UNIVERSITÄT HOHENHEIM

Wine (viticulture) in the Light of Climate Change in Germany

Prof. Dr. Christian Zörb

Science & Technology Lecture
Yamamoka Memorial Foundation
March 24th 2021 KYOTO

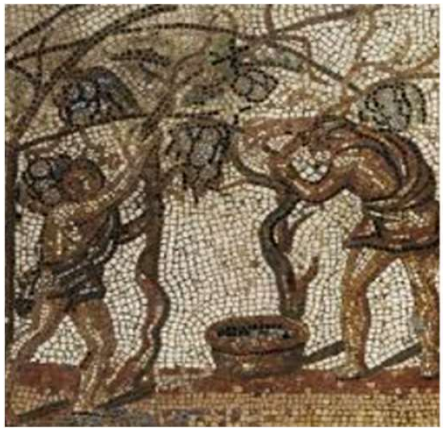
200 JAHRE 1818 2018
UNIVERSITÄT HOHENHEIM

Institut für Kulturpflanzenwissenschaften

Qualität pflanzlicher Erzeugnisse

Wine Region, South West Germany


Neumagnerer Weinschiff ca. 220 BC



Universität Hohenheim (Stuttgart)

Picture, Zörb

Universität Hohenheim (Stuttgart), red Saloon

Picture, Zörb

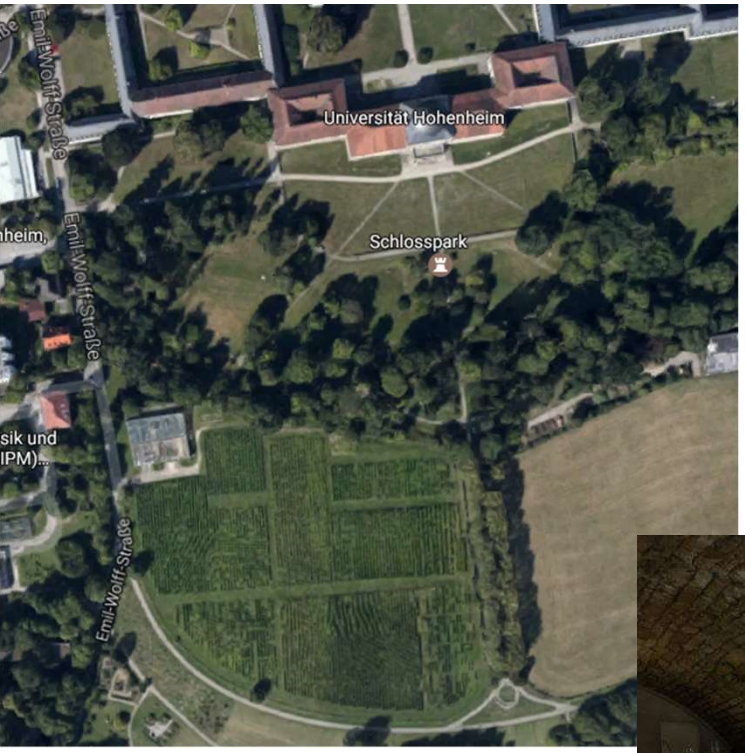
Universität Hohenheim (Stuttgart), Palace Park

Picture, Zörb

Universität Hohenheim (Stuttgart), Vine Yard

Picture, Zörb

Vine Yard and Wine Cellar Uni Hohenheim




Picture, Zörb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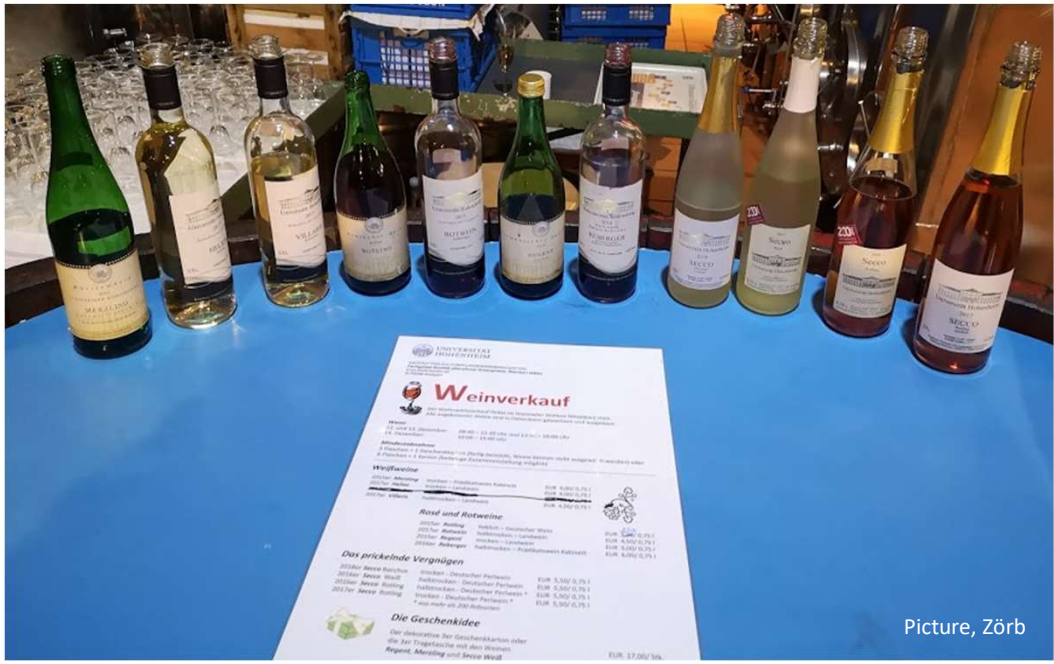


Picture, Zörb


Classes in Viticulture, Bachelor


Weißherbst
Übungen
WS 2019/2020

Wine in the Light of Climate Change in Germany

Agenda

- Climate change problems and challenges
- Viticulture in Germany
- Silviculture as an option
- Diverse training systems as option
- Drought stress research
- New varieties

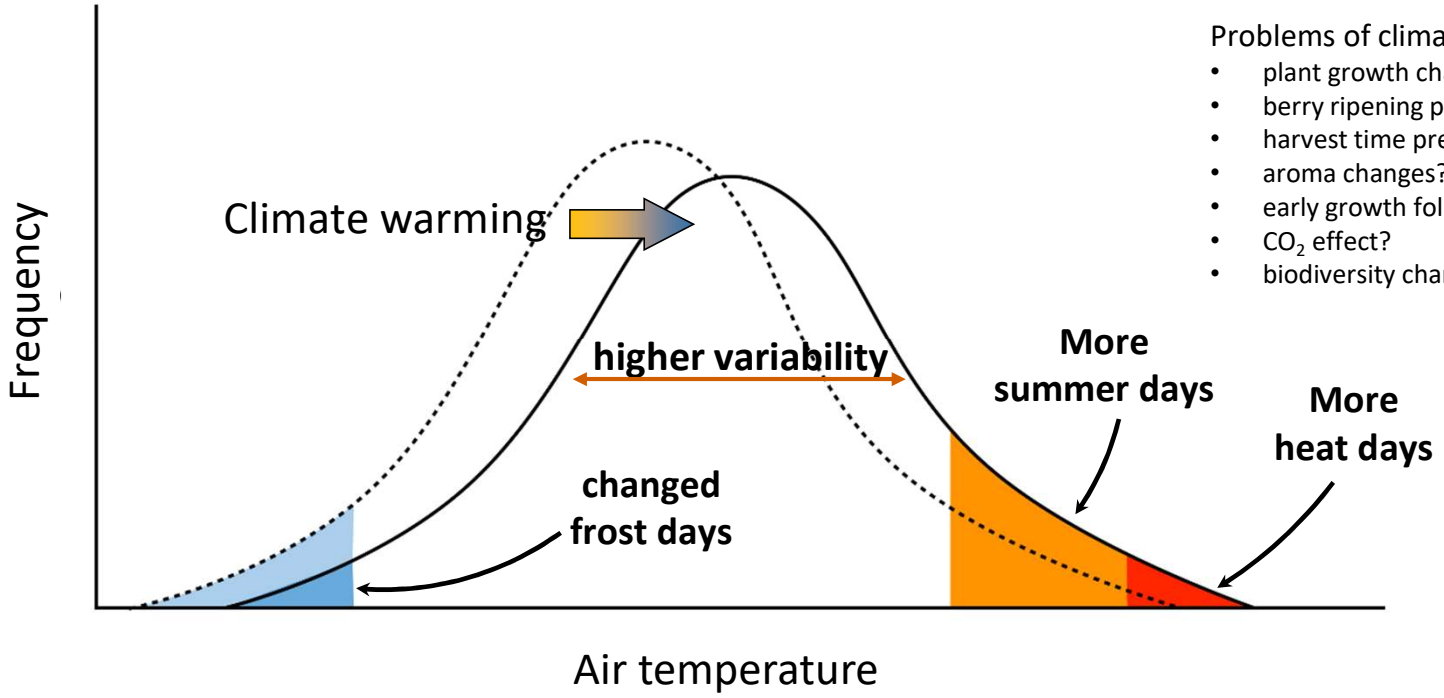
Which changes are necessary for to maintain our viticulture? Will the future aroma of wine be changed?

Wikipedia.de

Picture, Zörb

Picture, Zörb

Influence of rising temperature and increasing variability on exteme weather events in climate change



Problems of climate change

- plant growth changed, varieties suitable?
- berry ripening period shortened
- harvest time prematured
- aroma changes?
- early growth followed by frost?
- CO_2 effect?
- biodiversity changed?

Summer day: T_{max} > 25 °C
Hot days: T_{max} > 30 °C
Frost days: T_{min} < 0 °C

According to Feldmann et al. (2010)

Frost event after warm April in early May 2020


Picture: Zörb


Picture: Zörb

Free Air Carbon Enrichment (FACE)

Biodiversity in the vineyard


Picture, Zörb


Picture, Zörb

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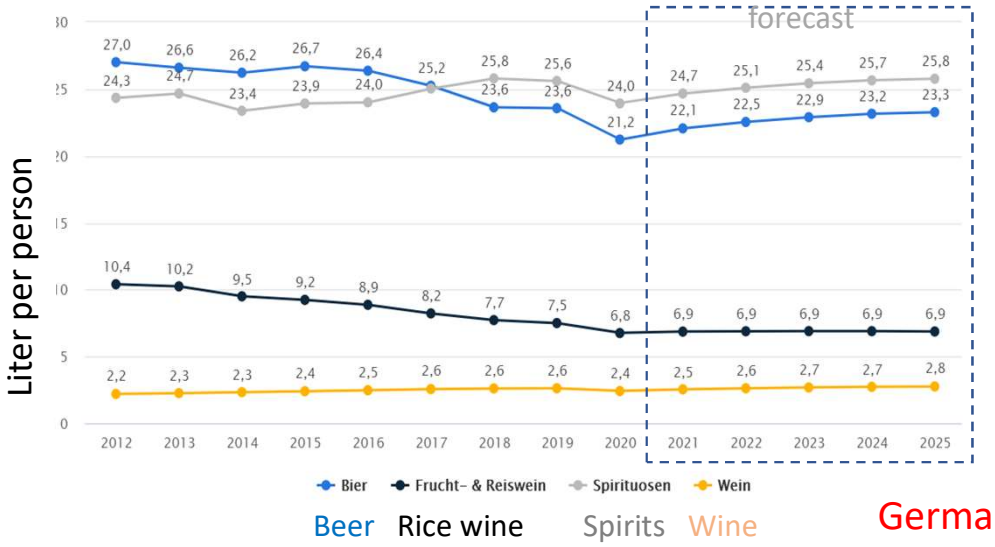
Viticulture in Japan日本のブドウ栽培

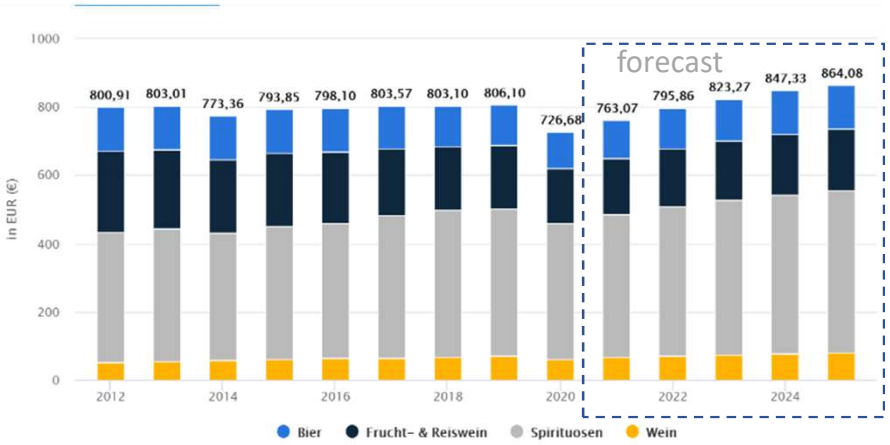
- since about 12. Century
- some wild varieties: *Vitis coignetiae (*but not *Vitis vinifera)*
- mostly production of raisins, (sugar compensation)
- wine produced by buddist monks for „medical“ purpose
- Muscat Bailey a sweet white wine, produced in Japan;
- also: Koshu and Zenkoji grapevine at Jujisan and west of Tokyo area
- Tokachi-Ikeda Reseach Institute for Viticulture and Enology (池田町ブドウ・ブドウ酒研究所),

Japan: average consumption per capita, per year



Beer Rice wine Spirits Wine

Japan: average sales per capita, per year

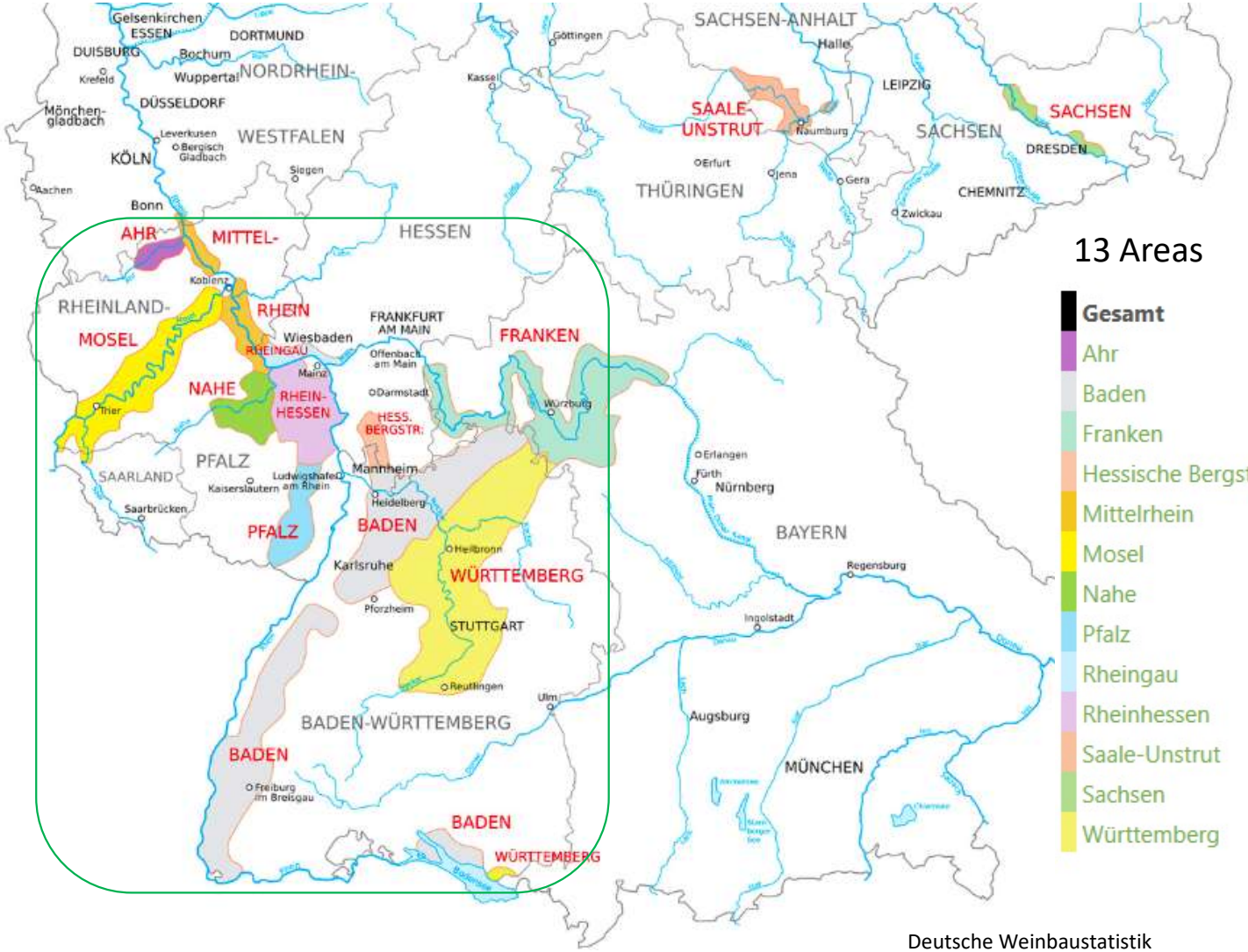


Beer Rice wine Spirits Wine

Germany: 20 L wine
3 L Champagne

Source: Statistica

Areas for growing high quality wine ´Qualitätswein´ in Germany



13 Areas	(ha)
Gesamt	**102.425**
Ahr	564
Baden	15.818
Franken	6.124
Hessische Bergstraße	452
Mittelrhein	468
Mosel	8.792
Nahe	4.202
Pfalz	23.592
Rheingau	3.167
Rheinhessen	26.563
Saale-Unstrut	768
Sachsen	502
Württemberg	11.343

Deutsche Weinbaustatistik

Steep vineyards

Picture, Zörb

Steep vineyards with old structures


Picture, Zörb


Picture, Zörb

Viticulture in Germany: 100 000 ha

Common produced wine varieties in Germany

Riesling	22,7%
Müller-Thurgau	12,5%
Spätburgunder	11,5%
Dornfelder	7,8%
Grauburgunder	5,5%
Silvaner	4,9%
Weißburgunder	4,7%
Portugieser	3,4%
Kerner	2,8%
Trollinger	2,2%

Deutsche Weinbaustatistik

Quality classes of wine produced

Type	Amount	Percentage
Landwein	342.240 hl	3,7 %
Qualitätswein	7.239.015 hl	78,7 %
Prädikatswein	1.620.753 hl	17,3 %
Insgesamt	9.202.008 hl	100,0 %

Amounts according to wine types

Type	Amount	Percentage
Weißwein	4.347.000 hl	58,6 %
Rotwein	2.257.000 hl	30,5 %
Rosé	808.000 hl	10,9 %

General taste of wine produced

Taste type	Amount	Percentage
dry	3.296.000 hl	44,5 %
semi-dry	1.637.000 hl	22,1 %
sweet	2.443.000 hl	33,0 %

Vineyard Uni Hohenheim, autumn 2020

Bild, Zörb

Vineyard Uni Hohenheim, late autumn 2020

Picture, Zörb

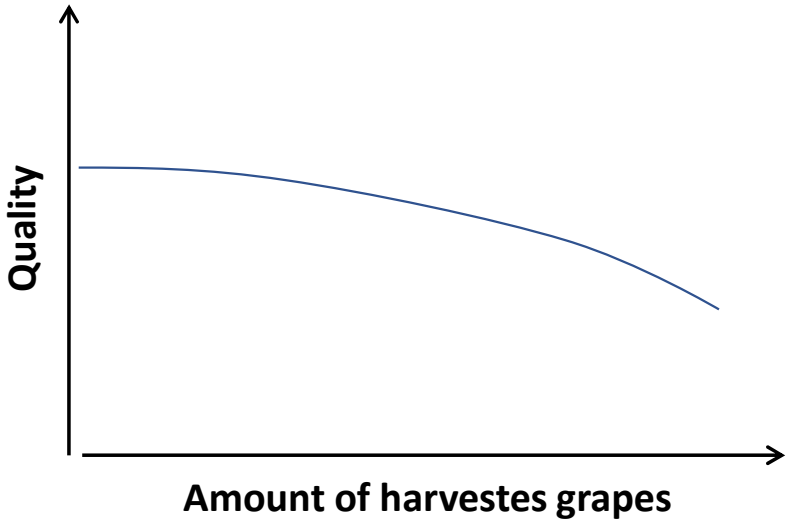
Vineyard Uni Hohenheim, winter 2021

Picture, Zörb

Picture, Zörb

Picture, Zörb

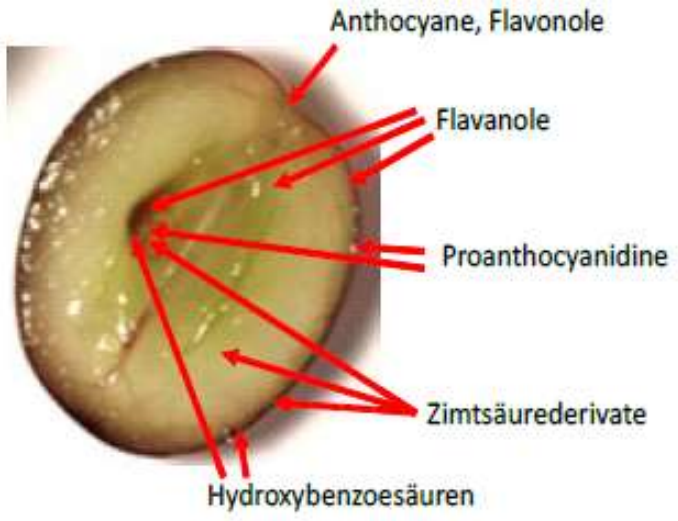
Wine: Quantity versus Quality



The quantity-quality rule in viticulture: Schematic representation of the opposing relationship between the level of yield and the quality of the berries for wine production.

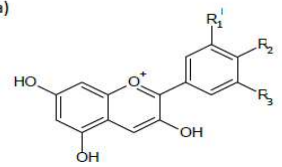
Source: Diagnose des Ernährungszustandes von Kulturpflanzen Kapitel Weinbau (Zörb, Merkt); Agrimedia 2019

Health promoting substances in wine



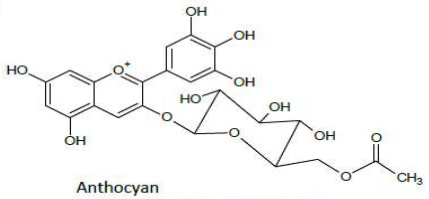
Anthocyanidines

a)



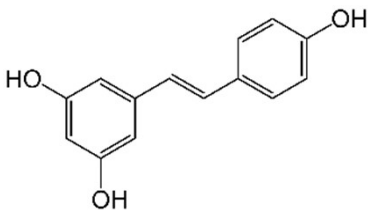
Anthocyanidine
Delphinidin: $R_1 = R_2 = R_3 = OH$
Cyanidin: $R_1 = R_2 = OH$, $R_3 = H$
Petunidin: $R_1 = OCH_3$, $R_2 = R_3 = OH$
Paeonidin: $R_1 = OCH_3$, $R_2 = OH$, $R_3 = H$
Malvidin: $R_1 = R_3 = OCH_3$, $R_2 = OH$

b)

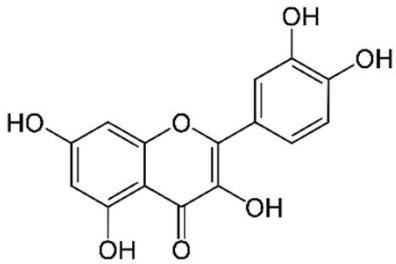


Anthocyan
Delphinidin-3-*O*-acetylglucosid

Resveratrol (a stilbenoid)



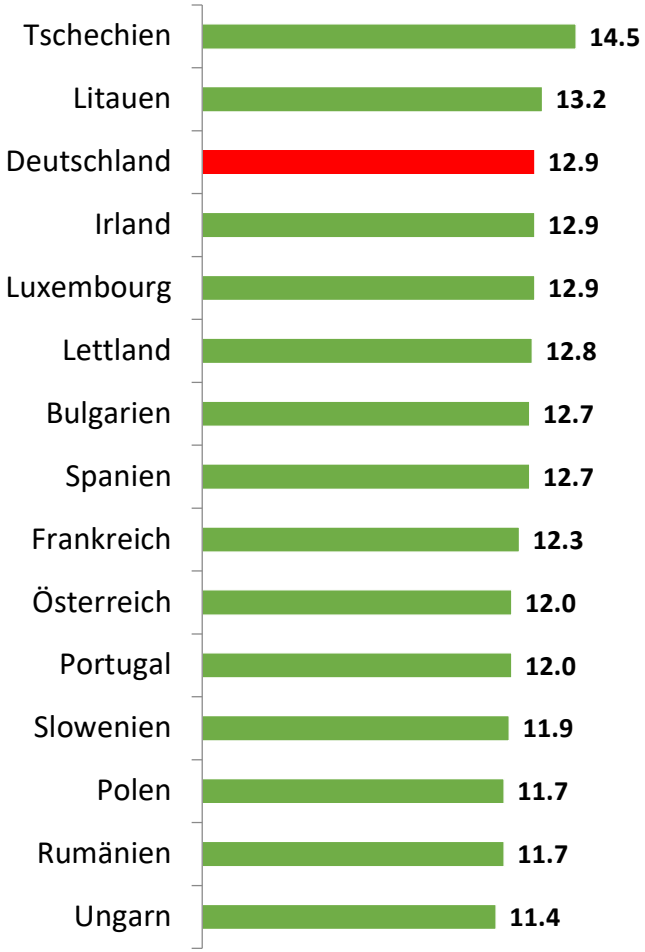
Quercetin (a flavonol)



Quercetin is a plant flavonol from the flavonoid group of polyphenols. Quercetin has a bitter flavor.

Alcohol consume in Europe

yearly per capita in Litre pure alcohol



Source, WHO 2016-2018

Coose responsibly **enjoy and share** **drink in moderation**

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AGROFORESTRY

Simulatneous culitvation of trees and vines

Nitrogen isotope discrimination
Microvinification
Wine sensory analysis

ARCHIVES OF AGRONOMY AND SOIL SCIENCE
https://doi.org/10.1080/03650340.2018.1493197

Published 2018

Taylor & Francis
Taylor & Francis Group

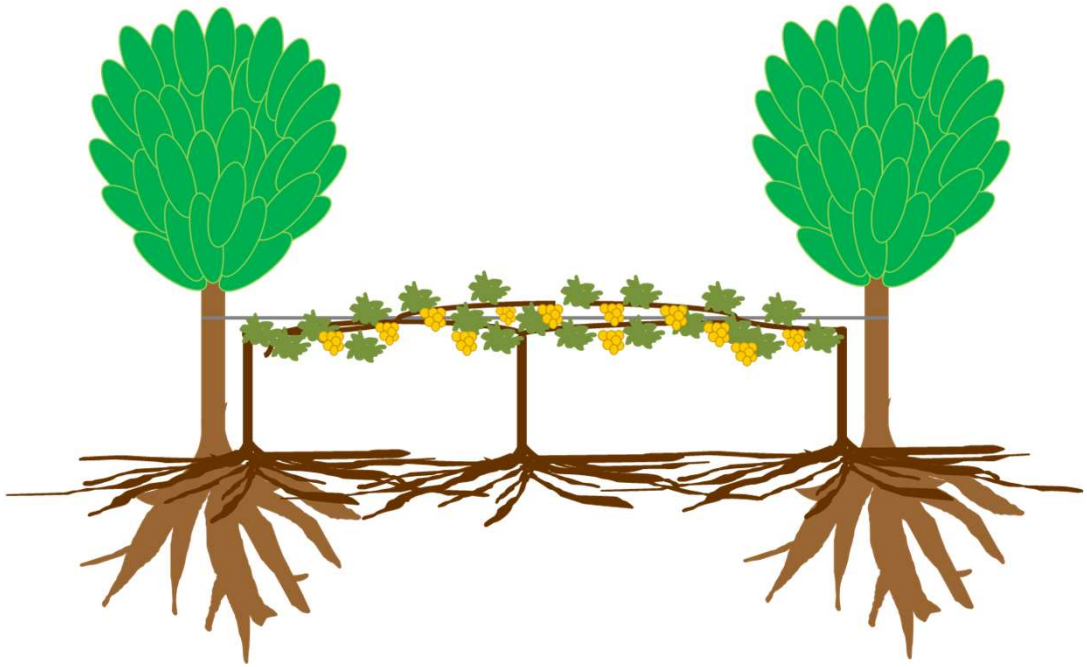
Check for updates

Interaction between grapevines and trees: effects on water relations, nitrogen nutrition, and wine

Carina P. Lang[a], Nikolaus Merkt[a], Christoph-Martin Geilfus[b], Simone Graeff–Hönninger[c], Judy Simon[d], Heinz Rennenberg[e] and Christian Zörb[a]

Co-cultivation of trees and vines

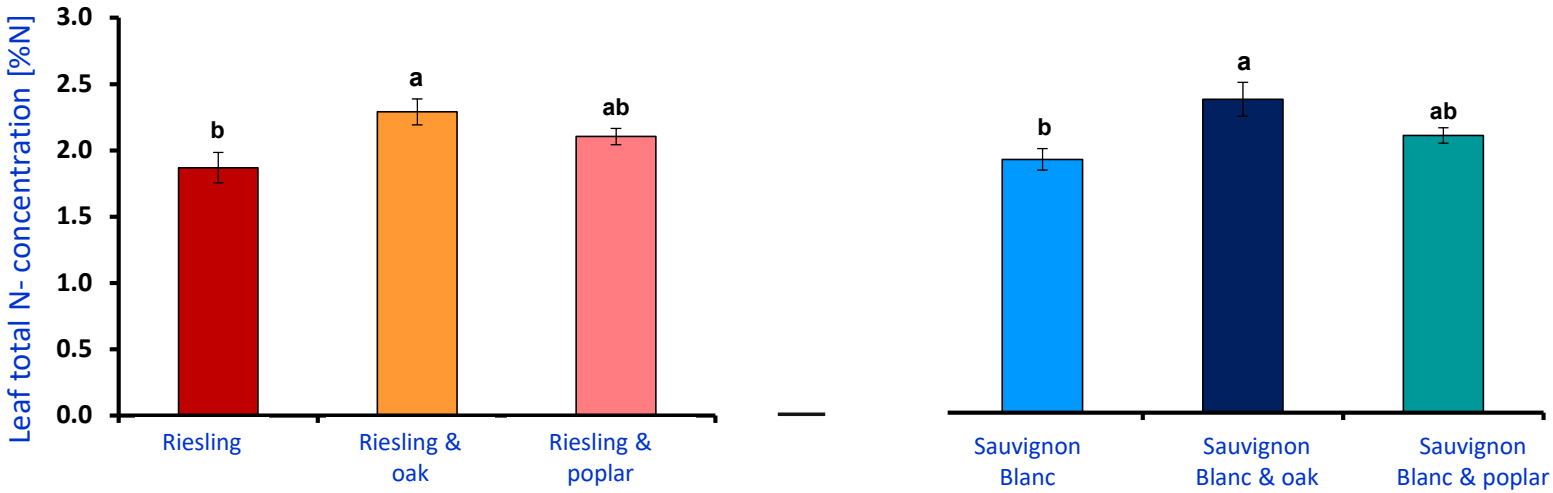
single cropping	mixed cropping
Sauvignon Blanc (S)	Sauvignon Blanc & oak (SO)
Riesling (R)	Sauvignon Blanc & poplar (SP)
oak (O)	Riesling & oak (RO)
poplar (P)	Riesling & poplar (RP)



Nitrogen isotope discrimination assay

Figure & Foto: Lang, C.P.

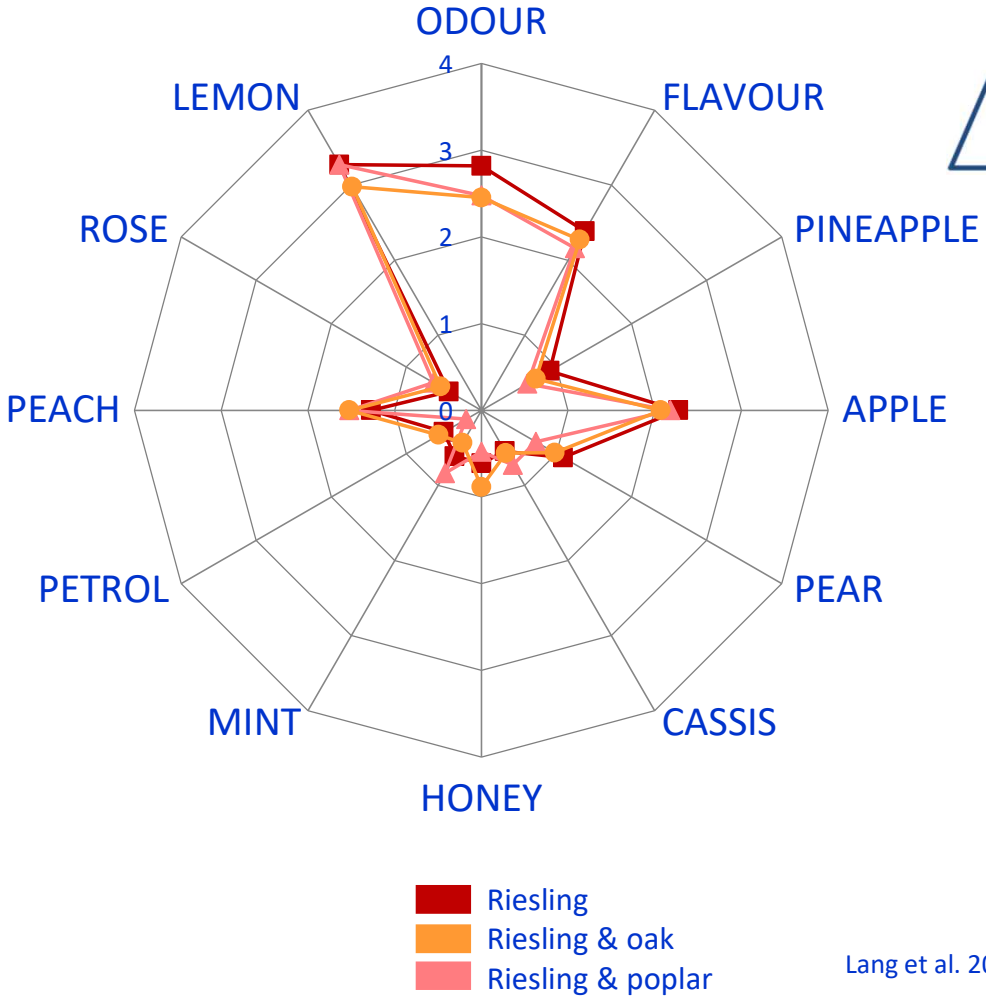
Nitrogen uptake in single cropping vs mixed cropping systems



→ **Mixed cropping systems increase leaf N- content and N uptake**

Lang et al. 2018

Effect of silviculture on wine aroma attributes



Silviculture: slighty changed individual wine aroma attributes

Lang et al. 2018

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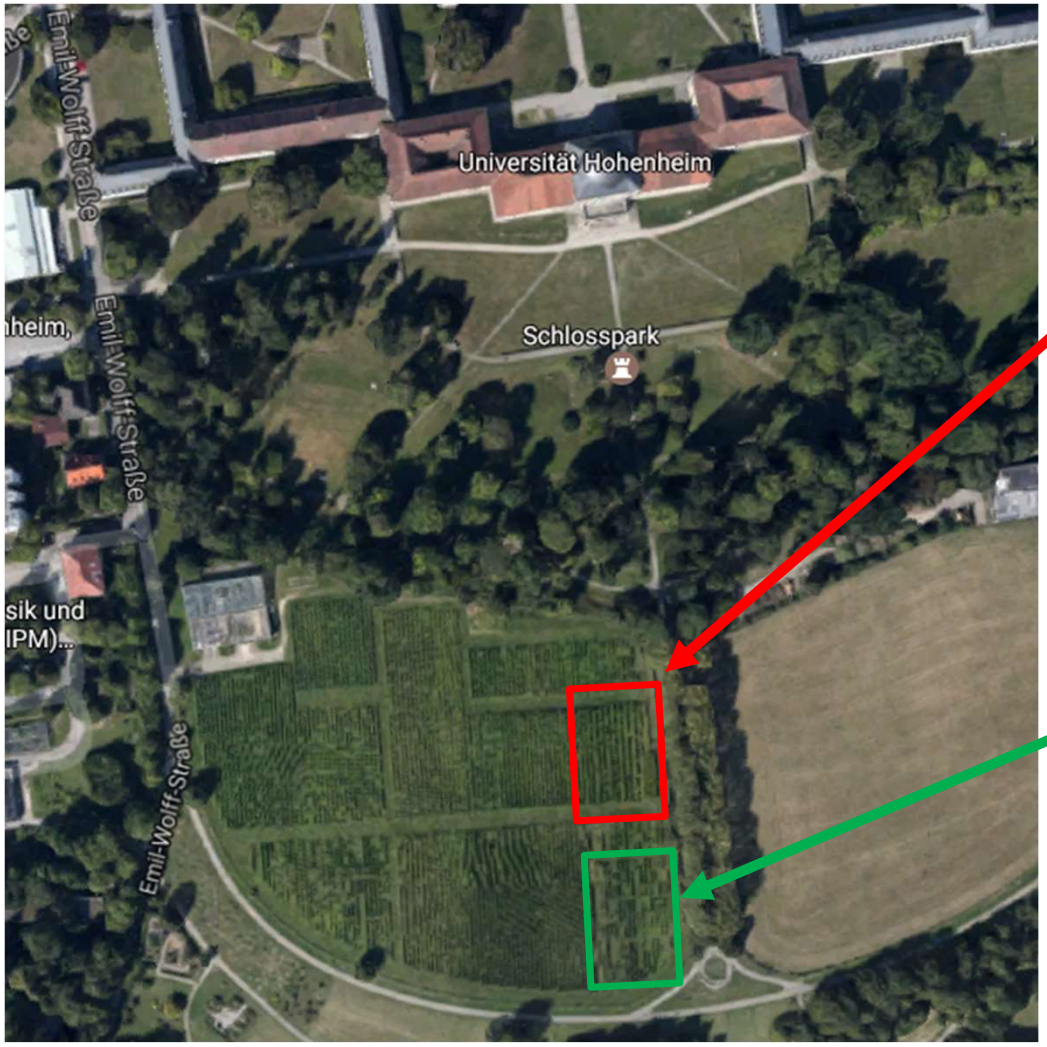
Vineyard, University of Hohenheim (ca. 2 ha)



18 different grapevine training systems

Variety Helios (white wine)

Research Question:

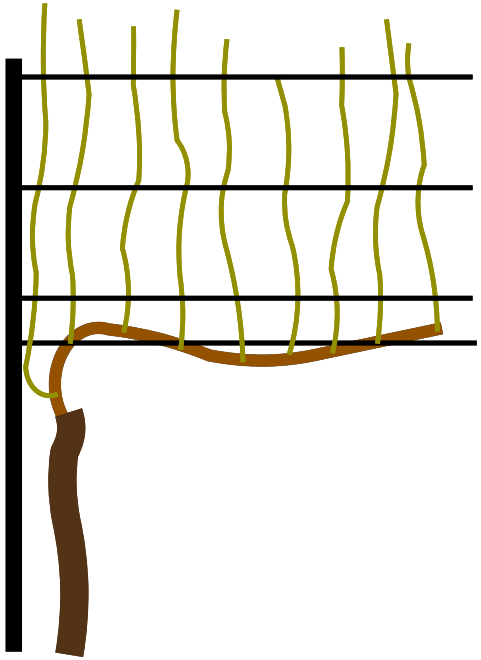
- **Which training system performs better in climate change**

250 different grapevine varieties

Research Question:

- **Which varieties do better in climate change**

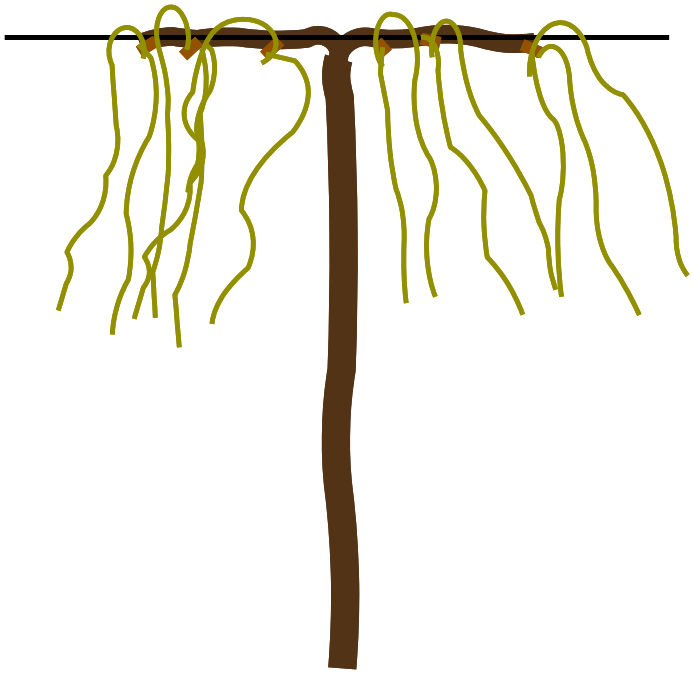
18 different training (pruning) systems at vinyard University of Hohenheim (only 4 are shown here)



Options: vertical

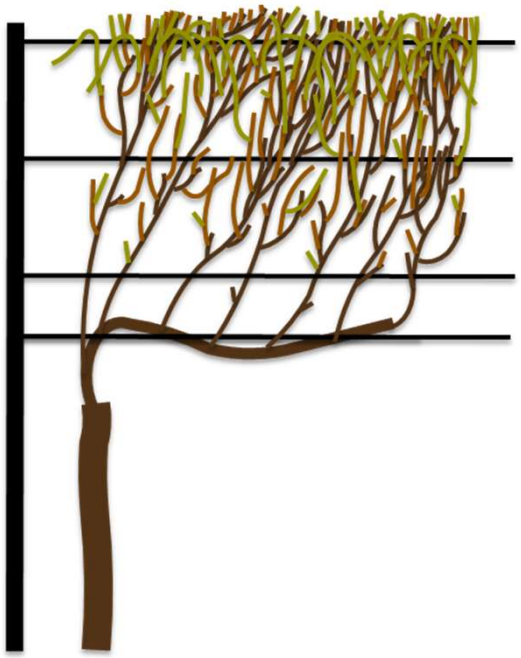
Spaliererziehung

Mosel-Einpfahl-Erziehung



hanging

T-Umkehrerziehung



minimal

Minimalschnitt

Metabolic Responses in Grapevine Leaves and Wine of the Different Training Systems (GC-MS/MS)

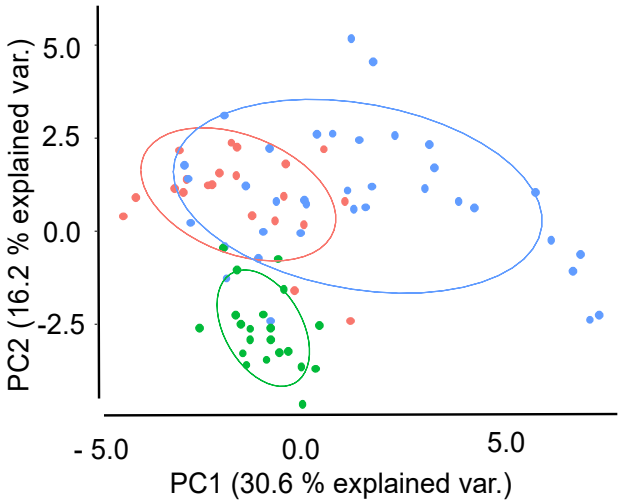
UNIVERSITY OF HOHENHEIM

Principal Component Analysis

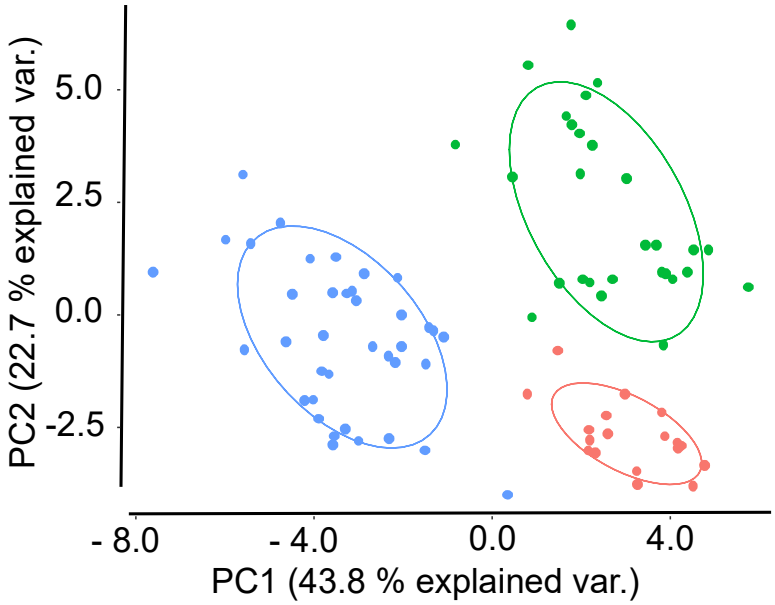
- Vertical shoot positioning systems
- Minimal pruning systems
- Hanging shoot systems

Paper under submission

Leaf



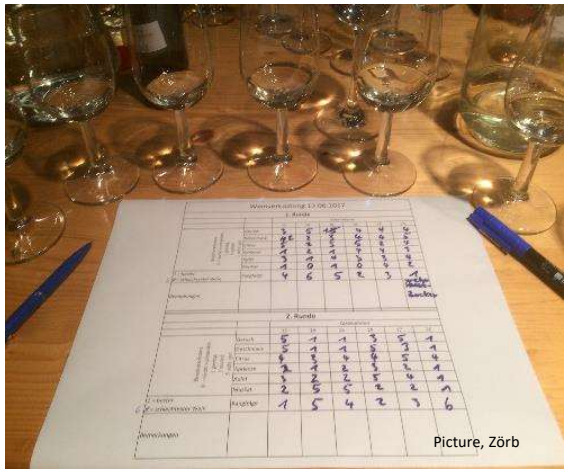
Wine

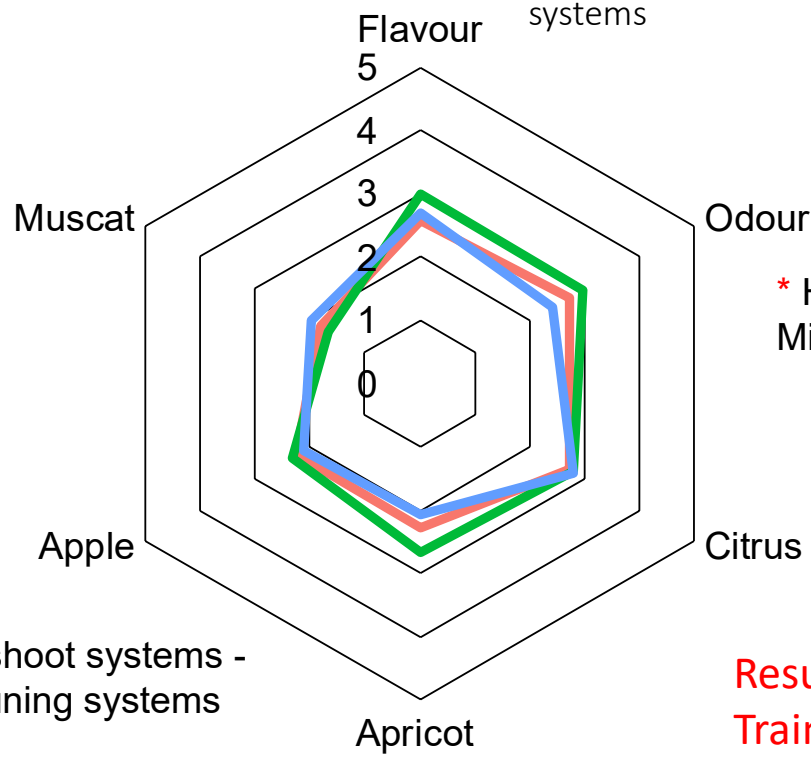


Wine sensory profile

UNIVERSITY OF HOHENHEIM

Variety Helios (white wine)





* Hanging shoot systems - Vertical shoot positioning systems

* Hanging shoot systems - Minimal pruning systems

* Hanging shoot systems - Vertical shoot positioning systems

Paper under submission

Vertical shoot positioning systems
Hanging shoot systems
Minimal pruning systems

*significantchange

* Hanging shoot systems - Minimal pruning systems

Result
Training systems may be changed according to the local climate without large effects on wine aroma

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Effect of drought, heat and combined stress

Heat, 29°C – 39°C

50% of field capacity

\+ Heat plus drought in combination

2 varieties, Riessling and Cabernet Sauvignon

University of Hohenheim and
Washington State University

Analyses: plant physiologial stress parameter (Photosynthesis rate, stomata regulation, ABA, prolin,…)

Results of the drought, heat and combined stress experiments with grapevine

- Combined heat and drought is not the sum of stress from heat and drought alone
- There is unique response of combined stress (signature for decreasing stomatal conductance and photosynthetic rate)
- Stomatal conductance has a signature particularly for combined stress in contrast to individual stresses
- While plants open their stomata under heat conditions to lower the leaf temperature, they close their stomata under water deficit to save water.
- The pattern of proline (prolin concentration and key gene P5CS expression) was particularly influenced by combined stress.
- Drought stress hat greatest influence on ABA concentration (plant stress hormone) and NCED1 gene expression (key enzyme of ABA synthesis)

Climate change with more drought and heat events therefore has great influence on grapevine physiology

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Picture, Zörb

Breeding of new varieties

(the classcicak breeding process takes 20-30 years)

- resistance against fungal disease
- viral diseases
- with new quality aspects
- changed structure of the clusters
- later ripening to cope against climate change

Germany: Regent, Helios, Villaris, Solaris Calardis blanc, Souviniac,…

Japan: Shinano-Riesling

Picture, Zörb

Grafting of new variety on old roodstock

UNIVERSITÄT HOHENHEIM

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Markus Dier

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Johanna Beeck & Frederic Fürsternberger

The whole Group of Viticulture

DFG Deutsche Forschungsgemeinschaft

Bundesministerium für Bildung und Forschung