



Selection and characterization of grape varieties best suited to climate change scenarios foreseen for the near future - **WineClimAdapt**

The partnership:



PROGRAMA DE
DESENVOLVIMENTO
RURAL 2014 · 2020

PDR2020-101-031010

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PROGRAMA DE
DESENVOLVIMENTO
RURAL 2014 · 2020



UNIÃO EUROPEIA
Fundo Europeu Agrícola
de Desenvolvimento Rural
A Europa Investe nas Zonas Rurais

The problem:

Southern Europe is one of the world regions where climate change (CC) will be most pronounced;

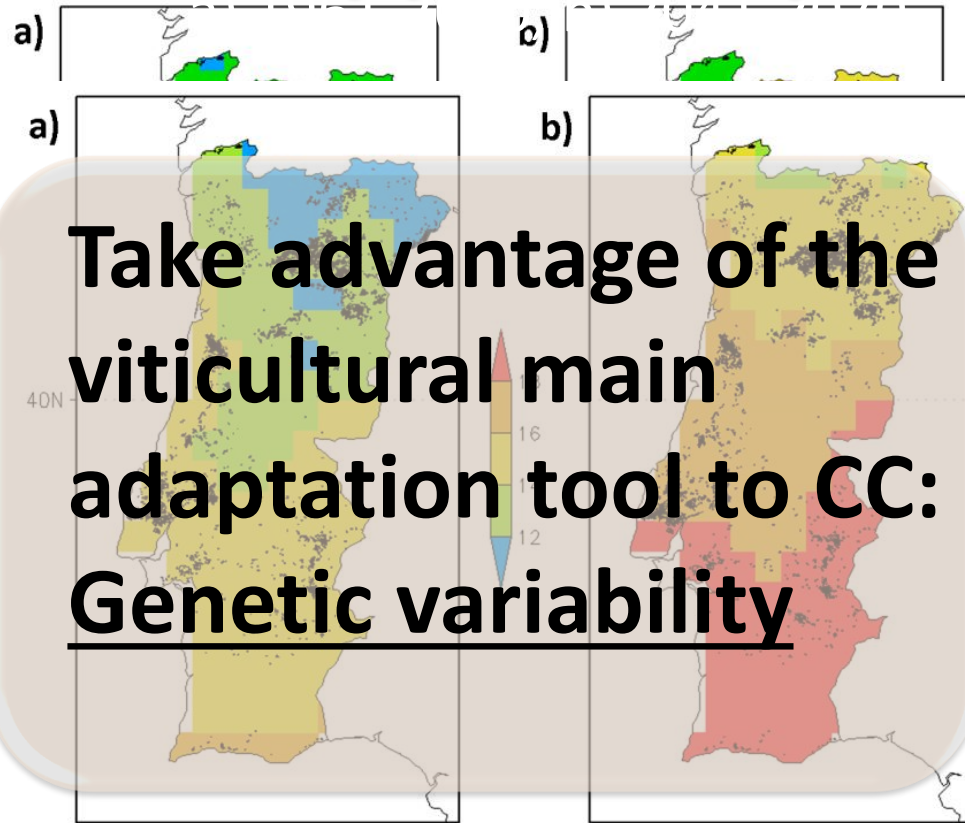
Grapevine varieties in cultivation are already very close to their climatic limits (e.g. Alentejo).

1. Huglin Index:

a) 1961-2000, b) 2041-2070

2. Dryness Index:
a) 1961-2000, b) 2041-2070

The opportunity:



Take advantage of the viticultural main adaptation tool to CC: Genetic variability



Main objectives:

Elaborate an adaptability ranking of 189 grapevine varieties

(phenology, resistance to abiotic stresses and heat waves)

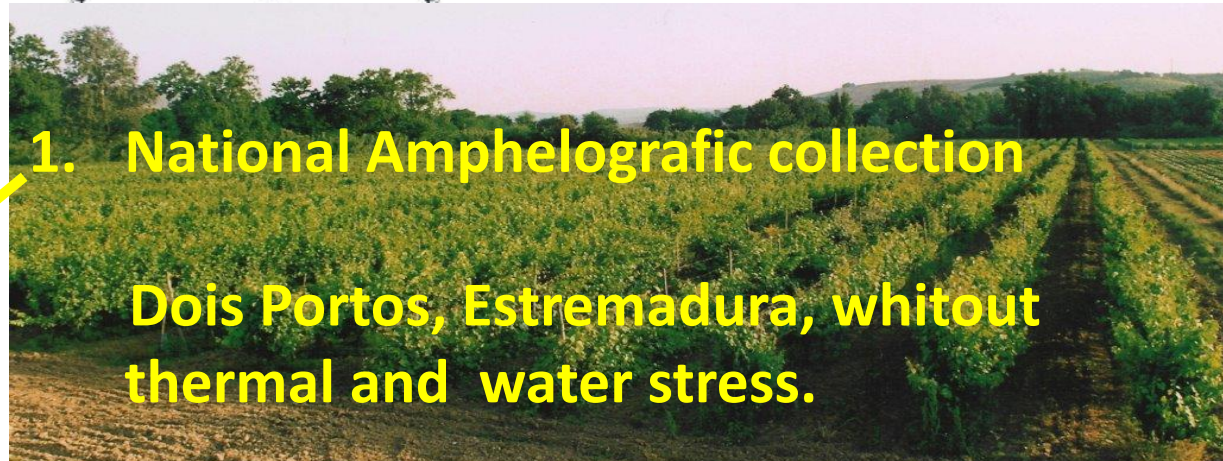
Quantify the agronomic and oenological potential of grape varieties best suited to climate change scenarios.

(production, alcohol, phenolic compounds and aroma precursors, sensorial profile)

Identify molecular markers of tolerance to dryness and heat

(for use in future selection works)

The experimental fields:

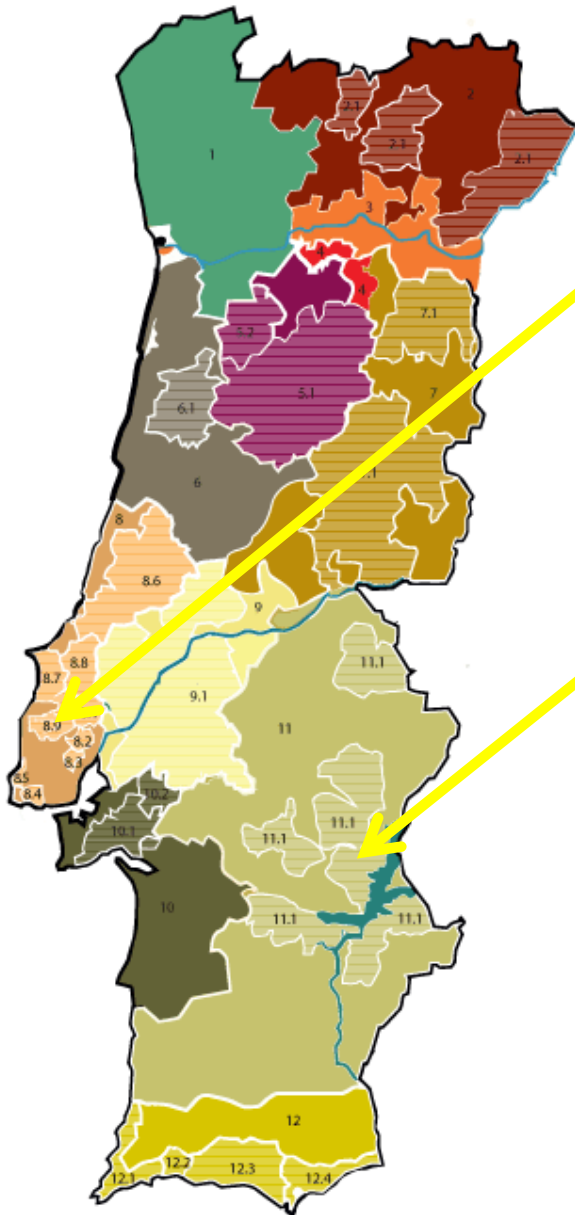


1. National Ampelografic collection

Dois Portos, Estremadura, without thermal and water stress.

2. Herdade do Esporão Ampelografic field

Reguengos de Monsaraz, Alentejo, dry and hot conditions, with 3 water regimes: rainfed, deficit irrigation (with and without sunscreen) and full irrigation



Tasks:

Quantify the adaptability of grape varieties (2018-2019).

Phenological characterization; water use efficiency quantification and heat stress tolerance at the varietal level (isotopic composition, aerial thermography, vegetation indices).

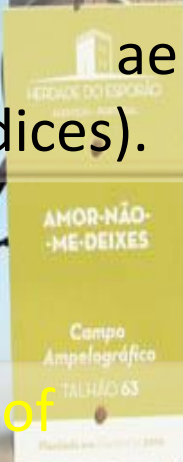


Characterize agronomically and oenologically the best adapted vine varieties (2020-2022).

Agronomic behavior; phenological and cultural modeling; sensitivity of secondary metabolites to temperature; sensorial, phenolic and odorant profile of wines. Provide data for molecular association studies (2020-2022).

Demonstration of techniques and results dissemination (2019-2021).

To quantify clones adaptability (2021)



First results:

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***RANKING OF RESISTANCE
TO HEAT WAVES
(concluded)**

***PHENOLOGICAL MODELING
(ongoing)**

“Spring Warming” model (10
years of data at CAN and 5 years
at CAHE)



The 2018 heat wave

RED VARIETIES

WHITE VARIETIES

Air Temperature (°C)

Vapor Pressure Deficit (Kpa)

Variety	E	W	Avg	Variety	E	W	Avg
Afrocheiro	1	3	2	Manteúdo Preto	1	3	2
Alicante Bouschet	5	5	5	Marselan	4	5	4
Alvalerhão Ceitão	1	3	2	Marufo	2	5	3
Alvalerhão	1	1	1	Merlot	1	3	2
Amaral	1	3	2	Molar	1	2	2
Amor-Não-Me-Deixes	2	3	3	Monvedro	2	3	2
Amostrinha	1	3	2	Moreto	1	2	1
Aragonez	1	2	2	Moscatel Galego Tinto	1	2	2
Azal Espanhol	2	5	4	Negra Mole	1	4	2
Azal Tinto	1	2	1	Patorra	1	4	2
Baga	1	2	1	Pedral	1	2	2
Bastardo	1	1	1	Petit Verdot	5	5	5
Bastardo Tinto	2	2	2	Pical	3	5	5
Babal	1	3	2	Pilongo	1	2	1
Bombalino	1	3	2	Pinot Noir	2	5	3
Borraçal	5	5	5	Preto Cardana	1	3	2
Branjo	1	2	2	Preto Martinho	1	3	2
Cabernet Franc	1	1	1	Prieto Picudo	2	2	2
Cabernet Sauvignon	1	4	3	Ramisco	1	1	1
Caladoc	1	3	2	Rufete	1	2	1
Canarate	1	3	2	Sangiovese	1	4	3
Carignan	3	4	3	Sousão	1	2	1
Carrasquenho	1	1	1	Syrah	3	5	4
Castelão	1	5	3	Tinta Barroca	2	4	3
Castelinho	1	2	1	Tinta Bragão	1	3	2
Cidadelhe	2	5	3	Tinta Caiada	1	3	2
Cidreiro	1	1	1	Tinta Carvalha	1	2	1
Edsaut	1	2	1	Tinta da Barca	4	5	5
Cornifesto	1	3	2	Tinta Francisca	1	2	1
Corropio	1	4	3	Tinta Gorda	1	2	1
Corvo	2	5	4	Tinta Grossa	1	2	1
Dolcetto	3	5	4	Tinta Miúda	1	2	1
Donzelinho Tinto	1	3	2	Tinta Pomar	1	4	2
Espadeiro Mole	5	5	5	Tintinha	1	3	2
Espadeiro	1	5	3	Tinto Cão	1	2	2
Ferreira	5	5	5	Touriga Fêmea	1	2	1
Galego	1	1	1	Touriga Franca	1	2	1
Gouveio Preto	1	3	2	Touriga Nacional	1	2	1
Grenache	1	2	1	Trincadeira	1	2	2
Jaen	1	1	1	Vinhão	1	5	3
Malbec	3	5	4	Zinfandel	3	5	4

Variety	E	W	Avg	Variety	E	W	Avg
Alfrocheiro Branco	1	2	1	Luzidío	1	3	2
Alicante Branco	1	2	1	Macabeo	1	2	1
Almafra	1	3	2	Malvasia	2	4	3
Alvadurão	1	2	1	Malvasia Baixa	1	4	3
Alvarinho	3	5	4	Malvasia Cândida	1	2	2
Antão Vaz B	1	3	2	Malvasia Fina	1	2	1
Arinto	2	3	2	Malvasia Rei	1	2	1
Arinto do Interior	1	2	1	Mantouso	1	3	2
Arinto do Pico	1	2	2	Molinha Macia	1	1	1
Avesso	4	5	4	Montua	2	4	3
Azal	1	4	2	Moscatel Galego Branco	1	2	1
Barcelo	1	2	2	Moscatel Graúdo	2	3	2
Bastardo Branco	1	4	2	Moscatel Nunes	1	3	2
Batoca	1	2	2	Mourisco Branco	1	2	1
Beba	1	1	1	MüllerThurgau	1	2	1
Bical	2	3	2	Pardina	1	2	1
Binzelo	1	1	1	Parellada	1	1	1
Boal Espinho	1	3	2	Pé Comprido	1	2	1
Boal Ratinho	1	2	1	Pedro Ximenez	1	2	1
Boal Vencedor	2	5	3	Pernum	1	5	3
Branco de Gouvães	1	2	1	Petit Maseng	1	3	2
Cascal	1	1	1	Prosecco	1	1	1
Castelão Branco	1	1	1	Rabigato	1	3	2
Cayetana	1	3	2	Rabigato Moreno	1	2	1
Cerceal Branco	2	5	3	Rabo de Ovelha	1	4	2
Cercial	1	1	1	Riesling	1	3	2
Chasselas	1	1	1	Roupeiro Branco	1	2	1
Chenin	1	3	2	Samarinho	1	3	2
Codega do Larinho	1	1	1	São Mamede	5	5	5
Dedo de Dama	2	5	3	Sarigo	1	2	1
Diagalves	2	4	3	Sauvignon	2	3	2
Doçal	1	1	1	Seara Nova	1	1	1
Dona Branca	1	3	2	Sercial	2	2	2
Donzelinho Branco	2	5	4	Silvaner	2	3	2
Douradinha	1	1	1	Síria	1	3	2
Encruzado	1	3	2	Tália	1	4	2
Esgana Cão	1	2	1	Tamarez	1	3	2
Esganinho	5	5	5	Terrantez	1	1	1
Esganoso	1	1	1	Terrantez do Pico	1	1	1
Fernão Pires	1	3	2	Trajadura	1	2	1
Feteasca Alba	1	2	1	Trincadeira Branca	1	1	1
Folgasão	1	5	3	Trincadeira das Pratas	1	2	2
Fonte Cal	1	1	1	Uva Cão	1	3	2
Galego Dourado	1	2	1	Uva Salsa	1	1	1
Gewurtztraminer	2	5	3	Valente	1	3	2
Gouveio	1	3	2	Verdejo	1	4	3
Gouveio Estimado	2	5	4	Verdelho	1	2	1
Granho	1	1	1	Vermentino	1	2	2
Jampal	5	5	5	Viognier	1	3	2
Lameiro	1	1	1	Viosinho	2	3	3
Larião	1	3	2	Vital	1	2	1
Loureiro	2	3	2				

ROSE VARIETIES

Variety	E	W	Avg	Variety	E	W	Avg
Ahmeur bou Ahmeur	4	5	5	Dedo de Dama	1	2	2
Rabigato Francês	1	4	3	Roal	1	2	2

Intensity of the sunburn verified in the Herdade do Esporão Ampelographic filed in the rows East and West faces (intensity 1 to 5, being 1 very tolerant and 5 very sensitive) 2018.

The 2018 heat wave

A stylized illustration of a wooden cart overflowing with purple grapes. The cart is positioned in the foreground, and the grapes are piled high, spilling out. In the background, there is a bright yellow sun in a blue sky, and a green landscape with a small white building with a red roof on a hill.

From the 103 white varieties under study, only 3 varieties were classified as extremely sensitive and 5 as very sensitive. 44% (with different geographic origins) behaved as extremely tolerant.

Regarding the 82 red varieties, there was an increase in the varieties classified as extremely sensitive and very sensitive varieties (17%) and a reduction on the varieties classified as extremely tolerant (30%).

Only 4 rose varieties were studied and Ahmeur bou Ahmeur stands out. This variety was very sensitive to sunburn despite its North African origin.

First results:

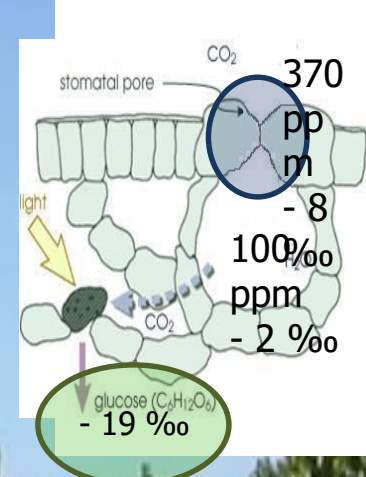
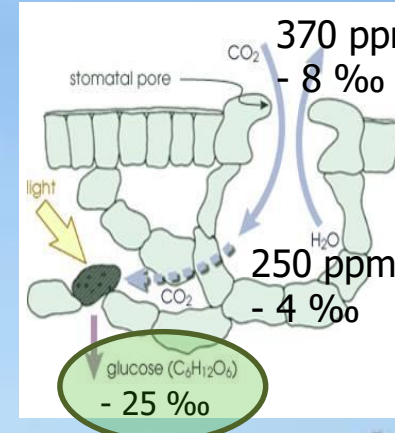
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- Heat stress
- Water stress

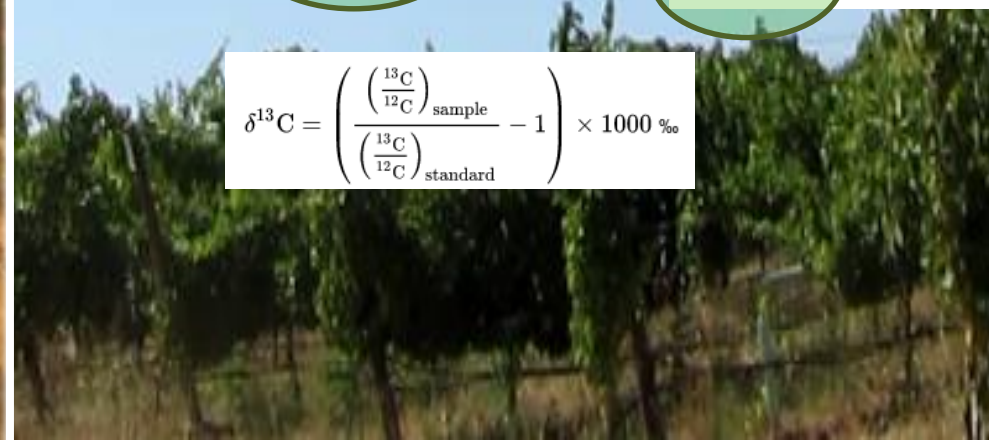
Tools:

Thermal imaging,
Vegetation indices,

Stable isotope composition
(at phloem and berry sugars)



$$\delta^{13}\text{C} = \left(\frac{\left(\frac{^{13}\text{C}}{^{12}\text{C}} \right)_{\text{sample}}}{\left(\frac{^{13}\text{C}}{^{12}\text{C}} \right)_{\text{standard}}} - 1 \right) \times 1000 \text{ ‰}$$





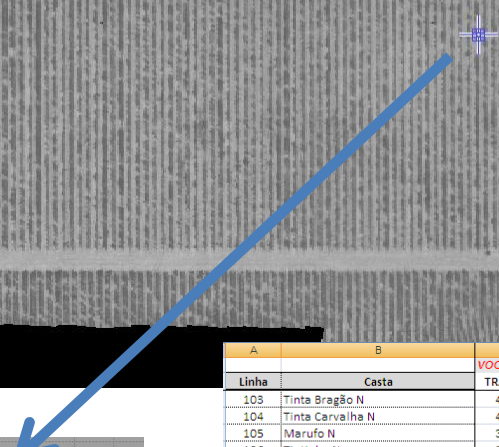
Vegetation indices:

GRVI1 – Green-red vegetation index
EVI – Enhanced vegetation index
NDVI - Normalized Difference
Vegetation Index
NDVI-GREEN - Normalized Difference
Vegetation Index - Green
SR - Simple Ratio Index
SAVI - Soil Adjusted Vegetation Index

Other spectral indices:

CRI1 - Carotenoid Reflectance Index 1
CHL-RED-EDGE - Chlorophyll Red-Edge
ARI1 - Anthocyanin Reflectance Index
SIP1 - Structure Insensitive Pigment Ind.
RE-NDWI - Red Edge - Normalized
Difference Water Index
PSRI - Plant Senescence Reflectance
Index

28	29	29	29	29	30	31	33	35	37	40	41	41	41	41
28	29	29	29	29	30	31	33	35	37	40	41	41	41	41
28	29	29	29	29	30	31	32	35	37	40	41	41	41	41
28	28	29	29	29	30	31	32	35	37	40	41	41	41	41
28	28	29	29	29	30	31	32	34	37	41	41	41	41	41
28	29	29	29	29	30	31	33	35	38	41	41	41	41	41
29	29	29	29	29	30	31	33	36	39	41	41	41	41	41
29	29	29	29	29	30	31	33	36	39	41	41	41	41	41
30	30	30	30	30	30	31	33	36	39	41	41	41	41	41
30	30	30	30	30	30	31	34	36	39	41	41	41	41	40
30	30	30	30	30	30	31	34	36	39	41	41	41	41	40
30	30	30	30	30	30	31	34	36	39	41	41	41	41	40
30	30	30	30	30	30	31	33	36	39	40	40	40	40	40
30	30	30	30	30	30	31	33	36	39	40	40	40	40	40
30	30	30	30	30	30	32	34	36	39	40	40	40	40	40
30	30	30	30	30	31	32	34	37	40	40	40	40	40	40



A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
Linha	Casta	VOO 1	VOO 2	VOO 3	VOO 1	VOO 2	VOO 3	VOO 1	VOO 2	VOO 3	VOO 1	VOO 2	VOO 3	VOO 1	VOO 2	VOO 3		DECLIVE (voo1->voo2)			
		TRAT a	TRAT a	TRAT a	TRAT b	TRAT b	TRAT b	TRAT c	TRAT c	TRAT c	TRAT d	TRAT d	TRAT d					TRAT a	TRAT b	TRAT c	TRAT d
103	Tinta Bragão N	4.5	10.1	8.0	4.9	8.2	7.1	6.4	9.3	8.0	4.3	8.2	6.3					61.1	36.1	30.7	42.2
104	Tinta Carvalha N	4.1	9.2	7.6	4.5	7.7	6.4	6.4	8.4	7.8	4.5	8.0	6.8					54.6	34.8	22.1	37.7
105	Marufo N	3.1	8.6	6.8	2.6	5.7	5.0	4.9	6.6	6.3	3.8	7.1	5.7					60.1	32.9	18.1	36.3
106	Tintinha N	3.6	9.7	8.5	3.8	7.1	6.7	6.1	8.6	8.2	4.8	8.6	7.4					65.8	35.9	26.5	41.3
107	Pé Comprido B	3.4	9.3	7.6	3.6	6.5	5.9	5.3	7.3	6.5	4.8	8.0	6.5					64.0	31.3	21.4	35.8
108	Bastardo Tinto N	2.6	8.7	7.4	3.5	6.8	6.2	4.9	6.9	6.4	4.2	7.3	5.8					65.8	35.9	21.7	33.5
109	Bobal N	3.3	9.8	8.3	3.2	6.3	6.7	4.1	6.2	6.2	4.1	7.8	6.8					70.6	33.3	22.9	40.2
110	Corvo N	2.7	9.3	7.6	3.5	7.4	7.2	4.8	7.7	7.4	4.3	7.7	6.6					71.5	42.2	31.0	36.4
111	Rabigato Francês R	3.3	9.3	7.7	3.6	6.8	6.6	4.5	7.6	6.9	3.6	6.6	5.3					64.8	35.6	33.8	32.4
112	Trincadeira Branca B	1.7	8.0	6.5	1.6	5.4	4.6	3.5	6.5	6.2	3.1	6.6	5.6					69.2	41.7	32.4	37.3
113	Monvedro N	1.8	8.3	6.7	2.7	6.8	6.5	4.3	7.6	7.3	3.7	7.9	7.2					71.3	44.0	35.8	45.5
114	Donzelinho Tinto N	2.5	9.2	7.2	3.1	6.9	6.1	4.1	7.1	7.0	4.1	7.9	7.2					72.7	40.8	32.6	41.9
115	Azal Espanhol N	1.2	7.9	6.4	2.6	6.2	5.5	3.7	7.0	6.4	3.2	7.4	6.1					73.0	39.3	36.0	46.6
116	Pedro Ximenez B	2.5	8.8	7.6	3.7	7.9	7.0	4.3	8.2	7.4	3.7	8.5	7.0					69.2	45.6	41.8	51.9
117	Cabernet Franc N	0.9	6.7	5.5	1.7	5.8	4.9	2.3	6.0	5.0	3.5	8.0	6.6					62.9	44.1	40.2	49.4
118	Molar N	2.0	8.7	7.4	2.1	6.8	5.5	3.0	7.2	6.4	2.7	8.1	6.3					73.6	51.0	45.4	58.5
119	Preto Martinho N	1.7	7.9	6.3	1.2	5.5	4.2	3.2	6.9	6.4	3.3	8.1	6.7					67.5	46.8	40.6	51.9
120	Granho B	3.0	8.9	7.7	2.9	6.8	6.0	4.3	8.0	7.8	4.2	9.8	8.3					64.3	40.6	39.8	60.3
121	Seara Nova B	2.7	9.2	7.9	2.7	6.8	6.0	4.8	8.1	8.0	4.2	9.2	8.6					70.9	45.3	36.0	54.2
122	Terrantez B	2.5	8.6	7.4	3.4	6.7	6.4	5.0	8.2	8.2	4.1	8.3	7.8					66.8	36.1	33.9	46.1
123	Bêba B	1.8	7.7	6.6	2.3	5.7	4.9	4.1	7.3	7.3	4.0	8.7	7.3					64.2	37.0	35.1	52.0
124	Castelinho N	2.8	9.0	8.2	3.6	6.6	6.0	4.8	7.8	7.9	4.3	10.3	8.3					67.9	32.3	32.9	65.6
125	Mourisco Branco B	-0.1	6.3	6.1	0.9	4.5	4.6	1.7	5.9	6.3	2.8	7.4	6.8					70.1	39.6	45.8	50.3
126	Müller Thurgau B	1.9	7.6	7.0	2.9	6.1	5.7	4.2	6.5	6.4	4.0	9.5	6.3					61.8	34.8	47.0	59.6
127	Alvadorão B	1.9	7.9	7.0	2.8	6.8	6.0	4.2	6.7	6.3	4.1	9.6	7.9					65.6	43.5	49.5	59.6
128	Amor-Nô-Me-Deixes N	2.8	8.2	7.6	3.1	6.5	6.0	3.8	7.9	7.5	3.3	8.7	7.2					58.5	37.8	44.8	58.7
129	Branco de Gouvães	1.3	6.7	6.5	2.4	6.0	5.9	3.0	7.6	7.2	3.5	9.3	7.9					59.4	39.3	50.7	63.3
130	Pical N	3.1	7.9	8.1	3.8	7.3	6.9	4.5	9.4	9.2	4.1	10.2	8.7					52.4	37.9	52.3	66.6
131	Boal Espinho B	1.5	6.2	6.3	1.7	5.1	5.6	3.5	8.1	7.6	3.0	9.3	7.8					50.9	37.2	50.3	68.6
132	Touriga Fêmea N	2.9	7.2	7.7	3.4	6.9	7.2	3.5	8.3	7.5	3.9	9.6	8.6					46.9	38.2	52.2	62.6
133	Esganinho B	3.2	6.8	7.8	3.9	6.5	7.3	3.5	8.2	7.9	4.6	10.0	9.1					39.2	28.6	51.5	58.7
134	Galego N	2.1	5.6	5.8	2.2	5.2	5.2	3.2	6.7	6.1	4.1	9.2	7.7					37.3	32.7	38.3	55.6
135	Manteúdo Preto N	2.8	6.9	7.0	3.3	6.1	6.2	3.8	8.2	7.4	4.2	9.8	8.4					44.4	30.0	47.6	61.4
136	Malvasia Babosa B	3.0	7.2	7.0	4.0	6.8	7.1	3.8	8.0	7.7	4.9	10.3	8.9					45.7	30.1	45.9	58.5
137	Alicante Branco B	-0.3	4.4	5.1	0.8	3.7	4.4	1.5	5.4	5.4	2.2	7.8	6.7					50.7	32.6	42.9	60.5
138	Luzidio B	2.5	6.4	6.8	3.4	5.7	6.2	3.3	7.3	7.1	4.3	10.2	8.6					43.2	25.4	43.5	64.4
139	Ramisco N	1.0	5.2	5.3	0.9	4.1	3.8	2.1	6.2	5.8	2.0	7.5	6.0					45.2	34.8	44.8	59.7
140	Tinta Grossa N	3.2	7.2	7.7	3.9	7.9	7.5	4.1	9.0	7.9	4.8	11.0	9.4					43.8	43.3	53.6	67.5
141	Bombalino N	2.9	7.3	7.5	2.4	6.3	6.3	3.3	8.3	7.4	3.5	9.2	7.9					47.8	42.8	53.9	62.2
142	Valente B	3.2	7.7	8.0	2.9	7.5	7.1	3.9	8.9	8.0	4.7	10.4	9.2					48.6	50.1	55.2	61.8
143	Donzelinho Branco B	2.7	6.3	6.4	2.2	6.0	5.9	1.9	6.8	6.0	3.2	8.6	7.4					38.6	41.0	53.8	59.3
144	Fonte Cal B	3.2	7.5	7.9	2.9	7.0	7.0	4.3	8.8	8.1	4.5	9.7	8.9					46.1	44.2	49.5	56.1