.01 (**) and 0.001 (***) levels of significance.

Results



Discussion and conclusions

The application of 5% kaolin resulted in the formation of a whitish dry residue on the exposed leaves which increased the reflector capacity (Fig. 1). One of the direct effects of this application was a significant reduction of leaf temperature (Table 1). Consequently, during the summer period, the degradation of photosynthetic pigments was not as evident as in control ones (Table 2). Measurements of gas exchange indicate significantly higher A in kaolin leaves (Fig. 2). Particularly at ripeness stage, the increase in A was more evident than the slight increase in g_s during warmer periods of the day, leading to higher A/g_s and lower C_i/C_a. The increase of the photosynthetic rate in kaolin treated leaves was associated to an improvement of the PSII photochemical efficiency. At harvest, mainly in 2012, the kaolin effect had a clearly positive impact on the productivity performance of the vines (Table 4).

In conclusion, the results of this study, carried out with grapevines of the same variety and under similar field-grown conditions, emphasized the beneficial role of kaolin as a short-term measure for growing grapevines under high irradiance levels and heat/water stress conditions, such as in Douro region. Particularly during the ripening stage, the photosynthetic capacity depression was associated with important photochemical and biochemical changes that can negatively compromise the grape production, particularly emphasized in low yield years.

References

See *Proceedings of Xth International Terroir Congress* for more details.

Acknowledgments

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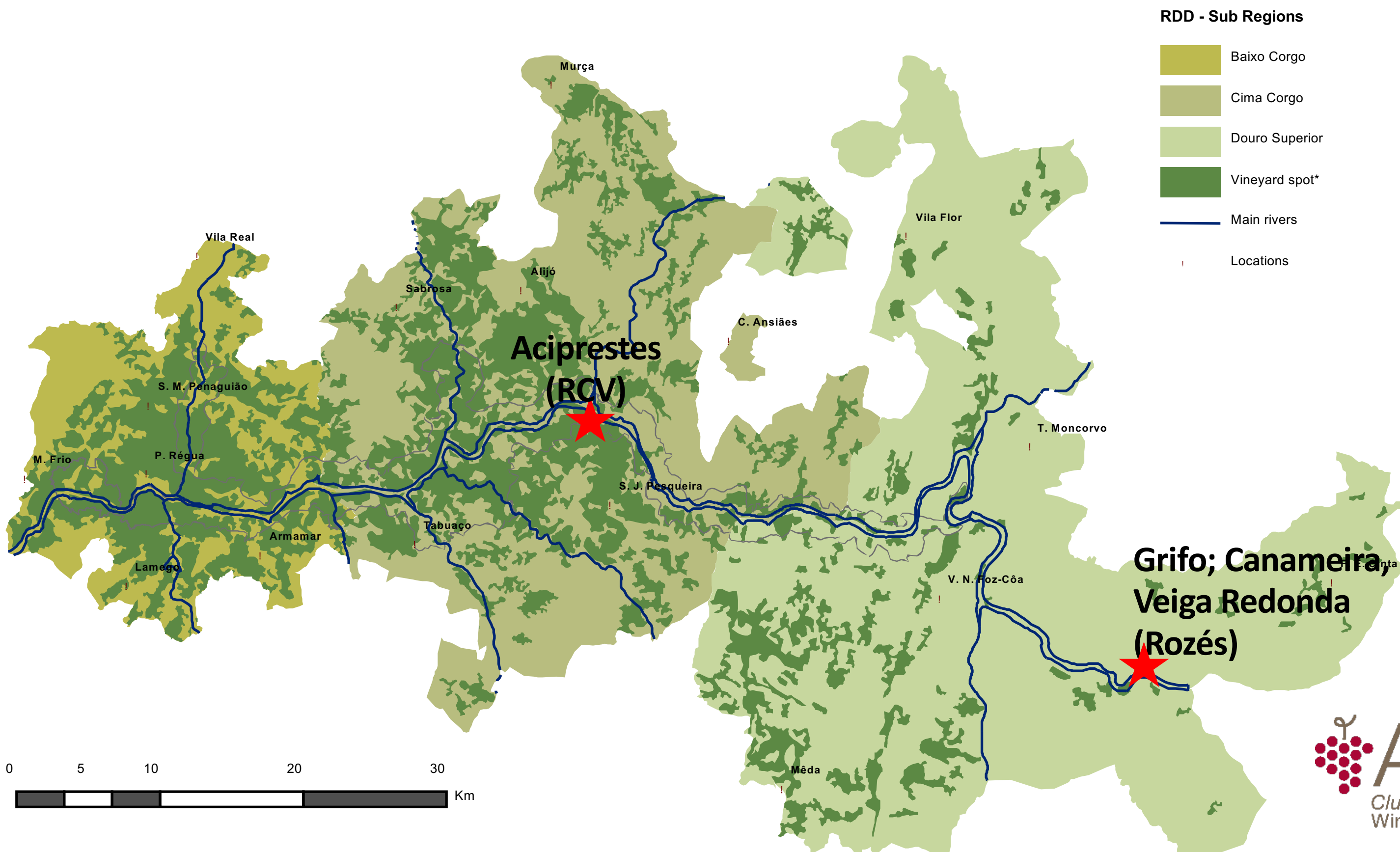
FCT Fundação para a Ciência e a Tecnologia

Promote the efficient use of water – Deficit irrigation trials

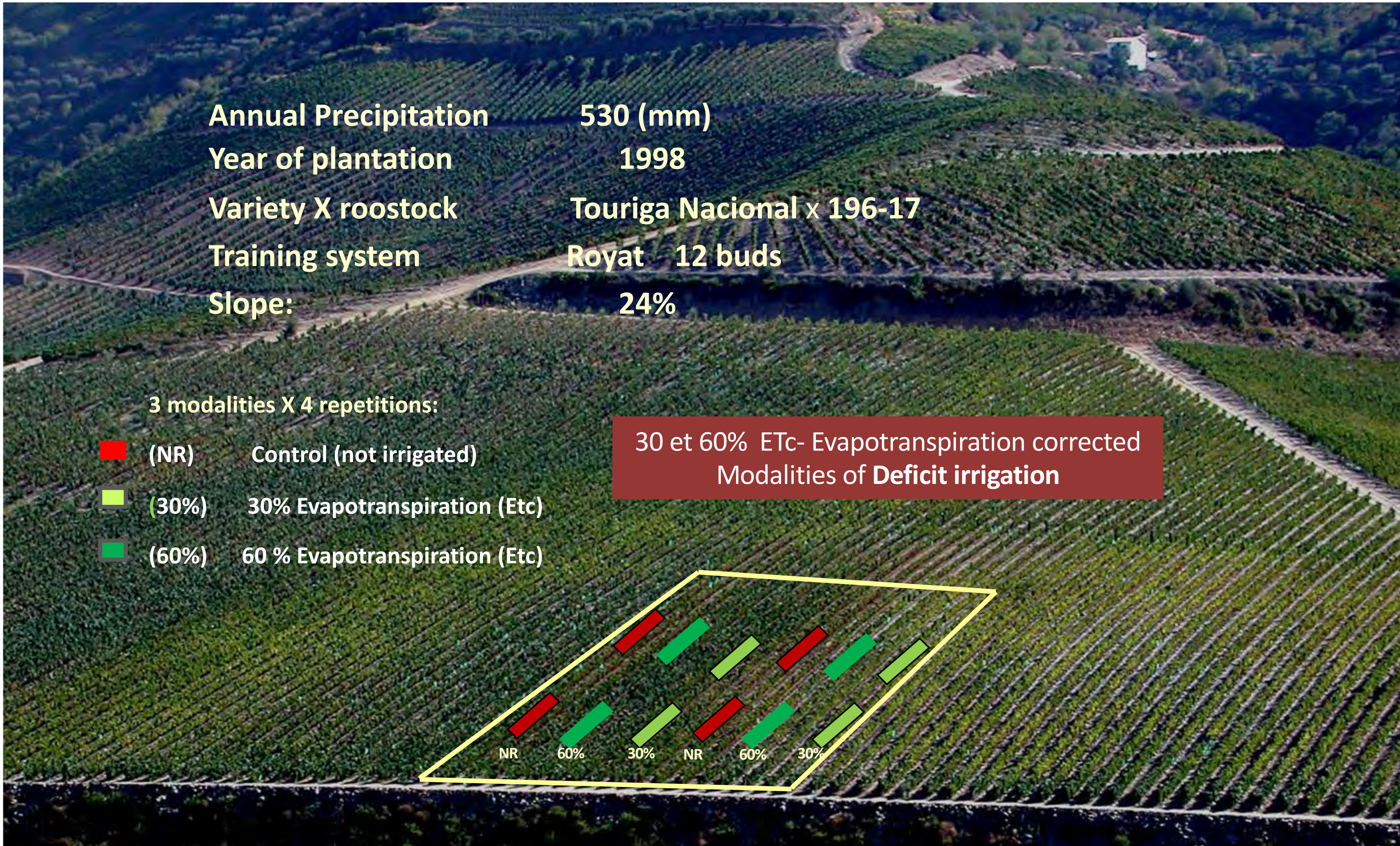
Irrigation is strongly regulated in the Douro Wine Region



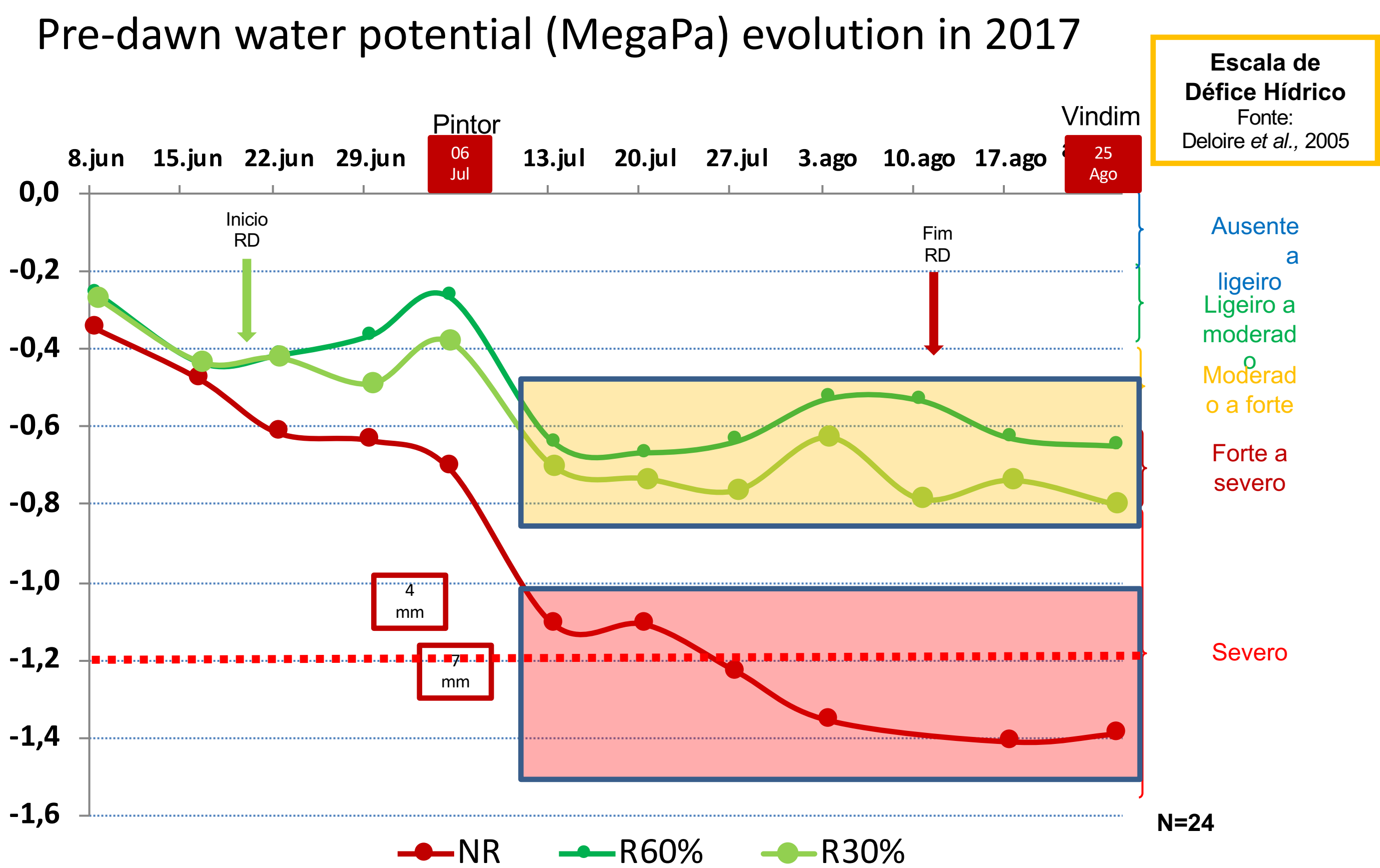
Two varieties under study: Touriga Nacional and Touriga Franca

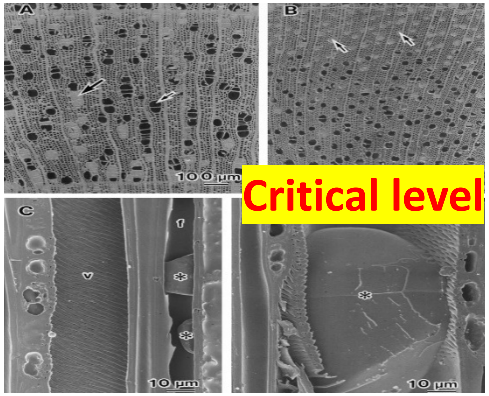
Trial installed in a comercial vineyard under study since 2002

REAL COMPANHIA VELHA

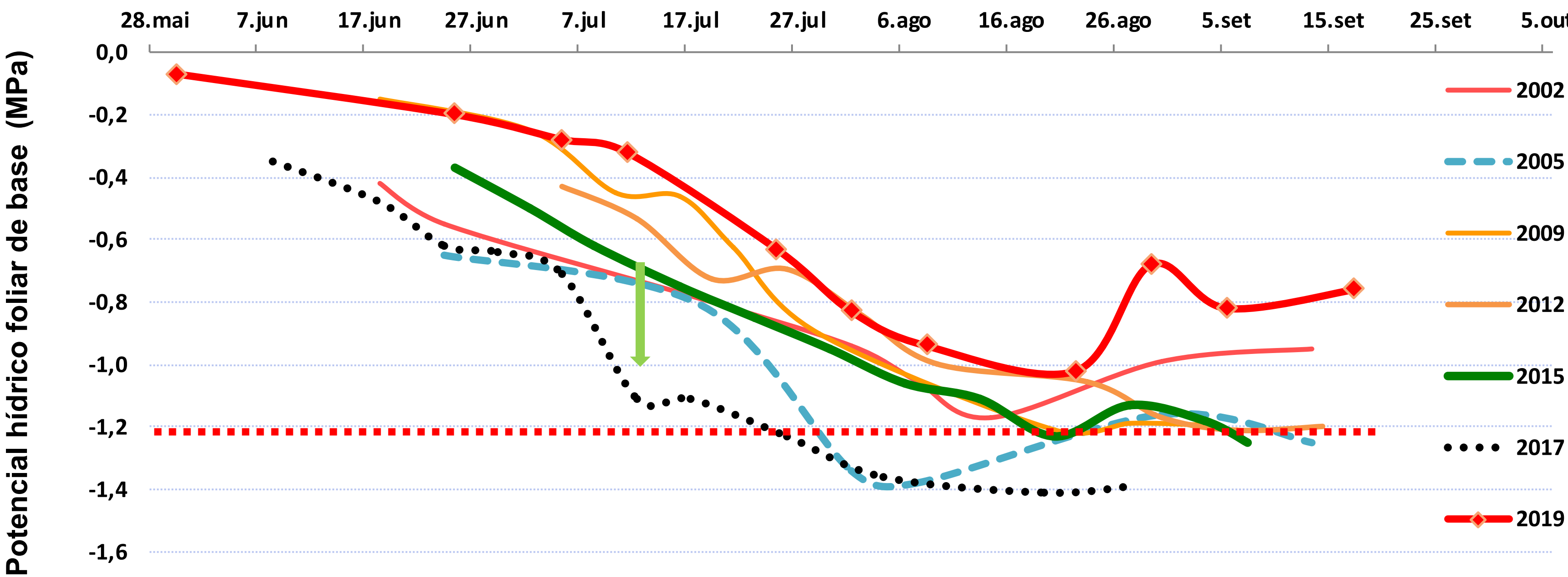


▪ Sholander chamber pression - An important tool for assessing hydric status

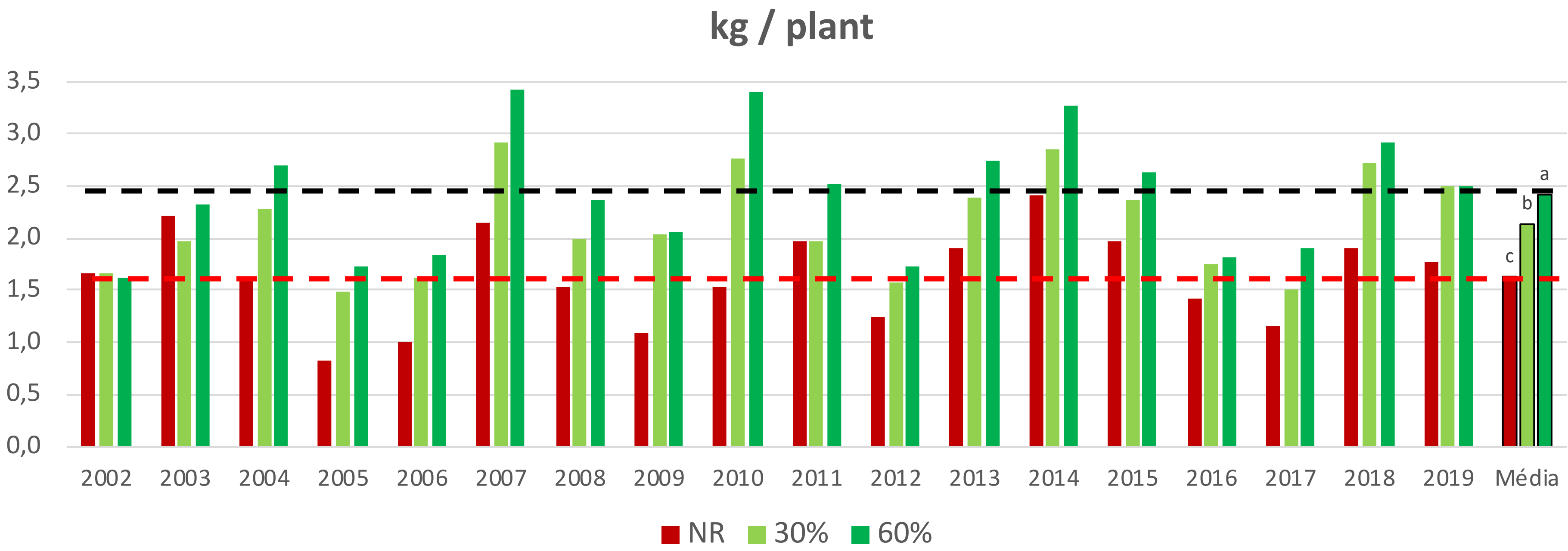




▪ Pre-dawn water potential (MegaPa) evolution in control plot (nor irrigated) (2002-2019)

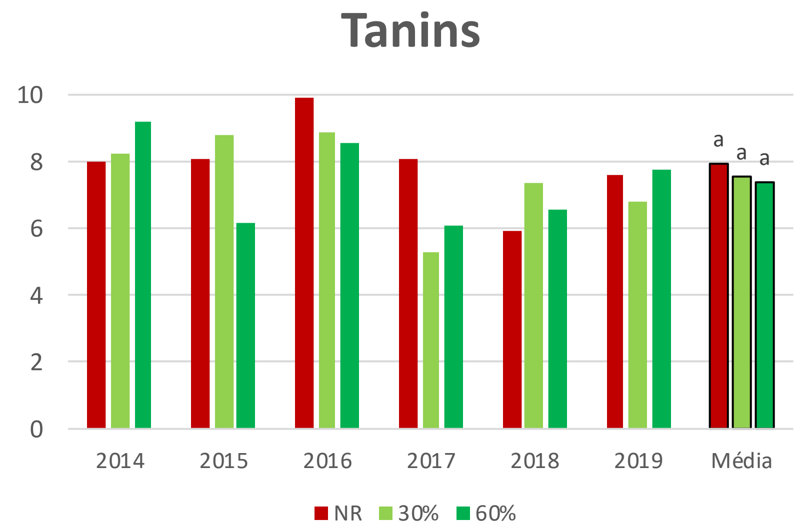


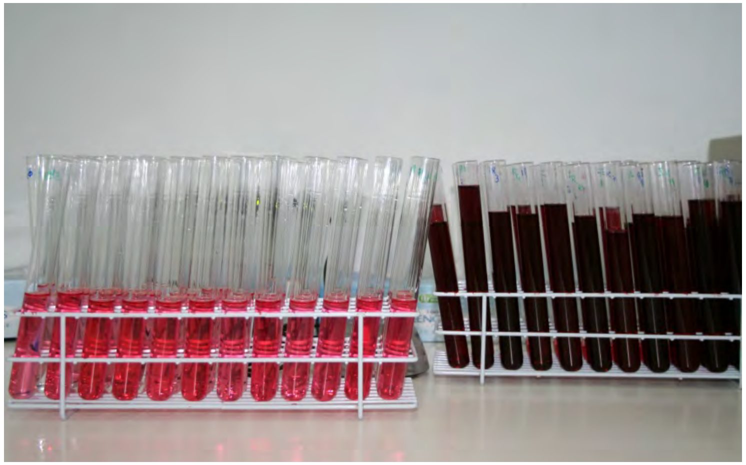
▪ Analysis of production / plant (2002-2019)

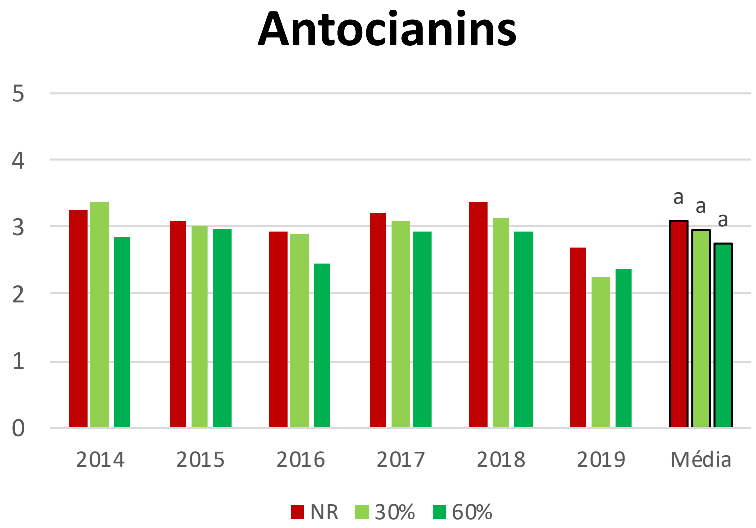


Deficit irrigation allow to regulate the production at **reasonable levels (1,5 to 2,5 kg/plant)**

Analyses of grape quality (2014 - 2019)





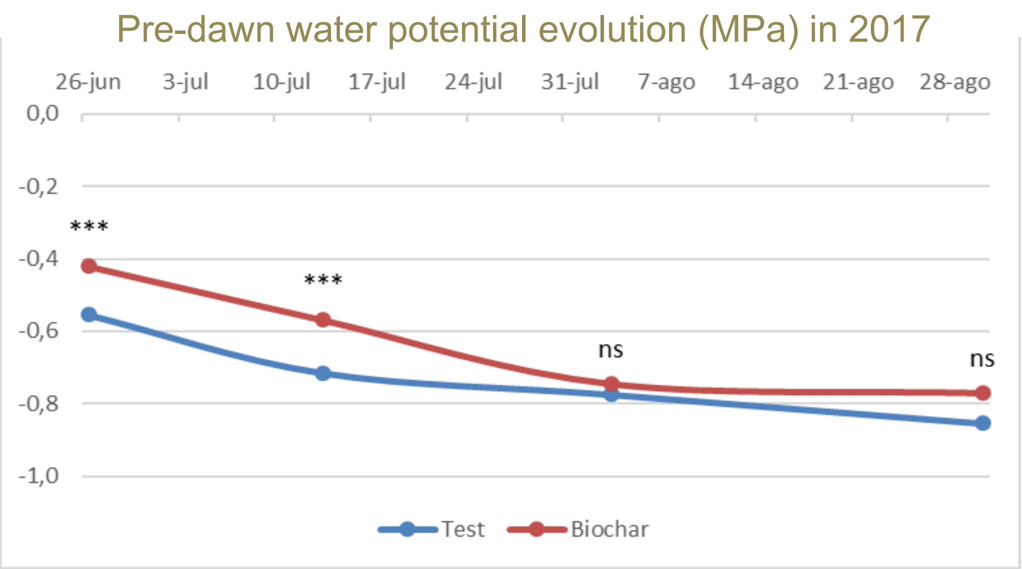


The two modalities of Deficit Irrigation **did not result in negative impacts** in Antocianins and Tannins

■ In available places, install water reservoirs

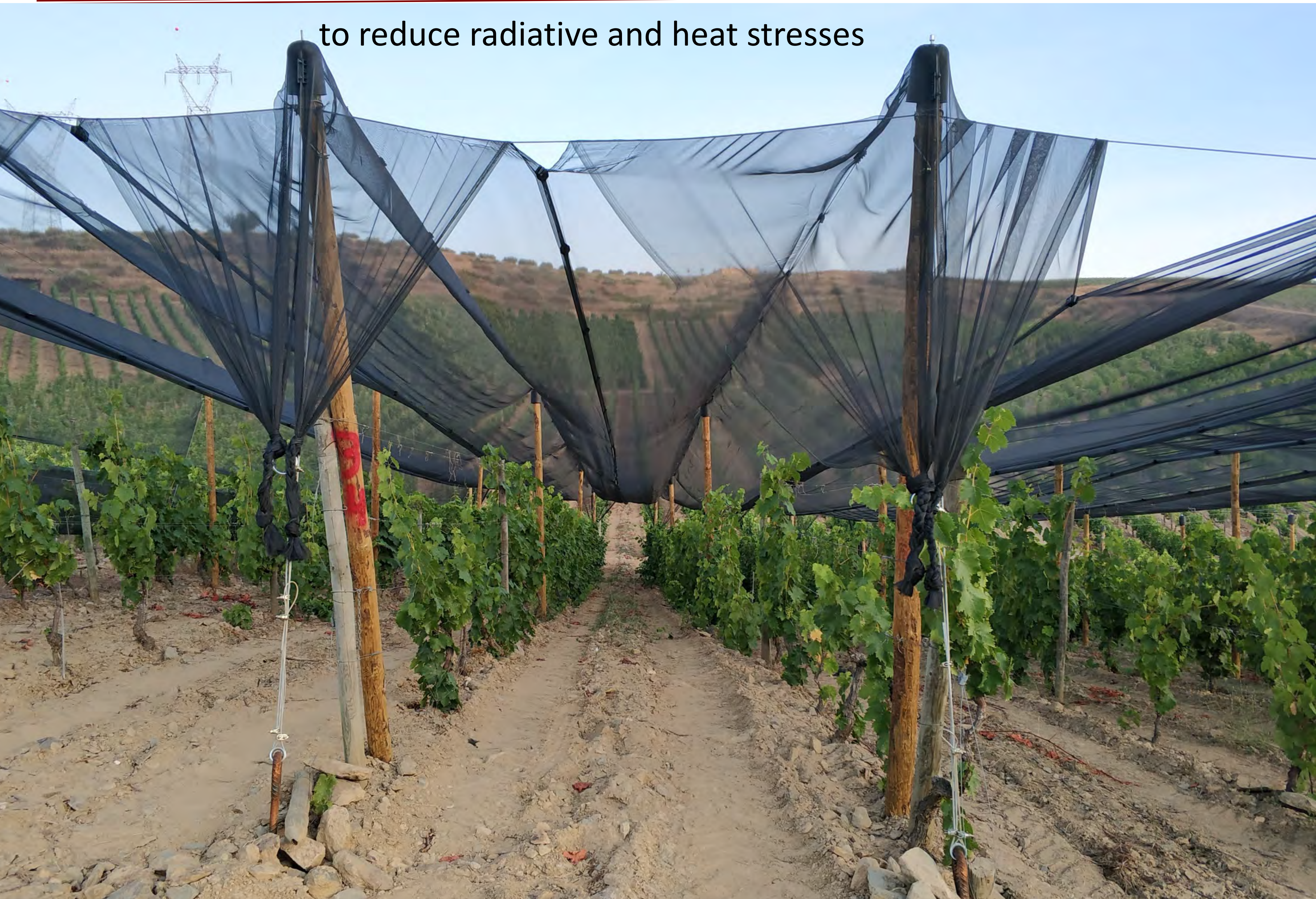
▪ Ongoind studies- Application of “BIOCHAR” to vineyard soil

BIOCHAR- charcoal produced from plant matter that cab be applied to soil to improve its characteristics



▪ Ongoind studies- Application of “shading nets”

to reduce radiative and heat stresses



Work ongoing related with precision viticulture

- **Project WINESPECTRA - Management of deficit irrigation in vineyards based on vegetation indexes**
- **Partnership:** Sciences faculty of University of Porto, ADVID, Real Companhia Velha and Symington Family Estates

Evaluate the potential of vegetation indexes based on reflectance data, to estimate water status of vineyards

- **Project VINIOT - Network-based precision viticulture service IoT sensors for digital transformation of SMEs in the SUDOE space**
- **Partners:** AIMEN, AGACAL, ADVID, IFV, INRA, AGAMELARIOJA, FEUGA, IRSTEA

Creation of a new technology monitoring service for vineyards in real time, to assess relevant parameters in viticulture such as water status, grape maturity or pest and phytosanitary status

▪ General conclusions

- There are several adaptation measures to climate change

- The adaptation measures should not be applied in a general way, but **validated** in different terroirs, years and different production objectives (ideally by each wine company)

- Serious and long-term studies are needed to allow us to correctly **diagnose the problem** and consequently **define the most appropriate solutions**

- Those studies should result in **guidelines that allow the recommendation of most effective adaptation measures** to reduce viticulture's vulnerability to climate change


ADVID
Cluster da Vinha e do Vinho
Wine and Vine Cluster
Thanks for your attention
Obrigada!