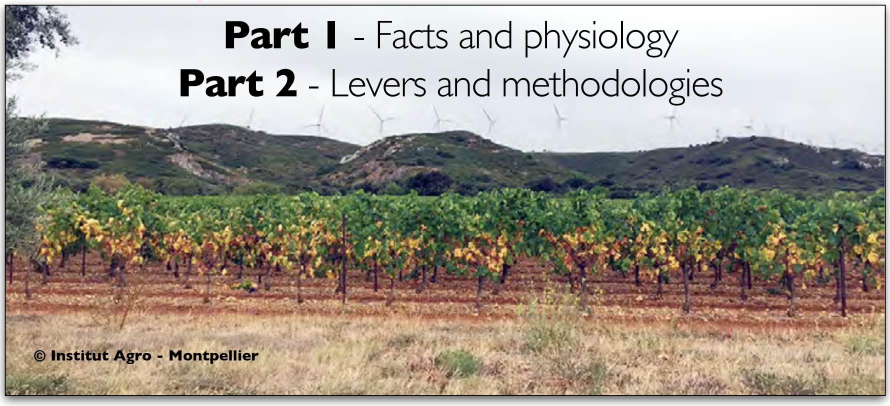
Grapevine ideotypes coping with CC

Séminaire Laccave 2.21 Idéotypes & Vins de demain - 27 & 28 mai 2021



Charles Romieu & Laurent Torregrosa
(M. Rienth, N. Luchaire, A. Bigard, R. Shahood, M. Breil, P. This, H. Ojeda, B. Muller, C. Houel, A. Doligez, L. Lecunff, A. Pellegrino et al.)

Part 1 -
Facts and physiology

Grapevine response to CC

Growth & C balance
Primary metabolism
Secondary metabolism
New phenotypes

Temperature/water/CO2/radiations

Physiol. responses →	**New phenotypes**
PS and respiration Transpiration and stomata regulation Vascular hydraulics Nutrient assimilation & fluxes Morphogenesis and **growth rate** **C allocation and balance** Plant growth regulators' balance **Fruit I^ary^** metab (energetic balance) **Fruit II^ary^** metabolisms	Phenology Green biomass & Yield **Fruit composition** Pest & disease susceptibility Plant sustainability (C cycle)

Torregrosa L. Romieu C (2021) Grapevine ideotypes coping with CC. Seminaire Laccave. Ideotype - 27 et 28 mai 2021

Part I - Facts and physiology

Grapevine response to CC

Growth & C balance
Primary metabolism
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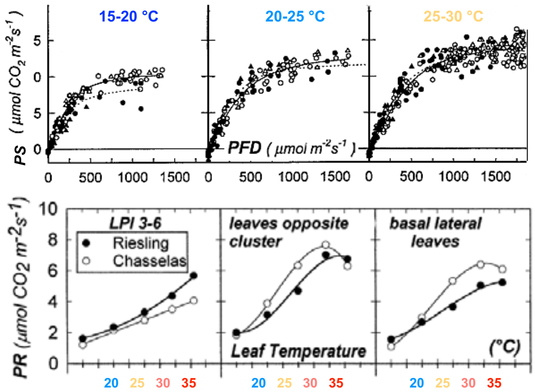
New phenotypes

> During the day, C assimilation gain = PS - PR



Zufferey et al. (2000)

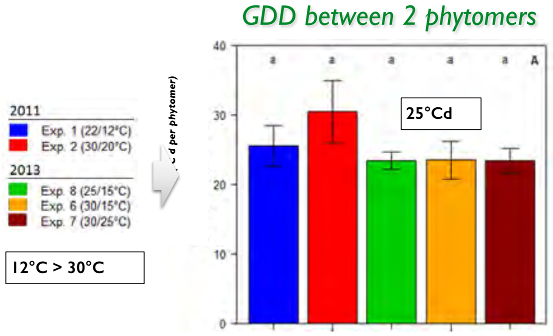
C assimilation depends on T° (+ PAR, VPD, FTSW...)

Part I - Facts and physiology

Grapevine response to CC

Growth & C balance
Primary metabolism
Secondary metabolism
New phenotypes

> C needs for growth depends on phyllochron



Linear relation between growth and T°

Luchaire et al. (2017)

Temperature increases C demand of vegetative organs

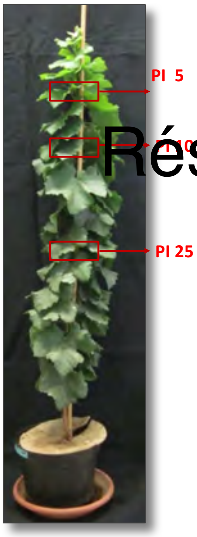
Microvines in Phenopsis platform *(https://www6.montpellier.inrae.fr/lepse/M3P)*

Part I -
Facts and physiology

Grapevine response to CC

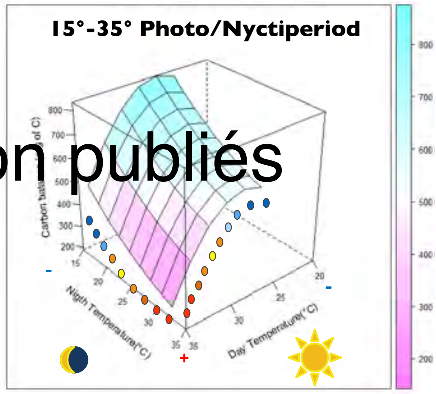
Growth & C balance
Primary metabolism
Secondary metabolism
New phenotypes

> C balance at vine level = PS - PR - NR - V biomass



VPD (2 kPa) PAR/14 h PP (560 µmol.m-2.s-1)

Résulats non publiés



Luchaire et al. (unpublished)

High T° at night or day degrades C balance

Microvines in Phenopsis platform *(https://www6.montpellier.inrae.fr/lepse/M3P)*

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Part I -
Facts and physiology

Grapevine response to CC

T° and C balance
Primary metabolism
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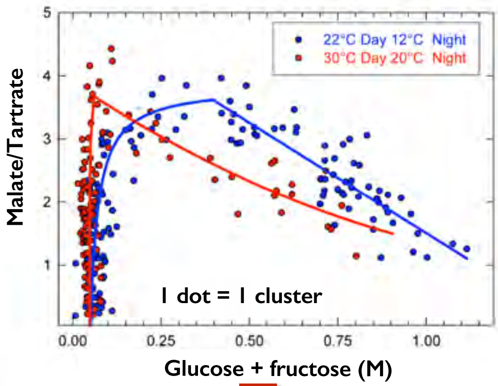
New phenotypes

> Primary metabolism of the fruit



C allocation depends on T°

Temperature desynchronizes sugar and organic acid metabolism in ripening grapevine fruits and remodels their transcriptome

M Rienth, L Torregrosa, G Sarah, M Ardisson, JM Brillouet, C Romieu

BioMed Central

Microvines in Phenopsis platform *(https://www6.montpellier.inrae.fr/lepse/M3P)*

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Part I -
Facts and physiology

Grapevine response to CC

T° and C balance
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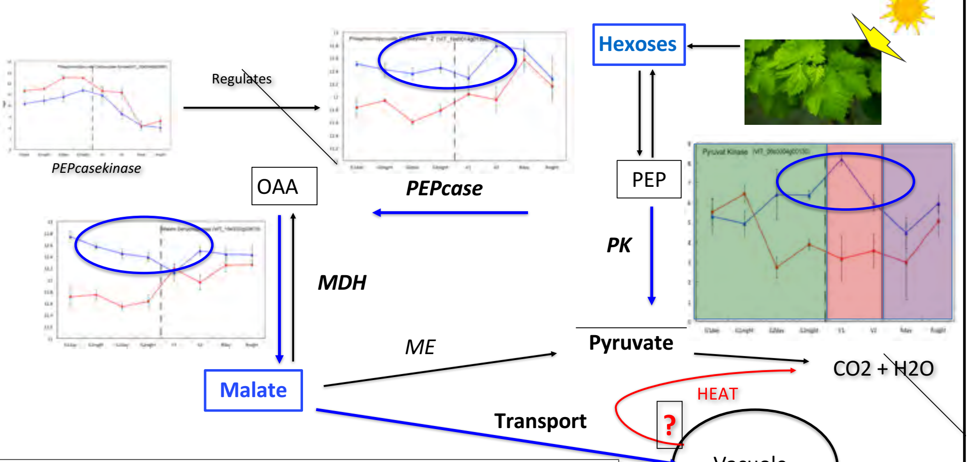
> Energy supply: sugars vs malate metabolism



Under high T° (high growth & respiration)
Sugar is limiting to support glycolysis,
malate synthesis and sugar unloading?

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Part I -
Facts and physiology

Grapevine response to CC

T° and C balance
Primary metabolism
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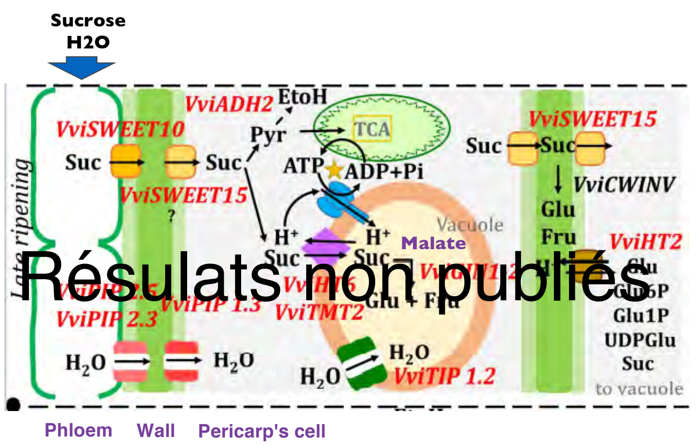
New phenotypes

> Sugar/malate breakdown nexus : a conceptual framework



Transcripts repressed at the stop of phloem unloading highlight the energy efficiency of sugar import in the ripening *V. vinifera* fruit.

bioRxiv

Stefania Savoi, Laurent Torregrosa, Charles Romieu
doi: https://doi.org/10.1101/2021.01.19.427234

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Part I -
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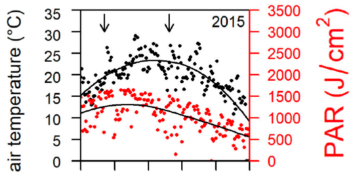
New phenotypes

36 varieties
Bordeaux

Relative contribution of variance components (%)

	Source	Sugar concentration			Sugar accumulation		
		$S_{95-conc}$	$t_{95-conc}$	r_{conc}	$S_{95-cont}$	$t_{95-cont}$	r_{cont}
Berry weight at V	BW_V	6.6	3.0	21.7	88.7	3.1	31.4
Rainfall at pre-V	RR_{f-v}	44.1	12.3	7.3	5.8	3.6	0.7
Light during ripening	PAR_{V-95}	13.6	ns	22.8	ns	59.4	51.9
Temperature during ripening	T_{V-95}	ns	30.7	31.2	ns	20.9	ns
Water deficit	$\delta^{13}C$	16.5	3.0	2.0	2.9	4.8	ns

But possible confounding effects !



frontiers in Plant Science

Adapting Wine Grape Ripening to Global Change Requires a Multi-Trait Approach

Bruno Suter[1], Agnes Destrac Irvine[1], Mark Gowdy[1], Zhanwu Dai[1,2] and Cornelis van Leeuwen[1*]

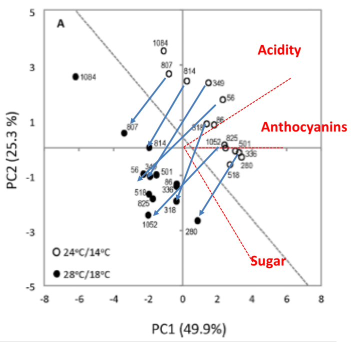
ORIGINAL RESEARCH
published: 05 February 2021
doi: 10.3389/fpls.2021.624867

Part I -
Facts and physiology

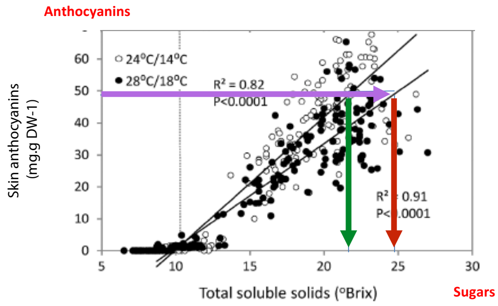
Grapevine response to CC

T° and C balance
Primary metabolism
Secondary metabolism
New phenotypes

> T° changes secundary metabolite balance



Tempranillo clones (Spain)



Harvest at higher brix to keep color constant

+ Sugar - Acids

Tempranillo clones differ in the response of berry sugar and anthocyanin accumulation to elevated temperature

Marta Arrizabalaga[a,b], Fermín Morales[c], Mónica Oyarzun[a], Serge Delrot[b], Eric Gomès[b], Juan José Irigoyen[a], Ghislaine Hilbert[b], Inmaculada Pascual[a,*]

Plant Science 267 (2018) 74–83

Part I -
Facts and physiology

Ideotypes coping with CC: **observations** & questions ?

INRAE l'institut Agro

Macrovines experimented in the field conditions...

> **Performing** in stable environments
> **Managing** multi-factor interactions
> **Comparing** regional experiments

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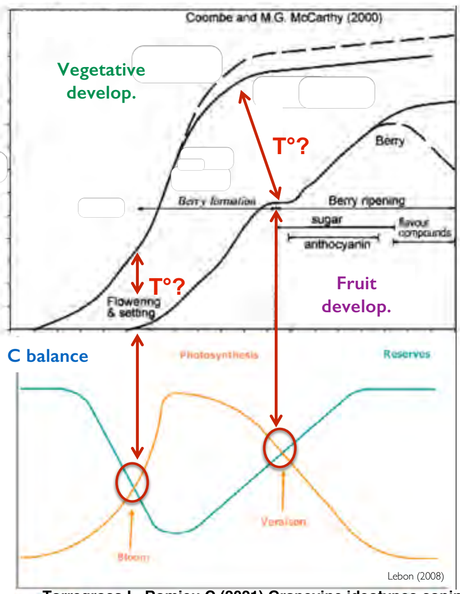
Part I -
Facts and physiology

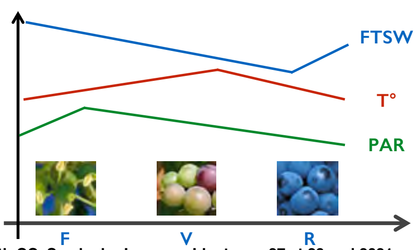
Ideotypes coping with CC: **observations** & questions ?

INRAE l'institut Agro



The perenial grapevine is a **complex system**

Interactions between several cycles
Veget x Reprod. functions
Critical C balance regulations



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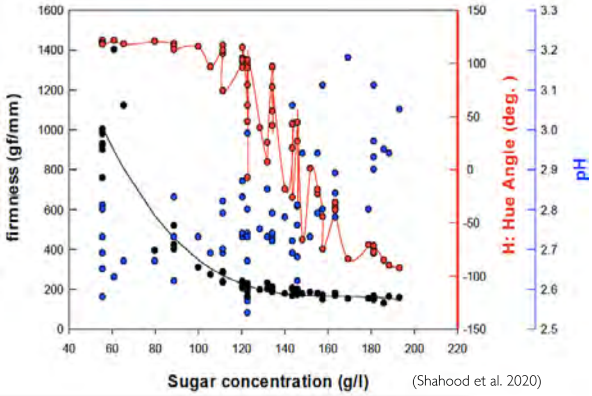
Part I -
Facts and physiology

Ideotypes coping with CC: **observations** & questions ?

The grapevine fruit is **a berry not a grape !**



(Shahood et al. 2020)

For some questions, downscaling from bunch to berry be required

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Part I -
Facts and physiology

Ideotypes coping with CC: observations & **questions**?

Mécanismes d'acclimatation similaires
Capacité adaptative = Plasticité variétale

1. Objectiver les **interactions entre facteurs abiotiques**
   > Simultanés ou décalés (intracycle)
   > Multifactoriels ou cumulatifs (intercycles)

2. Comprendre les **réponses physiologiques**
   > Relation entre variables (clés d'arbitrage, biomasse, métabolisme 1/2)
   > Niveau de régulation pertinent : baie vs population

3. Comment hierarchiser les compromis **pour les viticulteurs**
   > Pérennité vs stabilité de la production
   > Rendement vs qualité oenologique

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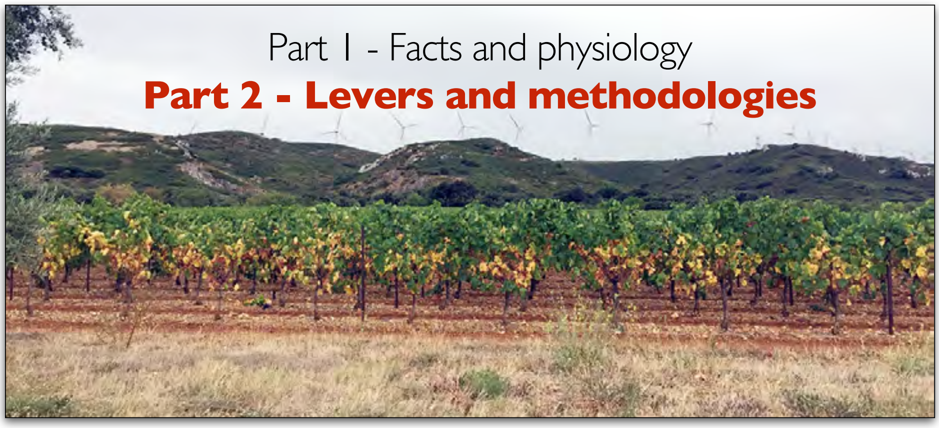
Grapevine ideotypes to cope with CC

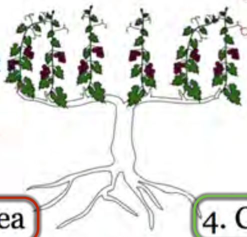


Charles Romieu & Laurent Torregrosa
(M.. Rienth, N. Luchaire, A. Bigard, R. Shahood, P. This, H. Ojeda, B. Muller, C. Houel, A. Doligez, A. Pellegrino et al.)

Mitigate CC effects ?

1. Viticultural practices
- Irrigation
- Shading
- Mist cooling
- Canopy management

2. Wine processing
- De-alcoolization
- Acidification
- New yeast strains
- Water dilution



3. Change growing area
- Move to a higher altitude
- Move to a cooler latitude

4. Change cultivars
- Selection from germplasm
- Breeding new cultivars

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> Ideotypes » Qualité œnologique » et T°

Pas abordés ici : Rendement/Pérennité/Stress hydrique (G2WAS, PANEL 279, Resist'EAU)

Traits pertinents : concentrations impactées par T°

Sucres
Acides (malique et K+, pH, AT (tartrique))
Antho
Autres metab 2

Phénologie : échapper aux périodes les plus chaudes

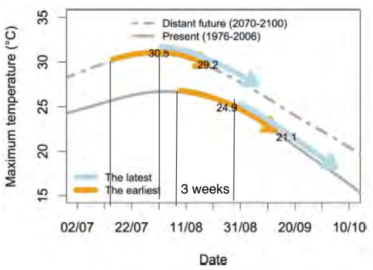


FIGURE 3 | Simulations of maximum temperatures during the ripening period for two virtual extreme genotypes and two climatic datasets. The arrows represent the ripening periods, i.e., 35 days starting at 50% véraison, for two virtual genotypes: the earliest and the latest that should be found in an infinite progeny from a Riesling × Gewurztraminer cross. Two climatic datasets are used: historical data from 1976 to 2006 and simulated data (A1B scenario) for Colmar (48°04′46.3″N 7°21′26.0″E). Details in Duchêne et al. (2010). The figures are the mean values of maximum temperatures during these periods.

Molecular Tools for Adapting Viticulture to Climate Change

Éric Gomès[1], Pascale Maillot[2,3] and Éric Duchêne[2,]*

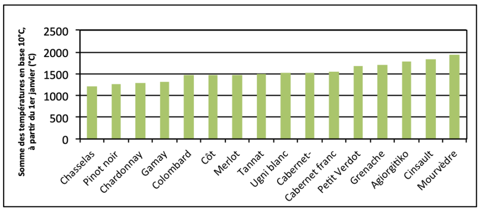
Climate changes
Effects on the vine
New cultivars / T°
Conclusions

Varieties adapted to **high T°**?

Late ripening
Fruit composition
Breeding

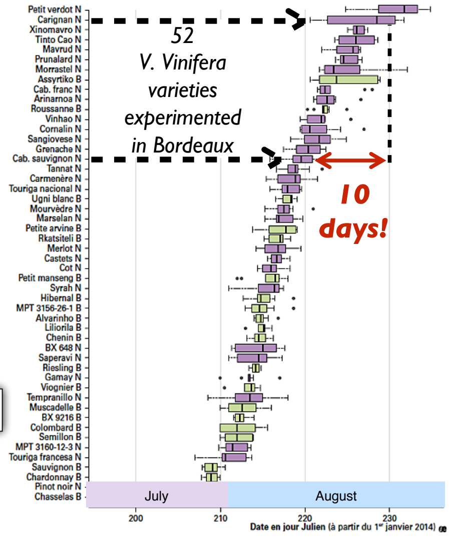
Late ripening varieties

Require an higher ∑ t°



Van Leeuwen et al. (2008)

Does phenology segregate enough?



Ollat et al. (2015)

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Précocités pour atteindre un objectif sucre

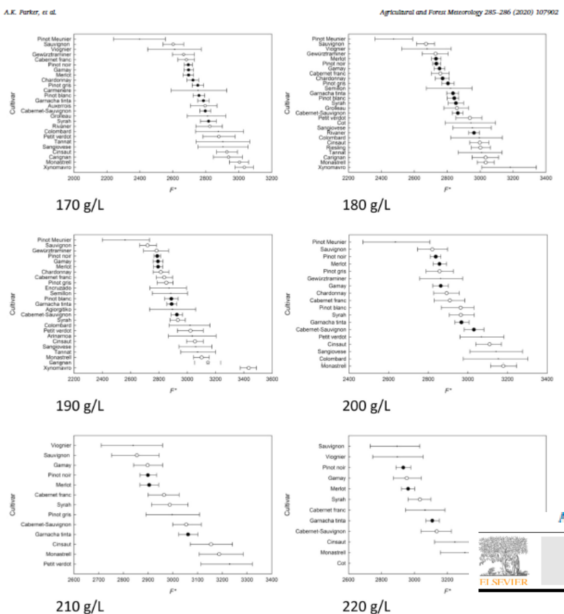


Fig. 2. Classification and confidence intervals (CI) of cultivars for the Day Of the Year (DOY) to reach sugar concentrations of 170, 180, 19
the Grapevine Sugar Ripeness (GSR) model. Closed circles correspond to parameterisations where CI <100, open circles correspond to CIs
no circle corresponds to CIs in the range of 201–350. Cultivar parameterisations with CIs > 350 or negative efficiencies are not depicted.
using the GSR model.

Agricultural and Forest Meteorology 285–286 (2020) 107902

Contents lists available at ScienceDirect

Agricultural and Forest Meteorology

journal homepage: www.elsevier.com/locate/agrformet

Temperature-based grapevine sugar ripeness modelling for a wide range of *Vitis vinifera* L. cultivars

Amber K. Parker[a,*], Iñaki García de Cortázar-Atauri[b], Laurence Gény[c], Jean-Laurent Spring[d], Agnès Destrac[e], Hans Schultz[f], Daniel Molitor[g], Thierry Lacombe[h], Antonio Graça[i], Christine Monamy[j], Manfred Stoll[f], Paolo Storchi[k], Mike C.T. Trought[a,l], Rainer W. Hofmann[a], Cornelis van Leeuwen[e]

Sugar accumulation/genotypes :

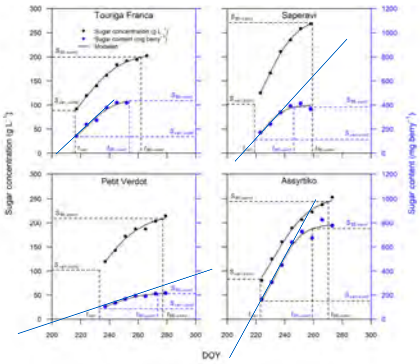


Fig.2

frontiers in Plant Science

Adapting Wine Grape Ripening to Global Change Requires a Multi-Trait Approach

Bruno Suter[1], Agnès Destrac Irvine[1], Mark Gowdy[1], Zhanwu Dai[1,2] and Cornelis van Leeuwen[1]*

DUREE CHARGEMENT SUCRES (Jours)

Cultivar	mesuré	correction	durée
Prunelard	32		37
saperavi	33	8 (1.25)	38
Carmenere	35		40
Morrastel	35		41
Riesling	35		41
PN	36		41
Ptt Verdot	36	25 (1.7)	41
Melot	36		41
Gen	36		41
Touriga N	36		42
Cot	37		43
chard	37		43
Cab fr	38		44
viogn	38		44
gam	39		44
Tempranillo	40		46
ptt Arvine	41		48
Castets	41		48
Marselan	43		49
Rouss	43		50
Hibernal	44		51
Touriga Franca	44	12(1.27)	51
Arinarnoa	44		51
Cab sauv	44		51
Cari	44		51
Chenin B	45		52
Assyrtiko	45	7(1.15)	52
sauv B	47		54
Muscadelle	47		55
Tinto Cao	48		55
BX9	48		55
semillon	48		56
Mourvedre	51		59
BX6	54		62
UB	56		64
Sangiovese	56		65
moyenne			48

Recalculated from Fig.4

Single berries development elucidated in 2020

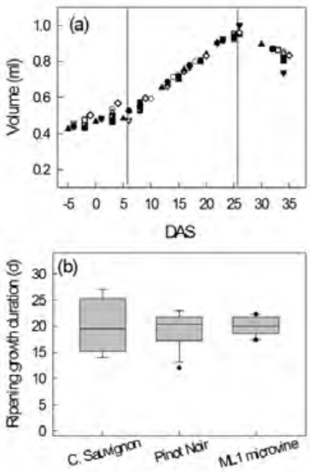


FIGURE 2. Duration of the second growth phase in individual berries.

Syrah

2nd growth period : only 3 weeks :
C sauvigon, Pinot, ML1, Syrah, Zinfandel ….

Received: 18 June 2020 Accepted: 9 September 2020 Published: 20 November 2020
DOI:10.20870/oeno-one.2020.54.4.3787

OENO One

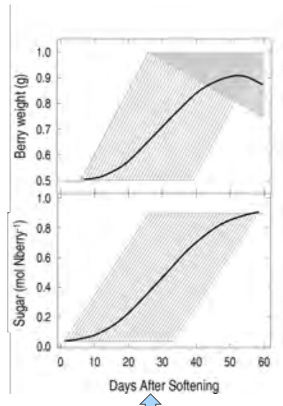
First quantitative assessment of growth, sugar accumulation and malate breakdown in a single ripening berry

Rezk Shahood[1,2], Laurent Torregrosa[1,3], Stefania Savoi[1], Charles Romieu[1,3]*

Berry development hidden in unsynchronized cohorts until 2020 !

Single Berry

Berry cohorts future wine



GxE acts on fluxes (water,solutes) and synchronism

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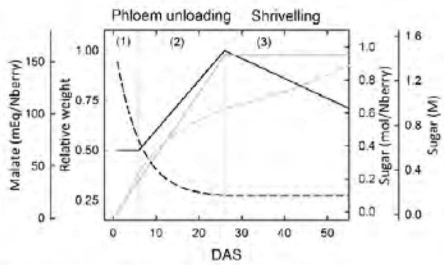

FIGURE 9. Minimal model of berry ripening.

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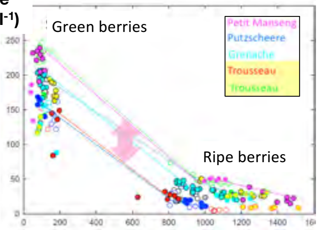
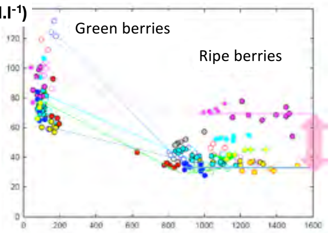
Varieties adapted to **high T°**?

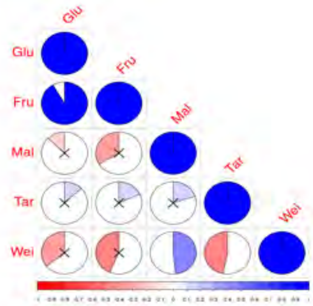
Malate (mmol.l^{-1})



Tartrate (mmol.l^{-1})



Correlations at phloem arrest (= physiological ripening)



frontiers in Plant Science — *Vitis vinifera* L. Fruit Diversity to Breed *Varieties Anticipating Climate Changes* — *A Bigard, D Berhe, Y Sire, H Ojeda, JP Péros, A Doligez, C Romieu, L. Torregrosa* — ORIGINAL RESEARCH published: 01 May 2018 doi: 10.3389/fpls.2018.00455

frontiers in Plant Science — Vitis vinifera L. Diversity for Cations and Acidity Is Suitable for Breeding Fruits Coping With Climate Warming — *A Bigard, C Romieu, Y Sire, L. Torregrosa* — ORIGINAL RESEARCH published: 18 September 2020 doi: 10.3389/fpls.2020.01175

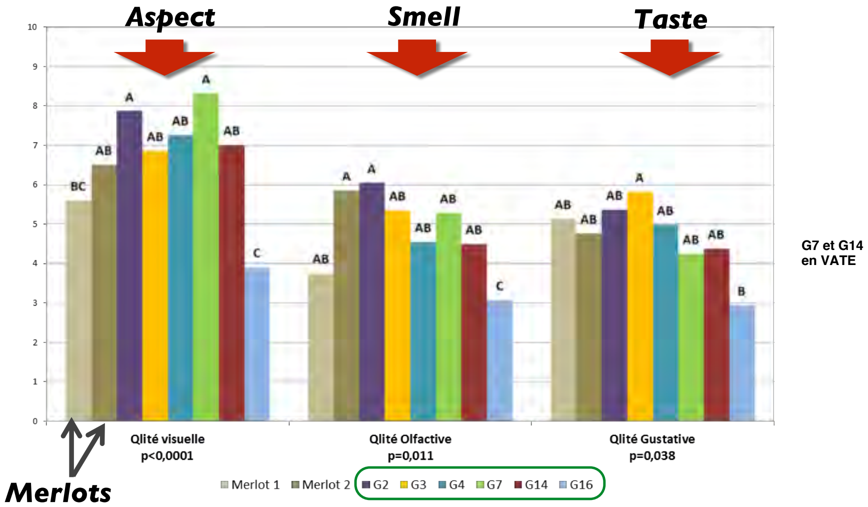
VDQA : un exemple d'ideotype oeno

Climate changes
Effects on the vine
New cultivars / T°
Conclusions

Varieties adapted to high T°?

Harvest date shift
Fruit composition
Breeding

Qualitative profile per comparationem Merlot



Genotypes with naturally low sugars in ripe berries

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Climate changes
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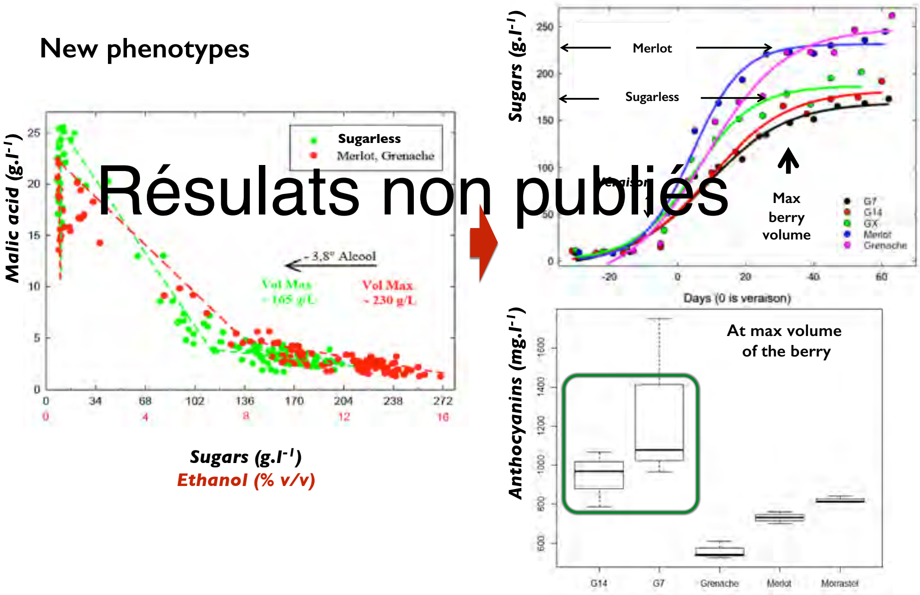
Varieties adapted to **high T°**?

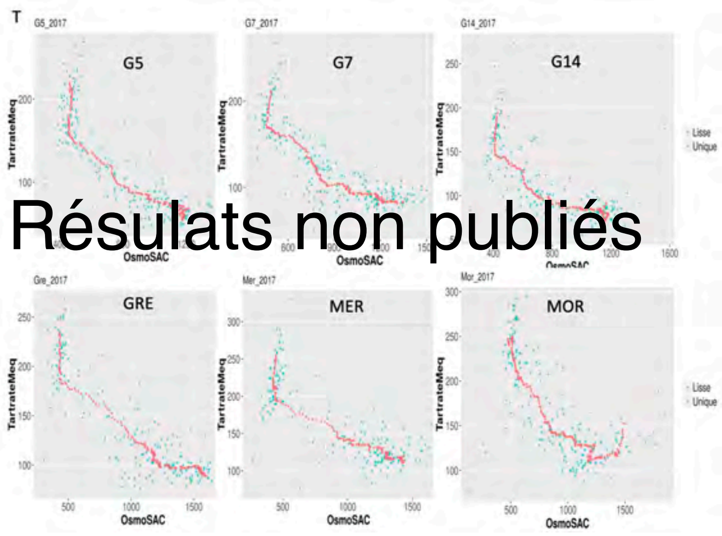
Harvest date shift
Fruit composition
Breeding

New phenotypes



L. Torregrosa et al. (2019) Cultivars better coping with warming and drought - 14th of Nov. 2019 - ICVV Logrono (Spain)

Single berry Sugar/tartrate relationship



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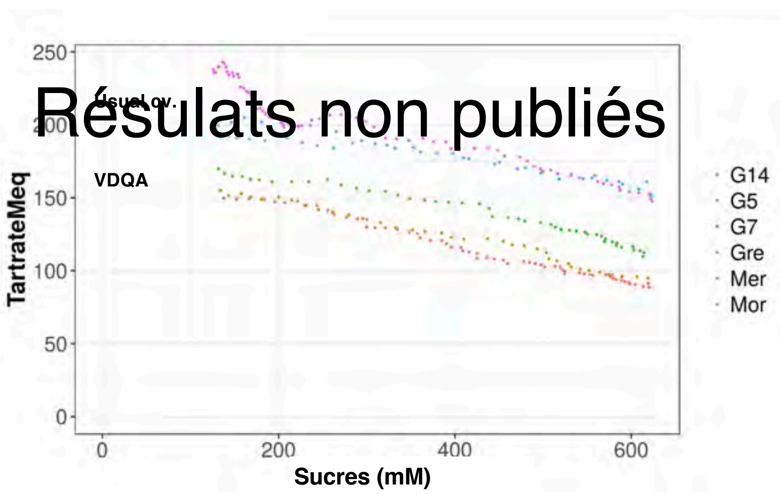
Single berry Sugar/tartrate relationship



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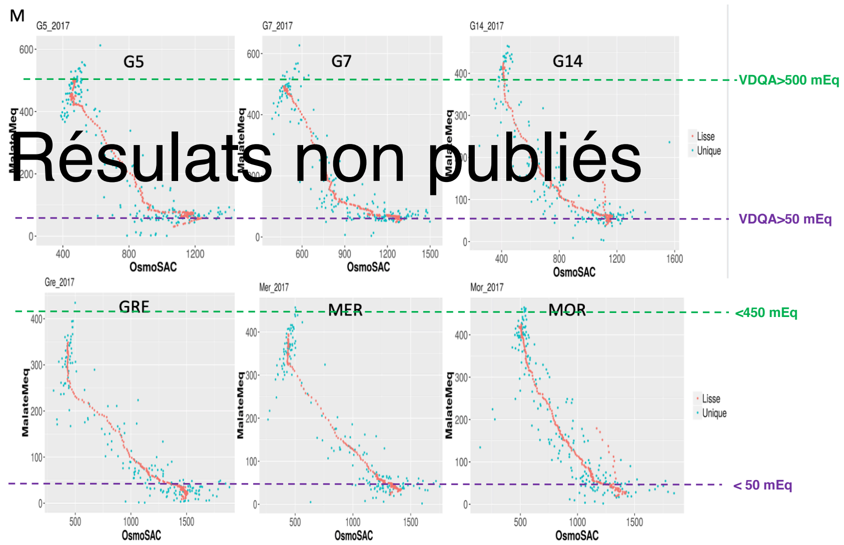
Single berry Sugar/malate relationship



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Climate changes
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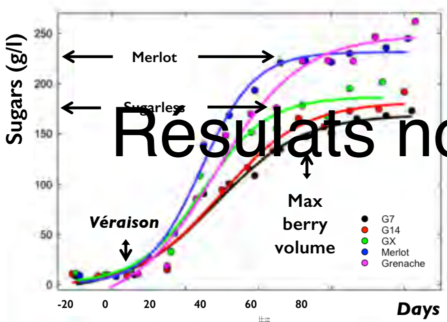
Harvest date shift
Fruit composition
Breeding

Sugarless variants **X** **Microvines**

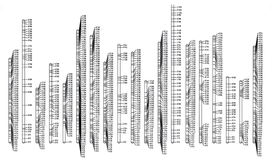


Sugarless
Disease^R
run1/rpv1
X
HomoZ
ren3/rpv3

(150 ind.)

Résulats non publiés

Pre-breeding



Sugarless QTLs

Extreme phenotypes Pre-breeding

Torregrosa L. Romieu C (2021) Grapevine ideotypes coping with CC. Seminaire Laccave. Ideotype - 27 et 28 mai 2021

Climate changes
Effects on the vine
New cultivars / T°
Conclusions

Varieties adapted to **high T°**?

Harvest date shift
Fruit composition
Breeding

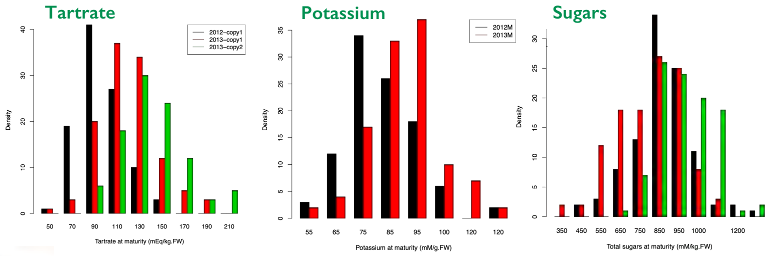
Segregating microvines

\+

Genotyping/phenotyping tools

Pinot Noir X Ugni Blanc

Houel et al. BMC Plant Biology (2015) 15:205
DOI 10.1186/s12870-015-0588-0



BMC Plant Biology Identification of stable QTLs for vegetative and reproductive traits in the microvine (*Vitis vinifera* L.) using the 18 K Infinium chip

C Houel, R Chatbanyong, A Doligez, M Rienth, S Foria, N Luchaire, C Roux, A Adivèze, G Lopez, M Farnos, A Pellegrino, P This, C Romieu, L Torregrosa

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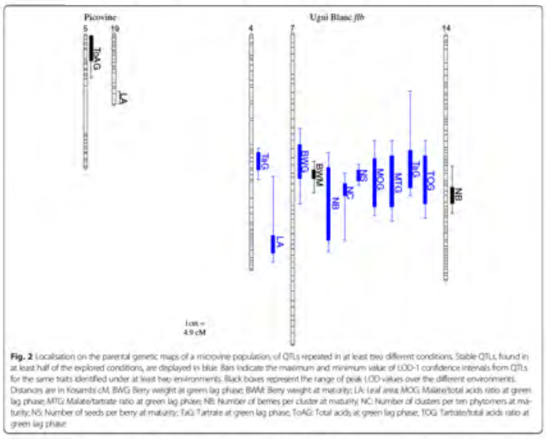
Identification of stable QTLs for vegetative and reproductive traits in the microvine (*Vitis vinifera* L.) using the 18 K Infinium chip



QTLs
for
Sugars
Organic acids
Cations

BMC Plant Biology

Cléa Houel[1,2], Ratthaphon Chatbanyong[1,2], Agnès Doligez[2*], Markus Rienth[1,2,3,4], Serena Foria[5], Nathalie Luchaire[1,6], Catherine Roux[2], Angélique Adivèze[2], Gilbert Lopez[1], Marc Farnos[2], Anne Pellegrino[6], Patrice This[2], Charles Romieu[2] and Laurent Torregrosa[1]

Houel et al. BMC Plant Biology (2015) 15:205
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Questions/conclusion selection de varietes / T°

1. QTLs Ok, microvigne OK > Outils de l'UMT genovigne

2. Boite noire asynchronie – Baie unique revele des faits physio

3. Qu'est ce qui se passe apres la matu physio : sur metab et solutes inorganique… concentration… Quid evolution des metab 2

4. Lien avec la qualité œnologique : UMT MiniRobot
Oenotypage a haut débit pas seulement sur caractère rédhibitoires…

Torregrosa L. Romieu C (2021) Grapevine ideotypes coping with CC. Seminaire Laccave. Ideotype - 27 et 28 mai 2021